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ABSTRACT

The Quantity-Quality Tradeoff of Children in a Developing Country: Identification Using Chinese Twins*

Testing the tradeoff between child quantity and quality within a family is complicated by the endogeneity of family size. Using data from the Chinese Population Census, this paper examines the effect of family size on child educational attainment in China. We find a negative correlation between family size and child outcome, even after we control for the birth order effect. We then instrument family size by the exogenous variation that is induced by a twin birth, and find a negative effect of family size on children's education. We also find that the effect of family size is more evident in rural China, where the public education system is poor. Given that our estimates of the effect of twinning on non-twins at least provide the lower bound of the true effect of family size (Rosenzweig and Zhang, 2006), these findings suggest a quantity-quality tradeoff of children in developing countries.

JEL Classification: J13, J18, J24, O10

Keywords: quantity-quality tradeoff, twins, China

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1. Introduction

The relationship between family size and child outcome has fascinated social scientists for decades, particularly since the emergence of the theory of the quantity-quality model that was developed by Gary Becker and his associates (Becker, 1960; Becker and Lewis, 1973; Willis, 1973; Becker and Tomes, 1976).[1] According to this model, an increasing marginal cost of quality (child outcome) with respect to quantity (number of children) leads to a tradeoff between quantity and quality. Numerous empirical studies have attempted to test the quantity-quality tradeoff, and have either confirmed the prediction by observing a negative correlation between family size and child quality or found no such correlation (Blake, 1981; Knodel et al., 1990; Knodel and Wongsith, 1991; Sudha, 1997; Ahn et al., 1998).[2] However, most studies simply treat family size as an exogenous variable, and thus cannot establish causality. Both child quantity and quality are endogenous variables, because childbearing and child outcome are jointly chosen by parents (Browning, 1992; Haveman and Wolfe, 1995), which means that they are both affected by unobservable parental preferences and household characteristics.

One important method for tackling endogeneity is to use the exogenous variations in family size that are caused by the natural occurrence of twins to isolate the causal effect

[1] Many aspects of household behavior have been considered to be associated with family size. For example, researchers have thoroughly documented evidence for the relationship between fertility and parental labor supply (Rosenzweig and Wolpin, 1980b; Angrist and Evans, 1998), maternal economic outcome (Bronars and Grogger, 1994), stability of marriage (Koo and Janowitz, 1983; Jacobsen et al., 2001), and children's attainments (King, 1987; Haveman and Wolfe, 1995).

[2] Also see King (1987) and Blake (1989) for a survey of early studies. Education and health are usually used as measures of child quality in the literature.

of family size on child quality.[3] A pioneer study using twins as a means of identification is that of Rosenzweig and Wolpin (1980a), who find that family size (as induced by the birth of twins) has a negative effect on children's education attainment in a small sample (25 twins in approximately 1,600 children) from India. However, a recent study by Black et al. (2005) that also uses twins as the exogenous variation but with a large sample of the entire population of Norway finds that the effect of family size is reduced to almost zero after controlling for birth order, and that there is a monotonic decline of educational attainment by birth order.[4] These new findings suggest that the omission of the birth order effect may lead to biased estimates of the effect of family size on child quality. Another recent study by Angrist et al. (2005) that uses both twin births and gender composition as the instrumental variables finds no evidence for a quantity-quality tradeoff of children in Israel.

The studies of Black et al. (2005) and Angrist et al. (2005) raise a provocative question: Is there a quantity-quality tradeoff as formulated by Becker? These new studies have made many improvements on the earlier study of Rosenzweig and Wolpin (1980a), in particular in terms of data quality and empirical specifications, and thus their evidence should be more robust. However, in addition to a larger sample size and improved model

[3] In addition to twins, some researchers also employ the gender of the first child (Lee, 2004) or the gender composition of the first two children (Conley, 2004a; Angrist et al., 2005) as the instrument for family size. The former instrument is based on the prevailing preference for sons that is observed in Asian countries, and the idea behind the latter instrument is that parents of same-gender siblings are more likely to go on to have an additional child (Angrist and Evans, 1998).

[4] Sociologists and psychologists have documented the effect of birth order on child outcomes. See, for example, the summary of the findings by King (1987) and Conley (2004b). Several earlier empirical studies were conducted by economists. For example, Hauser and Sewell (1985) find no significant effect of birth order, Behrman and Taubman (1986) show that children born later tend to have a disadvantage in education, and Hanushek (1992) reports a U-shaped pattern of education by birth order for large families.

specification, another important difference between the new studies and that of Rosenzweig and Wolpin is that the latter draws on data from a developing country, whereas the former use data from developed countries. In a rich country with a comprehensive welfare system such as Norway, where there is both a good public education system (even college is free) and generous government support for childbearing and childcare, the cost of children, and in particular the educational expenditure, accounts for just a small proportion of the budget of parents. Thus, the quantity-quality tradeoff may not be obvious in these countries. In contrast, in a developing country such as India, where there is neither a well-functioning public education system nor generous support for childbearing and childcare, the cost of child quality is mostly borne by the parents. Thus, the quantity-quality tradeoff is more likely to occur in a developing country.[5] Therefore, it is important to use good data from developing countries to verify whether the findings of Black et al. (2005) can be replicated.

In this paper, we test the quantity-quality tradeoff by mainly using the 1% sample of the 1990 Chinese Population Census. China has a poorly functioning education system, especially in rural areas, where poverty is the main reason that forces children to drop out of primary and high school (Brown and Park, 2002). Using education level and school enrollment as measures for child quality, we find a negative correlation between family size and child quality under various specifications, even after controlling for the birth order effect. The negative effect of family size on child education is identified by two-

[5] There is also some evidence from developing countries in studies of epidemiology and public health, although the methods of these studies are usually different from those of economists. See, for example, the survey by Karmaus and Botezan (2002).

stage least squares (2SLS) estimations using twin births as the instrument variable (IV) for family size. Our findings strongly support the prediction of Becker and his associates on the quantity-quality tradeoff of children, but differ from those of Black et al. (2005).

Using twin births as IV is not without caveats. Twining may affect sibling outcome through mechanisms other than family size, such as the reallocation of family resources from twins toward non-twin children and closer spacing between twins (Rosenzweig and Zhang, 2006). Thus, twinning is not a perfect IV. However, given that the reinforcing intra-family resource allocation (that is, parents invest more in non-twin children who have greater endowments) and the potential correlation between sibling outcome and closer spacing between twins may both bias the 2SLS estimates toward zero, our finding of a negative effect of family size implies that the true effect should be more negative after removing the bias, thus supporting the quantity-quality theory.

