Quality of Life – Impacts from the Family Planning Policy in China

A thesis

submitted in fulfilment

of the requirements for the degree

of

Doctor of Philosophy in Economics

at

The University of Waikato

by

Yun Liang

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

2018

Abstract

The relationship between population size, the quality of human capital, and the quality of life, interests social scientists. This topic is particularly important in China, where a previous ‘demographic gift’ is becoming a ‘demographic debt’ due to fertility below the replacement rate, and an aging society that places pressure on the social welfare system for elderly and young children. In this thesis, impacts of family size on aspects of the quality of life, such as the nutrient intakes of children and health outcomes of elderly are studied. The response of the working-age population in supporting the two groups through the channel of fertility is also studied. Multiple waves of data from the China Health and Nutrition Survey are used as the major data source.

The thesis uses changes in local regulations of family planning policy over time and space as a source of exogenous variation in family size to assist in identifying the causal effect of family size on the selected outcomes. Panel analysis is also applied to deal with the unobservable factors at individual level. For children, a quantity-quality trade-off is apparent when quality of children is measure by the nutrient intakes. The trade-off would be less apparent if exogenous sources of variation in family size were ignored. For the elderly, their health appears to be adversely affected by the number of grandchildren, especially for grandmothers and especially in urban areas.

Decomposition analysis for the urban-rural fertility gap finds that the fertility gap between women living in rural and urban area is mostly caused by their different characteristics, whereas the fertility gap between urban and rural *hukou* holders is more of an inherent thing that lowers the fertility of women with urban *hukou*. This finding suggests the possible policy trade-off between encouraging urbanisation and encouraging higher fertility may not be as strong as they initially appear.

Acknowledgement

This research uses data from China Health and Nutrition Survey (CHNS). We thank the National Institute for Nutrition and Health, China Center for Disease Control and Prevention, Carolina Population Center (P2C HD050924, T32 HD007168), the University of North Carolina at Chapel Hill, the NIH (R01-HD30880, DK056350, R24 HD050924, and R01-HD38700) and the NIH Fogarty International Center (D43 TW009077, D43 TW007709) for financial support for the CHNS data collection and analysis files from 1989 to 2015 and future surveys, and the China-Japan Friendship Hospital, Ministry of Health for support for CHNS 2009, Chinese National Human Genome Center at Shanghai since 2009, and Beijing Municipal Center for Disease Prevention and Control since 2011. I am grateful to Chief Supervisor Professor John Gibson for guidance of this research. I am also grateful for helpful suggestion from Steve Stillman on the research proposal and to Maria Fitzgerald, Steven Lim and Jacques Poot for their kind assistance.

Table of Contents

Chapter 1

Introduction

For decades, the relationship between population size, the quality of human capital, and the quality of life, have been of interest to social scientists. The interest by policy-makers in the size and rate of growth of the population, and more recently in the ageing and age structure of the population (Bloom, Canning, & Fink, 2010), also attests to the importance of these topics. At the microeconomic level, the particular question of how variation in family size may affect the quality of the family members, and especially the quality of the children, has been widely studied by economists.

A popular theoretical framework on this topic is the child quantity-quality trade-off theory developed in Becker & Lewis (1973). By treating both the number of children and investment on each child as choice variables, this theoretical framework leads to predictions that exogenous factors that decrease the number of children would increase parental investment per child and hence lead to an increase in human capital. Some confirmation of these predictions came from early empirical work using regression modelling (e.g. Becker & Tomes, 1976; Hanushek, 1992). The general idea that population growth rates may be too high, and that these high rates lead to there being insufficient resources to invest in the human capital of each person, as the trade-off theory suggests, has motivated government intervention in many developing countries where it is felt that the fertility rate was too high for economic development (Angrist, Lavy, & Schlosser, 2010).

The family planning policy in China is a famous example. At the second meeting of the fifth People's Congress in June 1979, the so-called one-child policy (hereafter, OCP) was launched with the goal to move toward a small-family culture, which in principle allows just one child per couple. This strict policy, plus the traditional son-preference, caused some social problems such as rapid growth in the number of abortions (Hesketh, Lu, & Xing, 2005) that contributed to the unbalanced sex ratio (Li, Yi, & Zhang, 2011; Bulte, Heerink, & Zhang, 2011). At about the time when the OCP was introduced, the total fertility rate in China decreased dramatically, from nearly three children per woman before the introduction of the policy in 1978 to less than two children per woman by 1993, with further falls to below 1.5 after 1997.[1] Therefore, after some years had elapsed this dramatic fall in the fertility rate showed up in the rapidly increasing ageing rate (e.g. Meulenberg, 2004) although concerns about ageing were less apparent at the time that the OCP was introduced.

In part due to the problems being caused by the strict one-child policy, reforms were introduced in 1984. Specifically, Central Document 7 was issued to "establish a family planning strategy that was realistic, fair and reasonable to the people, easy for cadres to implement, yet capable of achieving the Party's goal of holding the population …" (Greenhalgh, 1986, p. 492). This document was the break point of the policy to change from a set of universal rules to a more flexible and locally-specific set of rules. Further reform occurred when the Population and Family Planning Law of the People's Republic of China was adopted on the 25th meeting of the Standing Committee of the Ninth National People's Congress in

[1] Appendix 1 plots the total fertility rate for China from 1960 to 2015, plus the annual change in the total population, sourced from the World Bank. The time trends of the two measures are quite consistent.

2001 and took effect in September 2002, which advocated for each couple to have only one child but officially allowed local exceptions for additional sanctioned births. In 2015, the policy was further relaxed to universally allow each couple to have two children irrespective of circumstances (Zou, Zhao, & Peng, 2015). The fertility rate has stabilised and has even slightly increased (as has the change in total population, with both trends shown in Appendix 1) during the period when these more flexible rules have been introduced.

The variation in the stringency of the family planning policy in China over time and also across locations is used in this thesis as a natural experiment. In particular, with this variation there is an exogenous factor that should affect family size, and that therefore helps to overcome the problem that the number of children and family size are, at least partially, the outcome of choices made by parents. Consequently, simple regression analyses of how the quality of human capital or aspects of the quality of life (such as health) varies with family size are unlikely to identify causal effects, and are therefore unlikely to be valid tests of the quantity-quality trade-off theory, due to the endogeneity of family size.

Other studies also deal with this problem of endogenous family size by seeking exogenous sources of variation in fertility to examine the effect from child quantity on child quality. For example, Lee (2008) finds adverse effects on investment in education coming from the greater number of siblings in Korea, when son preference is used as the source of exogenous variation in fertility (since parents are more likely to stop trying to have children if earlier born children are boys, but would keep trying for more children if the earlier born children are girls). Li, Zhang & Zhu (2008) use Chinese twins as instrumental variables for family size and find a negative effect of family size on children's education. Relatedly, Angrist, Lavy and Schlosser (2010) use multiple instrumental variables including twin births, mixed-sex children preference and ethnic differences, and find no evidence for quantity-quality trade-offs. One study that uses exogenous variation due to the one-child policy is Zhang, Xu and Liu (2016), which shows that the risk of being over-weight for children without siblings is higher than for those with siblings in China. Another study to use the OCP as the source of exogenous variation is Liu (2014), who finds that the height of children (as an indicator for human capital) can be significantly affected by the number of siblings, but the educational attainment of children is only weakly affected.

It is not surprising that several studies in the literature focus on China, given that population related issues are particularly important there. The 'demographic dividend' gained from having the growth of the working age population exceed the growth of the total population contributed to nearly a quarter of the economic growth of China in the past three decades, but it is forecast to become a 'demographic debt' after 2020 (Cai & Lu, 2016). According to the historical data from the World Bank, in the past three decades, the annual population growth rate decreased from 1.25 in 1980 to only 0.48 in 2010. At the same time, the age dependency ratio for old people increased from 7.5 per cent in 1980 to over eleven per cent in 2010, whereas the same ratio for young people decreased from over sixty percent to less than a quarter in those three decades. According to the China Population Census data, the average family size in China decreased from four in 1990 to slightly above three in 2010, indicating that the average family size is gradually reducing over time. The decrease in family size and the population growth rate, and the changing age structure over three decades in China, places pressure on the social security system and the public caring system for elderly and young children. Consequently, it is important to study the quality of life for the two dependent groups, the children and the old people in the family, as well as the response of the working-age population in supporting the two groups through the channel of fertility.

These three issues, relating to impacts from fertility on the health outcomes of the two dependent groups in the family: children and the elderly, and the determinants of fertility for the generation in the middle (that is, the prime-age or working-age population) are studied in this thesis. The major data source for the thesis is the China Health and Nutrition Survey (CHNS), provided by Carolina Population Centre and the Chinese Centre for Disease Control and Prevention. The CHNS survey is an ongoing international collaborative project between the Carolina Population Centre at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at the Chinese Centre for Disease Control and Prevention, which was designed to examine the effects of the health, nutrition, and family planning policies and programs implemented by national and local governments. The survey follows the same households and collects detailed social-economic information at individual level plus the policy related information at the community level, such as the availability of exceptions to the one-child policy. To the best of my knowledge, this is the best data source that can provide the information needed to define the dynamic and localized measures of the eligibility for extra births for each woman under the family planning policy, as described below, and also to examine the changes in family and individual characteristics over time.

The remainder of the thesis is constructed as follows. In Chapter 2, the factors that affect fertility choice are studied, with the main focus on whether the urban-rural fertility gap in China is due to different characteristics of urban and rural people or due to something inherent about urban life. A variety of decomposition methods are used to examine the rural-urban fertility gaps using both *de facto* (living in an urban area) and *de jure* (holding an urban *hukou*) criteria for defining the urban population. The *hukou* is the registration system that categorizes people into two types, the agricultural (rural, or *nongye* in Chinese) *hukou* holders and the non-agricultural (urban, or *feinong in Chinese*) *hukou* holders, where this classification is given at birth according to parental *hukou* status, irrespective of birth place.[2]

The urban-rural fertility gap is of great interest in China. The current two-child policy in China shows an attempt by the government to increase fertility, possibly due to the fact that the fertility rate is below replacement level. Whether the policy will increase fertility as proposed is questionable. One possible headwind to this policy-driven attempt to increase fertility is that China is becoming more urban (the share of urban population increased from about one-fifth in the year 1980 to almost one-half in the year 2010) and urban fertility is lower than rural fertility. Nevertheless, China needs to keep urbanizing to sustain the momentum of economic development, so whether urbanization will drag down the fertility rate, and by how much, is an important issue to the policy-makers. A version of Chapter 2 of the thesis has published in *Asia & the Pacific Policy Studies* (Liang & Gibson, 2017a).

[2] Before 1998, it was determined by the mother's *hukou* status (Liu, Rizzo, & Fang, 2015). The *hukou* system also contains information on the place of *hukou* registration (*hukou suozaidi* in Chinese), irrespective of the place of residence. This information on place of registration is not relevant to this thesis, and is of declining relevance overall since millions of people now live away from their place of registration (Li & Gibson, 2013). Thus, when writing about *hukou* status, this thesis will only refer to the urban-rural classification contained in the *hukou* registration.

In this regression study of the determinants of the number of surviving children of women, one of the main predictive factors is a measure based on the one-child policy. Specifically, I apply the similar approach to Liu (2014) to design a dynamic identification variable for each woman at child-bearing age for their eligibility for having a second child under the local implementation of the family planning policy. This eligibility variable can be different for the individual over time due to the change in their personal conditions and also due to the change in the local policy regulations. Given that birth is not an immediate event, a woman would be defined as eligible until the end of her child-bearing period from the point she became eligible. For example, a woman who was only allowed to have one child could become eligible for a second child if her first child was a girl and the local OCP regulation allowed a woman whose first child was a daughter to have a second child. She would be treated as an eligible woman for her entire child-bearing period from the year when her daughter was born. Alternatively, a woman with rural *hukou* who was originally allowed to have two children could become ineligible for having a second child if her *hukou* type changed from rural to urban so that exceptions for two children applied to rural *hukou* holders became inapplicable to her. However, the eligibility identification for this woman would remain 'yes' if she had the opportunity to give birth twice before the change in her *hukou* status (noting that there are birth spacing restrictions, as well). Building up from this individual level of eligibility identification variable, the local stringency of the one-child policy is defined as the proportion of women in each community who were eligible to have a second child according to the family planning policy in that time and place.

The study in Chapter 2 uses the CHNS data from the 2011 survey wave, which covers Heilongjiang, Guangxi, Guizhou, Henan, Hubei, Hunan, Jiangsu, Liaoning, and Shandong provinces, plus three municipalities of Beijing, Shanghai and Chongqing. The Poisson regression shows a positive and significant impact on fertility from the eligibility of having two children under the local implementation of the one-child policy, and a positive but insignificant influence from the policy strength at the community level. Urban residence and urban *hukou* both show negative and significant impacts on the number of children, with the coefficients for urban *hukou* three times larger than the coefficients for urban residence.

The decomposition from the regression results of the rural-urban gaps in this chapter shows that the large fertility-depressing effect is more from holding urban *hukou* than from living in an urban area. The fertility gap between urban and rural areas can mostly be attributed to the difference in the average characteristics of women living in each type of area, whereas more of the gap remains unexplained if we compare women with different *hukou* status. This result suggests that the adverse effect from urbanization on fertility may not be as large as it appears. Because the urban *hukou* is a *de jure* definition, it could be reformed by changing the registration constraints to suit the needs of increasing fertility and encouraging urbanization simultaneously (in contrast, the driving forces for changes in the share of the population with urban or rural residence are more fundamental factors associated with economic development that are hard for policy makers to change in the short-run).

The results in Chapter 2 reveal several important factors that would significantly affect the fertility choice of women in China. One of them is the family planning policy. The results confirm that the one-child policy is a good source of exogenous variation in family size, and so can be used to assist in the econometric identification of the relationships studied in the other two chapters of the thesis. More relaxed local fertility rules that allow more women to be eligible to have two children leads to higher fertility, and in turn, leads to bigger family size. In the next two chapters, the thesis studies the impacts of the family size on the quality of life of the family members, with the focus on the two dependent groups; children, and the elderly. These chapters build on the analysis in Chapter 2, but rather than working with a single wave of CHNS data, they use multiple waves that open up the chance to have temporal variation in the local stringency of the one-child policy as a source of the exogenous variation in family size.

In Chapter 3, the focus is placed on the young part of China's population. The 'quality' of children is measured by their intakes of dietary energy, protein and fat. Unlike more widely studied quality measures, such as educational attainments and height-for-age, the intakes of nutrients directly represent the family investment in each child, and hence is a good indicator to test the response of parents to the different family size. In contrast, height for age and educational attainment partly reflect genetic endowments that the parents are not able to manipulate, while they do have control over the diets of children. Also, the nutritional status of children is estimated to be important to the school enrolment of children (Alderman, Behrman, Lavy, & Menon, 2001), and hence will further affect the quality of children in the future. This chapter studies the impacts that the number of siblings of each child under the age of 18 have on the nutrient intakes of those children using three different methods, the ordinary least square (OLS) method, the two-stage least squares (2SLS) method and the fixed-effect (FE) panel analysis. The aim of using these multiple methods is to get robust results on the existence (or not) of the child quantity-quality trade-offs in China with regard to nutritional status of children. A version of the chapter is online as a working paper, and has published in *China Economic Review* (Liang & Gibson, 2017b) .

For the 2SLS method in Chapter 3, the variation in family size is instrumented by the local stringency of the one-child policy. As discussed in the study in Chapter 2, these fertility control regulations and differing eligibility for exemptions are important determinants of fertility at the micro level. In Chapter 3, this measure is adapted to consider the temporal and spatial variation in the one-child policy, and this should be a good instrumental variable because it is relevant in the sense that the policy had a strong control on fertility in China.[3] For the analysis in Chapter 3, the local strength of the fertility control policy is calculated as a community level measure, and this should only affect children's nutrition status through the channel of its influence on fertility.

Taking the advantage of the panel structure of the CHNS data, the fixed-effect (FE) approach using panel data analysis is also used to test effects of the change in the sibling numbers on the change in the nutrient intakes of children. By using changes, any time-invariant unobserved effects are purged from the analysis. For the research in this chapter, seven waves of CHNS data, from 1991, 1993, 1997, 2000, 2004, 2006 and 2009 are used, with individuals needing to be

[3] Women in China need to get birth permission, which is determined by the local implementation of the family planning policy, for their babies to be registered under the *hukou* system. The birth registration is highly related to the right to obtain schooling and other social benefit, which provides an incentive for people to avoid the unsanctioned births. From 1997, out-of-plan births and children of unmarried women may be allowed to get birth registration. While this possibly reduced the effects from the family planning policy on fertility decisions, by weakening one of the main sanctions, the local rules around the one-child policy remained a strong exogenous factor for choices of family size by many Chinese couples (Li, Zhang, & Feldman, 2010).

available for at least two of the seven waves to be included in the analysis sample. Results from the panel analysis and the 2SLS regressions both confirm the existence of the child quantity-quality trade-off in China when nutritional status is used as one of the measures of child quality. This trade-off is less apparent from the OLS regressions, when the possible endogeneity of family size is not controlled for.

The results in Chapter 3 show negative impacts from the higher number of children on the nutritional status of the children. This consistency with the predictions of the trade-off theory of Becker and Lewis (1973) may be thought of as a good sign for the development of China's human capital, given the currently small family size and low fertility rate in China. However, this is not the end of the story. The number of children in a family can affect not only the quality of children, but also the life quality of other members in the family.

In Chapter 4, the focus of the thesis shifts to the health of the elderly, which is another group of people whose life quality is heavily dependent on the support from others in the extended family, due to the incomplete nature of the formal social security system (Giles & Mu, 2007; Mu & Du, 2017). A large share of old people in China depend on their adult children, which introduces a potential competition between these old people and the young children in the family, for the transfers of money and time from the working age adults. Also, it is a tradition for grandparents, especially grandmothers, to provide help in looking after young grandchildren. This duty could be a burden to the elderly and reduce the investments (either money or time) that they put into their own health. Using four waves of CHNS data, the research reported in Chapter 4 examines the impacts from the number of grandchildren on the grandparents' likelihood of having high blood pressure, of being overweight, of self-reporting poor health, and of having difficulties in performing daily activities of living.[4] A version of Chapter 4 is also available online as a Waikato working paper (Liang & Gibson, 2017c) and has been submitted to *Review of Economics of the Household*.

As in Chapter 3, the instrumental variables method and panel analysis are used as the approaches for dealing with the possible endogeneity of the family size. One difference from Chapter 3 is that three of the outcomes studied are dichotomous, and so Probit estimation is required and the approach to implementing instrumental variables for these outcomes is akin to control function estimation (Islam & Smyth, 2015). The number of grandchildren is instrumented by three family planning policy related variables, including the eligibility for having two children that applied to the respondents (the grandparents), the eligibility for having two children for the adult children of the respondents (the parents) and the community level stringency of the one-child policy. Furthermore, to allow for differences in the effects of grandchild numbers on grandparent health, for men and women, and between urban and rural areas, the regressions are conducted for the overall sample and also for the sub-samples of males and females, and urban and rural residents, respectively.

The results in Chapter 4 suggest a strong influence from the size of the grandchild cohort on the health outcomes of the elderly cohort, albeit with influences that are sensitive to the particular outcomes and to the choice of sub-samples. For example, having more grandchildren is expected to reduce the

[4] Twenty indexes range from value one, indicating no difficulties, to value four, which indicates an inability to perform a certain routine day-to-day activity, are used to made up a standardized score (with mean zero and standard error one) to reflect the level of difficulties. This composite measure, referred to as the ADL score in Chapter 4, indicates worse health when the score is higher.

likelihood of being overweight for grandmothers, but has no impact on the same risk for grandfathers. A strong adverse effect from having a higher number of grandchildren on the likelihood of self-reporting poor health is found for urban grandparents, whereas the effect for rural grandparents is not apparent.[5] The panel analysis suggests that the ADL score is higher for respondents with more grandchildren, across all of the sub-samples, although not all of the marginal effects are statistically significant; whereas the cross-sectional analysis show that the ADL scores for all sub-samples are significantly affected by the number of grandchildren, with the higher the number of grandchildren the lower the ADL scores for males and rural residents but the higher the ADL scores for females and for urban residents (where higher scores are worse).

The uneven effects from the number of grandchildren on different sub-groups and different outcomes revealed in Chapter 4 suggest that health insurance and social support systems for old people should be oriented to the needs of different groups. Moreover, public support to young children that reduces the caring needs from family member may also have positive effects on the health of the elderly. For instance, the health status of grandmothers is more likely to be affected by the number of grandchildren, than is the case for grandfathers, possibly because grandmothers have a heavy duty in taking care of the young grandchildren. Hence, better public child-care facilities may help to reduce this burden and consequently improve the health of grandmothers. Senior citizens in urban areas suffer more, in terms of their health, from having a higher number of grandchildren than do the elderly in rural areas, possibly due to the more severe

[5] Self-reported health is a subjective measure because the criteria for assessing the health conditions could differ amongst different people, but it can still show differences in real health (Mu, 2014).

education competition for children in urban areas than in rural areas which forces the urban working-age generation to put more resources into the human capital of the children at the possible expense of the elderly. This difference might be compensated by reducing the inequality in the quality of schooling between urban areas and rural areas.

Chapter 5 draws together the three strands of the thesis, and summarizes the key research contributions of each of the main chapters, and also discusses the limitations of the research. The quantity and quality of population in China is the main interest of this thesis. A particular contribution of the thesis is to consider three generations: starting with the generation in the middle (that is, women of child-bearing age, which also overlaps with the prime-age or working-age population), and then considering the next generation (children), and finally considering the previous generation (the grandparents).

Thus, the thesis examines the factors that affect the number of children in the family, as a study on the quantity of population, with the focus on the family planning policy and the rural-urban fertility gaps. On the quality side, the thesis studies the nutrient intake of children, as a measure of parental investment in those children, and the health of the elderly. For both of the dependent generations – the children and the elderly – the results indicate the existence of a trade-off between family size and life quality for family members. Consequently, with the on-going changes in family size in China, driven partly by fertility decisions and the family planning policy, it can be expected that there will be a continued effect on the quality of China's human capital and on the quality of life for young and old generations.

Reference

Alderman, H., Behrman, J., Lavy, V., & Menon, R. (2001). Child Health and School Enrollment: A Longitudinal Analysis. *The Journal of Human Resources, 36*(1), 185-205.

Angrist, J., Lavy, V., & Schlosser, A. (2010). Multiple Experiments for the Causal Link between the Quantity and Quality of Children. *Jounal of Labor Economics, 28*(4), 773-824.

Becker, G. S., & Lewis, H. G. (1973). On the Interaction between the Quantity and Quality of Children. *The Journal of Political Economy, 81*(2), S279-S288.

Becker, G. S., & Tomes, N. (1976). Child Endowments and the Quantity and Quality of Children. *Journal of Political Economy, 84*(4, Part2), S143-S162.

Bloom, D. E., Canning, D., & Fink, G. (2010). Implications of population ageing for economic growth. *Oxford Review of Economic Policy, 26*(4), 583-612.

Bulte, E., Heerink, N., & Zhang, X. (2011). China's one-child policy and 'the mystery of missing women': ethnic minorities and male-biased sex ratios. *Oxford Bulletin of Economics and Statistics, 73*(1), 21.

Cai, F., & Lu, Y. (2016). Take-off, persistence and sustainability: The demographic factor in Chinese growth. *Asia and the Pacific Policy Studies, 3*(2), 203-225.

Giles, J., & Mu, R. (2007). Elderly Parent Health and the Migration Decision of Adult Children: Evidence from Rural China. *Demography, 44*(2), 265-288.

Greenhalgh, S. (1986). Shifts in China's population policy, 1984-86: Views from the central, provincial, and local levels. *Population and Development Review, 12*(3), 491-515.

Hanushek, E. A. (1992). The Trade-off between Child Quantity and Quality. *Journal of Political Economy, 100*(1), 84-117.

Hesketh, T., Lu, L., & Xing, Z. W. (2005). The effect of China's one-child family policy after 25 years. *New England Journal of Medicine, 353*(11), 1171.

Islam, A., & Smyth, R. (2015). Do fertility control policies affect health in old age? Evidence from China's One-Child experiment. *Health Economics, 24*, 601-616.

Lee, J. (2008). Sibling size and investment in children's education: an asian instrument. *Journal of Population Economics, 21*, 855-875.

Li, C., & Gibson, J. (2013). Rising Regional Inequality in China: Fact or Artifact? *World Development, 47*, 16-29.

Li, H., Yi, J., & Zhang, J. (2011). Estimating the Effect of the One-Child Policy on the Sex Ratio Imbalance in China: Identification Based on the Difference-in-Differences. *Demography, 48*(4), 1535-1557.

Li, H., Zhang, J., & Zhu, Y. (2008). The Quantity-Quality Trade-off of Children in a Developing Country: Identification using Chinese Twins. *Demography, 45*, 223-243.

Li, S., Zhang, Y., & Feldman, M. W. (2010). Birth Registration in China: Practices, Problems and Policies. *Population Research and Policy Review, 29*, 297-317.

Liang, Y., & Gibson, J. (2017a). Location or Hukou: What Most Limits Fertility of Urban Women in China. *Asia and the Pacific Policy Studies, 4*(3), 527-540. doi:10.1002/app5.188

Liang, Y., & Gibson, J. (2017b). Do siblings take your food away? Using China's One-Child Policy to test for child quantity-quality trade-offs. *China Economic Review*. https://doi.org/10.1016/j.chieco.2017.10.006

Liang, Y., & Gibson, J. (2017c). Do more grandchildren lead to worse health status of grandparents? Evidence from the China Health and Nutrition Survey. *Working Papers in Economics,, 17*(18). Retrieved from https://ideas.repec.org/p/wai/econwp/17-18.html

Liu, H. (2014). The quality-quantity trade-off: evidence from the relaxation of China's one-child policy. *Journal of Population Economics, 27*(2), 565-602.

Liu, H., Rizzo, J. A., & Fang, H. (2015). Urban-rural disparities in child nutrition-related health outcomes in Chian: the role of hukou policy. *BMC Public Health, 15*, 1159.

Meulenberg, C. (2004). Definitely Probably One: A Generation Comes of Age Under China's One-Child Policy. *World Watch, 17*(5), 31-33.

