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Fiscal decentralization and China's regional infant mortality

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Abstract

Regional Chinese infant mortality rates (IMRs) are examined using a stochastic frontier method for the first time. The composite error term method yields estimates of large underreporting of IMRs over time and provinces in China during the past 30 years. China does not follow the standard growth paradigm of more growth leading to lower IMRs. Fiscal decentralization has not alleviated the problem of high IMRs. Both IMRs and the sex ratio at birth suggest reported data constitute a floor or minimal level of demographic distress across provinces with millions of missing females not fully included in the data. China's one-child policy leads to not only underreporting by families but also reporting abuse by local officials who want to be promoted. The *hukou* system and unbalanced government development policies exacerbate the issue.

JEL classification: J11; O23; O53; P25

Keywords: Infant mortality; China's regions; Fiscal decentralization

1. Introduction

While China is similar to other countries by having a negative long-run causal relationship between per capita income and population growth (Hasan, 2010), they have supplemented the need to lower population with the well-known one child per family policy. The policy has impacted the

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infant mortality rate (IMR) that has long been used as key measure of the economic development of a country. In China, infant mortality has been suspected of being underreported for many decades given a historic bias towards male births. However, after the Communist revolution infant mortality rate and the bias towards male births appeared to fall (Coale & Banister, 1996). More recently, the strict one child per family legislation and improved abortion/ultra sound methods have led to a rise in the sex ratio to levels suggesting the bias towards male births has returned (Coale & Banister, 1996). Indeed, the one-child policy has led to millions of females aborted according to the most recent (2005) mini census (Ridley, 2012) and over-reporting of twins that do not actually exist (Huang, Lei, & Zhao, 2014). Infant mortality in middle income countries is most likely to be underreported in general (Anthopolos & Becker, 2010), and China as a middle income country with a strict population control policy in a society biased toward male births is therefore quite likely to have high IMR underreporting. Underreporting suggests that the true IMR is consistently above the reported rate of IMR variation across time and provinces in China including very recent censuses (e.g., for the 2010 census, see Du & Zhang, 2014; Zhao & Yang, 2013).

While the stochastic frontier method (SFM) has been applied to cost and production functions for many years (e.g. Bauer, 1990; Fare & Grosskopf, 2005), it has only recently been considered in explaining infant mortality (Anthopolos & Becker, 2010) and never within China. The SFM with a one-sided error is applied with the assumption that the reported IMR is much lower than the true IMR resulting in a one-sided "frontier" that, if underreporting did not happen, would represent a true IMR frontier. Such a frontier would still be subject to random noise, but cannot be modeled using an OLS average function ignoring the one-sided underreporting. A province with relatively little underreporting would form the frontier as a "best practice" region that may still have a high IMR by world standards. As our analysis will compare provinces within China only, the frontier analyzed here cannot be used to compare relative regional reporting performance with other countries. Section two discusses the literature. Section three outlines the method and data. Section four presents the results and section five concludes.

2. Literature review

There have been a number of studies that explored IMR underreporting and missing women for China. Traditional Confucian philosophy reflected in the "San Cong Si De" saying of three obediences and four virtues gave women no rights as possessions of men for thousands of years. After the revolution in 1949, legal gender equality in the workplace did not stop the discrimination and unusually high female mortality rate (Jiang, Li, Feldman, & Barricarte, 2012). Wolf and Huang (1980) attribute the female infant mortality to infanticide and abandonment because of male preference. Banister (1987) identifies several sources of underreporting such as unlikely reporting of infant deaths when the deaths happen in the first week of life, infanticide, stringent fertility targets, sex-selective underreporting due to one-child policy etc. while Das Gupta and Li (1999) compare China's experience with some other Asian countries. Sen (1990) estimates 100 million women missing in China using a normal sex ratio at birth and non-gender-biased mortality. His work is modified by Klasen and Wink (2002) who include overall health conditions as well. More recently, Bulte, Heerink, and Zhang (2011) cited a figure of 40 million missing women and held the one-child policy responsible for 50% of them. Coale and Banister (1994) found that Chinese parents have changed from selecting sons via infanticide and abandonment of female babies by the use of ultrasound B. Cao and Wang (2010) document the threat of high IMRs to small ethnic groups and the consequent loss of racial and cultural diversity. Wei and