We are among the first to draw on twins data from a developing country to test the theory of the quantity-quality tradeoff of children. Given that the quantity-quality tradeoff is expected to be more pronounced in developing countries, it is surprising that few previous studies have drawn on twins data from developing countries, although this is probably due to difficulty in obtaining data. We are also among the first to explicitly examine the tradeoff in the context of China. Most of the previous related studies explore the determinants of Chinese children's educational attainment, and emphasize the rural-urban gap (Knight and Li, 1993, 1996; Hannum, 1999; Connelly and Zheng, 2003), gender inequality (Broaded and Liu, 1996; Hannum, 2002, 2003; Tsui and Rich, 2002), or poverty and credit constraints (Brown and Park, 2002). However, these studies either ignore the effect of family size or merely treat it as an exogenous control variable. To the best of our knowledge, the only exception is a working paper by Qian (2005), who attempts to use China's birth control policy as an identification to test the quantity-quality tradeoff.[6]

Knowing the true effect of family size on child quality has important policy implications for developing countries, and in particular for China. Our findings suggest that the birth control policy in China has a potential positive effect in increasing the quality of children. If, as we have found, a smaller family size is generally associated with a better average education outcome for children, then the one-child (or two-child) policy has improved child quality by reducing the number of children in a household. In particular, we find that the tradeoff between quantity and quality is more pronounced in rural areas, where the least well-off people live. This implies that the birth control policy, if it is as effective as expected by policy-makers, is more fruitful in enhancing the quality of rural children and ultimately economic growth (Li and Zhang, 2007).

The rest of the paper is structured as follows. Section 2 specifies our empirical strategy. Section 3 describes our sample. Section 4 presents our estimates of the effect of family size on children's educational outcomes, and Section 5 concludes.

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[6]Qian (2005) uses the triple interaction of the sex of the first child, the birth cohort of that child and local policy relaxation (sex*cohort*policy relaxation) as an IV, and finds that there is no quantity-quality tradeoff. Two things are worth mentioning. First, this triple interaction could be endogenous, because it reflects the sex preference of parents. Families with sex preference are more likely to have selected the sex of their firstborn after the one-child policy was implemented (before the one-child policy, they could have had more children in the hope of having a boy), i.e., the sex*cohort interaction within a locality is likely to pick up the sex preference. Moreover, localities with strong sex preference are more likely to relax the one-child policy, i.e., policy relaxation would be a result of sex*cohort. Second, Qian uses a sample of children aged 9-28. Many of the older children of the households may have left home (and thus not been tracked in the census), and the sex of the first child may not have been observed for many households. Thus, the "first child" would be the oldest staying child, which cannot be random in China. However, Qian also uses twins as an IV in some specifications, and finds a quantity-quality tradeoff, which is similar to our finding.

2. Empirical Method

We follow the recent empirical literature and specify our general estimation as follows,

$$EDU = \beta_0 + \beta_1 SIZE + X\beta_2 + Z\beta_3 + \varepsilon, \tag{1}$$

where EDU is the educational attainment of the child as measured by the two educational outcome variables of education level and school enrollment. The variable SIZE is the number of children in the family, and the coefficient β_1 is what interests us. X is a vector of child characteristics including age, gender, ethnic group, birth order, and place of residence, and Z stands for a set of parental attributes, including their age and education level. We also run separate regressions for the rural and urban samples to allow the effect of family size to interact with residence areas.

The coefficient β_1 as estimated by the ordinary least squares (OLS) method may merely suggest a correlation, rather than a causal effect, because family size is likely to be endogenous. Following Rosenzweig and Wolpin (1980a) and Black et al. (2005), we use the birth of twins as an identifying instrument for family size. The first stage of the two-stage least squares (2SLS) estimation is given by

$$SIZE = \alpha_0 + \alpha_1 TWIN + X\alpha_2 + Z\alpha_3 + \upsilon, \tag{2}$$

and equation (1) becomes the second stage. In (2), TWIN is a dummy variable that equals 1 if the *n*th delivery is a multiple delivery and 0 otherwise, and all of the other variables are the same as specified in (1).

As noted by Rosenzweig and Wolpin (2000), the presence of any twin birth in a family makes for an inappropriate instrument, because its probability increases with the number of deliveries. To avoid this problem in estimating the 2SLS models, we restrict the sample to families with at least *n* births so that we can be fairly confident that the families with twins at the *n*th delivery have the same preference for number of children as those with singleton births. If the occurrence of multiple births is randomly assigned by nature, then twin births should have little or no effect on children's education except through family size. Thus, the 2SLS estimate of β_1 would consistently measure the causal effect of family size on child quality. We will further discuss the validity of twins instrument in Section 4.1.

3. Data

We mainly use the 1% sample of the 1990 Chinese Population Census that was collected by the Chinese National Bureau of Statistics (formerly the State Statistic Bureau). It is the fourth of its kind, following the three censuses that were conducted in 1953, 1964, and 1982.[7] The 1% sample covers 11,475,104 individuals from 2,832,103 households. The dataset contains a record for each household, and includes variables that describe the location, type, and composition of the households. Each household record is followed by a record for each individual residing in the household. The individual variables include demographic characteristics, occupation, industry, education level, ethnicity, marital status, and fertility.

[7] The two earlier censuses are not available to researchers. The 1982 census is less useful for our purposes due to the lack of school enrollment information and explicit rural identifiers, although we perform some sensitivity analysis using the 1982 sample. The latest census, which was conducted in 2000, will be available soon.

We use the relation identifier to match children to their parents within the households. Specifically, we identify individuals who are labeled “child” as the primary observation, and obtain the family size by counting the number of children in the household. We then attach the data of the parents, that is, those who are labeled “household head” or “spouse,” to all of the children in the household. For each mother, we also have data on the total number of children born and the number of children still alive, which helps us to identify whether the family size is complete.

To facilitate our analysis, we use a sub-sample of the census data. First, we only use children of the household head, because we can only match the parental information and count the number of children of a couple for such children. Second, we drop households with no children or with a family size that exceeds the total number of surviving children, the latter of which is likely to be the result of data error.[8] Third, we restrict the sample to children who were between 6 and 17 years old and whose mothers were aged no more than 35 in the census year. We use 6 as the lower bound for the age of children because it is the minimum age of school enrollment in China, and no education information was recorded for children younger than 6 in the census. Restricting the mother’s age to less than or equal to 35 makes it fairly certain that no adult children have moved out of a household. We impose such a restriction because we are unable to track children who had already left the household by the time of the survey.[9] Finally, we exclude some

[8] This discrepancy may arise as a result of adopted children, but there is no information in the data to distinguish between adoption and birth.

[9] With this restriction, only about one percent of the households have children that live outside of the household. We also conduct regressions using a sample excluding these families and obtain the same results.

households with missing information on fathers,[10] and a small number of families with a birth that occurred before the mother was 16.

With these restrictions, we are left with a sample of 675,492 children from 447,159 households. As the census does not include an explicit twins identifier, we define children who were reported to be born in the same year and month to the same woman as twins. One percent of our sample comprises twin births. The first two columns of Table 1 report the summary statistics for the whole sample and the sample excluding twins. No significant differences can be observed between the two columns, as the statistics remain almost the same for each variable.

