Xiao Jiang and Luis Villanueva

Smith, Malthus and Recent Evidence in Global Population Dynamics

March 2015
Working Paper 02/2015
Department of Economics
The New School for Social Research

Smith, Malthus and Recent Evidence in Global Population Dynamics*

Xiao Jiang† Luis Villanueva‡

Abstract

In conventional economic theories, population is determined outside of the economic system. However, classical political economists such as Adam Smith and Thomas Malthus have long argued for the endogenous determination of population, hence establishing a connection between economics and demography. Foley (2000) used empirically established global per capita output-fertility schedule based on the 1960-1992 Extended Penn World Tables to project the population stabilizing level of world per capita output and population. In this paper we intend to update this line of research using more recent empirical evidences. We find that the world production still exhibits strong pattern of Smithian increasing returns to scale, and most countries' population have been stabilizing along a convex path in the income-fertility schedule. Our projection suggests that the world population will stabilize at per capita income around $ 13,550 in 2005 PPP, and by the year of 2011, the world per capita output was still about $2,824 short. The world population will stabilize around 10 billion assuming the absence of any exogenous shocks to the empirically established global income-fertility relation.

JEL Classification: B12; J11.
Keywords: Growth, Demographic Equilibrium, Classical Economics.

1 Introduction

The ever expanding global population accompanied by economic growth since the 18th century has been a source of anxiety for the human race. A well-known example is Thomas Malthus (1798) who views human population as the major constraint for economic growth. Malthus anticipates that human beings will eventually reach a "gloomy" stable demographic equilibrium with low per

*Work in progress, do not cite or circulate without authors' permission.

†Assistant Professor, Economics Department, Denison University, Granville, Ohio, USA. Email: jiangx@denison.edu.

‡Assistant Professor, Economics Department, Denison University, Granville, Ohio, USA. Email: villanueval@denison.edu. We like to thank Duncan Foley and Thomas Michl for their valuable comments and suggestions, and Tingting Tang for her research assistant work

capita income and high fertility rate. At this equilibrium, any economic growth will be counteracted by even more rapid population expansion due to the mechanism of decreasing returns to labor, henceforth the returning of the low-income demographic equilibrium. Fortunately, human history so far has been, to a large extent, putting Malthus and his followers' population anxieties at ease. What is likely to follow economic growth is in fact the decline (rather than the increase) of fertility. The tendency of decreasing fertility with growing income is called *demographic transition* and it plays a central role in current discussions on population dynamics.

Foley (2000) puts forward an alternative theory of demographic equilibrium by combining the theory of demographic transition with Adam Smith's insights on division of labor. According to Foley, in contrary to the gloomy Malthusian equilibrium, there exists a Smithian demographic equilibrium associated with high income and low population. The stability of this equilibrium is ensured by the simple mechanism that population expansion enables more and deeper division of labor, which leads to increasing returns to labor, henceforth real income growth; but population expansion is in turn contained by real income growth due to the mechanism of demographic transition. Using the Extended Penn Wold Data for the period 1963-1992, Foley was able to empirically estimate that the Smithian demographic equilibrium will occur at the world per capita income level of 6500 - 7500 in PPP $\$_{1990}$, and the world population will eventually stabilize at 7.5 - 8.5 billion.

It has been more than 20 years since 1992, the most recent data point in Foley's analysis. In the past 20 years, the global economy has experienced significant changes characterized by even more rapid growth of per capita income, the widening of global income inequality, and the acceleration of structural transformation in both developed and developing countries. This paper intends to update Foley's (2000) research by using the most up-to-date data on income, fertility and population. Section 2 of this paper briefly introduces the concept of demographic equilibrium, and then explains the empirical method based on this concept. Section 3 exhibits the global income-fertility relationship and its evolution from 1970s to 2000s, and presents our new projection for the population stabilizing level of per capita income and population. Our results will be compared with Foley's (2000) projection as well as the population prospect from the United Nation Population Division (UNPD). Section 4 discusses our results and concludes the paper.

