Food and Agriculture Organization of the United Nations

FAO Statistics Working Paper Series / 20-18

METHODOLOGICAL NOTE ON NEW ESTIMATES OF THE PREVALENCE OF UNDERNOURISHMENT IN CHINA

FAO Statistics Working Paper Series
ESS/ 20-18

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Food and Agriculture Organization of the United Nations Rome, 2020

Cafiero, C.; Feng, J. and Ishaq, A. 2020. *Methodological note on new estimates of the Prevalence of Undernourishment in China*. FAO Statistics Working Paper 20-18. Rome, FAO. https://doi.org/10.4060/cb0172en

ISBN 978-92-5-133015-9

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Abstract

This paper presents new estimates of the extent of food consumption inequality in mainland China and discusses their implications for the estimated prevalence of undernourishment (PoU). The new food consumption inequality estimates are based on the joint analysis of food consumption and food expenditure data obtained from two separate household surveys, covering the period from 2011 to 2017. The results reveal much less inequality in dietary energy consumption than previously assumed and imply a substantial downward revision of the estimated series of the PoU for China, which becomes more in line with other assessments of food insecurity and with other development indicators.

Keywords

Prevalence of undernourishment; food security indicators; China; food consumption inequality.

1. Overview

The Food and Agriculture Organization of the United Nations (FAO) estimates the prevalence of undernourishment (PoU) in all countries and regions of the world by assuming a probabilistic model for the distribution of the per capita levels of habitual dietary energy consumption in the population. The distribution is characterized in terms of the average (the mean dietary energy consumption in the population) and the coefficient of variation (CV, which is a measure of inequality in food consumption level within the population) . As differences in observed food consumption of different people may also reflect differences in dietary energy requirement due to sex, age, body mass and physical activity levels, the key parameter to determine the extent of undernourishment is the coefficient of variation (CV|y) that can be traced back to differences in the households' socio-economic characteristics that are independent of sex, age, body mass and physical activity of their members.

For mainland China, the last time the CV|y was estimated directly from official survey data was in 1999, in preparation for the first edition of *The State of Food Insecurity in the World* (SOFI) report. Later, lack of access to the needed data prevented updates and the parameter has been kept constant since then. As a result, FAO's current assessments of the PoU for China do not reflect possible changes in food consumption inequality within its population since 1999, and therefore may be inaccurate. Such changes may have occurred as a consequence of the likely increases in the levels of dietary energy intake for the poorer strata of the Chinese population due to the rapid, intense economic growth in the country over the last two and a half decades. If food consumption of the poor has increased more than that of the rich, overall inequality, and therefore the PoU, should be lower.

Granular data on food consumption that allow a direct assessment of the inequality in the levels of habitual dietary energy consumption across different population groups are rare. For China, such data are currently publicly available only from the nutrition module of the China Health and Nutrition Survey (CHNS – see further for a description of the survey). As the CHNS also provides information on the income decile group to which the surveyed individuals belong, its data can be used to directly estimate CV|y. Unfortunately, CHNS data only cover 12 provinces and municipalities and are publicly available only up to 2011.

To obtain estimates of the CV|y for the entire Chinese population, and for years more recent than 2011, a different strategy is needed. In this paper, we exploit the obvious consideration that, given prevailing food prices, at any given time and for a given population there must be a strict, positive association between food expenditure and dietary energy consumption: those who spend more on food would be eating more, and likely have larger dietary energy intakes. If such an association exists, and it is proven to be strong, which is our working assumption, it can be used to predict dietary energy consumption levels of households with known levels of food expenditure.

To pursue such strategy, we use data from the China Household Finance Survey (CHFS – a fuller description is provided further below), which covers 28 provinces and municipalities with samples that are designed to be representative of the population of mainland China and is available for the years 2011, 2013, 2015 and 2017. The data are

used to estimate average monthly food expenditures for households belonging to different income decile groups. By contrasting these to the findings from the analysis of the CHNS data, we empirically validate the relation that exists between average food expenditure and average dietary energy consumption in 2011 and use it to predict average dietary energy consumption levels by income decile in China. These predictions are used to estimate the CV|y in 2013, 2015 and 2017, which is in turn used to update the estimates of the PoU.

In practice, we compute the average, habitual daily dietary energy consumption (DEC) in 2011 by province (or municipality) and income decile from the CHNS, and the average, monthly food expenditure (FOOD_EXP) for the same 12 provinces of municipalities, also by income decile, from the CHFS. This yields a total of 120 pairs of observations on DEC and FOOD_EXP, one per income decile in each of the 12 provinces or municipalities. With these data on hand, we estimate a function that links the two variables, exploring different alternative formulations to capture a possible non-linear relation between the two variables. With the estimated model, we predict a level of DEC that can be associated with the level of FOOD_EXP reported by each income decile household group, in each of the provinces/municipalities covered by the CHFS in 2011, 2013, 2015 and 2017. The weighted average and the weighted standard deviations across provinces/municipalities and income deciles, calculated using the respective population size in each group as weights, are used to compute an estimate of the coefficient of variation in habitual dietary energy consumption due to differences in income (CV|y) for the whole population of mainland China, which is used to update the PoU estimates.

Results show that, already in 2011, inequality in habitual dietary energy consumption in mainland China was substantially lower than that formerly assumed by FAO, and that such level of inequality has remained fairly constant since. Ceteris paribus, a revision of CV|y from 30.5 percent (the value currently used by FAO to inform the PoU) to about 15 percent (the value resulting from the analysis presented in this paper) reduces the estimated PoU for mainland China from 9.6 percent (as reported by FAO in *The State of Food Security and Nutrition in the World*, 2019 edition) to a value that is significantly less than 2.5 percent, which is the lowest value FAO reports for this indicator. Such a downward revised estimate of PoU in China appears to be much more in line with the picture that emerges from analysis of several other socioeconomic indicators for China over last two decades.