It is worthwhile to first outline the institutional background of non-tertiary education in China before we offer the definitions of the education variables. In 1986, the Law of Compulsory Education officially declared the implementation of nine compulsory years of schooling (six years of primary school and three years of junior high school) throughout China. However, the policy of compulsory education was not implemented uniformly across the country. The "Resolution on Educational System Reform," which was initiated in 1985, devolved the total responsibility of implementing compulsory education to local governments, and thus the provision of basic education depends on the local budget or level of economic development (He, 1996). As a result, access to education in rural areas is much worse than in urban areas, because rural citizens and governments are much poorer. In the poor rural areas, public schools are not widely available, and even in regions where the schooling system is publicly provided to all children, it is not totally free and parents still need to pay tuition and fees. Such a

[10] Data on fathers were missing for 7 percent of all cases. In addition to dropping these observations, we also perform the estimations by creating categories of missing father variables, and the results are the same.

financial burden is one of the main reasons why poor families, who are often unable to borrow funds to finance their children's education, pull their children out of school (Brown and Park, 2002).

In this paper, we employ two education variables that are reported in the census: education level and school enrollment. Education level is defined as an ordered discrete variable that indicates three education levels: illiterate, primary school, and junior high school and above.[11] School enrollment is defined as a binary indicator that equals one if a child was enrolled in school or had graduated, and zero if a child had dropped out of school or never enrolled. Previous research has shown that school enrollment is a good indicator of educational attainment in developing countries (Glewwe and Jacoby, 1995; Alderman, et al., 2001; Glewwe et al., 2001). Table 1 shows that the average enrollment rate is 70 percent for the full sample, and that children at the three education levels account for 28, 69, and 3 percent, respectively. For children who were at least 8 years old, the enrollment rate rises to 91 percent and the education level also improves.

An important aspect of the data is that there is a large rural-urban difference in both education and fertility. In columns 3 and 4 of Table 1, we report the attributes of the rural and urban subsamples separately. Of all of the children, 88 percent were from rural areas. Note that although there is no rural-urban difference for the education variables for the whole sample of children, there is a large difference among children of 8 years and over. The reason for the lack of difference in the whole sample is that rural children went to

[11] The census codes the education level into seven categories: Illiterate, Primary School, Junior High School, Senior High School, Technical School, Junior College, and University. As the proportion of respondents with an education level of senior high school or above is very small in the sample (less than 0.01 percent), we classify all of these observations into the third level of junior high school and above. Having more categories for education levels does not change our results.

school earlier. In urban areas, the enrollment age was normally seven or eight for the generation of children in our sample, and that age requirement has been strictly enforced. However, children in rural areas were able to go to school as early as 6. Note also that the fertility of rural families is much higher than that of urban families, with the rural-urban gap in the number of children being as large as one. Over four fifths of the rural households had more than one child in comparison to only one fifth of the urban households.[12] These rural-urban differences make it important to analyze the rural and urban subsamples separately.

To gain a picture of how education may vary with family size, we present in Table 2 children's education level by family size for both the rural and urban subsamples. To control for the age effect, we report the proportion among young children (aged 13 or below) who have at least primary school education and the proportion among older children (aged over 13) who have at least junior high school education. Several aspects are worth noting. First of all, there is a clear pattern that a greater family size is associated with lower average education. Although only children aged below 13 appear to have a lower education than children in two-child families, there is a monotonically decreasing trend for family sizes of two to six and above. Moreover, the advantage of two-child families over single-child families disappears for children who are older than 13. Second, on average, urban children seem to have a higher education level than rural children. Except for young children in the only-child group, urban children are better in

[12] Although the one-child policy had been in force for ten years by the time of the census in 1990, there is empirical evidence that the policy was more effective in deterring second births in urban areas than in rural areas (Zhang and Spencer, 1992; Ahn, 1994).

education regardless of family size and gender. Finally, male children consistently have better education than female children in the rural sample, but the gender-based difference is less explicit in the urban sample.

4. The Effect of Family Size on Children's Education

In this section, we run OLS and 2SLS regressions to systematically test whether family size has a negative effect on children's educational attainment in China. We first discuss several issues regarding the validity of twins IV. Then we use twins at the *n*th delivery (*n*=1, 2, 3) to instrument family size and perform estimations as specified by equations (1) and (2). We also examine whether the effect of family size is different in rural versus urban areas, and check the heterogeneity of the effect under other sample stratifications as well. For all of the estimations, we control for a full set of child and parent attributes that comprises the cubic form of child age, gender, indicator of being *Han* Chinese, birth order, parents' age and education level, and rural (if applicable) and provincial dummies. Due to space constraint, the estimates for these control variables are not reported.

4.1. Twins Instrument

Unobserved Family Preferences

Before reporting the estimation results, we first discuss the validity of using twin births as our IV. A good instrument should be highly correlated with the number of children in a family, but should not affect the child outcome except through family size. That is to say, a valid IV should not be correlated with unobserved parental and household characteristics that are captured by the error term in equation (1). The birth of twins is an important source of exogenous variation in fertility that has been used in previous research (Rosenzweig and Wolpin, 2000), and is believed to be unlikely to depend on family background.[13] Although the correlation between twin births and unobserved household attributes is untestable by design, we follow Black et al. (2005) and examine whether the occurrence of twins is associated with certain observed characteristics, such as the education level of parents. Similar to their findings, the *F*-tests based on linear probability models suggest that the probability of having a twin birth is uncorrelated with the education level of either mothers or fathers in our sample.

Birth Spacing

Another concern is that a twin birth may affect child outcome through birth spacing. There are two possible ways that twin births may affect sibling outcome via spacing. In both cases, the 2SLS estimates of the effect of family size could be biased. First, if the space between the two following siblings has a significant effect on the quality of previous children, then the birth of twins may influence the outcome of early children by effectively reducing the space toward zero. In other words, twin births may affect the quality of prior children through both increased family size and narrowed spacing, which are inherently undistinguishable.

[13] The existence of sex-selective abortion in China might undermine the validity of twinning instrument as the access to ultrasound use and abortion services allows parents to "choose" which birth to give. This became a more serious issue after China implemented the one-child policy since 1979. However, our analysis using the 1982 census data suggests that this does not seem to be a big concern. See more discussion on the one-child policy in Section 4.4.

To address this possibility, we follow Black et al. (2005) and use samples of families without twins to check whether child education is correlated with the age gap (spacing) between the two immediately following siblings. Specifically, we examine the first children in families with at least three births, and first and second children in families with at least four births. As shown in Table A1, almost all of the OLS coefficients on spacing appear to be significantly negative, which means that a child is better educated if the following births have a smaller spacing.[14] If this can be arguably extended to the case of twins, then twinning should improve sibling outcome since the spacing between twins is zero, and thus the spacing effect of twining should bias our estimate of the quantity-quality tradeoff toward small or no negative effect. Given this potential bias, if we still find a large negative effect of family size, we can be fairly certain that there exists a quantity-quality tradeoff.