Mu, R. (2014). Regional Disparities in Self-reported Health: Evidence from Chinese Older Adults. *Health Economics, 23*(5), 529-549.

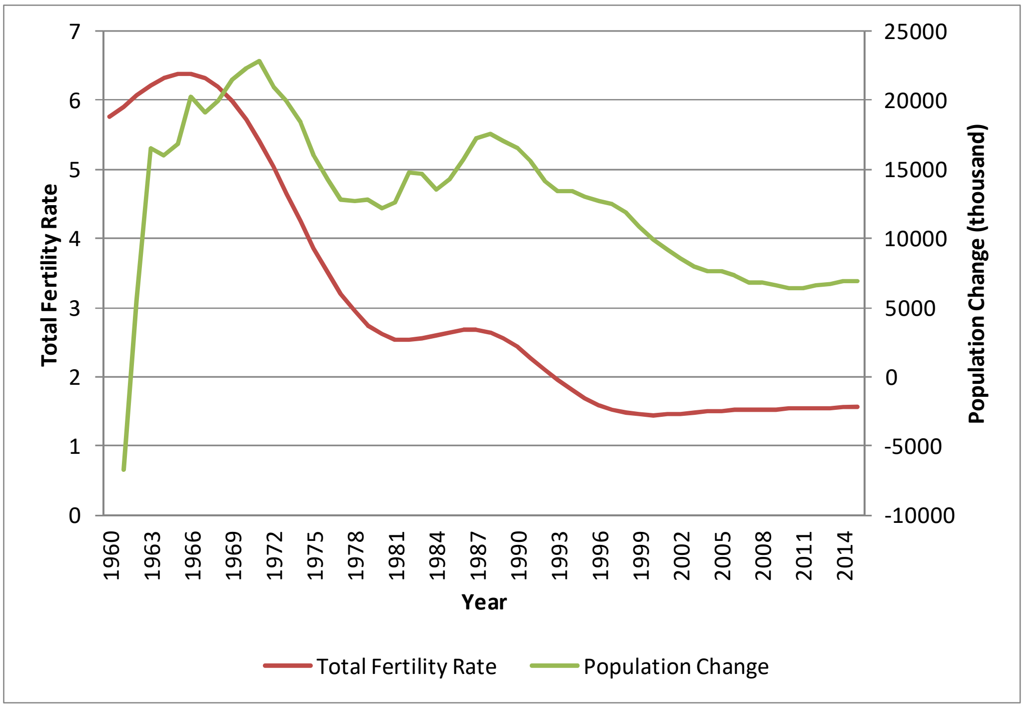
Mu, R., & Du, Y. (2017). Pension coverage for parents and educational investment in children: Evidence from urban China. *World Bank Economic Review, 31*(2), 483-503.

Rosenzweig, M. R., & Zhang, J. (2009). Do Population Control Policies Induce More Human Capital Investment? Twins, Birth Weight and China's "One-Child" Policy. *Review of Economic Studies, 76*(3), 1149-1174.

Zhang, J., Xu, P., & Liu, F. (2016). One-child policy and childhood obesity. *China Economic Review*. doi:10.1016/j.chieco.2016.05.003

Zou, C., Zhao, J., & Peng, X. (2015). *Xinhua Net*. Retrieved from Xinhua Net: http://news.xinhuanet.com/health/2015-10/30/c_128374158.htm

Appendix 1: Total Fertility Rate and Change of Total Population in China, 1960-2015



Note:

1. Source: The World Bank http://data.worldbank.org/country/china?view=chart, retried in August 2017.
2. Total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with current age-specific fertility rates.
3. Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values shown are midyear estimates.
4. On 1 July 1997 China resumed its exercise of sovereignty over Hong Kong; and on 20 December 1999 China resumed its exercise of sovereignty over Macao. Unless otherwise noted, data for China do not include data for Hong Kong SAR, China; Macao SAR, China; or Taiwan, China. National accounts have been revised from 2010-2015 based on the National Bureau of Statistics data and World Bank estimates. The new base year is 2010.
5. Source Organization: (1) United Nations Population Division. World Population Prospects, (2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) United Nations Statistical Division. Population and Vital Statistics Report (various years), (5) U.S. Census Bureau: International Database, and (6) Secretariat of the Pacific Community: Statistics and Demography Programme.

Chapter 2[6]

Location or Hukou:

What Most Limits Fertility of Urban Women in China?

Yun Liang and John Gibson

Yun Liang

PhD Student, Economics Department
University of Waikato
Private Bag 3105
Hamilton, New Zealand, 3240.

Tel: + 64 (0)7 838 4289

Email: lysh8@hotmail.com

John Gibson

Economics Department
University of Waikato
Private Bag 3105
Hamilton, New Zealand, 3240.

Tel: + 64 (0)7 838 4289

Email: jkgibson@waikato.ac.nz

[6] This has published in *Asia & the Pacific Policy Studies* (Liang & Gibson, 2017a).

Location or Hukou:

What Most Limits Fertility of Urban Women in China?

Abstract

China's fertility rate is below replacement level. The government is attempting to increase this rate by relaxing the one-child policy. China faces a possible trade-off since further urbanization is needed to raise incomes but may reduce future fertility. We decompose China's rural-urban fertility gaps using both *de facto* and *de jure* criteria for defining the urban population. The fertility-depressing effects of holding urban *hukou* are more than three times larger than effects of urban residence. Less of the rural-urban fertility gap by *hukou* status is explained by the differences in characteristics of the two groups, than for the fertility gap by place of residence.

Key words: fertility, hukou, urbanization, China

JEL Classification: J13

Acknowledgements

This research uses data from China Health and Nutrition Survey (CHNS). We thank the National Institute for Nutrition and Health, China Center for Disease Control and Prevention, Carolina Population Center (P2C HD050924, T32 HD007168), the University of North Carolina at Chapel Hill, the NIH (R01-HD30880, DK056350, R24 HD050924, and R01-HD38700) and the NIH Fogarty International Center (D43 TW009077, D43 TW007709) for financial support for the CHNS data collection and analysis files from 1989 to 2015 and future surveys, and the China-Japan Friendship Hospital, Ministry of Health for support for CHNS 2009, Chinese National Human Genome Center at Shanghai since 2009, and Beijing Municipal Center for Disease Prevention and Control since 2011. We are grateful to helpful comments from participants at the ESPE conference, and especially Steven Stillman. We also thank the Human Ethics Committee of the Waikato Management School for ethical approval.

2.1 Introduction

China is only a decade from its expected peak population of 1.42 billion in 2028. In that year, a little over one-third of people – 37.8 percent – will be aged under 35 while the same age group now are 46.5 percent of the population. This falling share means about 110 million fewer Chinese will be of an age where it is likely that they could still have children in the future and so the inexorable momentum of population decline sets in. Thus, forecasts of China's population by the end of the century are of just over one billion, which will be under two-thirds of India's population then and just one-third larger than Nigeria (United Nations *et al.*, 2015).

This demographic reversal will have profound effects on economic and social policy. In the economic sphere, it is likely that any position China achieves as the largest economy in the world will be short-lived; the United States will have 450 million people by century-end so China will need to get to about half of the per-capita income of the U.S. if it is to be ahead in total economic size (French, 2016). This is unlikely because the American workforce is expected to grow 30 percent between now and 2050, owing chiefly to immigration, while in China, the workforce will be 23 percent smaller in 2050 than now and this smaller workforce will face a much larger burden of supporting an elderly population. In fact, almost one-quarter of China's growth over the past three decades was from the 'demographic dividend' of having the working age population grow faster than the total population, but this becomes a 'demographic debt' after 2020 that drags the growth rate down (Cai & Lu, 2016).

In light of these demographic trends, China's policy-makers have changed course and after 35 years of trying to restrict population growth using the one-child policy (hereafter, OCP), couples can now, irrespective of circumstances, have two children (Xinhua Net, 2015). Yet even with this relaxation, which many experts view as too little and too late (French, 2016), China faces hard policy trade-offs in raising fertility from the current sub-replacement rate of around 1.5 (Cai, 2010; Peng, 2011). The trade-off focused on in this study is that China is much less urbanized than typical for a country of its income level; the 2010 census showed a de facto urban population that was just under one-half of the total population (Chan & Wan, 2017). Urban women have lower fertility rates than rural women (Guo *et al.,* 2012), and China must continue urbanizing to increase productivity and avoid the 'middle income trap' and, thus, further downward pressure on fertility is likely.

In this article, we study fertility gaps between urban and rural women, using data from the China Health and Nutrition Survey (CHNS). We test whether the gap of about 0.5 children per ever-married woman, which is equivalent to just under half the urban fertility rate, is due to different characteristics of urban and rural people or due to something inherent about urban life. In particular, we examine fertility rates if urban women had the same characteristics as rural women, and vice versa. A feature of our analysis is that we allow for China's simultaneous use of de facto and de jure counts when defining the urban population (Chan & Wan, 2017). Under China's statistics, a woman can be defined as urban either because she lives in an urban area (a *de facto* criterion) or from having urban *hukou* (a *de jure* criterion).

We find that after controlling for various personal and household characteristics, the fertility-depressing effects of holding urban *hukou* are more than three times larger than are effects of urban residence. In other words, part of the urban-rural fertility gap in China reflects institutional factors, and the different constraints faced by the different types of *hukou* holders. Thus, comparisons of urban and rural fertility that do not account for the rigidities imposed by the *hukou* system may overstate the decline in fertility that the continued urbanization of rural women is likely to bring and may make policy trade-offs appear harder than they truly are.

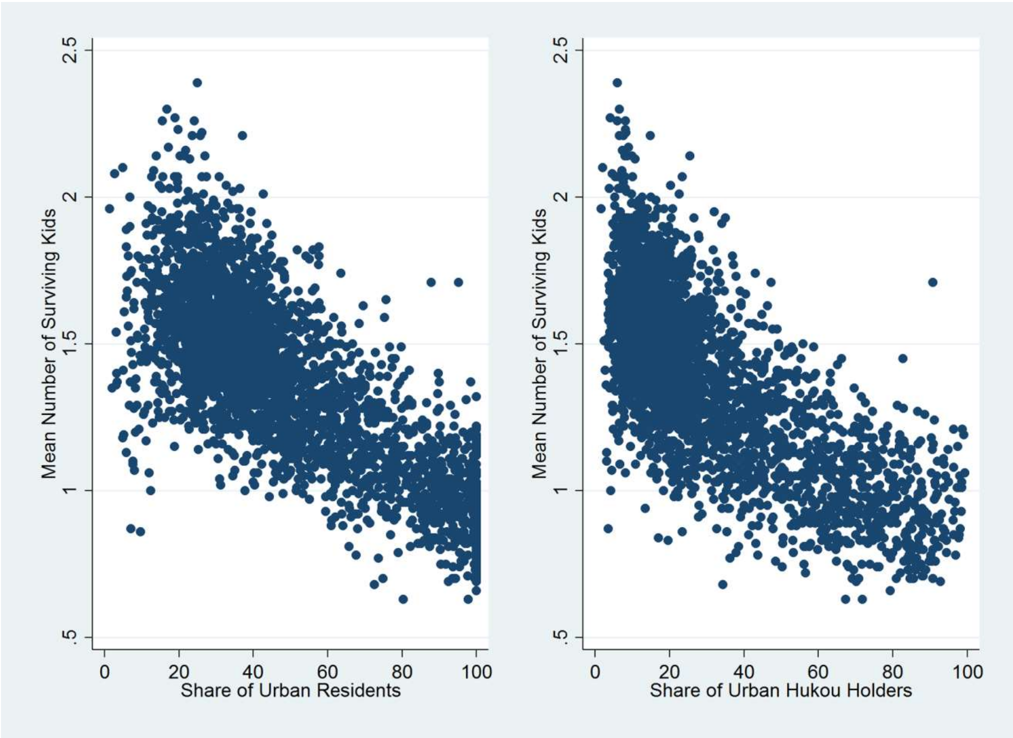
2.2 Background and Literature

When China introduced the OCP in 1979, the total fertility rate (TFR) had already fallen sharply, from six children per woman in the late 1960s to just 2.8 by the late 1970s (Peng, 2011). While a slight rise in the TFR followed, this blip was an echo of the early 1960s rebound in fertility after the disastrous Great Leap Forward, as a larger cohort entered child-bearing age. Given this already declining TFR, there is debate in the literature about the role of government policy versus other more fundamental factors in contributing to China's fertility decline. If policy is not the major determinant of fertility, then a reversal of policy, such as the 2015 changes that allow two children, may not have much effect.

One fundamental factor highlighted in the literature is the inverse relationship between urbanisation and fertility (Guo *et al.*, 2012; Kulu, 2013). This relationship is seen in Figure 1 in county level data from China's 2010 Population Census, where the urban population is in terms of those living in urban areas in the left panel, and those with urban *hukou* in the right panel. The fertility rate falls from around 1.7 surviving children per woman aged 15 to 64 at the lowest urbanization levels to around 1.0 for counties with the highest urban population share. The time-series data show the same inverse relationship; from

1970 to 2014, the share of the urban population increased from about one-sixth to one-half and the TFR fell from 5.7 to 1.5 (World Bank, 2016). Moreover, urbanization is forecast to be the main factor behind China's future fertility decline (Guo *et al.*, 2012).

Figure 1: Fertility and Urban Population Share at County Level, 2010 China Census



The prior studies with a focus on rural-urban differences consider locations but not another rural-urban classification in China – the *hukou* system. *Hukou* is the registration system created in 1955, which divided Chinese into two categories: agricultural *hukou* (rural *hukou*) and non-agricultural *hukou* (urban *hukou*). The *hukou* status is assigned to each child at birth according to parental *hukou* status, irrespective of birthplace.[7] A rural *hukou* holder may apply to change to urban *hukou* when enrolling in university, having a job in a state-owned enterprise or as a senior administrator, or when demobilized from military service

[7] Before 1998, the *hukou* status of the new-born baby was determined by the mother's *hukou* status (Liu, Rizzo & Fang,. 2015).

(Liu, Rizzo & Fang, 2015). Urban *hukou* holders have better publicly provided education and health care, but until recently, the family planning policy had more exceptions for rural *hukou* holders, such as the girl-exception where some provinces let rural *hukou* holders have a second birth when the first child was a girl.[8]

2.3 Data Description

We use data from the 2011 wave of the CHNS, which is the wave with the largest coverage of China among all available waves. In particular, the 2011 wave is the only wave that includes the three municipalities of Beijing, Shanghai and Chongqing. The data let us look at impacts on fertility from both residential location and *hukou* status of each sampled woman. We also decompose the rural-urban fertility gaps (under both the location and *hukou* classification of urban) into explained and unexplained components.

2.3.1 Data

The CHNS survey covers a wide range of information at the individual, household and community level. In particular, it provides detailed relationship files for each individual, even if they live in different households, and this enables an accurate measure of fertility. The survey also obtains the *hukou* status of each individual,

[8] The new two-child policy (TCP) allows all couples to have two children, with no variation by area or *hukou* status (Xinhua Net, 2015). The results below show that differences in policy-driven classifications, such as *hukou*, have significant effects on rural-urban fertility gaps. Because policy appears as an important fertility determinant, changing policy, as from the OCP to the two-child policy, should be expected to have an effect on fertility, although it is too early to see this in the data.

which lets us control both for the location and for *hukou* differences amongst sampled women.

The survey employs a multistage, random cluster sampling procedure to draw the sample from selected provinces and municipalities in China. In each selected region, counties are stratified by income (low, middle, and high), and a weighted sampling scheme is used to randomly select four counties to form the rural sample. The urban sample is formed from the provincial capital and a low-income city. Villages and townships within the sampled counties, and urban and suburban neighbourhoods within the sampled cities, are selected randomly. The survey started with Guangxi, Guizhou, Henan, Hubei, Hunan, Jiangsu, Liaoning, and Shandong provinces in 1989, added Heilongjiang in 1997 and added the three municipalities of Beijing, Shanghai and Chongqing in 2011. The 12 provinces and municipalities in the 2011 wave are shown in Figure 2 and are distributed over the four levels of urbanization recognized in China (Guo *et al.*, 2012).

The individuals included in this research are ever-married women of Han ethnicity aged between 20 and 52.[9] This age range covers women of child-bearing age and satisfying the legal requirement for having children.[10] Respondents aged 52 in the 2011 survey were 21 years old when the OCP was introduced, so all sampled women were restricted by this policy throughout their child-bearing period.

After excluding women with incomplete information, the final sample includes 2543 observations. Amongst them, about one-fifth of the rural residents

---

[9] We exclude ethnic minorities because they were mostly exempted from the OCP.

[10] Marriage is the traditional and legal pre-condition of child bearing in China. The legal marriage age is 20 for women and 22 for men from 1980 onwards. Children born with either parent younger than the legal marriage age will be considered an illegal birth (just one child in the 2011 CHNS was of this type).

are urban (non-agricultural) *hukou* holders, while about 15 per cent of urban residents hold rural *hukou*. In other words, 11 per cent of agricultural *hukou* holders live in urban areas, and the share for non-agricultural *hukou* holders living in rural areas is more than a quarter. This is not surprising given that university students, senior administrators and government officials are all granted urban *hukou* irrespective of their original *hukou* status and then keep that status notwithstanding current location.[11]

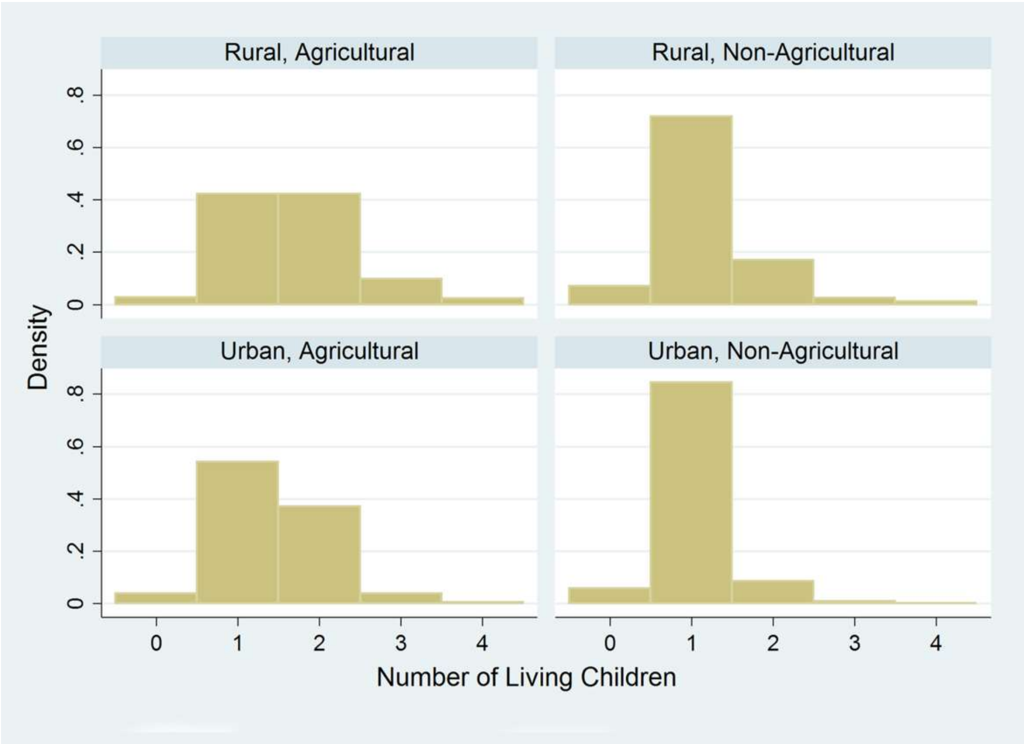
Figure 2: Map of Survey Regions, China Health and Nutrition Survey, 2011

[11] CHNS is a longitudinal survey following people in the same households. Whether the person was born at the current place or has always lived at the current place is not covered and so cannot be used to detect migrants in our sample. We have reason to believe that the sampled women are mostly permanent residents in the community where surveyed.

2.3.2 Preliminary Results

The outcome variable representing fertility in this article is the number of surviving children of an ever-married female at the survey time, following Fang *et al.* (2013). This number equals the total number of births from a woman minus the number of her children who died. Currently pregnant women count as one birth.[12]

Figure 3: Fertility Distribution of the Estimation Sample by Residence and Hukou Status, China Health and Nutrition Survey, 2011



The mean fertility rate is 1.39 children per woman in our sample. The gap of about 0.5 children between urban and rural women is almost half of the mean fertility of urban women. The gap is wider between urban and rural *hukou* holders (1.65 for rural and 1.09 for urban) than between urban and rural residents (1.58 for rural and 1.11 for urban). Figure 3 plots the distribution of fertility for these four groups; rural and urban represents residence status, and agricultural and non-

[12] The infant mortality rate in China is low so it is reasonable to include expected births by pregnant woman as part of the cumulative fertility measure (Fang *et al.,* 2013).

agricultural represents *hukou* status.[13] One child is the modal choice for non-agricultural *hukou* holders, at 72 per cent for those living in rural areas and 85 per cent in urban areas. On the other hand, agricultural *hukou* holders in rural areas are just as likely to have two children as one child, and 37 per cent of agricultural *hukou* holders living in urban areas have two children compared with just 9 per cent for non-agricultural *hukou* holders in urban areas.

Regressions are another way to consider the relationship between the urban indicators and fertility. The measure of individual fertility is a count variable, so ordinary least squares is not appropriate, but a Poisson model is suitable.[14] This model takes the following form:

$$\log(Fertility) = \alpha + \beta U + \varepsilon \quad (1)$$

where *Fertility* is the count of surviving children of each woman, *U* is the vector of urban status, which could include urban residence, or *hukou* status, or both indicators simultaneously. The coefficients from a Poisson regression are interpreted as the expected change in the log of the outcome from a one-unit increase in the right-hand side variables, ceteris paribus. In the case of dummy variables, the coefficients show the expected difference in the log count from the reference group, with a negative coefficient representing a smaller mean outcome than for the reference group. For example, the first model in Table 1 shows that the mean log count of child numbers for women living in urban areas is expected

[13] Number of living children is truncated at four. Only seven cases in the sample exceed this value, and they are all in the rural-agriculture group.

[14] Other options are the negative-binomial, and zero-inflated models, and tests for choosing amongst these are discussed in Bauer, Goehlmann and Sinning. (2007). There is not a large proportion of zeros in the distribution of child numbers, so zero-inflated models should not be needed. Goodness-of-fit tests after the Poisson regressions give no reason to reject that model and choose negative binomial regressions.

to be 0.355 lower than for women living in rural areas, whose log count of mean fertility is 0.455. This means that the estimated urban fertility is $e^{(0.455-0.355)}$=1.11, which is 0.47 fewer children than the rural rate of $e^{(0.455)}$=1.58, and the difference is statistically significant at the one-percent level.

Table 1: Unconditional Poisson Regressions of Fertility Using Two Indicators of Urban Status

	(1)	*(2)*	*(3)*
Urban residence	-0.355***		-0.140***
	(0.019)		(0.026)
Urban *hukou*		-0.417***	-0.331***
		(0.019)	(0.026)
Constant	0.455***	0.499***	0.514***
	(0.013)	(0.013)	(0.014)
Pseudo-R^2	0.016	0.023	0.024
Number of Observations		2543	

Note: *** p<0.01, ** p<0.05, * p<0.1.

The coefficient for urban *hukou* is more negative than is the coefficient for urban location (comparing columns (1) and (2) of Table 1) and both are significant at the one-percent level. When the two indicators are both included in the model, the urban *hukou* shows a much stronger impact on fertility than does the urban residence, consistent with the patterns in Figure 3. Specifically, the coefficient on urban *hukou* is more than twice as large as the coefficient on urban residence, suggesting that *de jure* urban status matters more to fertility than *de facto* urban location.

2.4 Multivariate Analysis

In this section we use two different approaches to test urban effects on fertility. In the first, we repeat the regressions reported in Table 1 but add a series of conditioning variables. In the second, we use regression techniques to decompose the fertility gap between urban and rural women into explained and unexplained parts.

2.4.1 Poisson Regression

We start by regressing fertility on the two urban indicators, urban residence and urban *hukou*, along with other control variables, using the Poisson regression. The full model is as seen below:

$$\log(Fertility) = \alpha_0 + \beta_1 Urban + \beta_2 NonAg + \beta_3 \boldsymbol{X} + \beta_4 \boldsymbol{Z} + \varepsilon \quad (2)$$

where *Urban* indicates urban residence, and *NonAg* indicates urban (non-agricultural) *hukou* holders, $\boldsymbol{X}$ is a vector of OCP measures, and the vector $\boldsymbol{Z}$ has other socioeconomic factors. The summary statistics of the outcome and control variables for all sampled women, categorized by the two urban indicators, are listed in Appendix 1.

The number of children that sampled women had is a cumulative measure that might not closely relate to current policy. Therefore, we use eligibility for having two children to represent the OCP impact on fertility, where this equals one if the woman satisfied the OCP exceptions for having two children at any stage until one year prior to the survey time, and is zero otherwise. The local OCP strength measure is the share of women eligible to have two children in each community at the survey time (Liang & Gibson, 2017). About 72 per cent of rural women in the sample were eligible to have two children before the 2011 survey, while the share was only around 45 per cent for urban women.

Amongst the control variables, female employment is considered to have large impacts on fertility. We follow Fang *et al.* (2013) in splitting employed women by job type (working as farmer, fisherman or hunter versus other jobs). Farm jobs provide more flexibility than the off-farm jobs, and rural women could potentially work their own land while this is not available for urban women (Fang, *et al.*, 2013). The share of women working in farm jobs is about two percent for urban residents and less than one percent for urban *hukou* holders, but about 37 per cent for rural residents and 43 per cent for rural *hukou* holders. The reference group in the regression is the 'not employed' group, which includes people not in the labour force, and people currently unemployed and actively job-seeking. We also control for other individual attributes, including age (in five-year age groups), whether currently married, number of siblings, highest qualification gained (primary school, lower middle school, upper middle school, technical or vocational qualifications, university or college qualifications, and master's degree or higher), annual income for the respondent and the household, whether living in an owner-occupied dwelling and the province fixed effect (with Beijing as the reference category).

Table 2 presents results for the full model, with the first two columns for the raw form of the coefficients and standard errors and the next two columns for their exponential terms. Recall that the coefficients are interpreted as the difference in the log of the expected outcome (number of children) owing to a one-unit change in the covariate. In other words, the difference between the default value of one and the exponential form of the coefficient shows the percentage change in the outcome for a one-unit change in the covariate.