The paper is organized as follows. Section 2 introduces the methodology that FAO uses to estimate the PoU, highlighting the role that each parameter plays in its computation and the preferred data sources to estimate them. To motivate the need for a revision of one of the parameters for China, specific attention is devoted to the data environment that FAO uses to inform its current estimates of the PoU for mainland China. Section 3 delineates the analytic strategy followed to indirectly estimate the CV|y for the entire population of mainland China. Section 4 describes the data used, while section 5 presents the results and discusses their implications, putting them in relation to recent assessments of the socio-economic progress in China over the past few decades. Section 6 concludes.

2. Background and motivation

FAO estimates the prevalence of undernourishment in all countries and regions of the world by assuming a probabilistic model for the distribution of the levels of habitual, dietary energy consumption in the population, and contrasting them with the distribution of dietary energy requirements that are consistent with the populations' distribution by age, sex, body masses and physical activity levels. The formula used is:

with $=\int_{-\infty}(|;\ )$ [1]

$= \blacklozenge$ [2]

where $(.\ )$ is the distribution of the daily, habitual, dietary energy consumption levels normalized to refer to a theoretical "average" individual that represents the population in terms of age, sex, body mass and physical activity levels. To keep the number of needed parameters to the minimum essential, the distribution is typically assumed to be lognormal, and thus fully characterized by only two parameters, DEC and CV. Furthermore, the CV is decomposed into two components: CV|y and CV|r, which reflect, respectively the part of variation in food consumption that can be associated with differences in incomes across households, and the part that can be linked to Estimating the PoU, therefore, requires providing a value for each of four parameters:

- MDER, which is an estimate of the lower bound of the range of dietary energy requirements that are compatible with a normally active and healthy life for the average individual in a population.
- CV|r, an estimate of the coefficient of variation (i.e., the standard deviation divided by the mean) of the distribution of energy requirements for the same average individual in the population.
- DEC, which is an estimate of the average habitual, daily dietary energy consumption in the population, expressed in per capita level.
- CV|y is an estimate of the coefficient of variation of the distribution of per capita levels of habitual dietary energy consumption in the population that can be associated with differences in the households' socio-economic characteristics that are independent of sex, age, body mass and physical activity.

While a minimal amount of sufficiently detailed data to describe the population structure and to characterize the distributions of energy requirements, and therefore to estimate both MDER and CV|r, are easily available for virtually all countries in the world,[1] sufficiently detailed data on food consumption at individual or household level to estimate DEC and CV|y are much harder to find.

To publish the complete series of PoU for all monitored countries, FAO typically relies on the latest available data on both the level and the distribution of food consumption from different official sources. The distribution is efficiently defined as a lognormal distribution, characterized by only two parameters: the mean daily per capita dietary energy consumption (DEC) and the coefficient of variation (CV). While an estimate of DEC can typically be obtained as the ratio between the country's total food supply,

1 The main source of population data at national, regional and global level is the biannual UN World Population Prospects (WPP). See https://population.un.org/wpp/.

expressed in dietary energy equivalent (Dietary Energy Supply – DES), and the total population size, adjusted for household and retail level waste, and therefore can be estimated by national food balance sheets and population data, even if no recent food consumption survey is available, the CV can be estimated directly only from data on quantities of food consumed by individuals in a nationally representative population survey.

In preparation for each new edition of *The State of Food Security and Nutrition in the World (SOFI)* report, the series of PoU are updated every year based on revised series of population data and of Food Balance Sheets. CV|y's are revised less frequently, when new food consumption data from surveys are made available. Direct revisions involve the series up to the date of the last available survey and the estimated CV|y is typically kept constant after that.[2]

For mainland China, the last time it was possible to directly estimate the CV from survey data was in 1999, in preparation for the first edition of the SOFI report. This was possible thanks to the collaboration between the Statistics Division at FAO and the China National Bureau of Statistics (CNBS), which provided data on average dietary energy consumption in the national population of mainland China in 1996, tabulated by income deciles. Since then, food consumption data from the annual urban and rural population surveys have been made available by CNBS only as average quantities of major food groups, by population groups. These data cannot be used to obtain an estimate of the CV, as they provide no information on the possible inequality in dietary energy consumption levels across households. As a consequence, the CV for China used for PoU assessments has been kept constant since 1999.

This practice creates an obvious problem, as it is quite likely that levels of dietary energy intake in China have increased considerably and, arguably, much more for the poorer than for the richer strata of the Chinese population. World bank estimates of shared prosperity in 2013-15, for example, show 1.75 percentage points higher average total consumption growth for the bottom forty percent of the population when compared to that of the total population in mainland China. (World Bank, 2019). If we take total consumption expenditure as a proxy for real disposable income and if we further consider that the poor have typically higher income elasticity of food consumption than the rich, all of this is a strong argument to expect that an estimate of the CV|y in China today should be (possibly much) lower than one based on 1996 data.

3. An analytic strategy to combine data from different surveys to estimate CV|y

From the discussion in the previous section, it is evident that a revision of the estimates of the CV|y, and therefore of the PoU values published by FAO for China, is urgently needed. The best option to conduct such a revision would be to process quantitative food consumption data from nationally representative household surveys, similar to

[2] For countries where reliable estimates of the prevalence of severe food insecurity (FI_{sev}) based on the FIES are available, trends in CV|y, have been modeled based on the difference between the values of FI_{sev} and that of the PoU computed assuming constant CV, from 2014 on.

those used to obtain the estimate in 1996. Unfortunately, although annual living condition household surveys that collect food consumption data have been conducted in China since 1999, data are only disseminated in aggregate form.[3] Despite several attempts, thus far FAO has not been able to access the household-level microdata needed to obtain estimates of apparent dietary energy intake.

As no other nationally representative household survey exists to provide quantitative food consumption data, the second best option - and the one used in this paper - is to use a combination of two separate surveys: one that provides data on dietary energy intake and the other that provides data on household food expenditures. To the extent that the two surveys cover overlapping domains in terms of represented population, their data can be used to establish an empirical model linking dietary energy intake to food expenditure across income deciles.

