# ESSAYS ON HEALTH AND FAMILY ECONOMICS

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**ESSAYS ON HEALTH AND FAMILY ECONOMICS**

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This dissertation consists of three essays on health economics and family economics.

Chapter 1 studies the impact of school on childhood obesity in Australia. Consistent with the global obesity epidemic, Australia's rate of childhood obesity has shown an alarming upward trend. While a trend of this magnitude can only be explained by the environment, the exact mechanism remains unclear. I compare early school entrants to late entrants, and finds large differences. This chapter reveals that the school environment is responsible for the phenomenon, and that the environment contributes mostly by exposing children to sugar-sweetened beverages, rather than by causing a lack of physical exercise.

Chapter 2 investigates the impact of gender-neutral and marriage-neutral custody laws on domestic violence and homicide in the United States. Using the difference in timing of custody law changes across different states, I find that a custody regime which is neutral in both gender and marriage leads to significant decline in domestic violence for women, and homicide for both men and women.

Chapter 3 studies teen childbearing and establishes its quantitative relationship with maturation of adolescents. Teen childbearing is a particular social concern because unlike most other risky behaviors like smoking and binge drinking, it is a lifelong responsibility that cannot be reversed. Nevertheless, this irreversibility also makes it difficult to identify whether the involved individuals regret their childbearing decision or not. The answer to this question matters to adolescent policies since only if teen childbearing leads to maturation and regret, the society is in a position to intervene the autonomy of adolescents. This chapter applies the methodology devised in Mak (2015) to measure maturation using the

simultaneous changes in many reversible risky behaviors. We find that teen childbearing is associated with 18% more probability of being mature conditional on being immature in the previous period for females; the corresponding figure for males are much smaller in magnitude. Together with some other supporting evidence, this result indicates that teen childbearing is a very negative shock to the involved females, yet the involved males tend to leave the burden to their partners.

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# PREFACE

I am extremely grateful to my advisor Arie Beresteanu for his support and guidance during my Ph.D. studies. I would also like to thank my other committee members Federico Zincenko, Marla Ripoll and Lisa Bodnar for their useful feedback.

Finally, I would like to thank my brother Eric Mak and my parents for their unconditional love. Their tremendous support helped me in completing this long journey.

# 1.0 DOES SCHOOL STARTING AGE MATTER? THE IMPACT OF SCHOOL ON CHILDHOOD OBESITY, DIET AND TIME USE IN AUSTRALIA

## 1.1 INTRODUCTION

Childhood obesity rates are generally rising in many countries, a phenomenon known as the *obesity epidemic*. In Australia, one in five children are now considered to be overweight or obese by the age of five.[1] The large change in the obesity rates over time has drawn the attention of researchers in multiple fields (Cawley, 2010) due to its negative consequences for health, academic, and economic outcomes in adulthood.[2]

This dramatic increase in childhood obesity rates, which took place within a window of just a few decades, is unlikely to be due to genetic changes across cohorts. It is logical for health economists and researchers to turn to environmental changes, particularly exercise and diet, to explain childhood obesity. Concerning exercise, Cawley et al. (2007, 2013) find that physical education has some impact on childhood and teenage obesity. Concerning diet, Schanzenbach (2009) finds that regularly eating school lunch increases obesity rates by 2%,

[1] See also Ogden et al. (2002). In the United States, reports indicate that the prevalence of obesity quadrupled between 1965 and 2000.

[2] Previous research has revealed the association between childhood obesity and health problems such as type 2 diabetes. Educators find that obese children generally have worse academic outcomes than children with a healthy weight (Taras and Potts-Datema, 2005). As childhood obesity usually persists into adulthood, it may also be a leading cause of adult obesity and its associated economic outcomes, such as decreased earnings (Cawley, 2004).

and Anderson and Butcher (2006) conclude that increasing children's exposure to junk food at school by 10% leads to a 1% increase in average body mass index (BMI). As Anderson et al. (2011) point out, these studies are mostly across-school comparisons, and most of them conclude that a weight-worsening school environment increases the likelihood of childhood obesity.

Although they are significant, these figures are an order of magnitude smaller relative to the overall increase in childhood obesity. One possible reason for this is that diet and exercise time may not have much cross-sectional variation across schools. This is especially true in the case of the United States, whose National School Lunch Program guarantees that the school lunches meet particular standards. In Australia, school lunches and physical exercise are not under centralized management. However, guidelines issued by the government do require that food items provided in school canteens do not differ by a large degree in terms of nutritional values across schools. Therefore, all Australian children have rather homogeneous school environments. This explains the relatively small effects found in the literature.

This paper adopts another identification strategy to complement the literature discussed above. Instead of comparing across schools, this paper compares children who have had earlier exposure to the school environment ("early entrants" hereafter) against their counterparts who have had later exposure ("late entrants" hereafter). This identification strategy of contrasting the school versus the home environment can examine whether the school environment is responsible for childhood obesity in Australia. In school, children experience an environment with regulated exercise and diet. In principle, one might expect that children in school should be less prone to childhood obesity than children at home. However, this paper's findings are the opposite: Children in school have a one-fourth higher probability of being obese than children at home. This figure is significant enough to explain the childhood obesity trend.

A caveat: A direct comparison as it is would be unwarranted. Due to selection, early entrants may differ ex-ante from late entrants. In the language of treatment effects, the two groups differ in their pre-treatment characteristics. As the treatment of concern, the school environment may not cause the difference in obesity rates between the early entrants and the late entrants, even if there is a difference in obesity between the two groups. To achieve a fair comparison, I use a RD design to construct valid comparison groups. Specifically, this paper compares children who are just eligible for school versus children who are just ineligible for school, as determined by an age cutoff. The two groups are thus very close in age, and therefore very close in their pre-treatment characteristics as well. As children may not comply perfectly to the eligibility rule, my design belongs to the class of fuzzy RD that largely resembles an instrumental variable setting (Angrist and Lavy, 1999). Methodologically, this paper is most similar to Anderson et al. (2011) in the sense that these researchers also use age cutoff rules for school attendance to study the effect of school on BMI in the United States.

This paper uses data from the Longitudinal Study of Australian Children (LSAC), which contains rich information on Australian children, including those who attend school early and those who do not. In particular, the LSAC contains children's time-use diaries and information regarding food exposure. With these data, I am able to present a more complete analysis that links school attendance, exercise and diet, and ultimately childhood obesity. Analyses that include all of these variables are not available in the previous literature. The LSAC also contains alternative weight outcome measures to offer a broader picture of health. As discussed in Cawley et al. (2013), BMI itself does not capture all potential weight problems. Measures such as waist-to-height ratio can be an even better indicator of problems with overweightness or high fat accumulation. This paper's results include both BMI and alternative measures.

My results reveal that children who enter school early are at least 26% more likely to be obese, and 22% more likely to have a waist-to-height ratio exceeding 0.5, which is a benchmark for central obesity problems. This is consistent with the evidence of increased exposure to sugar-sweetened beverages at school, as early entrants are 19% more likely to be exposed to them. Time use analysis shows no significant difference between early and late entrants, as active time in school substitutes active time with parents.

In sum, the analysis supports the following story on the cause of childhood obesity: Going to school earlier shifts a large part of the children's time with parents to time in school, especially on weekdays. In addition, schools usually offer different food options than those available at home, which affects children's diet patterns and junk food consumption. Children in school have a substantially larger intake of sugary drinks, whereas their intake of fat and their total time for physical exercise does not differ from children at home.

Using a similar strategy, Anderson et al. (2011) analyze the case in the United States, and find no significant impact of school on childhood obesity. The United States data do not have information on time use and diet; therefore, the exact channel of how school attendance affects obesity rates of children cannot be studied. It is thus unclear whether school and home differ in these two aspects, or if their effects offset each other, resulting in no significant change in childhood obesity. In contrast, the rich data of the LSAC allow this paper to study these critical factors of childhood obesity, adding to the earlier literature on this important social issue.

Studying obesity pertains to the ongoing debate about the setting of school entry age rules, which vary across countries.[3] In Australia, different states and territories have varying age cutoffs for school entry. The Ministerial Council of Education, Employment, Training

[3]In countries like Japan and Germany, children typically start school at the age of six. There are also countries which have earlier school entry age thresholds, e.g. the United Kingdom, where children enter school at the age of five.

and Youth Affairs made suggestions for a uniform school entry age ranging from four years five months to four years eight months (Solutions, 2006; Edwards et al., 2011). This would generally make children eligible for school at a younger age than now. More recently, the Australian Primary Principals' Association proposed a higher standard age of five and a half years. While Suziedelyte and Zhu (2015) conclude that an early school start improves Australian children's cognitive skills and negatively affects non-cognitive skills, its effect on children's physical health has not yet been studied.

The rest of this paper is organized as follows. Section 1.2 reviews the literature on child obesity, with a focus on the school environment. Section 1.3 provides a summary of the Australian education system, and the state-specific age cutoff rules for school entry. Section 1.4 describes the data used, and defines important variables. Section 1.5 presents the RD design in detail, showing how eligibility for school attendance can be a strong and valid instrumental variable. Section 1.6 reports the effects of school on different weight measures, diet, and children's time use. Section 1.7 shows subgroup analysis. Section 1.8 concludes.

## 1.2 LITERATURE REVIEW

This literature review summarizes the factors that relate to school children obesity. Cawley (2010) offers a comprehensive summary on the recent progress on general childhood obesity. Taking an intellectual debt, here I abstract some of his key points and relate to the findings in this paper about school children, complementing them with a discussion on the literature on school lunches. A discussion on the school environment in Australia follows.

### 1.2.1 Obesity-Causing Factors

**Drop in Food Prices** First of all, he first reports that food prices has dropped significantly over time (Christian and Rashad, 2009), and that could increase food intake; in particular, Beghin and Jensen (2008) find that, due to the drop in the price of sugar, soft drink producers tend to substitute high-fructose corn syrup for sugar. Together with my findings that Australian children in school are more prone to sugary drinks intake, the empirical evidence leads to a conclusion that the increased obesity rate among school children can be due to the exposure to affordable sugary drinks.

**Advertising** Another possible channel is through advertising (Cawley and Kirwan, 2011): producers who receive agricultural price supports need to engage in commodity-specific advertising; these funds are often used to promote fast-food menu items. Unlike children at home who stay under the monitoring of parents, children in school may have more free time during lunch breaks and the transit between home and school. Henceforth children at school are more likely to be attracted by the advertisement.

**Substitutes for Maternal Care** A literature finds that maternal employment is an important determinant of childhood obesity (Anderson et al., 2003; von Hinke Kessler Scholder, 2008; Fertig et al., 2009; Cawley and Liu, 2012). As they argue, a (full-time) working mothers often cannot take care their children properly. Consequently, their children often need to consume prepared foods, instead of having regular meals. Moreover, these children may also be sent to child care; Herbst and Tekin (2011) find that they are are more likely to be obese. The school is, to some extent, an extension of child care for older children. Therefore, it is natural to hypothesize if the school leads to similar childhood obesity effects. This argument, however, also implies that working mothers could be more likely to send their children to school earlier, it confounds the effect of the school on childhood obesity. To eliminate this confounding influence, the regression discontinuity design becomes necessary. This ensures a fair comparison between early and late school entrants.

**School Lunches** Another literature that this paper covers concerns about school lunches. Woo Baidal and Taveras (2014) review the previous researches on school lunches, which mostly point to a fact that school lunches were once problematic: "[school children] consumed more saturated fat than was recommended, and sodium intake was excessive in all age groups. Children ate more than 500 excess calories from solid fats and added sugars per day.", yet are improving. The literature find a small and sometimes negative effect (Schanzenbach, 2009; Millimet et al., 2010) on different school-level programs (diet reforms), such as the School Breakfast Program (SBP) and the National School Lunch Program (NSLP). More recently, Gundersen et al. (2012) uses a more advanced non-parametric, partial identification strategy that handles non-random selection and misclassification errors, finding a mildly positive effect with large bounds. Therefore it is hard to reach a consensus on this issue. The situation is also likely to change as the school lunch improves in quality over time.

### 1.2.2 The Australian School Environment

In Australia, school lunches are not under centralized supply. In the school canteens, most children buy their own food. Some schools may let the parents to instruct on the food selection for their children, but children largely have their own freedom to choose what they eat.

Australia has some guidelines to the provision of food in school canteens. The Australian Department of Health commenced the National Healthy School Canteens (NHSC) project in 2008. The project develops national guidelines to the school canteens on the making of healthy food. The guideline offers detailed recommendations on the types of food, the number of servings, the amount per serving. In each state and territory of Australia, there are specific guidelines as well. For instance, the New South Wales government develops the Fresh Tastes Strategy which is mandatory for all public schools in the state. For non-government schools, The Catholic Education Commission and Association of Independent Schools both expressed their support to the program. In an evaluation report, it states that "nearly all (98%) of the Canteen Managers surveyed reported that they had made all or some of the changes to meet the requirements of the Strategy". In a descriptive study, it is noted that although positive effects are evident, the degree of implementation vary (Ardzejewska et al., 2013). The situation in other provinces are similar. A list of state-level guidelines are listed below in Table 1.

In more recent years, a few states have started to impose a ban on sugar sweetened beverages. For instance in NSW, a ban on selling sugar sweetened beverages was imposed in 2007. However, violations of the rules are reported and the ban has only been imposed in government schools. Catholic and private schools only indicated that they encouraged such changes. Drinks are classified as "green" , "amber" or "red" in school. Under the ban, only some sugar sweetened drinks categorized as "red" can no longer be sold in school canteens and vending machines [4]. This leaves a lot of room for sweetened drinks to be still available in the school environment.

As a preview, the data I am using for this paper offer information on two cohorts of children in Australia. Therefore it provides a chance for me to explore whether children's exposure to sugary drinks or other unhealthy food items is improving or worsening over the years in Australia.

[4]For example, sugar sweetened drinks with less than 100kJ per serve and less than 100mg of sodium per serve can still be offered.

| Province | Program |
|---|---|
| New South Wales (NSW) | Fresh Tastes Strategy |
| Australian Capital Territory (ACT) | National Healthy School Canteens Guidelines |
| Victoria (VIC) | School Canteen and Other Food Services Policy |
| Queensland (QLD) | Smart Choices |
| Western Australia (WA) | Healthy Food and Drink |
| South Australia (SA) | Right Bite Strategy |
| Northern Territory (NT) | Northern Territory Canteen, Nutrition and Healthy Eating Policy |
| Tasmania (TAS) | National Health School Canteens Guidelines |

Table 1: Australian Provincial-Level School Canteen Guidelines

## 1.3 BACKGROUND

### 1.3.1 Education System in Australia

In Australia, different states and territories have their own school entry age policy. The number of intakes in a school year and the name of the first year of formal schooling also varies across states. The following table summarizes the school entry age cutoffs of each state and territory.

In most states, there is a single intake in a school year, except for South Australia and Northern Territory. In those two states, children only have to be five years old at the beginning of a school term. Due to limitation of survey data in which interviews are administered at a certain time of a year, it is not possible to determine the accurate school entry age for those children in the two states.

As Table 2 shows, most states allow children to enter the first year of formal schooling when they turn five years old in a year. In my paper, I include children from the following four states: New South Wales (NSW), Victoria (VIC), Western Australia (WA), and Australian

| State or Territory | First Year of School | Eligibility (Child turns 5 by) |
|---|---|---|
| Australian Capital Territory | Kindergarten | April 30 |
| New South Wales | Kindergarten | July 31 |
| Northern Territory | Transition | Within the year |
| Queensland | Year 1 | January 1 |
| South Australia | Reception | Within the year |
| Tasmania | Preparatory | January 1 |
| Victoria | Preparatory | April 30 |
| Western Australia | Pre-primary | June 30 |

Table 2: School Entry Age Rules in Australia

Capital Territory (ACT). As mentioned above, I do not include children from Northern Territory and South Australia due to the multiple school intakes in a year. As for Queensland, there is only one single intake but there was no formal pre-Year 1 program, and so most children start their first year of school at an older age. The four states I analyze on have similar school entry policies, in which they are have one single intake in a year and the first year of formal schooling is of a kindergarten, pre-Year 1 level. The relationship of school cutoff dates and school attendance is shown in Section 1.4.

### 1.3.2 Discussion on Common School Starting Age Across States and Territories

A common school entry age across all Australian states and territories has been debated among by educators. At the Ministerial Council of Education, Employment training and

Youth Affairs, a suggestion of a uniform age ranging from four years five months to four years eight months for school eligibility is discussed in a review (Solutions, 2006; Edwards et al., 2011). This in general makes children eligible to be at school at a younger age. More recently in the media, education experts call for a uniform, yet older school starting age. The Australian Primary Principals' Association proposes that the standardized age across all states and territories to be five and a half years. For instance, in New South Wales, children can start school as young as 4 and a half years old. Under the proposed rule, children would instead be at least 5 years old to be permitted to start kindergarten. A major focus is on how school exposure affects children in terms of cognitive, non-cognitive, and health development. Suziedelyte and Zhu (2015) provide evidence on Australian context that an early school start tends to increase cognitive skills, but reduces non-cognitive skills. It is unclear yet whether school exposure can significantly affects physical health of children in terms of weight outcomes. My paper addresses this issue.

## 1.4 DATA

This paper uses the data from the Longitudinal Survey of Australian Children (LSAC). The LSAC tracks a nationally representative group of Australian children and their families biannually, starting from year 2004. There are two cohorts in the data: the Kindergarten (K) cohort which includes children born between March 1999 and December 1999, and the Birth (B) cohort which has children born between March 2004 and December 2004. The B cohort is of less than 1 year old by the time the survey begins, so there is considerably more information on activities, diet and family conditions of those children upon birth compared with the K cohort. Overall, the data from both cohorts allow me to study the effect of early school start at age 4-5 (which happens at Wave 1 of K cohort data and Wave 3 of B cohort) on children's weight outcomes at age 6-7 (two years later). Table 3 summarizes age of children at each wave of interview of both cohorts.

| Cohort | Wave 1(2004) | Wave 2(2006) | Wave 3(2008) | Wave 4(2010) | Wave 5(2012) |
|---|---|---|---|---|---|
| K | 4-5 Years | 6-7 Years | 8-9 Years | 10-12 Years | 12-14 Years |
| B | 0-1 Year | 2-3 Years | 4-5 Years | 6-7 Years | 8-10 Years |

Table 3: Age at Each Wave of Interview

As explained in Section 1.3, my sample consists of children in the following four states and territories: New South Wales (NSW), Victoria (VIC), Australian Capital Territory (ACT) and Western Australia (WA). The attrition rate from one wave to another is small. There is no evidence of joint significance of demographic and socioeconomic factors (such as number of siblings, parents' age, language spoken at home, and household income) on attrition [5].