The impacts on fertility of urban residence and of urban *hukou* remain negative and statistically significant with the covariates included. Compared with the unconditional results in Table 1, the apparent impact of urban *hukou* is approximately halved (with the raw coefficient going from −0.33 to −0.17), while the impact of urban residence is reduced to one-third of its previous value (from −0.14 to −0.05). Thus, with covariates included in the model, the negative effect on fertility of holding urban *hukou* is more than three times as large as is the effect of living in an urban area.

Table 2: Poisson Regression of Fertility, Full Model

	Raw Form		*Exponential Form*	
	Coefficient	*Standard Error*	*Coefficient*	*Standard Error*
Urban residence	-0.0492**	(0.023)	0.952**	(0.022)
Urban *hukou*	-0.174***	(0.026)	0.841***	(0.022)
Eligibility for having two children	0.197***	(0.027)	1.218***	(0.033)
Community OCP strength	0.0216	(0.053)	1.022	(0.054)
Age range [20,25)	-0.600***	(0.084)	0.549***	(0.046)
Age range [25,30)	-0.383***	(0.056)	0.682***	(0.038)
Age range [30,35)	-0.170***	(0.047)	0.844***	(0.040)
Age range [35, 40)	-0.0868*	(0.046)	0.917*	(0.042)
Age range [40, 45)	-0.0901**	(0.044)	0.914**	(0.040)
Age range [45, 50)	-0.00306	(0.042)	0.997	(0.042)
Number of siblings	0.0185***	(0.006)	1.019***	(0.006)
Currently married	0.000625	(0.056)	1.001	(0.056)
Working in other occupations	-0.0482*	(0.026)	0.953*	(0.024)
Working as a farmer, fisherman or hunter	0.0481	(0.030)	1.049	(0.032)
Primary school	-0.0702*	(0.037)	0.932*	(0.034)
Lower middle school	-0.100***	(0.034)	0.905***	(0.030)
Upper middle school	-0.210***	(0.039)	0.810***	(0.032)
Technical/vocational degree	-0.189***	(0.045)	0.827***	(0.037)
University degree or higher	-0.215***	(0.044)	0.806***	(0.035)
Annual individual income (000)	-0.000472	(0.000)	1	(0.000)
Annual household income (000)	0.000256	(0.000)	1	(0.000)
Owner-occupied household	-0.00541	(0.030)	0.995	(0.029)
Constant	0.417***	(0.085)	1.518***	(0.129)
Number of Observations	2543			
Pseudo-R^2	0.058			

Notes:

The fixed effects for province and municipalities are not reported.

OCP, one-child policy.

***p<0.01, **p<0.05, *p<0.1.

Amongst the control variables, being eligible to have two children has a significant and positive impact on fertility, raising the expected number of children by 22 per cent. However, the OCP strength at the community level does not have a significant influence on individual fertility. The fertility rate is also higher for women with more siblings, while working in off-farm jobs and having higher education are estimated to lower fertility, especially for those who gained formal qualifications beyond the level of lower middle school qualification (the compulsory education level in China). Income, marriage status and housing tenure are estimated to have no significant impact on fertility.[15]

The inference to be drawn from Table 2 is that urban fertility is lower than rural fertility in China, under both the de facto and de jure urban-rural criteria, and the differences remain statistically significant after we account for socio-economic factors and family planning policy. However, there are possible nuances to this conclusion. For example, more urbanized areas may provide more opportunities to gain higher education and off-farm jobs, so these negative effects of control variables should be partially attributed to urban residence. To further study the fertility gap between urban and rural women, we next turn to regression decompositions to break the observed differences into two parts, the portion that can be explained by differences in characteristics and the portion that is unexplained.

2.4.2 Decomposition using Regressions

Because fertility is a count variable, we decompose the fertility gap between urban and rural women into explained and unexplained parts by applying Blinder-Oaxaca decompositions using the method for count data models developed by Bauer, Goehlmann and Sinning (2007) and made available as a *Stata* estimator by Sinning, Hahn and Bauer (2008). An overview of generalized linear decomposition, based on the treatment in Oaxaca and Ransom (1994), is:

$$\bar{Y}_{\mathrm{A}} - \bar{Y}_{\mathrm{B}} = (\bar{X}_{\mathrm{A}} - \bar{X}_{\mathrm{B}})\beta^{*} + \bar{X}_{\mathrm{A}}(\beta_{A} - \beta^{*}) + \bar{X}_{\mathrm{B}}(\beta^{*} - \beta_{B}). \quad (3)$$

[15] The effects from the province and municipalities are controlled but not reported in the table. It is estimated that women in Heilongjiang, Liaoning and Jiangsu had the lowest fertility and women in Henan, Guangxi and Guizhou had the highest after accounting for socio-economic characteristics and policy effects.

In the nonlinear case it is:

$$\bar{Y}_A - \bar{Y}_B = \{E_{\beta^*}(Y_{iA}|X_{iA}) - E_{\beta^*}(Y_{iB}|X_{iB})\} + \{E_{\beta_A}(Y_{iA}|X_{iA}) - E_{\beta^*}(Y_{iA}|X_{iA})\} + \{E_{\beta^*}(Y_{iB}|X_{iB}) - E_{\beta_B}(Y_{iB}|X_{iB})\} \quad (4)$$

where group A represents the majority group with higher outcomes, and B the minority group with lower outcomes (Sinning, Hahn & Bauer, 2008). In our context, group A is rural women, with higher fertility and a larger sample proportion, and group B is urban women. The first term in Equation (3) reflects the portion of the fertility gap that is owing to differences in characteristics. The next two terms reflect the difference due to coefficients, which may indicate an advantage for rural women $\{E_{\beta_A}(Y_{iA}|X_{iA}) - E_{\beta^*}(Y_{iA}|X_{iA})\}$, while for urban women, $\{E_{\beta^*}(Y_{iB}|X_{iB}) - E_{\beta_B}(Y_{iB}|X_{iB})\}$ indicates any disadvantage in terms of fertility. β^* is defined as a weighted average of the coefficient vectors β_A and β_B: $\beta^* = \Omega\beta_A + (I - \Omega)\beta_B$, where Ω is a weighting matrix and ***I*** is an identity matrix.

Different assumptions about the form of Ω can be considered. If it is assumed that Ω is an identity matrix, one obtains the usual Oaxaca decomposition (Oaxaca, 1973), where the difference in characteristics is valued using the coefficients from the rural model for fertility. Another widely used assumption is that Ω = 0 (Blinder, 1973), so the coefficients from the urban model are used to value the difference in characteristics. In addition to these two popular approaches, Reimers (1983) proposes the weighting matrix **Ω** = 0.5***I***, which defines β^* to be a simple average of the estimated coefficients for the two groups, Cotton (1988) chooses the weighting matrix **Ω** = *s****I***, where *s* denotes the relative sample size of the majority (rural) group; and Neumark (1988) and Oaxaca and Ransom (1994) propose a pooled model to derive the counterfactual coefficient vector β^*. Another intuitive decomposition considers the coefficient on the group indicator variable in the full regression (pooling urban and rural women together) as measuring the unexplained gap (Elder, Goddeeris, & Haider, 2010).

In this research, there is no reason to favour one assumption about the form of Ω over the other. We apply all six decompositions to provide robust inferences about the importance of characteristics versus coefficients in explaining the fertility gap.[16] The results are reported in Table 3, with the top panel showing the decomposition of fertility gaps between urban and rural residents, and the bottom panel the gaps between urban and rural *hukou* holders.[17] In our context, the majority group and advantage will refer to the rural women in both panels.

The raw gap in average fertility of urban and rural residents is 1.58−1.11 = 0.47 (see Table A1). If the mean values of characteristics for rural residents are combined with the coefficients for urban residents, the gap in mean fertility would close by 0.38 children, which is 80.8 per cent of the total gap. The differences in average characteristics appear even more important when the coefficients for rural residents are used, with 90.1 per cent of the fertility gap explained. The upper bound for the explained gap is from the pooled model method derived by Neumark (1988), which shows that 93.3 per cent of the raw difference in urban-rural fertility is due to the different characteristics of urban and rural women. Thus, almost all of the lower fertility of female urban residents is due to their different characteristics, compared with those of rural women, with very little of the gap due to an unexplained 'structural' effect of urban living.

---

[16] The Stata command *nldecompose* provided by Sinning *et al.* (2008) gives the opportunity to do this, for five of the methods. We also adapt the Elder *et al.* (2010) method, which was based on continuous outcomes, by using the marginal effect from the Poisson regression on the group indicator to measure the unexplained gap in fertility, where the indicator variable equals one for women who are the urban residents (or urban *hukou* holders) and zero otherwise.

[17] The regressions for the subsamples used by the decompositions are listed in Appendix 2.

Table 3: Decomposition of the Urban/Rural Gaps in Fertility using Six Different Formulations of the Counterfactual Case

	Explained gap		Unexplained gap		
	Size	Percentage of total		Size	Percentage of total
Urban residence, gross difference = 0.47					
Pooled model (Elder)	0.402	85.53		0.068	14.47
Rural model (Ω =1)	0.424	90.11		0.047	9.89
Urban model (Ω =0)	0.380	80.81		0.090	19.19
Simple average (Ω =0.5)	0.401	85.24	Advantage	0.051	10.88
			Disadvantage	0.018	3.89
Weighted average (Ω =0.6)	0.406	86.15	Advantage	0.042	8.96
			Disadvantage	0.023	4.89
Pooled model (Neumark)	0.439	93.32	Advantage	0.013	2.69
			Disadvantage	0.019	3.99
Urban hukou, gross difference=0.56					
Pooled model (Elder)	0.319	56.96		0.241	43.04
Rural model (Ω =1)	0.320	56.94		0.242	43.06
Urban model (Ω =0)	0.463	82.34		0.099	17.66
Simple average (Ω =0.5)	0.394	70.08	Advantage	0.058	10.28
			Disadvantage	0.110	19.64
Weighted average (Ω =0.54)	0.389	69.17	Advantage	0.054	9.64
			Disadvantage	0.119	21.19
Pooled model (Neumark)	0.468	83.30	Advantage	0.044	7.75
			Disadvantage	0.050	8.95

The raw gap in fertility between urban and rural *hukou* holders is 0.56, and this gap is less explained by the differences in average characteristics of the two groups. The lower panel of Table 3 shows that if rural *hukou* holders had the characteristics of urban *hukou* holders and kept their own coefficients, the fertility gap would be closed by 0.32 children, accounting for 56.9 per cent of the raw difference. This is almost the same size as the explained gap estimated by the Elder, Goddeeris and Haider. (2010) decomposition method. The counterfactual results based on the assumptions of Ω =0.5 and Ω =0.54 (the share of rural *hukou* holders in the sample) show about seventy per cent of the raw difference can be attributed to differences in the characteristics. It is only when the urban coefficients are used, or when the Neumark (1988) approach to using a pooled model is used, that about 80 per cent of the fertility gap is explained by differences in characteristics. Thus, compared with decomposing urban-rural gaps by place of residence, when they are decomposed by *hukou* status, the gap is both larger and less explained by differences in characteristics.

In addition to showing the overall importance of characteristics versus coefficients, some of the decompositions can also be used to allocate the unexplained differences between the two groups. Looking at the counterfactual results based on the assumptions of simple average and weighted average for the weighting matrix, if urban and rural women are classified by their residence status, rural life gives a fertility advantage of around ten per cent of the gap between urban and rural fertility rates, while urban life gives a fertility disadvantage of about four to five per cent of the gap. For the classification based on *hukou* status, however, something inherently disadvantageous about urban *hukou* contributes much more to the unexplained gap; using the weighted average, the fertility disadvantage of urban *hukou* is equivalent to 21.2 per cent of the total urban-rural fertility gap (and to 19.6 per cent of the gap if using the simple average weighting matrix). The urban *hukou* fertility disadvantages are about twice as large as are the fertility advantages for agricultural *hukou* holders.

The decomposition results show that most of the differences between the fertility of female urban residents and female rural residents can be explained by differences in their characteristics (including different OCP rules). The different methods of decomposition do not really matter to this claim, with the explained share of the gap ranging from 81 to 93 per cent. However, if we compare fertility of urban and rural *hukou* holders, less of the gap is explained by different characteristics (on average, just 70 per cent is explained) and the different decomposition methods give a wider range of results. This suggests there is something inherent for urban *hukou* holders that causes lower fertility than for rural *hukou* holders compared with the situation for urban residents versus rural residents.

2.5 Discussion and Conclusions

China's current fertility rate is below replacement level, and the government has begun to make changes in an attempt to increase this rate, including by relaxing the family planning policy to let every couple have two children. However, given that China is becoming more urban, and that urban fertility is lower than rural fertility, it is important to examine whether urbanization might drag down future fertility. Indeed, to the extent that there may be something inherent in urban life that reduces fertility, China would seem to face a difficult policy trade-off because it needs to keep urbanizing in order to become richer but this urbanization may further depress fertility, and sub-replacement fertility will be a drag on future economic growth.

In this research, we decomposed China's rural-urban fertility gaps. Our results suggest that the trade-off is more apparent than real. Some of the lower fertility of urban women may be due to the rigidities imposed by *hukou* status, which matters far more to fertility than does the issue of where they reside. In other words, if rural women with agricultural *hukou* move to the city, the expected reduction in their fertility is much less than what is expected when an agricultural *hukou* holder converts to non-agricultural *hukou* (irrespective of whether they live in urban or rural areas). Because *hukou* registration is an idiosyncratic and legal feature of China rather than a fundamental socio-economic constraint, it could be reformed by China's policy-makers to weaken these possible trade-offs between goals of encouraging urbanization and encouraging higher fertility. Indeed, amongst the many reasons to reform *hukou* (Chan & Wan, 2017) the possible positive impact on fertility is not one that has been highlighted previously.[18]

Our decompositions show that most of the fertility gap between urban and rural areas can be attributed to the difference in the average characteristics of women living in each type of area. In contrast, more of the gap remains unexplained if we compare women with different *hukou* status. In other words, even if the covariates that we control for were changed so that they take on the average values for women with agricultural *hukou* – and these covariates include the different family planning rules that women were exposed to over time – for women with non-agricultural *hukou* their fertility would still remain considerably lower than for the agricultural *hukou* women. Because our decomposition also controls for location (and in turn, when studying location gaps it controls for *hukou* status), the size of the remaining unexplained gap suggests that there is an unobserved effect that leads to low fertility amongst non-agricultural *hukou* holders. Because most of the women in urban areas hold non-agricultural *hukou*, the previous literature that has not distinguished between China's de facto and de jure classifications of the urban and rural population will tend to attribute this *hukou* effect to an effect of urban life on fertility.

Our data come from the CHNS, which longitudinally follows the same households (even though we focus only on the latest and largest wave), so it is

[18] An alternative interpretation suggested by a referee is that China's policy-makers could allow more rural women to move to cities without changing their *hukou* status and this may reduce fertility by less than if *hukou* status was changed. However, there are welfare costs for people who live in cities without the non-agricultural *hukou*, so this is not a policy we would recommend.

possible that migrants who frequently change addresses will be under-represented in our sample. These migrants are more likely to be people who do not change their *hukou* status even as they move from rural to urban areas, and their fertility behavior may be more like that of rural women than urban women if this potentially under-sampled group are migrants who circulate between urban and rural areas. Thus, if there is any sampling bias in our study, it would be in the direction of finding a larger gap between the fertility of women in urban and rural areas than might exist if these short-term migrants were fully covered. This suggests, once again, that the apparent policy trade-off between encouraging continued urbanization and raising the fertility rate may be smaller than it appears.

References

Bauer, T. K., Goehlmann, S. & Sinning, M. (2007). Gender differences in smoking behaviour. *Health Economics*, *16*(9), 895-909.

Blinder, A. S. (1973). Wage discrimination: Reduced form and structural estimates. *Journal of Human Resources, 8*(4), 436–455.

Cai, Y. (2010). China's below-replacement fertility: Government policy or socioeconomic development? *Population and Development Review, 36*(3), 419-440.

Cai, F. & Lu, Y. (2016). Take-off, persistence and sustainability: The demographic factor in Chinese growth. *Asia & the Pacific Policy Studies*, *3*(2), 203-225.

Chan, K.W. & Wan, G. (2017). The size distribution and growth pattern of cities in China, 1982–2010: analysis and policy implications. *Journal of the Asia Pacific Economy*, *22*(1), 136-155.

Cotton, J. (1988). On the decomposition of wage differentials. *Review of Economics and Statistics, 70*(2), 236–243.

Elder, T.E., Goddeeris, J.H. & Haider, S. J. (2010). Unexplained Gaps and Oaxaca-Blinder Decompositions. *Labour Economics, 17*, 284-290.

Fang, H., Eggleston, K. N., Rizzo, J. A., & Zeckhauser, R. J. (2013). Jobs and kids: female employment and fertility in China. *IZA Journal of Labor & Development, 2*(1), 1-25.

French, H. (2016). China's Twilight Years. *The Atlantic* June Issue. https://www.theatlantic.com/magazine/archive/2016/06/chinas-twilight-years/480768/

Guo, Z., Wu, Z., Schimmele, C. M., & Li, S. (2012). The effect of urbanization on China's fertility. *Population Research and Policy Review, 31*(3), 417-434.

Kulu, H. (2013). Why do fertility levels vary between urban and rural areas? *Regional Studies, 47*(6), 895-912.

Liang,Y. & Gibson, J. (2017). Do siblings take your food away? Using China's One-Child Policy to test for child quantity-quality trade-offs. *China Economic Review*. https://doi.org/10.1016/j.chieco.2017.10.006

Liu, H., Rizzo, J. A., & Fang, H. (2015). Urban-rural disparities in child nutrition-related health outcomes in China: The role of hukou policy. *BMC Public Health, 15*, 1159

Neumark, D. (1988). Employers' discriminatory behavior and the estimation of wage discrimination. *Journal of Human Resources, 23*(3), 279–295.

Oaxaca, R. L. (1973). Male–female wage differentials in urban labor markets. *International Economic Review, 14*(3), 693–709.

Oaxaca, R. L. & Ransom, M. R. (1994). On discrimination and the decomposition of wage differentials. *Journal of Econometrics*, *61*(1), 5-21.

Peng, X. (2011). China's demographic history and future challenges. *Science, 333*(6042), 581-7.

Reimers, C. W. (1983). Labor market discrimination against hispanic and black men. *Review of Economics & Statistics, 65*(4), 570-579.

Sinning, M., Hahn, M. & Bauer, T. (2008). The Blinder–Oaxaca decomposition for nonlinear regression models. *Stata Journal, 8*(4), 480-492.

United Nations, Department of Economic and Social Affairs, Population Division. (2015). *World Population Prospects: The 2015 Revision, Volume I: Comprehensive Tables* (ST/ESA/SER.A/379).

World Bank. (2016). *World Development Indicators*. Retrieved from http://data.worldbank.org

Xinhua Net (Chinese). (2015). Retrieved from http://news.xinhuanet.com/health/2015-10/30/c_128374158.htm

Appendix 1: Summary Statistics for the Estimation sample, China Health and Nutrition Survey, 2011

	Categorized by Location		*Categorized by hukou*	
	Rural	*Urban*	*Rural*	*Urban*
Fertility	1.58	1.11	1.65	1.09
Urban residence			11.23%	73.73%
Urban *hukou*	20.39%	85.04%		
Eligibility for having two children	72.37%	43.40%	72.71%	46.86%
Community OCP strength	62.16%	35.57%	63.10%	38.02%
Mean age	40.27	40.35	40.08	40.56
Age range [20,25)	5.20%	1.86%	6.02%	1.36%
Age range [25,30)	8.82%	9.68%	9.02%	9.32%
Age range [30,35)	10.26%	14.57%	9.83%	14.49%
Age range [35, 40)	18.09%	18.28%	17.53%	18.90%
Age range [40, 45)	24.21%	21.99%	24.36%	22.12%
Age range [45, 50)	25.99%	24.93%	26.85%	24.07%
Age range [50, 52]	7.43%	8.70%	6.38%	9.75%
Currently married	98.42%	95.70%	98.83%	95.59%
Number of siblings	3.14	2.33	3.28	2.27
Not employed	21.05%	16.52%	20.69%	17.54%
Working in other occupations	41.51%	81.33%	36.68%	81.61%
Working as a farmer, fisherman or hunter	37.43%	2.15%	42.63%	0.85%
No qualification	11.58%	3.03%	13.87%	1.53%
Primary dchool	23.55%	4.40%	25.09%	5.17%
Lower middle school	45.13%	23.56%	46.52%	24.83%
Upper middle school	10.59%	21.90%	9.24%	21.95%
Technical/vocational degree	4.14%	13.78%	2.86%	13.98%
University degree or higher	5.00%	33.33%	2.42%	32.54%
Annual individual income (000)	16.45	29.08	15.09	28.97
Annual household income (000)	47.95	68.47	41.82	72.83
Owner-occupied household	96.18%	84.26%	96.18%	85.85%
Beijing	4.54%	19.75%	5.50%	16.61%
Liaoning	6.12%	2.54%	4.84%	4.49%
Heilongjiang	10.72%	6.84%	11.89%	6.02%
Shanghai	3.75%	17.50%	1.91%	17.80%
Jiangsu	11.12%	6.35%	9.10%	9.32%
Shandong	8.55%	6.45%	8.07%	7.29%
Henan	11.32%	6.84%	13.28%	5.17%
Hubei	11.05%	6.84%	10.71%	7.80%
Hunan	8.42%	5.87%	7.63%	7.12%
Guangxi	13.95%	6.84%	14.53%	7.12%
Chongqing	7.89%	10.75%	9.54%	8.47%
Guizhou	2.57%	3.42%	3.01%	2.80%
Number of observations	1,520	1,023	1,363	1,180

Appendix 2: Poisson Regressions of Fertility on Urban Life by Subgroups, China Health and Nutrition Survey, 2011

	Categorized by Location		*Categorized by hukou*	
	Rural	*Urban*	*Rural*	*Urban*
Urban residence			-0.00506	-0.0459
			(0.035)	(0.031)
Urban *hukou*	-0.127***	-0.193***		
	(0.035)	(0.042)		
Eligibility for having 2 children	0.281***	0.0896**	0.251***	0.157***
	(0.037)	(0.039)	(0.039)	(0.038)
Community OCP strength	-0.0515	-0.0217	-0.121	0.0586
	(0.078)	(0.082)	(0.079)	(0.080)
Age range [20,25)	-0.591***	-0.639***	-0.672***	-0.538***
	(0.098)	(0.176)	(0.100)	(0.199)
Age range [25,30)	-0.403***	-0.300***	-0.440***	-0.279***
	(0.071)	(0.084)	(0.074)	(0.082)
Age range [30,35)	-0.221***	-0.0483	-0.271***	-0.0143
	(0.062)	(0.067)	(0.066)	(0.062)
Age range [35, 40)	-0.154***	0.0269	-0.208***	0.0930*
	(0.059)	(0.061)	(0.065)	(0.055)
Age range [40, 45)	-0.152***	0.0308	-0.191***	0.0685
	(0.056)	(0.060)	(0.061)	(0.056)
Age range [45, 50)	-0.0151	0.0119	-0.0668	0.0667
	(0.054)	(0.057)	(0.059)	(0.053)
Number of siblings	0.0133*	0.0268***	0.0133*	0.0311***
	(0.008)	(0.008)	(0.008)	(0.008)
Currently married	0.122	-0.0572	0.0756	-0.035
	(0.085)	(0.070)	(0.089)	(0.070)
Working in other occupations	-0.0632*	-0.0515	-0.0686**	-0.0715*
	(0.033)	(0.041)	(0.034)	(0.043)
Working as a farmer, fisherman or hunter	0.0382	0.0461	0.0246	0.234*
	(0.034)	(0.086)	(0.034)	(0.120)
Primary school	-0.0445	-0.174*	-0.0807**	0.0346
	(0.040)	(0.093)	(0.039)	(0.118)
Lower middle school	-0.0737**	-0.216***	-0.0958***	-0.0828
	(0.037)	(0.083)	(0.036)	(0.108)
Upper middle school	-0.199***	-0.278***	-0.233***	-0.145
	(0.047)	(0.087)	(0.049)	(0.109)
Technical/vocational degree	-0.137**	-0.309***	-0.196**	-0.175
	(0.068)	(0.088)	(0.083)	(0.109)
University degree or higher	-0.309***	-0.297***	-0.147*	-0.219*
	(0.074)	(0.089)	(0.077)	(0.112)
Annual individual income (000)	8.72E-05	-0.00126***	-8.7E-06	-0.00114**
	(0.001)	(0.000)	(0.001)	(0.000)
Annual household income (000)	0.000157	0.000515**	-6.5E-05	0.000752***
	(0.000)	(0.000)	(0.000)	(0.000)
Owner-occupied household	-0.00909	-0.0136	0.0366	-0.0502
	(0.054)	(0.035)	(0.062)	(0.033)
Constant	0.290**	0.476***	0.372***	0.167
	(0.125)	(0.128)	(0.132)	(0.139)
Number of Observations	1,520	1,023	1,363	1,180
Pseudo-R^2	0.057	0.027	0.049	0.025

Notes:

The fixed effects for provinces and municipalities are not reported.

OCP,one-child policy.

****p*<0.01, ***p*<0.05, **p*<0.1.

Chapter 3[19]

Do Siblings Take Your Food Away?

Using China's One-Child Policy

to Test for Child Quantity-Quality Trade-offs

Yun Liang and John Gibson

Yun Liang

PhD Student, Economics Department
University of Waikato
Private Bag 3105
Hamilton, New Zealand, 3240.

Tel: + 64 (0)7 838 4289

Email: lysh8@hotmail.com

John Gibson

Economics Department
University of Waikato
Private Bag 3105
Hamilton, New Zealand, 3240.

Tel: + 64 (0)7 838 4289

Email: jkgibson@waikato.ac.nz

[19] This has published in *China Economic Review* (Liang & Gibson, 2017b).

Do Siblings Take Your Food Away?