A second way that a twin birth can affect child quality through spacing is that the probability of twins increases with maternal age at birth (Bronars and Grogger, 1994). Thus, a mother is more likely to give a twin birth if that birth is farther in space from the previous birth, conditional on her age at the previous birth. If such kind of spacing similarly affects the outcome of prior children, then a twin birth will be (negatively) correlated with sibling outcome beyond the channel through family size, leading to a negative bias in the 2SLS estimates of the family size effect.

[14] One explanation for this result is that parents tend to give more equal treatment to children having closer spacing. More equal treatment would make increasing their average quality more expensive and drive parents to move more resources away (from children in the following births) to older siblings, hence increasing the siblings' quality. Rosenzweig and Zhang (2006) use this logic to argue for the intra-family resource re-allocation from twins to non-twin siblings, as shown below.

However, this potential bias can be tackled by including the spacing between the potential twin birth and the previous birth as a control in our estimation. In practice, when we use twins at the *n*th delivery to instrument family size, we add a spacing variable that measures the age difference between the *n*th and (*n*-1)th deliveries.[15] Unless there is a serious bias, the estimates will not be much changed by the additional control. As we will show later in this section, controlling for spacing immediately prior to the potential twin birth has very little effect on our estimates.

Inter-Child Reallocation

Finally we discuss the concern that twin births may directly affect child quality by changing the intra-family resource allocation. This point, raised by Rosenzweig and Zhang (2006), argues that for parents who reinforce endowment differences across children (that is, invest more in children with greater endowments), twinning will result in the allocation of resources toward non-twin siblings because 1) per-child investments in twins are more costly compared with non-twins due to closer-spacing; and 2) twins tend to have inferior birth endowments compared with non-twin siblings, such as lower birth weight (Behrman and Rosenzweig, 2004). Moreover, consistent with the findings of Behrman et al. (1994), Rosenzweig and Zhang (2006) find some empirical evidence of the reinforcing behavior of parents, using a sample of Chinese twins.

Therefore, without taking account of such a reinforcing effect on non-twins, which is a positive bias, the negative effect of increased family size on the average child outcome will be underestimated (i.e. biased toward zero) if researchers only look at the impact of

[15] Implicitly, this is equivalent to controlling for mother's age at the *nth delivery* since we already include children and their mother's age in the regression.

twin births on non-twin children. As Rosenzweig and Zhang put it, the estimates of the effects of twinning on twins and non-twin siblings bound the true quantity-quality tradeoff for an average child, with the latter estimates always giving the lower bound, which may be zero or even positive as found in some recent studies. Although controlling for birthweight may help tighten up the range of the upper and lower bounds, the census data that we use do not contain such information. However, to the extent that our estimates can be interpreted as the lower bound of the effect of family size, if we still find negative estimates, the true effect should be more negative and thus the findings would support the quantity-quality theory. The important point is that since we know the direction of possible bias in the IV estimate (i.e. biased toward zero), the IV bias is not a problem for us in inferring the direction of the quantity-quality tradeoff if our IV estimate is negative. On the other hand, if we find a positive IV estimate, we would be unable to draw any conclusions on the tradeoff.

4.2. OLS and 2SLS Estimations

Table 3 presents the OLS and 2SLS estimates of the effect of family size on children's education for the full 1990 sample, along with the first-stage relationship between family size and twins at the *n*th delivery.[16] The results with education level as the dependent variable are reported in the first three columns, and the results with school enrollment as the dependent variable are reported in the last three columns. From top to bottom, we list in three panels the estimates for families with at least *n* births in

[16] The *t*-statistics that are reported here, as in all of the regressions in this paper, allow for the correlation of errors for any two children in the same family.

increasing order of *n* from 1 to 3. For *n*=2 or 3, we examine children of all parities and children prior to parity *n* respectively.

Similar to the pattern we observe in Table 2, the OLS estimates in columns 1 and 4 consistently show a significantly negative correlation between family size and children's education, regardless of the dependent variable and sample used. For example, the OLS coefficient in the top panel (column 4) suggests that, everything else being constant, having one more child in the family reduces a child's probability of enrollment by approximately 3 percentage points.

Using twin births as IV, the 2SLS estimates in columns 3 and 6 continue to suggest a negative effect of family size on child outcome except for the middle panel of families with 2 or more births, and the results are qualitatively the same for both education outcomes. In particular, the 2SLS coefficients on family size are significant at the one percent level for families with 1 or more births (top panel), and significant at the ten percent level for those with 3 or more births (bottom panel). Note that given previous discussions, our 2SLS estimates may be subject to positive biases induced by not taking into account the closer space between twins or resource allocation from twins to non-twin siblings. Hence, that our negative estimates understate the true effect of family size indeed implies the existence of a quantity-quality tradeoff. Moreover, as shown here, controlling for the space between parity *n* and parity *n*-1 only marginally changes the estimates, suggesting that the bias from omitting this variable is negligible. Finally it is worth noting that the first-stage relationship is very significant for all of the specifications, with *t*-ratios of well above 40. Consistent with the previous literature, the effect of a twin birth on family size increases with a higher parity, which ranges from 0.6 to 0.9 in our sample.

Although not reported, the control variables have the expected signs. In general, male or *Han* children have an educational advantage over female or minority children, and rural children tend to have inferior education outcomes compared with urban peers. We also add a vector of birth order indicators to examine whether the effect of family size is partially driven by birth order. In fact, the addition of birth order controls has very little effect on both the OLS and 2SLS coefficients on family size. This result is in stark contrast to that of Black et al. (2005), who find that the effect of family size becomes trivial once the birth order effect is controlled. We also find little evidence of a monotonic decline of child quality by birth order, as distinct from Black et al. (2005). Rather, although the coefficients on second child have a negative sign in Table 3, we find that the coefficients on higher birth orders are positive in some cases, which indicates that children who are born later in large families are more likely to have an advantage over children who are born earlier (conditional on family size).

4.3. Effects in Rural and Urban Areas

As discussed in Section 3, there is a considerable rural-urban gap in access to and completion of schooling in China. This gap is the result of both supply- and demand-side factors. On the supply side, the average school quality is much better in urban China than in rural China. While urban public schools receive substantial subsidies from local governments, many rural schools are badly funded, and thus short of well-trained teachers. The lack of government funding compels many rural schools to become selffinanced, which forces many rural children out of school because their parents cannot afford to pay the school fees (Brown and Park, 2002). On the demand side, rural parents may have lower educational aspirations for their children than urban parents. This is probably due to the lower return and higher opportunity cost of sending children to school for rural families, because rural children can contribute to the household income by carrying out farm and house work even at a very young age.[17]

Because of the rural-urban education gap, we expect the effect of family size on child quality to be different in rural and urban areas. Given that public education is more prevalent and children's education held to be more important in urban China, having an additional child in the family may result in a smaller adverse impact on the average child education compared to the effect in a rural family. In this sense, the rural-urban difference within China to some extent resembles the difference between China and Norway. To allow for disparity in the effect of family size between rural and urban areas, we present in Table 4 the results of the same regressions as in Table 3 using the rural and urban subsamples respectively. We skip reporting the estimates for enrollment as they are very similar to those for education level.