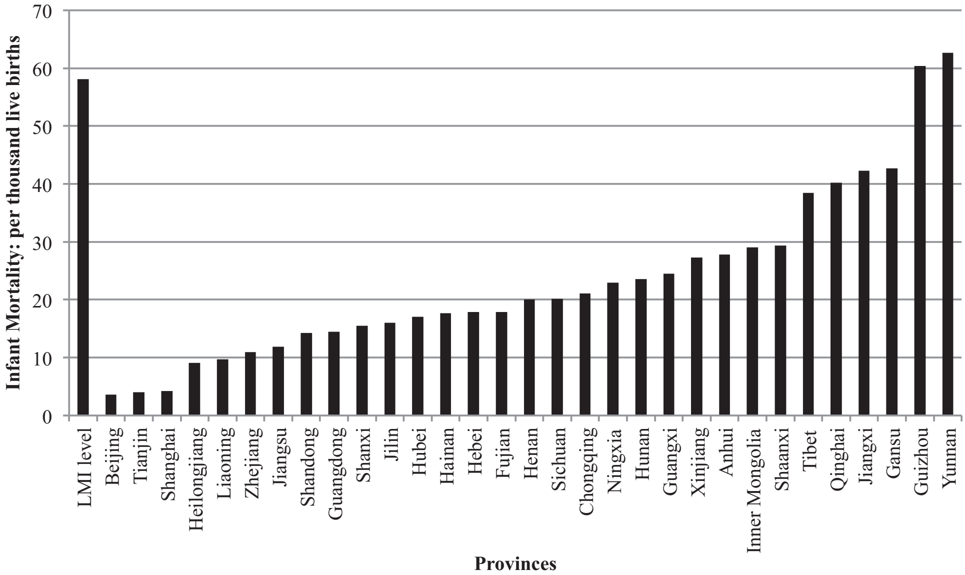

Fig. 1. A: A comparison of Chinese provincial infant mortality rates and all lower middle income countries in 2000. Data Sources: LMI level average IMR from World Health Organization, http://www.who.int/healthinfo/statistics/mortality_life_tables/en/index.html; Provincial IMRs in China from National Bureau of Statistics.
Remarks: "LMI" level refers to the average level of Infant Mortality Rate for all Lower Middle Income Countries. The LMI countries are Angola, Armenia, Belize, Bhutan, Bolivia, Cameroon, Cape Verde, China, Congo, Côte d'Ivoire, Djibouti, Ecuador, Egypt, El Salvador, Georgia, Guatemala, Guyana, Honduras, India, Indonesia, Iraq, Jordan, Kiribati, Lesotho, Maldives, Marshall Islands, Micronesia (Fed. States of), Mongolia, Morocco, Nicaragua, Nigeria, Pakistan, Papua New Guinea, Paraguay, Philippines, Republic of Moldova, Samoa, Sao Tome and Principe, Senegal, Sri Lanka, Sudan, Swaziland, Syrian Arab Republic, Thailand, Timor-Leste, Tonga, Tunisia, Turkmenistan, Tuvalu, Ukraine, Uzbekistan, Vanuatu, Viet Nam and Yemen, as classified by World Health Statistics 2011.

Zhang (2011) predicted the rising sex ratio due in part to the high IMRs will increase the already high household savings rate even more. Using a holistic approach, Song and Burgard (2008) are pessimistic about any reduction in urban/rural IMR disparities even with continued economic growth and improvements in public health. None of these studies applied a SFM.

A comparison of year 2000 IMRs in China's provinces and lower middle income group countries (Fig. 1A) shows China's IMRs compare favorably with other countries. The IMRs in Beijing, Tianjin and Shanghai are even lower than the 6.78 average of the high income country group. Among the four "super" municipalities that are directly administered by the central government, only the newly created municipality in 1997 – Chongqing – has a relatively high (21.10) infant mortality. Chongqing is high as it was a part of Sichuan Province that is an inland and relatively underdeveloped region. To strengthen inland development and coordinate the resident resettlement from the reservoir areas of the Three Gorges Dam project, Chongqing was upgraded into the only "super" municipality in western China. The provinces with relative high IMRs are concentrated in western, southwestern and inland China. The five ethnically minority populated autonomous regions-Inner Mongolia, Guangxi, Tibet, Ningxia and Xinjiang have higher than average infant mortality but still lower than those for Guizhou and Yunnan. This is not surprising since those autonomous regions receive more transfers from the central government for the consideration of national unity and pacifying the minorities. Even being compared with the average level of 28.83 of the upper middle income group, China is still one of the best performing countries if one excludes the regions of Inner Mongolia, Shaanxi, Tibet, Qinghai, Jiangxi, Gansu, Guizhou and Yunnan.

