How Does Birth Endowment Affect Individual Resilience to an Adolescent Adversity?*

Ruifei Guo† Junsen Zhang‡ Ning Zhang§

Abstract

Studies on heterogeneous effects of adversities usually explore one exogenous variation in adversity. We explore two exogenous variations to examine how birth endowment changes individual resilience to an adolescent adversity. While China's send-down campaign offers a social experiment that exposes people to an adversity in adolescence, we use twins' difference in birthweight as a natural experiment on birth endowment. The use of exogenous variations in both endowment and adversity enables us to clearly identify the interaction effect of endowment and adversity. We find that effects of send-down experience on income, education, and health differ by birthweight. For brothers with a 10% difference in birthweight, if the higher-endowed male was sent down, then he would earn approximately 12% more than his co-twin. For sisters with a 10% difference in birthweight, if the higher-endowed female was sent down, she is 8% more likely to upgrade her education after the send-down movement, and 9.8 percentage points less likely to be overweight or have chronic diseases. Long-term consequences of an adolescent adversity differ substantially by birth endowment.

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†Center for Health Economics and Management, Economics and Management School, Wuhan University. Email: rufei_guo@whu.edu.cn

‡School of Economics, Zhejiang University. Email: jszhang@cuhk.edu.hk

§Department of Economics, University of Oxford. Email: ning.zhang@economics.ox.ac.uk

1 Introduction

Does endowment affect individual resilience to adversities? A burgeoning strand of literature documents that one-time shocks have persistent impacts on later-life outcomes (Almond and Currie, 2011; Currie and Vogl, 2013). Effects of adversities are heterogeneous. Disadvantaged groups tend to suffer more from adversities (Bharadwaj et al., 2015; von Hinke Kessler Scholder et al., 2014; Almond et al., 2018). The literature suggests that individual characteristics affect resilience to adversities. However, a clean identification of the interaction effect of endowment and adversity requires the lightning to strike twice, that is, for two exogenous shocks to happen to the same group of people (Almond and Mazumder, 2013; Almond et al., 2018; Adhvaryu et al., 2018; Malamud et al., 2016). If the observed endowment correlates with unobserved family background, and we observe resilience to adversity for the higher-endowed people; we are uncertain whether it is the observed endowment or the unobserved family background that contributes to resilience to adversity. Thus, the exogeneity of both endowment and adversity are crucial to understanding their interaction effect, as well as the evaluation of a set of public policies that insure families and children against negative shocks.

We find that an adolescent adversity strengthens the higher-endowed individual relative to the lower-endowed one. We take advantage of the Chinese twins data and a historical context in China to explore exogenous variations in endowment and adversity, and estimate their interaction effect on later-life outcomes of individuals. The specific adversity in this study is China's send-down campaign, which sent urban youths aged 13–25 to rural areas. From 1968 to 1979, more than 17 million urban youths were sent down (Bernstein, 1977; Bonnin and Horko, 2013). At the end of the campaign in 1980, almost all send-down youths had returned to urban areas. Given that these youths lived in harsh rural conditions and perform hard agricultural work, their send-down experience was commonly perceived as an adolescent adversity (Zhou and Hou, 1999; Li et al., 2010). Although the incidence of send-down depends on a child's family background, the differ-

ence in send-down status between genetically identical (monozygotic, MZ) twins largely removes the selectivity in send-down status.

Our measure of endowment is the birthweight differences between MZ twins. Birthweight, a commonly recorded measure of neonatal health, proxies for the initial endowment of an infant's health human capital. While cross-sectional variations in birthweight captures differences in genes and family background, within-MZ-twin differences in birthweight reflect differences in prenatal nutrition intakes, which result from random events such as womb positions (Behrman and Rosenzweig, 2004).

We begin by documenting some stylized facts about the send-down movement and examining selection of send-down status across and within families. More than one-third of the affected cohort (born between 1946 and 1961) in our sample were sent down. A simple comparison between send-down and non send-down MZ twins shows that the send-down campaign was not selective in terms of birthweight.

We then apply the Chinese twins data and employ the within-MZ twin estimator to investigate the interaction effect of send-down and birthweight on individual socioeconomic outcomes. To explore heterogeneous effects by gender, we estimate the interaction effect for males and females separately. We find that the send-down experience strengthens the heavier-at-birth child relative to his/her co-twin, and the effect is different for males and females. For brothers with a 10% difference in birthweight, if the higher-endowed male was sent down, then he earns approximately 12% more than his co-twin. By contrast, we do not detect any statistically significant interaction effects of send-down and birthweight on female income. Instead, we find an interactive effect on female education and health. For sisters with a 10% difference in birthweight, if the higher-endowed female was sent down, she is 8 perentage points (pp) more likely to upgrade her education after the send-down movement, 9.8 pp less likely to be overweight, and 9.8 pp less likely to have chronic diseases.

To shed light on mechanisms, we examine effects of the interaction term on mari-

tal transfers, spousal schooling years, employment status, Party membership, and non-cognitive skills. The interaction effect of send-down and birthweight on male income can be explained by parental reinforcement behavior. If the higher-endowed male was sent down, then he would receive 16%–45% more wedding gifts from his parents and marry a woman who has 0.55 more years of schooling. We then rule out the possibility that send-down strengthens the higher-endowed child through its impact on employment status or on the Chinese Communist Party (CCP) affiliation. We find no evidence that the interaction term affects individual earnings through its impact on non-cognitive skills, leaving the channel through family and marriage as the most plausible explanation. Our results are robust to alternative specifications. Our findings suggest that an adolescent adversity, namely, send-down experience, will strengthen the higher-endowed individual relative to the lower-endowed one.

Our paper contributes to the literature in multiple aspects. First, we exploit two exogenous variations to provide a clean identification of the interaction effect between endowment and adversity on socioeconomic outcomes. Only a handful of recent studies have started to exploit two exogenous variations to identify an interaction effect. Aguilar and Vicarelli (2018) investigate the interaction between extreme rainfall shocks and Mexico's PROGRESA program of conditional cash transfer, finding no interaction effect of the two shocks on outcomes of early-age children.[1] Using a similar research design, Adhvaryu et al. (2018) find that PROGRESA mitigates the negative impact of rainfall shocks for child outcomes at ages 12 to 21. Gunnsteinsson et al. (2016) find that Vitamin A supplementation at birth protects children against losses from a tornado. Rossin-Slater and Wüst (2015) find that a nurse home visiting program shortly after birth can substitute for a childcare program aimed at preschool children. While most of the previous studies examine two closely spaced shocks, our study examines two shocks that happened

[1]Malamud et al. (2016) also find no interaction effect of family and school environment. They obtain variations in family environment by using a change in abortion ban, and obtain variations in school environment by using a regression-discontinuity design based on admission exams.

more than 10 years apart: weight at birth and send-down in adolescence. We focus on the interaction effect between endowment and adversity on long-term outcomes, such as income, education, and health in adulthood. Our findings highlight that the effect of adversities hinges critically on individuals' endowment, the effect is gender dependent, and intra-household allocation plays a role. These findings contribute to the understanding of heterogeneous effects of adversities on individual outcomes (Almond and Currie, 2011; Currie and Vogl, 2013).

Second, we contribute to the literature on long-term consequences of the send-down movement. Although the early study of Zhou and Hou (1999) finds that send-down experience benefits the educated youths, Xie et al. (2008) show that send-down is non-beneficial. Li et al. (2010) find that send-down experience raises earnings and increases parental transfers. Send-down interrupts people's education (Han et al., 2019), changes their financial behavior (Fan, 2020), and modifies their belief (Roland and Yang, 2017). A closely related study is Gong et al. (2020), who estimate heterogenous effects of send-down experience on adult health by using the framework of the marginal treatment effect. While Gong et al. (2020) examine heterogenous effects of send-down status by the marginal propensity to treat, we examine heterogenous effects by birthweight, which specifically measures the initial stock of health human capital. To the best of our knowledge, no previous studies have investigated heterogeneous effects of send-down experience by the health endowment at birth (Zhou and Hou, 1999; Li et al., 2010; Gong et al., 2015; Fan, 2020; Zhang et al., 2020). Furthermore, we contribute to this literature by shedding light on the gender difference in the effect of the send-down movement. Numerous discussions have been carried out about the different effects of send-down on males and females (Bernstein, 1977; Liu, 1998), but a rigorous research that provides evidence of gender difference is still lacking.