2 Smith, Malthus and Demographic Equilibrium

The stabilization of world population relies on the existence of stable demographic equilibrium. Malthus in 1798 famously proposed the existence of a demographic equilibrium based on two postulates. First, human reproductive tendency goes hand in hand with real income, when income raises, human soci-

ety will have higher fertility rate due to the "passion between the sexes". Second, population expansion will quickly surpass the growth of real output, hence it will exert downward pressure on the average income of the population. In modern economic jargon, this second postulate is called the law of diminishing marginal returns to labor. Thus, the positive relation between real income and fertility from the first postulate together with the negative relation between population growth and income from the second postulate form a stable demographic equilibrium where the human population gravitates itself to. This Malthusian equilibrium is typically associated with low income and high population because any income growth would be counteracted by the force of diminishing marginal returns to labor due to even more rapid population expansion.

Fortunately, human history to a large extent has been unkind to Malthus's postulates. Firstly, constant technical progress enabled rapid accumulation of capital and growth of real output on world scale. Secondly, what tends to follow income growth is in fact reduced fertility rather than population expansion. As countries develop and industrialize, cost of health care and education tends to go up, women are more likely to enter into the labor-force to become wage laborers, and equally importantly contraceptive measures become more acceptable and effective, all these factors give households in industrialized societies the tendency and ability to reduce, defer or refuse fertility. This is also known as the theory of demographic transition.

The theory of demographic transition is not only a valid empirical attack on Malthus's population theory, but also it puts the whole concept of demographic equilibrium in question. The Population Division of the United Nations (UNPD) has been undertaking rigorous researches on demographic dynamics and conducting population projections since 1951 by relying on extrapolation method to determine the future level of fertility and mortality rates and cohort method to obtain a distribution of its effects by age and sex rather than on any equilibrium method. However these estimates and projections are subjected to revisions on regular basis due to the uncertainty involved in these methods (O'Neill et al., 2001). For example, in the 19th revision of the world population prospects series published in 2006, the UNPD projected that by 2075 world population would peak at 9.22 billion and after reaching its maximum, world population might stabilize [1] at 8.97 billion by 2300 (UN-DESA, 2013). However, small differences in the projected level of fertility rate have significant effects on the future population size. For example if total fertility were 0.3 children above the replacement level, the projected world population in 2300 would be four times as large as the originally projected level. The uncertainties surrounding the projected fertility rate come from the lack of a clear theory of demographic equilibrium in the empirical methods they reply on.

[1] Although, the term "stabilization" is not related to any equilibrium mechanism; instead it is the result of statistical extrapolation.

Foley (2000) proposed the existence of another demographic equilibrium - the Smithian equilibrium. Essentially, the Smithian equilibrium is a combination of the theory of demographic transition and Adam Smith's insight that division of labor leads to increasing returns to labor. While demographic transition ensures a negative relationship between real income (which is a proxy for the level of modernization and development) and fertility, Smith's insights on division of labor establishes a positive relationship between population and income - population growth enables more and deeper division of labor, which leads to productivity growth and eventually higher real income (increasing returns to labor). Demographic transition together with Smithian increasing returns to labor form a stable demographic equilibrium the world population supposes to orient itself to. In contrary to the Malthusian equilibrium, Smithian equilibrium is often associated with high income because this equilibrium can only be reached after having some good level of economic growth achieved.

Assuming an equal sex ratios in birth, population dynamics as in Foley (2000) can be considered in terms of "total fertility rate" f, and the world population will stabilize in long-run if the world fertility rate stays at 2 - the "2-children-per-couple" replacement level. If we measure income level by real per capita GDP (output) x, then the aforementioned population dynamics can be depicted by the f-x relationship as illustrated in figure 1 below.