In the data, there is a clear discontinuity of school attendance across the cutoff dates for all four states. A significant increase of the percent of children who are at school exists. While NSW has the least increase in percent of children who start school, the jump is still very obvious. In Section 1.5, I will discuss the estimation strategy of using eligibility for school entry as an instrumental variable (IV) for school attendance. Plots of school attendance rate against age of children will be shown to show the discontinuity.

Apart from measures of weight outcome, the LSAC contains questions related to the diet of children. Another useful feature of the LSAC is the availability of children's time-use diaries. The Time Use Diary (TUD) records children's activities in a day which can be used to construct exercise time variables in my analysis.

[5] Results are available upon request.

### 1.4.1 Children's Weight and Obesity Measures

**1.4.1.1 BMI and Weight Status** The focus of this paper is on the physical health of children, in particular their weight outcomes. Body mass index (BMI) is defined as weight (in $kg$) divided by squared height ($m^2$). At each wave of the data, interviewers were instructed to measure the study children's weight in light clothing to the nearest 50g, by using glass bathroom scales (Wake and Maguire, 2012). Height on the other hand was measured twice without shoes, to the nearest 0.1 cm. A portable rigid stadiometer was used. Whenever the two height measures differed by more than 0.5 cm, another measurement was taken and the average of the two closest figures are used to construct an average. Otherwise, the average of the first two measurements are used. To assess weight status, the children are classified as normal weight, overweight, or obese according to the International Obesity Taskforce (IOTF) BMI cutoffs (Cole et al., 2000), and similarly using Cole et al. (2007) for underweight cases. The cutoffs are gender and age specific. Unlike the case of adults, for each gender the cutoffs change according to the age of children [6]. My paper focuses on normal, overweight, and obese children [7].

**1.4.1.2 Waist-to-Height Ratio** This paper is the first to study the causal impact of school on waist-to-height ratio (WHtR). There are studies in the medical literature which suggest that waist-to-height ratio (WHtR) is a better measure of central obesity, and a better predictor for diseases associated with abdominal fat (e.g. Type II diabetes). It also excels in predicting cardiovascular diseases in children compared to using BMI (Savva et al., 2000). In particular, WHtR is described as an easy and non-age-dependent index for screening overweight and obesity in children (Yan et al., 2007). A systematic review by Browning

[6] See the Appendix for the age and gender-specific cutoffs for girls and boys

[7] Only around 5% of children are underweight in the data. Children who are classified as underweight in Wave 1 or Wave 2 are not included in my sample.

et al. (2010) concludes from 28 studies that the mean boundary values for WHtR from 14 different countries (which include Caucasian, Asian, and Central American subjects) is 0.5. The fact that WHtR adjusts waist circumference for height offers a single useful boundary value for difference ethnic, age and gender groups. Though there are recent attempts which suggest that WHtR should still have gender, age and population group specific cutoffs; there is no updates on Australian children of the age range of my study as of today. Therefore, throughout the paper I am using 0.5 as the cutoff, which is the commonly used boundary value.

### 1.4.2 Diet and Time Use

Apart from weight outcomes, my paper is the first to study intermediate outcomes as diet and exercise time of children, which are considered to be main contributors to weight outcomes in the medical literature. While studies have shown that poor diet (e.g. exposure to junk food), lack of physical activities, and high amount of sedentary hours can contribute to higher weight of children, there is so far no studies done on the causal impact of school on them. For instance, Anderson et al. (2011) have shown the impact of school on BMI and overweight/obese status in the case of the United States, yet no analysis was done on the above factors. The LSAC on the other hand, provides sufficient information for these to be studied individually.

The LSAC provides two 24-hour time use diaries of children, one on a weekday and another on a weekend. The activities are finely categorized, which provides great details on time use of children in terms of physical activities and sedentary behaviors. As children start to spend a significant amount of time at school, whether they have appropriate amount of active time at school depends on the school environment and the curriculum. There can also be substitution between school and parental exercise time (e.g. if a child spends a lot of active time at school, he/she may tend to engage in less physical activity with parents). It is therefore important to study whether the overall active time changes. In terms of diet, during each interview, parents are asked how many servings the child has had a certain type of food in the past 24 hours. Though a serving does not necessarily convert to a standardized amount (as people may have different ideas of how large a ”serving” is), the questions give an idea of how often a child has had different categories of food; or at least, whether a child has exposure to certain types of food. Junk food exposure can be a contributor to heavier weight. The LSAC provides information on the exposure to sugar sweetened beverages, as well as food items with a high fat content. Upon school entry, children start to spend a large amount of time at school. A change from the home environment to school may cause a significant change in diet and exposure to different food categories. In Australia, there is no official school lunch policy, but tuck shops, vending machines or school canteens are available. The fact that there is a shift of a large amount of time from being at home to in school poses a risk on children's exposure to junk food.

**1.4.2.1 Diet** In the main survey, parents are asked how many times a child has eaten certain categories of food items in the last 24 hours. The questions include a broad spectrum of food items.

Food items which are considered as having high fat content include the following:

- Biscuits
- Pie
- Hot chips or french fries
- Potato chips or savoury snacks

The above items cover most of the commonly consumed high fat food of Australian children. Portion size is not mentioned in the data, and if any, it is highly debatable to have a common consensus of what is "one serving". Lumping the answers of the above "fatty food" categories, I construct a variable summarizing the number of times a child consumes fatty food [8].The majority of children have had at least some fatty food items. It is rarely a case that one has not had any in a day.

Sugar sweetened beverages on the other hand include soft drink or cordial. It is asked in one single question in the interview. I again construct a categorical variable summarizing whether a child has any exposure to them. In addition, at the intensive margin another categorial variable summarizes the options of: none, once, or more than once a child has had sugary drinks in a day. The portion size of each consumption is unknown. This variable however gives information on the frequency of consumption in a day.

**1.4.2.2 Time use: Exercise and Active Time** LSAC collects time-use diary (TUD) of the study children over two separate days. The design aims for offering two 24-hour diaries, one on a specified weekday and another on a specified weekend day. The diaries were distributed after the interview, with the interviewer showing how to complete a diary to the respondent. Though the respondent received suggested dates to complete the diary, it can be the case that it is not followed. As such, the suggestion was to complete it on the same day in the next week. The objective of random allocation of days in a week was to have an even distribution among the 7 days in a week. Activities are recorded in 15-minute intervals, with 26 options of activity to choose from. The diaries also indicate the location which the activity took place (5 choices), and the person(s) the activity was done with (7 choices). As children were relatively young during the interview period, diaries were completed by adults (mostly the child's mother).

As children grow, the types of activities they might pursue became different. For example,

[8] In each of the question, the answer options are: not at all; once; and more than once.

the activity choices in age 4-5 and age 6-7 are not the same (but the diary design remains consistent across the two cohorts). In the Appendix, a sample diary of each age is given.

To construct time use variables, I focus on the time spent on physical activities. The time spent measured is converted to hours, with the time in the weekday diary multiplied by 5, and that in a weekend diary multiplied by 2. These represent the weekly active hours. To ensure that the time measure is a good representation of weekly time spent, only observations which consist of one weekday and one weekend diaries are included.

At age 4-5, children are young and physical activities in this paper can include moderate activities such as walking. In my paper, the activities included are:

- Walking (for travel or for fun)
- Riding bicyle, trike, etc.
- Active free play or other play/activities
- Organized lessons/activity
- Other exercise: swim/dance/run about
- Visiting people, special event, party
- Taken places with adult (e.g. shopping)

The definition of active time here includes all the time that a child is not inactive, and includes the time which a child is alone or with other people (e.g. with adults). As suggested by the Australian government, children of this age range should have at least 3 hours per day of active time, which amounts to 21 hours per week. The guideline does not only limit to vigorous sports as children are relatively young and generally do not participate in organized sport activities. In fact, most of the children in my data reach the required amount of active time per week.

## 1.5 ESTIMATION STRATEGY

### 1.5.1 Validity of RD design

**1.5.1.1 School Entry Rules and Timing of School Entry** Fig. 1 shows the plots of percentage of children in school against the months away from the corresponding cutoff for each state or territory. It shows that indeed the school entry rules strongly affects the percentage of children who enter school. The highest compliance rate occur in WA. The percentage of in-school children increases significantly at the cutoff. The lowest compliance occurs in NSW. Regardless, school entry rules have strong correlation with the timing that children attend school across all states. The required monotonicity assumption in a regression discontinuity design is satisfied. This shows the validity of using school eligibility of children as an IV for school entry in the subsequence analysis in this paper.

**1.5.1.2 Exogeneity Assumption** The validity of a RD design relies on no manipulation of birth timing of children around the cutoff. In particular, parents may tend to manipulate the timing depending on family and child characteristics. In the US, Dickert-Conlin and Elder (2010) find that there is no discontinuity in the number of births at the cut-off. In my paper, I check by plotting the density of age in months away from the cutoff. Note that in the case of discrete running variable (where age is not continuous in my data), using a standard Mccrary test for discontinuity is not appropriate. In particular, Mccrary test relies on local linear regression (Lee and Card, 2008). Presented below is a density plot. There is no observed discontinuity at zero (i.e. the cutoff). Further, I also investigate the following: household income per child, main language spoken by study child at home, child's birthweight, and child's weight status at age 2-3.[9] As observed in Fig. 3, the mean value of

[9]Weight status at age 2-3 is only available for the B cohort. However, the birthweight plot includes all children.

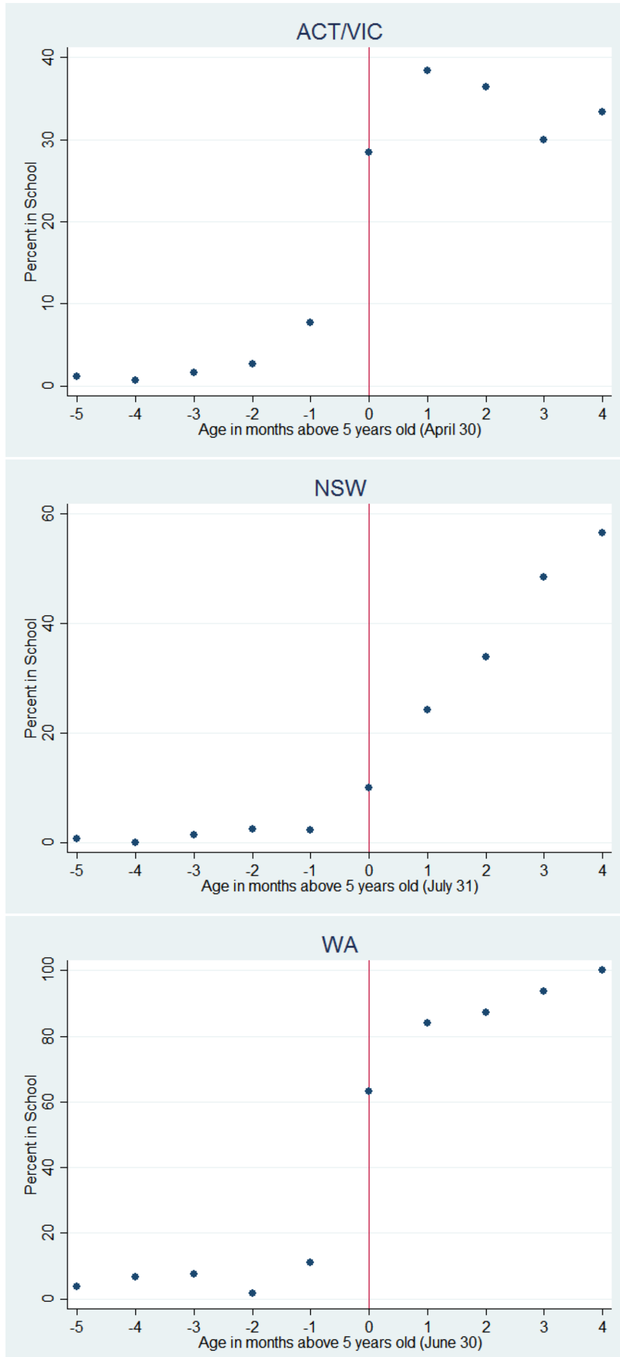


Figure 1: Effects of school cutoff rule on school attendance in ACT/VIC, NSW and WA

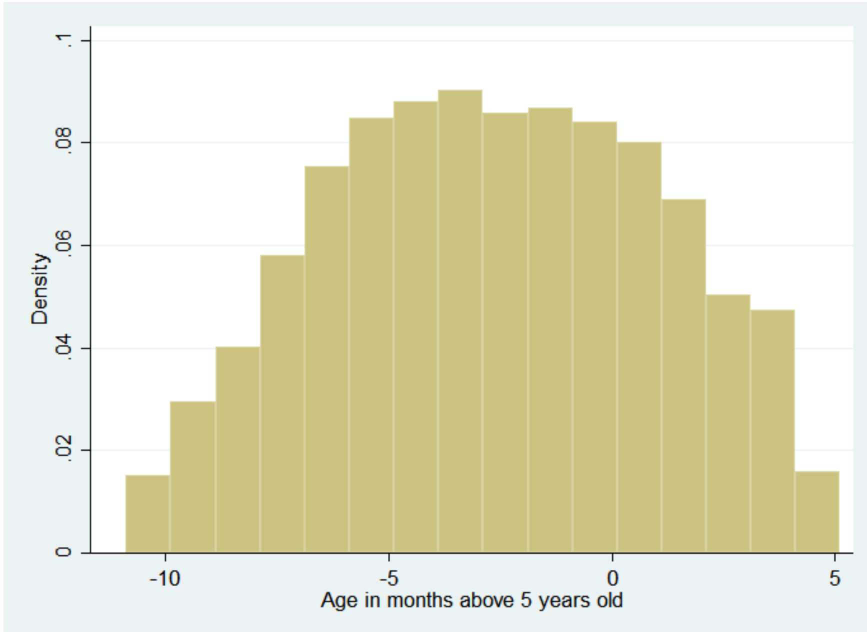


Figure 2: Density plot of children's age above cutoff

each variable is plotted against children's age. There appears to be no discontinuity in any of the above covariates. In particular, it is important to note that there is no discontinuity in the probability of overweight 2 years before the school year (i.e. age 2-3).[10] Therefore, it is highly unlikely the case that there is any selection.

[10] No discontinuity is found in other covariates such as number of siblings at home, mother's education, gender of child, height of child etc. Other plots available upon request.

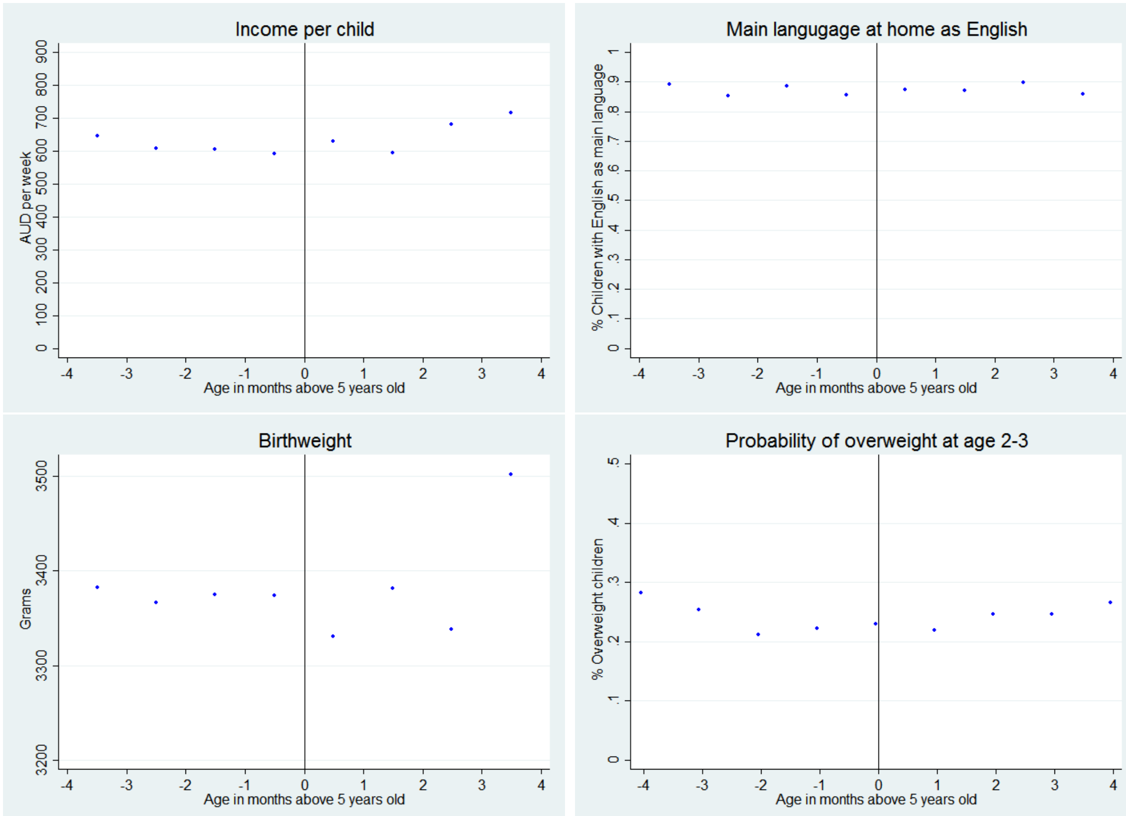


Figure 3: Plots of family and child characteristics against child's age above cutoff

### 1.5.2 Econometric Specification

Consider an estimation equation showing the relationship between the outcome variable $Y_i$ and school attendance $Sch_i$:

$$Y_i = \gamma_0 + \gamma_1 Sch_i + \gamma_2 X_i + \epsilon_i \tag{1.1}$$

Where $Sch_i$ is a binary variable which takes the value of 1 if a child begins school early, and 0 otherwise. $X_i$ includes other control variables which includes gender, state fixed effects, and age deviation from the cutoff date. Alternatively, there can be interaction terms of the control variables with $Sch_i$ to allow for heterogeneous treatment effect.

As described in Table 2, an Australian child is eligible to attend school only when she turns five years old by a certain cutoff date (which varies by states and territories). As the probability of school attendance does not jump from zero to one at the cutoff, it is a fuzzy regression discontinuity (Imbens and Lemieux, 2008) design.