Finally, our findings imply that public policies on prenatal nutrition intakes can enhance individual resilience to adversities. Birthweight differences, especially those within

MZ twins, reflect prenatal nutrition intakes of fetuses (Behrman and Rosenzweig, 2004; Abu-Saad and Fraser, 2010; Emmett et al., 2015; Grieger and Clifton, 2015). Existing studies have shown that birthweight is a strong and persistent predictor of individual educational attainment, health, and labor market outcomes (Behrman and Rosenzweig, 2004; Almond et al., 2005; Black et al., 2007; Figlio et al., 2014). However, few studies examine how prenatal nutrition intakes affect individual resilience to adversities. Our findings suggest that prenatal nutrition intakes profoundly mitigate negative consequences of adversities. As plenty of public policies target at improving prenatal nutrition intakes (Hoynes et al., 2011; Kowaleski-Jones and Duncan, 2002; Barber and Gertler, 2010), our findings contribute to the understanding on the long-term effect of such policies.

The rest of this paper is organized as follows. Section II introduces the background of the send-down movement. Section III describes the data set. Section IV introduces our empirical strategy. Section V presents our main empirical results. Section VI discusses robustness checks and alternative explanations. Section VII concludes the paper.

2 Institutional Background

During the Cultural Revolution in China, Chairman Mao Zedong launched the large-scale send-down movement of sending the urban youths to rural areas. Chairman Mao issued a directive on December 21, 1968, urging young people to *"go to the countryside to be re-educated by the poor and lower-middle peasants."* During the mass movement, from 1967 to 1978, the state "send-down" policy led to 17 million urban youths to live and work in rural areas, equivalent to about one-tenth of China's non-farming population in 1999 (Pan, 2002). Its purpose was to "revolutionize the thinking of the urban youths, train successors to the revolutionary proletarian cause," and solve the problems of employment and urbanization (Bernstein, 1977). From 1968 to 1969, 4.6 million youths were sent to the countryside. A slowdown occurred in the early 1970s because of economic recovery and

reopening of schools. In 1974, the leadership's renewed interest in the movement resulted in an increase in departures, with over 7.6 million urban youths being sent down to rural areas. In 1980, the Party decided to end the movement and allow the youths to return to their families in the cities. As the most intensive nationwide political movement during that time, the campaign had profound effects on the socioeconomic status of the affected cohort in China.

Although some youth might be inspired by the revolutionary propaganda and volunteer for the program (especially at the beginning of the movement), historical documents show that the majority of send-down youths were reluctant and were mandated by the government to go to the countryside. Their reluctance was attributed to the poverty and hardship that they have to endure in rural areas (Bernstein, 1977). After Chairman Mao's directive in December 1968 that urged educated young people to "go to the countryside to be re-educated by the poor and lower-middle peasants," the send-down movement became a nationwide compulsory movement with a top-down mobilization system to ensure compliance. At the top, the State Revolutionary Committee pinned down send-down plans for the State Council every year. At the municipal level, the local government allocated a quota to each family according to the socio-political background of families. In particular, children from certain class origins (e.g., counter-revolutionaries, pre-liberation capitalists, and landlords) were among the priority group to be sent down, whereas those from some class origins (e.g., revolutionary cadres, pre-liberation industrial workers, and peasants) might be exempted. At the bottom level, schools, parents' work units, and residential organizations acted in concert to mobilize support for compliance with the rustication program (Rene, 2013).

In addition to selection across local government and family backgrounds, within family selection was prevalent and varied with government rules. In the early 1970s when the rate of rustication was low, government rules allowed siblings to stay in the city if one sibling was already been sent to the countryside. However, in 1974 when the send-

down movement was intensified, the rule was changed to permit only one sibling of each family to stay in the city (Bernstein, 1977). The family-related selection rules were widely applied and forced families to make a send-down choice among their multiple eligible children.

Send-down was a very hard experience for those affected adolescents. As reported in many documents (Bernstein, 1977; Zhou and Hou, 1999), many send-down youths were assigned to carry out hard manual labor in the fields for as long as 12 hours a day, 7 days a week. On average, they stayed in rural areas for about three to five years. Xi Jinping, the current president of China, also had his own send-down experience: "When Xi Jinping was sent-down in a remote village in Shanxi province, he worked in a chilly river, together with the villagers, to remove frozen water from dams during the cold winter. They worked day and night, and finally restored several dams in a month ..."[2]

Numerous send-down youths who went through the harsh experience claim that they benefited from the experience. In Xi Jinping's narrative, he said, "The seven-year hard life in the countryside has been a great treasure for me. I gain two things from it: first, I understand the meaning of seeking truth from facts. This is something that really benefits me throughout my life. The second is to cultivate my self-confidence. I have been living through such hardship, so I am confident that I can solve other difficult problems in life as well."[3] Other than President Xi, many send-down individuals, especially the ones who achieve socioeconomic success, said in their memoirs that they never regret to experiencing the send-down. The send-down experience strengthened their mind and motivated them to work hard, which proved beneficial for their current success (Bonnin and Horko, 2013). This fact echoes a recent strand of the literature that suggests that early setbacks can be beneficial to future success, because people learn from failures (Cope, 2011; Burnette et al., 2013; Wang et al., 2019).

[2]Chinese CCP News (12/22/2014): http://dangshi.people.com.cn/n/2014/1222/c85037-26251425-2.html

[3]People.cn (12/11/2012): http://www.people.com.cn/n/2012/1211/c33232-19859617.html

Chairman Mao passed away in 1976. In 1977, university entrance exams were reinstated, inspiring the majority of rusticated youth to attempt to return to the cities once the send-down policy was lifted. The send-down experience ultimately resulted in different lives between the sent-down children and their non-sent-down siblings. The send-down experience became an unforgettable event for that cohort, and affected the socioeconomic status of the send-down youths for a lifetime.

3 Data

We use data from the Chinese Adult Twins Survey (CATS), which was carried out by the Urban Survey Unit of the National Bureau of Statistics (NBS) in June and July 2002 in five cities of China, namely, Chengdu, Chongqing, Harbin, Hefei, and Wuhan. The local statistical bureaus identified same-sex adult twins aged between 18 and 65 years and completed the questionnaires through face-to-face personal interviews. CATS collected a rich amount of information from the respondents, including their birthweight, send-down experience, education history, income, marital status, and employment status. Completed questionnaires were collected from 1,495 pairs of same-sex adult twins (2,990 respondents), including 919 pairs of MZ twins (1,838 individuals) and 576 pairs of dizygotic twins (1,152 individuals). Li et al. (2010) provide a detailed description of the CATS.

We focus on the sample of the send-down cohort who were born between 1946 and 1961 and end up with 341 matched pairs of identical (monozygotic, MZ) twins.[4] The proportion of people who were sent down starts at 11% for those born in 1946, quickly increases to more than 50% during 1948 and 1959, and sharply declines after 1960 (Figure 1). The trend of the send-down proportion in CATS is quite similar to the trend found in the 2010 baseline survey of the China Family Panel Studies, a national representative survey conducted by the Institute of Social Science Survey of Peking University. The

[4]The sample sizes in regressions may be different due to missing values of the outcome variables.

average send-down rate was higher in CATS than in CFPS because the CATS sample was drawn from five large cities that were more affected by the send-down movement compared with the national average.

We summarize the characteristics of our CATS sample in column (1) of Table 1. On average, the twins were 47 years old, weighed 2.34 kilograms at birth, earned 789 Chinese yuan in real terms (with 2002 taken as the base year), and had 11 years of schooling. Almost all of the sampled twins have ever been married. Approximately 47% of our sample were males and only 57% were employed in 2002 (survey year). Many of the send-down cohorts lost their jobs during the reform on state-owned enterprises (SOEs) in 1998 (Giles et al., 2006; Knight and Li, 2006). We will discuss the potential confounding effects of the mass job loss in the SOE reform in Section 6.