During the past 30 years, falling provincial IMRs were expected given a regionally decentralized authoritarian system resulting in spectacular poverty reduction and economic growth (Xu, 2011). As an important component of regional decentralization, fiscal decentralization became a critical part of successful resource allocation. China's fiscal decentralization follows a gradualist approach with four packages in 1980, 1985, 1988 and 1994 respectively. The first three reforms were characterized by the central government's case-by-case devolution of fiscal power to various sub-national governments while the last was in the form of tax-sharing with all sub-national governments under a nationwide uniform standard known as the Tax-Sharing System reform. Numerous studies (e.g., Bahl, 1999; Boadway & Shah, 2007; Lardy, 1998; Zhao, 2009) have documented these reforms. If measured by expenditure decentralization alone, China has been quite fiscally decentralized with about 70% of public funds spent by sub-national governments. The figure is much higher than those in developed federal countries such as Germany (40%) and the U.S. (46%) according to Wong (2006). Arguable China has been fiscally over-decentralized (Wang, 1997) although sub-national governments do not have the authority over determining the tax bases or the tax rates on the revenue side.

A large body of literature has identified many potential benefits and risks of fiscal decentralization.[2] However, quantitative evidence of a link between regional fiscal decentralization and the quality of healthcare delivery in the regions is unclear. If it is more efficient for sub-national governments to spend public resources, a healthier labor force can be expected. Martinez-Vazquez and McNab (2003) classify the effect of fiscal decentralization on healthcare service as the intermediate effect of fiscal decentralization on economic growth. We examine whether this direct effect is significant. Compared to other healthcare indictors such as life expectancy and maternal mortality, the IMR is more sensitive to public health expenditures by governments. Blaxter (1981) and Sen (1998) contend that the quality of life rests heavily with healthcare, medical knowledge and medical insurance. Infant mortality can reflect all of these factors. Unlike life expectancy, infant mortality is more affected by public healthcare expenditures rather than private healthcare investments and individual life style.

Using both low and high income 1970–1995 cross-country data with OLS and fixed-effect estimations, Robalino, Picazo, and Voetberg (2001) find a significant impact of fiscal decentralization on infant mortality reduction even in an environment of high corruption. A weakness associated with cross-country data is that there are substantial differences in the culture, history, institutions, religion and natural resources across countries. Uchimura and Jutting (2007) analyze a panel of Chinese counties from 1995–2001 and find that more fiscally decentralized counties have lower IMRs if they have a well-functioning transfer system among sub-national governments and a strengthened local fiscal capacity. However, their study does not control for healthcare input factors such as healthcare expenditures or healthcare output factors such as the number of hospitals or doctors. As these important input/output variables have been included as proxies for healthcare physical and human capital in most previous infant mortality research, we also include them. Asfaw, Frohberg, James, and Jutting (2007) use rural IMRs 1990–1997 in 14 Indian states to document that fiscal decentralization does play a statistically significant role in reducing rural IMRs. However, they also find that a low level of political decentralization can erode the effectiveness of fiscal decentralization in reducing IMRs in rural India. In contrast, Jin and Sun (2011) use Chinese provincial infant mortality data 1980–2003 with both OLS and panel Feasible Generalized Least Squares to show an overall adverse impact of fiscal decentralization on the infant mortality reduction. Following Zhu, Fu, and Li (1998), Tang and Bloom (2000) focus on rural areas and present a case study of a poor rural county in China. They find little evidence that radical fiscal decentralization leads to increased healthcare outcomes. Green and Collins (1994) even suggest some degree of centralization instead of fiscal decentralization in resource allocation and planning for primary healthcare. Therefore at best there is mixed evidence for a fiscal decentralization/IMR relationship in China.

3. Method and data

The core data are a provincial data set used by Jin and Sun (2011) to analyze regional IMRs using OLS with further description of these 1980–2003 census years only data found in their paper. While they use the number of doctors per 10,000 inhabitants to represent human capital in the health sector, we also add in the overall human capital in a province using the human capital index found in Li and Liu (2011). We also include historic and future provincial economic growth performance given the importance of economic growth during the sample period. Historic economic growth is the annual average growth rate of a province's Gross Regional Product, 1952–1979. Future economic growth is the same but for the years 2003–2008. The hypothesis for both of these variables is that they will serve to lower a province's IMR thanks to earlier development and/or the capacity to support future development.