In this paper, we use the CHNS as the source of dietary intake data, and the CHFS for food expenditure data. We then estimate the model using the observations from the two surveys for the same set of 12 provinces. First, from CHNS data we compute the average daily dietary energy intake across all households that fall into the same income decile group, treating it as an estimate of the level of *habitual,* per capita dietary energy consumption (DEC) in that group.[4] We thus obtain a total of 120 observations, one per each income decile in each of the 12 provinces covered by the 2011 CHNS. Then, we compute the average, per capita, monthly food expenditure (FOOD_EXP) also for each group of income decile in each province from the CHFS. With the observations that match provinces/decile groups available in CHNS, we obtain a sufficiently reliable and large sample size to estimate a function that links habitual DEC to food expenditure (a total of 120 pairs of DEC and FOOD_EXP).

Next, using the estimated function, we produce an estimate of habitual DEC for each income deciles in all provinces and years covered by the CHFS, thus generating all the observations we need to estimate the CV|y for mainland China in 2011, 2013, 2015 and 2017. To obtain a full series of CV|y for the entire monitored period, we interpolate linearly between the value originally estimated for 1996 and the new value estimated for 2011. Finally, we use these values to update the series of CV|y currently used to estimate the PoU in China and generate new series of PoU from 2000 to 2018.

4. Data and methods

One major data source on dietary energy intake in China is the widely cited China Health and Nutrition Survey (CHNS), conducted since 1990 as an ongoing open cohort, international collaborative project between the National Institute for Nutrition and

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[3] The Household Survey on Income and Expenditures and Living Conditions in China is conducted, annually, by the China National Bureau of Statistics (CNBS) since 2013 and was previously conducted as two separate surveys for the urban and rural populations). Food consumption data are only reported as average quantities of major food groups, at the level of households group (e.g., by province). If separately available, the quantities of food acquired by each household might be converted into equivalent dietary energy consumption, which in turn could inform estimates of CV|y.

[4] The assumption is that the variation in the average per capita level of recorded food consumption across the members of households belonging to the same income group can reasonably be attributed to idiosyncratic individual or household characteristics and to measurement errors, and therefore should not contribute to estimating the CV|y that is relevant for the PoU.

Health (NINH, former National Institute of Nutrition and Food Safety) at the Chinese Center for Disease Control and Prevention (CCDC) and the Carolina Population Center at the University of North Carolina at Chapel Hill. In its latest edition in 2015, it covers a panel of 12 provinces and 3 municipalities (Beijing, Chongqing and Shanghai) (see Map in figure 1) . These provinces and municipalities span the Southern and the Eastern parts but do not cover the Northern and the Western parts of China.

The CHNS provides a rich set of information, including data collected using a nutrition module that allow for computing the individual, habitual daily dietary energy intake as the average of three, 24-hour recall recordings of food intake data. One important feature of the CHNS data is that they also include information that allow for classification of the households into groups of similar income levels.

The CHNS is arguably the only suitable large-scale source of food intake data in China that can be used to study the actual distribution of levels of dietary energy consumption within different population strata, such as across individuals of different sex and age, within groups of same income level, and across income groups. Unfortunately, it only covers part of the country (see Figure 1).

Extending the results of the analysis of average levels and variability of food consumption to the total population might imply the risk of bias induced by the fact that the population in the included provinces may differ, in substantial ways, from the national population. One concern is specifically related to the fact that the population in provinces not included in the CHNS have generally lower levels of disposable income – and therefore of food consumption – than the ones included.

Figure 1 Map of provinces covered in the China Health and Nutrition Survey

SOURCE: https://www.cpc.unc.edu/projects/china/about/proj desc/chinamap

Map conforms to Map No. 4170 Rev. 18.1 UNITED NATIONS, February 2020

To fill the data gap on food consumption in other provinces of China, we use also data from another survey, the China Household Finance Survey (CHFS), a project that has been collecting micro-level financial information about Chinese households all over the country since 2010. It is managed by the Survey and Research Center for China Household Finance of the Research Institute of Economics and Management at the Southwestern University of Finance and Economics in Chengdu, Sichuan, China. Data are representative at the provincial level and make it possible to compute average monthly household consumption expenditure on different categories of goods and services.

A review of the literature reveals that CHFS data is a very solid source of evidence on consumption in China, corroborated by various theories of consumption. For example, Zhang and Cao (2012) and Han and Si (2020), using data from various rounds of CHFS during 2011 -2017, studied the impact of asset portfolios household consumption of durable and non-durable goods. These studies report a positive, significant association between household wealth and durable as well as non-durable consumption expenditures. Han and Si (2020) report that this association is stronger for day-to-day living expenditures that include food expenditures compared to luxury expenditures.

In our use of the CHFS data we focus on expenditures classified as “food” and compute the average across groups of households classified by decile of total real consumption expenditure

Our strategy is to link habitual food consumption, measured in terms of equivalent dietary energy intake, to average monthly food expenditure, measured in real monetary terms, for the provinces and income deciles where it is possible to characterize both variables, and then to exploit data on food expenditure available for all provinces and income deciles from the CHFS to predict the average apparent dietary energy consumption by income decile in the provinces not covered by the CHNS in 2011, and in all provinces of mainland China in 2013, 2015 and 2017.

Table 1 reports average apparent dietary energy consumption (DEC) and average monthly food expenditure (FOOD_EXP) for 10 provinces and 2 municipalities covered by the CHNS in 2011. The data tabulated by decile of per-capita income in each province/municipality is what we use in estimating a model that links the two variables.

The 120 pairs of values are plotted against each other in the chart of Figure 2 revealing how habitual dietary energy consumption increases as the average monthly food expenditure increases up to levels of around 400 Yuan, but not beyond that.

Using these data, we estimate a reduced form function that links DEC to FOOD_EXP, exploring alternative specifications for the functional form. The relationship is statistically significant and non-linear evident from the scatterplot. The best fitting relationship is the cubic function reported as equation [3], which reveals an ^{2} of 0.49.

$$= 1043.1 + 3.18 - 0.0043\ ^2 + 0.000006\ ^3 \quad \text{(Hot:−bstat= 0) (13.5) (4.8) (−2.8) (1.85)} \qquad [3]$$

Equipped with this relationship, we predict levels of DEC for all income decile groups in all the provinces and years (2011, 2013, 2015 and 2017) for which the CHFS provides data on FOOD_EXP.