An immediate consequence of the send-down movement on the affected cohort is the interruption of schooling (Han et al., 2019). High schools and colleges were shut down for years during the movement. Many send-down youths tried to make up for their lost education via re-schooling after returning to cities. Given that the send-down movement interrupted the education progress of the relevant cohort, more than 18% of the sample upgraded their education through re-schooling after the Cultural Revolution.[5] After return, send-down individuals picked up 0.64 years of schooling on average.

We construct two variables to measure people's health status. The first variable measures overweight status. Using self-reported height and weight, we calculate the body mass index (BMI) of twins.[6] We then define an indicator of overweight status, which equals 1 if the BMI is equal to or greater than 25, and 0 otherwise.[7] The medical literature has documented a strong association between overweight and health risk. Our second

[5]If an individual's education is interrupted during Culture Revolution and he/she takes additional education after the revolution, we think that he/she has done re-schooling. The years of schooling after the interruption is defined as the re-schooling years.

[6]BMI is defined as body weight divided by the square of body height, expressed as kg/m^2.

[7]BMI is used to categorize people as underweight, normal weight, overweight, or obese. According to the customary BMI thresholds of the 1995 World Health Organization report, 25 is the commonly accepted cut-off point for being overweight.

measure is an indicator variable on chronic diseases. CATS records 12 types of chronic diseases: hemicrania, hay fever, skin rash, hearing damage, hypertension, neurasthenia, alcohol addiction, cardiomyopathy, neck injury, dorsum injury, arm injury, and leg injury. The indicator on chronic diseases equals 1 if the individual has any type of chronic diseases, and 0 otherwise. Table 1 shows that the average BMI is 22.79, 20% of the sample were overweight, and 57% of the sample reported at least one type of chronic disease.

We then divide the sample based on the send-down status of twin pairs in Table 1. For 124 twin pairs, both twins were sent down (column (2)); for 101 twin pairs, one of the twins was sent down (columns (3) and (4)); and for the remaining 116 twin pairs, neither was sent down (column (5)). Our source of variation mainly comes from one-send-down families. Among the one-send-down twin pairs, the average birthweight is similar between the send-down and non-send-down twins, suggesting no selection of send-down in terms of birthweight. Send-down twins are 8% more likely to be employed and have an approximately 10% higher monthly income compared with non-send-down twins. Send-down twins are 4% more likely to upgrade his/her education after the movement and obtain 0.2 more years of schooling. In addition, send-down twins have higher BMI and are 3 pp more likely to be overweight. This simple comparison indicates that the send-down experience is associated with higher likelihood of employment, higher income, more years of re-schooling, but perhaps poorer health.

4 Empirical Strategy

In this section, we discuss our empirical specification of the within-MZ twin estimator, which exploits the differences in send-down experience and in birthweight within MZ twin pairs. We examine the interaction effect of birthweight and send-down experience on various individual outcomes.

The regression equations for each twin from the same MZ pair are as follows:

$$Y_{1j} = \beta_1 SD_{1j} \times 10lnBW_{1j} + \beta_2 SD_{1j} + \beta_3 10lnBW_{1j} + \mu_j + \epsilon_{1j}, \tag{1a}$$

and

$$Y_{2j} = \beta_1 SD_{2j} \times 10lnBW_{2j} + \beta_2 SD_{2j} + \beta_3 10lnBW_{2j} + \mu_j + \epsilon_{2j}, \tag{1b}$$

where subscript j indexes twin pair; subscript $i \in \{1, 2\}$ indexes the twin; and Y_{ij} is a measure of outcome variables, including income, post-send-down schooling, and overweight status among others. The term SD_{ij} is the send-down status of twin i in family j, and $lnBW_{ij}$ is the log birthweight of twin i in family j. For ease of interpretation, we multiply log birthweight by 10. The term $SD_{ij} \times 10lnBW_{ij}$ is the interaction of these two variables. The term μ_j is a twin-pair fixed effect accounting for any common factors (both observed and unobserved) that affect the outcomes of both twins. The term ϵ_{ij} denotes the error term.

Both send-down status (SD_{ij}) and birthweight variable ($10lnBW_{ij}$) may correlate with unobserved confounders, leading to biased estimates of all coefficients. We use the within-twin difference to eliminate the twin-pair fixed effect μ_j, and reach the first-difference equation:

$$\Delta Y_j = \beta_1 \Delta SD_j \times \Delta 10lnBW_j + \beta_2 \Delta SD_j + \beta_3 \Delta 10lnBW_j + \Delta\epsilon_j, \tag{2}$$

where $\Delta x_j = x_{1j} - x_{2j}$ denotes the difference in variable x between twin 1 and 2 in twin pair j.[8] Our primary coefficient of interest is β_1, which captures the difference in the effects of send-down on the outcomes of a twin pair who have a 10% difference in birthweight. Meanwhile, the coefficient β_2 is the effect of send-down on the outcome variable if the send-down individual has the same birthweight as his/her co-twin. Similarly, β_3 is the effect of birthweight on individuals' outcome if the twins have the same send-down

[8]One unit increase in $\Delta 10lnBW_j$ represents approximately a 10% difference in birthweight between the twins. As a first approximation, consider $\mathbf{d}10lnx = 1$, then $\frac{\mathbf{d}x}{x} = 10\%$. For a discrete change of x, consider $10lnx_1 - 10lnx_2 = 1$, then $\frac{x_1 - x_2}{x_2} = e^{0.1} - 1 \approx 10.5\%$.

experience.

A clean identification of the interaction effect requires exogenous variations in both birthweight and send-down status (see Section A1 in the appendix for a mathematical proof). Figure 2 shows that substantial variations exist in birthweight within twin siblings. The solid blue line marks the birthweight distribution for 160 pairs of male same-sex twins, and the dashed red line marks the birthweight distribution for 181 pairs of female same-sex twins. For male (female) same-sex twins, the average birthweight difference is 0.0088 (0.0039) kilograms, with a standard deviation of 0.32 (0.35) kilograms. The average of the absolute value of the within-twin birthweight difference is 0.20 (0.23) kilograms for male (female) same-sex twins, which is about 10% of the average twin birthweight. The specification, where we multiply log birthweight by 10, will allow us to interpret estimates relative to the mean of the absolute value of the within-twin birthweight difference. Although within-twin variations in birthweight is believed to be exogenous (Behrman and Rosenzweig, 2004; Almond et al., 2005; Black et al., 2007; Figlio et al., 2014), the selection in send-down status could still be a concern, especially within a twin pair (Li et al., 2010).

The literature documents that the send-down movement discriminates across families. An early study finds that children of college-educated parents are more likely to be sent down than children of non-college-educated parents (Zhou and Hou, 1999). To examine selection in send-down, we regress individuals' send-down status on birthweight, gender, and average schooling years of parents (column (1) of Table 2). We do not detect statistically significant correlations between send-down status and each of these variables. However, as the selection could be gender-specific, we further divide our sample by gender. For males (column (2)), a 10% higher birthweight is associated with a 19% lower likelihood of being sent down, although the effect is only marginally significant at the 10% level. For females (columns (3)), birthweight is positively correlated with send-down status, but the effect is statistically insignificant. These results suggest that

send-down status can be selective across families and the effect is gender-specific.

We then regress individuals' send-down status on birthweight using the within-MZ-twin fixed effect model to control for selection across families. This specification examines the selection within twin pairs. The result is reported in column (4) of Table 2. We do not observe a statistically significant correlation between birthweight and send-down status using the within-twin specification. Furthermore, we check the selection within families for male twins and female twins separately and report the result in columns (5) and (6) of Table 2. We do not find a significant correlation between birthweight and send-down experience either. The results suggest that send-down is non-selective on children's birthweight within MZ twins.

Although send-down status is non-selective on birthweight, it could still be possible that parents can conduct selective send-down based on their children's differences that are unobservable to the researchers. Li et al. (2010) suggest that parents tend to send down the weaker child, that is, parents send down the child with a lower unobserved endowment. As derived in Section A1 in the Appendix, if birthweight and the unobserved endowment are substitutes, then we obtain an upper bound estimate for β_1. If birthweight and the unobserved endowment are complements, then we obtain a lower bound estimate for β_1. If birthweight and the unobserved endowment do not have an interaction effect on the outcome variables, even if send-down is selective on the unobserved endowment, Equation (2) will yield a consistent estimate of β_1.