The empirical model is Jin and Sun (2011) equation one but modified by the addition of several macroeconomic variables plus their assumption of a normal error term is relaxed to account for the one-sided nature of IMR underreporting as suggested by Anthopolos and Becker (2010).

$$
\begin{aligned}
IMR_{it} = {} & \beta_0 + \beta_1 FD_{it} + \beta_2 \mathrm{lnGRPPC}_{it} + \beta_3 \mathrm{lnHEPC\_HA}_{it} + \beta_4 \mathrm{HESG}_{it} + \beta_5 \mathrm{BEDP}_{it} \\
& + \beta_6 \mathrm{DOCP}_{it} + \beta_7 \mathrm{GEO}_{it} + \beta_8 \mathrm{FD}_{it} \times \mathrm{GEO}_{it} + \beta_9 \mathrm{FER}_{it} + \beta_{10} \mathrm{URBAN}_{it} \\
& + \beta_{11} \mathrm{GROWTHIST}_{it} + \beta_{12} \mathrm{YEAR}_{it} + v_{it} - u_{it}
\end{aligned}
$$

Here $i = 1,..,31$ provinces and $t = 1980, 1981, 1989, 1990, 2000$ and 2003. Table 1 defines each independent variable except HESE and HEPC HA. The table also describes the hypothesized impacts on the IMR dependent variable with further discussion of each impact found in Jin and Sun (2011). HESE is the share of health expenditure in total annual expenditure and is omitted in the SFM equations because it was found to be highly correlated with HESG. HEPC HA is a predicted variable derived from an auxillary equation regressing HEPC on FD and GRPPC. It represents the indirect impact of fiscal decentralization on IMR via health care expenditures. The composite error term consists of the standard white noise "v" and a second component "u" representing technical inefficiency. "v" is assumed to be an identically and independently distributed (i.i.d.) normal variable with zero mean and an unknown variance (var-v). The second component "u" is one-sided and assumed to be i.i.d. positive truncations of a normal distribution with unknown mean (m) and variance (var-u). Anthopolos and Becker (2010) assume that "u" has a half-normal distribution which restricts "m" to be equal to zero and nested within the more general truncated normal. As theory provides no guidance as to what the underlying density function of IMR underreporting might be, we examine both half-normal and a more generalized truncated normal distribution. The truncated normal is superior if the mean of the one-sided distribution is non-zero. Whether a SFM is superior to OLS can be tested by estimating "g" equal to [(var-u)/(var-v + var-u)]. "*g*" ranges between zero and one. If "g" is close to zero, the variance of "u" is small and OLS estimates may be sufficient as within sample technical inefficiency is low. If, on the other hand, "*g*" is close to unity, var-u is large and a frontier production function is superior to OLS. We use LIMDEP 9.0 software.

Table 1
Summary statistics.

Variables	Obs.	Mean	Std. Dev.	Min.	Max.	Expected signs
Dependent variable						
Infant Mortality Rate (IMR) (‰)	178	32.00	21.18	3.66	121.92	
Independent variables						
FD ratio (defined as the ratio of per capita provincial budgetary expenditures to the sum of per capita central budgetary expenditures and provincial budgetary expenditures)	182	0.63	0.14	0.33	0.93	–
Real Gross Regional Product per capita in log form (**lnGRPPC**)	182	7.50	1.32	5.31	10.76	–
Public healthcare expenditures per capita in log form (**lnHEPC**)	178	3.60	0.74	2.27	5.83	–
The share of public health expenditures in Nominal Gross Regional Product (**HESG**)	178	0.03	0.02	0.002	0.12	–
The number of medical beds per ten thousand persons (**BEDP**)	182	25.02	11.27	0.17	62.10	–
The number of doctors per ten thousand persons (**DOCP**)	182	17.63	9.44	0.13	46.30	–
Geographical location for each province (**GEO**)	186	2.65	0.90	1	4	+
Natural population growth rate (**FER**)	180	11	5.35	−1.35	23.57	+
Urbanization rate (**URBAN**, the percentage of urban population in total population)	182	0.27	0.17	0.09	0.82	–
The average growth rate of per Capita Real Gross Regional Product from 1952 through 1979 (**GROWTHIST**)	182	4.89	2.06	0.60	11.02	–
Real Gross Regional Product from 2003 through 2008 (**GROWTHFUT**)	182	11.95	1.83	8.87	19.30	–
Year dummy (**YEAR**)	182	1990	9.48	1980	2003	–

Data source: National Bureau of Statistics in China.
Notes: IMR is census data.

Once estimates of underreporting are computed, they are compared using simple correlation (due to limited data) with the 1981, 1989 and 2000 Sex Ratio at Birth (SRB) and the IMRs. The SBR is the annual number of live males to females born to a population. Globally, the SBR is remarkably constant over time and countries with a ratio above 106 considered to be abnormal (Lai, 2005). As China has SRBs much greater than 106 in some provinces, we investigate whether underreporting and high reported IMRs are associated with this. If IMR underreporting is relatively high when the SRB is low, then provinces with relatively low SRBs may be falsely seen as not a concern when they should be. Or, in other words, the wide variation in provincial SRBs like the IMR variations may be partly artificial.

Table 2
Regression results: dependent variable: yearly provincial infant mortality rate (‰).