Using China's One-Child Policy

to Test for Child Quantity-Quality Trade-offs

Abstract

We test for the existence of a trade-off between child quantity and child quality in Chinese families. We use changes over time and space in the local stringency of the one-child policy as a source of exogenous variation in family size. Investment in child quality is measured by intake of three nutrients, using seven waves of data from the China Health and Nutrition Survey. For all three nutrients, a quantity-quality trade-off is apparent, which persists for fats if child-specific effects are introduced. The trade-off would be less apparent if exogenous sources of variation in family size were ignored.

Keywords: Child quality, Nutrients, One-Child Policy, Quantity-Quality trade-off, China

JEL Classifications: I12, J13, O15

Acknowledgements

This research uses data from China Health and Nutrition Survey (CHNS). We thank the National Institute for Nutrition and Health, China Center for Disease Control and Prevention, Carolina Population Center (P2C HD050924, T32 HD007168), the University of North Carolina at Chapel Hill, the NIH (R01-HD30880, DK056350, R24 HD050924, and R01-HD38700) and the NIH Fogarty International Center (D43 TW009077, D43 TW007709) for financial support for the CHNS data collection and analysis files from 1989 to 2015 and future surveys, and the China-Japan Friendship Hospital, Ministry of Health for support for CHNS 2009, Chinese National Human Genome Center at Shanghai since 2009, and Beijing Municipal Center for Disease Prevention and Control since 2011. We are grateful to helpful comments from participants at the ESPE conference, and especially Steven Stillman. We also thank the Human Ethics Committee of the Waikato Management School for ethical approval.

3.1 Introduction

For decades, the relationship between the number and quality of children in a family has been of interest to demographers and economists. The quantity-quality trade-off theory suggests a negative relationship between the two, stating that “an increase in quality is more expensive if there are more children because the increase has to apply to more units” and “an increase in quantity is more expensive if the children are of higher quality, because higher-quality children cost more” (Becker & Lewis 1973, p.S280). This theory, plus evidence that children from larger families tend to have worse outcomes, underpins many interventions in developing countries where fertility rates may be considered too high to enable sustainable economic development (Angrist, Lavy, & Schlosser, 2010). In particular, it is expected that policies discouraging large families should lead to increased human capital, which will result in higher lifetime earnings and better life outcomes at the individual level and will contribute to faster economic development in the aggregate.

Despite the importance of the quantity-quality trade-off theory, empirical evidence for these relationships is mixed. Li, Zhang and Zhu (2008) point out that the trade-off is more likely in developing countries, where parents bear a larger share of child rearing cost than in developed countries where the welfare state may subsidize these costs. Empirical research is also complicated by the fact that both the number of children and the investment in each child are choice variables. Thus, studies treating family size as exogenous may not uncover causal effects. To get around this problem, many studies seek to exploit exogenous variation in fertility. For example, Rosenzweig and Wolpin (1980), Li *et al.* (2008), Angrist *et al.* (2010) and Abdul-Razak, Abd Karim, and Abdul-Hakim (2015) use multiple births, while Conley and Glauber (2006), Lee (2008), and Angrist *et al.* (2010) use the gender composition of early births.[20] One contributor to exogenous variation in family size, which this paper uses, is the changing stringency of family planning policy (Huang, 2015; Liu, 2014; Qian, 2009; Zhang, Xu, & Liu, 2016). Another complication comes from the measures of child quality; sometimes a trade-off is apparent for one measure of child quality but is very weak for another, even with the same data and empirical methods (Black, Devereus, & Salvanes, 2005; Liu, 2014).

This paper tests for a trade-off between the quantity and quality of children in China. Intakes of three nutrients are used as the measure of child quality. Two approaches are used to get around endogeneity problems and to control unobserved heterogeneity. First, we use the one child policy (hereafter, OCP) in China as a source of exogenous variation in family size in two-stage least squares (2SLS) models. Second, we use fixed effects (FE) models to examine how changing sibling numbers affects nutrient intakes, allowing for unobserved heterogeneity of children. In other words, the longitudinal data let us examine within-child variation over time, to allow for child-specific responses that could bias cross-sectional results if there are unobservable factors that confound comparisons of outcomes prior to, and after, a change in family size. A further advantage of the FE approach is that it is not affected by the weakening identification power of the OCP after 1997 as restrictions were gradually relaxed. With results from these two methods in conjunction, we provide a comprehensive test for the existence of a quality-quantity trade-off.

[20] Bhalotra and Clarke (2016) note that twins may not be quasi-random, due to positive selection of healthier women into twinning. Studies that ignore this form of selection may be biased in the direction of not finding a quantity-quality trade-off even when it exists.

The differing strength of the OCP over time and space aids the analysis by providing a source of identifying fertility variation. For example, the total fertility rate fell dramatically, from over three before the introduction of the policy to just above 1.5 by 2006.[21] Amongst children in our estimation sample, only a quarter were from one-child families in 1991 but almost one half were by the year 2000. Also, boys have a higher probability of being the only-child than do girls, in all survey waves. This difference is very likely due to OCP exceptions that allowed families to have a second birth if the first child is a girl, and highlights the policy-induced variation in family structure.

The measures of child quality used in this paper are children's intakes of dietary energy, protein, and fat. Prior studies using the OCP as a source of exogenous variation in family size use education and health outcomes as the indicators of child quality. For example, Liu (2014) uses children's height-for-age and Huang (2015) uses enrolments in post-compulsory schooling while earlier studies for China, with different identification approaches, focus on similar health and education outcomes (Li *et al.*, 2008; Lu & Treiman, 2008; Rosenzweig & Zhang, 2009). Although less studied, nutrient intakes are not only measures of parental investment in children, they are also important inputs into human capital that have their own long-term impacts (Behrman, Deolalikar, & Wolfe, 1988). We contend that nutrients directly reflect how resources are allocated to each child, and give a good testing ground for the quantity-quality trade-off theory. Compared to educational and health outcomes, nutrient intakes are less affected

[21] Total fertility rate is "the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with current age-specific fertility rates" (The World Bank). Appendix 1 shows the total fertility rate of China from 1977 to 2009.

by unobserved personal factors, such as ability and genetics. Thus, in conjunction with the exogenous variation over time and space due to differing strength of the OCP, the use of these novel indicators of investment in children may provide more robust tests of the quantity-quality trade-off than in the existing literature.

In testing for a quantity-quality trade-off, we also shed light on factors influencing the fertility level, with the first-stage equation of the 2SLS approach predicting sibling numbers. Building on Liu (2014), in this paper we define a dynamic measure of OCP strength that accounts for the change in local OCP regulations and how the changes affect local women's eligibility to have a second child. This indicator, along with urban *hukou* status and the local development level, are estimated to be significant influences on fertility .

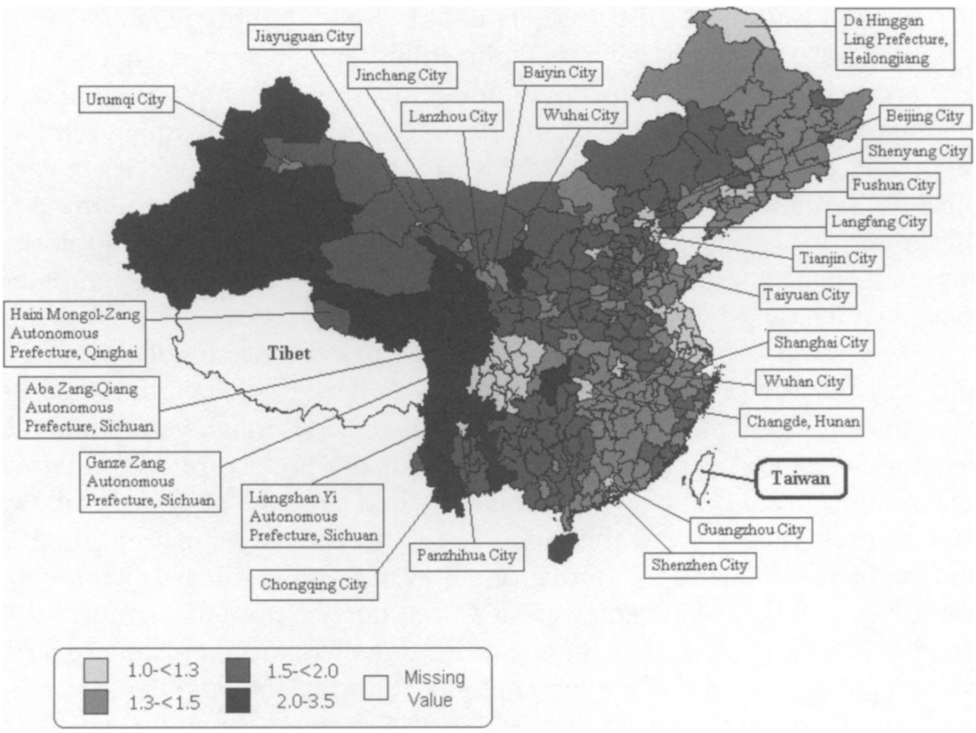
The remainder of the paper is structured as follows: Section 3.2 provides a brief review of the one-child policy, while Section 3.3 discusses the empirical methods. Section 3.4 describes the CHNS data we use, paying particular attention to the measures of OCP strength and the nutrient intakes. Section 3.5 reports the regression results and the discussion and conclusions are in Section 3.6.

3.2 Background to the One-Child Policy

The one-child policy was introduced in 1979, and originally limited all couples in China to strictly one child. After four years, the OCP was decentralized and started to become less restrictive (Greenhalgh, 1986), possibly in response to various problems caused by the initial policy, including rapid growth in the number of abortions (Hesketh, Lu, & Xing, 2005). Starting in 1984, different exceptions to the strict rule of one child per couple were introduced, and these were applied in different areas, and also changed over time.

The decentralized OCP is represented in Figure 1 by the metric of "policy fertility" as reported by Gu, Wang, Guo and Zhang (2007). Policy fertility is the fertility levels that would obtain locally if married couples had births at exactly the levels permitted by local policy. The data in the figure are for 420 prefecture-level units in China in the late 1990s, with areas given a darker shade representing those where more couples were allowed to have more than one child. There was clearly large variation across the country, with parts of western China having policy fertility rates between 2.0 and 3.5, compared with much of central and southern China where the policy fertility rates were from 1.3 to 2.0. Only small parts of the country (albeit, areas with dense populations) had policy fertility rates that were as low as from 1.0 to 1.3.

Figure 1: Geographic Distribution of Policy Fertility at the Prefecture Level, China, late 1990s



Source: Gu, B, Wang, F, Guo, Z and Zhang, E (2007) 'China's Local and National Fertility Policies at the End of the Twentieth Century' *Population and Development Review*, 33(1) pp.143, Figure 2.

Further relaxation and decentralization followed in 1997 with the 'Opinion of the Ministry of Public Security on Improving the Administrative System of *hukou* in Rural Areas'. This Ministry controls the *hukou* registration system and provides identity booklets. The 1997 changes permitted out-of-plan children and the children of unmarried couples to receive birth registration, further reducing effects of family planning policy on fertility (Li, Zhang, & Feldman, 2010). However, some provinces still required the local Public Security Department to be notified of unsanctioned births in order for babies to be registered, or needed similar documentation from the Population and Family Planning Bureau to allow birth registration (Li, Zhang, & Feldman*,* 2010). Thus it remained true that for many Chinese parents the OCP remained an important exogenous factor affecting their number of children.

In 2002, the Law on Population and Family Planning was adopted and formalised the family planning principle of "advocate one-child per couple" while allowing local exceptions for a second child (The Legislative Affairs Commission of the Standing Committee of the National People's Congress of the People's Republic of China, 2002). Under the 2002 law, couples volunteering to have only one child regardless of the local exceptions get a "Certificate of Honour for Single-Child Parents" and are eligible for small cash rewards until their child is a certain age. On the other hand, couples who have more children than local policy allows need to pay a social maintenance fee for the unsanctioned birth(s), which is often a multiple of the previous year's average household disposable income in the area where they live.

In this research, we use survey data collected between 1991 and 2009. Over these two decades the strength of the one-child policy varied considerably.

Thus we are able to examine impacts on children who had been born in periods when the OCP had been strictly applied, and also when it had been somewhat relaxed, in addition to variation over space in the stringency of the policy. We successfully match each child to a mother, and hence are able to see how the OCP applied to the mother, given her birth history and the status of her and her children. Consequently, the impacts from the OCP on the number of siblings of the sample children are well captured in these survey data.

While it is outside of our sample period, it is worth noting the recent changes to China's family planning policy that let all legally married couples have two children notwithstanding all of the limitations introduced in previous regulations (Xinhua Net, 2015). This large break from previous policy heralds the end of the one-child policy but not necessarily the end of attempts by policy makers in China to intervene into fertility decisions. In other words, the number of children is still not a completely free choice of the parents, unlike in most of the rest of the world. The official end of the OCP also bookends a generation of children, born between 1980 and 2015, where many of them grew up without any siblings. For example, the share of children from sole-child families in our sample increased from about one-quarter in 1991 to over one-half by 2006, and in urban areas exceeded 70% in that year. Thus it is not exaggerating to think of the OCP as one of the largest policy-induced natural experiments in human history.

3.3 Empirical Methods

We start by regressing nutrient intakes on the number of children, along with other control variables, using Ordinary Least Squares (OLS). We initially ignore the panel structure of the data. Most previous studies do not have panel data so we want to see if the lack of controls for unobservable fixed effects makes prior studies more likely to find a trade-off between quantity and quality that disappears once fixed effects are introduced.

Following the recent literature, our general estimation approach is as seen below:

$$Nut = \propto_0 + \propto_1 Sibling + \propto_2 X + \propto_3 Z + \varepsilon \quad (1)$$

where *Nut* is the vector of intakes of energy, protein and fat for each child. The vector *X* has a set of child characteristics, including gender, age (in quadratic form), whether first-born, *hukou* status, and province of residence. We use the urban/rural status from the *hukou* registration (a *de jure* measure) because the OCP restrictions are based on *hukou* status.[22] Also, the social benefits system provides differential access to food subsidies, and to education and health facilities, based on registration status rather than on residency. The vector *Z* has the years of education of the parents, the median nutrient intake levels of adults in each community, the median household per-capita income (in 2009 prices), and a local development index based on 12 community-level attributes.[23]

The main focus is the coefficient $\propto_1$ on the variable *Sibling*, for how many siblings the child had at the time of the survey (aged under 18 and living in the same household). A negative coefficient suggests a trade-off between child quantity and quality. With OLS this can only be interpreted as a conditional

---

[22] About 12% of children live in a different sector (urban or rural) than the sector of registration. See Appendix 2 for details.

[23] The index is designed by the CHNS team as an urbanicity scale, which is constructed from 12 community level indicators of: population density, education, sanitation, housing, transportation infrastructure, communications, health infrastructure, traditional market development, economic activitiy, diversity, modern markets and social services. The details of the construction of the scale can be found in Jones-Smith & Popkin (2010).

correlation since family size may be endogenous (Black *et al.,* 2005; Li *et al.,* 2008; Liu, 2014). Therefore, in this research we also use instrumental variables (IV) and fixed effects (FE) approaches to get around this problem.

We use the community level OCP strength as the identifying instrument in the first stage regression for sibling numbers, with the same control variables as in equation (1):

$$Sibling = \beta_0 + \beta_1 OCP + \beta_2 X + \beta_3 Z + \delta \quad (2)$$

The variable *OCP* is the share of women in the community eligible to have two children under the local OCP at any stage up to one year prior to the survey (for ever-married women aged from 20 to 49). During the period covered by the data, a legally married woman in China could have an extra child if she satisfied the exceptions imposed by the local implementation of the OCP.[24] Since women can choose to have their second child at any time after meeting the conditions for the exception, we follow Liu (2014) in defining a woman as eligible to have two children if she met the OCP conditions at any stage up to the year prior to the survey. The following four OCP exceptions are included, also noting the birth gap constraints, *hukou* constraints, and the age constraints for the mothers:

a. whether the community allowed all women to have two children
b. whether the community allowed women to have two children if the first child was a girl, called the 'girl-exception'

[24] Marriage is the traditional and legal pre-condition of child bearing in China. The legal marriage age is 20 for women and 22 for men from 1980 onwards, and was 18 for women and 20 for men between 1950 and 1980. Children born with either parent under the age limit will be considered an illegal birth.

c. whether the community allowed women to have two children if both parents are only-children, or one parent is only-child, or one parent and both grand-parents are only-children, called the 'only-child-exception'
d. whether the community allowed women to have two children if the parents worked in special occupations, called the 'occupation-exception'.[25]

For example, if a woman had a daughter and lived somewhere with the girl-exception and the birth gap constraint was four years, then the woman is defined to be eligible to have two children when her daughter reached the age four. If she became eligible in 1992, then her status will be 'yes' from the 1993 survey wave onwards. We then define the local OCP strength as the proportion of women in each community who were eligible to have two children according to the above rules, denominating by the number of ever-married women aged from 20 to 49. Higher values of this measure indicate more relaxed local regulations for the women in the communities, and this should be positively related to the number of siblings. Moreover, by controlling for the local development index, and for nutrient intakes of adults, any potential correlation between parental preferences for child quality and the relaxation of the OCP is controlled for, so the variation in the measure of OCP strength should have no direct impact on child nutrient intakes except via its impact on fertility choice (Liu, 2014).

Our OCP variable based on four types of exceptions is more comprehensive than some measures in the literature that use a limited number of exceptions (e.g. Short *et al.,* 2001; Yang, 2007), and this should increase the correlation between our measure of OCP strength and family size. Also, by

[25] Since communities where these special occupations are prevalent may differ in unobserved ways from other communities, we did a sensitivity analysis that ignored this exception and the results were largely the same.

defining this measure at the community level rather than considering eligibility for individuals, we reduce the impact that any prior individual choices (such as over fertility and occupations) that affect specific eligibility for an exception have, and instead we focus on the community-level constraints that affect fertility of individuals but which do not reflect individual unobservable attributes.

For the FE approach, we estimate impacts from changes in sibling numbers, using the panel structure of the data. In this approach, the variables are all measures of changes. The variables in the control vectors X and Z in equation (1) that can change over time are kept for the panel analysis, and those that are time-invariant, including gender, whether the first child in the family and the province of residence, are dropped from the vectors of control variables. In both the FE and IV analysis, to allow the effects on the nutrient intakes to interact with gender, we run regressions separately for boys and girls.

3.4 Data and Descriptive Analysis

The main source of data for the analysis is the China Health and Nutrition Survey (CHNS), provided by Carolina Population Centre and the Chinese Centre for Disease Control and Prevention. The CHNS survey is an ongoing international collaborative project, which amongst other things, aims to examine the effects of health, nutrition, and family planning policies and programs. It is one of the few surveys to provide information on variation in the local stringency of the OCP. The CHNS is a longitudinal survey, following the same households over time and collecting relationship information on all family members, even those outside the household. For example, all children of each woman are covered no matter whether living with the mother at the time of the survey. This helps us better define eligibility for having two children because the birth rules are based on all children that each woman ever had. The surveys cover economic status, such as household income and subsidies; social status such as *hukou* and family composition; and parental investments in children such as the spending on inputs into their human capital formation. In particular, it has detailed data on individual diets, which provides our outcome measures.

3.4.1 Measures of the One-Child Policy Strength

Two sources are used to define the OCP regulations in each community. One source is the CHNS community level data, where the local exceptions for a second or third child are reported by the public officials responsible for the OCP implementation. Three out of four exceptions covered by the questionnaire are used in defining the local OCP strength, in terms of whether all women in the community were allowed to have two children, the girl-exception and the only-child-exception.[26] The second source is government documents about provincial OCP regulations, which are used to identify the girl-exception, the only-child-exception and the occupation-exception when the CHNS information is missing. In addition, these documents provide information about the constraints on applying the exceptions in each province in different years, including the birth-gap for consecutive children, the age limitations on mothers and the *hukou*

[26] The last exception was to allow a second child if the first child was handicapped. We exclude it in this paper because we are not able to tell whether the first child was handicapped for each family, and hence cannot apply this exception to the families.

requirement.[27] The four exceptions, along with the constraints, are then applied to the families in the sample to define women's eligibility for having two children.

3.4.2 Nutrient Intakes

The CHNS respondents keep three-day records of their food consumption, in terms of meals per person per day, and daily food intake. This information is then checked by the research team and reported as three-day average daily intakes for fat, protein, carbohydrate and total energy from all sources, with energy measured in kilocalories (kcal) and the others three items in grams.[28] We focus on total energy, fat and protein. Diets with more fat and protein are traditionally seen as better nutrition than carbohydrate-rich diets in China (Zhang, Xu, & Liu, 2016) and the higher income elasticity for protein and fat reflects this. Thus, intakes of these two nutrients should capture dietary preferences and reflect investments in each child. Total energy intake is used as a general measure of the nutrition level.

We use 'relative nutrient intake' as the outcome variables, which is the ratio of each child's three-day average nutrient intake level to the Recommended Nutrient Intake (RNI) for their age-gender group. The RNIs are from the Chinese Dietary Reference Intakes (DRIs) (Chinese Society of Nutrition, 2006) , which are based on Recommended Dietary Allowances (RDA), and are the level of intake

[27] For example, Liaoning required the mother to have rural *hukou* when applying the girl-exception, and further required the first girl to have rural *hukou* since 2003; in 1990, Hubei set the birth-gap constraints to be four years and required mothers to be over 28 when having the second child, and relaxed the age limit of the mothers to be 25 in 1999 and changed the birth-gap constraint to be two years and only applied to women aged below 28.

[28] Each member in the family is asked to report everything they eat for three meals and all snacks per day, for three days, including the type of food and amount of each food item, such as grams of rice for lunch in day one. The method of preparing the food is also recorded for the purpose of transferring the food amount into nutrient measures.

that satisfies most individuals' needs in certain age, gender, and physiological status groups, and is set as 1.2×EAR (Estimated Average Requirement).[29] For infants, we use Adequate Intakes (AI), due to lack of information on RNI (the AI are similar to, but not as precise as RNI). Thus, we consider physical differences between boys and girls, and between children of different age groups, which makes inter-personal comparison of nutrient intakes easier. Ratios smaller than one show insufficiency of the nutrients and ratios exceeding one indicate that the daily intakes are more than sufficient.

3.4.3 Sample Selection

Seven waves of CHNS data, from 1991, 1993, 1997, 2000, 2004, 2006 and 2009 are used. Nine provinces are covered by the survey, except Liaoning was absent in 1997 and Heilongjiang was absent in 1991 and 1993. We do not require a balanced sample for our analysis so we begin by using all the observations. We include children with biological, step and foster parent-child relations and prioritize child-parent dyads where the parent is in the same household as the child, since that is the parent who should determine the diet of the child. We only consider children of the majority Han ethnicity, and exclude Han children living in communities where Han are not a majority, since diets in non-Han areas may be quite different.

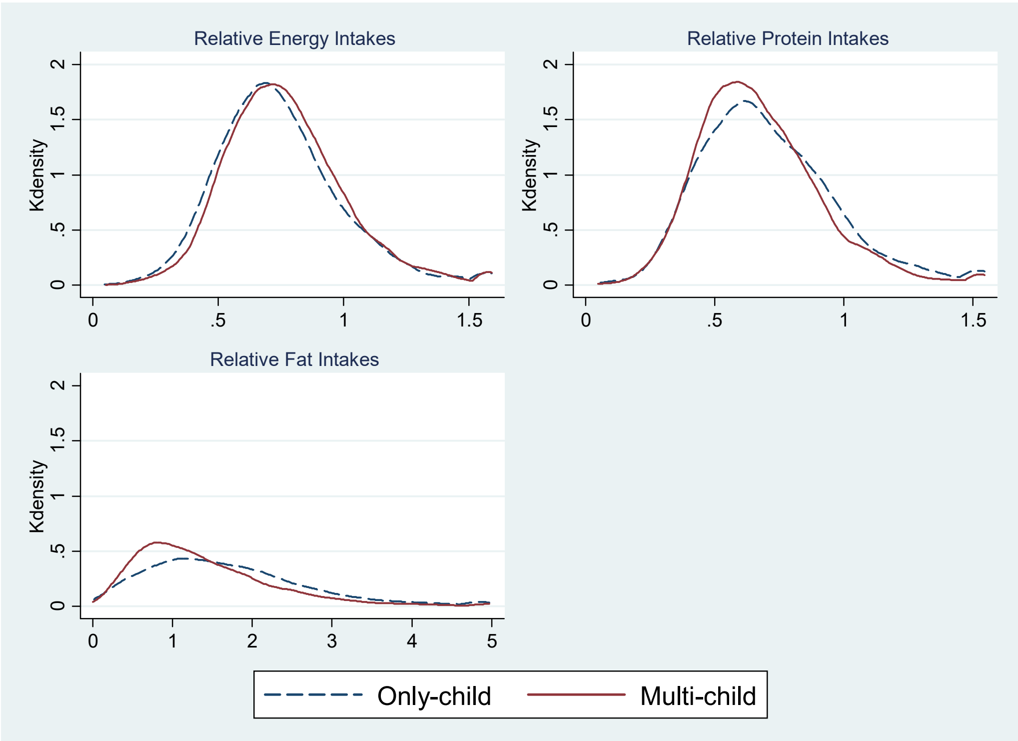
[29] When the standard deviations (SD) for the group are available and the nutrient intakes of the population are normally distributed, RNI equals EAR plus 2SD, otherwise it is set as 1.2×EA (Chinese Society of Nutrition, 2006). In this research, 1.2×EA is used as the reference level for each nutrient due to the lack of information on the SD of the population. RNI for boys and girls aged under 18 are exactly the same for fat but differ in some age ranges for protein. For energy, the RNI is higher for boys than for girls at all ages.

We also exclude households whose residents include children aged over 18, since diets of these adult children are less likely to be determined by their parents. In addition, households with children born before 1976 are excluded because the fertility choices of those families were not affected by the OCP (Qian, 2009; Zhang, Xu, & Liu, 2016). Households with twins are also excluded from our sample, since the investments by parents in the twins and in the siblings of the twins may not be comparable with those for other children (Li *et al.,* 2008; Liu, 2014; Rosenzweig & Zhang, 2009). We further require that children are present in at least two waves of the survey, since we need this for the fixed effects analysis. In order to calculate community level OCP strength, we also drop communities with fewer than three ever-married women aged from 20 to 49. As a result of the selection criteria, our sample is not a balanced sample although it is still quite large with over ten thousand observations. The number of communities also varies over time, since communities without eligible children are excluded from the sample. For rural communities the range is from *n*=104 in 2009 to *n*=126 in 2000, and from *n*=46 in 2009 to *n*=69 in 2000 for urban communities.