Figure 1: Income, Fertility and Demographic Equilibria

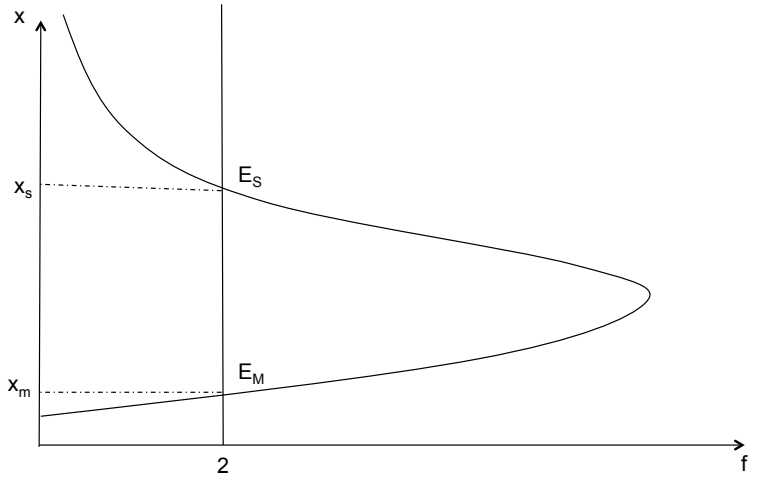


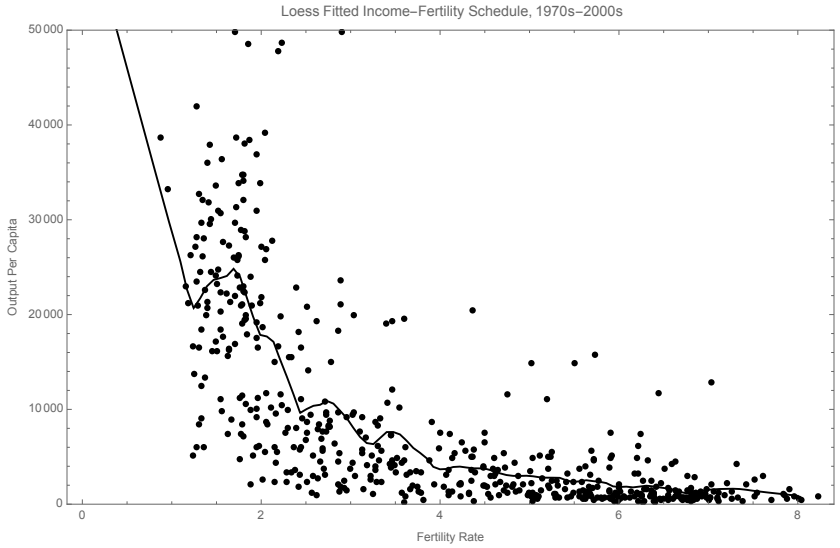
Figure 1 above is a theoretical income-fertility schedule. The upward sloping section of the schedule depicts the Malthusian positive income-fertility relation whereas the downward sloping section of the schedule depicts the negative income-fertility relation based on the theory of demographic transition. At the point where $f = 2$, there exists two demographic equilibria: the low per capita

income Malthusian equilibrium and the high per capita income Smithian equilibrium. The stability of each demographic equilibrium is ensured by diminishing marginal returns to labor in the Malthusian case, and increasing returns to labor led by the increase and deepening of division of labor in the Smithian case. The income-fertility schedule will be empirically estimated and assessed in the next section.

3 World Income-Fertility Relationship, 1970s-2000s

To empirically estimate the global fertility-income relationship, Foley (2000) used the Extended Penn World Tables - a comprehensive international database that contains fertility rate and real output per capita data for over 120 countries for the period 1960-1992. In this paper we conduct the similar exercise using the most up-to-date version (version 4.0) of the data for the period 1963-2008. Output per capita in this version of the Penn World Tables is measured in 2005 constant purchasing power dollars.

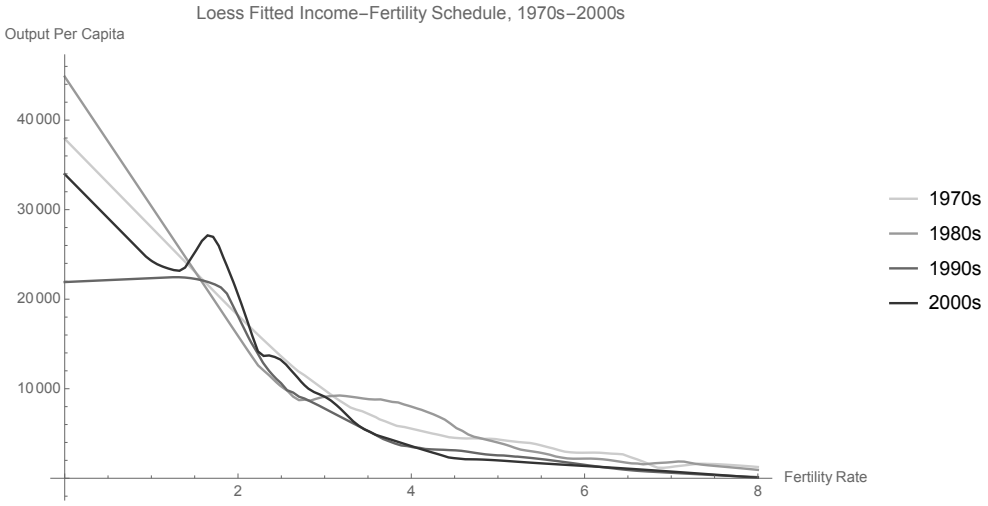
Figure 2: Loess Fitted Income-Fertility Schedule, All Decades