	Jin and Sun (2011)		Stochastic frontier approach	
	OLS	FGLS	Half-normal (i)	Truncated-normal (ii)
FD ratio	86.05* (45.64)	27.74 (21.26)	330.46 (239.57)	652.34*** (125.90)
lnGRPPC	2.01 (2.63)	0.85 (1.94)	−133.40*** (30.09)	−132.87*** (17.97)
lnHEPC_HA	−16.31*** (5.61)	−10.63*** (2.60)	19.86 (37.56)	−30.03 (24.38)
HESG	671.00*** (119.11)	586.91*** (88.40)	0.03 (0.09)	0.01 (0.04)
BEDP	0.28* (0.16)	0.22** (0.10)	1.16 (0.91)	1.60*** (0.59)
DOCP	−0.02 (0.18)	−0.10 (0.13)	2.14 (1.98)	0.63 (0.87)
GEO	8.47 (6.50)	2.09 (4.08)	55.12 (70.58)	47.38 (30.75)
FD*GEO	−4.02 (8.90)	5.43 (5.69)	−111.21 (99.86)	−139.79*** (42.44)
FER	−0.24 (0.30)	−0.20 (0.19)	−0.01 (0.12)	−0.04 (0.07)
URBAN	−36.16*** (9.91)	−12.80* (6.78)	52.41 (80.69)	7.83 (52.15)
HESE	1.49 (8.73)	−18.81 (12.12)		
GROWTHIST			−1.99 (6.78)	−1.97 (2.60)
YEAR			17.00*** (3.74)	17.00*** (2.16)
Constant	−7.50 (21.40)	19.43 (15.98)	−32,963.80*** (7193.26)	−32,989.17*** (4192.36)
Observation number	172	172	182	182
R-squared	0.62			
Wald Chi-squared		339.22		
Sigma-squared (v)			0.25	397.58
Sigma-squared (u)			29,619	20,05,071.15

Note:
* significant at 10%.
** significant at 5%.
*** statistically significant at 1%.
(1) In parentheses are standard errors of coefficients; (2) OLS are estimated with robust option; (3) FGLS is estimated correcting for heteroskedasticity and autocorrelation AR(1); (4) FGLS results are not that different from OLS, which indicates that the heteroskedasticity and autocorrelation AR(1) could be present but do not dramatically change OLS results.

Table 3
Regional IMRs, estimated underreporting and sex ratio at birth.

	Regions	1981	1989	1990	2000	2003
Beijing	Regional IMR	15.97	13.01	8.80	3.66	5.89
	Estimated underreporting	35.23	117.63	117.63	117.63	117.63
	Sex ratio at birth	107.02	107.49	–	114.58	–
Tianjin	Regional IMR	20.03	15.89	10.70	4.05	8.48
	Estimated underreporting	56.27	117.63	117.63	98.43	91.74
	Sex ratio at birth	107.67	110.14	–	112.97	–
Shanghai	Regional IMR	19.39	18.19	12.40	4.26	5.52
	Estimated underreporting	9.87	115.85	111.60	14.23	75.69
	Sex ratio at birth	105.37	104.84	–	115.51	–
Chongqing	Regional IMR	–	–	–	21.10	14.61
	Estimated underreporting	–	–	–	117.63	117.63
	Sex ratio at birth	–	–	–	115.8	–
Inner Mongolia	Regional IMR	41.37	45.16	29.00	29.08	25.98
	Estimated underreporting	34.84	22.74	24.28	18.27	14.43
	Sex ratio at birth	106.83	108.35	–	108.48	–
Liaoning	Regional IMR	22.09	23.75	18.70	9.66	13.70
	Estimated underreporting	19.96	93.34	95.67	58.52	70.89
	Sex ratio at birth	107.11	110.16	–	112.17	–
Jilin	Regional IMR	19.87	25.02	24.40	16.01	9.04
	Estimated underreporting	56.34	89.60	79.97	50.07	68.19
	Sex ratio at birth	107.77	108.67	–	109.87	–
Heilongjiang	Regional IMR	34.74	28.13	18.40	9.11	28.60
	Estimated underreporting	13.75	51.41	52.35	28.32	20.80
	Sex ratio at birth	106.89	107.3	–	107.52	–
Hebei	Regional IMR	21.44	17.53	9.20	17.88	19.65
	Estimated underreporting	37.50	91.61	87.46	88.02	37.12
	Sex ratio at birth	108.19	112.49	–	118.46	–
Jiangsu	Regional IMR	33.00	23.87	15.00	11.92	8.71
	Estimated underreporting	7.33	27.07	31.26	11.48	19.45
	Sex ratio at birth	107.87	114.93	–	120.19	–
Zhejiang	Regional IMR	35.64	25.93	17.10	10.99	11.23
	Estimated underreporting	11.47	43.90	48.68	10.46	17.78
	Sex ratio at birth	108.83	117.64	–	113.11	–
Anhui	Regional IMR	30.40	31.44	26.10	27.78	28.55
	Estimated underreporting	35.09	52.49	52.58	34.42	50.74
	Sex ratio at birth	112.45	110.87	–	130.76	–
Fujian	Regional IMR	22.59	27.39	23.00	17.91	14.60
	Estimated underreporting	66.81	89.12	81.09	14.10	18.27
	Sex ratio at birth	108.64	110.29	–	120.26	–
Jiangxi	Regional IMR	46.60	46.99	43.00	42.26	25.80
	Estimated underreporting	39.32	80.24	61.34	27.41	51.61
	Sex ratio at birth	107.86	110.82	–	138.01	–
Shandong	Regional IMR	20.06	19.84	12.90	14.30	15.01
	Estimated underreporting	13.78	56.13	49.77	14.96	20.39
	Sex ratio at birth	109.86	115.12	–	113.49	–
Henan	Regional IMR	20.54	23.49	18.50	20.08	13.06
	Estimated underreporting	47.83	81.85	67.41	22.80	37.98
	Sex ratio at birth	110.32	116.21	–	130.3	–
Hubei	Regional IMR	39.65	34.20	25.10	17.02	15.23
	Estimated underreporting	19.14	41.59	34.00	12.22	21.86
	Sex ratio at birth	106.97	109.56	–	128.02	–