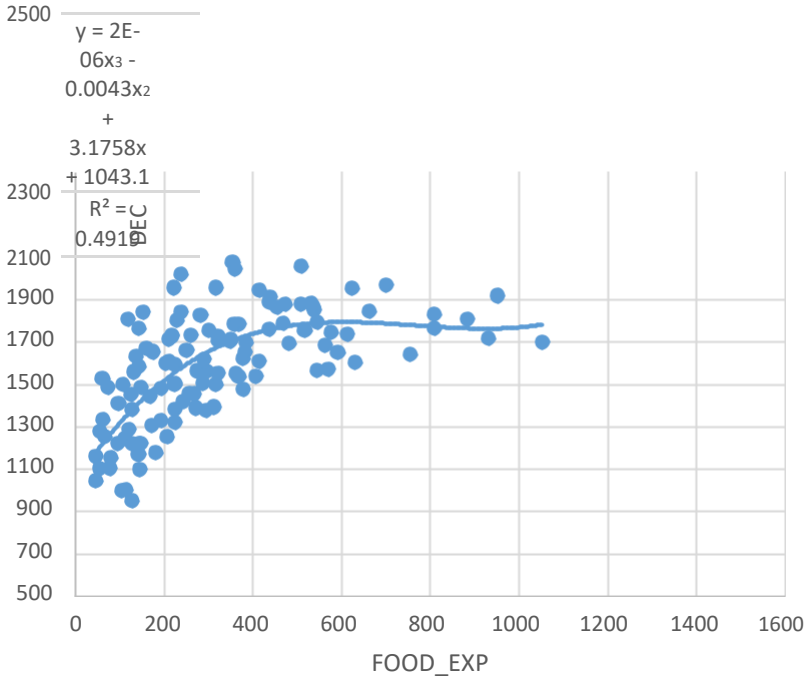
Before going further in the analysis, we verify that the model predicts sufficiently well the observed DEC in 2011 in the provinces covered by the CHNS. The charts in Figure 3 show the correspondence between the actual (vertical axis) and predicted (horizontal axis) values of DEC across the 10 income deciles in each province and city confirming an overall adequate predictive ability. The low correlation between DEC and FOOD_EXP in Beijing and in Shanghai is the result of the extremely low variability in food consumption in these municipalities, the lowest of all the areas covered, with a CV of DEC across income deciles of only 7.6 percent and 5.1 percent, respectively (see last column in Table 1).

Table 1 **Data on habitual daily Dietary Energy Consumption (DEC, kcal/capita/day) and average food expenditure (FOOD_EXP, yuan/month) in 2011 in mainland China for households in different income/total consumption expenditure groups for the provinces covered in both CHNS 2011 and CHFS 2011.**

		DECILE OF INCOME/TOTAL CONSUMPTION EXPENDITURE												
PROVINCE/CITY	VARIABLE	1	2	3	4	5	6	7	8	9	10	MEAN	S.D.	CV
BEIJING	DEC (Kcal)	1504.3	1477.3	1609.1	1564.0	1649.9	1843.9	1830.4	1807.5	1717.4	1728.9	1673.28	126.66	7.6 percent
	FOOD_EXP (Yuan)	*287.0*	*379.0*	*415.0*	*544.7*	*591.4*	*663.3*	*808.7*	*884.0*	*931.2*	*2565.1*	*806.95*	*620.93*	*76.9 percent*
CHONGQING	DEC (Kcal)	1103.2	996.4	1099.7	1177.8	1252.2	1320.4	1376.9	1393.5	1696.8	1884.4	1330.12	263.27	19.8 percent
	FOOD_EXP(Yuan)	*54.6*	*104.7*	*144.8*	*180.9*	*207.8*	*225.1*	*295.0*	*312.6*	*385.0*	*532.3*	*244.27*	*134.56*	*55.1 percent*
GUANGXI	DEC (Kcal)	1278.2	1243.0	1306.0	1443.0	1499.1	1600.9	1454.8	1714.2	1784.7	1763.7	1508.76	190.80	12.6 percent
	FOOD_EXP(Yuan)	*55.5*	*111.4*	*172.7*	*168.5*	*223.4*	*204.4*	*268.1*	*325.2*	*368.2*	*809.6*	*270.70*	*200.31*	*74.0 percent*
GUIZHOU	DEC (Kcal)	1043.6	949.6	1288.4	1222.1	1222.4	1451.2	1457.0	1499.3	1621.7	1878.3	1363.36	261.88	19.2 percent
	FOODEXP(Yuan)	*46.1*	*128.7*	*121.1*	*127.4*	*143.9*	*125.6*	*257.4*	*316.4*	*377.3*	*508.6*	*215.25*	*137.90*	*64.1 percent*
HEILONGJIANG	DEC (Kcal)	1485.9	1669.4	1595.5	1731.4	1703.0	1785.7	1888.6	1787.5	1736.7	1918.3	1730.20	122.12	7.1 percent
	FOOD_EXP(Yuan)	*73.7*	*160.4*	*223.6*	*260.8*	*349.1*	*359.0*	*436.8*	*469.1*	*613.7*	*952.1*	*389.84*	*239.62*	*61.5 percent*
HENAN	DEC (Kcal)	1161.2	1104.9	1220.9	1168.9	1485.7	1480.5	1733.3	1661.1	1710.5	1851.7	1457.87	262.61	18.0 percent
	FOOD_EXP(Yuan)	*45.9*	*78.7*	*96.1*	*142.3*	*148.0*	*194.1*	*217.9*	*250.7*	*350.8*	*537.6*	*206.21*	*139.46*	*67.6 percent*
HUBEI	DEC (Kcal)	1253.0	1809.0	1631.1	1654.0	1801.1	1842.5	1956.1	2076.9	1913.3	1952.7	1788.98	220.65	12.3 percent
	FOOD_EXP(Yuan)	*66.4*	*119.0*	*137.0*	*175.4*	*228.5*	*239.2*	*222.2*	*354.6*	*438.8*	*624.1*	*260.51*	*159.98*	*61.4 percent*
HUNAN	DEC (Kcal)	1154.4	1222.7	1381.1	1418.9	1563.8	1620.0	1753.8	1652.3	1685.2	1793.7	1524.58	209.21	13.7 percent
	FOOD_EXP(Yuan)	*109.6*	*197.1*	*235.1*	*300.4*	*373.3*	*423.0*	*489.1*	*553.6*	*729.5*	*965.0*	*437.57*	*246.80*	*56.4 percent*
JIANGSU	DEC (Kcal)	1332.7	1498.4	1558.9	1763.7	1714.2	2019.9	1826.8	1956.2	1862.6	2056.4	1758.97	224.16	12.7 percent
	FOOD_EXP(Yuan)	*62.8*	*107.6*	*132.0*	*142.6*	*210.5*	*239.1*	*282.5*	*317.0*	*455.3*	*509.0*	*245.84*	*140.39*	*57.1 percent*
LIAONING	DEC (Kcal)	1001.6	1327.5	1381.7	1388.7	1553.5	1536.6	1537.6	1753.9	1866.3	1699.7	1504.70	234.19	15.6 percent
	FOOD_EXP(Yuan)	*114.5*	*193.2*	*224.2*	*271.8*	*322.4*	*367.8*	*406.6*	*517.2*	*535.7*	*1052.1*	*400.56*	*252.20*	*63.0 percent*
SHANGDONG	DEC (Kcal)	1527.6	1409.6	1583.1	1841.5	1608.8	1727.1	2044.3	1946.1	1878.0	1969.6	1753.58	202.86	11.6 percent
	FOOD_EXP(Yuan)	*61.1*	*97.3*	*144.3*	*153.3*	*211.9*	*218.8*	*359.8*	*415.1*	*472.9*	*701.0*	*283.55*	*190.54*	*67.2 percent*
SHANGHAI	DEC (Kcal)	1504.5	1562.0	1551.4	1761.0	1692.6	1744.8	1572.4	1602.2	1640.3	1706.9	1633.82	84.11	5.1 percent
	FOOD_EXP(Yuan)	*225.5*	*296.6*	*361.6*	*437.4*	*481.5*	*576.5*	*570.1*	*630.6*	*754.7*	*1497.0*	*419.51*	*336.76*	*80.3 percent*