3.4.4 Descriptive Analysis

The mean values of the outcome variables, instrumental variable, and control variables are reported in Table 1. The mean fat intake is more than recommended, while energy and protein intakes are, on average, below recommendations. These measures already control for gender and age effects and so the higher intakes of boys suggest some son preference. Relatedly, the number of siblings has a mean of almost one for girls and just 0.79 for boys while girls are more likely to be first-born than boys. It seems that parents whose first-born is a girl are more likely to have another child. The other Table 1 nutrient intake statistics are for adults; these are not normalized by recommended level, so the higher values for males than for females may reflect their stature and activity.

Figure 2: Kernel Densities Functions of the Relative Nutrient Intakes for Children from Only-Child and Multi-Child Families, CHNS, 1991-2009



Notes:

Sample from the CHNS, 1991-2009, Han children aged between 0-18 from Han communities. Relative intakes at the top one percent are grouped at the 99 percentile for each nutrient item.

Figure 2 shows graphs of kernel density functions for the three nutrients, pooling all survey waves and comparing children from only-child families with others.[30] Children with no siblings had a greater density at the lower level of relative energy intakes than children with siblings, and greater density at the higher level of relative protein and fat intakes. Children from multi-child families had more density around the mean for protein intakes while only-children had heavier tails at the higher intake levels. This pattern is even stronger for relative

[30] For display purposes, relative intakes are trimmed at the 99th percentile. The raw distributions are all normal distributions with long tails, with the upper tails for fat being extremely long.

fat intakes; children with siblings have more density in the range of 0.5 to 1.5 while only-children have a flatter distribution and much lower density at values below 1. Given preferences of parents and children for high protein and high fat food (Zhang, Xu, & Liu, 2016), these patterns suggest that children from sole-child families get more dietary resources than children with siblings.

To show how the intakes vary over time, we plot the mean intakes for boys and girls in each wave for children from only-child families and multi-child families in Figure 3. The trend is for energy and protein intakes to go down, whereas fat intakes increased. Previous research using the CHNS data also notes that total energy intakes of Chinese children have decreased slightly over time while there has been an increase in dietary diversity and in fat intakes (Liu, Fang, & Zhao, 2013). The time trends for boys and girls had no obvious differences.

Figure 3: Time Trends of the Relative Nutrient Intakes for Children from Only-Child and Multi-Child Families, CHNS, 1991-2009, for Boys and Girls respectively

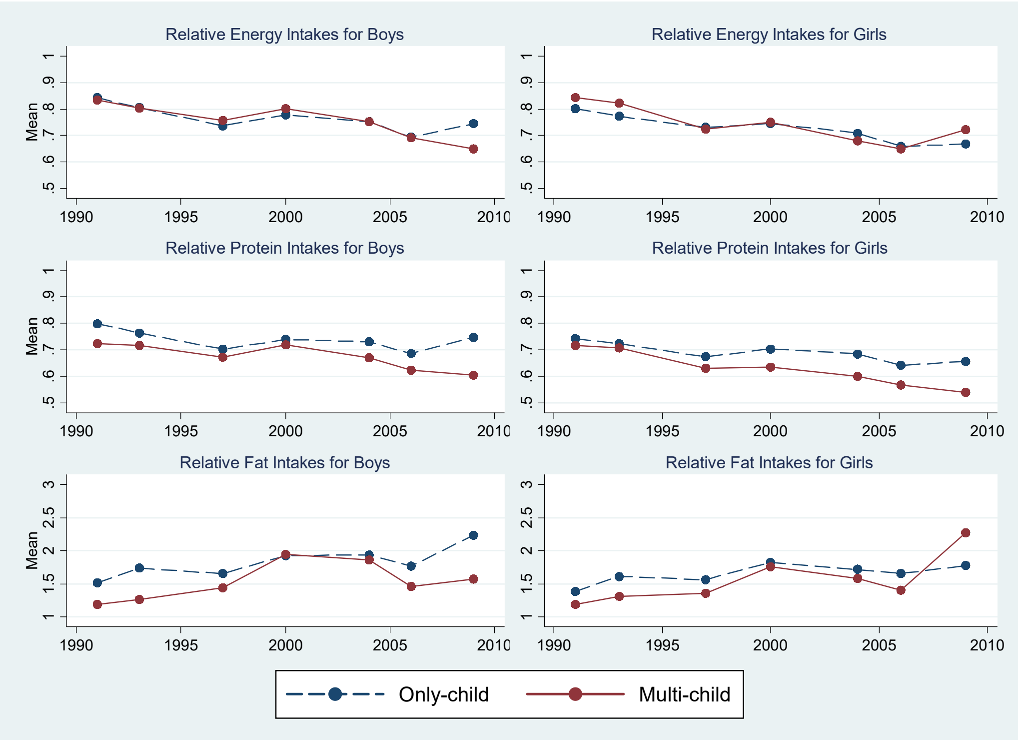


Table 1: Descriptive Statistics for the Estimation Sample, CHNS, 1991-2009

	All Children	Boys	Girls
Outcomes			
Relative Energy Intakes	0.77	0.78	0.76
Relative Protein Intakes	0.69	0.71	0.67
Relative Fat Intakes	1.55	1.59	1.50
Instrument			
Community OCP Strength[1]	0.82	0.82	0.81
Children's Characteristics			
Number of Siblings	0.85	0.78	0.93
Age (2-digit)	9.51	9.43	9.59
First-born Child	63.71%	61.20%	66.69%
Urban *hukou*	31.06%	30.57%	31.66%
Parents' Characteristics			
Mother's Years of Schooling	7.19	7.21	7.18
Father's Years of Schooling	8.63	8.63	8.64
Community Characteristics			
Median Per-capita Real Household Income (yuan)[2]	3863	3871	3853
Local Development Index[3]	52.18	51.85	52.57
Median Energy Intakes of Adults (kcal)[4]	2375	2573	2205
Median Protein Intakes of Adults (gram)	69	75	64
Median Fat Intakes of Adults (gram)	63	67	59
Province of Residence			
Liaoning	6.30%	5.82%	6.86%
Heilongjiang	8.16%	8.01%	8.34%
Jiangsu	12.08%	12.50%	11.59%
Shandong	10.91%	10.65%	11.23%
Henan	13.54%	13.45%	13.65%
Hubei	15.86%	15.25%	16.58%
Hunan	12.37%	12.24%	12.52%
Guangxi	15.58%	16.76%	14.17%
Guizhou	5.20%	5.31%	5.07%
Survey Year			
1991	19.18%	19.02%	19.36%
1993	20.90%	20.70%	21.14%
1997	19.00%	18.73%	19.32%
2000	17.07%	17.18%	16.94%
2004	10.44%	10.46%	10.42%
2006	8.54%	8.73%	8.32%
2009	4.87%	5.18%	4.50%
Total Number of Observations	10,842	5,889	4,953

Notes:

1. Community OCP strength is the proportion of women eligible to have two children according to the local rules, with the number of ever-married women aged 20 to 49 in each community as the denominator.
2. Median per-capita household income is adjusted to 2009 prices.
3. The index is designed by the CHNS team as an urbanicity scale, which is constructed from 12 community level indicators of: population density, education, sanitation, housing, transportation infrastructure, communications, health infrastructure, traditional market development, economic activitiy, diversity, modern markets and social services. The details of the construction of the scale can be found in Jones-Smith & Popkin (2010).
4. The median intake of each nutrient item is calculated based on the raw intake levels for adults in the same community in each wave. In each community, the base population is all adults aged above 18 for the column 'All Children', all males aged above 18 for the column 'Boys' and all females aged above 18 for the column 'Girls'.
5. Values in the table are means unless noted otherwise.

In terms of differences in intakes for children from multi-child families versus children from only-child families, these are more apparent for protein and fat intakes. Only-children had higher relative protein intakes than for those with siblings in all waves, irrespective of gender. For fat intakes, the gaps varied from almost none in the 2000 survey wave to larger gaps in the earlier and later waves. Interestingly, girls with siblings in the 2009 survey wave had higher fat intakes than only-child girls, reversing the pattern seen in all prior waves. Whether these raw patterns persist once we control for other characteristics of the child, of their family, and of the community – particularly the stringency of the local OCP regulations – is explored with the regression analyses in the next section.

3.5 Regression Results

3.5.1 Impacts from Child Quantity

3.5.1.1 Cross-sectional Results

We begin with OLS and 2SLS regression results for the three measures of nutrient intakes, initially ignoring the panel structure of the data. For all estimation methods and outcomes studied, we present regressions for all children first, and then for boys and girls separately.

Table 2 has regression results from OLS and from both stages of the 2SLS approach for all children. The nutrient intakes are the dependent variables for the OLS regressions (columns 1, 4, 7) and for the second stage of the 2SLS (columns 3, 6, 9). The dependent variable for the first stage regressions (columns 2, 5 and 8) is the number of siblings. The instrumental variable positively affects sibling numbers; as a higher share of women in a community were allowed to have a second child, under the local OCP exceptions, the number of siblings for each child increased. The *F*-tests for excluding the local OCP strength variable from the first stage are larger than 10, and so based on the rule-of-thumb from Bound, Jaeger, and Baker (1995), this indicates that there are no problems with weak instruments.

The OLS results suggest that nutrient intakes are lower for children with more siblings, although only for fat intake is the effect statistically significant (at the 1% level). According to the OLS results, the addition of a sibling would be expected to reduce the fat intake of a child by about 10% of the recommended level. The trade-offs seem much larger in the 2SLS results, ranging from -0.18 for dietary energy to -0.38 for fats, and these 2SLS results are statistically significant for energy (at the 10% level) and for protein (at the 5% level).[31] An added variable form of the Durbin-Wu-Hausman (DWH) test for endogeneity (from Davidson & MacKinnon, 1993) shows a significant difference between the OLS and 2SLS results for energy and protein so the OLS results for these nutrients will be inconsistent due to the endogeneity of sibling numbers. However, for fat intakes, the wide standard errors around the 2SLS results make them insignificantly different from the OLS results.[32]

Thus, when boys and girls are pooled together, the valid models are 2SLS

[31] The strength of these results, compared to OLS, may reflect reverse causation from nutrients to family size when the potential endogeneity of sibling numbers is not accounted for. For example, if parents are trying to increase family size, for whatever reason, they may try to raise energy, protein, and fat intakes of the mother to ensure a successful pregnancy and parental diet is likely to have an impact on the diet of the existing children. Using an IV for factors that exogenously constrain family size can help to reduce bias from reverse causation.

[32] In a sensitivity analysis we split the sample into high development and low development communities. In the high development communities the local OCP strength was a more binding instrument (first stage *F*-test of 25) and the 2SLS coefficient for sibling numbers in the fat intakes regression was much more precisely estimated than in the full sample results, and was significantly different from the OLS result.

for energy and protein, and OLS for fats. The trade-off effects in these models range from -0.11 to -0.22 and are statistically significant at 10% (energy), 5% (protein), and 1% (fats) levels. So an additional sibling reduces nutrient intakes by between one-tenth and one-fifth of the recommended level, which is a substantial effect. This trade-off is more precisely measured for the more preferred nutrients of fats and proteins.

In the OLS results, but not in the 2SLS results, there is a statistically significant gender effect, with girls getting intakes (relative to requirements) of energy, protein, and fats that are 2%, 4%, and 10% lower than for boys, all else the same. Based on the DWH test results, only the OLS model for fats would be considered as insignificantly affected by endogeneity, and so the most valid inference is that some form of gender bias causes girls to have fat intakes that are one-tenth of the recommended level lower than for boys. The other (related) gender effect is in terms of sibling numbers, with a girl having 0.2 more siblings than a boy, on average. To further examine possible gender heterogeneity in the trade-off effect from sibling numbers on nutrient intakes, we run the OLS and 2SLS regressions separately for boys and girls, with results reported in Table 3.

The gender disaggregated results in Table 3 suggest that the trade-off effects for energy and protein intakes seen in the pooled sample are due to boys, where the DWH tests support the 2SLS results over the OLS results. In contrast, the trade-off between sibling numbers and the quality of diet observed through the lens of fat intakes is apparent for both boys and girls according to the valid OLS models.

The other feature of the results in Table 3 is for the first-stage models in columns (2), (5) and (8). It appears that the number of siblings that a girl has is more strongly affected by external factors than is the case for boys. Thus, for girls the coefficients on the strength of the local OCP is about 0.15, versus 0.12 for boys, so as more women in a community are allowed to have a second child, if the existing child is a girl she is more likely to get an extra sibling compared with if the child is a boy. Similarly, while having urban *hukou,* or living in an area with higher levels of the local development index both reduce the number of siblings that a girl has by about one-quarter, for boys the effect is only about one-half as large. Thus, for a girl the external constraints on fertility decisions of the family that may yield an extra sibling may be more important than for a boy, which is also seen in the first-born child indicator; a boy who is a first born has significantly fewer siblings than a first-born girl, which again reflects a form of son-preference.

.In summary, the cross-sectional results suggest that fat intakes show a significant effect of sibling numbers for both boys and girls. The reduction in fat intakes for girls, due to having an extra sibling, is approximately twice as large as the reduction for boys. For energy and protein intakes, the significant trade-off seen in the 2SLS results is only for boys. While these cross-sectional results have plausible treatments for the number of siblings being an endogenous choice variable they do not deal with child-specific heterogeneity and so we now turn to panel regression results that look at within-child variation over time.

Table 2: Impacts on Relative Nutrient Intakes for All Children Aged under 18, CHNS, 1991-2009

	Relative Energy Intakes			Relative Protein Intakes			Relative Fat Intakes		
	OLS	First Stage	2SLS	OLS	First Stage	2SLS	OLS	First Stage	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Instrument – Local OCP Strength		0.142**			0.141**			0.135**	
		(0.027)			(0.027)			(0.027)	
Number of Siblings	-0.00212		-0.179+	-0.00069		-0.222*	-0.109**		-0.378
	(0.005)		(0.098)	(0.005)		(0.100)	(0.021)		(0.381)
Female	-0.0193**	0.194**	0.0148	-0.0417**	0.194**	0.00112	-0.0995**	0.194**	-0.0472
	(0.006)	(0.018)	(0.019)	(0.005)	(0.018)	(0.020)	(0.031)	(0.018)	(0.069)
First-born Child	-0.00705	-0.711**	-0.133+	0.000334	-0.712**	-0.158*	-0.0817+	-0.711**	-0.274
	(0.008)	(0.020)	(0.070)	(0.006)	(0.020)	(0.072)	(0.046)	(0.020)	(0.261)
Urban *hukou*	0.0157*	-0.186**	-0.0193	0.0188*	-0.191**	-0.0263	0.0105	-0.188**	-0.0434
	(0.007)	(0.019)	(0.021)	(0.007)	(0.019)	(0.023)	(0.036)	(0.019)	(0.075)
Local Development Index	0.0612**	-0.188**	0.0239	0.0628**	-0.204**	0.0128	0.102*	-0.169**	0.0511
	(0.012)	(0.037)	(0.026)	(0.011)	(0.036)	(0.026)	(0.048)	(0.036)	(0.099)
Total Number of Observations	10,842	10,842	10,842	10,842	10,842	10,842	10,842	10,842	10,842
Adjusted R-squared	0.137	0.528	0.024	0.167	0.527	-0.023	0.179	0.529	0.168
F-statistics for excluding local OCP strength			28.53			27.71			25.41
P-value for added variable Hausman Test			0.056			0.0138			0.484

Notes:

The dependent variable for the first stage is the number of siblings. All regressions control for age, age squared, years of schooling of parents, median household income, median nutrient intakes, and have dummy variables for province of residence and survey waves. Robust, clustered, standard errors, which allow for the potential correlation for the same children in different waves, are shown in parentheses.

** $p < 0.01$, * $p < 0.05$, + $p < 0.1$

Table 3: Impacts on Relative Nutrient Intakes for Children Aged under 18 by Sex, CHNS, 1991-2009

	Relative Energy Intakes			Relative Protein Intakes			Relative Fat Intakes		
	OLS	First Stage	IV	OLS	First Stage	IV	OLS	First Stage	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Boys (5889 observations)									
Instrument - Local OCP Strength		0.126**			0.126**			0.122**	
		(0.033)			(0.033)			(0.033)	
Number of Siblings	0.00665		-0.314+	0.00656		-0.350+	-0.0669**		-0.39
	(0.008)		(0.184)	(0.008)		(0.194)	(0.026)		(0.503)
First-born Child	-2.4E-05	-0.760**	-0.244+	0.00325	-0.760**	-0.269+	-0.0309	-0.759**	-0.276
	(0.009)	(0.025)	(0.141)	(0.010)	(0.025)	(0.150)	(0.036)	(0.025)	(0.387)
Urban *hukou*	0.0250*	-0.116**	-0.0157	0.0237*	-0.120**	-0.0229	0.0604	-0.116**	0.0196
	(0.010)	(0.025)	(0.027)	(0.011)	(0.025)	(0.030)	(0.038)	(0.025)	(0.080)
Local Development Index	0.0495**	-0.144**	-0.0029	0.0743**	-0.151**	0.0133	0.129*	-0.131**	0.0806
	(0.016)	(0.045)	(0.036)	(0.016)	(0.045)	(0.040)	(0.057)	(0.045)	(0.093)
Adjusted R-squared	0.14	0.558	-0.193	0.149	0.558	-0.203	0.328	0.559	0.308
F-statistics for excluding local OCP strength			14.88			14.74			14.03
P-value for added variable Hausman Test			0.0411			0.0278			0.512
Girls (4953 observations)									
Instrument - Local OCP Strength		0.157**			0.151**			0.146**	
		(0.041)			(0.042)			(0.042)	
Number of Siblings	-0.00851		-0.0774	-0.00578		-0.136	-0.153**		-0.421
	(0.007)		(0.110)	(0.006)		(0.098)	(0.035)		(0.572)
First-born Child	-0.0133	-0.655**	-0.0586	-0.00118	-0.656**	-0.0873	-0.137	-0.655**	-0.313
	(0.014)	(0.033)	(0.071)	(0.008)	(0.034)	(0.066)	(0.092)	(0.033)	(0.340)
Urban *hukou*	0.00551	-0.262**	-0.0135	0.0142	-0.270**	-0.0228	-0.0469	-0.270**	-0.123
	(0.012)	(0.030)	(0.031)	(0.010)	(0.029)	(0.030)	(0.064)	(0.029)	(0.140)
Local Development Index	0.0520**	-0.248**	0.0331	0.0409**	-0.269**	0.00252	0.117	-0.217**	0.0535
	(0.018)	(0.059)	(0.040)	(0.015)	(0.059)	(0.033)	(0.082)	(0.058)	(0.197)
Adjusted R-squared	0.124	0.504	0.105	0.187	0.503	0.085	0.099	0.506	0.09
F-statistics for excluding local OCP strength			14.28			13.23			12.11
P-value for added variable Hausman Test			0.533			0.162			0.649

Notes: See Table 2

Table 4: Panel Regression Results, CHNS, 1991-2009

	Relative Energy Intakes			Relative Protein Intakes			Relative Fat Intakes		
	All Kids	Boys	Girls	All Kids	Boys	Girls	All Kids	Boys	Girls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Number of Siblings	-0.0169	-0.00779	-0.0136	-0.017	-0.000658	-0.0163	-0.132**	-0.108	-0.134+
	(0.015)	(0.027)	(0.018)	(0.016)	(0.035)	(0.017)	(0.050)	(0.075)	(0.074)
Urban *hukou*	-0.0193+	-0.0236	-0.0161	-0.0294*	-0.0381*	-0.0155	-0.0127	0.00643	-0.0132
	(0.011)	(0.016)	(0.016)	(0.012)	(0.018)	(0.016)	(0.041)	(0.059)	(0.056)
Local Development Index	0.0305	0.0215	0.0424	0.0459+	0.0777*	0.00866	0.0477	-0.0308	0.242+
	(0.024)	(0.035)	(0.032)	(0.023)	(0.037)	(0.028)	(0.084)	(0.102)	(0.147)
Total Number of Observations	10,842	5,889	4,953	10,842	5,889	4,953	10,842	5,889	4,953
Total Number of Individuals	3,693	1,993	1,700	3,693	1,993	1,700	3,693	1,993	1,700
Adjusted R-squared	0.089	0.079	0.087	0.09	0.07	0.116	0.143	0.248	0.083
F-stat for all u_i=0	1.405**	1.269**	1.516**	1.271**	1.242**	1.232**	1.595**	1.219**	1.744**

Notes:

All regressions control for age, age squared, years of schooling of parents, median household income, median nutrient intakes, and dummy variables for survey waves. Robust standard errors, which allow for the potential correlation for the same children in different waves, are shown in parentheses.

** p<0.01, * p<0.05, + p<0.1

3.5.1.2. Panel Results

The results of using child-specific fixed effects are reported in Table 4. The *F*-tests reported at the bottom of the table are all significant at 1% level, showing that the fixed effects cannot be excluded from any of the equations. In other words, there seem to be important, unobserved, child-specific effects that affect nutrient intakes and the omission of these from the previous models may have affected the results for tests of the quality-quantity trade-off.

The fixed effects results show that the negative effect of siblings on nutrient intakes is larger for girls than for boys, for all three nutrients, and is larger for fats than for the other two nutrients. An increase in the number of siblings (by one sibling) will decrease a child's fat intake by 13% of the recommended level for girls and by 11% for boys (and also by 13% in the gender-pooled sample). This is consistent with other studies using CHNS that find an only-child has a higher chance of being overweight (Zhang, Xu, & Liu, 2016). For relative energy and protein intakes, the negative effects are smaller and statistically insignificant, in contrast to the cross-sectional 2SLS results.

3.5.2 Impacts from Other Factors

Although the main purpose of the regression models is to test for a quality-quantity trade-off that operates through the effect of sibling numbers on nutrient intakes, the effects of some other factors are also notable. In the OLS cross-sectional results, the local development level appears to have a significant positive effect on all three nutrient intakes, and although this effect disappears in the 2SLS results it (partially) reappears in the fixed effects results. There are similar changes in results for whether the child holds urban *hukou*, which has positive effects on energy and protein intakes in the OLS results but negative effects, especially on protein, in the fixed effects results. There is also a consistent significant impact of the median nutrient intake level of the adults in the community. It seems that a significant factor in the children's nutrient intakes is what other people (adults) eat in the community.

3.6 Conclusions and Discussion

In this paper we have tested for a trade-off between child quantity and quality in Chinese families. We used seven waves of CHNS data, with the quality of children measured by their intakes of energy, protein and fat, relative to recommended intakes for their age and gender. Two mechanisms are used to deal with possible bias in the estimation of causal effects coming from the endogeneity of the fertility choices. The first one is the 2SLS approach using the local strength of one-child policy restrictions as the instrumental variable when estimating sibling numbers (which are the quantity variable in the trade-off analysis). The second one is the fixed effects approach using the panel structure of the CHNS data to examine how changes over time in nutrient intakes of the same child are related to the changes in their sibling numbers. Together with the OLS results, this paper provides a comprehensive test of the quantity-quality trade-off theory in the context of China.

In general, the results are supportive of there being a quantity-quality trade-off, with an extra sibling reducing nutrient intakes by between one-tenth and one-fifth of the recommended level. The negative effect of an extra sibling on fat intakes is somewhat larger for girls than for boys and is still apparent when child-specific fixed effects are used. In contrast, the effects on energy and protein intakes are more apparent for boys than for girls, and are not statistically significant when fixed effects are used. While the negative effect on energy and protein intakes shows that fewer children will result in better nutrition since the average intakes for these two nutrients are below the recommended level, the reduction in fat intakes caused by the larger number of sibling is not necessarily bad for health since average fat intakes exceed the recommended level. Fat is a preferred nutrient in China (Zhang, Xu, & Liu, 2016), so the strength of the results for fat intakes, and the gender differences are consistent with son preferences. Moreover, given that total energy from all sources is below the recommended level, more fat will raise energy intake, and so fat is not solely a bad influence on health. Combining the effects on all three nutrient items together, we conclude that the trade-off between child quantity and quality exists in China with regard to nutrition.

Although there is reasonable consistency between the various estimation methods, a possible weakness is that our instrumental variable does not identify all fertility constraints (despite the strength of our instrument in the first stage regression). As noted in other studies, the penalty for the unsanctioned birth also matters (Liu, 2014) but we do not have data on these penalties. Relatedly, the reduced influence of OCP on fertility choices in later years may weaken its identification power. The fixed effects approach does not suffer from this potential weakening, and is useful in capturing the within-person changes to avoid omitted variable bias, but only a minority of the sampled children experiencing a change in sibling numbers during the duration of the survey. Another weakness is that we cannot control for food prices, which are not collected in the CHNS. Food prices may affect the mix of nutrients, and potentially affect the estimation of the child quantity-quality trade-off since they are an important factor in the cost of raising a child. However, the bias from the omitting food prices may not matter here because we control for community level nutrient intake, which will also reflect local food prices.

References

Abdul-Razak, N. A., Abd Karim, M. Z., & Abdul-Hakim, R. (2015). Does Trade-Off Between Child Quantity and Child Quality Exist in Malaysia? *The Singapore Economic Review*, *60*(4), 1-19.

Alderman, H., Behrman, J. R., Lavy, V., & Menon, R. (2001). Child Health and School Enrolment: A Longitudinal Analysis. *The Journal of Human Resources*, *36*(1), 185-205.

Angrist, J., Lavy, V., & Schlosser, A. (2010). Multiple experiments for the causal link between the quantity and quality of children. *Journal of Labor Economics, 28*(4), 773-824.

Banister, J. (2009). Coping with Population Aging in China. *The Conference Board*.

Banister, J., Bloom, D. E., & Rosenberg, L. (2012). Population aging and economic growth in China. *The Chinese Economy,* 114-149.

Becker, G.S., & Lewis, H.G. (1973). On the Interaction between the Quantity and Quality of Children. *Journal of Political Economy*, *81*(2), S279-S288.

Becker, G. S., & Tomes, N. (1976). Child endowments and the quantity and quality of children. *Journal of Political Economy, 84*(4), S143-S162.

Behrman, J. R., Deolalikar, A. B., & Wolfe, B. L. (1988). Nutrients: Impacts and determinants. *The World Bank Economic Review, 2*(3), 299-320.