School attendance itself can be endogenous. For instance, children who come from a disadvantaged background (e.g. low income families) may tend to be in school earlier for parents to avoid childcare costs. The casual impact of school attendance on an outcome can be found by using a binary instrument of whether a child is eligible for school at a year to instrument for school attendance. A child is considered to be eligible if she turns age five by the cutoff date in the state she resides in. The different age cutoffs in each state is listed in Table 2. The first and second stages of estimation are:

$$Sch_i = \alpha_0 + \alpha_1 \nVdash (age_i \geq 5) + \alpha_2 X_i + f(age_i - 5) + \zeta_i \tag{1.2}$$

$$Y_i = \beta_0 + \beta_1 Sch_i + \beta_2 X_i + g(age_i - 5) + \eta_i \tag{1.3}$$

where $f$ and $g$ are polynomials in the running variable of age. However, due to the nature of the data in which the exact birth dates are not known, the age information available is in months. This leads to a case of discrete running variable and using high order flexible polynomial can lead to a collinearity problem [11]. The solution adopted here is to non-parametrically control for age effects, and use age in months dummies as in (Suziedelyte and Zhu, 2015). To avoid perfect collinearity with the indicator for school eligibility and the constant term , the dummy for the month just before and after the cutoff are treated as baseline dummies.

Note that the first stage equation involves a binary dependent variable of school attendance. As pointed out by Baum et al. (2012), the usual approach of using linear probability model (LPM) in the first stage regression is not appropriate. One well known flaw is that the fitted values are not confined to the unit interval. Predicted probabilities can then be above one or below zero. Though some support the idea that LPM is easier to be implemented and works fine for values near the averages in the sample (Wooldridge, 2010; Angrist and Pischke, 2008), Lewbel et al. (2012) have shown that LPM cannot even give the correct sign of the treatment effect in a simple example in their paper. The "wrong" effect can even be found to be statistically significant, leading to an incorrect conclusion in the opposite direction.

In my paper, I opt to use a "probit two-stage least squares (probit-2sls)" approach proposed by Cerulli et al. (2012) when the outcome variable of interest $Y_i$ is continuous. This involves a first stage probit regression, and using the fitted probabilities I perform standard two stage least square as the second stage. Standard errors are adjusted.

When instead the outcome variable is binary, I adopt a bivariate probit model. It is used for estimations with weight status as the dependent variable (e.g. whether a child is

[11] It is found that $age$, $age^2$ and higher order terms of age are highly collinear.

obese or not). The identifying assumption is an exclusion restriction, that $\mathbb{1}(age_i \geq 5)$ is not included in the list of independent variables in the outcome equation. In particular, the equations become:

$$Sch_i^* = \alpha_0 + \alpha_1 \mathbb{1}(age_i \geq 5) + \alpha_2 X_i + f(age_i - 5) + \zeta_i \tag{1.4}$$

$$Y_i^* = \beta_0 + \beta_1 Sch_i + \beta_2 X_i + g(age_i - 5) + \eta_i \tag{1.5}$$

in which the latent variable $Sch_i$ takes the value of 1 if $Sch_i^* > 0$ and 0 otherwise. Similarly, $Y_i$ takes the value of 1 if $Y_i^* > 0$ and 0 otherwise. The error terms are assumed to follow the joint normal distribution:

$$\begin{bmatrix} \zeta_i \\ \eta_i \end{bmatrix} = N\left( \begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix} \right) \tag{1.6}$$

where $\rho$ represents the correlation between $\zeta_i$ and $\eta_i$. As $\rho$ can be non-zero, the estimation calls for a simultaneous estimation by Maximum Likelihood of the two equations (4) and (5). The log-Likelihood function can be found in p.123 of Maddala (1983). The estimation is unbiased even in the presence of an endogenous independent variable in the outcome equation (Greene and Hensher, 2010).

## 1.6 RESULTS

This section presents the results of the estimations outlined in the previous section. Note that all t-statistics in the regression of school attendance on whether a child is eligible for school exceeds 4.5 in all cases. To avoid including children who are too far away from the cutoff, only children five months above and below the cutoff date are included [12]

### 1.6.1 Weight and Obesity Measures

**1.6.1.1 BMI, Overweight Status, and Obesity** The impacts of school on BMI, probability of overweight, and probability of obese are presented in Table 4. The results for the K Cohort and B Cohort are shown respectively in columns (1)-(3) and (4)-(6). When merging the two cohorts, the result is shown in Table 5 instead. Note that across all regression results, school eligibility is statistically significant in the "first-stage" regression which school attendance is the dependent variable.

In all the columns which BMI is the dependent variable, a probit two-stage-least squares estimation is implemented as discussed in Section 1.5. In the columns which probability of overweight or obese is studied, a bivariate probit estimation is adopted. Therefore, an additional row showing the probit average treatment effect (ATE) is shown for those cases.

In the available data, the maximum age of children who are eligible for school is 4.98. To avoid including children who are too young and far away to the left from the cutoff, in each panel, I include observations which are within 5 months away from the cutoff date on the left. In all specifications, dummies of age in months (away from cutoff) and state fixed effects are included. There is no need to include other control variables given the RD design. Instead, subgroup analysis will be discussed in Section 7 to allow for different constant terms and slope estimates for specific groups (in terms of gender, types of school attended etc.). In particular, it is reasonable to believe that the marginal effects for boys and girls can be different.

[12] The maximum number of months above the cutoff in the data is 4.98. This serves as a guideline for choosing the lower bound on the left of the cutoff.

| | K Cohort | | | B Cohort | | |
|---|---|---|---|---|---|---|
| | Panel A: Instrumental Variable | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | BMI | Prob (Over) | Prob (Obese) | BMI | Prob(Over) | Prob(Obese) |
| In School Early | 0.205 | 0.474 | 1.183*** | 0.205 | 0.652* | 1.413*** |
| | (0.624) | (0.425) | (0.405) | (0.624) | (0.390) | (0.396) |
| Mean (dep. var.) | 16.77 | 0.208 | 0.059 | 16.77 | 0.210 | 0.068 |
| Std (dep. var.) | 2.103 | 0.405 | 0.235 | 2.103 | 0.408 | 0.251 |
| Probit LATE | | 0.147 | 0.230 | | 0.214 | 0.352 |
| | Panel B: First Stage | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | Prob(School) | Prob(School) | Prob(School) | Prob(School) | Prob(School) | Prob(School) |
| Eligible for School | 0.540*** | 0.525*** | 0.555*** | 0.540*** | 0.680*** | 0.706*** |
| | (0.136) | (0.140) | (0.133) | (0.136) | (0.141) | (0.141) |
| | Panel C: Reduced Form | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | BMI | Prob (Over) | Prob (Obese) | BMI | Prob(Over) | Prob(Obese) |
| Eligible for School | 0.125 | -0.098 | 0.208 | 0.125 | 0.104 | 0.169 |
| | (0.200) | (0.135) | (0.202) | (0.200) | (0.137) | (0.197) |
| Number of Obs. | 1872 | 1872 | 1872 | 1760 | 1760 | 1760 |

Table 4: BMI, Probabilities of Overweight or Obese at Age 6-7

**K and B Cohorts:**

In Table 4, columns (1) and (4) show the impact of school on the mean BMI at age 6-7. Columns (2) and (5) present the effects on the probability of overweight. Overweight is defined as the status which a child is considered to be so, depending on the age and gender specific cutoffs [13]. Overweight in this paper is defined as a category which includes all children passing the overweight cutoff (i.e. including obese children). Columns (3) and (6) show the effects on the probability of obese.

As observed in Panel A columns (1) and (4), the effect of school on BMI is positive yet statistically insignificant. Columns (2) and (4) show that the effect on the probability of overweight is positive. It is statistically insignificant for the K Cohort, and significant at 10% level for the B Cohort. In terms of magnitude of the school effects, it is greater for the B Cohort. For the B Cohort, children who enter school early are 21.4% more likely to be overweight. For the K Cohort, early entrants are 14.7% more likely to be so. The probability of obese is shown to be positive and statistically significant in both column (3) and column (6) at 1% level. Note that economically the effects are also significant. For the K Cohort, children who enter school early at age 4-5 are 23.0% more likely to be obese at age 6-7. The effects for the B Cohort is even larger at 35.2%.

Overall, it is observed that the effect on BMI and the probabilities of overweight and obese are larger for the B Cohort than that of the K Cohort. However, it is shown that both cohorts display similar pattern that the mean BMI does not change significantly, yet the probability of obese increases for children who enter school early.

[13]The specific cutoff values of BMI for overweight and obese status are shown in the appendix

| Panel A: Instrumental Variable | | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| | BMI | Prob (Over) | Prob (Obese) |
| In School Early | 0.388 | 0.485* | 1.203*** |
| | (0.444) | (0.280) | (0.290) |
| Mean (dep. var.) | 16.77 | 0.209 | 0.063 |
| Std (dep. var.) | 2.153 | 0.407 | 0.243 |
| Probit LATE | | 0.153 | 0.259 |
| **Panel B: First Stage** | | | |
| | (1) | (2) | (3) |
| | Prob(School) | Prob(School) | Prob(School) |
| Eligible for School | 0.613*** | 0.605*** | 0.619*** |
| | (0.981) | (0.099) | (0.096) |
| **Panel C: Reduced Form** | | | |
| | (1) | (2) | (3) |
| | BMI | Prob (Over) | Prob (Obese) |
| Eligible for School | 0.191 | 0.001 | 0.186 |
| | (0.147) | (0.096) | (0.141) |
| Number of Obs. | 3632 | 3632 | 3632 |

Table 5: Merged: BMI, Probabilities of Overweight or Obese at Age 6-7

**Merged:**

The two cohorts of children display similar pattern in weight outcomes. Merging the cohorts, the results remain to be very similar in Table 5: a small, positive but insignificant change in the mean BMI;, a moderate increase in the probability of being overweight, and a very significant impact on the probability of obese [14]. In particular, early school entrants are 25.9% more likely to be obese, and the result is significant at 1% level. Overall, it is safe to conclude that school has a positive and significant impact on the probability of obese. The

[14]Due to the nature of the data the running variable is discrete. For completeness, standard RD plots of the probabilities of overweight and obese are still presented in the appendix.

merged data provide enough observations to redo the above in a more localized approach. Limiting to children only 3 months above and below the cutoff, the result on the probability of obese is even stronger. Children who enter school early are 33.7% more likely to be obese (statistically significant at 1% level). If including children who are just 1 month away from the cutoff, the result remains to be robust. Early school entrants are 39.3% more likely to be obese (statistically significant at 1%).

The fact that the two cohorts have similar pattern in weight change from age 4 to 6 serves as a justification for merging the two in subsequence analysis. Though not entirely ideal, this step is necessary as a solution to the low number of observations in the data. Since time-use diaries are not readily available from all children, it is critical to do so in order to do any analysis on exercise habits, as well as subgroup analysis.

**Distributions of BMI:**

Tables 4 and 5 have shown that the effect of school on mean BMI is minimal. It is important to note though, a regression of the average BMI may not present the whole picture. The fact that the probability of obese shows a significant result calls for a comparison of the distributions of BMI between the "in school early" vs. "not in school early" groups.

A way to understand the difference between the "in school early" group vs. the "not in school early" group is to compare their BMI distribution plots. It is unfortunate that the K Cohort starts with data when children are aged 4-5. However, the B Cohort contains information of BMI when children are only aged 2-3. It is therefore possible to see whether early and late entrants differ 2 years before the school entry year.

Figure 4 presents the distributions of BMI of the two groups at the time before school, i.e. BMI at age 4-5, BMI at age 2-3; and that of birthweight. The longer green dashline at each BMI graph represents the cutoff for overweight, and the purple one represents that

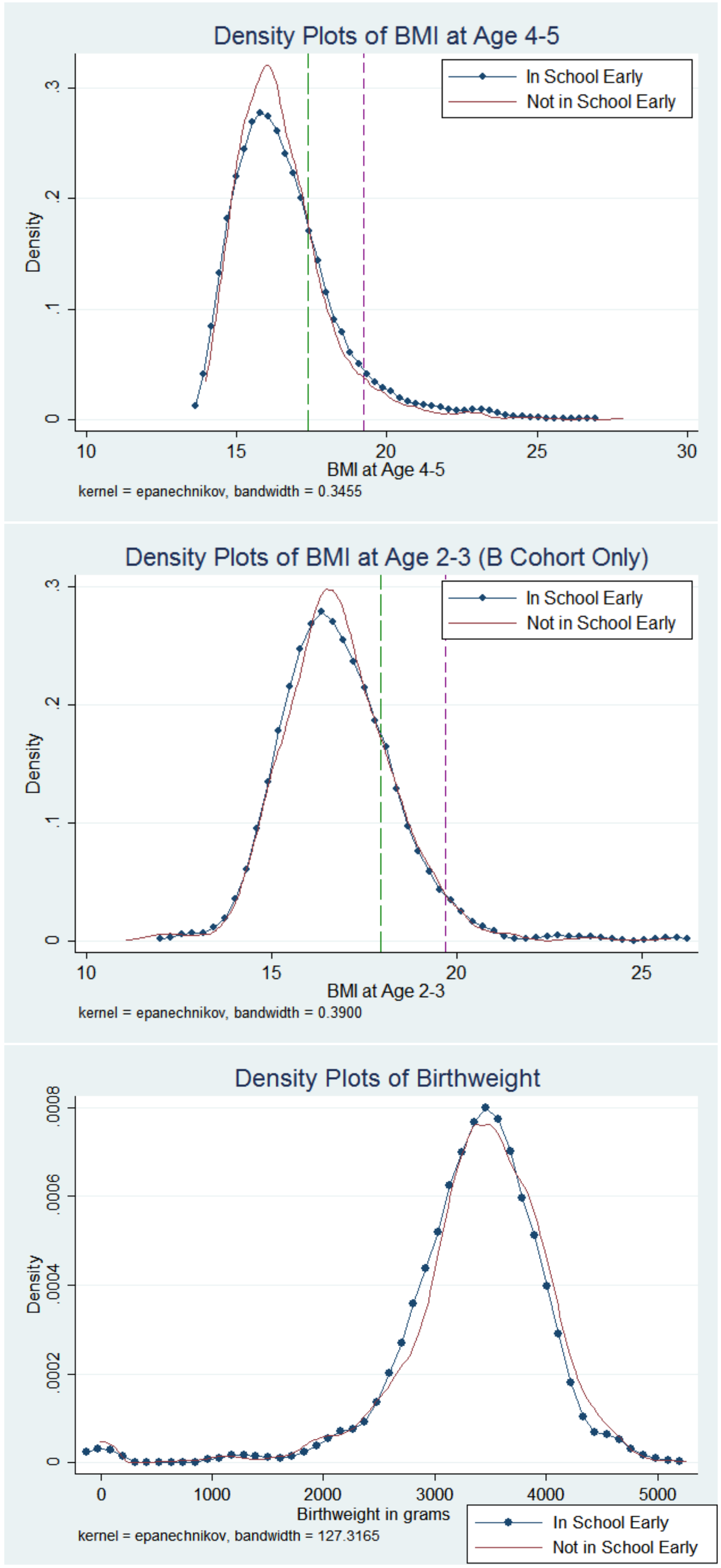


Figure 4: Distributions of BMI at or before School Entry Year, and Birthweight

for obese status [15]. Across all the distribution plots, the two groups display no significant difference in all the "pre-school" periods. There is minimal difference at age 4-5, the time which the early entrants have just started school for less than a year (school usually starts at January to February in Australia, and the interviews began in April). Potentially, any positive impact on weight would be present for the early entrants, making the two groups a bit less similar. When looking at age 2-3 (two years before the entry year), early entrants are also very similar to that of late entrants in terms of BMI distribution. Moving to an even earlier period, the birthweight distributions of early and late entrants are similar. In fact, if any, the early entrant group is slightly lighter in terms of birthweight. Regardless, standard first-order stochastic dominance tests have found no significant difference in the distributions between the two groups of children.

As observed in Fig. 5 , there is significant difference between the two groups at age 6-7, in which the "in school early" group tends to be more likely to be obese. In particular, the distribution of the "in school" group display an extra "hump-shape" region to the right of the obese cutoff. The first-order stochastic dominance test rejects the null hypothesis that the distributions of early and late entrants are identical at 5% significance level [16].

The idea is that though there may be no significant change in mean BMI due to school. However, there can still be difference in the BMI distribution, which essentially affects the likelihood for children to be passing the obesity cutoffs. Fig. 4 and Fig. 5 offer an explanation to the regression results in Table 5, in which no significant change is found on the mean BMI, whereas there exists a significant impact of school on the probability of obese.

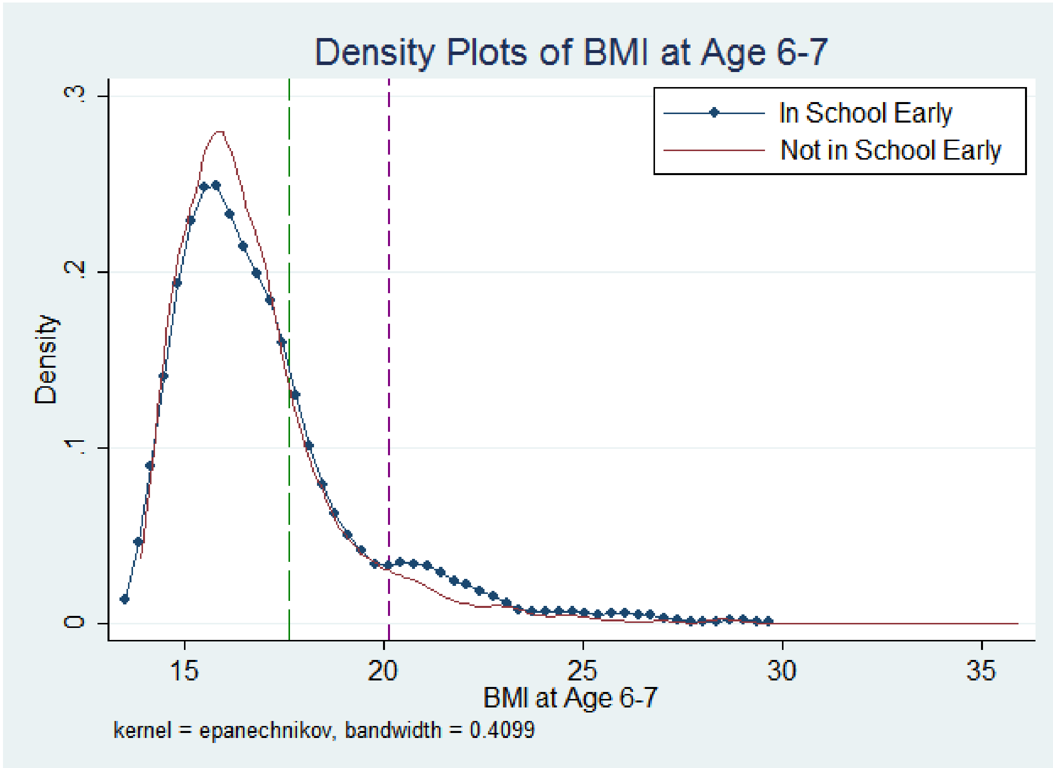


Figure 5: Distributions of BMI at Age 6-7

| | (1)<br>5 Months from Cutoff | (2)<br>3 Months from Cutoff | (3)<br>1 Month from Cutoff |
|---|---|---|---|
| In School Early | 0.695*** | 0.691** | 0.751* |
| | (0.251) | (0.279) | (0.436) |
| Mean (dependent variable) | 0.191 | 0.185 | 0.191 |
| Std(dependent variable) | 0.393 | 0.388 | 0.393 |
| Probit LATE | 0.218 | 0.212 | 0.233 |
| Number of Obs. | 3663 | 2392 | 859 |

Table 6: Waist-to-Height Ratio at Age 6-7 (Within 5 Months away from Cutoff)

### 1.6.2 Waist-to-height Ratio

As we can see in Table 6, the impact of school on waist-to-height ratio at age 6-7 is presented. As discussed in Section 1.4, children are recommended to have a waist-to-height ratio (WHtR) not exceeding 0.5. The two cohorts are merged together. To be concise, I present here the IV regressions in one table, summarizing the results when limiting to 5 months away from the cutoff in Column (1), and 3 months only in Column (2). [17] The coefficients are very similar in both cases, with 1% and 5% statistical significance respectively. When further limiting to only 1 month away from the cutoff in Column (3), the result remains to be similar in magnitude, with significance 10% . Across all the columns the probit LATE effect shows that children who are in school earlier tend to be more likely to be having a WHtR exceeding 0.5. The effect ranges from 21.2% to 23.3%.