To construct the income-fertility schedule for each of the four decades from 1970s to 2000s, we compute the 5-year-average of output per capita and fertility rate for each country centered around 1975, 1985, 1995, and 2005, and plot them on the $f-x$ plane. Figure 2 above is the income-fertility schedule for five decades all together, and the fitted line is the Loess fit. It is evident from figure 1 that the overall income-fertility relation is a negative one following the pattern of

demographic transition, and the plot exhibits a clear convex path for $f - x$. However, there also appears to be a small Malthusian region with rising income and fertility in the data, as illustrated by the Loess fitted line.

Figure 3: Loess Fitted Income-Fertility Schedule, 1970s, 1980s, 1990s, and 2000s



To acquire some understanding of how did the income-fertility schedule change over time, figure 3 above plots the Loess-fitted income-fertility schedule for each decade on the same plot. Overall, figure 3 illustrates the process of population stabilization towards the Smithian equilibrium along a convex $f - x$ path as observed in figure 2. Examining the figure carefully, we realize that most low income and high fertility (developing) countries experienced slight leftward shift of the income-fertility schedule from 1970s to 1990s; however, as for 2000s these countries tend to move along a convex $f - x$ path rather than shifting the schedule to the left. It is also interesting to see that the small Malthusian region is a more recent phenomenon, it only started appearing in 1990s amongst mostly developed countries that have more or less stabilized their population.

The overall tendency for countries to move along the convex downward sloping income-fertility path is an important evidence for the Smithian mechanism of population stabilization via increasing returns to scale. To extract the exact functional relationship between income and fertility, we construct a model of nonlinear best fit for all the data points in figure 2. And then we use this model to project the population stabilizing level of income - the Smithian equilibrium, and eventually the population level associated with it. Before the projection, we test the quality of our nonlinear fitted model by first conducting an in-sample projection. From 1975 to 2005, for every 5 years we compute the world per capita output using the Extended Penn World Tables, and then, we plug these values in our nonlinear fitted model to project the world fertility rate for the

corresponding years. Finally, we compare our projected results with the actual world fertility rates from World Bank's World Development Indicators (WDI).

Year	x	Projected f	Actual f
1975	\$5085	4.18	4.14
1980	\$5635	3.79	3.71
1985	\$6155	3.50	3.54
1990	\$6754	3.24	3.27
1995	\$7257	3.06	2.85
2000	\$8166	2.80	2.65
2005	\$9240	2.57	2.54

Sources: The Extended Penn World Tables, World Development Indicators (World Bank), and authors' own calculations.

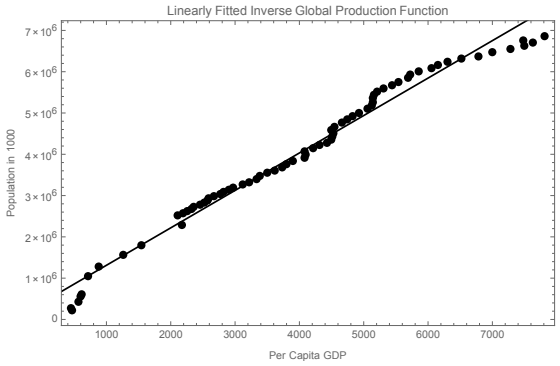
The result of our in-sample projection is presented in Table 1, which indicates that our nonlinear fitted model tends to project world fertility rates quite accurately comparing to the actual ones coming from the World Bank's WDI. Therefore, we rely our projection of future world population dynamics on this model.