Source: our elaborations on data from the China Health and Nutrition Survey (CHNS) and the China Household Finance Survey (CHFS)

Figure 2 **Habitual dietary energy consumption levels plotted against average monthly food expenditure levels.**



Having confirmed the reasonableness of its predictions, we apply the model to all income groups in all provinces, generating values of average DEC to be used in estimating the coefficient of variation of DEC due to income in China. To recognize the uncertainty associated with our prediction model, we add to each predicted DEC a random draw from a normal error distribution with mean zero and standard error equal to the standard deviation of the 120 prediction errors obtained when estimating the model. We repeat the random draw 10 000 times and each time compute the coefficient of variation as the weighted average ratio between the weighted average and the weighted standard deviation of the average DEC across all income decile groups in all provinces, using the population size as weights.

Figure 3 Ability of our model to predict differences in Dietary Energy Consumption (DEC) across income groups, in 12 provinces or municipalities in China

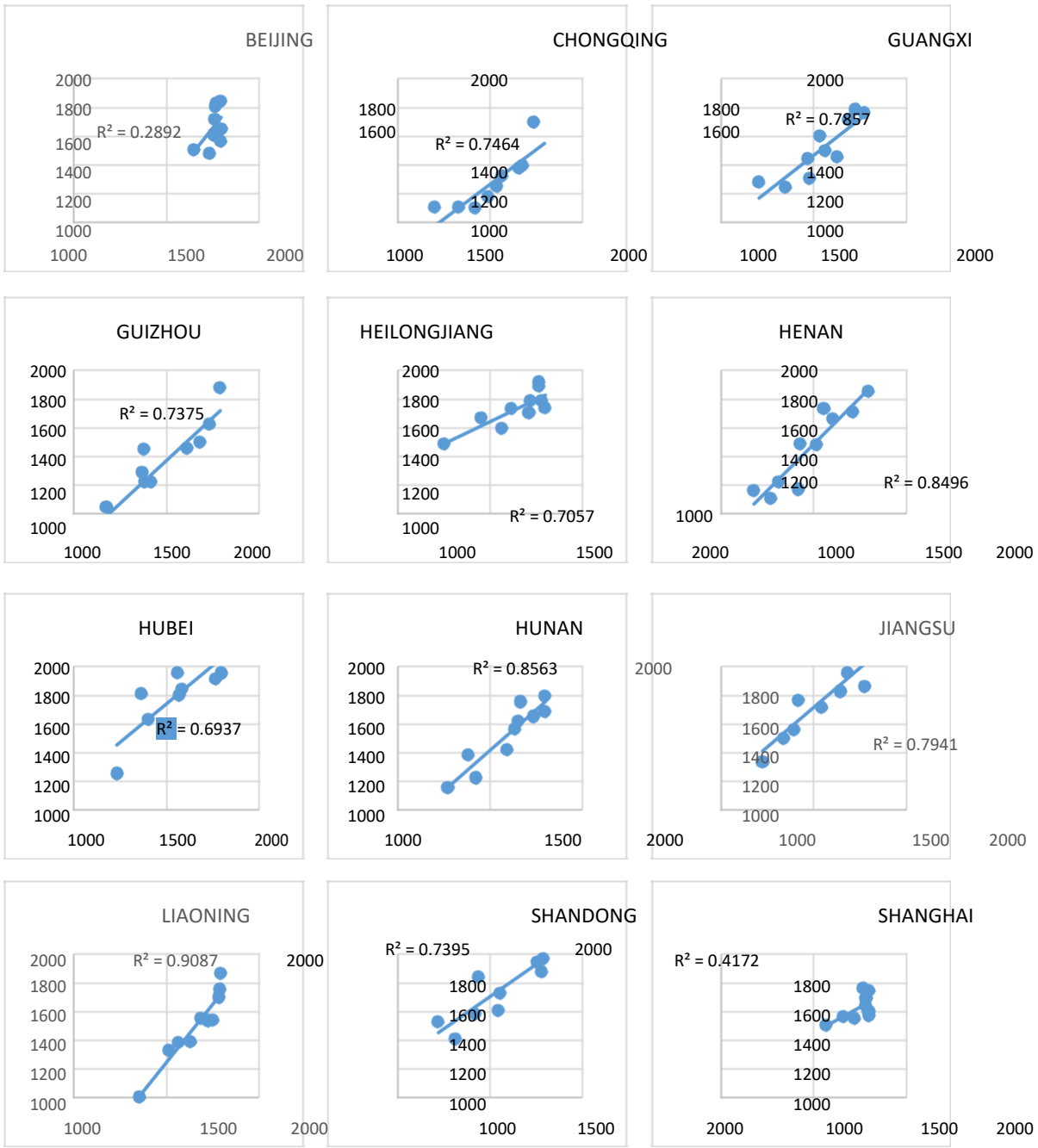


Table 2 Coefficients of Variation of habitual DEC due to differences in income (CV|y) and other parameters used to estimate the PoU in mainland China.

Parameters	1996	…	2011	2013	2015	2017