It is of significant health concerns of children as central abdominal obesity can be detrimental, and highly associated with risk of heart attack and other obesity-related cardiovascular diseases (Savva et al., 2000). Moreover, as mentioned in Section 1.4, WHtR is considered as another measure of obesity. It is important to note that positive significant impact of school on the likelihood of WHtR exceeding 0.5 matches with the BMI results in Table 5. Using either measure, children who are in school tend to be more likely to be obese after 2 years. Again, I present here the comparison of the density plots of the "in school early" vs. "not in school early" group on their WHtR at age 6-7. The reference line is at 0.5 for the plots at age 6-7. However, at age 2-3, children are of a very young age and there is no common consensus as to a threshold value of the ratio. As a result, no reference line is shown in the corresponding diagram.

[15] The overweight and obese cutoffs are gender and age specific. The average cutoff values are shown in the graphs.

[16] In fact, the p-value is close to 1%.

[17] The first-stage results are similar to that of Table 5, showing that school eligibility is a strong IV for school entry. Results available upon request.

Again one way to see the change in WHtR is to compare the distribution of it before and after the entry year. In Fig. 6 the distributions of WHtR at age 2-3 and 6-7 are shown respectively. At age 2-3 [18], early and late school entrants display a very similar distribution of WHtR. If any, the early entrants are having smaller WHtR than late entrants in general. However, at age 6-7, there exists a difference between late and early entrants. Those who enter school early tend to be more likely to have WHtR exceeding 0.5. A first-order stochastic dominance test rejects the null hypothesis that the two distributions are equal at 10% significance level.

[18] Only WHtR of cohort B is available. As explained before, at the first wave of data of the K cohort children are already at age 4-5.

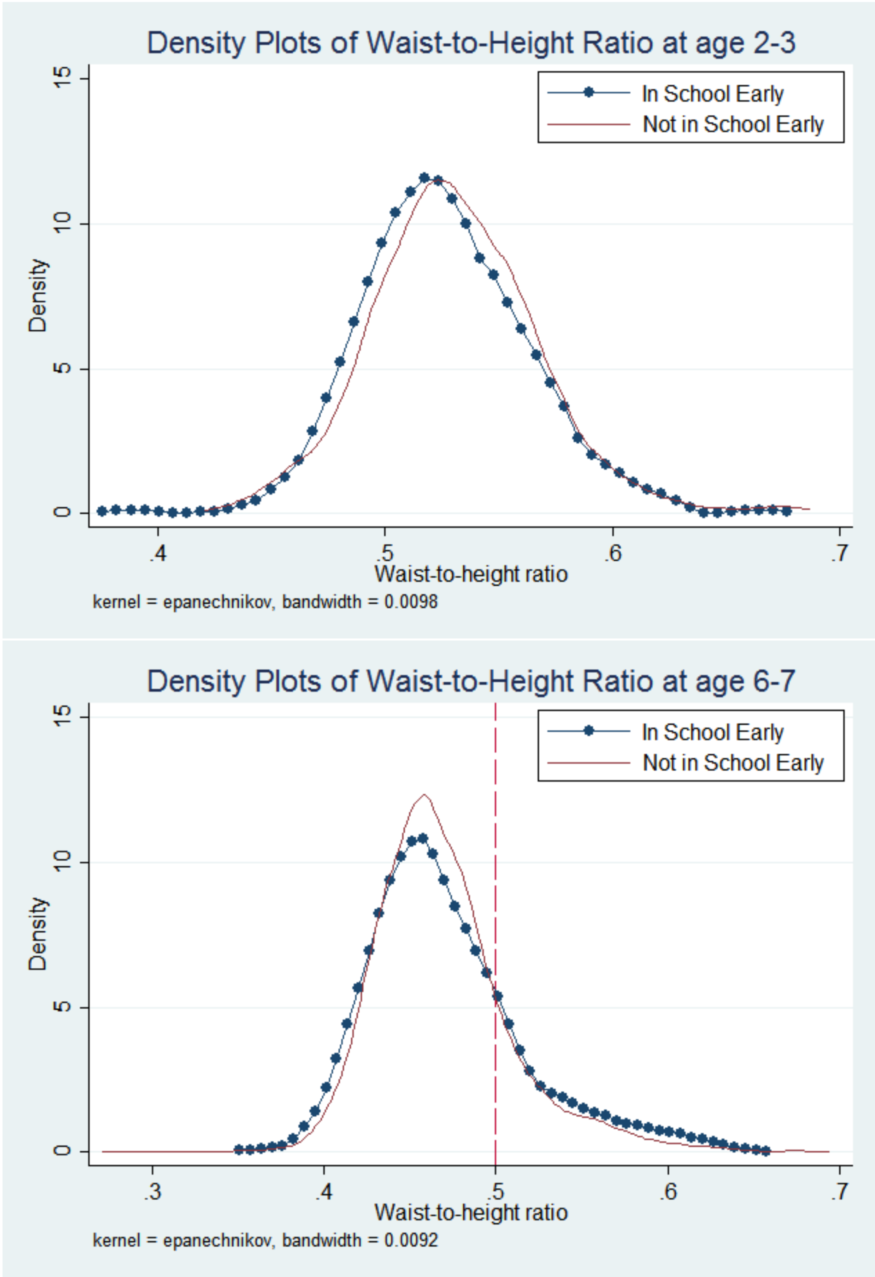


Figure 6: Distributions of WHtR at age 2-3 and 6-7

### 1.6.3 Diet, Exercise, and Screen Time

**1.6.3.1 Diet at Age 4-5** I explore the effect of school on two categories of food consumption: sugary drinks and food with high fat content.

**Sugary Drinks:**

The LSAC contains information about children's diet on a particular day in the format of interview questions, asking parents how many times in a day the study child has consumed certain types of food. In particular, sugary drinks and food with high fat content are generally believed to be associated with adverse weight outcomes. The following provides estimates of the impact of school on those food items.

The median consumption of softdrink or cordial in the sample at age 4-5 is 0 times in a day, implying that most children are not yet exposed to sugary drinks at this young age. It is meaningful to see if school entry itself leads to children's exposure to sugary drinks. In Table 7, the dependent variable is binary, which takes the value of 1 when a child consumes more than 0 times of sugary drinks; 0 otherwise.

As observed in Column (1), including children who are within 5 months from the cutoff gives a positive estimate but it is statistically insignificant. Economically, the effect is not small as a 11% increase in the probability of having sugary drinks. Moving closer to the cutoff, Column (2) shows a bigger effect which is statistically significant at 5%. The effect is large as children who are in school are 19.5% more likely to have sugary drinks. The result remains to be robust as only children who are just within 1 month from the cutoff are included. Possibly due to the low number of observations, the result is only 10% significant. However, it is important to note the magnitude of school's effect on sugary drinks exposure is similar and stronger than that of Column (2) at 25.5%.

At the intensive margin, in Table 8 the dependent variable takes the value of 2 if the child consumes sugary drinks more than once; a value of 1 if only once; and 0 otherwise.

A bivariate ordered probit estimation is implemented as the dependent variable can take 3 possible values. A similar pattern is found as that of Table 7. When including children who are within a wider range of 5 months away from the cutoff, the effect is not as strong as the other columns. Column (1) shows that the average treatment effects are not strong and of small magnitude. However, when including only children who are 3 months away from the cutoff at Column (2), a stronger effect is found which is significant at 5% level. The effect on the probability of having 0 sugary drinks is -19.3%; that on having sugary drinks once in a day is 5.7%. Children who enter school early are 13.6% more likely to have them more than once. Effects of similar magnitude is found in Column (3) in which a narrower age range of 1 month away from the cutoff is included. Once again the result suffers from the problem of low number of observations, but it is important to note that the estimated effects are of very similar magnitudes as that of Column (2).

| | Prob (Consumed softdrink/cordial) | | |
|---|---|---|---|
| | (1)<br>5 Months from Cutoff | (2)<br>3 Months from Cutoff | (3)<br>1 Month from Cutoff |
| In School Early | 0.288 | 0.513** | 0.668* |
| | (0.235) | (0.260) | (0.384) |
| Mean (dependent variable) | 0.364 | 0.369 | 0.377 |
| Std(dependent variable) | 0.481 | 0.483 | 0.485 |
| Probit LATE | 0.110 | 0.195 | 0.255 |
| Number of Obs. | 3660 | 2391 | 860 |

Table 7: Sugary drink exposure at age 4-5

| | Ordered Probit: softdrink/cordial | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| | 5 Months from Cutoff | 3 Months from Cutoff | 1 Month from Cutoff |
| In School Early | 0.261 | 0.508** | 0.515 |
| | (0.228) | (0.243) | (0.357) |
| Mean (dependent variable) | 0.517 | 0.522 | 0.531 |
| Std(dependent variable) | 0.745 | 0.745 | 0.748 |
| Prob (Softdrink=0) | -0.099 | -0.193 | -0.197 |
| Prob (Softdrink=1) | 0.033 | 0.057 | 0.059 |
| Prob (Softdrink¿1) | 0.066 | 0.136 | 0.138 |
| Number of Obs. | 3660 | 2391 | 860 |

Table 8: Ordered probit regression of sugary drink consumption at age 4-5

**Food with High Fat Content:**

Consuming food items with high fat content, like the case of sugary drinks, can contribute to higher weight of children. As explained in Section 1.4, fatty food items include the following: biscuits, pie, hotchips or french fries, and potato chips or savoury snacks. Unlike the case of sugary drinks, most children have some exposure to fatty food items (only around 10.6% have none). To summarize the effect of fatty food consumption, a categorial variable is constructed: 0 for zero times of consumption, 1 for once in a day; 2 for two times; and 3 for three or more times. As a result, a bivariate ordered probit estimation is used.

| | Ordered Probit: High Fat Food Items | | |
|---|---|---|---|
| | (1)<br>5 Months from Cutoff | (2)<br>3 Months from Cutoff | (3)<br>1 Month from Cutoff |
| In School Early | -0.094 | -0.099 | -0.437 |
| | (0.196) | (0.252) | (0.327) |
| Mean (dependent variable) | 1.688 | 1.705 | 1.704 |
| Std(dependent variable) | 0.953 | 0.952 | 0.960 |
| Prob (High fat food=0) | 0.018 | 0.019 | 0.092 |
| Prob (High fat food=1) | 0.019 | 0.020 | 0.081 |
| Prob (High fat food=2) | -0.009 | -0.009 | -0.042 |
| Prob (High fat food¿2) | -0.028 | -0.030 | -0.130 |
| Number of Obs. | 3649 | 2382 | 854 |

Table 9: Ordered probit regression of high fat food consumption at age 4-5

As Table 9 presents, there is no clear evidence of school leading changes to high fat food consumption. The effects in all columns are negative and statistically insignificant. The effect on the probability of each consumption level is presented in the table. Overall, most of the effects are economically insignificant too.

**1.6.3.2 Time use: Active Time at Age 4-5** At a young age of age 4-5, the Australian government gives suggestion of the amount of active time per day. Section 1.4, the included "active" activities included. Note that the activities included are not necessarily high energy expending (such as organized sports which are much more common at an older age).

In Table 10, columns (1) and (2) show the results of the impact of school on the weekly hours of active time. The effects are negative yet statistically insignificant. Columns (3) and (4) instead study whether children meet the threshold of the suggested 3 hours or more of active time per day. As the hours in the data are converted to weekly terms, the corresponding threshold is 21 hours per week. The dependent variable takes the value of 1 if a child meets the requirement, 0 otherwise. As both columns show the effects are negative and statistically insignificant. If anything, school tends to reduce the total active time of children. There is however not enough evidence that the effect is significant.

Concluding from Tables 7-10, children who are in school early tend to be more likely exposed to sugary drinks in both the extensive and intensive margins. This potentially can be a factor contributing to the adverse weight outcomes. On the other hand, there is little to no evidence that school affects high fat food consumption. While generally it is believed that attending school shifts time spent with parents partially to school time, the overall active time of children is not significantly affected. If any, there is some reduction in the active time, but not in a large magnitude that affects of chance of hitting the suggested level of active time by the Australian government. The fact that there is an increased exposure to sugary drinks along with no improvement in active time is likely to contribute to heavier weight of children, or even central obesity as measured by the waist-to-height ratio.

| | (1) Within 5 Months | (2) Within 3 Months | (3) Within 5 Months | (4) Within 3 Months |
|---|---|---|---|---|
| | Weekly Hours | Weekly Hours | Prob(Weekly Hrs.¿=21) | Prob (Weekly Hrs.¿=21) |
| In School Early | -3.202 | -2.485 | -0.357 | -0.337 |
| | (4.331) | (4.796) | (0.296) | (0.353) |
| Mean (dep. var.) | 30.949 | 31.043 | 0.674 | 0.664 |
| Std(dep. var.) | 16.788 | 17.080 | 0.469 | 0.472 |
| Number of Obs. | 1969 | 1307 | 1969 | 1307 |

Table 10: Age 4-5 active time and probability of being active for at least 21 Hours per Week

## 1.7 SUBGROUP ANALYSIS

As mentioned in Section 5, the results presented are for the overall sample averages. In particular, one may be especially interested in any significant difference in school's impact on the weight outcomes among different subgroups. For example, boys and girls may experience different effects due to different development profiles over age. Also, the comparison between government vs. non-government schools is of particular interest, as most of the diet guidelines are imposed on the government sector [19].

| | All | Boys | Girls | Non-gov't Schools | Gov't Schools | Low Income per Child |
|---|---|---|---|---|---|---|
| In School early | 1.203*** | 1.100** | 1.300*** | 0.991 | 1.305*** | 0.960* |
| | (0.290) | (0.510) | (0.348) | (0.833) | (0.308) | (0.534) |
| Probit LATE | 0.259 | 0.224 | 0.289 | 0.191 | 0.291 | 0.177 |
| No. of Obs. | 3632 | 1881 | 1751 | 1234 | 2398 | 798 |

Table 11: Subgroups: Probability of Obese

As observed in Table 11, girls tend to be more severely affected by school in the probability of obese (28.9% more likely vs. 22.4% for boys). In comparing government schools vs. non-government schools, an interesting pattern arises. The effect for children who attend government schools is much stronger (29.1% vs. 19.1% in the non-government sector). Despite the fact that guidelines regarding diet are imposed in government schools in Australia, it appears that there is room for improvement. One may worry that is just due to the selection (i.e. children who come from low income families tend to attend government schools). However, as I limit the sample to families which have an income per child below

[19] For easy comparison, I list the effect of the whole sample and contrast it with the subgroup results. Non-government schools here include both private and catholic schools.

the median, the effect is in fact less than that of the overall sample. Due to the low number of observation, it is understandable that statistical significance is not strong. Regardless, the magnitude of the effect itself is smaller at 17.7% only. It is likely the case that selection of children with low family income cannot fully explain the difference between government vs. non-government schools.

| | All | Boys | Girls | Non-gov't Schools | Gov't Schools | Low Income per Child |
|---|---|---|---|---|---|---|
| In School early | 0.695*** | 0.694* | 0.730** | 0.388 | 0.809*** | 0.571 |
| | (0.251) | (0.392) | (0.333) | (0.615) | (0.281) | (0.556) |
| Probit LATE | 0.218 | 0.209 | 0.237 | 0.108 | 0.261 | 0.175 |
| No. of Obs. | 3663 | 1894 | 1769 | 1239 | 2424 | 804 |

Table 12: Subgroups: Probability of Having a Waist-to-Height Ratio Exceeding 0.5

Table 12 instead presents the results on the probability of having a waist-to-height ratio exceeding 0.5, the benchmark for central obesity problem. A similar pattern to that of Table 11 is observed. Girls tend to be more heavily affected than boys (ie. 23.7% more likely vs. 20.9%). Again, a comparison between the government schools and non-government schools give the same conclusion. The magnitude of effect is much larger in the government sector (26.1%) than that of the non-government one (10.8%). Limiting to a sample of low income group cannot explain such a difference. The fact that the results from Table 11 and 12 are consistent indicates that government schools in general are doing worse. This points to the direction that more enforcement should be done on the guidelines regarding diet and healthy lifestyles in schools.

## 1.8 CONCLUSION

This chapter studies the impact of school on childhoold obesity in Australia. I implement a fuzzy regression discontinuity (RD) design, in which I exploit the continuity in individual characteristics around the age cutoff for school entry. I apply this design to data from the Longitudinal Study of Australian Children (LSAC). My analysis reveals significant differences across early and late entrants. Early entrants are at least 26% more likely to be obese, and 22% more likely to have a waist-to-height ratio exceeding 0.5 (an indicator for central adiposity). They are also 19% more likely to be exposed to sugar-sweetened beverages. The two groups showed no significant difference in exercise time, since exercise time with parents was largely substituted with that in school. This Australian case is of particular interest because the LSAC contains rich information on diet and time use, enabling this design to explore theses factors apart from the overweight and obesity status of children. This analysis complements the previous studies on childhood obesity.