Table 3 (*Continued*)

	Regions	1981	1989	1990	2000	2003
Hunan	Regional IMR	51.18	45.97	38.10	23.61	14.56
	Estimated underreporting	19.53	62.36	37.83	24.48	45.54
	Sex ratio at birth	107.61	110.25	–	126.92	–
Guangdong	Regional IMR	19.30	22.14	15.90	14.46	9.91
	Estimated underreporting	28.34	48.93	31.89	20.50	35.22
	Sex ratio at birth	110.47	111.99	–	137.76	–
Guangxi	Regional IMR	32.13	36.09	44.00	24.53	19.69
	Estimated underreporting	43.85	59.55	24.65	27.43	35.18
	Sex ratio at birth	110.69	116.91	–	128.8	–
Hainan	Regional IMR	–	36.81	29.20	17.71	25.07
	Estimated underreporting	–	60.85	72.00	79.16	101.44
	Sex ratio at birth	–	114.86	–	135.04	–
Shanxi	Regional IMR	31.18	32.03	19.20	15.52	20.55
	Estimated underreporting	60.01	99.45	93.31	46.73	77.63
	Sex ratio at birth	109.35	109.64		112.75	–
Sichuan	Regional IMR	–	–	–	20.16	41.00
	Estimated underreporting	–	–	–	41.07	39.59
	Sex ratio at birth	107.95	111.96	–	116.37	–
Guizhou	Regional IMR	71.44	58.94	52.40	60.36	33.40
	Estimated underreporting	64.12	98.09	94.19	86.26	117.63
	Sex ratio at birth	106.84	101.24	–	105.37	–
Yunnan	Regional IMR	82.83	70.62	65.80	62.67	25.78
	Estimated underreporting	33.79	75.64	51.51	43.56	102.70
	Sex ratio at birth	106.17	107.42	–	110.57	–
Tibet	Regional IMR	–	103.10	96.20	38.48	26.19
	Estimated underreporting	–	12.78	11.70	44.76	44.02
	Sex ratio at birth	–	–	–	–	–
Shaanxi	Regional IMR	47.84	32.84	22.00	29.39	31.85
	Estimated Underreporting	56.11	94.47	85.19	68.84	72.55
	Sex Ratio at Birth	109.17	111.35	–	125.15	–
Gansu	Regional IMR	32.71	35.59	31.50	42.69	23.48
	Estimated underreporting	24.79	61.06	54.33	79.92	117.63
	Sex ratio at birth	106.27	110.82	–	119.35	–
Qinghai	Regional IMR	91.61	77.23	66.30	40.20	33.41
	Estimated underreporting	39.18	71.18	61.23	86.09	96.40
	Sex ratio at birth	106.22	104.36	–	103.52	–
Ningxia	Regional IMR	60.10	46.60	37.30	22.96	25.24
	Estimated underreporting	14.33	25.00	23.66	34.07	40.86
	Sex ratio at birth	106.18	110.82	–	107.99	–
Xinjiang	Regional IMR	121.92	–	–	27.29	38.56
	Estimated underreporting	13.40	–	–	13.17	14.40
	Sex ratio at birth	106.07	104.63	–	106.65	–

Sources: Lai (2005).