CV|y (percent)	30.5		16.24	15.82	15.36	14.92
CV|r [(a)] (percent)	11.3		11.3	11.3	11.3	11.3
MDER [(b)] (Kcal)	1862		1889	1887	1885	1883
DEC [(c)] (Kcal)	2682		2938	2965	2996	2981
PoU (percent)	15.6		<2.5	< 2.5	< 2.5	< 2.5
Current values as			*2010-12*	*2012-14*	*2014-16*	*2016-18*
estimated by FAO						
PoU (percent)	*n.a.*		*10.9*	*10.3*	*10.1*	*10.0*
FIsev (percent)	*n.a.*		*n.a*	*n.a*	*1.1*	*1.9*

[(a),(b)] CV|r and MDER for the average individual in the population of mainland China are estimated by FAO based on UN World Population Prospects data, 2019 revision.

[(c)] The average DEC for mainland China used to estimate the Prevalence of Undernourishment is estimated by FAO based on data on the Total Food Supply from the Food Balance Sheets published annually by FAO (See FAOSTAT)

5. Results

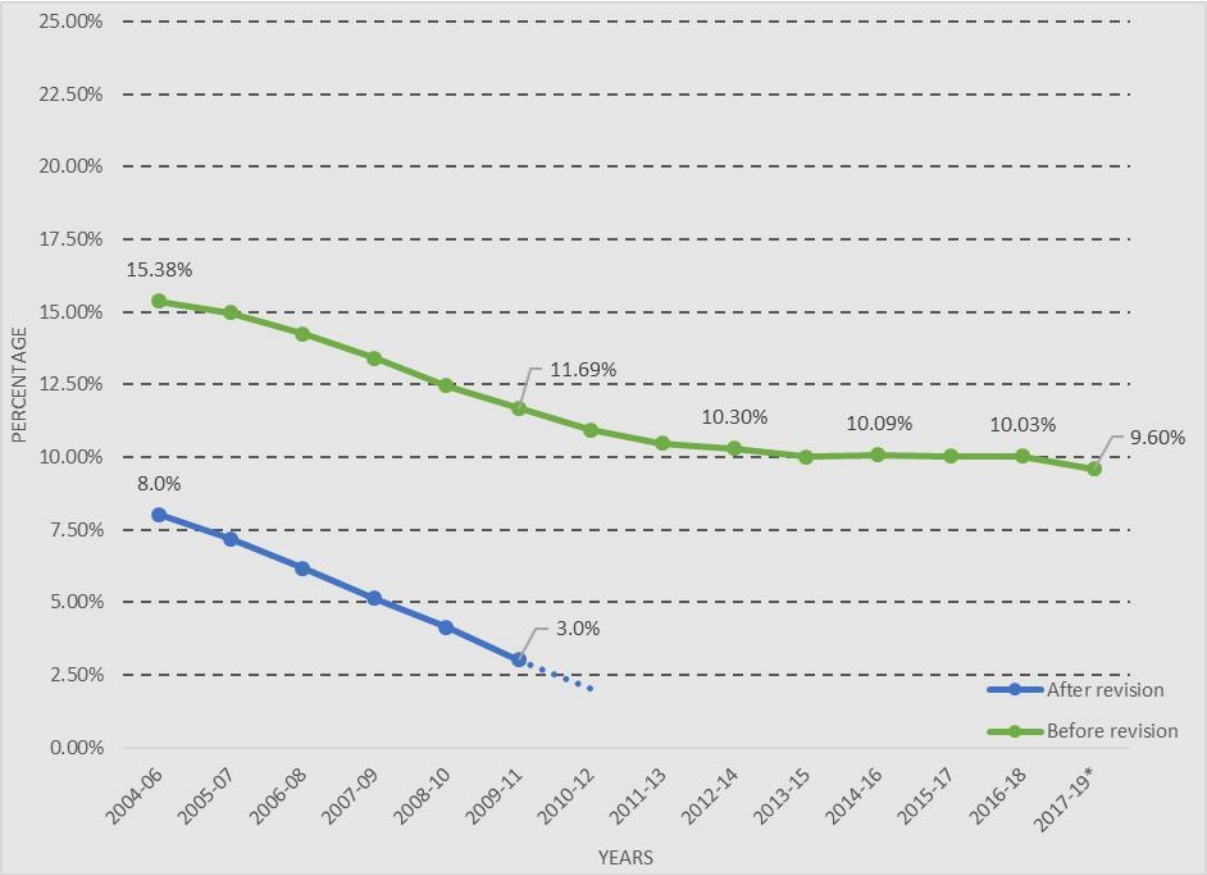
Based on the simulated values of average DEC across different income groups in all provinces of China, the coefficient of variation of habitual dietary energy consumption in mainland China due to differences in income levels in the population, is estimated to have been 16.24 percent in 2011 and to have fallen to 14.92 percent in 2017. These values, in combination with the other parameters estimated by FAO, generate PoU estimates that are less than 2.5 percent, which is the lowest value that can be reliably reported using the FAO methodology.