5 Main Results

In this section, we present our main results on the interaction effect of send-down and birthweight on income, post-send-down schooling, and health outcomes. We first present the outcome for the full sample, and then discuss the results by gender.

Columns (1) and (2) of Table 3 present the estimates of Equation (2) using $\Delta ln(Income)$

and $\Delta IHS(Income)$ as the outcome variables for the full sample, where IHS(Income) is the inverse hyperbolic sine transformation of income (Bellemare and Wichman, 2020).[9] We do not find any significant interaction effect of send-down and birthweight on income. We find that the interaction term has a positively significant effect on schooling picked up after send-down (columns (3) and (4)). For a twin who is 10% heavier at birth than his/her co-twin, being sent down increases his/her likelihood of re-schooling by 4.5 pp and his/her re-schooling years by 0.15 years relative to the co-twin. We also detect a negative interaction effect on overweight status (column (5)). For a twin who is 10% heavier at birth than his/her co-twin, being sent down reduces his/her likelihood of overweight by 7.4 pp. Overall, the send-down experience appears to strengthen the higher-endowed twin in terms of education and health.

Since effects could be very different by gender, we present the estimates for males and females separately. Panel A of Table 4 presents the estimates using male twins, and Panel B of Table 4 presents the estimates using female twins. For a male who is 10% heavier at birth than his co-twin, his send-down experience increases his income by approximately 12% relative to that of his co-twin (columns (1) and (2) in Panel A). These results are statistically significant at the 5% level. Send-down and birthweight do not display statistically significant interaction effects on the re-schooling behavior or health outcomes of males (columns (3)–(6)).

By contrast, for females we do not detect an interaction effect of birthweight and send-down on income, but detect significant interaction effects on education and health. For a female who is 10% heavier at birth than her co-twin, being sent down increases her likelihood of re-schooling by 8 pp and her re-schooling years by 0.26 years relative to those of her co-twin (columns (3) and (4) in Panel B). Send-down experience also reduces the heavier-at-birth female's likelihood of overweight by 9.8 pp, and reduces her likelihood of having chronic diseases by 9.8 pp relative to those of her co-twin (columns (5)

[9]We apply the inverse hyperbolic sine (IHS) transformation to income because it approximates the natural logarithm of that variable and allows retaining zero-valued observations.

and (6) in Panel B). We also test the whether the difference between men and women are statistically different by interacting gender dummy with the independent variables and present the results in Table A2. Consistent with the main results, the effects of send-down and birthweight on income, reschooling, and health are statistically different for men vs women.

Our findings on the interaction effects of birthweight and send-down on income, education, and health help explain the heterogeneous effects of send-down in the literature. Previous studies show that the send-down experience benefits the send-down youths (Zhou and Hou, 1999). By contrast, a recent study finds that the send-down experience does not have beneficial effects when controlling for endowment and family background by using the sibling fixed-effect model (Xie et al., 2008). In another related study, Gong et al. (2020) use CFPS data and apply a regression discontinuity approach to study the effect of send-down on later life health outcomes. They find that send-down youths were more likely to develop mental disorders but not worse physical outcomes. In our paper, we find that female send-down twins with higher endowment are less likely to be overweight or suffer from chronic diseases than their non-send-down counterparts. Our results suggest that the higher-endowed twin tends to gain from the send-down experience relative to the lower-endowed one and the effect is gender-dependent. The sign and magnitude of the effect of send-down on individual income or education depend on individual endowment and gender.

6 Mechanisms

In this section, we discuss other mechanisms that may drive our main result. We check the interaction effects of send-down and birthweight on marital transfers, spousal schooling years, employment status, CCP membership, and non-cognitive skills. Given that the main results are gender-specific, we present the results in this section by gender as well.

6.1 Family and Marriage

One reason for the within-household differences in child outcomes is parental compensation or reinforcement behavior (Almond and Mazumder, 2013; Behrman et al., 1982). If parents allocate more resources to a higher-endowed (lower-endowed) child, then they reinforce (compensate) this child's endowment. A major indicator of parents' compensation or reinforcement behavior in China is the amount of their wedding gift for their children (Brown et al., 2011). Although a wedding gift mostly happens once in a lifetime, the wedding gift is large in magnitude and proxies for parents' resource allocation to their child after his/her send-down experience. CATS included information on wedding gifts from parents. The average value of a wedding gift was 2799.6 *yuan* for males and 1852.2 *yuan* for females in real terms (with 2002 taken as the base year), approximately 3.2 and 2.6 times of the average monthly income of males and females, respectively.

We estimate Equation (2) by using $\Delta ln(Gift)$ and $\Delta IHS(Gift)$ as the outcome variables (columns (1) and (2) of Table 5), respectively. We split the sample by gender because marriage and parental wedding transfer for sons and daughters are quite different. We find that parents offer the send-down son a 16% higher wedding gift if he is 10% heavier at birth than his co-twin (column (1) in Panel A).[10] This interaction effect is statistically significant at the 1% level. When we use $IHS(Gift)$ to incorporate the extensive margin of the parents' transfers to children, parents give the send-down son a 45% higher wedding gift if he is 10% heavier at birth than his co-twin (column (2) in Panel A). These results suggest that parents reinforce a male's endowment if he was sent down. By contrast, if a male stayed in the city while his brother was sent down, then the parents compensate for his endowment. If parental reinforcement for the send-down son only functioned via increased monetary transfer, it is implausible that the increased monetary transfer contributes to the son's income.

[10]For an equation $ln(y) = \alpha + \beta x + \epsilon$, β serves as a good proxy for the percentage change in y for a one-unit increase in x when β is smaller than 0.1. For a large $\beta > 0.1$, we use $e^{\beta} - 1$ to calculate the percentage change. For example, the coefficient 0.115 in column (1) of Table 4 Panel A suggests that the outcome changes by 12% for a one-unit increase in the interaction $\Delta SD_j \cdot \Delta 10 lnBW_j$.

For parental resource allocation to be a valid mechanism behind the results on males' income, the increased monetary transfer should empower males in the long run. We find that when the wedding gift is higher, the man also married a better-educated wife, who would accompany the man for many years. For a male who is 10% heavier at birth than his co-twin, the send-down experience enables him to marry a female with 0.55 more years of schooling than his co-twin's wife (column (3) in Panel A). By contrast, for the female sample, the interaction effects on marital transfers or spousal schooling years are absent (columns (1) to (3) in Panel B). The literature documents that husbands and wives can learn from each other and that spousal education increases the income of their partners (Huang et al., 2009; Tiefenthaler, 1997). The results suggest that parental reinforcement for the send-down son, via increased monetary transfer, takes the form of finding a better wife for the son, and thus contributes to the son's income many years later.

In a close related study, Li, Rosenzweig, and Zhang (2010) explore the send-down movement and employ the same data on Chinese twins to study effects of altruism, favoritism, and guilt on parental wedding transfers toward their children. They are the first to identify the guilt motive, which induces parents to provide more wedding gifts to sent-down youth. Li et al. (2010) do not separate the sample by gender, and have not examined the interaction effect between send down and birthweight. Our findings suggest that higher-endowed males receive more wedding transfers because of their send-down experience. The guilt motive is not uniform across family members.

6.2 Employment Status

From the above data section, a simple comparison between send-down and non-send-down twins shows that send-down individuals are more likely to be employed. The interaction between send-down and birthweight could affect males' income through employment. In this subsection, we estimate Equation (2) by using an indicator on employ-

ment as an outcome variable to check this hypothesis. Before presenting the result, noted that in our sample, the proportion of individuals currently employed is 57%, which seems to be lower than expected for our sample of individuals aged from 41 to 56 years.[11] The main reason for this observation is the SOE reform in 1998, which caused a large proportion of state employees to lose their jobs (Giles et al., 2006; Knight and Li, 2006). In our sample, 29% of males and 46% of females were "retired" or "unemployed" in 2002.

To examine whether the change in employment status drives our estimates on income, we estimate Equation (2) by using employment status as the outcome variable (column (4) of Table 5). We present the result for males and females in panel A and B, respectively. We do not find a statistically significant interaction effect of birthweight and send-down on the employment status of males or females. The employment channel does not appear to drive the interaction effect of send-down and birthweight on individual income.