4. Results

Regression results (Table 2) indicate the use of a component error term is superior to OLS with almost all variation found in the second component and “g” equal to one. When a more restrictive half-normal distribution is applied, most regression coefficients are not significant at the 10% level and the resulting frontier estimate of underreporting appears uniform across years and provinces (column i). As this is highly unlikely given the discussion in the literature and Jin and Sun's (2011) earlier results, we reject the half-normal results in favor of the more general truncated normal (column ii).[3] With the truncated normal assumption, we obtain an interesting frontier across time and space plus have coefficients similar to those found by OLS with one exception. The exception is the log of GRP per capita coefficient is now negative and significant. Jin and Sun's positive and significant coefficient which they did not expect and report as contradictory now switches to the expected result of stronger economic growth lowering the IMR. While the number of doctors per 10,000 persons (DOCP) and the degree of urbanization (URBAN) also switch signs compared to their results, neither of the coefficients is significant using a SFM suggesting weak evidence against their expected finding that health sector human capital and higher urbanization lowers IMRs.[4] As for the additional variables we included, only a trend variable is significant supporting the literature showing that IMRs increased over time. High historic regional growth lowers IMR levels as expected but the coefficient is insignificant. As future economic growth was consistently insignificant in initial regressions, we dropped the variable entirely.

The more general truncated normal frontier estimates yield a frontier with each census year/province as one point of the frontier (Table 3). When the one-sided component index is higher, the underreporting is less. Provinces with an index at or even above 100 are forming a "best practice" frontier which could still be far inferior to worldwide standards. In the few cases where the index is greater than one, we treat the data point as at 100% or "no underreporting." [5] The frontier reveals a wide variation in underreporting across provinces with the "best practice" provinces including the municipal areas such as Beijing and Tianjin in some years. The six regions (Beijing, Shanghai, Tianjin, Helongjiang, Jilin and Liaoning) believed to have the best health care systems in the 1980s (Lai, 2005) appear to have low underreporting in 1990 (Table 4) with the exception of Heilongjiang. However, this low underreporting does not carry over to 2000 or 2003. The −0.19 correlation suggests when the reported IMRs are higher underreporting increases. If a province reduces the IMR through economic growth, underreporting will also be reduced. If IMRs increase despite economic growth due to China specific factors such as the one-child population policy, underreporting will also increase. For example, high growth Shanghai has a large drop in underreporting from the 1980/1981 period to 1989/1990 but a large increase when comparing 1989/1990 to 2000/2003.

While the IMR and underreporting have a negative correlation (Table 4) across all three years 1981, 1989, 2000 (−0.06), the value is near zero as the negative correlation in 1981 and 1989 (−0.1 and −0.23) becomes positive in 2000 (0.13). We see weak evidence that as China modernized, relatively low regional IMRs were associated with more underreporting unlike the 1980s when the opposite was the case. With the SRB, the 1981 correlation with the underreporting index

Table 4
Correlation between IMR, underreporting and sex ratio at birth.

	1981	1989	2000	Overall
IMR × UR	−0.10163	−0.226009197	0.133301	−0.06125
UR × SRB	0.282064	−0.379691632	−0.198	−0.13644
SRB × Ratio	−0.78731	−0.679964309	−0.8486	−0.83672
UR × Ratio	−0.12902	0.220012954	0.092702	−0.03331

Notes: "UR" = Underreporting; "SRB" = Sex Ratio at Birth; "Ratio" = Male IMR/Female IMR.

is positive (0.28) but then becomes negative in both 1989 (−0.38) and 2000 (−0.2) suggesting underreporting is associated with high regional SRBs. As the regional SRBs are abnormally high by world standards already (Lai, 2005), the problem of IMR underreporting suggests even higher SRBs than the actual SRBs reported. So we find additional evidence that the number of missing females may be worse than the available data indicate.

5. Conclusions and policy implications

Using a SFM, we find a large amount of underreporting of the IMR across Chinese provinces. Though strong economic growth and fiscal decentralization have characterized China's economy over the past 30 years, we find no consistent reduction in either the IMR or IMR underreporting except that an overall reduction in a province's IMR does seem to reduce underreporting in the sample period. Unlike a prior study, we find that per capital GRP growth reduces the IMR in general. Only weak evidence is found for historic or future growth on either side of the sample period impacting on a province's IMR. While underreporting is not strongly associated with high or low IMRs, it is positively associated with high SRBs suggesting the actual IMR and SRB data may constitute a floor or minimal level of the demographic crisis in China's regions with respect to missing females. The standard finding in developing countries of stronger GDP growth associated with lower IMRs appears to hold for China as well even with special demographic policies, exceptional fiscal decentralization and a historic/cultural bias towards male heirs not always found elsewhere. Recent reforms to increase transparency in government can be evaluated by how much the underreporting of IMRs further decreases as China grapples with the demographic and political consequences of a growth slowdown.