Interestingly, the OLS estimates show that the effect of family size is smaller in urban areas than in rural areas. As in column 1, the estimates for the rural sample are very close to those for the full sample. In contrast, the OLS coefficients on family size for the urban sample, as listed in column 4, are smaller in magnitude, and some even are not statistically different from zero. It is also worth noting that ethnic- and gender-based differences are less explicit among urban children (not shown). Although there is a clear

[17] See Becker (1991), Johnson (1994), Dasgupta (1995), and Ray (1998) for arguments on the benefits of children in developing countries.

educational advantage for male or *Han* children in rural areas, the evidence from urban children shows an insignificant ethnic effect and even a negative male effect.[18]

Not surprisingly, the quantity-quality tradeoff appears to only exist for rural families, as suggested by the 2SLS estimates in columns 3. As with the full sample estimates, we find an effect of family size significant at the one percent level for n=1 case and an effect significant at the ten percent level for n=3 case in the rural sample, although the estimates for first and second children in the latter case turn marginally insignificant. Nevertheless, for the urban sample (column 6), none of the 2SLS estimates is statistically different from zero at the ten percent level, which implies the absence of quantity-quality tradeoff in urban families. Note that as our estimates are potentially upward biased, the zero effects for urban families are still likely to be consistent with the quantity-quality tradeoff, and the consistency is more evident for the rural sample for which the negative effects are detected.

So far, we find that family size is negatively correlated with children's educational attainment in China, both when we measure education by discrete levels and by the probability of being enrolled in school. The negative effect is not sensitive to the inclusion of controls for birth order and spacing. By examining the rural and urban subsamples separately, we find that the adverse impact of family size is smaller in urban China. We also observe some evidence of a negative second-child order effect, but do not identify a significant negative effect of higher birth orders in large families.

[18] The absence of an educational advantage for boys in urban China has also been observed in recent literature (for example, Tsui and Rich, 2002; Connelly and Zheng, 2003).

4.4 The One-Child Policy

One concern about the previous rural-urban differences in the effect of family size on child outcome is to what extent such disparities can be attributed to the variation in birth control policy between rural and urban China. China introduced its unique one-child policy in 1979. Under this policy, each couple is allowed to have only one child.[19] Households are given birth quotas, and they are penalized for “above-quota births.” Parents with above-quota children are forced to pay for each additional birth and may be subject to other punishment or criticism. In contrast, parents who comply with the one-child policy receive cash subsidies from the government, and their children can also receive free health care such as immunizations.

However, the local implementations of this policy demonstrate great heterogeneity, especially between rural and urban areas. In general, the penalties for above-quota births are much more severe in the urban areas than the rural areas (Banister, 1987). Urban citizens who violate the policy have to pay fines that are proportional to their monthly salaries, sometimes as high as 70 percent. They are demoted or rendered illegible for promotion forever if they work in state-owned enterprises or institutions, which were the major urban employers in the 1980s. As a contrast, the only severe punishment in rural areas is a one-shot payment for above-quota births. Even the payment itself may not be very effective in rural areas because many poor farmers cannot afford to pay it (Li and Zhang, 2004). Because of the difficulty in implementations and the potential for social

[19] This policy only applied to the *Han* Chinese during most of the 1980s; minorities were normally allowed to have two children. In some regions such as Xinjiang and Tibet, minorities can even have more than two children.

unrest, in some rural areas and in certain years the policy has been relaxed to allow people to have second children if the first is female (Qian, 1997; Chow, 2002).

Given that the one-child policy has been enforced more strictly in urban China, one may argue that parents who have above-quota children are inherently different from those who comply with the birth control policy and thus have fewer children. This may alternatively explain why the quantity-quality tradeoff is not observed in our urban sample. For example, richer families that are able and willing to pay fines to have additional children can invest more per child anyway. Likewise, parents do not choose to have fewer children because they want to trade quantity for quality but because they are not allowed to have more.

To address this problem, we have attempted to control for family preferences to some extent by restricting the sample to families with at least *n* births in previous estimations. In another check, we redo the analysis using the 1982 census data. Since all the sampled children (aged 6 and above) in 1982 were born before 1979, the impact of the one-child policy, if any, should be minimal. Table 5 replicates the regressions in Table 4 using the rural and urban subsamples from the 1982 census.[20] Although the OLS coefficients on family size are closer between the two subsamples, again, none of the 2SLS estimates for the urban sample is significantly different from zero. However, for the rural families, the 2SLS estimates in the middle (n=2) and bottom (n=3) panels show some evidence of a

[20] As the 1982 census does not include an explicit rural identifier, we use the occupation code to define rural children as those whose parents were engaged in a broad range of agricultural business. Although this categorization may understate the rural population (77 percent in 1982 compared with 88 percent in 1990), it is the best approximation we can make. To see whether this would lead to a severe problem, we reestimate the 1990 sample using occupation-based rural identifier, and our results are not significantly changed.

negative effect of family size on children’s education level. The results in Table 5 suggest that, even in absence of a (potentially) large effect of birth control policy, we are still unable to find a quantity- quality tradeoff in the urban sample. This implies that our results in Section 4.3 are not largely driven by the birth control policy.

4.5. The Heterogeneous Effects of Family Size

In the final part of this section, we test the sensitivity of our estimates to more stratification of the sample. Specifically, we estimate the effect of family size by child gender and by mother’s education, respectively. As the effect has been shown to differ between rural and urban areas, we skip the estimations for the full sample and perform the sensitivity test only for the rural and urban samples. The upper and lower panels in Table 6 separately report the OLS and 2SLS coefficients on family size for rural and urban samples.

In the first two columns we break the samples down by gender to see whether the effect of family size differs between boys and girls. Although the OLS estimates show that the effect of family size is more negative for girls than for boys, the picture from the 2SLS estimates is not as clear. The effect appears to be more pronounced for rural girls when we use the IV of twins at the first delivery, but becomes larger for rural boys in families with at least three births. Despite the mixed results for the 2SLS estimations for the rural sample, we continue to identify a rural-urban gap that is independent of gender, namely, a smaller effect of family size in urban areas.

In the last three columns we stratify our sample by mother’s education level. As household income is not observed in our sample, we use mother's education as a control for financial constraints. If better educated mothers are less financially constrained, then we should see a smaller effect of family size on the educational outcomes of their children. We break mother's education in the rural sample into the three groups of illiterate, primary school, and all the other levels above primary school. As urban women are generally better educated than rural women, to avoid a group with too few observations we break the urban sample down into the categories of below junior high school (illiterate and primary school), junior high school, and above junior high school.