6.3 Party Membership

Previous studies find that the send-down experience of a male increases his likelihood of being a member of the CCP (Li et al., 2010), which promotes one's career in the government or in SOEs, thereby increasing one's income. In column (5) of Table 5, we examine the effect of birthweight and send-down on CCP membership. Consistent with previous studies, we find that the send-down experience increases the likelihood of being a CCP member by 20 pp for a male who has a similar birthweight as his co-twin. This estimate is statistically significant at the 5% level. However, the interaction effect of birthweight and send-down on CCP membership is statistically insignificant for both men and women, thereby suggesting that joining the CCP is not the reason behind the positive interaction effect of send-down and birthweight on male income.

[11] The retirement age is normally 60 years for males and 50 (or 55) years for females.

6.4 Non-cognitive Skills

Adversities can have a long-term impact on individuals' non-cognitive skills (Almond and Mazumder, 2013), which are important factors that influence socioeconomic achievement (Heckman and Rubinstein, 2001). In this subsection, we examine whether the interaction affects the main outcomes through its effect on non-cognitive skills. The CATS data set provides measures on the handling of emotions as proxies for non-cognitive skills. The respondents rate their frequencies of experiencing five types of emotions, namely, sadness, fear, happiness, anger, and repulsion, and then rate, if each of these emotions arises, whether they can "hide it from others" and "control it in an appropriate level of expression." The ratings are measured on four-point scales. We conduct factor analyses to generate factor scores on the frequency of negative emotions and on the degree to which the respondents can hide and control their emotions. The exact survey instruments and factor analyses are described in Section A2 in the Appendix.

We then examine if the interaction effects of birthweight and send-down works via changes in non-cognitive skills, which are more likely affected by post-natal environmental factors than cognitive skills are (Polderman et al., 2015). We do not find any interaction effect of birthweight and send-down on the frequency of feeling negative emotions, the ability to hide emotions from others, or the ability to control emotions at proper levels (columns (6)–(8) of Table 5). Therefore, changes in non-cognitive skills are unlikely to serve as channels through which send-down experience strengthens the stronger male relative to the weaker one. However, we do find that a 10% increase in birthweight increases a male's ability to hide his emotions from others by a 0.16 standard deviation (column (7) in Panel A of Table 5). This effect is statistically significant at the 5% level. The stronger ability of higher-endowed males to hide their emotions may help them go through the adversity of send-down experience and gain an economic advance in the future.

In a related but different study, Wang and Zhou (2017) compare send-down people

with their non-send-down counterparts using China General Social Survey (CGSS); they find that send-down people have worse marriage outcomes and lower levels of happiness than their non-send-down counterparts. Our empirical design differs from that of Wang and Zhou (2017). We find that male send-down twins with higher birthweight are more likely to marry spouses with higher education, and female send-down twins with higher endowment are worse at controlling their emotions.

7 Discussions

7.1 External Validity

Comparisons with representative data

Twins may not be representative of the overall population, especially in terms of birthweight. In this subsection, we discuss the representativeness of twin sample by comparing CATS with other representative data sets. In particular, we compare CATS (2002) with Chinese Families Panel Survey (CFPS, 2010) and Chinese Household Income Project (CHIP, 2002). CFPS is a national representative sample that contains rich information on birthweight and individual social economic outcomes. However, the earliest comprehensive CFPS is conducted in 2010, which does not match the year of CATS (2002). To supplement CFPS, we also compare our twins data with CHIP (2002), which contains rich information on individual social economic outcomes but does not contain information on birthweight or health measures. To facilitate the comparability of CFPS and CHIP to the twins' sample, we apply the same sample selection criteria to CFPS and CHIP as we did to CATS. Specifically, we restrict the CFPS and CHIP sample to the send-down cohort (born between 1946 and 1961) with urban *hukou*.

We present the comparison among CATS (2002), CFPS (2010), and CHIP (2002) in Table A1. The age of the send-down cohort in CHIP is similar to CATS but CFPS is older than CATS because CFPS data is conducted in 2010. The employment rate and monthly

income in CHIP data is higher than CATS, while CFPS sample has a lower employment rate than the other two data sets because most of the send-down cohort retired in 2010 comparing to CATS (2002) and CHIP (2002). The schooling years for the twins' sample is higher than that for the non-twin sample. In addition, the send-down cohort in CFPS is more likely to be overweight. For other measures such as the fraction of people being ever married, we did not find a statistically significant difference across the three samples for other measures, such as the fraction of people being ever married. Note that even if twins differ from the general population in certain observables or unobservables, the within-twin estimator can control for the selection that is common to the twins, in our case the selectivity that is associated with twins from households that are different.

Additionally, the average birthweight in the twins' sample is 2.34 kg, whereas that for the non-twin population in CFPS is 3.06 kg. We also plot the distribution of twins and non-twin birthweight distribution from CATS and CFPS and report them in Figure A1. The distribution of the twin birthweight is shifted leftwards compared with the non-twin birthweight distribution. In particular, the average and median of twin birthweight approximately lie at the 30th percentile of the birthweight distribution of the general population. Thus, the twins' birthweight is more likely to be representative of low birthweight children.

High versus low birthweight population

Motivated by the fact that twins birthweight tend to represent low birthweight population, we examine wehther our results vary nonlinearly across the distrbution of birthweight. Specifically, we check whether our main results differ by the average birthweight of each twin pair. We generate an indicator variable *HighAvgBW* that is equal to one if the average birthweight of the twins is above median (2.35 kilograms), and is equal to zero

otherwise. We estimate Equation (3),

$$\begin{aligned}\Delta Y_j =& \alpha_1 \Delta SD_j \times \Delta 10 lnBW_j + \alpha_2 \Delta SD_j \times \Delta 10 lnBW_j \times HighAvgBW \\ &+ \alpha_3 \Delta 10 lnBW_j + \alpha_4 \Delta 10 lnBW_j \times HighAvgBW + \alpha_5 \Delta SD_j + \Delta \epsilon_j.\end{aligned} \tag{3}$$

The coefficient α_1 captures the differential effects of send-down by a 10% birthweight difference for twin pairs with below-median average birthweight, and $\alpha_1 + \alpha_2$ captures the differential effects of send-down by a 10% birthweight difference for twin pairs with above-median average birthweight. We are also interested in α_2, which indicates whether the effect of $\Delta SD_j \times \Delta 10 lnBW_j$ differs between high and low birthweight population or not. Similarly, α_3 captures the returns to birthweight if the twins have the same send-down experience for the low birthweight twins, and α_4 captures the non-linear effects of birthweight. The term α_5 is the effect of send-down on the outcome variable if the send-down individual has the same birthweight as his/her co-twin.

Table A4 in the appendix shows estimates of Equation (3) for income, education, and health outcomes. Although the inclusion of interaction terms with $HighAvgBW$ inflates the standard errors, the results still deliver interesting patterns. We focus our discussion on the comparison with our baseline results.

For males, the send-down experience still increases the income of the higher-endowed twin, and the interaction effect is larger for twins with above-median average birthweight (columns (1) and (2) in Panel A), but coefficients (α_1 and α_2) are statistically insignificant. Conditional on low average birthweight, the send-down experience reduces the likelihood of being overweight for the higher-endowed twin. However, the interaction effect on being overweight is not carried over to the sample of high average birthweight (column (5) in Panel A).

For females with below-median average birthweight, the send-down experience continues to empower the higher-endowed in terms of more re-schooling, lower likelihood of being overweight, and less chronic diseases than their non-send-down counterpart;

α_1s remain statistically significant at least at the 5% level (columns (3)–(6) in Panel B). We do not detect statistically significant heterogeneous effects of $\Delta SD_j \times \Delta 10 lnBW_j$ by $HighAvgBW$, as the corresponding estimates of α_2s are all statistically insignificant.

We also estimate Equation (3) for the mechanism variables (Table A5 in the appendix). Similar to the results on male income, the estimates of (α_1 and α_2) on male marriage gifts remain positive but they lose statistical significance. More interestingly, the send-down experience empowers the higher-endowed male to marry highly educated females only for twins with above-median average birthweight.

Overall, although some results differ by birthweight level, the general effect of send-down and birthweight does not vary across high average vs low average birthweight twins. This present result is consistent with (Figlio et al., 2014), which shows that the effect of birthweight on test scores does not vary significantly across birthweight distribution.