# 2.0 THE IMPACT OF GENDER-NEUTRAL AND MARRIAGE NEUTRAL CHILD CUSTODY LAW ON DOMESTIC VIOLENCE AND HOMICIDE

## 2.1 INTRODUCTION

Divorce has been an important topic in many research studies in different fields, including family economics. Divorce allows marriages to end and many seek to analyze the benefit vs. cost of couples exiting their relationship. For married couples who have children, another major decision upon divorce is the custody of their children. In the United States, maternal preference was imposed in many states until the 1970s. The "Tender Years Doctrine" was in place in many states, which had a presumption that the mother is a more suitable custodian for a child in case the parents separate. Starting from a court case in New York State in 1973 that ruled out such presumption, many other states took a similar step. Maternal preference is no longer the presumption and many states have adopted the "Best Interests of the Child" (BIOC) doctrine instead. As the name suggests, it is gender-neutral and selects custodian based on several criteria (which are believed to be in the best interest of the child). As a result, joint custody becomes possible. Compared to the past, custody law in many states is now more favorable towards the father in case of divorce.

The law was not uniformly imposed and states adopted the law in different years. This provides an opportunity to exploit the timing variation in identifying the impact of custody law on domestic violence and homicide. Studies have shown that change in family law can have an impact on such crimes. An example is by Stevenson and Wolfers (2006). They studied the impact of no-fault divorce law. In particular, their result suggested that passing the law leads to decreased rates of domestic violence for both men and women, and homicide for women.

Custody law change can have an impact on domestic violence and homicide, as it induces a change in the right of the father in a relationship (i.e. the father can have a chance to share the custody of the child in case of divorce or dissolution of a relationship). Moreoever, a parent could lose the right to child custody if evidence of domestic violence is found by the police. This "cost" would not be present when the change in custody law is not imposed (as the father has no chance of the getting the custody anyway). My paper aims to study empirically the effect of custody law change on domestic violence and homicide.

Compared to divorce laws, studies on child custody law change is relatively little. Chen (2013) has found that gender-neutral custody law led to higher likelihood of divorce in the United States. Halla (2013) studies instead the impact of joint custody law on a range of family outcomes. In particular, there is a decrease in domestic violence and suicide with the switch to joint custody law.

It is important to note that the change in child custody law can affect both married and unmarried couples, albeit at different times for various states. As pointed out by Rose and Wong (2014), it is crucial to separate the effects of a gender-neutral law vs. marriage-neutral law. Only a regime which is neutral in both can affect unmarried couples. The precise definition of changes in the law is especially important in studying the topic of domestic violence. In fact, according to Kenney and McLanahan (2006), one major consistent pattern researchers have found regarding differences between cohabiting and married couples, is a higher rate of domestic violence among the former. Therefore each type of law change which affects different groups of people can lead to varying impact on doemstic violence and homicide.

Cohabitation rates in the United States have significantly increased in the past three decades. According to Bumpass and Lu (2000), there is an increasing trend of children live in cohabiting families. The number of unwed women has increased significantly, with births to those women born into cohabitation increased from 29% to 39% in the United States during the period of 1980-1984 to 1990-1994. This shows that the study of domestic violence in cohabitation is not only relevant for adults, but also on the welfare of children.

Cohabiting and married couples can be fundamentally different in terms of tendency in imposing intimate-partner domestic violence. Therefore, separation of the effect of a law change in child custody which affects marrried couples only versus one that affects also unwed couples is important. According to Rose and Wong (2014), the laws can be classified under three rigimes: (1) both gender and marriage non-neutral, (2) gender-neutral only, but marriage non-neutral, (3) both gender and marriage neutral. This paper studies the effect of the different changes in custody laws according to the three regimes.

The rest of this chapter is organized as follows. Section 2.2 explores the difference between married vs. cohabiting couples in domestic violence in previous studies, and gives an outline of the changes in custody law. Section 2.3 discusses the data used. Section 2.4 illustrates the empirical strategies. Section 2.5 presents estimation results of the impact of different custody laws on domestic violence and homicide. Section 2.6 concludes.

## 2.2 BACKGROUND

### 2.2.1 Domestic Violence in Relationships

Stets and Straus (1989) commented on the relatively higher assault rates among married couples that "the marriage license" is a "hitting lecense". It showed the prevalence of violence in marriages. The high level of domestic violence is documented in the two National Family Violence Surveys in 1975 and 1976. In fact, domestic violence does not only affect the couples who directly engage in the violence. According to Straus and Gelles (1990) and Straus (2017), over 50% of the men who are frequent assulter to their wives also abuse their children frequently.

Violence is in fact even more common and severe among cohabiting couples than the married counterpart (Yllo and Straus, 1981; Lane and Gwartney-Gibbs, 1985). According to Lane and Gwartney-Gibbs (1985), males tend to use more extreme forms of violence than women.

Explanations behind the higher rates of domestic violence in cohabiting relationship are mainly based on instutional differences. For instance, marital norms can lead to less violence in marriage. In terms of economic incentives, marriage involves higher investment in the relationship as well as more time and financial costs in ending one. Therefore, married couples tend to avoid violence which can lead to a divorce. Moreover, Kearney and Levine (2012) pointed out that there could be selection into different types of relationships. "Better" cohabiting couples are more likely to proceed to marriage, while those who remain as cohabitation are more likely to have lower average quality (e.g. lower earnings and education) and have higher tendency to engage in violence.

During the 1970'a, cohabitation rate has increased significantly (Glick and Spanier, 1980; Spanier, 1983). From the Current Population Survey, it is observed that more than 1.1 million unwed couples were cohabiting. Among these couples, 24% had one or more children present in he households. In 2016, 18 miilion adults were cohabiting with an unwed partner. Cohabiting couples are often more violent than married ones. It applies to both the frequency of physical assaults, and also the severity of the assaults.

### 2.2.2 Custody Law Changes

During the 1970s, many states dropped the default presumption that the mother was more suitable than the father as a custodian for children upon dissolution of marriage. The tender years doctrine was gradually replaced by the"best interest of the child doctrine", in which certain critera were used to determine the custody of the children. In 1973, there was a case of Watts v. Watts, where the Family Court of New York stated that the tender years doctrine's presumptions violated the right of fathers to "equal protection of the law under the Fourteenth Amendment of the United States Constitution". Since then, there were increasing effort in moving towards a gender-neutral approach in awarding custody of children.

With simply a change of custody law towards being more gender-neutral, unwed fathers however, would not be enjoying the same right as fathers in marriages. It was not until the Uniform Parentage Act in 1973, that an unwed father would have the same right as the mother regardless of whether he was married or not. The Act was indroduced by the National Conference of Commissioners on Uniform State Law. For the states which adopted the Act, custody law became marriage-neutral. As long as paternity could be proven, custody assignment should not be determined by whether the parents were married or not.

One key factor in this paper is the legal coding of the years of adoption of custody law change for each state. In the study of family laws, there are considerably more attention on divorce laws. For example, two commonly used codings for unilateral divorce law change are by Friedberg (1998) and Gruber (2004). As for child custody law, one existing legal coding I found was from Brinig and Buckley (1997). The below table shows the coding in that paper.

However, as pointed out by Chen (2013), joint custody is not what fundamentally affects the bargaining position in marriage. Rather, gender-neutrality is the necessary precondition for joint custody to be awarded. As for cohabiting couples, it is important to note that only

| Years of Adopting Joint Custody Law (Brinig and Buckley, 1997) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Alabama | | Indiana | 1973 | Nebraska | 1983 | South Carolina | |
| Alaska | 1982 | Iowa | 1977 | Nevada | 1981 | South Dokota | 1989 |
| Arizona | 1991 | Kansas | 1979 | New Hampshire | 1974 | Tennessee | 1986 |
| Arkansas | | Kentucky | 1979 | New Jersey | 1981 | Texas | 1987 |
| California | 1979 | Louisiana | 1981 | New Mexico | 1982 | Utah | 1988 |
| Colorado | 1983 | Maine | 1981 | New York | 1981 | Vermont | 1992 |
| Connecticut | 1981 | Maryland | 1984 | North Carolina | 1979 | Virginia | 1987 |
| Delaware | 1981 | Massachusetts | 1983 | North Dakota | 1993 | Washington | |
| Florida | 1979 | Michigan | 1981 | Ohio | 1981 | West Virginia | |
| Georgia | 1990 | Minnesota | 1981 | Oklahoma | 1990 | Wisconsin | 1979 |
| Hawaii | 1980 | Mississippi | 1983 | Oregon | 1987 | Wyoming | 1993 |
| Idaho | 1982 | Missouri | 1983 | Pennsylvania | 1981 | | |
| Illinois | 1986 | Montana | 1981 | Rhode Island | 1992 | | |

Table 13: Years of Adopting Joint Custody Law

when custody assignment becomes also marriage-neutral, then it would affect the incentive of cohabiting couples in terms of marriage, divorce, or even domestic violence.

This paper incorporates three regimes as classified in Rose and Wong (2014) to study the impact of custody law change on domestic violence and homicide. As stated in section 2.2.2, cohabiting couples may behave differently than married couples, and different custody law change can therefore have differential impact on the overall domestic violence and homicide rates.

To summarize, as pointed out by Rose and Wong (2014), there can be three regimes of custody law change: (1) in a state, child custody remains non-neutral in terms of both marriage and gender; (2) only becomes gender-neutral, but remains to be non-neutral in marriage; (3) neutral in both gender and marriage[1].

[1] Readers may refer to Rose and Wong (2014) for the year codings of the change in custody law regarding gender neutrality and marriage neutrality

In terms of unwed couples, in case (1), the mother will have the child custody upon dissolution of relationship. This applies to both married and unmarried couples.

In regime (2), for unwed couples, the mother will gain custody with marriage non-neutrality. However for married couples, there is a chance for the father to be granted custody. In this case, an effect (if any) on domestic violence may be seen on married couples. Such a change, however, does not affect non-married couples.

In regime (3), for both married and unwed couples, there is a chance for the father to be granted custody. Therefore when a state adopts this regime, the incentive of both types of couples in engaging violence can be affected.

## 2.3 DATA

As in Stevenson and Wolfers (2006), the data of domestic violence and homicide come from two sources. The first one is the Family Violence Surveys undertaken by sociologists Murray A. Straus and Richard J. Gelles in 1976 and again in 1985. These household-level data are not ideal as there is a large gap of time between the two cross-sectional surveys are conducted. This would make the dynamic effect of the differential timing of the law reform across states impossible to be identified. However, a standard differences-in-differences strategy (DID) can still be implemented as states adopted changes in custody law at different years.

The second data source is the FBI Uniform Crime Reports (UCR). This provides yearly state-level data on homicides. The richness of the data also provides the chance of looking at the victim-perpetrator relationships. The problem of underreporting is not a concern. As shown in Stevenson and Wolfers (2006), generally the FBI counts of murder are consistent with the independently gathered murder counts from the National Center for Health Statistics (NCHS).

## 2.4 EMPIRICAL STRATEGY

### 2.4.1 Domestic Violence

Household-level data are used in analyzing the impact of custody law on domestic violence. I estimate

$$\begin{aligned} Domestic\ Violence_{i,s,t} =& \beta_0 + \beta_1 Gen\ Neutral_{s,t} + \beta_2 Gen\ Marriage\ Neutral_{s,t} + \boldsymbol{\beta' X_{i,s,t}} \\ & + \alpha_t + \sigma_s + \epsilon_{i,s,t} \end{aligned} \tag{2.1}$$

where $Domestic\ Violence_{ist}$ is a dummy variable which has a value of one when domestic violence occured within a household, and 0 otherwise. The focus of the estimation is on the two dummy variables: $Gen\ Neutral_{s,t}$ and $Gen\ Marriage\ Neutral_{s,t}$. The former is a dummy variable that is equal to one if a state adopts gender-neutral custody law only (but remains non-neutral in terms of marriage) at time $t$. The latter is a dummy variable that is equal to one if the state adopted both gender-neutral and marriage-neutral custody laws.

### 2.4.2 Homicide

State-level data are used in analyzing homicide. As in Stevenson and Wolfers (2006), I also consider different definitions of intimate homicide. The broadest definition includes all homicide by non-strangers, the middle category includes all homicide commited by any family member or romantic partners, and the narrowest category includes only spousal homicide.

In each estimation, I do the following regression analysis:

$$Homicide_{s,t} = \beta_0 + \beta_1 GenNeutral_{s,t} + \beta_2 MarriageNeutral_{s,t} + \boldsymbol{\beta' X_{s,t}} + \alpha_t + \sigma_s + \epsilon_{s,t} \tag{2.2}$$

In this specification, $GenNeutral_{s,t}$ is a dummy variable which represents the effect of a state which adopts only gender-neutral custody law. $MarriageNeutral_{s,t}$ instead represents the effect of a state which becomes also marriage-neutral (conditional on being gender-neutral). In all estimations, I include all states which pass a gender-neutral custody law before a marriage-neutral one (if any), and those states which have been always non-neutral in both as the baseline.

As pointed out by Stevenson and Wolfers (2006), the coding of married couples as having spousal relationship is clear. However, it may present problems for cohabiting partners, or just partners with romantic relationship [2]

## 2.5 RESULTS

### 2.5.1 Results on Domestic Violence

In table 14 the results of the impact of custody laws on overall violence are shown. Severe violence includes the following violent actions: kicked, bit, hit with fist, hit or tried to hit partner, threatened with gun or knife, or used a gun or knife, in the past year. Overall violence is instead more general. It also includes: threw something at partner, pushed, grabbed or shoved, and slapped.

As shown in the table, two types of overall violence are analyzed: men to women, and women to men. Note that it is unclear whether the couples are legally married or not. For each outcome of interest, different estimation specifications are tested: (i) the basic difference-in-differences (DID) estimate, (ii) when state fixed effects are added, (iii) when

[2]It also applies to other relationships such as separated spouses, common-law marriages, etc., as the definition of these relationships might have changed over time in the data. The category of "family member or partner of romantic interest" would likely include these relationships including cohabiting couples. This is explained in detail in Section 2.5.

| | Overall Violence | | | |
|---|---|---|---|---|
| | Men to Women | | Women to Men | |
| Average incidence: | 11.7% | | 11.9% | |
| | Gen Neutral Only | Both Neutral | Gen Neutral | Both Neutral |
| Diffs-in-diffs | -0.57% | -5.20%** | -2.04% | -2.95% |
| | (2.43) | (2.10) | (2.19) | (1.89) |
| Add state FE | -2.14% | -5.19%*** | -1.98% | -2.80%*** |
| | (2.58) | (1.75) | (2.37) | (1.00) |
| Add individual controls | -1.81% | -6.20%*** | -1.79% | -2.57% |
| | (2.35) | (1.79) | (2.01) | (1.62) |
| Add state-level | -2.96% | -1.48% | -2.09% | -2.73% |
| time-varying controls | (2.25) | (2.27) | (1.92) | (1.70) |
| Probit | -1.45% | -5.40%*** | -1.41% | -2.17% |
| | (1.92) | (0.68) | (1.53) | (1.21) |

Table 14: Effects of Custody Laws on Overall Domestic Violence

individual controls are also added, and (iv) the richest specification when having state-level time-varying controls on top of those used in (iii). A probit estimation is then presented in addition to the basic OLS estimations.

In column (1), all the results of the effect of gender-neutral custody law are consistently negative, albeit none is statistically significant. It is however economically significant as the average rate of overall violence from men to women is 11.7%. Adding state fixed-effects is very important as it takes into account of any difference in the intercepts for each state in the regression. The magntitude of the effects range from -2.96% to the smallest of -1.81% (not counting the result of basic DID) as different specifications are tested.

In column (2), the effect of a regime with both gender-neutral and marriage-neutral custody laws has even a greater negative effect on overall violence from men to women. The estimates are all negative across different specifications, with most results statistically significant except the one when state-level time-varying controls are added. It is important to note though there is high correlation among some of the controls [3]. For example, the raw correlation between the "ratio of female to male employment rates" and the "maximum level of AFDC for a family of four" is 0.47. The correlation between the maximum level of AFDC also has a correlation as high as 0.57 with that of log personal income per capita. The correlation of log personal income per capita has a correlation of 0.81 with the female to male employement ratio. Dropping the variables of log personal income per capita and female to male employment ratio, the effect of a regime both neutral in gender and marriage would be -5.92% and statitically significant at 1% level.

Columns (3) and (4) suggest that the effects of custody law change on the overall violence from women to men are consistently negative. In terms of magnitude, it ranges from -2.95% to -2.17%. This amounts to almost one-fifth to one-fourth of the average incidence rates

[3] The state-level time-varying controls used are the same as in Stevenson and Wolfers (2006)

during the 1976-1985 period. Most of the results are not statisically significant.

Overall in Table 14, when compared with the results from Halla (2013), an interesting pattern is observed. In Halla (2013), the effect of joint custody law on overall violence is much smaller. In Halla (2013), the effect on overall violence from men to women ranged from -2.7% to 0.3% (the largest effect as -2.7% is statistically significant only at 10%). And the result for overall violence from women to men was very insignificant. My result instead suggests that there is strong evidence a regime neutral in both gender and marriage can significantly reduce the overall violence from men to women. The effect from different specifications averages to be around -4.69%, which is close to two-fifth of the average incidence rate during the study period. As a regime which is neutral in both gender and marriage can affect cohabiting couples apart from married couples, my result is consistent with the idea that cohabiting couples tend to be more likely to engage in domestic violence. If custody law change indeed reduces domestic violence, a regime which can affect cohabiting couples (and not only married couples) is more likely to have a bigger impact on domestic violence.

Table 15 shows the results of the effect of custody law regimes on severe violence. In terms of magnitude of the estimated results, they are of economic significance as the average invidence rates of severe violence are much smaller than overall violence (3.4% vs. 11.7% for the case of men to women, and 4.6% for the case of women to men). In terms of statistical significance, there is some evidence that there is a reduction of the level of severe violence from men to women in the case of custody rigime which is both gender and marriage neutral. The results range from -2.63% to -1.17% (which are 77% and 34% of the average incidence rates respectively). The estimate for the specification with all types of controls is statistically significant at 10%. As mentioned before, there is high correlation among some of the state-level time-varying controls used in the specification. Dropping the female to male employment ratio and log personal income per-capita, the coeffcent estimate of a regime

| | Severe Violence | | | |
|---|---|---|---|---|
| | Men to Women | | Women to Men | |
| Average incidence: | 3.4% | | 4.6% | |
| | (1) | (2) | (3) | (4) |
| | Gender Neutral | Both Neutral | Gender Neutral | Both Neutral |
| Diffs-in-diffs | 1.66% | -1.17% | 1.59% | -0.04% |
| | (1.29) | (1.11) | (1.74) | (1.42) |
| Add state FE | 1.22% | -1.45% | 1.71% | 0.06% |
| | (0.80) | (0.81) | (1.57) | (1.01) |
| Add individual controls | 1.32% | -2.63% | 2.04% | 0.14% |
| | (1.14) | (0.81) | (1.65) | (1.41) |
| Add state-level | 0.82% | -2.20%* | 0.15% | 1.23% |
| time-varying controls | (1.14) | (1.02) | (1.44) | (1.60) |
| Probit | 0.95% | -1.16%** | 2.26%* | -0.11% |
| | (0.93) | (0.27) | (1.55) | (1.48) |

Table 15: Effects of Custody Laws on Severe violence

which is "both-neutral" would be -2.91% and would be significant at 1% level. In columns (3) and (4), there is no evidence that the custody law change has any significant impact on the severe violence from women to men.