To some extent, the results by educational group are consistent with our expectations. With the OLS estimates, the effect of family size decreases in magnitude with the level of the mother's education for both rural and urban children, although a few OLS coefficients for the urban sample are not statistically significant. However, the evidence is less explicit when we look at the 2SLS estimates. Again, for the rural sample the variation in effects across educational groups depends on the IV (and the sample) that we use. For the urban sample, we do not detect a tangible effect of family size for any subgroup, as all of the 2SLS estimates are statistically insignificant.

5. Conclusions

In this paper, we test the theory of quantity-quality tradeoff of children using a representative census dataset from China. We find evidence that family size is negatively correlated with children's education. The negative effect of family size is robust to various specifications, including those that control for parental characteristics and birth order effect. We then instrument family size with twin births to explore the causal link between family size and child education, and find supportive evidence. We further find that the effect of quantity on quality is not uniform between rural and urban areas. More precisely, the tradeoff relationship is more evident in rural China, but the effect diminishes or even vanishes for urban China. We also find that the effect differs according to the gender of the child and the mother's education level. Given that our estimates are probably upward biased toward zero due to the direct effects of twin births on child outcome through mechanisms other than family size, our results provide the lower bound of the negative effect and suggest a quantity-quality tradeoff indeed.

Overall, our findings evidently support the prediction of Becker (1960) and Becker and Lewis (1973) of the quantity-quality tradeoff of children, but differ from those of Black et al. (2005). The most important difference between our study and that of Black et al. (2005) is that they draw on data from Norway, which is a developed country, whereas we draw on data from China, which is a developing country. In a rich country with a comprehensive welfare system such as Norway, where there is both a good public education system and generous government support for childbearing and childcare, the quantity-quality tradeoff may not be obvious. However, in a developing country such as China, where there is neither a good public education system nor generous support for childbearing and childcare, the cost of child quality is mostly borne by the parents. Thus, the quantity-quality tradeoff is more likely to happen in the Chinese case.

Although this study has its limitations, it is among the first to explicitly measure the effect of family size on child outcome in China. Previous empirical tests are often limited by a small sample size or by the fact that they do not take into account the endogeneity of family size, both of which are tackled in this paper. Given that public education is insufficiently funded in many areas of China, our findings suggest a plausible determinant of children's education in China that has not been well explored in the literature. Nonetheless, due to the data limitations, we are unable to examine more aspects of child quality (such as health and labor market outcomes), and are thus ill inclined to generalize our results to a broader extent. Future work may rely on more comprehensive and traceable household data that give researchers information on the completed education of children even if they have left the family.

This paper may shed some light on other issues in China, such as the one-child policy. Since its inception in the late 1970s, China's one-child policy has been controversial, and has drawn attention from politicians, the mass media, and academics alike. Although there is still no consensus on many of the positive or negative aspects of this forced birth control policy, a recent study by Li and Zhang (2007) does show that the population reduction as a result of the dramatic population control policy has indeed helped the growth of the Chinese economy since the late 1970s. This study indicates that a possible effect may be that children are of better quality under the policy, because the size of their family would have been larger had the policy not existed. However, to better understand the long-term effect on child outcome in adulthood, more work is badly needed in this area.

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Table 1: Descriptive Statistics of the 1% Sample of the 1990 Population Census

	Full sample		By area	
Variables	Including twins (1)	Excluding twins (2)	Rural (3)	Urban (4)
Observations of children	675,492	665,738	595,729	79,763
Age	8.71 (2.39)	8.72 (2.39)	8.78 (2.42)	8.27 (2.08)
Male	0.52 (0.50)	0.52 (0.50)	0.52 (0.50)	0.52 (0.50)
Han	0.91 (0.28)	0.91 (0.28)	0.91 (0.29)	0.93 (0.26)
Rural	0.88 (0.32)	0.88 (0.32)	-	-
Education (aged 6 and above)				
Enrolled	0.70 (0.46)	0.71 (0.46)	0.71 (0.46)	0.70 (0.46)
Illiterate	0.28 (0.45)	0.28 (0.45)	0.28 (0.45)	0.30 (0.46)
Primary school	0.69 (0.46)	0.69 (0.46)	0.69 (0.46)	0.67 (0.47)
Junior high school and above	0.03 (0.15)	0.03 (0.15)	0.03 (0.15)	0.03 (0.17)
Education (aged 8 and above)				
Enrolled	0.91 (0.28)	0.91 (0.28)	0.91 (0.29)	0.97 (0.16)
Illiterate	0.07 (0.43)	0.07 (0.26)	0.08 (0.27)	0.03 (0.16)
Primary school	0.89 (0.31)	0.89 (0.31)	0.89 (0.31)	0.92 (0.27)
Junior high school and above	0.04 (0.19)	0.04 (0.19)	0.03 (0.18)	0.05 (0.22)
Observations of families	447,159	442,423	376,680	70,479
Number of children	2.10 (0.90)	2.09 (0.89)	2.26 (0.87)	1.27 (0.57)
Having 2 and more children	0.74 (0.43)	0.75 (0.43)	0.85 (0.36)	0.23 (0.42)
Having 3 and more children	0.27 (0.45)	0.27 (0.45)	0.32 (0.47)	0.04 (0.19)
Having a multiple birth	0.01 (0.10)	-	0.01 (0.10)	0.01 (0.09)
Mother's age	31.6 (2.8)	31.6 (2.8)	31.5 (2.9)	32.5 (2.2)
Father's age	34.2 (3.8)	34.2 (3.8)	34.1 (3.9)	34.8 (3.2)

Note: Standard deviations are shown in parentheses. All sampled children were aged at least 6 in 1990, with non-missing information on both mothers and fathers. Mother's age is restricted to be no more than 35 at the census year.

Table 2: Descriptive Statistics of Education Level by Family Size: 1990 Census

	Family size					
	1-child	2-child	3-child	4-child	5-child	6+child
Full sample	116,766	296,082	183,606	59,846	15,046	4,146
	Primary school and above (age<=13)					
All	0.68	0.73	0.68	0.64	0.61	0.57
Male	0.69	0.73	0.69	0.66	0.63	0.59
Female	0.64	0.72	0.66	0.63	0.60	0.56
	Junior high school and above (age>13)					
All	0.52	0.42	0.33	0.24	0.17	0.17
Male	0.51	0.43	0.36	0.28	0.22	0.21
Female	0.54	0.40	0.29	0.21	0.14	0.15
Rural sample	61,784	277,474	179,236	58,579	14,639	4,017
	Primary school and above (age<=13)					
All	0.70	0.73	0.67	0.64	0.61	0.57
Male	0.72	0.73	0.69	0.66	0.63	0.59
Female	0.64	0.72	0.66	0.62	0.60	0.56
	Junior high school and above (age>13)					
All	0.42	0.37	0.31	0.22	0.16	0.15
Male	0.43	0.39	0.35	0.27	0.21	0.19
Female	0.40	0.34	0.27	0.19	0.13	0.13
Urban sample	54,982	18,608	4,370	1,267	407	129
	Primary school and above (age<=13)					
All	0.65	0.78	0.77	0.72	0.67	0.59
Male	0.65	0.78	0.76	0.72	0.66	0.65
Female	0.65	0.77	0.77	0.72	0.67	0.55
	Junior high school and above (age>13)					
All	0.78	0.78	0.71	0.73	0.59	0.56
Male	0.75	0.76	0.68	0.73	0.54	0.56
Female	0.83	0.80	0.73	0.73	0.63	0.56

Note: All sampled children were aged at least 6 in 1990, with non-missing information on both mothers and fathers. Mother's age is restricted to be no more than 35 at the census year.