7.2 Rounding and Heaping in Self-reported Birthweight

The birthweight data collected in CATS is based on individual recall, and exhibits heaping on 0.5 kg levels, as shown in Figure A2. To deal with the problem of heaping, we explore in two directions: (i) we examine whether the likelihood of rounding vary with observed individual characteristics; and (ii) we estimate the underlying true birthweight distribution following the method proposed by Diebold et al. (1997), redo our main analysis using the estimated birthweight data, and find that our results are robust.

Determinants of birthweight rounding

We generate an indicator variable $BWRounding$ that is equal to one if the reported birthweight is a multiple of 0.5, and is equal to zero otherwise. In our sample, 57% of the birthweight are multiples of 0.5, indicating frequent rounding in birthweight reporting. We then examine whether the likelihood to round varies systematically with individual characteristics. Specifically, we regress $BWRounding$ on log birthweight, gender, schooling years, and send-down years.

Table A6 in the Appendix shows the results. We find that male twins are 7.3 pp less likely to report birthweight as a multiple of 0.5, suggesting that male twins are less likely to round birthweight than female twins (column (1)). The estimate is statistically significant at the 10% level. Other variables, including log birthweight, schooling years, and send-down years, do not predict *BWRounding* in OLS or within-twin-FE regressions. Overall, birthweight rounding maybe more problematic for females twins. Within twin pairs, we do not detect systematic rounding behavior by observed individual characteristics.

A correction for rounding and heaping

To deal with the heaping issue, we follow Diebold et al. (1997) to estimate a mixture model for reported birthweight to adjust the rounded and heaped data. In particular, we assume the true birthweight follows a normal distribution with mean μ and standard deviation σ. We assume that people report true birthweight with probability p, or alternatively report a number rounding to the closest multiple of 0.5 with probability 1-p. If the reported birthweight is not a multiple of 0.5, then the reported birthweight is the true birthweight. If the reported birthweight is a multiple of 0.5, then the reported birthweight may represent a rounded birthweight.

With these assumptions, we uncover the data generating process for the reported (heaped) birthweight data and link it to the true birthweight. We apply the minimum distance method to estimate parameters μ, σ, and p. Specifically, we divide the values of reported birthweight into N cells, and then find the parameter values that minimize the following objective:

$$\sum_{n=1}^{N} (O_n - E_n)^2 / E_n$$

where O_n is the actual number of observations in cell n, and E_n is the expected number of observations given by the parameterized data generating process in cell n. We use

seven cells: 1.1-1.5, 1.6–2, 2.1–2.5, 2.6-3, 3.1–3.5, 3.6-4, 4 and above. The estimated values for μ, σ, and p are 2.3, 0.6, and 0.55 respectively. In particular, the estimated value of $p = 0.55$ suggests that among the 57% of individuals whose reported birthweight are multiples of 0.5 kg, about 21% ((55 - 43)/57) report birthweight truly, and the rest 79% report to a rounded number.

Using the estimated parameters and specified data generating process, we adjust our heaped birthweight data, and create a new estimated birthweight variable. Figure A2 in the Appendix shows the kernel densities of the reported birthweight (solid blue line) and the estimated birthweight (dashed red line). Heaps at multiples of 0.5 largely disappear in the estimated birthweight. We then replicate our main results (Tables 4 and 5 in the main text of the revised manuscript) using the estimated birthweight to replace the reported birthweight. We find qualitatively similar results (Table A7 and Table A8 in the Appendix). In sum, although rounding in birthweight is salient, the presence of rounding and heaping does not drive our results.

7.3 Send-down Years

Determinants of send-down years

In this section, we explore variations in send-down years. The send-down years vary across individuals due to geographical policy variations and timing of send-down. Figure A3 shows the distribution of send-down years from the CATS data set for the send-down cohorts. Most of the youths were sent down for two or three years. People sent down earlier stayed longer in the countryside. Figure A4 plots the average send-down years by the starting year of one's send-down experience. People sent down in 1968 stayed in the countryside for more than five years on average. The average send-down years decline by the send-down starting year, and fell to less than two years for people sent down in 1977. The pattern is consistent with the official ending of the movement in 1980, which mainly reflects cross-cohort differences in send-down years.

Because twins are born in the same year, conditional on both twins being sent down, 83.7% of twin pairs were sent down in the same year. The send-down starting year does not drive the within-twin differences in send-down years. Despite that, the within-twin variation in send-down year is substantial. Approximately half of our sample twin pairs have different send-down years. Conditional on a non-zero difference of send-down years within twins, 48.5% of twin pairs have one or two years difference in send-down years, and 51.5% of twin pairs have three or more years difference. Within-twin differences in send-down years partly result from the different years in which twins returned to cities. Conditional on both twins being sent down, 54.5% of twin pairs returned to cities in the same year, which is much lower than the 83.7% of twin pairs sent down in the same year. Early return may reflect parental favoritism towards one child over the other (Li et al., 2010).

We also examine the selection of send-down years by regressing send-down years on birthweight, gender, and average schooling years of parents (Table A9). Using the within-twin fixed-effect model (columns (4)–(6)), we do not observe statistically significant correlations between birthweight and send-down years. Although birthweight does not predict send-down years, we can not rule out the possibility that unobservable parental preferences or other factors may determine within-twin differences in send-down years.

Robustness using send-down years

With selection considerations in mind, we go forward to estimate Equation (2) by replacing the send-down dummy with send-down years. The results are shown in Tables A10 and A11. For males, the interaction of send-down years and birthweight has a positive effect on income (columns (1) and (2) in Panel A of Table A10). The coefficient on the interaction term indicates that, for a male who is 10% heavier at birth than his co-twin, one more year of send-down increases his income by approximately 5% relative to that of his co-twin. The estimates are statistically significant at the 5% level. For female twins, we do not detect a statistically significant interaction effect of birthweight and send-down on

their income (columns (1) and (2) in Panel B).

In terms of re-schooling, for a female who is 10% heavier at birth than her co-twin, one more year of send-down increases her likelihood of re-schooling by 2.5 pp and increases her re-schooling years by 0.1 years relative to her twin sister (columns (3) and (4) in Panel B). One more year of send-down also reduces the heavier-at-birth female's likelihood of overweight by 2.7 pp and her likelihood of having chronic diseases by 3.6 pp (columns (5) and (6) in Panel B). By contrast, send-down years and birthweight have no statistically significant effect on the re-schooling behavior and health outcomes of males (columns (3)–(6) in Panel A).

For parents' wedding transfer, the son with one more year of send-down is offered by his parents a 5% higher bride price if he is 10% heavier at birth than his co-twin (column (1) in Panel A of Table A11). This interaction effect is statistically significant at the 5% level. When we use $ln(1 + Gift)$ to incorporate the extensive margin of the parents' transfers to their children, the son with one more year of send-down is given a 20% higher bride price if he is 10% heavier at birth than his co-twin (column (2) in Panel A). A higher bride price for a male is also associated with a better-educated wife. For a male who is 10% heavier at birth than his co-twin, one more year of send-down increases his wife's schooling year by 0.2 (column (3) in Panel A). By contrast, for females, the interaction effects on transfers or spousal schooling years are statistically insignificant (columns (1)–(3) in Panel B). Similar to our main regression results, the interaction term only has minor effects on the other outcome variables. Overall, the results obtained by using send-down years are consistent with our main results.

Non-linear effects of send-down years

The rich variations in send-down years allow us to examine the non-linear effects of send-down years. As previously mentioned, half of the twins with difference years of sent-down experience have one- or two-year difference, and half have three-year difference or higher. We generate an indicator variable that is equal to one if the twin pairs have three

or more years difference in send-down years and is equal to zero otherwise. We estimate Equation (4) and present the results in Table A9 in the appendix.

$$\begin{aligned}\Delta Y_j =& \theta_1 \Delta SDY_j \times \Delta 10 lnBW_j + \theta_2 \mathbf{I}[|\Delta SDY| \geq 3] \times \Delta SDY_j \times \Delta 10 lnBW_j \\ &+ \theta_3 \Delta SDY_j + \theta_4 \mathbf{I}[|\Delta SDY| \geq 3] \times \Delta SDY_j + \theta_5 \Delta 10 lnBW_j + \Delta \epsilon_j.\end{aligned} \tag{4}$$

For males, the send-down experience has a positive effect on the income of higher-endowed twins. This effect does not differ for twins who were sent down longer (column (1) and (2) in Panel A). The estimates of θ_1 and θ_2 for income variables are statistically insignificant. For males who have a short send-down duration, the send-down experience reduces the likelihood of higher-endowed twins to be overweight. However, this positive health return disappears in cases of long send-down duration (column (5) in Panel A).