Bhalotra, S. R., & Clarke, D. (2016). The Twin Instrument. *IZA Discussion Paper* No. 10405.

Black, S. E., Devereux, P. J., & Salvanes, K. G. (2005). The more the merrier? the effect of family size and birth order on children's education. *Quarterly Journal of Economics, 120*(2), 669-700.

Bound, J., Jaeger, D. A., & Baker, R. M. (1995). Problems with instrumental variables estimation when the correlation between the instruments and the endogenous explanatory variable is weak. *Journal of the American Statistical Association, 90*(430), 443–450.

Bredenkamp, C. (2009). Policy-related determinants of child nutritional status in China: The effect of only-child status and access to healthcare. *Social Science and Medicine, 69(10),* 1531-1538.

Bulte, E., Heerink, N., & Zhang, X. (2011). China’s one-child policy and 'the mystery of missing women': Ethnic minorities and male-biased sex ratios. *Oxford Bulletin of Economics and Statistics, 73*(1), 21-39.

Conley, D., & Glauber, R. (2006). Parental educational investment and children's academic risk: Estimates of the impact of sibship size and birth order from exogenous variation in fertility. *The Journal of Human Resources, 41*(4), 722-737.

Chinese Nutrition Society. (2006). *Dietary nutrient reference intake for Chinese residents, Chinese DRIs*. China Light Industry Press.

Davidson, R., & MacKinnon, J. (1993). *Estimation and Inference in Econometrics* Oxford University Press: New York.

Glewwe, P. (1999). Why does mother's schooling raise child health in developing countries? evidence from Morocco. *The Journal of Human Resources, 34*(1), 124-159.

Greenhalgh, S. (1986). Shifts in China's population policy, 1984-86: Views from the central, provincial, and local levels. *Population and Development Review, 12*(3), 491-515.

Gu, B., Wang, F, Guo, Z., & Zhang, E. (2007). China's local and national fertility policies at the end of the twentieth century. *Population and Development Review, 33*(1), 129-147.

Hanushek, E. A. (1992). The trade-off between child quantity and quality. *Journal of Political Economy, 100*(1), 84-117.

Hausman, J. (1978). Specification Tests in Econometrics. *Econometrica*, 46(6), 1251-1271.

Hesketh, T., Lu, L., & Xing, Z. W. (2005). The effect of China's one-child family policy after 25 years. *The New England Journal of Medicine, 353*(11), 1171-1176.

Huang, Y. (2015). *Does A Child Quantity-Quality Trade-Off Exist? Evidence from the One-Child Policy in China*. Paper presented at the Annual Conference 2015 (Muenster): Economic Development - Theory and Policy, Verein für Socialpolitik / German Economic Association. Retrieved from http://EconPapers.repec.org/RePEc:zbw:vfsc15:113215 .

Jones-Smith, J., & Popkin, B. (2010). Understanding community context and adult health changes in China: Development of an urbanicity scale. *Social Science & Medicine, 71*(8), 1436-1446.

Lee, J. (2008). Sibling size and investment in children's education: An Asian instrument. *Journal of Population Economics, 21*(4), 855-875.

Li, H., Yao, X., Zhang, J., & Zhou, L. (2005). Parental childcare and children's educational attainment: Evidence from China. *Applied Economics, 37*(18), 2067-2076.

Li, H., Zhang, J., & Zhu, Y. (2008). The Quantity-Quality Trade-off of Children in a Developing Country: Identification Using Chinese Twins. *Demography, 45*(1), 223-243.

Li, J. (2004). Gender inequality, family planning, and maternal and child care in a rural Chinese county. *Social Science and Medicine, 59*(4), 695-708.

Li, S; Zhang, Y., & Feldman, M. W. (2010). Birth Registration in China: Practices, Problems and Policies. *Population Research and Policy Review, 29,* 297-317.

Liu, H., Fang, H., & Zhao, Z. (2013). Urban-rural disparities of child health and nutritional status in China from 1989 to 2006. *Economics and Human Biology, 11*(3), 294-309.

Liu, H. (2014). The quality-quantity trade-off: Evidence from the relaxation of China's one-child policy. *Journal of Population Economics, 27*(2), 565-602.

Lu, Y., & Treiman, D. J. (2008). The Effect of Sibship Size on Educational Attainment in China: Period Variations. *American Sociological Review, 73*(5), 813-834.

Qian, N. (2009). Quantity-quality and the one child policy: the only-child disadvantage in school enrollment in rural China. NBER Working Paper no. 14973. *National Bureau of Economic Research.*

Rosenzweig, M. R., & Wolpin, K.I. (1980). Testing the Quantity-Quality Fertility Model: The Use of Twins as a Natural Experiment. *Econometrica, 48*(1), 227-240.

Rosenzweig, M. R., & Zhang, J. (2009). Do population control policies induce more human capital investment? Twins, birth weight and China's 'one-child' policy. *The Review of Economic Studies, 76*(3), 1149-1174.

Shi, Z., Lien, N., Kumar, B. N., & Holmboe-Ottesen, G. (2005). Socio-demographic differences in food habits and preferences of school adolescents in Jiangsu province, China. *European Journal of Clinical Nutrition, 59*(12), 1439-1448.

Short, S., & Zhai, F. (1998). Looking locally at China's one-child policy. *Studies in Family Planning, 29*(4), 373-387.

Short, S., Xu, S., Zhai, F., & Yang, M. (2001). China's one-child policy and the care of children: An analysis using qualitative and quantitative data. *Social Forces, 79*(3), 913-943.

The Legislative Affairs Commission of the Standing Committee of the National People's Congress of the People's Republic of China. (2002). *Population and Family Planning Law of the People's Republic of China.* The China Population Publishing House.

Wang, F. (2005). Can China Afford to Continue Its One-Child Policy?' *Asia - Pacific Issues,* (77), 1.

Wang, Z., Zhai, F., Du, S., & Popkin, B. (2008). Dynamic shifts in Chinese eating behaviors. *Asia Pacific Journal of Clinical Nutrition, 17*(1), 123-130.

World Bank. (2016). *World Development Indicators*. Retrieved http://data.worldbank.org/indicator/SP.DYN.TFRT.IN

World Health Organization. (2007). *Computation of Centiles and Z-Scores for Height-For-Age, Weight-For-Age and BMI-For-Age.* Retrieved http://www.who.int/growthref/computation.pdf .

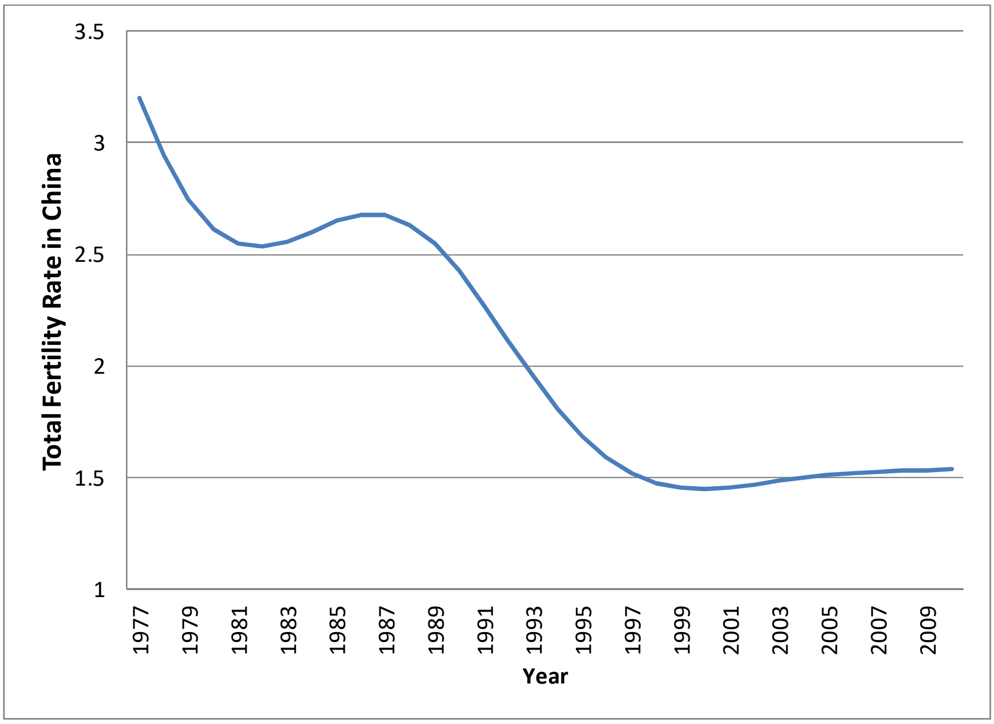
Xinhua Net (Chinese). (2015). Retrieved from http://news.xinhuanet.com/health/2015-10/30/c_128374158.htm

Yang, J. (2007). China's one-child policy and overweight children in the 1990s. *Social Science and Medicine, 64*(10), 2043-2057.

Zhang, J., Xu, P., & Liu, Feng. (2016). One-child policy and childhood obesity. *China Economic Review* (2016), http://dx.doi.org/10.1016/j.chieco.2016.05.003

Zhu, W. X. (2003). The One Child Family Policy.*Archives of Disease in Childhood, 88*(6), 463-464.

Appendix 1 Time Trend of the Total Fertility Rate in China, 1977-2009



Sources: World Development Indicators http://data.worldbank.org/indicator/SP.DYN.TFRT.IN , retrieved September 2016.

Source Note: Total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with age-specific fertility rates of the specified year.

Appendix 2 Sample Distribution of Children by Urban and Rural Location and *Hukou*, CHNS, 1991-2009

	Boys		Girls		All Children	
	Rural	Urban	Rural	Urban	Rural	Urban
Rural *hukou*	88.3%	13.9%	87.8%	11.1%	88.1%	12.6%
Urban *hukou*	11.7%	86.1%	12.2%	88.9%	11.9%	87.4%
Number of observations	4,397	1,492	3,696	1,257	8,039	2,749

Notes

Sample is from CHNS, 1991 to 2009 waves, all children aged below 18, Han ethnicity with valid information of nutrient intakes, personal characters and parents' characters and living in a community where Han is the major ethnicity.

Chapter 4

Do More Grandchildren Lead to Worse Health Status of Grandparents? Evidence from the CHNS

Yun Liang and John Gibson

Yun Liang

PhD Student, Economics Department
University of Waikato
Private Bag 3105
Hamilton, New Zealand, 3240.

Tel: + 64 (0)7 838 4289

Email: lysh8@hotmail.com

John Gibson

Economics Department
University of Waikato
Private Bag 3105
Hamilton, New Zealand, 3240.

Tel: + 64 (0)7 838 4289

Email: jkgibson@waikato.ac.nz

Do More Grandchildren Lead to Worse Health Status of Grandparents? Evidence from the CHNS

Abstract

China is rapidly aging and the social security system provides insufficient pension coverage. Consequently, almost 80 percent of elderly people depend on their children or other relatives for financial support. We use China Health and Nutrition Survey data to test if more grandchildren adversely affects elder health. This could occur because grandparents and grandchildren compete for financial support from the working adults in a family and because grandparents often have to care for young grandchildren and may neglect their own health. Since the number of grandchildren is a choice variable, we use exogenous variation in fertility for two generations under local implementation of the one child policy. We also take advantage of the panel data to deal with unobservable factors. The health of the elderly appears to be adversely affected by the number of grandchildren, especially for grandmothers and especially in urban areas.

Keywords: elderly, grandchildren, health, one-child policy, China

JEL Codes: I12; J14

Acknowledgements

This research uses data from China Health and Nutrition Survey (CHNS). We thank the National Institute for Nutrition and Health, China Center for Disease Control and Prevention, Carolina Population Center (P2C HD050924, T32 HD007168), the University of North Carolina at Chapel Hill, the NIH (R01-HD30880, DK056350, R24 HD050924, and R01-HD38700) and the NIH Fogarty International Center (D43 TW009077, D43 TW007709) for financial support for the CHNS data collection and analysis files from 1989 to 2015 and future surveys, and the China-Japan Friendship Hospital, Ministry of Health for support for CHNS 2009, Chinese National Human Genome Center at Shanghai since 2009, and Beijing Municipal Center for Disease Prevention and Control since 2011. We are grateful to helpful comments from participants at the 3rd Annual Workshop on Population Ageing and the Chinese Economy, especially to Hanming Fang, Jin Feng, Katjia Hanewald, Bei Lu and Mike Orszag. We also thank the Human Ethics Committee of the Waikato Management School for ethical approval.

4.1 Introduction

China is becoming an aging society due to the rapid fall in the fertility rate in recent decades and to increases in life expectancy. However, the social security system has not developed to the level of providing adequate pension coverage (Giles & Mu, 2007; Mu & Du, 2017). For example, almost 80 percent of the very elderly, which we define as people aged 85 years and above, are dependent on their children or other relatives for financial support (UNFPA, 2006).

The well-being of the elderly may be endangered by these circumstances, especially with regard to financial security and health conditions. Several studies in the literature consider aspects of this well-being. For example, Giles, Wang and Zhao (2010) study the family support available to the rural elderly, in relation to the rural-to-urban migration of their adult children, while Feng *et al.* (2012) and Zhang (2013) analyze the policy challenges posed by meeting the escalating demands of care for the elderly. A particular feature, given the long-term effects from the family planning policy, is the pressure on the working generation to support retired parents, since one couple might have to support four parents (World Bank, 1997). In this regard, Islam and Smyth (2015) show a negative effect of the number of children on parental health, for elderly parents when they focus on self-reported health, although this is not apparent for other health measures. Mu (2014) also studies self-reported health for older Chinese adults and highlights the disparities, while Xu *et al.* (2015) focus on an objective input into health by evaluating the macronutrient intake status of older Chinese people.

In contrast to Islam and Smyth (2015), we examine the relationship between the number of grandchildren and the health of the elderly in China. To the best of our knowledge, this is the first paper in the literature to examine effects in China from the size of the third generation on the health of the first generation, using the exogenous variation provided by the local implementation of the population control policy as a source of identification. In particular, we control for both whether the elderly in our sample, which is those age 55 years and above, were eligible to have a second child under the local implementation of the one-child policy (OCP), and also if their children were eligible to have a second child. Since we use both of these instrumental variables, we can rule out that our results are just due to any adverse effect on health from own-fertility, which is the relationship studied by Islam and Smyth (2015).

Although less studied, there are plausible reasons to expect that the higher the number of grandchildren the worse will be the health of grandparents. First, the grandparents and grandchildren are competing for resources (money and attention) from the prime-age adults in the family; thus more grandchildren could potentially reduce the value of resources transferred or the amount of care available to the elderly. Second, it is common in China that grandparents (and particularly grandmothers) are a major help in taking care of young grandchildren; the need for the grandparents to carry out this duty could see them paying insufficient attention to their own health and well-being.

While there is an existing literature that examines the relationship between outcomes for grandchildren and grandparents, the focus is on the effects on grandchildren rather than the effects that we study, on the grandparents. For example, Boca, Piazzalunga and Pronzato (2017) use data from the Millennium Cohort Study in the United Kingdom and find significant differences in the ability of children to perform certain tasks, depending on whether they were cared for by their grandparents rather than cared for in formal child care centers. Moreover, the association between grandparent care and child outcomes differs according to levels of social advantage.

In this paper we use four different health measures, which cover both objective and subjective assessments. Specifically, we consider difficulties in performing activities of daily living (ADL), being overweight (defined as the body mass index exceeding 25), having high blood pressure (HBP) and having self-reported poor health. We perform regressions of these variables on the number of grandchildren (along with various control variables) with and without consideration of the potential endogeneity of grandchild numbers. We also report the results of a panel analysis, where the identification relies on changes in the number of grandchildren. The results are somewhat sensitive to which of the health measures is considered, and to the sub-sample of respondents who are studied. In general, it is the ADL scores that are most adversely affected by the number of grandchildren. Among the different sub-population groups, the health of elderly urban residents is more adversely affected by the number of grandchildren than is the case for the rural residents, and females are more likely to be adversely affected than are males.

4.2 Background

4.2.1 China's Population Planning Policy

According to the 2010 China Population Census, over 13 percent of people in that year were aged above 60. This share is predicted to rise to be over a quarter by the year 2030 (UN, 2017). The legacy of the population planning policy is argued to be a major source of this rapid increase in the share of the elderly, which is not matched by the other demographic ‘giant’ India, where the fertility rate fell more smoothly over time.

To briefly recap, over the last several decades China has developed a series of policies to control fertility that are described in more detail in Liang and Gibson (2017). In 1979, the most strict fertility control policy, the one child policy (OCP), was introduced to restrict each couple to have just one child. After four years as a national-level policy, the OCP was decentralized and started to become less restrictive (Greenhalgh, 1986), where this change was possibly in response to various problems caused by the initial policy, including rapid growth in the number of abortions (Hesketh, Lu, & Xing, 2005).

Starting in 1984, different exceptions to the strict rule of one child per couple were introduced, and these were applied in different areas, and also changed over time. Specifically, in 1984, Document 7 was issued to allow decentralization of the policy. Various exceptions, such as allowing a second birth when the first child was handicapped, were then applied in different areas. In 2002, the Law on Population and Family Planning was adopted and this formalized the family planning principle of ‘advocate one-child per couple’ while allowing local exceptions for a second child (The Legislative Affairs Commission of the Standing Committee of the National People’s Congress of the People’s Republic of China, 2002). Under the 2002 law, couples who volunteered to have only one child, regardless of the local exceptions which may have allowed more, would get a “Certificate of Honour for Single-Child Parents” and were eligible for small cash rewards until their child reached a certain age. On the other hand, couples with more children than local policy allowed had to pay a social maintenance fee for unsanctioned birth(s), which was often a multiple of the previous year's average household disposable income in the area where they resided.

In addition to fertility control policies varying by area, they also varied according to *hukou* (household registration) status. Since many people with non-agricultural *hukou* lived in rural areas, and *vice versa* for agricultural *hukou* holders living in the cities, there was further variation in local fertility according to the interaction of *hukou* status and residential location (Liang & Gibson, 2017b). It was not until 2015 that the fertility control policies were once again put on a national basis, by letting all couples have two children, irrespective of their circumstances (Xinhua Net, 2015). Thus, for 31 out of the 35 years that some variant of the OCP operated, there was local variation in the strength of its implementation and this provides a source of exogenous variation in fertility. Moreover, with the policy being in place for so long it affected the fertility of two generations of women and we exploit that feature in our instrumental variables strategy, distinguishing between the constraints applying to the fertility of the elderly people we study and those applying to the fertility of their children.

4.2.2 Public and Private Transfers

The public pension system in China is far from universal, and reflects historical divisions in the centrally-planned economy between the comprehensive welfare support offered to urban people (the so-called 'iron rice bowl') compared to the much lower benefits for rural dwellers, who were largely meant to be self-reliant. In 1991, China introduced the Rural Old-Age Pension Program, which was a voluntary contributions-based program to be operated by local governments (Tao, 2016). The proportion of the rural population who had joined this program (as contributors before they could be recipients) peaked at 15 percent in 1997 and then fell to 11 percent by 2004. Around that time, only about seven percent of the rural elderly aged 60 and older were receiving old-age insurance or pension benefits (Ebenstein & Leung, 2010). For rural residents who had not been in formal employment and had no deposits in their pension account, they could start receiving the money after reaching age 60, under the condition that their children had contributed to the system if those children were employed. If a broader definition of the rural population is used, coverage may be even lower, since rural migrants in urban areas, of which there are over 220 million (Gibson & Li, 2017), may not be covered by either the urban or rural pension systems.

Urban pensions in the centrally-planned era were provided by the state-owned enterprises but this system was reformed from 1997. The urban public pension consists of a pay-as-you-go (PAYG) system funded by a 20 percent payroll tax from employers which is supplemented with a funded system based on individual accounts which are financed by employee contributions of eight percent of their wages (Mu & Du, 2017). However the funded accounts have suffered because some local governments took capital out of these to fund pension payments for the PAYG component since obligations often exceeded the incoming revenue from payroll taxes. Individuals start receiving this pension if they have a history of at least 15 years of depositing into the pension account, and have formally retired after they reach the legal retirement age.

The value of the pension received is determined by the amount of contribution to the system during the employed phase of life, the retirement age, and the average income level in the province. The pension payments can range from 20% to 200% of average provincial income, showing a large inequality in the financial well-being of China's elderly. Family support, in particular, financial transfers and health care from adult children, remain the main source of old age support in China. Thus it is not surprising that Lei *et al.* (2012) find that the financially more capable adult children are able to provide more transfers to their parents. A corollary to this finding is that, to the extent that there is a lack of other sources of support to the elderly, the adult children will face a bigger financial burden. Since young children in the family will also tend to reduce the surplus financial resources of the working adults, these children may cause a reduction in the financial support that can be provided to the elderly. It is this potential competition for resources that may generate some adverse effects from a larger number of grandchildren on the health of the elderly, in addition to the direct health effects caused by grandparents caring for their grandchildren.

4.3 Empirical Methods

We start by regressing health outcomes on measures of the number of grandchildren, along with other control variables, using Ordinary Least Squares (OLS). Our general estimation approach is as seen below:

$$H = \propto_0 + \propto_1 G + \propto_2 \boldsymbol{X} + \propto_3 \boldsymbol{Z} + \varepsilon \qquad (1)$$

where H is the vector of the selected health outcomes for the respondents, including whether they have been diagnosed with high blood pressure (HBP), whether their body mass index exceeds 25 (overweight), whether they report poor health from a four-level self-reported health question (poor health), and their level of difficulty in carrying out activities of daily living (ADL). The question used to create the variable 'Poor Health' asks the respondent to state if their health status is either '1=Excellent', '2=Good', '3=Fair' or '4=Poor'. We define the 'Poor Health' dummy variable to be equal to one if the respondents selected the response '4' for this question and zero otherwise.[33] The ADL is a composite measure made up from 20 indexes of whether the respondent has difficulties in doing twenty routine day-to-day activities, which are: running a kilometer, walking a kilometer, walking 200 meters, walking across the room, sitting for two hours, standing up after sitting, climbing a flight of stairs, climbing a few steps with no pause, lifting a five-kilogram bag, bathing themselves, eating alone, putting on clothes, combing hair, using the toilet, shopping, cooking, using public transportation, managing money, using a telephone and squatting, kneeling or bending.[34] The raw scores range from one for no difficulty to four for not being able to perform the task. The ADL score that we use in the analysis is a standardized total of all these indexes above with mean zero and standard error one, and higher values of the index indicate worse health. We run linear regressions for the ADL score, and Probit regressions for the other three health outcomes.

The variable G is the number of grandchildren, which is our main variable of interest. The vector $\boldsymbol{X}$ has a set of time-varying individual characteristics, including age (in quadratic form), *hukou* status, marriage status, employment status, education level, household per-capita income, whether the person is a regular smoker and the daily amount of cigarettes smoked, whether they are a tea/coffee drinker and their daily consumption of tea/coffee, whether they drink

[33] If we had included 'Fair' health as part of the 'Poor Health' dummy, the proportion of elderly respondents defined to be in poor health would have increased from 12% to 57%. Regressions using the two definitions of 'Poor Health' as outcomes have similar conclusions and hence we stick with the narrow definition which is consistent with the response for the categorical question.

[34] The questionnaire components on ADL were selected by the CHNS team to be comparable with the Health and Retirement Survey and other U.S. –based National Center of Health Statistics surveys.

alcohol, household size, whether they live in an owner-occupied dwelling and whether they live with their children plus the measure of the local development level. The vector ***Z*** has a set of time-invariant factors, including gender, urban/rural status of residence and province of residence.[35]

A concern with OLS estimation of equation (1), where the number of grandchildren is a covariate, is that the estimated coefficients may be biased due to endogeneity. The number of grandchildren is a combined result of the birth behaviors of the respondents and of their adult children. These fertility decisions are (partly) a choice variable that can be affected by health and financial status, which are also correlated with the outcome variables.

The direction of this potential bias is ambiguous. On the one hand, in the absence of fertility control constraints, financially secure and healthier adults may choose to have more children, and thus end up with more grandchildren. This channel could lead to a positive relationship between the number of grandchildren and the health outcomes of the grandparents. Relatedly, having healthier elderly parents may reduce the burden on working-age adults and thereby positively affect their birth decisions, which again would show up as a positive relationship between the higher number of grandchildren and the better health of the grandparents. On the other hand, high parity could be associated with some chronic diseases (Kington, Lillard, & Rogowski, 1997), and this could be

[35] CHNS is a longitudinal survey that follows people in the same households who are typically surveyed at the same addresses in each wave. The question of whether the respondent has always lived in the area has a very low response rate, but we have reason to believe that the sampled respondents are mostly permanent residents in the community. The sampled communities maintain their urban or rural status which is why the urban-rural status of respondents is treated as time-invariant. Consequently we are not able to contribute findings on how the health of temporary migrants (whose place of *hukou* registration differ from the residential address) may be affected by their number of grandchildren.

manifested as a relationship between having those diseases in old age and a higher number of grandchildren. In other words, there would be a negative relationship between the number of grandchildren and the health status of grandparents.

We use two methods to get robust estimates that should overcome these threats to identification. One approach is to take advantage of the panel data, which enable us to deal with the unobservable factors that affect both the number of grandchildren and the health outcomes of the elderly. The panel regression model takes the following form, where *H*, *G* and $\boldsymbol{X}$ are as defined in equation (1). Any unobserved individual factors that are time-invariant, where these γ_i may be part of the ε in equation (1) and are potentially correlated with *G*, will be dropped out of the panel data model once differencing is applied, for any individual who appears in the sample more than once, where all respondents in our sample satisfy this condition. Consequently, the coefficient β_1 is for the estimated effect from the change in the number of grandchildren on the change in the health outcome, and the error term μ should not have a component that is possibly correlated with the change in the number of grandchildren.

$$\Delta H = \beta_0 + \beta_1 \Delta G + \beta_2 \Delta \boldsymbol{X} + \mu \quad (2)$$

The other approach we use to deal with potential endogeneity is to use the one child policy as the source of exogenous variation in the number of grandchildren. We define a legally married woman in China as being eligible to have an extra child if she satisfied the exceptions allowed by the local implementation of the OCP at any stage up to the year prior to the survey (Liang & Gibson, 2017). Along with the birth gap constraints to prevent closely-spaced births, and the *hukou* constraints which depended on whether a woman held agricultural or non-agricultural *hukou*, and the age constraints on the minimum allowable age of the mothers for giving birth a second time, we consider three OCP exceptions:

(a) Whether the community allowed all women to have two children;

(b) Whether the community allowed women to have two children if the first child was a girl, which was called the 'girl-exception', and

(c) Whether the community let women have two children if both parents are only-children, or one parent is an only-child, or one parent and both grand-parents are only-children, which was called the 'only-child-exception'.[36]

A legally married man is defined to be eligible for fathering a second child if his wife is eligible. Thus, all adults who were ever-married up to one year prior to each survey wave will have a value of zero or one indicating their eligibility of having two children under the local OCP.