For comparison, the estimates of PoU resulting from both scenarios (with and without revision of CV|y) are presented in Table 2. It is clear that keeping CV|y constant at the level of 1999 (current practice at FAO), reported in the bottom panel of Table 2 produces a much higher (above 10 percent) estimate of PoU in China.

Such a high level of PoU values fail to represent the welfare gains that the country has experienced from high and sustained economic growth, reducing poverty and income and/or consumption inequality over the last two decades. However, the PoU values produced using the estimate of CV|y from simulation exercise presented in this paper are much lower (see upper panel of table 2).

Figure 4 presents the two series of PoU (with and without revision of CV|y) in mainland China. According to the new estimates China had already reached the lowest level of PoU that can be reliably monitored using FAO methodology (i.e., 2.5 percent) by 2010-12.

Figure 4 Prevalence of undernourishment in mainland China, before and after the revision of the CV|y



6. Discussion

The new estimates of PoU in China, based on the revised assessment of CV|y, are significantly lower than previously thought, a result that is broadly consistent with the findings of other research reporting low elasticities of food consumption with respect to income in China (see for example You, Imai and Gaiha, 2015).

Given the size of the population in China, this will have strong direct implications for the prevalence of undernourishment estimated at the regional level in Asia and at the global level, a reason why it becomes crucially important to validate our results against any other possible evidence, before suggesting that they be adopted as FAO new official statistics for China.

The first immediate comparison can be made against the prevalence of severe food insecurity (FI_{sev}) estimated by FAO based on the Food Insecurity Experience Scale data collected by FAO through the Gallup World Poll since 2014 and used to inform part of the SDG indicator 2.1.2.[5] FI_{sev} is an alternative way to assess the extent of serious food deprivation in a population, and is expected to closely match the PoU at country level.

5 See http://www.fao.org/faostat/en/#data/FS, and http://www.fao.org/sustainable-development-goals/indicators/212/en/.

Figure 5 Comparisons between estimates of the prevalence of undernourishment and of the prevalence of severe food insecurity in 2017-19 for a number of countries.

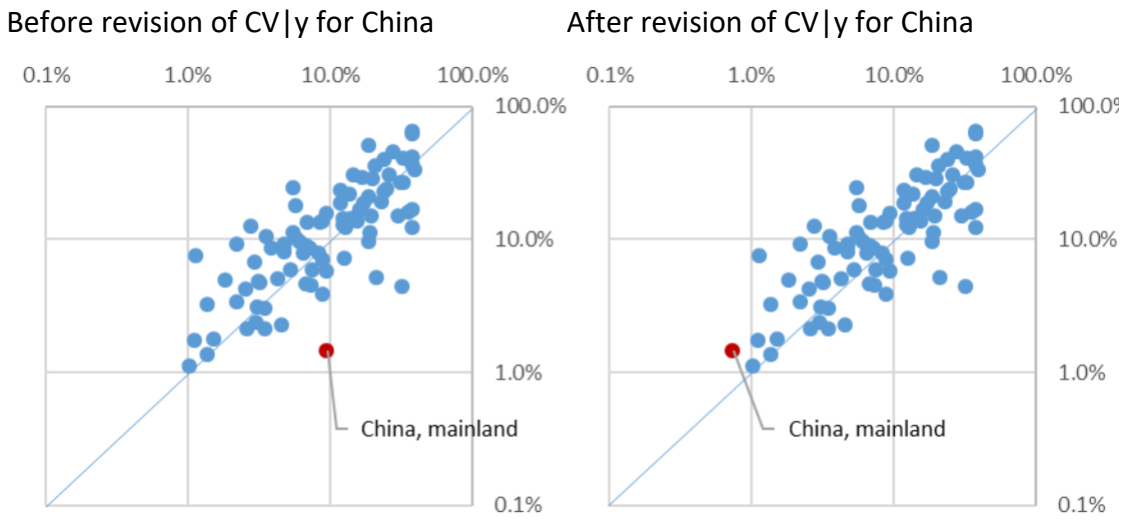


Figure 5 shows a scatter plot of the latest estimates of PoU and FI_{sev} in 2017-19 for all countries where both estimates are available and are larger than 1 percent. The juxtaposition of the two charts demonstrates the position that China, mainland would have without adopting the revision presented in this paper (left panel) and after having implemented it (right panel). It demonstrates that the revised estimate of PoU for China is considerably more in line with the corresponding FI_{sev} estimate.

A second piece of evidence in support of the conclusion that the new estimates of PoU for China are much more reasonable than the old ones, comes from the consideration that the new series much more consistent with the declining estimates of extreme poverty (7.91 percent in 2011 to 0.56 percent in 2016) published by the World Bank over the last decade.[6]

Finally, there is a growing body of evidence, based on various sources, which confirms how China's economic growth over the last few decades has been unique when compared to the rest of the world.

Among the various sources of information, CHFS data – the ones we also use in this paper – attracted a great deal of attention both in academic as well as in policy circles. Researchers have used CHFS data to cross-check the validity of estimates of the prevalence of poverty, inequality and of the time evolution of income and consumption patterns in the country. Zhang *et al.* (2014) estimate and compare poverty incidence rates in China using the CHFS of 2011 and three other nationally representative surveys: the China Family Panel Studies (CFPS) of 2010, the Chinese General Social Survey (CGSS) of 2010, and the Chinese Household Income Project (CHIP) of 2007. After adjusting for differences to make the estimates as comparable as possible, they find estimates of poverty based on per capita household expenditure from CHFS, CFPS, CGSS to be closely aligned (ranging between 12 and 20 percent at $1.50-per-day poverty line).

6 http://iresearch.worldbank.org/PovcalNet/povOnDemand.aspx

These compare reasonably well with World Bank's estimates of extreme poverty for 2010, which are of 11.2 percent, 21.3 percent and 0.75 percent percent, respectively, for mainland China, rural and urban China, suggesting that extreme poverty has been essentially a rural problem in China.