Table 3: OLS and 2SLS Estimates of the Effect of Family Size on Children's Education Outcomes: 1990 Census

	Dependent variable					
	Education level (1=illiterate, 2=primary school, 3=junior high school or above)			Whether or not enrolled in school (1=yes, 0=no)		
	OLS	First stage	2SLS	OLS	First stage	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
IV: twin at 1st delivery	Sample: all non-twin children (N=672,207)					
Number of children	-0.028*** (-42.59)	0.555*** (42.38)	-0.040*** (-2.83)	-0.027*** (-43.42)	0.555*** (42.38)	-0.030** (-2.19)
IV: twin at 2nd delivery						
	Sample A: non-twin children in families with 2 or more births (N=553,438)					
Number of children	-0.038*** (-48.07)	0.696*** (57.62)	-0.011 (-1.11)	-0.036*** (-47.27)	0.696*** (57.62)	-0.009 (-0.94)
	Sample B: 1st child in families with 2 or more births (N=327,363)					
Number of children	-0.031*** (-29.58)	0.780*** (56.55)	0.002 (0.18)	-0.027*** (-28.64)	0.780*** (56.55)	0.002 (0.21)
Number of children (control for spacing)	-0.033*** (-31.09)	0.833*** (61.84)	0.002 (0.27)	-0.028*** (-29.44)	0.833*** (61.84)	0.002 (0.19)
IV: twin at 3rd delivery						
	Sample A: non-twin children in families with 3 or more births (N=256,487)					
Number of children	-0.044*** (-29.19)	0.821*** (51.25)	-0.027* (-1.95)	-0.040*** (-27.94)	0.821*** (51.25)	-0.025* (-1.87)
	Sample B: 1st and 2nd children in families with 3 or more births (N=204,901)					
Number of children	-0.038*** (-21.42)	0.857*** (51.75)	-0.024* (-1.70)	-0.032*** (-19.85)	0.857*** (51.75)	-0.025* (-1.82)
Second child	-0.029*** (-16.26)		-0.031*** (-11.15)	-0.021*** (-12.55)		-0.022*** (-8.42)
Number of children (control for spacing)	-0.040*** (-22.35)	0.884*** (54.29)	-0.023* (-1.65)	-0.035*** (-21.05)	0.884*** (54.29)	-0.023* (-1.73)
Second child (control for spacing)	-0.027*** (-15.16)		-0.030*** (-10.14)	-0.019*** (-11.31)		-0.021*** (-7.49)

Note: *, **, and *** represent significance levels of 10, 5, and 1 percent. Robust t-statistics, which allow for correlation of errors within family, are shown in parentheses. All regressions include age, age squared, and age cubed, indicators for male and *Han*, parents' age and age squared, parents' education level, and rural and provincial dummies. N represents the number of observations.

Table 4: OLS and 2SLS Estimates of the Effect of Family Size on Children's Education Level: 1990 Census (Rural vs. Urban)

	Dependent variable: education level (1=illiterate, 2=primary school, 3=junior high school or above)					
	Rural			Urban		
	OLS	First stage	2SLS	OLS	First stage	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
IV: twin at 1st delivery	Sample: all non-twin children					
		N=593,186			N=79,021	
Number of children	-0.030*** (-43.69)	0.505*** (33.61)	-0.042** (-2.46)	-0.003 (-1.37)	0.785*** (37.81)	-0.024 (-1.13)
IV: twin at 2nd delivery						
	Sample A: non-twin children in families with 2 or more births					
		N=529,511			N=23,927	
Number of children	-0.038*** (-47.22)	0.689*** (54.93)	-0.013 (-1.21)	-0.022 (-4.96)	0.849*** (21.04)	-0.008 (-0.25)
	Sample B: 1st child in families with 2 or more births					
		N=312,378			N=14,985	
Number of children	-0.030*** (-27.91)	0.771*** (53.64)	0.000 (0.04)	-0.027*** (-4.16)	0.922*** (22.52)	0.007 (0.23)
Number of children (control for spacing)	-0.031*** (-29.27)	0.826*** (58.85)	0.001 (0.11)	-0.026*** (-3.93)	0.947*** (23.52)	0.006 (0.18)
IV: twin at 3rd delivery						
	Sample A: non-twin children in families with 3 or more births					
		N=250,646			N=5,841	
Number of children	-0.044*** (-29.06)	0.824*** (50.51)	-0.026* (-1.85)	-0.023** (-2.31)	0.680*** (7.89)	-0.050 (-0.50)
	Sample B: 1st and 2nd children in families with 3 or more births					
		N=200,538			N=4,403	
Number of children	-0.038*** (-21.38)	0.856*** (50.81)	-0.021 (-1.49)	-0.012*** (-0.93)	0.803*** (8.88)	-0.049 (-0.55)
Second child	-0.030*** (-16.78)		-0.032*** (-11.70)	0.004 (0.39)		0.009 (0.58)
Number of children (control for spacing)	-0.040*** (-22.26)	0.885*** (53.38)	-0.020 (-1.44)	-0.012*** (-0.96)	0.790*** (8.95)	-0.049 (-0.56)
Second child (control for spacing)	-0.028*** (-15.73)		-0.032*** (-10.71)	0.005 (0.42)		0.011 (0.59)

Note: *, **, and *** represent significance levels of 10, 5, and 1 percent. Robust t-statistics, which allow for correlation of errors within family, are shown in parentheses. All regressions include age, age squared, and age cubed, indicators for male and *Han*, parents’ age and age squared, parents’ education level, and provincial dummies. N represents the number of observations.