Based on our nonlinear fitted model, the Smithian equilibrium will occur at the world per capita output level of \$13,550 in 2005 PPP, which is the level of per capita output corresponding to the population stabilizing rate of fertility of 2. The world per capita output in 2011 was \$10,727 in 2005 PPP, which was \$2,824 short from the population stabilizing income level. The Smithian equilibrium in Foley (2000) was estimated occurs at \$6500 - 7500 in 1990 PPP, the conversion factor between 1990 and 2005 PPP USD is about 1.31, hence, this puts our estimate to \$10,344 in 1990 PPP to compare with Foley's results. One of the main reasons for such difference comes from the decreased convexity of the world nonlinear fitted income-fertility schedule in our sample, which makes the stabilization of population via increasing per capita income relatively more difficult.

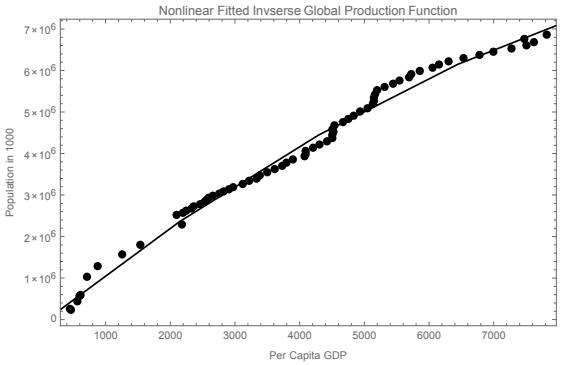
Finally, we intend to project the level at which the world population will stabilize at. Angus Maddison's economic historical data (1 A.C. - 2012) illustrates a robust relationship between per capita output and population; however, it is debatable of whether a linear or a nonlinear curve will be the best description for this relationship.

Figure 4: Per Capita Output and Income Relation

(a) Linear Fit



(b) Nonliear Fit



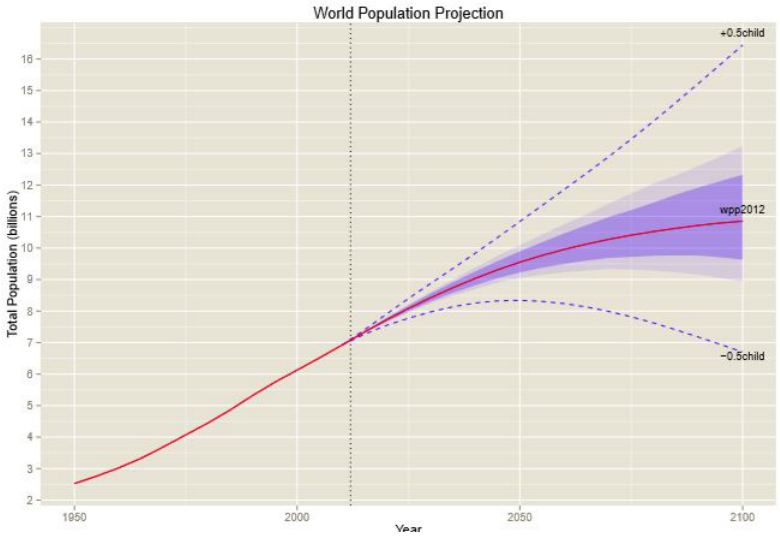
The plots in figure 4 above are scatter plots for per capita output and population from the Angus Maddison data. One can also view these plots as the inverse global production function with labor inputs (population) on the y-axis and real per capita output on the x-axis. The upper panel fits the data using a linear model. This linear model projects that the world population will stabilize at around 10 billion, roughly 3 billion above the current level. However, past 20 years have been marked by very rapid global economic growth, reflected by the flatter region of near the end of the per capita output-population plots in figure 4. Hence, one might also consider fitting the data using a model of nonlinear best fit as in the lower panel. Based on the nonlinear model, the world population is projected to stabilize much sooner, at 8.3 billion.