### 2.5.2 Results on Homicide

Homicide is categaorized as committed by (1) spouse, (2) any family member or romantic interest and (3) nonstranger. As pointed out by Stevenson and Wolfers (2006), it is not clear which exact category that cohabiting couples would be coded. However, it is very likely that they are at least being classified as nonstrangers.

Table 16 shows the results on each type of homicide of women. In columns (1) and (2), the results refer to the regression when only state and year fixed effects are used. In columns (3)-(6), other controls are added on top of the fixed effects. The controls are the same ones as those used in Stevenson and Wolfers (2006) for easy comparison. [4] In particular, the results in columns (5) and (6) serve as the "placebo". For example, the "noninitimate homicide" which corresponds to the spousal category is defined as aggregate homicide minus the spousal portion. The same applies to the other rows of results: the non-intimate homicide is calculated as the aggregate homicide minus the corresponding intimate portion.

Columns (1) and (3) show that there is not enough statistical evidence that gender-neutral custody law can lead to a significant impact on intimate homicide faced by women, regardless of the definition of intimate homicide. Conditional on a gender-neutral custody law is in place, it is clear that a consistent negative impact is observed when marriage-neutral custody law is adopted from the results of columns (2) and (4). The results are

[4] The other controls include a dummy variable for whether there is death penalty, the Donahue and Levitt Effective Abortion Rate,state incarceration rate, AFDC rate for a family of four, log state personal income per capita, unemployment rate, female-to-male employment rate, share of a state's population of age 14-19, etc., and share of Black, White, and other population in a state

robust to whether the control variables are added on top of state and year fixed-effects. The magnitude of the effects is also economically significant. The effects, depending on the definition of intimate homicide used and regression specification, range from -23.8% to -17.10%. [5] This shows that a custody law change in terms of marriage neutrality has a significant reduction effect on intimate homicide. When controls are added, the results on the three categories of intimate homicide are statistically significant at 10%, 1% and 1% respectively.

Columns (5) and (6) show that for the placebo non-intimate homicide, results are not statistically significant. Here I focus on the discussion on the coefficient of the impact of adding a marriage-neutral custody law. For homicide by non-spouse, the magnitude of the coefficient is much less than that of spousal homicide. Similar pattern is observed in the results of homcide by family vs. non-family members. The effect on homicide by strangers is estimated to be positive and statistically insignificant. A comparison between columns (4) and (6) makes it obvious that passing a marriage-neutral custody law conditional on being gender-neutral has a significant negative impact on intimate homicide of women.

I repeat the same analysis on intimate homicide of men. From Table 17, columns (1) and (3) suggest that the result of gender-neutral custody regime is not obvious. However, columns (2) and (4) show that marriage-neutral custody law has a significant negative impact on intimate homicide by family member or known person. Homicide by family member or person with romantic interest has a decline of 25.5% when state and year fixed effects are used. The result is robust when controls are added, with the effect as -20.20%. When compared with the placebo result in column (6), the magnitude is much larger. A similar pattern is observed for homicide committed by nonstranger, the effect is -13.9% when controls are added. These results are all statistically significant either at 5% or 1%. Similar to the

[5]In particular, when adding a dummy of whether unilateral divorce law is in place , the results are still valid.

| | With state and year FE's | | With FE's and controls | | | |
|---|---|---|---|---|---|---|
| | Intimate homicide | | Intimate homicide | | Non intimate homicide | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | Gender neutral | Marriage neutral | Gender neutral | Marriage neutral | Gender neutral | Marriage neutral |
| | | | Women murdered by | | | |
| Spouse | 0.75% | -18.89%** | -4.14% | -17.10%* | 4.61% | -10.52% |
| | (0.64) | (8.98) | (6.25) | (9.16) | (3.83) | (8.41) |
| Family | 4.62% | -23.8%*** | -0.30% | -22.25%*** | 5.09% | -3.16% |
| | (4.66) | (8.10) | (4.77) | (8.06) | (4.47) | (10.24) |
| Known | 4.93% | -20.0%*** | -0.08% | -18.69%*** | 8.01% | 1.48% |
| | (3.83) | (7.08) | (3.89) | (6.94) | (5.93) | (13.00) |

Table 16: Effect of Custody Laws on Intimate Homicide of Women

| | With state and year FE's | | With FE's and controls | | | |
|---|---|---|---|---|---|---|
| | Intimate homicide | | Intimate homicide | | Non intimate homicide | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | Gender neutral | Marriage neutral | Gender neutral | Marriage neutral | Gender neutral | Marriage neutral |
| | | | Men murdered by | | | |
| Spouse | -5.14% | -9.06%** | 0.11% | -1.37% | 3.46% | -8.52% |
| | (8.27) | (12.08) | (8.39) | (11.71) | (2.80) | (5.98) |
| Family | -10.49% | -25.5%*** | -7.60% | -20.20%** | 5.86% | -5.21% |
| | (4.93) | (8.28) | (5.18) | (8.50) | (2.96) | (6.34) |
| Known | -0.46% | -14.1%** | -1.66% | -13.9%** | 10.45%*** | 0.41% |
| | (3.26) | (5.97) | (3.36) | (6.23) | (4.03) | (8.18) |

Table 17: Effects of Custody Laws on Intimate Homicide of Men

result in Stevenson and Wolfers (2006), there seems to be some evidence that law change has a correlation with homide of men by stranger. In their paper, unilateral divorce law has a negative relationship with all non-intimate homicide except the one which corresponds to the "non-known" category. The relationship with homicide by stranger was shown to be positive for men, albeit not statistically significant. Here in my result, gender-neutral custody law has a positive correlation with that, and it is statistically significant at 1% level.

## 2.6 CONCLUSION

This chapter studies the effect of gender-neutral and marriage-neutral custody laws on domestic violence and homicide. Changes in family laws, such as unilateral divorce, have been shown in the literature to have an impact on both. In my paper, these is suggestive evidence that a custody law regime which is both neutral in gender and marriage has the largest impact on domestic violence and intimate homicide, compared to one that is only gender neutral. This is consistent with previous studies that domestic violence can be more prevalent among cohabiting couples, rather than married couples. A regime which is neutral in both gender and marriage would be affecting not only married couples, but also unwed ones. Compared to the previous study by Halla (2013), who studied the effect of joint custody law, my paper reveals that defining custody law change in terms of gender and marriage neutrality instead shows a significant impact on the outcomes.

# 3.0 TEEN CHILDBEARING, MATURATION, AND GENDER ASYMMETRY

(with Eric Mak)

## 3.1 INTRODUCTION

Adolescents, being immature, lacks the non-cognitive skill (Cunha and Heckman, 2007) to appropriately consider the future. Therefore, adolescents have a tendency to engage in many risky behaviors, generally defined as behaviors which generate immediate gratification in the expense of future health. Upon maturation, they acquire this non-cognitive skill. With this non-cognitive skill, the future health cost of engaging in risky behaviors now weighs more than their present gratification, resulting in the general moderation of many risky behaviors in adulthood. This general reversal in risky behaviors, as a general life-cycle fact observed by many studies, is a sign of regretting earlier actions done during immaturity. This argument is formalized in Gruber (2000) in which adolescents are being time inconsistent. A time-inconsistent individual would deflate the negative consequences in the far future, in favor of immediate gratification. Upon maturation, this time-inconsistency is relieved, and his risky behaviors exhibit reversals.

Yet not all risky behaviors can be reversed. Among all adolescent risky behaviors, teen childbearing is one of particular social concern due to its irreversibility. Unlike most risky behaviors smoking or binge drinking that can be moderated, teen childbearing is a lifelong responsibility. This lifelong responsibility is loaded with many negative consequences, such as lowered human capital investment and wage (Lundberg and Plotnick, 1995; Klepinger et al., 1999), poor child development, and even that of siblings (Heissel et al., 2017). Given that teen childbearing is prevalent in the United States and other developing countries (Kearney and Levine, 2012), there is an urgent call for social action in addressing this particular problem. A quote from Gruber (2000), cited by a review essay of Aizer et al. (2017) about teen childbearing, summarizes this point:

> We **believe** that adolescents are not behaving in their own best interests and because we feel that something should be done to help them.

While this paternalistic belief has a natural appeal, justifying it is not straightforward as the word "believe" indicates. The irreversibility of teen childbearing implies that one cannot observe adults reversing their earlier childbearing decision made during adolescence. From behavioral data, what can only be observed is the prevalence of teen childbearing. This prevalence could have been explained by revealed preferences, such that teen childbearing is an optimal action. Despite its association to many negative outcomes, teen childbearing may lead to some unobserved benefits that the economist cannot observe — for instance, having a kid earlier rather than waiting until the 30s leads to more enjoyment for the mother.

The distinction between regret and reveal preferences is not purely an academic issue, but it also the founding stone behind adolescent policies: only if there is regret, the society is in a position to call for interventions that restrict the autonomy of adolescents. Generally, behavioral economists advocate an individualistic intervention if possible, since regret may not equally apply to every individual (Camerer et al., 2003).[1] Specifically, to justify an inter-

[1] Camerer et al. (2003) proposes that in case individual-level identification is not possible, one should

vention against teen childbearing, one needs to argue that teen childbearing is associated to concurrent maturation, so that after maturation an individual wants to reverse this decision despite not being able to do so.

We approach the identication problem by examining the life-cycle pattern of other risky behaviors that are reversible, such as smoking and binge-drinking. It is well-known that most risky behaviors exhibit general cessation in the early twenties when the adolescents become mature, smoking for instance (DeCicca et al., 2008); the age trends of these behaviors all exhibit a strongly inverted-U shaped pattern. These behavioral reversals indicate that many matured adults regret on their earlier risky behaviors during adolescence.

Mak (2015) devises a methodology to construct a behavioral measure of maturation (immature versus mature), using multiple reversible risky behavior outcomes. Based on the theory, the maturation of an individual would lead to the moderation in his/her many risky behaviors simultaneously; this **simultaneity** of behavioral changes act as the source of identification of the maturation timing for that particular individual. This idea has a time-series analogue, in which the timing of recession of a single country is identified by the sudden change in many time series, e.g. GDP, unemployment, inflation rate, etc.. Mak (2015) first adopts the methodology to a panel data context, with many individuals and many outcomes.

The identification argument remains valid even after controlling for individual and age fixed effects in a differences-in-differences (DID) sense, thereby controlling for individualistic base propensities of engaging in the risky behaviors and age-related changes in the external environment. For instance, some people has a consistent affinity to alcohol than others; after age 21, drinking becomes legal in the United States. These confounders would affect risky behaviors independent to maturation. A valid measurement of maturation must control for

adopt a asymmetric policy that has a large benefit to help the individuals who regret and a small cost for those who do not.

these confounders.

We regard maturation as a binary treatment in a standard linear panel data model, yet in our case, the treatment timing is unobserved. Mak (2015) shows that, if the common trend assumption holds globally, then the DID estimate is non-zero when the treatment occurs, but not for the other periods — maturation "leaves a mark" to the behavioral tracjectory of an individual. By computing the DID estimate over all periods in the sample, one can identify the treatment timing even if it is unobserved, essentially without extra assumptions.

After measuring maturation, we find that maturation is a strong predictor of teen childbearing, particularly for females. From the summary statistics, we also note that by age 30, about 10% of males have a child that is not residing in their households, while for females the figure is less than 5%. These two findings, in together, suggest that adolescent males tend to be not take responsibility after the event of teen childbearing has occurred; whereas teen childbearing females suffer more from its consequences. Since maturation is about re-thinking the consequences brought by an action, maturation should be more related to female childbearing, and indeed it is the case. In sum, we find evidence of regret among adolescents engaging in teen childbearing, particularly for females.

The use of multiple behaviors to measure non-cognitive skill is not new. For example, Cunha et al. (2010) uses the Behavioral Problem Index (BPI), a checklist of problematic behaviors, to measure the non-cognitive skill of children in a skill formation model. The methodology in Cunha et al. (2010) differs from Mak (2015) in the sense that it is a factor model, where the non-cognitive skill is assumed to be solely responsible for the cross-behavior correlation (e.g. a low non-cognitive skill child would tend to have multiple risky behaviors). Mak (2015) controls for an individual fixed effect (that can correlate between behaviors, i.e. if one prefers smoking he/she may also prefer drinking) and common age trend. Maturation, as measured, is the **change** in non-cognitive skill rather than its levels.

## 3.2 BACKGROUND

As suggested by Lundberg and Plotnick (1995), teen marriage and childbearing has been a topic that traditionally belongs to sociology and psychology; see Hayes (1987) for an early review. In this literature, teen childbearing is perceived as a suboptimal decision, such that economic costs and benefits do not seem to apply.

Subsequently, an economic literature follows, testing if adolescents respond to economic incentives. Duncan and Hoffman (1990) finds only a weak income effect on premarital birth among black adolescent females, using data from the Aid to Families With Dependent Children (AFDC). Using data from the National Longitudinal Survey of Youth (NLSY), Lundberg and Plotnick (1995) considers a nested logit model that nests a chain of decisions consisting of premarital pregnancy, abortion, and marriage. The model examines whether economic and legal factors, such as the availability of abortion funding and the restrictiveness of abortion law, affects the likelihood of teen childbearing. It is found that there are substantial across-race differences — for Whites the responses are in line with theoretical predictions; while for Blacks there are no significant associations. Note that while economic incentives matter, it does not necessarily imply that teen childbearing is a perfectly rational action; a time-inconsistent individual would still responds to incentive since his/her actions are maximizing lifetime utility, albeit not perfectly.

Another literature estimates the causal impacts of teen childbearing, education attainment in particular. Early research documents a strong correlation between education attainment and the age of first birth (Moore and Waite, 1977; Mott and Marsiglio, 1985). To identify a causal relationship, one identification strategy is to use instrumental variables (IV), searching for exogenous determinants of age of first birth that are not directly related to education attainment. For instance, Rindfuss et al. (1980); Hotz et al. (2005) considers miscarriages as one exogeneous shock to early childbearing; see also Marini (1984); while Ribar (1994) considers age at menarche, availability of obstetrician/gynecologists, and the local abortion ratio. Alternatively, Geronimus and Korenman (1992) considers a sibling-difference identification strategy, that compares sisters who had different ages of first birth. Generally, this literature finds that teen childbearing causes a lower education attainment.

Implicitly, this IV strategy searches for variation that is independent to maturation, which lacks a measure in observational data on adolescent behaviors. Similarly, many papers about adolescence in general circumvents this measurement problem. Therefore, despite that studying adolescent behavior draws the attention of many economists, the economic literature does not explicitly discuss maturation, particularly in a quantitative manner.

Whereas most psychology and behavioral literature has stayed qualitative on the issue of maturation. In development psychology, stage theories such as Erikson (1994)'s celebrated theory on the youth divide the whole life-cycle into distinct stages, and conceptualize the maturation process as the transition between these stages. These stage theories documents behavioral changes in many aspects during this period, and propose that they are all due to an underlying psychological change — this idea is captured by the behavioral model of Gruber (2000) as well. Notably, in these stage theories, maturation is assumed to occur at a prescribed date for most individuals. For example, early adulthood is defined by Erikson (1994) to start at age 20. A similar comment applies to other stage theories. See Hayslip Jr et al. (2006) for a review. It should be noted though that the stage theories also emphasize individual differences; some adolescents would mature later than the others. This heterogeneity in maturation timing is important.

More recently, the neuroscience has important advances in the understanding of the adolescent brain. Due to the improvement in brain scanning techniques, brain researchers are now able to track the growth of the human brain in a much more informative manner.

As discussed in Steinberg (2014), puberty causes the adolescent brain to be more receptive to dopamine, resulting in a higher sensitivity to immediate gratification. Behaviorally, this fact leads to the affinity to risky behaviors among adolescents. During adolescence, the brain undergoes a structural transformation that may vary from individual to individual; before its completion, an adolescent remains less capable than a full adult in his/her moderation of immediate gratifications.

In addressing adolescent immaturity, Aizer et al. (2017) reviews two influential books: Steinberg (2014) recommends a policy that helps adolescents in their self-regulation. However, it should be noted that fostering self-regulation is not an easy task, especially among disadvantaged adolescents (Heckman and Kautz, 2013). Sawhill (2014) instead thinks of interventions that mitigates the negative effects of risky behaviors, taking the adolescent risky behaviors as given.

For teen childbearing in particular, Sawhill's recommendation is to promote the use of long-acting reversible contraception devices, which relieve the need for the adolescents to consider contraception every time they have sexual intercourse. Though as Aizer et al. (2017) comments, many adolescents fail to use these contraceptive devices even if they are available through Title X and Medicaid. Instead, Aizer et al. (2017) calls for attention to the disadvantaged neighborhoods, which are full of uncertainties that make adolescents less forward-looking than they should.

## 3.3 THEORY

### 3.3.1 A Model of Maturation

This section is based on Mak (2015). Here we provide the reader a non-technical introduction; the reader is referred to that paper for the technical details.

In the model, the adolescent is characterized by dual selves (Greer and Levine, 2006). The long-run self is the Planner, who decides how to perceive the actions done by the Doer in any period. The Planner has less discounting on the future than the Doer, so that their objectives do not perfectly align with each other. As a result, the Doer would perform an action that is perceived as sub-optimal by the Planner. As such, the Planner-Doer model serves as a tractable way to explain how a person would perform actions that would not be optimal from his own point of view, also known as time-inconsistency. Mak (2015) adds maturation —the reduction in discounting by the Doer— to this model, to explain the dynamics of this time-inconsistency.

The model is cast in discrete time. There is a representative adolescent who engages in risky behaviors, which generate immediate gratification but may cause a drop in health capital $h_{it}$. The utility is a function that depends positively on both the risky behaviors and health capital, such that there exists a trade-off between having a high level of risky behaviors today and to protect his health in the future.

The representative adolescent also have a binary maturation status $m_{it} \in \{0, 1\}$, such that 0 stands for immaturity and 1 stands for maturity. Only when $m_{it} = 0$ the Doer's discounting factor does not agree with that of the Planner; when $m_{it} = 1$ the two selves have identical discount factors so that the representative adolescent is time-consistent.