For females, in general, the interaction effects of send-down and birthweight do not differ substantially across short or long send-down duration. If there is any significant difference, the positive send-down response in re-schooling for the higher-endowed female is weaker in the case of long send-down duration (column 4 of Panel B). We also present the heterogeneity analysis of send-down duration for the mechanism variables (Table A10). Overall, the interaction effects between send-down and birthweight are present in the case of both short and long send-down duration. Moreover, the resilience to send-down of higher-endowed people turns out to be weaker in the case of long send-down duration.

8 Conclusion

We study how endowment changes individual resilience to an adolescent adversity. By using a sample of Chinese twins, we explore the exogenous variations in birthweight and send-down experience to identify the interaction effects of these two variables on

individual outcomes. We find that the send-down experience strengthens the heavier-at-birth individual in terms of income, education, and health.

We also find that the interaction effect is gender-specific. For brothers with a 10% difference in birthweight, if the higher-endowed male is sent down, then he earns approximately 12% more than his co-twin. The interaction effect of send-down and birthweight on male income can be explained by parental reinforcement behavior. If the higher-endowed male is sent down, he receives 16%–45% more wedding gifts from his parents and marries a woman who has 0.66 more years of schooling.

For females, we find interaction effects on education and health. For sisters with a 10% difference in birthweight, if the higher-endowed female is sent down, she is 8 pp more likely to upgrade her education after the send-down movement, 9.8 pp less likely to be overweight, and 9.8 pp less likely to have chronic diseases.

Our findings also have important implications on prenatal programs, if we generalize the findings based on within-twin differences in birthweight to birthweight variations across the population. To enhance individual resilience to adversities, public policies should target improving individual birth endowment, e.g., via prenatal supplements. The neonatal stock of health human capital substantially enhances individual resilience to an adversity in adolescence.

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Figure

Figure 1: Proportion of the send-down population by birth cohort

Note: This figure shows the proportion of the urban population sent down to the countryside for different birth cohorts. The dotted vertical lines indicate the cohorts born between 1946 and 1961 who were affected by the send-down campaign. The black line uses data from the China Adult Twins Survey (CATS), in which only individuals born between 1946 and 1961 report their send-down experience. The dashed line uses data from the urban population in the 2010 China Family Panel Studies (CFPS).

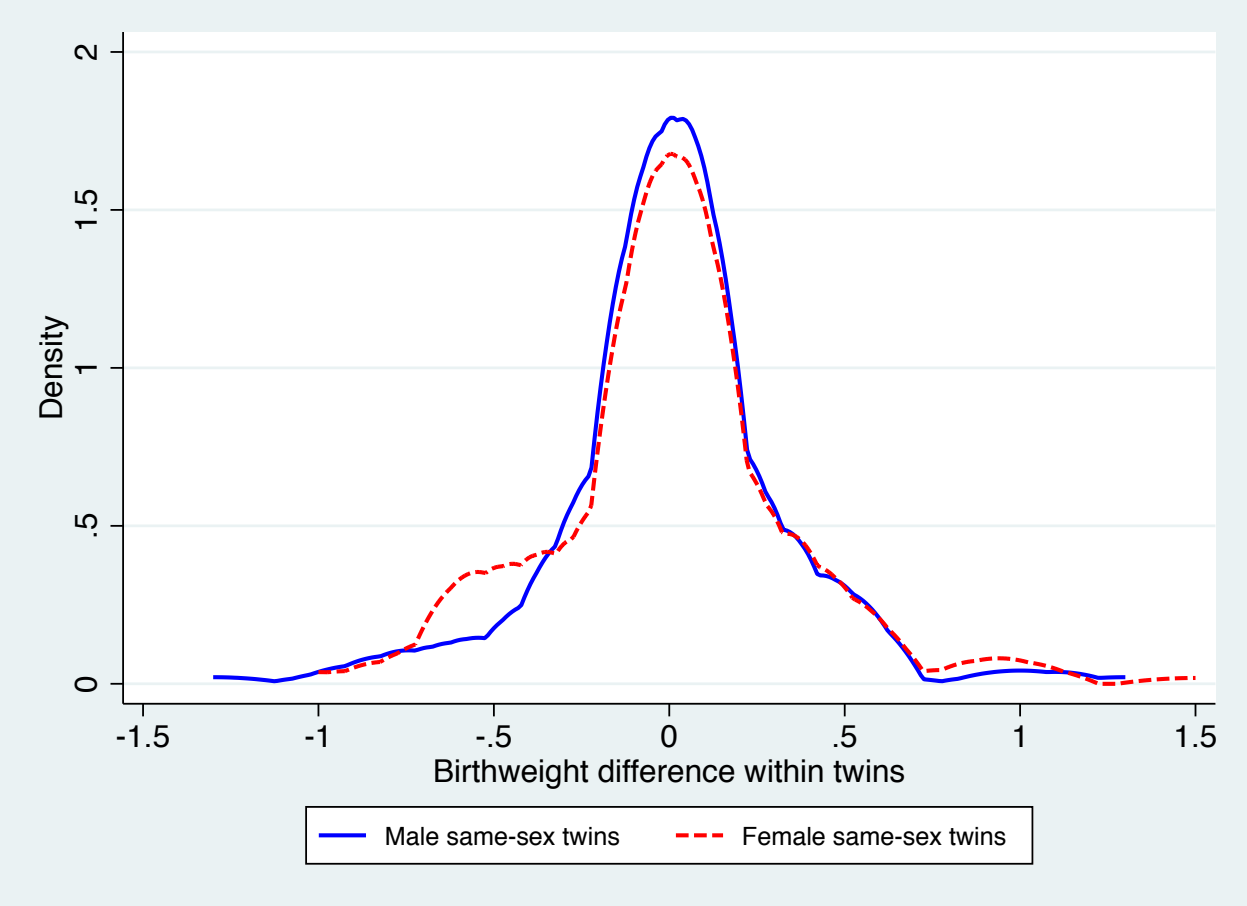

Figure 2: The distribution of birthweight differences within twins

Note: This figure shows the kernel density estimates of the distribution of birthweight differences. The blue line marks the birthweight distribution for 160 pairs of male same-sex twins, and the red dashed line marks the birthweight distribution for 181 pairs of female same-sex twins. For male (female) same-sex twins, the average birthweight difference is 0.0088 (0.0039) kilograms, with a standard deviation of 0.32 (0.35) kilograms. The average of the absolute value of the within-twin birthweight difference is 0.20 (0.23) kilograms for male (female) same-sex twins.

Tables

Table 1: Summary statistics

	Full sample	Both sent down	One sent down		Neither sent down
			Sent down	Not sent down	
	(1)	(2)	(3)	(4)	(5)
Demograhics					
Age	46.91	47.94	46.45	46.45	46.20
	(3.86)	(3.19)	(3.01)	(3.01)	(4.83)
Male	0.47	0.53	0.42	0.42	0.45
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Birth weight (*k.g.*)	2.34	2.30	2.43	2.42	2.32
	(0.60)	(0.55)	(0.66)	(0.66)	(0.58)
Ever married (dummy)	0.99	0.99	0.98	0.98	1.00
	(0.10)	(0.09)	(0.14)	(0.14)	(0.07)
Income and Employment					
Monthly income (¥ in year 2002)	788.81	808.34	866.73	785.55	735.77
	(589.45)	(554.71)	(558.90)	(655.92)	(606.73)
Employment (dummy)	0.57	0.55	0.67	0.59	0.52
	(0.50)	(0.50)	(0.47)	(0.49)	(0.50)
Education					
Total schooling years	10.70	10.54	11.08	11.04	10.55
	(2.48)	(2.39)	(2.27)	(2.02)	(2.79)
Schooling interruption years	1.68	1.73	2.45	1.51	1.35
	(4.42)	(4.43)	(5.59)	(3.85)	(4.04)
Re-schooling indicator (dummy)	0.18	0.21	0.23	0.19	0.14
	(0.39)	(0.40)	(0.42)	(0.39)	(0.35)
Re-schooling years	0.64	0.74	0.81	0.61	0.48
	(1.59)	(1.79)	(1.74)	(1.39)	(1.33)
Health					
BMI ($k.g./m^2$)	22.79	23.21	22.50	22.40	22.65
	(3.05)	(3.44)	(2.81)	(2.61)	(2.84)
Overweight (dummy)	0.20	0.24	0.18	0.15	0.18
	(0.40)	(0.43)	(0.38)	(0.36)	(0.38)
Chronic disease (dummy)	0.57	0.59	0.55	0.55	0.55
	(0.50)	(0.49)	(0.50)	(0.50)	(0.50)
Number of individuals	682	248	101	101	232