We are of the opinion that the linear model provides a more sensible and reliable population projection, although the nonlinear model provide a better fit between per capita output and population. For classical political economists such as Smith and Malthus, the wealth of the nations is measured by goods and

services produced by productive labor, hence the Smithian equilibrium must be the demographic equilibrium level associated with the wealth of the nations in classical notion. For the past 15-20 years, an important source of growth for global outputs are the FIRE (Finance, Insurance and Real Estate) sectors from developed countries (and more recently, emerging economies), and yet it is questionable whether incomes from the FIRE sectors should be counted as part of the total wealth of the nations or not. Foley (2013, 2011) raised a valid suspicion that incomes from the FIRE sectors are incomes of "unproductive labor" in classical sense - labors that redistribute the existing pool of the wealth of the nations rather than adding new values to it, hence it should not be counted independently as part of the global outputs. However, many countries still count the FIRE sectors' incomes as part of their GDP by the method of "imputation", that is imputing FIRE sectors' value-added by the incomes these sectors' workers receive (Foley, 2011). Therefore, if this were the case, then the recent growth of global per capita output must have been inflated in the "classical" sense. Hence, a linear model that fits the per capita outputs and population make more sense in our context because the slope is more influenced by historical data before the explosion of the FIRE sectors in the past 15-20 years.

To put things in perspective, we compare our population projection with the population projection from the UNPD.

Figure 5: UNPD World Population Projection, 2012



Source: UNPD, 2013

Figure 5 above is the most recent world population projection from UNPD. Although they refrain from the notion of population stabilization, their projection shows that the world population will peak at somewhere between 10-11

billion, which is not too off from our projection of 10 billion. However, the peak world population projected by the UNPD using the extrapolation and cohort methods is not a demographic equilibrium, the world population might decline, stay or even go above this level as new data is entered into the extrapolation process. Our projected 10 billion population on the other hand is the Smithian demographic equilibrium towards which the world population is expected to move, and once it is reached, in absence of other autonomous changes that shift the income-fertility schedule, the world population is expected to stabilize.

4 Concluding Remarks

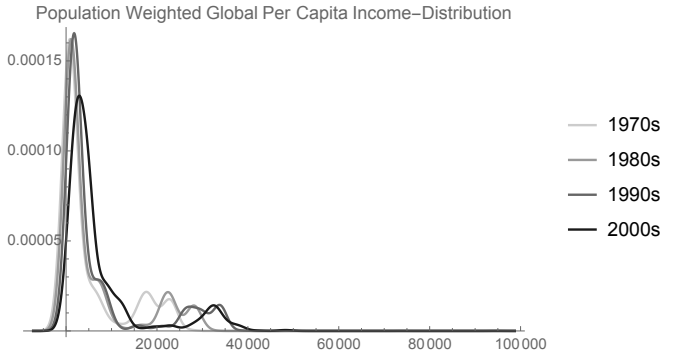
Using the framework provided by Foley (2000), our paper examines the evolution of the relationship between per capita output and population for the period of 1970s-2000s on a global scale. The Smithian mechanism of population growth leading to increased productivity and higher standard of living seems to be the driving force behind the decline in fertility rate in the period of our study; furthermore there seems to be strong empirically evidence for the stabilization of world population towards the Smithian equilibrium in progress. The notion of Smithian equilibrium also enables us to project, in a *ceteris paribus* environment, that the world population will stabilize at around 10 billion with per capita output of about $13,550 in 2005 PPP.

The overall observed tendency for countries to move toward the Smithian equilibrium over time seems to suggest that the anti-growth sentiments generated by the anxieties concerning population expansion from Malthus and his followers might not stand on an empirically solid ground. If the Smithian mechanism of increasing returns to population were the driving force for the fertility rate to reach the replacement level of 2, then the way to reach a stable demographic equilibrium would be to stimulate economic growth rather than containing or reducing it.