Poverty headcount for rural areas (26.67 percent) presented in Zhang *et al.* (2014) measured at the $1.50-per-day poverty line using data from CHFS (2011) – the other source of data we use – are also close to the world bank's estimate for rural China. Though these estimates are not directly comparable because of different thresholds used and of differences in the survey methodologies and in the construction of the consumption aggregate for households, the close approximation indicates robustness of consumption expenditure data collected in CHFS.

Zhang *et al.* (2014) also show that the distributions of household expenditures derived from the CFPS and CHFS exhibit similar patterns. Going one step, they compare the profiles of poor and non-poor households to ascertain whether the category labeled as "poor" refers to the same type of households in the three surveys (CFPS, CGSS and CHFS) and conclude that the households classified as poor are very similar across both rural and urban areas.

It may be worth noting that poverty estimates in Zhang et al. (2014) based on CHFS, CGSS and CHFS, at national as well as rural level, are higher than those published by CNBS and estimated from the CHIP, which is conducted on a subsample of the national household income and expenditure survey. One possible reason for the discrepancy can be found in the fact the CNBS may have purposely selected households whose members are literate so that they could keep a diary of household finance. This hypothesis is supported by the much smaller educational gap between the poor and the non-poor that is found in the CHIP sample. In so doing, however, the illiterate households, which happen to be more likely to be poor, may have been disproportionately excluded, resulting in a systematic sample selection bias. (Zhang *et al.*, 2014).

One potential source of concerns with our results that show a strong reduction in food consumption inequality, is that *income* inequality appear to have been rising in China between 1980s and 2008, when evaluated based on CNBS household surveys data (see Ravallion and Chen 2007; Luo *et al.* 2018; and Gradín and Wu, 2020). Similarly, research based on the CHIP consistently points to increasing inequality between 1988 and 2007—the years in which the survey was conducted. This phenomenon, however, is not inconsistent with our findings for two reasons: first, the increased in income inequality has been accompanied by an increase in average incomes across all income groups, even though proportionally, incomes of the rich have increased more. However, the combination of the values of the Engel coefficients (indicating that food expenditure grows more with income for the poor than for the rich) and the non-linearity we have noted in the relationship between dietary energy consumption and food expenditure, makes it very plausible that the increase in income inequality has not been associated with a parallel increase in food consumption inequality, Moreover the increasing trend in income inequality observed up to 2008 appear to have been followed by a decline in income inequality, after 2008, and this is irrespective of the data sources used (Xie *et al.* 2015; Luo *et al.* 2018; Sicular *et al.* 2020) . The 2018 World Bank report *China Systematic country diagnostic: Towards a more inclusive and sustainable development* says "that since 2008, inequality in China has been steadily declining. It adds that the

recent decline in inequality occurred during the time when the per capita consumption of the bottom 40 percent of the population grew relatively rapidly. This observation is also consistent with indications of rising relative wages of migrants and studies that indicate that regional inequality peaked in the second half of 2000s" (World Bank, 2018, p. 24).

Apart from declining poverty and income/consumption inequality trends, another observation that underscores the reasonableness of our revision of the estimate of food access inequality estimate in China is the changing size of the middle class in China. As a result of annual GDP growth of over 6 percent sustained for years, Sicular *et al.* (2020) report that the number of households attaining levels of income comparable to those of middle-class households in the developed world grew rapidly, and for the first time, constituted a substantial share of the population: the middle class share in total population increased from 7 percent to 19 percent between 2007-13.

One implication of the growth in the share of the middle class is a change in food consumption patterns in the country. Shufa Du *et al.* (2014), based on their observations from the series of CHNS between 1989-2011, show a significant shift in food consumption patterns in China. Diets containing refined rice, wheat and animal-source foods have increasingly replaced those with dominating share from coarse grains and minimal animal -source foods. It is therefore quite possible that dietary energy intake levels for the Chinese people in the lower end of the income distribution have increased considerably, much more than those in the upper end.

The World Bank's (2019) estimates of shared prosperity between 2013-15 show 1.75 percentage points higher average consumption growth for the bottom forty percent of the population when compared to that of the total population in mainland China. This is consistent with the significantly higher annualized consumption growth per capita estimate between 2013-2015 in the bottom 40 percent of the income distribution implied from our analysis of the CHFS data.

7. Conclusions

FAO has not updated the estimates of one of the key parameters needed to estimate the prevalence of undernourishment for China for a long time. As a consequence, current estimates of the PoU for mainland China, as presented up to the 2019 edition of *The State of Food Security and Nutrition in the World*, may have failed to reflect the improvements that the country has witnessed in the food consumption levels of the poorer strata of the population over the last couple of decades.

The analysis presented in this paper has demonstrated a way in which such an update can be conducted, using data from two reputable sources of data on food consumption and food expenditure in China. The innovative way to merge information obtained from two different surveys has made it possible to produce reasonable estimates of the recent values of the Coefficient of Variation of habitual DEC due to income (CV|y) for mainland China.

The results show that, already in 2011, the extent of inequality in dietary energy consumption in China was much lower than what is implied by the value of CV|y used by FAO to estimate the PoU. Levels of CV|y as estimated in this paper for 2011-2017

suggest that undernourishment in mainland China affected less than 2.5 percent of the population, which is the lowest level that the current FAO PoU methodology can reliably capture. The figure is also very much in line with the evidence provided by the estimates of the prevalence of severe food insecurity based on the Food Insecurity Experience Scale (FAO, 2019), and is also consistent with the trends and levels observed in other measures of wellbeing, like the series of incidence of extreme poverty in China produced by World Bank (World Bank, 2019).

The new profile of the prevalence of undernourishment that emerges from the revision is very consistent with a large body of evidence on recent socio-economic progress in China and suggest that a revision of FAO estimates of the inequality in dietary energy consumption across different income groups in China should no longer be postponed.

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ISBN 978-92-5-133015-9

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CB0172EN/1/07.20