We design three instrument variables to deal with the potentially endogenous nature of the number of grandchildren, based on this eligibility definition. First, we consider the eligibility of the respondent. This variable E_r, takes a value of one for respondents who were ever eligible and zero for others. Second, we count the total number of adult children of the respondent who were ever eligible to have two children under the local implementation of the OCP that they faced during their child-bearing years (E_k). For example, if a respondent has three children, and none of these children were ever eligible for a second birth, the variable E_k will take the value of zero. Finally, we consider the overall strength of the OCP in each community, as measured by the percentage of women aged 20 to

[36] Amongst the three exceptions, the first is very rare, the girl-exception is primarily applied to rural *hukou* holders, and the only-child exception is normally consistent with the OCP at provincial level.

49 in the community (at the time of each survey wave) who were eligible for a second child (E_c).

The main source of variation in these measures over time for each individual is the change in local OCP implementation during the period covered by the data, and the change in personal conditions, primarily age and *hukou* status. The respondents in this research are people aged 55 and above, and only some of them were directly constrained in their fertility decisions by the OCP. The others had already had enough of their child-bearing years elapse to have time for a second (or more) birth before the one-child policy was introduced. Their adult children, on the other hand, are all covered by the OCP during their child-bearing period and so the combination of these two variables should be relevant to the number of grandchildren. Moreover, the values of these two instrumental variables are not affected by the health outcomes of the elderly respondents, and they have no direct effect on the health outcomes of the elderly respondents other than through the channel of the number of grandchildren. Likewise, the community OCP strength is a measure that is calculated based on all local women of child-bearing age, which is clearly exogenous to any individual respondent and will not be affecting the health outcomes except through fertility. In other words, E_r, E_k, and E_c should all meet the requirements of valid instrumental variables.

The first stage regression, which is estimated using OLS, where G, $\boldsymbol{X}$ and $\boldsymbol{Z}$ are as defined in equation (1) and $\boldsymbol{OCP}$ is the vector of the three instrumental variables described above, is as follows:

$$G = \gamma_0 + \gamma_1 \boldsymbol{OCP} + \gamma_2 \boldsymbol{X} + \gamma_3 \boldsymbol{Z} + \delta \qquad (3)$$

We use the residuals from equation (3) in the second stage, instead of the predictions as in the usual two-stage least-squares analysis because we are running probit models for three of the four health outcomes. To be specific, the estimated residuals are included as an additional regressor in the second stage, which is equivalent to control function estimation (Islam & Smyth, 2015). A further advantage of using this added variable approach is that it allows a Durbin-Wu-Hausman (DWH) test for endogeneity, where statistically significant coefficients on the residuals imply that OLS results will be inconsistent, due to the endogeneity in the number of grandchildren, and this would then support the use of the IV results.

4.4 Data and Descriptive Analysis

The data we use for this research is from the China Health and Nutrition Survey (CHNS), a longitudinal survey from an international collaborative project between the Carolina Population Center at the University of North Carolina at Chapel Hill, the National Institute of Nutrition and Food Safety, and the Chinese Center for Disease Control and Prevention. The survey began in 1989, with follow-up waves every three-to-four years up to the year 2011. The sample covers up to 15 of the 30 provinces in China, although only a subset of provinces is present in all waves. A multistage, random cluster process was used to draw the samples from each province. A poor, middle-income, and rich county are sampled per province, along with the provincial capital or other large city, and a lower income city. The surveyed villages and townships within the selected counties, and the urban and suburban neighbourhoods within the selected cities, were chosen at random.

We use four waves of the CHNS data, for 1997, 2000, 2004 and 2006, because these waves have the required variables. There are only eight provinces covered by all four of these selected waves: Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi and Guizhou, so we restrict our attention to these areas. Although there is not national coverage for China with our sample, it does cover a wide area, extending from the northern to the southern part of China, and including coastal and inland areas, with these provinces exhibiting a lot of heterogeneity.[37] We therefore expect the results to be broadly representative.

Figure 1 CHNS provinces in the Sample

We restrict attention to respondents who are of Han ethnicity, aged 55 and above, who stayed in the survey for at least two of the four selected waves.[38] This

[37] Figure 1 shows the map of China, with the surveyed provinces shaded darker green.

[38] Minority respondents faced different OCP exemptions than those faced by the Han majority roup. Different life styles between minorities and the Han group may also cause different health status due to the factors that are not of core interest in this paper. Finally, the number of minority respondents is quite small, so we only consider the Han ethnic group in this research.

sample yields over four thousand observations, including 1444 unique individuals.[39] Amongst the sampled respondents, 40 percent lived in urban areas, and about half held urban *hukou* (noting that rural people who previously worked for a state-owned enterprise or attended university retain the urban *hukou* that was granted from that activity even if they return to live in the countryside). The share of female respondents slightly exceeds that of male respondents. The respondents are fairly evenly distributed among the sampled provinces, except the share living in Heilongjiang and Guizhou is slightly lower than for the other provinces.

Table 1 contains summary statistics for each of the health outcomes, for the control variables, and for the three instrument variables. We present the descriptive results for all observations and also for males and females, and urban and rural residents separately. It appears that men are less impaired in performing activities of daily living than are women. Rural residents are more limited than are urban residents in performing these daily activities. Almost one-third (31 percent) of the sample are overweight, in that their body mass index exceeds 25. The share of overweight men is similar to that of overweight women, but is much higher for urban residents than for rural residents. The share of respondents with high blood pressure is around one-fifth, and is much higher for urban residents than for rural residents. Across all of the sub-populations, from 10-14 percent of respondents rate themselves as having poor health.

[39] Sample attrition is very complex in CHNS, because it has communities/individuals left the survey and came back later and also one province joined in 1997. Regard to elderly, there are over 1% death of 1989 participants in each wave. (Popkin et. al., 2010) Other than those reasons causing people not appearing in all waves, the major cause of attrition in this chapter is natural disaster. In that case, we could safely say that attrition is not a source of bias for this chapter.

Table 1: Summary Statistics for the Regression Samples

	All	Male	Female	Rural	Urban
Outcomes					
ADL score	0.05	-0.09	0.18	0.08	0.02
Overweight	31%	29%	33%	23%	42%
High Blood Pressure (BP)	19%	18%	20%	14%	26%
Poor Health	12%	10%	14%	13%	11%
Instrument Variables					
Own Eligibility for having 2 children	89%	92%	86%	93%	83%
# children eligible to have a 2nd child	0.45	0.43	0.47	0.58	0.26
Community One-Child Policy strength	71%	71%	71%	78%	60%
Time-Varying Controls					
Number of Grandchildren	0.99	0.94	1.05	1.17	0.74
Annual per-capita Real Household Income (000)	17.33	18.69	16.12	15.96	19.37
Owner-occupied Household	85%	86%	83%	94%	71%
Household Size	3.32	3.36	3.28	3.49	3.07
Local Development Index (ln)	4.07	4.07	4.07	3.88	4.35
Urban *hukou*	49%	50%	48%	19%	93%
Mean Age	68.01	67.84	68.17	67.60	68.62
Currently Married	76%	88%	64%	76%	76%
Not Employed	66%	59%	72%	51%	88%
Working as a Farmer, Fisherman or Hunter	25%	28%	22%	41%	1%
Working in other Occupations	9%	13%	5%	8%	11%
No Qualification	62%	45%	77%	70%	50%
Primary School	18%	25%	12%	19%	17%
Lower Middle School	9%	14%	5%	7%	12%
Qualifications above Lower Middle School	10%	15%	6%	4%	21%
Live with Children	44%	43%	45%	45%	42%
Regular Smoker	26%	46%	8%	30%	20%
Daily Cigarette	3.15	5.87	0.73	3.70	2.32
Regular Tea/Coffee Drinker	43%	54%	33%	37%	52%
Daily frequency of Tea/Coffee	1.22	1.62	0.86	1.01	1.53
Alcohol Drinker	27%	48%	9%	29%	25%
Time-Invariant Controls					
Female	53%			52%	54%
Urban residence	40%	39%	41%		
Heilongjiang	6%	7%	5%	6%	6%
Jiangsu	16%	17%	16%	15%	18%
Shandong	13%	13%	14%	14%	12%
Henan	13%	13%	14%	13%	13%
Hubei	13%	13%	13%	10%	17%
Hunan	11%	12%	11%	12%	10%
Guangxi	16%	15%	18%	19%	12%
Guizhou	10%	10%	9%	9%	11%
Waves					
1997	28%	28%	28%	27%	29%
2000	26%	26%	25%	25%	27%
2004	25%	25%	25%	26%	23%
2006	22%	21%	22%	22%	20%
Observations	4,436	2,089	2,347	2,650	1,786

Notes:

The full sample (column 'All') includes people aged 55 and above with valid information from the China Health and Nutrition Survey, waves 1997, 2000, 2004 and 2006.

In terms of the instrumental variables, around 90% of the respondents had been eligible to have two children during their birth years. However, amongst their adult children, less than two-fifths (38.6%) were eligible to have an extra child, and the average number of adult children eligible for an extra child ranged from 0.26 in urban areas to 0.58 in rural areas. At the community level, an average of 78% of rural women aged between 20 and 49 met the eligibility criteria to have a second birth while in urban communities the proportion eligible for a second birth was just 60%. These rates also varied quite widely between provinces, with Jiangsu having over 90 percent of women eligible for a second birth but in Henan it was below 60 percent. This variation suggests that at the level of an individual woman and her husband, the exogenous constraint on the number of children (and, indirectly, on the number of grandchildren) varies over time and space and this aids our identification of causal effects. It is not surprising that in urban areas there are only two-thirds as many grandchildren (an average of 0.74) as in rural areas (an average of 1.17).

In terms of the control variables, about 90 percent of the respondents are either not employed (which includes being retired), or work as a farmer, fisherman or hunter. In other words, most of them do not have wage income and need to use savings or get financial support from others as a source of their living costs. Smoking, alcohol drinking and tea/coffee consumption have strong effects on health and in our sample men had higher consumption of these items than women. In particular, nearly half of male respondents are regular smokers and alcohol drinkers, while the corresponding share for female respondents is below one-tenth. Smoking and drinking are also more prevalent in rural areas. Although there are big differences in many variables by rural and urban location, the proportion of our sample of elderly who live with their adult children is roughly the same in both sectors, at just over 40 percent.

Figure 2: Number of Grandchildren and Health Outcomes, CHNS, 1997-2006

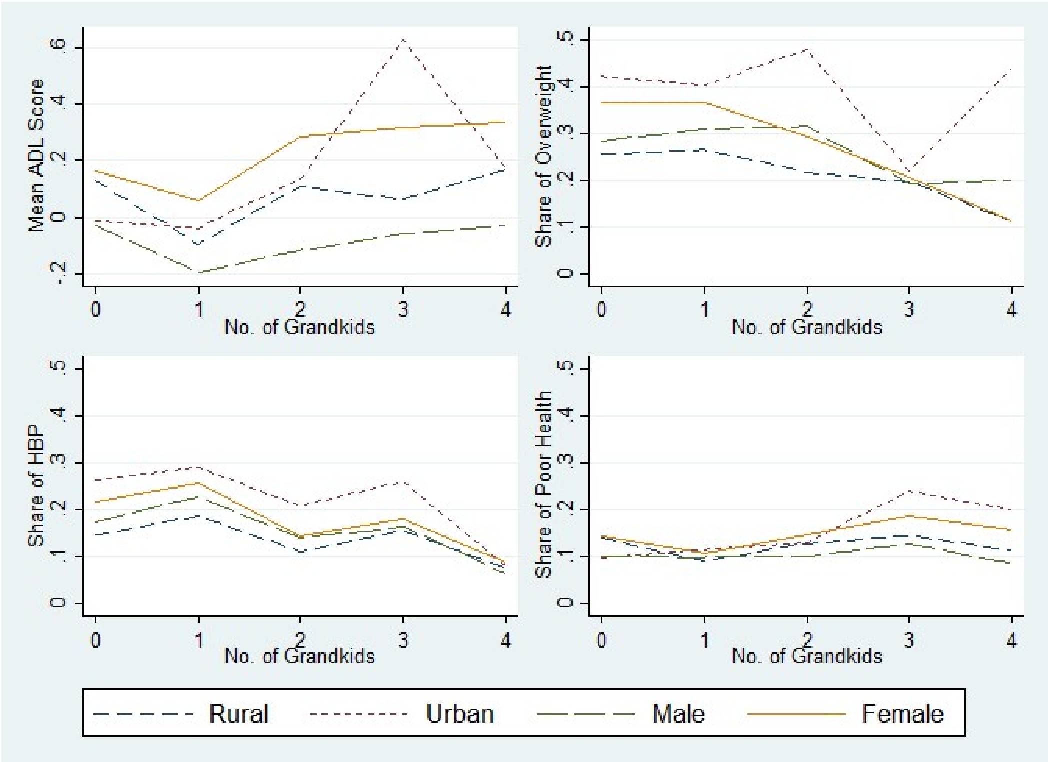


Figure 2 plots the relationship between the number of grandchildren and the four health outcomes for the elderly respondents.[40] The ADL scores are higher for individuals with more grandchildren, which means that these respondents have more difficulty in carrying out daily activities. The likelihood of having high blood pressure is lower for individuals with more grandchildren. The likelihood of females being overweight declines with the number of grandchildren, while patterns are less clear for the other groups. The likelihood of reporting poor health seem to have a weak relationship with the number of grandchildren, except that urban respondents and old women are more likely to report poor health if they have more than two grandchildren. As shown by the graphs, the relationship

[40] The number of grandchildren is truncated at four in the figure. About two percent of the respondents had more than four grandchildren.

between the number of grandchildren and the health outcomes differ across the different sub-groups of elderly. In the next section, we will run regressions to see if these patterns remain the same once we control for other social-economic factors.

4.5 Regression Results

In this section, we present the regression results from the three models described in section 3. For each model we estimate it on the full sample, and then on the male and female sub-samples, and on the urban and rural sub-samples.

4.5.1 Cross-Sectional Analysis

We first run cross-sectional regressions that ignore the panel structure of the data. The coefficients from the OLS and probit models (where probit coefficients are transformed into marginal effects) for the effects of the number of grandchildren on the four health outcomes are reported in Table 2. The models also include all of the control variables in Table 1, but coefficients on these are not reported for reasons of space. For the ADL score, positive coefficients indicate adverse effects from the number of grandchildren, that is, the more grandchildren, the more likely one is to have difficulties in performing daily activities. This relationship is positive, albeit statistically insignificant, for the overall sample, and is positive and precisely estimated for female respondents ($p<0.05$) and for urban residents ($p<0.10$).

For the other three outcomes, positive marginal effects mean that more grandchildren will result in having a higher likelihood of having these health problems. For example, males are more likely to be overweight, and females less likely, the more grandchildren they have. For urban residents, having more grandchildren is associated with reporting poor health. For the probability of having high blood pressure in all samples, and for being overweight and reporting poor health in rural areas, there is no apparent effect of having more grandchildren on health outcomes.

Table 2: Effect of the Number of Grandchildren on Grandparents' Health – Not Instrumented

	All	Male	Female	Rural	Urban
ADL score	0.0173	-0.0157	0.0515*	0.00886	0.0577+
	(0.019)	(0.029)	(0.024)	(0.022)	(0.035)
Overweight	-0.00128	0.0267+	-0.0264+	-0.00242	0.00794
	(0.011)	(0.015)	(0.014)	(0.011)	(0.023)
High BP	-0.0105	-0.0069	-0.0135	-0.00625	-0.0137
	(0.008)	(0.012)	(0.010)	(0.008)	(0.019)
Poor Health	0.00388	-0.00052	0.00882	-0.00032	0.0176+
	(0.005)	(0.007)	(0.008)	(0.006)	(0.010)
Observations	4,436	2,089	2,347	2,650	1,786

Notes:
Estimation is by OLS for the ADL score and by Probit for the other health outcomes, with marginal effects reported in the table.
Coefficients on the other control variables (all those listed in Table 1) are not reported here. Robust standard errors are in parentheses.
** p<0.01, * p<0.05, + p<0.1

Next, we report instrumental variables models that are designed to deal with the possible endogeneity of grandchild numbers. Before discussing the results for the effects on health outcomes, we report on tests of the validity of the instruments. Appendix 1 has the results of the first-stage regressions. The coefficients for the three instrument variables are statistically significant, and the F-statistics for the joint test of the coefficients on the instrumental variables equalling zero all exceed 30 (while the threshold for a 'weak' instrument is that the F-test exceeds 10). Given we are using three instrumental variables as the source of exogenous variation for one potentially endogenous variable, we have an over-identified model. The tests of the over-identifying restrictions show no evidence to doubt the validity of the instrumental variables.[41]

In Table 3 we report two types of results from our instrumental variables analysis. In the top panel of the table there are coefficients for the ADL scores and marginal effects for the other three health outcomes, to show the impact of an additional grandchild on grandparent health. The values are derived from models that have all of the control variables from Table 2 but, in addition, also include residuals from the first stage equations (which are reported in Appendix Table 1). With the addition of these residuals, the coefficients on the number of grandchildren can be interpreted as instrumental variables estimates (Vella, 1993), and this approach is equivalent to control function estimation (Islam & Smyth, 2015). The second panel shows the coefficients on the added residuals; when these coefficients are statistically significant an added-variable form of the Durbin-Wu-Hausman test suggests significant differences between OLS (or Probit) and instrumental variables estimates. In this case, the instrumental variables estimates should be favoured since they should be consistent irrespective of whether the number of grandchildren is endogenous or not.

The results in the lower panel of Table 3 suggest that the Probit results in Table 2 should be used for the analysis of being overweight. Thus, we do not dwell on the IV results for this outcome, which are all statistically insignificant. However, for the likelihood of having high blood pressure and self-reporting poor health, and for the activities of daily living scores, at least some of the residuals

[41] Amongst the 20 regressions (four outcomes and five samples) using instrumental variables, the smallest p-value from the over-identification tests was 0.21 (for the overweight outcome and urban resident sub-sample), and the largest p-value was 0.99 (for the overweight outcome with the full sample). Thus, these tests provide no significant evidence to doubt the validity of the three instrumental variables.

are statistically significant and so the OLS and Probit results in Table 2 may be affected by an endogeneity bias.

Table 3: Effect of the Number of Grandchildren on Grandparents' Health – Instrumented

	All	Male	Female	Rural	Urban
	Coefficients of Number of Grandchildren				
ADL score	-0.150*	-0.225*	-0.0932	-0.208*	0.0715
	(0.071)	(0.096)	(0.100)	(0.085)	(0.157)
Overweight	0.0322	0.0693	0.00104	0.0225	0.000295
	(0.046)	(0.069)	(0.060)	(0.049)	(0.104)
HBP	-0.00328	0.0318	-0.0214	-0.0808*	0.181*
	(0.036)	(0.051)	(0.048)	(0.039)	(0.079)
Poor Health	-0.015	0.016	-0.0394	-0.0463+	0.077
	(0.023)	(0.030)	(0.034)	(0.027)	(0.051)
	Coefficients for residuals				
ADL score	0.177*	0.220*	0.154	0.229**	-0.0146
Overweight	-0.0354	-0.0448	-0.0292	-0.0264	0.00805
High BP	-0.00769	-0.041	0.00847	0.0786*	-0.206*
Poor health	0.02	-0.0174	0.0513	0.0488+	-0.0625
Observations	4,436	2,089	2,347	2,650	1,786

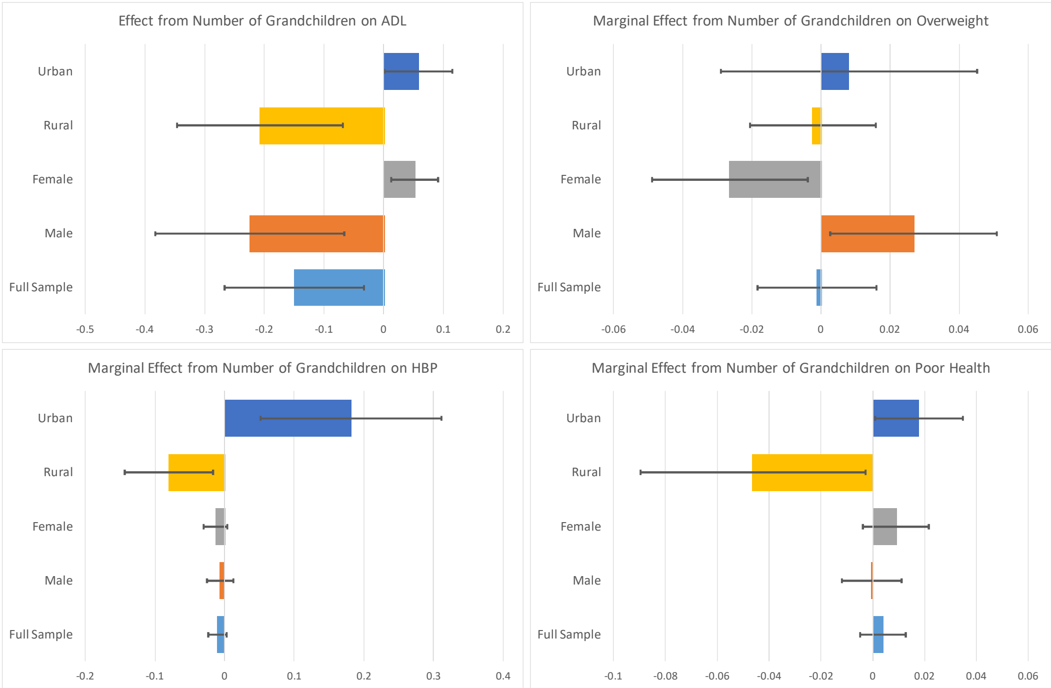
Note:
The first stage equations are reported in Appendix Table 1.
For other notes, see Table 2.

In terms of the likelihood of having high blood pressure, having more grandchildren makes this more likely for urban residents but less likely for rural residents according to the results in the top panel of Table 3. Likewise, for males and females there are offsetting effects, although these are not precisely estimated unlike for the division by place of residence. Consequently, the overall sample shows no net effect of grandchild numbers on the likelihood of being hypertensive, but that is because of the pooling of opposing effects. For the impacts on the ADL score, the coefficient for the number of grandchildren is significant and negative for the pooled sample (indicating fewer difficulties in performing the daily activities of living). However, this is driven by the large and significant effects for males and for rural dwellers, while there are insignificant and small effects for females and for urban dwellers (and the residuals for these two sub-samples are also not significant, so the OLS results should be used for them, since OLS is more efficient).

Since the significant levels from the added residuals suggests a combination of the results from Table 2, for some health outcomes and samples, and Table 3 for the others (when the added residuals are statistically significant), we compile the overall set of cross-sectional analysis results that should be used for each outcome and sample and illustrate these in Figure 3. This figure shows that there are significant impacts of grandchild numbers on ADL scores for all five samples, although the direction of the effect varies. For the overall sample, for males, and for rural residents, the effect on the ADL score is negative, which means that these respondents have fewer difficulties in performing daily activities, the more grandchildren they have. However, for females, and for urban residents, having more grandchildren means having more difficulties. In terms of the size of the effect, for males and for rural respondents, one more grandchild reduces the standardized ADL score by 0.2, whereas for females and for urban residents one more grandchildren increase this score by 0.05.

The effect of the number of grandchildren on the probability of being overweight also has offsetting effects for males and females. Specifically, the marginal effect from having one more grandchild is to increase the likelihood of being overweight by 2.7% for males and to decrease it by 2.6% for females. In contrast, when the sample is split by urban and rural location and also in the pooled sample results (where, for all three sets of estimates, men and women are pooled) there are no significant effects of grandchild numbers on risk of being overweight.

Figure 3: Effect of the Number of Grandchildren on Grandparents' Health, Cross-Sectional



Notes:

Estimation is from the OLS/Probit regressions when the added-variable form of the Durbin-Wu-Hausman test suggests no endogeneity, or from IV regressions otherwise, with marginal effects from the number of grandchildren plotted in the graphs. The 95% CI for estimates is shown by the grey bars.

For the likelihood of having high blood pressure or self-reporting poor health, the offsetting patterns occur in terms of the place of residence. Specifically, having one more grandchild leads to an 8.1% lower chance of being hypertensive (4.6% lower chance for reporting poor-health) for rural residents, while for the urban elderly an increase by one grandchild raises the risk of hypertension or poor health by about 18%.

One consistent pattern shown by the cross-sectional results is that the effects of the number of grandchildren are all tend to make indicators of health worse for urban residents, but better for rural residents. That is, in urban areas, having more grandchildren leads to higher ADL scores, more risk of being hypertensive, and more risk of self-reporting as unhealthy, while the effect of a higher risk of being overweight is imprecisely estimated. In contrast, in rural areas having more grandchildren improves the ability to carry out daily activities and reduces the risk of high blood pressure or self-reporting as unhealthy. One possible reason for the rural-urban difference could be the different burden of child caring and the different resource intensities of urban children compared to rural children. The competition in education for urban children is probably greater than for rural children, given the hierarchy of educational resources available in urban areas and the expectation that children will compete for places in tertiary institutions (which is much less likely for rural children). This focus on the educational needs of urban children could see the grandparents in these areas suffer, either because of resource constraints or because of the direct efforts that they make to assist in the education of the children.

4.5.2 Panel Analysis

The regression results that consider the panel structure of the data are reported in Table 4. The impacts on the ADL scores are all positive, which means that more grandchildren results in more difficulties in carrying out activities of daily living. This effect is especially apparent in the urban sub-sample, where the coefficient is precisely estimated ($p<0.01$) and is twice as large as for any other sub-sample. For the urban elderly, one more grandchild will increase their ADL score by 0.17, which is large effect compared to the urban average score of 0.02.