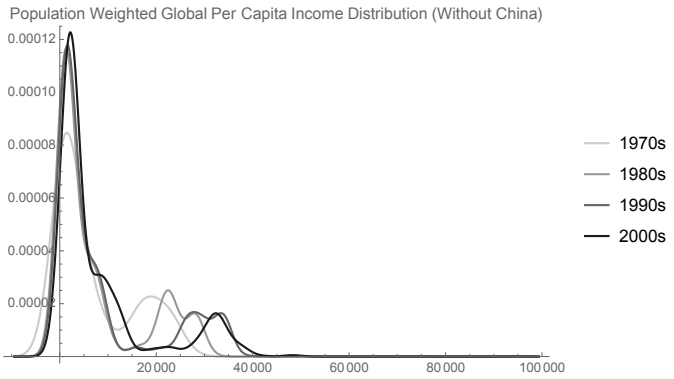
Although the Smithian mechanism of increasing returns to population might put some of the anxieties concerning world population expansion at ease, as mentioned in Foley (2000), the Smithian equilibrium tends to take place with wide world income inequality.

Figure 6: World Income Distribution, 1970s-2000s

(a) All Countries



(b) Without China



The upper panel of figure 6 above is the population-weighted histogram that shows the distribution of countries' per capita output over the four decades in our analysis. It is clear from the shape of the histogram that the cross-countries income inequality has been widening from 1970s to 2000s. Although it is evident from the 2000s plot that some countries with large population have escaped from extreme poverty, but the longer tail of the histogram also indicates the persistence and even the widening of world income inequality even in the 2000s. In fact, China was the country that made the difference for 2000s histogram, when China were removed from our sample, it becomes quite clear from the plot in the lower panel that during the four decades in our analysis, more and more countries (weighted by population) have became concentrated in low income category, while a small group of countries (weighted by population) have became richer over time. Hence, even if the world population stabilizes at the projected Smithian equilibrium, the wide world income inequality is expected to persist in absence of any exogenous interventions.

As hinted in Foley (2000), the extreme uneven world income distribution will result increasing international division of labor with a small group of rich countries specializing in producing capital and wealth and large number of poor countries specializing in producing people. Consequently, there will be more rapid flow of capital from rich to poor countries via FDI and trade, and flow of labor from poor to rich countries via trade, migration, adoption, and surrogate parenthood. Issues such as exploitation, international uneven development and human right violation might worsen if social institutions fail to adequately respond to these changes.

Finally this classical endogenous view of human population sheds a different light on international trade policies. In conventional international trade theory, population is often viewed as a resource endowed to a country exogenously, whereas in classical political economy, as we have seen, population is determined endogenously within the economic system. Hence, regarding the increasing international flows of labor and capital, the earlier approach would argue that countries with high labor-endowment should follow its comparative advantage and specialize in producing and exporting labor-intensive products; whereas our approach embracing the classical view would argue that large population is not an "endowment" per se, but instead a result of poverty, hence the objective for labor-abundant countries should be to grow out of its comparative advantage of labor-intensive production[2].This will involve active government policies to eliminate poverty, protect infant industries, foster economic and social upgrading and stimulate domestic economic growth.

[2]This view is also consistent with the *develomentalist* strand of literature international trade represented by Rodrik (2011), Hausmann et al. (2007) and Chang (2008)

References

[1] H. Chang. *Bad Samaritans: The Myth of Free Trade and the Secret History of Capitalism*. Bloomsbury Press, New York, 2008.

[2] D. Foley. Stabilization of human population through economic increasing returns. *Economic Letters*, 68:309–317, 2000.

[3] D. Foley. The political economy of u.s. output and employment 2001-2010. Conference paper for New Economic Thinking at Bretton Woods, April 2011.

[4] D. Foley. Rethinking financial capitalism and the "information economy". *Review of Radical Political Economics*, 45(3):257–268, 2013.

[5] R. Hausmann, J. Hwang, and D. Rodrik. What you export matters. *Journal of Economic Growth*, 12(1):1–25, 2007.

[6] T. Malthus. *An Essay on the Principel of Population*. IAP, Las Vegas, 1798.

[7] B. O'Neill, D. Balk, M. Brickman, and M. Ezra. A guide to global population projections. *Demongraphic Research*, 56(3):203–288, 2011.

[8] D. Rodrik. *The Globalization Paradox: Demoncracy and the Future of the World Economy*. W. W. Norton and Company, New York, 2011.

[9] A. Smith. *The Wealth of Nations*. University of Chicago Press, Chicago, 1776.

[10] United Nations Department of Econoics and Social Affairs, Population Division. *World Population Prospects: The 2012 Revision, Methodology*, 2013.