Policies to address the IMR underreporting can focus on both technical and non-technical reasons for underreporting. Technical reasons include low-quality census facilities, techniques and investigators (Zhang & Liu, 2014) that even if are modernized can still lead to biased survey results where respondents believe that their answers about pregnancies will also be used to enforce fertility laws (Song & Burgard, 2008). Non-technical reasons include the need to abandon the one-child policy that is very recently starting to happen given the many unintended consequences now evident from strict enforcement (Howden & Zhou, 2011). The policy leads to not only underreporting by families but also reporting abuse by local officials who want to be promoted (e.g., Lee & Feng, 2009; Zhang & Yuan, 2004). Local officials in urban areas are particularly problematic given the huge non-hukou migration of about 20% of the Chinese population (sometimes called "floating population" (Chan & Bellwood, 2011)) with births actually occurring in urban areas far more than statistics suggest. The "floating population" as the result of the hukou system and the significant increase in China's income inequality between rural and urban has grown rapidly since the late 1980s. These rural migrant workers are not entitled to urban benefits such as unemployment and health insurance while earning wages that allow a bare minimum standard of living. However, this vulnerable group is the backbone of China's export industry and manufacturing sector. Changing the unbalanced government development policies that favor more developed coastal and urban regions which caused the rapid rise in income inequality and hukou system problems are urgent tasks.

Except for the above factors, the traditional strong son preference and gender discrimination is a leading cause of high SRB and the IMR underreporting in China. The government should enhance the laws and policies on protecting women's rights and improving women's social status to provide a better environment for women. For example, the government could integrate the old-age insurance in the social security system by providing the insurance to the people above

60 years with only daughters (Jiang, Li, & Feldman, 2011) to help change attitudes towards females. Finally, the very recent attempt (see The Outline, 2015) by the government to improve the pension system in conjunction with abandoning the one child per family policy can help improve the chances of having a female child and to officially report it.

Areas for further research include the need for more study of the IMR underreporting within regions (e.g., Li, Zhu, & Feldman, 2004) using surveys or other methods that women can trust. Whether known underreporting in a given area impacts underreporting in the future and a woman's decision of where she has her child, especially if she is in the "floating population" needs additional study. Further study of the IMR/SBR links are also called for given the IMR underreporting, and large number of missing females in China leads to an imbalanced sex structure in China causing social problems. The shortage of marriageable females has caused a large number of surplus males in the marriage market, referred to as the "male marriage squeeze" (Das Gupta & Li, 1999; Li, Jiang, & Feldman, 2006; Tuljapurkar, Li, & Feldman, 1995). Among the unmarried men, many of them are rural peasants of low socioeconomic class and with limited education. Many studies showed that an overwhelming percentage of violent crimes were perpetrated by young, unmarried, low-status males. The sex imbalance could increase the levels of antisocial behavior and violence could impact the stability of society (Hesketh & Zhu, 2006). Such research would extend well beyond economics to analyze sociological and psychological changes in the core family unit that may cause China to lose her long term outlier IMR and SBR status (Alkerna, Chao, You, Pedersen, & Sawyer, 2014) and become more like other middle income countries.

Notes

2. See, Bird and Vaillancourt (1997), Lockwood (2006) and Jin (2009) for a comprehensive survey about possible advantages and disadvantages of fiscal decentralization.
3. Ideally, the mean of the one-sided distribution should be different from zero statistically. However, we found that the mean of −26,938 is not significantly different from zero due to high standard errors. Given that a truncated normal nests the half normal, we believe it is still the preferred result given the severe data limitations. We also assume Jin and Sun (2011)'s similar sample result of heterogeneity not being strong enough to dramatically change OLS results applies here as well though this is an area for further research. Data do not allow the usual use of lagged regressors and proxies to correct econometrically for heterogeneity beyond the use of a dummy control variable (GEO).
4. In addition to health sector human capital, the overall human capital in a province can also be measured by an index created by Li and Liu (2011). However these data do not include the 1980s limiting their use here. A preliminary regression (not shown) did indicate that overall human capital in a province looking only at four years will lower the IMR in that province. Because we felt it was important to include the 1980s to build on the results of Jin and Sun (2011), we did not continue using overall human capital in the final regressions.
5. Another interpretation is that in a few cases there is IMR over-reporting. Why a province might over-report IMR is unclear except if there was an incentive to garner federal health care money by exaggerating the true IMR.

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