In line with the cross-sectional results, the effects of changes in grandchild numbers on the likelihood of being overweight run in different directions for different groups. An extra grandchild makes elderly women five percentage points less likely to be overweight ($p<0.01$), while it has a positive but insignificant effect on the chance of men being overweight. The effects in urban and rural areas also run in the opposite directions but neither is statistically significant.

Table 4: Effect of the Number of Grandchildren on Grandparents' Health - Panel Analysis

	All	Male	Female	Rural	Urban
ADL score	0.0781*	0.084	0.0675	0.0587	0.166**
	(0.034)	(0.059)	(0.042)	(0.041)	(0.060)
Overweight	-0.0157	0.0179	-0.0522**	-0.00891	0.0166
	(0.012)	(0.015)	(0.019)	(0.007)	(0.044)
High BP	-0.00548	-0.00152	-0.00925	-0.00382	-0.00726
	(0.007)	(0.009)	(0.010)	(0.006)	(0.020)
Poor Health	0.0054	-0.00033	0.0121	0.00145	0.0187*
	(0.005)	(0.006)	(0.007)	(0.006)	(0.009)
Observations	4,436	2,089	2,347	2,650	1,786
Individuals	1,444	682	762	852	592

Note
See Table 2.

Unlike the results from the cross-sectional analysis, the change in the number of grandchildren does not seem to have a significant influence on the odds of having high blood pressure, for either the whole sample or for any sub-samples. The likelihood of self-reporting poor health also has weak relationship with the change in the number of grandchildren in general, but it is positive and significant when we restrict the analysis to urban residents, with similar magnitudes for the effect to what is seen from the cross-sectional analysis.

In summary, the panel analysis results indicate that an increase in the number of grandchildren harms the health of grandparents, in terms of weakening their abilities to perform daily activities of living. More grandchildren also makes the senior citizens in urban areas more likely to consider themselves to be unhealthy. On the other hand, extra grandchildren will reduce the chance that their grandmothers are overweight, possibly because the extra physical activities that the grandmother may take on to assist with raising a young grandchild may contribute to a reduction in her body mass index.

4.5.3 Robustness Analysis

The impacts from the number of grandchildren on health outcomes of their grandparents may take several years to eventuate. As a robustness analysis, we ran all of the models discussed above using the lagged number of grandchildren, where this is defined as the total number of grandchildren of the respondent in the previous survey wave.[42] The coefficients from these models all have the same signs as in the main results, but fewer of them are statistically significant. We interpret this as suggesting that the pattern of the main results is robust.

4.5.4 Summary of Results

A summary of the statistically significant and consistent results shown in the cross-sectional and panel analysis is that urban grandparents with more grandchildren are more likely to have difficulties in performing ADL and self-report themselves as unhealthy, comparing with those with fewer grandchildren. Grandmothers, who are often the major source of help in looking after young grandchildren, appear to have their body weight lowered when they have more grandchildren.

The statistically significant but inconsistent results from the cross-sectional and panel analysis are the impacts from the number of grandchildren on the ADL scores, where the cross-sectional result (from the IV analysis) suggests that one more grandchild will reduce the ADL score by 0.145, but the panel result suggest an increase of ADL score by 0.0782. Moreover, although not all of the marginal effects are statistically significant, the ADL score is always higher for

[42] When the information of the previous wave is missing, the number is taken from the closest earlier wave.

respondents with more grandchildren for all sub-groups in the panel analysis, whereas the cross-sectional results show different directions of effect for different sub-groups.

A plausible reason for this difference is that the results from cross-sectional analysis show a long-term impact from the number of grandchildren, whereas the results from the panel analysis are more of a short-term effect from a new-born grandchild. Since the physical burden of childcare is heaviest in the first couple of years, it is reasonable that the panel analysis results show that the increase in the number of grandchildren will increase difficulties in performing daily activities. The time horizon needed for effects to unfold may also account for the varying results for hypertension. The effect of grandchildren is significant and positive for the urban elderly, according to the cross-sectional analysis, but is negative and insignificant according to the panel analysis. This difference may reflect the fact that it takes a while for a person to change from normal blood pressure status to hypertensive status, which may not be detected by the panel analysis given the time period covered by the data in this research.

4.6. Conclusions and Discussion

The rapid increase in the elderly population of China, coupled with a very uneven and partial pension system, makes family support crucial for the health and wellbeing of the elderly. However, families also have other financial commitments and calls on their time, particularly when they have to care for children. In these circumstances, it is plausible that competition between the generations could see the health of the elderly suffer when their own children have more children to provide support for. A direct pathway is also possible, particularly for grandmothers, since they are often called upon to assist with the care of young children.

In this paper, we have used exogenous variation in fertility over two generations, due to spatial and temporal variation in the implementation of China's one-child policy, to seek causal evidence on the effect of grandchildren numbers on grandparent health. We also use panel analysis to deal with unobservable factors that may the relationship of interest. We find that the number of grandchildren has strong influences on the health of the grandparents, and having more grandchildren tends to be more of a harm than a benefit for the four health outcomes that we focus on. It is particularly for females, and particularly in urban areas, that health seems to be worse where there are more grandchildren. The sensitivity for these sub-populations may reflect the particular caring duties imposed on grandmothers, and the particular pressures of urban living which may especially result from competitive investment in the human capital of children.

These uneven effects from the number of grandchildren on different sub-groups of old people suggest a need for differentiated health insurance and social support systems for different groups of senior citizens. For example, interventions that pay particular attention to the care of elderly women and urban residents may be needed. To the extent that the new, unconditional two-child policy results in any increase in fertility, it may have adverse effects on the health of old people if their adult children have a second birth and ask for their help as a caregiver to these extra babies. Consequently, better public child-care facilities might also reduce the burden on grandparents from caring for the young grandchildren, which could help to improve their health status.

References

Boca, D. D., Piazzalunga, D., & Pronzato, C. (2017). The role of grandparenting in early childcare and child outcomes. *Review of Economics of the Household(4)*, 1-36.

Ebenstein, A., & Leung, S. (2010). Son preference and access to social insurance: Evidence from China's rural pension program. *Population and Development Review*, *36*(1), 47-70.

Feng, Z., Liu, C., Guan, X., & Mor, V. (2012). China's Rapidly Aging Population Creates Policy Challenges In Shaping A Viable Long-Term Care System. *Health Affairs, 31*(12), 2764-73.

Gibson, J. & Li, C. (2017). The Erroneous Use of China's Population and *per capita* Data: A Structured Review and Critical Test. *Journal of Economic Surveys*, *31*(4), 905–922.

Giles, J., & Mu, R. (2007). Elderly Parent Health and the Migration Decisions of Adult Children: Evidence from Rural China. *Demography, 44*(2), 265-288.

Giles, J., Wang, D., & Zhao, C. (2010). Can China's rural elderly count on support from adult children? Implications of rural-to-urban migration. *Journal of Population Ageing*, 3(3-4), 183.

Greenhalgh, S. (1986). Shifts in China's population policy, 1984-86: Views from the central, provincial, and local levels. *Population and Development Review, 12*(3), 491-515.

Hesketh, T., Lu, L., & Xing, Z. W. (2005). The effect of China's one-child family policy after 25 years. *The New England Journal of Medicine, 353*(11), 1171-1176.

Islam, A., & Smyth, R. (2015). Do fertility control policies affect health in old age? Evidence from China's One-Child experiment. *Health Economics, 24*(5), 601-616.

Kington, R., Lillard, L., & Rogowski, J. (1997). Reproductive history, socioeconomic status, and self-reported health status of women aged 50 years or older. *American Journal of Public Health, 87*(1), 33-37.

Lei, X., Giles, J., Hu, Y., Park, A., Strauss, J., & Zhao, Y. (2012). Patterns and correlates of intergenerational non-time transfers: evidence from CHARLS. *Policy Research Working Paper Series*, No 6076. The World Bank

Liang, Y., & Gibson, J. (2017). Do siblings take your food away? Using China's One-Child Policy to test for child quantity-quality trade-offs. *China Economic Review*. https://doi.org/10.1016/j.chieco.2017.10.006

Liang, Y., & Gibson, J. (2017b). Location or *Hukou*: What Most Limits Fertility of Urban Women in China? *Asia and the Pacific Policy Studies*, *4*(3): doi: 10.1002/app5.188.

Mu, R. (2014). Regional Disparities in Self-reported Health: Evidence from Chinese Older Adults. *Health Economics, 23*(5), 529-549.

Mu, R., & Du, Y. (2017). Pension coverage for parents and educational investment in children: Evidence from urban China. *World Bank Economic Review, 31*(2), 483-503.

Popkin, B., Du, S., Zhai, F., & Zhang, B. (2010). Cohort Profile: The China Health and Nutrition Survey—monitoring and understanding socio-economic and health change in China, 1989–2011. *International Journal of Epidemiology, 39*(6), 1435-1440.

Tao, J. (2016). Can China's new rural social pension insurance adequately protect the elderly in times of population ageing? *Journal of Asian Public Policy,* 1-9.

The Legislative Affairs Commission of the Standing Committee of the National People's Congress of the People's Republic of China. (2002). *Population and Family Planning Law of the People's Republic of China.* The China Population Publishing House.

United Nations Population Fund (UNFPA). (2006). Population Aging in China: Facts and Figures. United Nations: Geneva.

United Nations, Department of Economic and Social Affairs, Population Division (2017). *World Population Prospects: The 2017 Revision*, DVD Edition.

Vella, F. (1993). A simple estimator for simultaneous models with censored endogenous regressors. *International Economic Review*, *34*(2), 441-457.

World Bank. (1997). *China 2020: Old Age Security.* World Bank: Washington DC.

Xinhua Net (Chinese). (2015). Retrieved from http://news.xinhuanet.com/health/2015-10/30/c_128374158.htm

Xu, X., Byles, J. E., Shi, Z., & Hall, J. J. (2015). Evaluation of older Chinese people's macronutrient intake status: Results from the China Health and Nutrition Survey. *The British Journal of Nutrition, 113*(1), 159-171.

Yu, L. C., Mansfield, P. K., & Yu, Y. (1990). Gender and changes in support of parents in China: Implications for the One-Child Policy. *Gender and Society*, 4(1), 83-89.

Zhang, Y. (2013). Meeting the Ageing Challenge: China's Social Care Policy for the Elderly. In *China*: *Development and Governance* (pp. 343-349). World Scientific Publishing Pte.

Appendix 1: First-stage Regressions, Outcome Equals the Number of Grandchildren, OLS, China Health and Nutrition Survey, 1997-2006

	All	Male	Female	Rural	Urban
Own Eligibility for having 2 children	0.134+	0.158	0.123	0.13	0.11
	(0.072)	(0.143)	(0.087)	(0.113)	(0.096)
# Children eligible to have a 2nd child	0.380**	0.354**	0.406**	0.376**	0.385**
	(0.044)	(0.062)	(0.062)	(0.054)	(0.065)
Community OCP strength	-0.321**	-0.338*	-0.324**	-0.336**	-0.238*
	(0.085)	(0.134)	(0.114)	(0.125)	(0.109)
Female	0.0229			0.0198	0.0382
	(0.052)			(0.078)	(0.064)
Age	-0.0185	0.0414	-0.0549	-0.0892	0.0424
	(0.037)	(0.058)	(0.049)	(0.058)	(0.051)
Age Square	0.0174	-0.0246	0.0424	0.0724+	-0.0304
	(0.026)	(0.041)	(0.034)	(0.042)	(0.036)
Urban residence	-0.187**	-0.209*	-0.169+		
	(0.062)	(0.089)	(0.087)		
Urban Hukou	-0.019	-0.0458	-0.0144	0.00712	0.0581
	(0.060)	(0.086)	(0.084)	(0.081)	(0.083)
Currently Married	-0.289**	-0.295**	-0.296**	-0.258**	-0.270**
	(0.052)	(0.097)	(0.064)	(0.073)	(0.065)
Working as a Farmer, Fisherman or Hunter	-0.00448	-0.0658	0.103	-0.0392	0.0598
	(0.057)	(0.068)	(0.107)	(0.088)	(0.069)
Working in other occupation	-0.0723	-0.164*	-0.0105	-0.0823	0.0864
	(0.053)	(0.082)	(0.068)	(0.060)	(0.158)
Primary School Qualification	-0.0124	-0.0367	0.0346	0.00174	-0.0655
	(0.053)	(0.072)	(0.083)	(0.073)	(0.074)
Lower Middle school Qualification	-0.103	-0.115	-0.113	-0.131	-0.0715
	(0.074)	(0.096)	(0.118)	(0.124)	(0.085)
Higher level of qualification	-0.0682	-0.0999	0.0211	-0.296+	-0.0177
	(0.062)	(0.084)	(0.092)	(0.152)	(0.075)
Living with Children	0.0166	0.0502	-0.00309	0.037	0.0406
	(0.051)	(0.072)	(0.072)	(0.072)	(0.067)
Regular smoker	0.0133	0.0126	0.0000265	-0.00365	0.0794
	(0.064)	(0.079)	(0.110)	(0.089)	(0.076)
Daily consumption of Cigarette	-0.00308	-0.00243	-0.00289	0.000621	-0.0118*
	(0.004)	(0.005)	(0.008)	(0.006)	(0.006)
Regular Tea/Coffee Drinker	0.0271	0.0729	-0.00411	0.101	-0.0593
	(0.046)	(0.066)	(0.068)	(0.070)	(0.056)
Daily consumption of Tea/coffee	0.00397	0.000811	0.00974	0.00747	0.00012
	(0.011)	(0.014)	(0.017)	(0.018)	(0.012)
Alcohol Drinker	0.0279	0.0193	0.0475	0.0148	0.0614
	(0.042)	(0.049)	(0.084)	(0.064)	(0.048)
Annual per-capita real household income (000)	-0.00152*	-0.000826	-0.0033**	-0.00108	-0.00241+
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Owner-occupied Household	0.114**	0.03	0.178**	-0.0402	0.178**
	(0.038)	(0.060)	(0.051)	(0.081)	(0.045)
Household size	0.286**	0.270**	0.301**	0.304**	0.232**
	(0.017)	(0.024)	(0.024)	(0.023)	(0.021)
Local development Index	0.0162	-0.0955	0.11	-0.035	0.135
	(0.095)	(0.140)	(0.130)	(0.109)	(0.192)
Constant	0.256	-1.224	1.087	2.773	-2.403
	(1.375)	(2.057)	(1.834)	(2.062)	(2.059)
Observations	4,436	2,089	2,347	2,650	1,786
R-squared	0.441	0.426	0.457	0.443	0.41
First-stage F-statistics	67.1	29.68	45.38	48.75	31.64

Notes:

Fixed effects for survey wave and for province are included in the models but not reported here.

Robust standard errors are in parentheses. ** p<0.01, * p<0.05, + p<0.1

Chapter 5

Conclusion and Discussion

China launched its family planning policy in 1979 to control the population growth rate. The policy started by allowing just one child per couple, then decentralized and relaxed to allow various local exemptions for a second child, and more recently has changed to a nation-wide policy to allow two children for all legally married couples. The total fertility rate in China has decreased to below the replacement level since the introduction of the family planning policy and the average family size has decreased to just above three. The decreased total fertility rate has resulted in a decreased growth rate of the population and an ageing society. Whether family members have benefited from the decreased family size, and whether the family planning policy can continue shaping the population towards the desired size and structure, is the focus of this thesis.

Three issues are studied in the three main chapters. First, how fertility choices are affected by the family planning policy, by urban/rural location, and by *hukou* status are studied in Chapter 2. Building on this base, the question of how the nutrient intakes of children – as an indicator of parental investment – are affected by the number of siblings is studied in Chapter 3. Then, the question of how the health outcomes of grandparents are affected by the number of grandchildren is studied in Chapter 4. In all three chapters, the variation in the family planning policy over space (and also over time in Chapters 3 and 4) is used as a source of exogenous variation in family size to deal with the possible endogeneity that comes from fertility decisions being, partially, a choice variable. In Chapter 3 and 4, panel analyses are also used, to further control for possible biases from unobserved individual characteristics and to provide robust results on the causal effect from family size on the selected outcomes.

Results in this thesis show that the family size has strong impacts on aspects of the quality of human capital and the quality of life of family members. For most of the selected outcomes, fewer children in the family cause positive effects on the life quality of family members. However, the results are sensitive to the selection of outcomes and sample. For example, the higher number of grandchildren can reduce the risk of being overweight for their grandmothers, which is a positive effect, although other effects on health of grandmothers are negative. The family planning policy is seen to be strongly affecting people's fertility choices, and hence affects the quality of life. In general, the family planning policy has contributed to a reduction in the family size in China, and in turn increases the investment in each family member, which then potentially increases the life quality of all members in the family.

This thesis contributes to several aspects of the existing literature. First, the thesis uses a dynamic identification of family planning policy at both individual level and community level. In the existing literature, local one-child policy measures are often measured as the number of exceptions or the existence of certain exceptions. For example, Yang (2007) classified communities into three categories according to whether they had a one-child policy, a girl-exception policy, or a two-child policy, to identify the strength of the family planning policy. Islam & Smyth (2015) consider the girl-exception in rural areas only. While Liu (2014) uses the eligibility for having two children for each woman similarly to how this thesis does, that study only uses one wave of the CHNS data.

The measures of the one-child policy used in this thesis consider four different exceptions, as well as the age constraint on the mothers, the birth-spacing constraint, the *hukou* constraint, and the legal marriage constraint. These are defined using household and individual characteristics that could potentially satisfy the local exceptions to the family planning policy in order to be eligible for a second child. To the best of my knowledge, this is the first research that defines such measures using multiple waves of longitudinal data and shows the relevance of the exceptions to the fertility of couples over time and space. These relatively precise measures of the family planning policy provide the opportunity for better capturing the effect from the policy on the fertility choices.

Second, to study the fertility gaps between urban and rural women, the thesis decomposes the gaps into explained and unexplained parts to see if there is something inherent in being an urban woman that lowers fertility. In particular, the thesis uses both *de facto* (living in an urban area) and *de jure* (holding an urban *hukou*) criteria for the decomposition and finds that the urban *hukou* plays a more important role in the urban-rural fertility gaps. This result shows that the goals of increasing fertility and urbanization can be achieved simultaneously because the trade-off between the two purposes is not as inconsistent as it may seem if the fertility-depressing effects of holding urban *hukou* are rolled together with the effects of living in an urban area. Thus, it is possible that the reform of the *hukou* registration system could help in reducing the fertility-depressing influence of urbanization.

Third, this research is the first to examine the impacts from the number of family members in the third generation on the health of the first generation in China. The number of young children in the family not only affects the quality of the children, as shown by the results in Chapter 3, but also affects aspects of the quality of life of their grandparents, as shown by the results in Chapter 4. The impacts from the number of grandchildren on each health outcome and sub-sample are different, showing the needs for differentiated interventions from the social security and elder care system. In particular, older women and urban grandparents are the two groups that appear to be affected most strongly (and negatively) by the large number of grandchildren. Family planning and formal childcare policy directed towards urban areas and health insurance coverage directed towards women can be designed to deal with this influence.

The major limitation of the thesis is the lack of coverage and identification of the internal migrants in China. Data from the Population Census and surveys conducted by the National Bureau of Statistics and the Ministry of Agriculture both show that a high level of labour migration from rural to urban China (Giles & Mu, 2007; Li & Gibson, 2013). However, this thesis might only include a very small share of such working age population migrants because the CHNS data follows the same households over time, which in turn results in the respondents being treated as permanent residents at their survey address. Due to the lack of information on whether the respondents have always lived at the survey address, all respondents are treated as if they were non-migrants.[43]

The family planning policy and social welfare system in China are both regulated according to the *hukou* registration of citizens rather than the location of residence. Therefore it is reasonable to believe that the birth behaviour for migrant

[43] The question of whether the respondents lived in the same address in the last survey was asked but had a low response rate and hence is ignored in the thesis. The inconsistency between the *hukou* status and residence type (e.g. rural *hukou* holders live in urban areas) suggests that some of the sample are the internal migrants from rural to urban areas, but this is not direct information.

women of working age will most likely follow the pattern of their original place of living in the rural area, which is often close to their *hukou* registration place, rather than follow the pattern of their current place of living in the urban area. The fertility rate in rural areas is higher than the rate in urban areas and higher for rural *hukou* holders than for urban *hukou* holders. Therefore, if the internal migrants are fully captured and identified, the study in Chapter 2 would be likely to result in finding a larger fertility gap between urban and rural areas, which probably strengthens the conclusion in that chapter that policy trade-offs between encouraging continued urbanization and raising the fertility rate may be smaller than they appear.

Another limitation of the thesis is the possible weakness of the instrumental variables method that is caused by the incompleteness in the coverage of the fertility constraints. When designing the instrument variables, the thesis does not include the fines for unsanctioned births when using the family planning policy as the source of exogenous variation in family size. These penalties are shown to possibly have adverse effects on people's fertility choices (Liu, 2014; Zhang, Xu & Liu, 2016) but data on these fines are less easily obtainable than the data on OCP exemptions.[44] Also, the influence of the family planning policy on fertility choices may have reduced after 1997 due to the relaxation of the need for sanctioned births under the birth registration requirement (Li, Zhang & Feldman, 2010). Nevertheless, the dynamic identification of local family planning policy has helped to identify several interesting relationships in this thesis.

[44] The amount of fines for unsanctioned birth is often related to the annual income of the parents in the previous year. The data quality of the amount of fines applied to individuals in the CHNS data is not good enough for the analysis and hence is ignored in this study.

Reference

Giles, J., & Mu, R. (2007). Elderly Parent Health and the Migration Decisions of Adult Children: Evidence from Rural China. *Demography, 44*(2), 265-288.

Li, S., Zhang, Y., & Feldman, M. W. (2010). Birth Registration in China: Practices, Problems and Policies. *Population Research and Policy Review, 29*, 297-317.

Li, C., & Gibson, J. (2013). Rising Regional Inequality in China: Fact or Artifact? *World Development, 47*, 16-29.

Liu, H. (2014). The quality-quantity trade-off: evidence from the relaxation of China's one-child policy. *Journal of Population Economics, 27*(2), 565-602.

Islam, A., & Smyth, R. (2015). Do fertility control policies affect health in old age? Evidence from China's One-Child experiment. *Health Economics, 24*(5), 601-616.

Yang, J. (2007). China’s one-child policy and overweight children in the 1990s. *Social Science & Medicine*, *64*, 2043-2057.

Zhang, J., Xu, P., & Liu, Feng. (2016). One-child policy and childhood obesity. *China Economic Review*. http://dx.doi.org/10.1016/j.chieco.2016.05.003

Appendix Co-authorship Forms

Postgraduate Studies Office
Student and Academic Services Division
Wahanga Ratonga Matauranga Akonga
The University of Waikato
Private Bag 3105
Hamilton 3240, New Zealand
Phone +64 7 838 4439
Website: http://www.waikato.ac.nz/sasd/postgraduate/

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Co-Authorship Form

This form is to accompany the submission of any PhD that contains research reported in published or unpublished co-authored work. **Please include one copy of this form for each co-authored work**. Completed forms should be included in your appendices for all the copies of your thesis submitted for examination and library deposit (including digital deposit).

Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

Chapter 2
Liang, Y., & Gibson, J. (2017a). Location or Hukou: What Most Limits Fertility of Urban Women in China. Asia and the Pacific Policy Studies, 4(3). doi:10.1002/app5.188

Nature of contribution by PhD candidate	Conceptualizing and designing the study, designing the empirical strategy, data cleaning, empirical analysis and writing of initial draft.
Extent of contribution by PhD candidate (%)	80

CO-AUTHORS

Name	Nature of Contribution
John Gibson	Guidance, critical feedback and assisting with the journal revision process

Certification by Co-Authors

The undersigned hereby certify that:

❖ the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and

Name	Signature	Date
John Gibson	John Gibson	31 Aug 2017

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

Co-Authorship Form

Postgraduate Studies Office
Student and Academic Services Division
Wahanga Ratonga Matauranga Akonga
The University of Waikato
Private Bag 3105
Hamilton 3240, New Zealand
Phone +64 7 838 4439
Website:
http://www.waikato.ac.nz/sasd/postgradu

This form is to accompany the submission of any PhD that contains research reported in published or unpublished co-authored work. **Please include one copy of this form for each co-authored work.** Completed forms should be included in your appendices for all the copies of your thesis submitted for examination and library deposit (including digital deposit).

Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

Chapter 3
Liang, Y., & Gibson, J. (2017b). Do siblings take your food away? Using China's One-Child Policy to test for child quantity-quality trade-offs. China Economic Review. https://doi.org/10.1016/j.chieco.2017.10.006

Nature of contribution by PhD candidate	Conceptualizing and designing the study, designing the empirical strategy, data cleaning, empirical analysis and writing of initial draft.
Extent of contribution by PhD candidate (%)	80

CO-AUTHORS

Name	Nature of Contribution
John Gibson	Guidance, critical feedback and assisting with the journal revision process

Certification by Co-Authors

The undersigned hereby certify that:

- the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and

Name	Signature	Date
John Gibson	John Gibson	5 Mar 2018

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

Co-Authorship Form

Postgraduate Studies Office
Student and Academic Services Division
Wahanga Ratonga Matauranga Akonga
The University of Waikato
Private Bag 3105
Hamilton 3240, New Zealand
Phone +64 7 838 4439
Website:
http://www.waikato.ac.nz/sasd/postgradu

This form is to accompany the submission of any PhD that contains research reported in published or unpublished co-authored work. **Please include one copy of this form for each co-authored work.** Completed forms should be included in your appendices for all the copies of your thesis submitted for examination and library deposit (including digital deposit).

Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

Chapter 4
Liang, Y., & Gibson, J. (2017c). Do more grandchildren lead to worse health status of grandparents? Evidence from the China Health and Nutrition Survey. Working Papers in Economics, 17(18).
It has been submitted to Review of Economics of the Household.

Nature of contribution by PhD candidate	Conceptualizing and designing the study, designing the empirical strategy, data cleaning, empirical analysis, writing of initial draft and presentation at one workshop
Extent of contribution by PhD candidate (%)	85

CO-AUTHORS

Name	Nature of Contribution
John Gibson	Guidance and critical feedback

Certification by Co-Authors

The undersigned hereby certify that:

- ❖ the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and

Name	Signature	Date
John Gibson	John Gibson	5 Mar 2018