It is straightforward to show that when $m_{it} = 0$ (immature), the level of risky behaviors would be higher than when $m_{it} = 1$ (mature), and that this level is higher than the level that the Planner prefers. When the representative adolescent matures such that $m_{it}$ changes from 0 to 1, his level of risky behaviors would decrease.

For an immature adolescent, his actions are sub-optimal from the Planner's point of view. If possible, the Planner would wish to prevent the Doer from doing the sub-optimal action and this defines the regret discussed in the introduction. The Planner would have a demand for a technology that restricts the Doer's actions, such as parental control and legal restrictions. We label them measures of **external control** in distinction to **self-control**.

In Mak (2015), the risky behaviors are all reversible. When teen childbearing as an irreversible behavior is introduced, then it can be shown that the demand for external control is more, because once teen childbearing is realized, there is a permanent decrease in utility in every future period. This result justifies the policy concern discussed in Aizer et al. (2017), Steinberg (2014) and many others.

### 3.3.2 The Measurement Framework

This structural model implies that maturation implies a simultaneously moderation in many risky behaviors. In the application, we consider a measurement framework that consider maturation as a binary treatment event that affects behaviors.

Let $i$ indexes individuals and $t$ indexes age. The measurement model is:

$$y_{it} = \lambda m_{it} + \mu_i + \delta_t + \varepsilon_{it} \tag{3.1}$$

where $y_{it}$ is an outcome variable; in our application it is a behavioral index constructed by averaging across a vector of risky behaviors. $m_{it} \in \{0, 1\}$ is a binary maturation status. I consider maturation as a treatment which, once in place, is permanent, such that

$$m_{it} = 1(t > \tau_i)$$

where 1(.) is the indicator function. As such, once actual age $t$ passes $\tau_i$ (the maturation age of individual $i$), he becomes mature and his behaviors change by $\lambda$; we call $\lambda$ the maturation effect.

To control for cross-sectional and temporal heterogeneity, we introduce $\mu_i$ as an individual fixed effect; $\delta_t$ is a age effect; $\varepsilon_{it}$ is an error term; covariates can be included. The individual fixed effect $\mu_i$ represents the natural tendency to engage in the risky behavior, and $\delta_t$ captures age-related changes, such as passing the minimum legal drinking age.

Following the standard assumptions, We impose an exogeneity condition $E[\varepsilon_{it}|m_{it}, \mu_i, \delta_t] = 0$ and allow general correlations between $m_{it}, \mu_i$ and $\delta_t$. We assume that $m_{it}$ has full rank — in other words, the distribution of maturation timing is non-degenerate. Under this set of standard assumptions, the model can be estimated by ordinary least squares, controlling for individual and age fixed effects if the maturation $m_{it}$ is observable.

The econometric problem we face is that the maturation timing $\tau_i$ is latent, such that it is no longer possible to run this regression. We show that if maturation $m_{it}$ has a sufficiently large treatment (maturation) effect, we can nevertheless identify $\tau_i$ essentially without extra assumptions.

Graphically, the argument is shown in a graph reproduced from Mak (2015). See Figure 7. The two lines are in parallel, representing the individual fixed effect and the common trend of the two individuals $i$ and $i'$. After maturation, each of the two individuals experience a maturation effect $\lambda$. Although the maturation timings $\tau_i, \tau_{i'}$ are not observed, a period-by-period DID (calculating the relative change) is non-zero only when $i$ matures or $i'$ matures. The key identification requirement is that $\tau_i \neq \tau_i$; otherwise, the change of the two individuals would be indistinguishable from the common time trend $\beta_t$.

As a caveat, note that if $\lambda$ is replaced by $-\lambda$, the same DID estimate would be obtained. Therefore point identification the treatment timing for each individual would require an

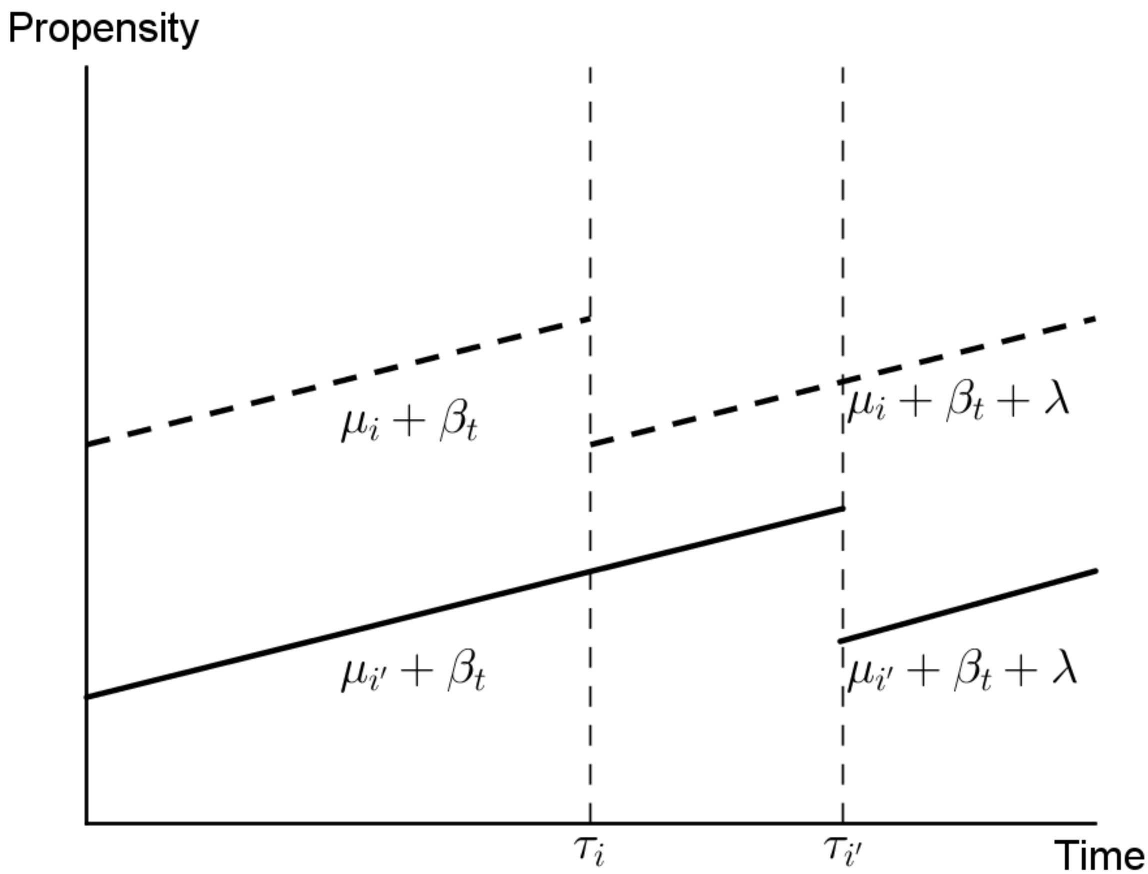


Figure 7: Difference-in-Difference Identification

additional sign restriction on $\lambda$ a priori. For risky behaviors, maturation would reduce risky behaviors. Hence in this application, the sign restriction is not controversial.

Formally, ignoring the error term at the moment, we can compute a DID estimate between any two individuals $i$ and $i'$ as:

$$\Delta y_{it} - \Delta y_{i't} = \lambda(\Delta T_{it} - \Delta T_{i't}) \tag{3.2}$$

which is zero unless $t = \tau_i + 1$ or $t = \tau_{i'} + 1$. Therefore, by computing the DID estimate for every period, one can jointly identify $(\lambda, \tau_i, \tau_{i'})$ when $\lambda \neq 0$, such that a treatment effect exists. Now reinstating the error term, Mak (2015) shows that if $\lambda$ is known, the correct identification for $\tau_i$ is achieved if:

$$|\lambda| > \max_{t'}\{\Delta\varepsilon_{it} - \Delta\varepsilon_{it'}\} \tag{3.3}$$

which is guaranteed if the error terms are small relative to the treatment effect. Notice that the identification condition is independent across individuals in a random sample.

Therefore for a more accurate identification, it is recommended to include more risky behaviors in the construction of the behavioral index $y_{it}$. If maturation affects all of these risky behaviors, averaging a large number of them would tend to reduce the error term variance. In practice, the model considers a behavioral index which is the average score of four risky behaviors: smoking, binge drinking, taking marijuana and taking hard drugs. Changing the set of risky behaviors do not significantly affect the identified $\tau_i$ for all individuals, with more than 70 percent of the estimates being invariant to the choice. See Mak (2015) for the details.

The model is estimated by first assuming the maturation timing $\tau_i$ for every individual, then estimate the panel data model as if $\tau_i$ is known, obtaining an estimate of the common parameter $\lambda$. The next step is to perform a least squares procedure, experimenting with potential values of $\tau_i$ to find the best-fit treatment timing that minimizes individual $i's$ sum of squared error. With $\tau_i$ updated, the panel data model is estimated again. Repeat the process until convergence such that all reported $\tau_i$ no longer change. This estimation is straightforward and convergence can be achieved within several rounds.

The key output of this algorithm is a set of maturation timings $\{\hat{\tau}_i\}_{i=1}^{N}$. With $\tau_i$ being measured, we can construct the maturation status $\hat{m}_{it}$ from definition as

$$\hat{m}_{it} = 1(t > \hat{\tau}_i) \tag{3.4}$$

In the application of this measurement model, there is one fundamental concern regarding the stepwise functional form of maturation. While assuming a discrete, stepwise maturation is an approximation, it grounds on and extends the developmental stage theories in psychology. There, a fixed maturation age applies for every individual, for instance, youth is **defined** to be ending at age 18 in most psychological studies since Erikson (1994). Interestingly, if maturation indeed occurs at a fixed date for all individuals, the model is not identified as maturation will not be distinguishable from the common age trend, which could possibly due to age-related factors other than maturation as discussed. Whereas the model can be extended to include multiple steps as shown in Mak (2015).

### 3.3.3 Comparison to the Skill Formation Model

Cunha and Heckman (2007) considers a framework of cognitive skill and non-cognitive skill. In their framework, the two skills are isomorphic in the sense that both skills are latent, and affect various measurements; there is no particular interpretation to the meaning of non-cognitive skill other than being a form of human capital. Specifically, their model consists of a measurement equation:

$$y_{it} = g(\alpha_{it}^{c}, \alpha_{it}^{n}, \varepsilon_{it}) \tag{3.5}$$

which is a non-linear factor model by itself, and a skill formation equation:

$$(\alpha_{it}^c, \alpha_{it}^n)' = f(\alpha_{it-1}^c, \alpha_{it-1}^n, \eta_{it}) \tag{3.6}$$

where $(\alpha_{it}^c, \alpha_{it}^n)$ are the cognitive skill and non-cognitive skill respectively, and that $\varepsilon_{it}, \eta_{it}$ are noise. Covariates can be included.

In Mak (2015), maturation is interpreted structurally as a change in time-inconsistency. The two frameworks are compatible with each other, although Mak (2015) explicitly predicts that after maturation, risky behaviors would be moderated. This prediction is crucial in supporting the sign restriction required for identification. Note that, nevertheless, a sign restriction is also needed in factor models including Cunha et al. (2010), or else:

$$y_{it} = \tilde{g}(-\alpha_{it}^c, -\alpha_{it}^g, \varepsilon_{it}) \tag{3.7}$$

with an approriately redefined function $\tilde{g}$ yields an equivalent measurement model.

As discussed in Cunha et al. (2010), the identification of their framework depends on exclusive measurements, i.e. some measurements depend only on one single skill, e.g. an intelligence score depends on only on the cognitive skill, while risky behaviors may depend on the non-cognitive skill. In Cunha et al. (2010), non-cognitive skills of children are measured by a behavioral checklist named by Behavioral Problems Index (BPI).

In Mak (2015) and this paper, maturation is measured by a set of reversible risky behaviors. However, we regard that assuming that the risky behaviors being exclusively due to the non-cognitive skill (or after controlling some covariates) is a questionable assumption particularly for adolescents. Smoking, binge drinking, and many risky behaviors can be a lifetime hobby for many; imposing that it is due to a lack of non-cognitive skill rather than due to idiosyncratic preferences is a very strong assumption. Therefore, we choose to control for an individual fixed effect. The resulting measurement framework is hence a fixed effect model in contrary to Cunha et al. (2010), which essentially is a random effect model that assumes that the two skills are orthogonal to the error term, and the covariates if included.

## 3.4 DATA AND AGE TRENDS

### 3.4.1 The Dataset

This paper uses data from the National Longitudinal Survey of Youth 1997 (NLSY97). The NLSY97 is a individual-level panel data set that tracks a set of 8,984 respondents, randomly selected with oversampling of blacks and hispanics.

The NLSY97 serves as one major data source in the study of adolescents transitioning into the adulthood. For our purpose, the NLSY97 surveys for each respondent a large battery of questions about their risky behaviors. A typical question in this battery is as follows: “Have you smoked a cigarette since the last interview on [date of last interview]?” Similar questions for other substance use are also available. This rich information allows us to systemmatically track the behavioral changes of the respondents yearly.

Another set of questions in the survey of interest concerns the fertility decisions of the respondents. In the NLSY97, a key variable reports, in each survey year, the current number of biological children in the household: specifically, it reports “the number of biological children born and residing in the household as of the survey date”. Another similar question reports the current number of biological children not residing in the household. From these two questions, we can identify how each respondent would respond when facing a new birth.

The data set also collect rich information regarding the respondents and their family. The data set is well-known to be maintaining a low attrition rate—in 2010, only 1,573 out of the 8,984 respondents do not answer the aforementioned smoking question, relative to 636 respondents in 1998. In the NLSY97, there are clearly some relatively sensitive questions that some respondents do not report any answer, but this difference in response rate largely do not vary across time.

### 3.4.2 Having a Biological Child

As a summary statistic, we report the fraction of respondents having at least one biological child by age and gender in Figure 8. The figure reveals that the two genders differ substantially in two aspects.

First, the two genders significantly differ in the total fraction of respondents having at least one biological child at any given age, segregated by whether the biological child is within the same household as the respondent. For females at age 20, the fraction for staying within the household is about 0.2; while for males at age 20, the fraction is only 0.05.

Given that the NLSY97 is a representative sample, and that the total number of biological births should be symmetric with respect to gender, one may expect that the proportion of respondents having at least one biological child (regardless of whether residing in the household) to be close across the two genders, but this is not the case. The asymmetry suggests that it is likely that the males are under-reporting the number of biological children, especially if the children is not residing in the current household.

Second, females are much more likely to have the biological children staying in their households relative to males — for females, the fraction of respondents having their biological children not staying in their households is minimal, while about half of the male adolescents younger than age 20 choose to have their biological children not staying with their own households. This can be interpreted as another sign of immaturity among adolescent males when engaging in relationship with adolescent females.

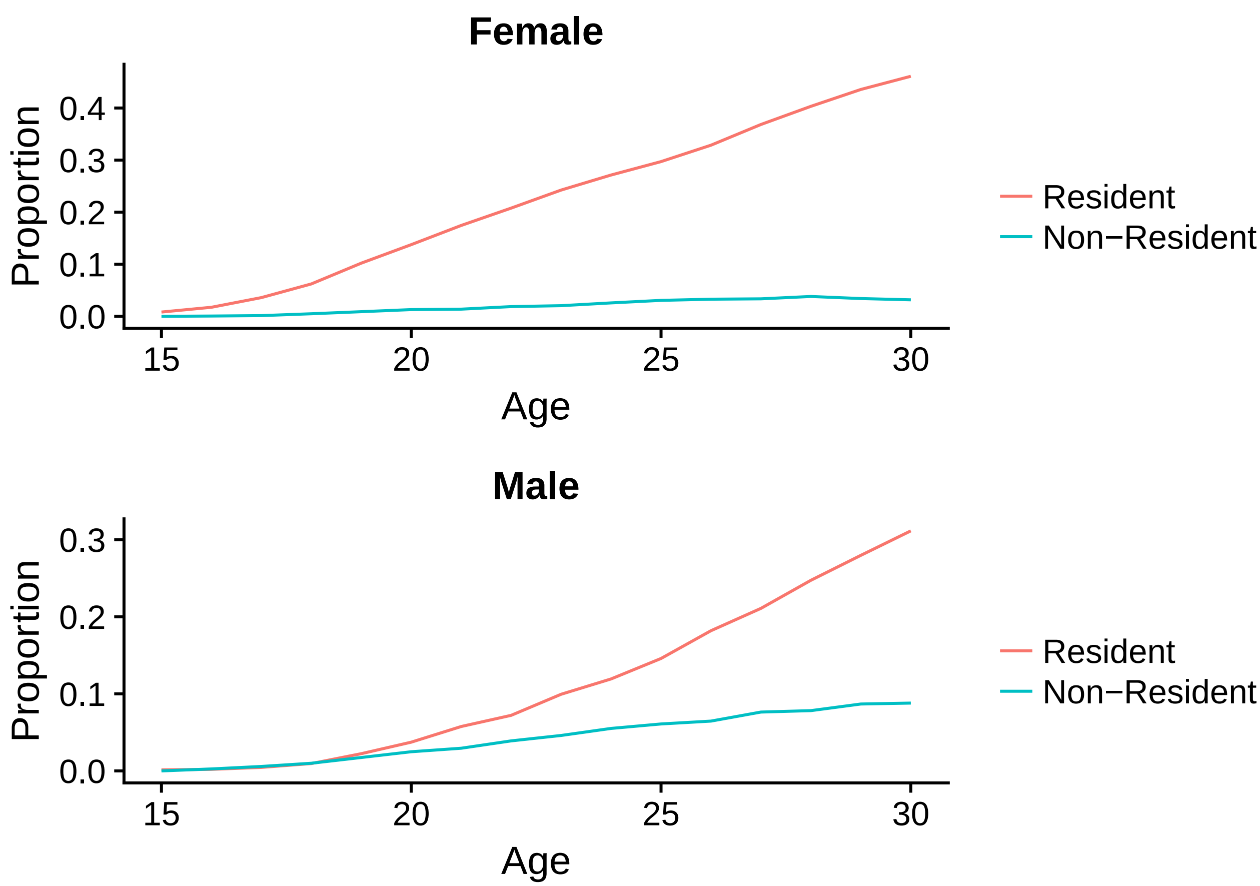


Figure 8: Number of Biological Children by Age

#### 3.4.3 Risky Behaviors

In this paper, we consider four risky behaviors for the measurement of maturation — smoking, binge drinking, taking marijuana and taking hard drugs. For smoking, taking marijuana and hard drugs, we define the participation rate as the fraction of respondents who currently are engaging in each respective risky behavior. For binge drinking, we define the event to occur if the respondent drinks 5 or more alcoholic drinks per day. Figure 9 reports the participation rate of each risky behavior by age and gender, scaled by their respective peaks for easy comparison.