Note: This table presents the summary statistics for the monozygotic twins in the send-down cohort (age 41–56 years in 2002). Column (1) shows the variable means for the full sample, column (2) for twins in the family where both twins are sent down, columns (3) and (4) for the family where only one of the twins is sent down, and column (5) for the family where neither of the twins is sent down. Standard deviations are enclosed in parentheses.

Table 2: Determinants of send-down status

	OLS estimates			Within-twin FE		
Sample	Full	Male	Female	Full	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)
Birthweight (log scale)	0.014	-0.709	0.674*	0.719	-0.042	1.280
	(0.311)	(0.460)	(0.408)	(0.703)	(0.893)	(1.057)
Male	0.085					
	(0.193)					
Average schooling years	0.051	0.049	0.051			
of parents	(0.049)	(0.064)	(0.076)			
Number of individuals	682	320	362	682	320	362
R-squared	0.005	0.012	0.011	0.002	0.000	0.008

Note: The dependent variable is an indicator variable that equals 1 if the twin was sent down, and 0 otherwise. The first three columns show the OLS estimates, while the last three columns show the within-twin FE estimates. Columns (1) and (4) show the results for the full sample, columns (2) and (5) for the male sample, and columns (3) and (6) for the female sample. Standard errors are enclosed in parentheses and are clustered at the twin-pair level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 3: Income, re-schooling, and health

Dependent variable	ln(Income)	IHS(Income)	Re-schooling indicator	Re-schooling years	Overweight	Chronic disease
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta SD \times \Delta 10 lnBW$	0.018	-0.028	0.045*	0.153**	-0.074***	-0.040
	(0.029)	(0.145)	(0.023)	(0.069)	(0.028)	(0.040)
ΔSD	0.132	0.418	0.040	0.199	0.030	0.000
	(0.083)	(0.267)	(0.044)	(0.149)	(0.046)	(0.062)
$\Delta 10 lnBW$	0.031	-0.028	-0.004	0.014	0.016	0.006
	(0.027)	(0.086)	(0.017)	(0.047)	(0.019)	(0.022)
Number of twin pairs	291	334	341	341	340	341
R-squared	0.013	0.009	0.011	0.012	0.028	0.004

Note: This table presents the estimates of Equation (2) on income, re-schooling, and health outcomes. The dependent variables in columns (1) to (6) are the within-twin differences in logarithm of income, inverse hyperbolic sine transformation of income, an indicator variable of whether the individual has any re-schooling, re-schooling years, an indicator variable of obesity, and an indicator variable of whether the individual has any chronic diseases. Robust standard errors are enclosed in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 4: Income, re-schooling, and health by gender

Dependent variable	ln(Income)	IHS(Income)	Re-schooling indicator	Re-schooling years	Overweight	Chronic disease
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A. Male same-sex twins					
$\Delta SD \times \Delta 10 lnBW$	0.115***	0.124**	-0.002	0.011	-0.023	0.038
	(0.038)	(0.054)	(0.017)	(0.045)	(0.059)	(0.061)
ΔSD	0.032	0.215	-0.047	-0.039	0.097	0.105
	(0.125)	(0.325)	(0.034)	(0.168)	(0.083)	(0.099)
$\Delta 10 lnBW$	-0.045	-0.055	-0.002	0.002	-0.009	0.005
	(0.040)	(0.056)	(0.032)	(0.079)	(0.038)	(0.035)
Number of twin pairs	138	156	160	160	160	160
R-squared	0.019	0.005	0.004	0.000	0.017	0.010
	Panel B. Female same-sex twins					
$\Delta SD \times \Delta 10 lnBW$	-0.019	-0.161	0.077**	0.262**	-0.098***	-0.098**
	(0.043)	(0.267)	(0.034)	(0.112)	(0.025)	(0.049)
ΔSD	0.240**	0.610	0.092	0.334	-0.008	-0.055
	(0.107)	(0.389)	(0.070)	(0.224)	(0.052)	(0.080)
$\Delta 10 lnBW$	0.080**	-0.043	0.003	0.050	0.025	-0.007
	(0.039)	(0.155)	(0.018)	(0.064)	(0.020)	(0.030)
Number of twin pairs	153	178	181	181	180	181
R-squared	0.059	0.018	0.038	0.034	0.063	0.026

Note: This table presents the estimates of Equation (2) on income, re-schooling, and health outcomes. Panels A and B report the results for the male and female samples, respectively. The dependent variables in columns (1) to (6) are the within-twin differences in logarithm of income, inverse hyperbolic sine transformation of income, an indicator variable of whether the individual has any re-schooling, re-schooling years, an indicator variable of obesity, and an indicator variable of whether the individual has any chronic diseases. Robust standard errors are enclosed in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 5: Marriage, employment, Party membership, and emotions

Dependent variable	ln(Gift)	IHS(Gift)	Spousal schooling years	Employment	Party membership	Negative emotion	Hide emotion	Control emotion
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Panel A. Male same-sex twins							
$\Delta SD \times \Delta 10 lnBW$	0.149**	0.377*	0.551**	-0.025	-0.049	0.019	-0.008	-0.108
	(0.068)	(0.194)	(0.279)	(0.039)	(0.047)	(0.057)	(0.116)	(0.072)
ΔSD	0.040	0.770	0.878*	0.094	0.203**	-0.069	-0.075	-0.114
	(0.145)	(0.489)	(0.503)	(0.083)	(0.088)	(0.126)	(0.159)	(0.192)
$\Delta 10 lnBW$	-0.068*	-0.109	-0.164	-0.062*	-0.002	-0.058	0.156**	0.082
	(0.041)	(0.133)	(0.145)	(0.032)	(0.023)	(0.035)	(0.061)	(0.083)
Number of twin pairs	93	149	155	160	155	160	152	150
R-squared	0.037	0.019	0.055	0.037	0.045	0.012	0.039	0.013
	Panel B. Female same-sex twins							
$\Delta SD \times \Delta 10 lnBW$	0.100	0.091	-0.114	-0.014	0.023	-0.047	0.081	-0.110*
	(0.137)	(0.383)	(0.199)	(0.055)	(0.044)	(0.093)	(0.083)	(0.064)
ΔSD	-0.348*	-0.471	0.537	0.065	0.048	0.139	-0.112	0.137
	(0.180)	(0.601)	(0.429)	(0.081)	(0.075)	(0.125)	(0.127)	(0.143)
$\Delta 10 lnBW$	0.123	-0.061	0.127	0.053*	-0.002	-0.047	-0.058	-0.018
	(0.091)	(0.181)	(0.187)	(0.028)	(0.021)	(0.046)	(0.054)	(0.045)
Number of twin pairs	89	170	181	181	177	177	166	167
R-squared	0.070	0.006	0.014	0.030	0.006	0.014	0.021	0.016

Note: This table presents the estimates of Equation (2) on marital outcomes, employment, Chinese Communist Party (CCP) membership, and non-cognitive skills. Panels A and B report the results for the male and female samples, respectively. The dependent variables in columns (1) to (8) are the within-twin differences in logarithm of parents' wedding gift, inverse hyperbolic sine transformation of parents' wedding gift, and spousal schooling years indicator variable of employment status, an indicator variable of CCP membership, frequency of feeling negative emotions, ability to hide emotions, and ability to control emotions. Robust standard errors are enclosed in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$