Table 5: OLS and 2SLS Estimates of the Effect of Family Size on Children's Education Level: 1982 Census (Rural vs. Urban)

	Dependent variable: education level (1=illiterate, 2=primary school, 3=junior high school or above)					
	Rural			Urban		
	OLS	First stage	2SLS	OLS	First stage	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
IV: twin at 1st delivery	Sample: all non-twin children					
		N=530,596			N=158,976	
Number of children	-0.040*** (-52.29)	0.348*** (17.26)	-0.024 (-0.70)	-0.033*** (-25.29)	0.369*** (11.61)	0.014 (0.29)
IV: twin at 2nd delivery						
	Sample A: non-twin children in families with 2 or more births					
		N=521,180			N=151,276	
Number of children	-0.042*** (-53.20)	0.567*** (29.51)	-0.062*** (-3.10)	-0.038*** (-27.25)	0.610*** (20.74)	-0.032 (-1.17)
	Sample B: 1st child in families with 2 or more births					
		N=249,495			N=75,735	
Number of children	-0.037*** (-29.78)	0.630*** (24.56)	-0.024 (-1.05)	-0.039*** (-17.17)	0.723*** (19.46)	-0.010 (-0.34)
Number of children (control for spacing)	-0.052*** (-40.47)	0.681*** (28.00)	-0.014 (-0.69)	-0.049*** (-20.78)	0.773*** (21.52)	-0.004 (-0.12)
IV: twin at 3rd delivery						
	Sample A: non-twin children in families with 3 or more births					
		N=403,746			N=92,828	
Number of children	-0.049*** (-44.63)	0.689*** (38.80)	-0.036** (-2.07)	-0.050*** (-21.31)	0.924*** (31.04)	0.007 (0.32)
	Sample B: 1st and 2nd children in families with 3 or more births					
		N=301,237			N=68,285	
Number of children	-0.049*** (-34.30)	0.742*** (40.17)	-0.028 (-1.59)	-0.055*** (-18.09)	0.906*** (28.03)	0.020 (0.76)
Second child	-0.028*** (-16.24)		-0.035*** (-5.67)	-0.022*** (-6.49)		-0.040*** (-5.48)
Number of children (control for spacing)	-0.057*** (-38.82)	0.785*** (44.05)	-0.023 (-1.38)	-0.060*** (-19.30)	0.922*** (29.39)	0.020 (0.78)
Second child (control for spacing)	-0.024*** (-13.86)		-0.036*** (-5.92)	-0.019*** (-5.68)		-0.040*** (-5.28)

Note: *, **, and *** represent significance levels of 10, 5, and 1 percent. Robust t-statistics, which allow for correlation of errors within family, are shown in parentheses. All regressions include age, age squared, and age cubed, indicators for male and *Han*, parents' age and age squared, parents' education level, and provincial dummies. N represents the number of observations.

Table 6: OLS and 2SLS Estimates of the Effect of Family Size on Children's Educational Level by Gender and Mother's Education: 1990 Census (Rural vs. Urban)

		Dependent variable: education level (1=illiterate, 2=primary school, 3=junior high school or above)				
		Gender		Mother's education		
		Male (1)	Female (2)	Low (3)	Median (4)	High (5)
		Rural Sample				
Twin at 1st delivery	OLS	-0.024***	-0.035***	-0.051***	-0.021***	-0.016***
		(-26.39)	(-37.86)	(-38.10)	(-22.88)	(-11.96)
	2SLS	-0.022	-0.061***	0.021	-0.018	-0.141***
		(-0.93)	(-2.79)	(0.64)	(-0.73)	(-4.24)
Twin at 2nd delivery	OLS	-0.033***	-0.041***	-0.057***	-0.026***	-0.024***
		(-29.36)	(-39.54)	(-38.36)	(-24.20)	(-14.21)
	2SLS	-0.025*	-0.001	-0.028	-0.009	-0.004
		(-1.87)	(-0.09)	(-1.04)	(-0.63)	(-0.24)
Twin at 3rd delivery	OLS	-0.038***	-0.046***	-0.061***	-0.029***	-0.024***
		(-17.08)	(-25.19)	(-23.57)	(-14.63)	(-6.81)
	2SLS	-0.045**	-0.013	-0.061**	-0.011	-0.006
		(-2.24)	(-0.74)	(-2.09)	(-0.55)	(-0.26)
		Urban Sample				
Twin at 1st delivery	OLS	0.000	-0.006**	-0.017***	-0.001	0.013***
		(0.05)	(-2.08)	(-4.05)	(-0.19)	(2.88)
	2SLS	-0.019	-0.027	-0.078	-0.038	0.007
		(-0.67)	(-1.02)	(-0.98)	(-1.08)	(0.28)
Twin at 2nd delivery	OLS	-0.018***	-0.026***	-0.026***	-0.019***	-0.009
		(-2.82)	(-4.65)	(-3.86)	(-2.79)	(-0.79)
	2SLS	0.021	-0.026	-0.040	0.036	0.020
		(0.45)	(-0.69)	(-0.77)	(0.61)	(0.39)
Twin at 3rd delivery	OLS	-0.022	-0.026**	-0.024*	-0.018	-0.020
		(-1.57)	(-2.22)	(-1.74)	(-1.18)	(-0.73)
	2SLS	-0.061	-0.034	-0.118	0.060	-0.164
		(-0.50)	(-0.25)	(-0.68)	(0.38)	(-0.81)

Note: *, **, and *** represent significance levels of 10, 5, and 1 percent. Robust t-statistics, which allow for correlation of errors within family, are shown in parentheses. All regressions include age, age squared, and age cubed, indicators for male and *Han*, parents' age and age squared, parents' education level, and provincial dummies. The low, median, and high levels of mother's education refer to illiterate, primary school, and above primary school for the rural sample, and below junior high school, junior high school, and above junior high school for the urban sample.

Appendix

Table A1: OLS Estimates of the Effect of Family Size and Birth Spacing on Children's Education Level: 1982 and 1990 Censuses

	Dependent variable: education level (1=illiterate, 2=primary school, 3=junior high school or above)					
	1982			1990		
	Full	Rural	Urban	Full	Rural	Urban
	(1)	(2)	(3)	(4)	(5)	(6)
	Sample: 1st child in non-twin families with 3 or more births					
Observations	202,295	165,819	36,476	120,291	117,885	2,406
Number of children	-0.058***	-0.054***	-0.066***	-0.043***	-0.042***	-0.029*
	(-31.99)	(-26.96)	(-15.01)	(-18.49)	(-18.21)	(-1.70)
Age gap (year) between the 2 following births	-0.010***	-0.011***	-0.007***	-0.004***	-0.004***	0.001
	(-13.62)	(-13.05)	(-4.31)	(-4.65)	(-4.45)	(0.26)
	Sample: 1st and 2nd children in non-twin families with 4 or more births					
Observations	143,930	122,602	21,328	51,977	50,916	1,061
Number of children	-0.061***	-0.057***	-0.071***	-0.038***	-0.037***	-0.076**
	(-21.86)	(-19.19)	(-9.49)	(-8.60)	(-8.38)	(-2.44)
Age gap (year) between the 2 following births	-0.015***	-0.015***	-0.011***	-0.008***	-0.008***	-0.008
	(-14.40)	(-13.60)	(-4.20)	(-5.12)	(-4.97)	(-0.91)
Second child	-0.038***	-0.040***	-0.030***	-0.033***	-0.034***	0.030
	(-13.77)	(-13.16)	(-4.41)	(-8.98)	(-9.40)	(1.17)

Note: *, **, and *** represent significance levels of 10, 5, and 1 percent. Robust t-statistics, which allow for correlation of errors within family, are shown in parentheses. All regressions include age, age squared, and age cubed, indicators for male and *Han*, parents' age and age squared, parents' education level, and rural and provincial dummies.