For each risky behavior without exception, the participation rate demonstrates a life-cycle profile that decreases soon after age 20. Without considering maturation such trends can be puzzling, since most respondents gain freedom in accessing cigarettes and alcohol after passing the minimum legal age. Also, the respondents gain financial freedom after working. The downward trend after age 20s can only be explained.

Among the risky behaviors, maturation can also explain the more acute reversal for taking marijuana and taking hard drugs. While maturation equally applies to change the cost-benefit calculus for all risky behaviors, taking marijuana and hard drugs bears more severe consequences. Therefore, matured respondents would tend to adjust these two risky behaviors.

Across the two genders, the decrease in trend happens earlier for females, which is consistent with the hypothesis that females mature earlier than males on average.

#### 3.4.4 Marriage

In this paper, we also investigate whether maturation is associated to marriage. Figure 10 reports the fraction of married respondents by age for each gender. Note that the fraction

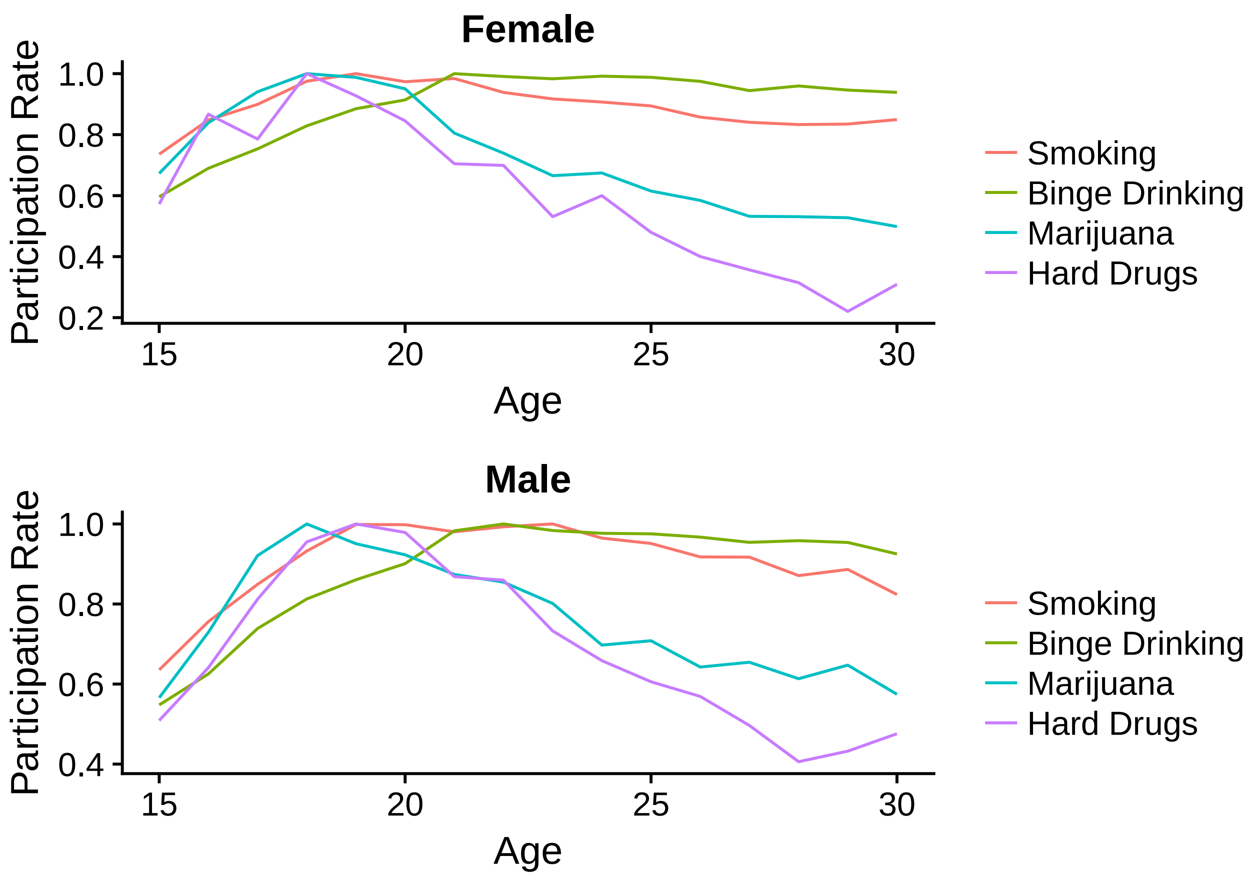


Figure 9: Participation Rate of Risky Behaviors by Age (as Fraction of Respective Peaks)

for both genders are substantially lower than those of having a biological child. The figure also reveals that the marriage females are marrying at older ages than males. This result is comparable to that reported by Díaz-Giménez and Giolito (2008), in which grooms are 2.5 years older than brides on average.

As a remark, the status of marriage is self-reported at the time of interview in the NLSY97. In contrast, Blank et al. (2007) considers the two courses of adminstrative records: the Vital Statistics and retrospective reports from the U.S. Census, and find significant discrepancies. Notably, the Vital Statistics show a discontinuous jump at the legal age of marriage in each state. However, the Census retrospective reports finds that the legal age shows very little compliance. As the study finds, there is substantial "avoidance behavior" in which some young couples misreport their age in their marriage certificates recorded by the Vital Statistics. Also, some couples would choose to marry at another state which has a lower legal age; the stayers would reveal a much stronger compliance behavior. Using the census data, Blank et al. (2007) finds that the age of marriage is only slightly affected by state laws.

### 3.5 MEASUREMENT OF MATURATION

This section reports the results of measuring maturation. Figure 11 plots the empirical distribution of maturation timings by gender. The density function is decreasing by age, which suggests that most adolescents are maturing around age 20 or before; it should be noted that there is a significant portion of individuals who mature later than age 20. Also, there is no significant difference between the distribution of maturation timings by gender. Note that because the sample ends at age 30, the maturation distributions are right-censored.

This measure of maturation is robust in several sense: First, we examine whether we

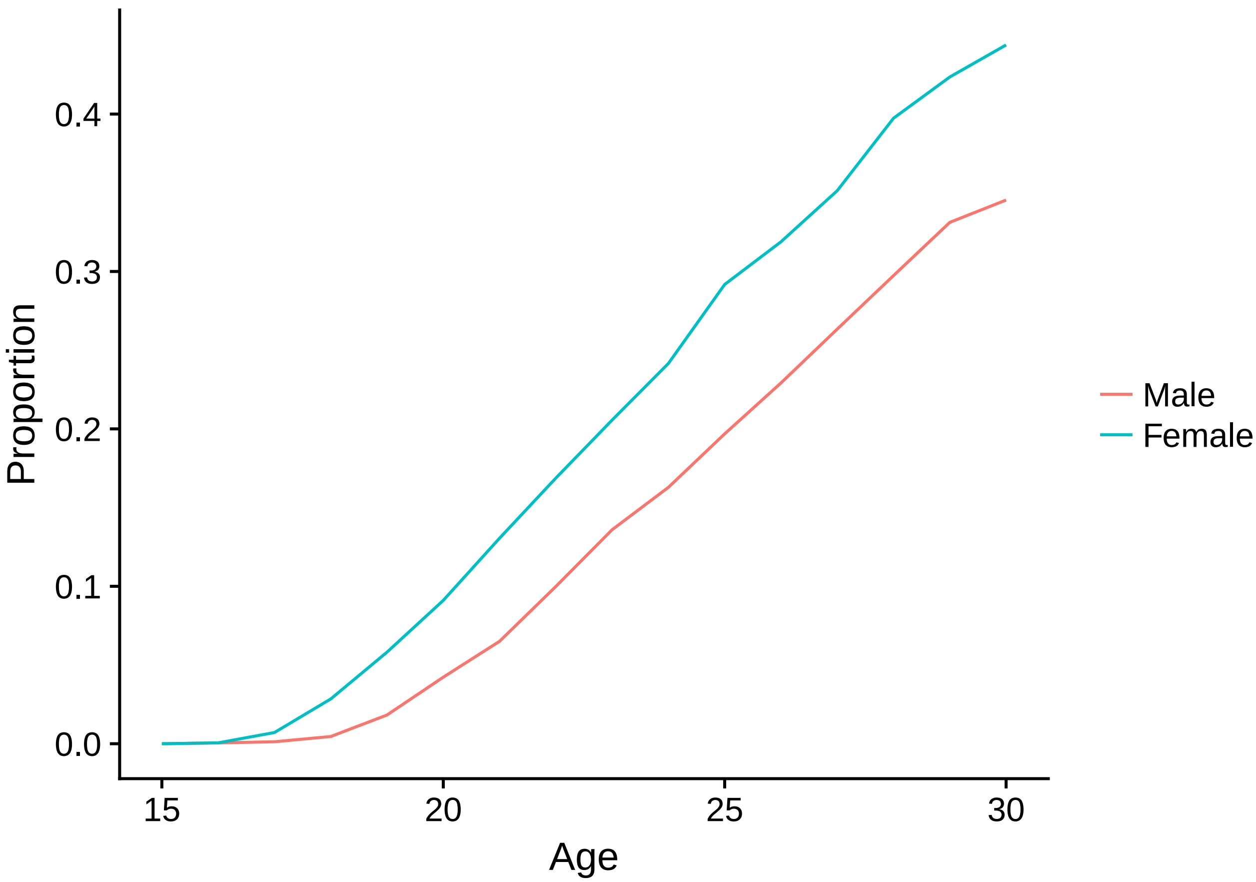


Figure 10: Marriage Rate by Age

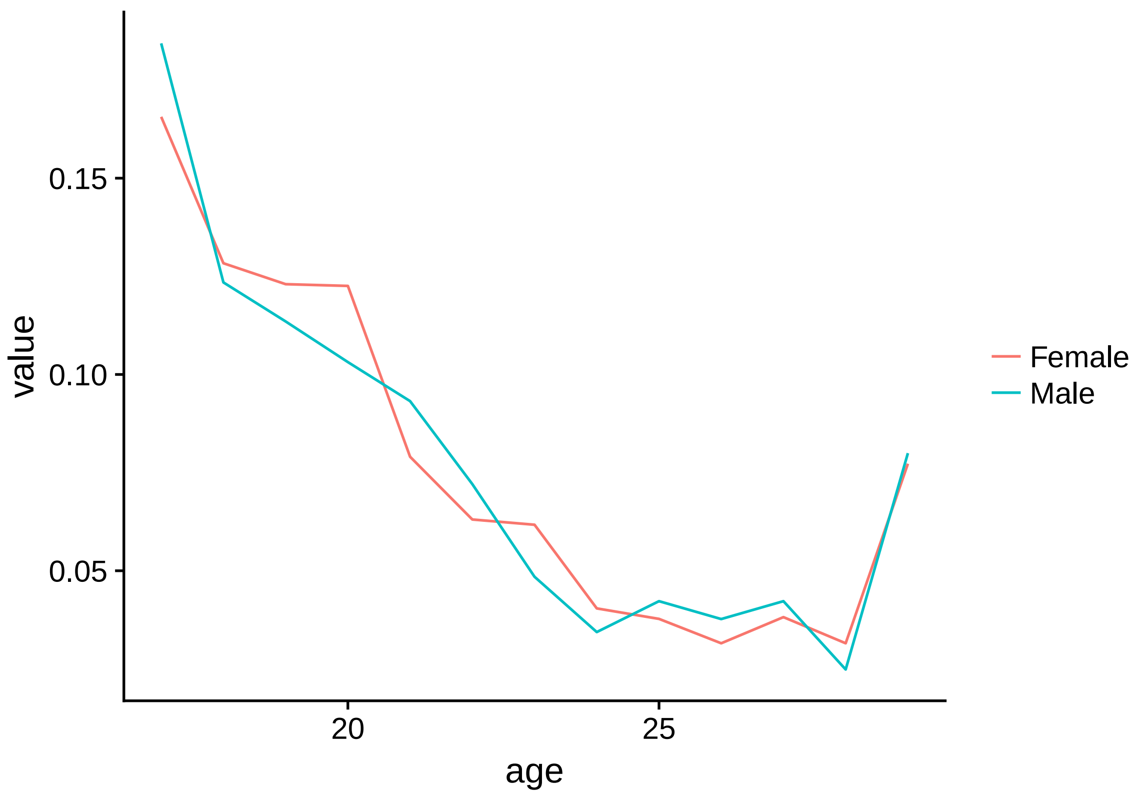


Figure 11: Probability Mass Function of Maturation Timing by Gender

separately run the algorithm by gender or pool them together would yield the same estimates of individual maturation timing $\hat{\tau}_i$; second, we consider a "leave-one-out" strategy by omitting one out of the four risky behavior measurements; third, we add covariates to the algorithm to better control for individual differences. The result are promising: for all three robustness checks, we find that above $70-80\%$ of the estimates are identical, and the rest are evenly spread out in terms of deviations in years.

The median maturation age of around 21 agrees with the present neuroscientic understandings of the human brain, whose main finding is that the part of the adolescent brain related to self-control matures the latest. At the present, despite the advances in brain imaging technologies, it remains impractical to directly measure brain activity outside the laboratory. Therefore, while researchers try to establish the associations between the human brain and human behaviors, often their conclusions are induced from simple reactions in the laboratory rather than actual, daily behaviors such as smoking and binge-drinking. Complementing their contributions, our behavioral-deduced maturation variable can serve as a corrobation device.

## 3.6 MATURATION AND TEEN CHILDBEARING

After measuring maturation, this section shows the relationship between maturation and teen childbearing, separably for males and females. Specifically, we run a least squared regression (i.e. linear probability model) to estimate the conditional probability

$$Pr(m_{it}=1|c_{it},c_{it-1}=0,m_{it-1}=0,X_{it}) \tag{3.8}$$

where $c_{it}\in\{0,1\}$ indicates whether the respondent has a biological child. The conditioning is on that last year $t-1$ the respondent does not have a biological child, i.e. the child is born in year $t$, and that the respondent was immature.

A positive coefficient of $c_{it}$ indicates that having a biological child in this year is positively correlated the maturation of the respondent.

The results for biological children residing in the same household are shown in Table 3.6. It turns out the coefficient is very large for females, with a coefficient of about 0.18. This indicates that females who have a biological child residing in the household are 18% more likely to mature within the same year, which is very large relative to the unconditional mean of 0.07 annual probability of maturation on average. For males, having a child residing in the household has a much smaller effect, sometimes being insignificant. This is because males are usually not the primary caregivers of their child.

Being married has a relative negative partial correlation to maturation. Combined with the result of childbearing, we interpret this as the result of sub-optimal marriages. Note that since our sample ends at age 30, being married in this sample implies marrying relatively early.

In the full specification, we also consider other predictors in $X_{it}$. In particular, we find that respondents not having a college degree have a 5 percentage points more probability of being mature. We interpret this as another evidence that negative shocks tend to force people mature.

A college environment is arguably more forgiving relative to the work environment. It is a well-known fact that many students who perform reasonably well in a high school environment fail in the college, resulting in a low rate of completion; some students even consider dropping out without a degree only near the finish line (Mabel and Britton, 2016). In contrast, the work environment requires one to bear full responsibility to their actions. Firms value workers who have professionalism and hence immature individuals, lacking in non-cognitive skill, are likely to fail in the work environment.

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | Maturity Status | | | |
| | Female | Female | Male | Male |
| | (1) | (2) | (3) | (4) |
| HasBioChild | 0.180*** | 0.203*** | 0.011 | 0.056** |
| | (0.017) | (0.019) | (0.015) | (0.026) |
| HasMarried | | −0.031** | | −0.035** |
| | | (0.013) | | (0.016) |
| Age | 0.012*** | 0.018*** | 0.013*** | 0.019*** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| ASVAB | | −0.0005*** | | −0.001*** |
| | | (0.0001) | | (0.0001) |
| College | | −0.081*** | | −0.094*** |
| | | (0.013) | | (0.013) |
| FirstMenstrual | | 0.007 | | |
| | | (0.005) | | |
| Constant | −0.086*** | −0.199*** | −0.101*** | −0.177*** |
| | (0.018) | (0.029) | (0.017) | (0.022) |
| Observations | 12,793 | 10,231 | 14,910 | 11,462 |
| $R^2$ | 0.024 | 0.036 | 0.016 | 0.028 |
| Adjusted $R^2$ | 0.023 | 0.035 | 0.016 | 0.028 |
| *Note:* | | *p<0.1; **p<0.05; ***p<0.01 | | |

Table 18: Probability of Maturation by Gender, Conditional on Current Immaturity and Not having a Biological Child Before

## 3.7 DISCUSSIONS AND CONCLUSIONS

This thesis chapter is a sketch attempt to discusss the quantitative relationship between maturation and teen childbearing, which shall be developed into a more comprehensive analysis.

Among all risky behaviors, teen childbearing is of particular social concern due to its irreversibility; but the same reason leads to a difficulty in identifying whether the teen parents mature and regret or not. Therefore, we consider other reversible risky behaviors such has smoking, binge drinking, taking marijuana and taking hard drugs, using them for measurement of maturation. Extracting a maturation measure using these risky behaviors, we then correlate this maturation measure with having the first biological child conditional on being immature, not having a biological child before, age and some other individual characteristics.

This result sheds light to adolescent policies on teen childbearing. The fact that many adolescents mature upon having a birth indicates that it is a very negative shock, consistent with the literature. This negative shock fosters maturation —a learning process— and a systematic change in risky behaviors as the consequences.

The fact that only females have a very large correlation indicates that when childbirth is not planned well in advance, females are the ones who suffer because they are biologically responsible to the childbirth; the involved males tend to avoid the responsibility as the NLSY97 data reveals. This gender asymmetry indicates that policy resources should be focusing on protecting females. For instance, a promotion of early pregnancy tests to teen females would be particularly useful. As Sawhill (2014) mentioned, it is hard to prevent immature behaviors including unprotected sex. Since long-run contraceptive devices are hard to promote (Aizer et al., 2017), early pregnancy tests would be a second best option.

Early pregnancy tests are available yet they require some knowledge. In particular, it requires the female to count the number of days of missing period. There is a chance of not detecting pregnancy if the pregnancy test is done too early, because by then the level of pregnancy hormones would be too low and hence cannot be detected. Therefore, it would be useful if resources can be put into compulsory medical checks in schools; promoting the self-recording of menstural cycle should be particularly helpful.

Teen childbearing is one among many policy issues where maturation is involved. Other policies include the setting of the legal age of substance use and voting, as well as the applicability of juvenile courts. Establishing a measure of behavioral maturation would be useful in the discussion of these contexts as well.

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