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Abstract: This study re-estimates dynamic efficiency based on the AMSZ (1989) criterion by exploiting the largest dataset assembled to date. It reveals that major economies conform to a similar "U-shaped curve" in their evolution of capital accumulation; that is, a period of decreasing efficiency followed by one of increasing efficiency. It also indicates that nations are not necessarily dynamically efficient if statistical bias is considered. As a prime example, China today is unquestionably in a serious state of dynamic inefficiency. The study discusses the theoretical limitations of AMSZ (1989), and calls for new breakthroughs in efficiency criteria.

Keywords: Dynamic efficiency; Capital over-accumulation; Cash-flow criterion; Interest rates; Pareto optimality

JEL classification: E22, E43, O57

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1. Introduction

In path-breaking research, Malinvaud (1953), Samuelson (1958), and Diamond (1965) built a model that violates the first fundamental welfare theorem[1]. By introducing overlapping generations, even in the absence of market failures and distortions, equilibrium of perfectly competitive market can be Pareto suboptimal. That is, when there is surplus capital accumulation, the interest rate (r) falls below the economic growth rate (g). As a result, maintaining market equilibrium requires more investment (gK) than the economy actually produces (rK) (Fama and French, 2002; Weil, 2008). At the individual level, if over-accumulation holds, increasing consumption today does not imply lower consumption in the future. When capital stock has exceeded the optimal level for maximizing social consumption, interest rates (r) become so low that financial approaches for transferring resources from one's youth to old age have been rendered ineffective—which enables Ponzi-schemes and leaves room for Pareto improvement. Therefore, instead of letting individuals save on their own, social planners can take advantage of the higher economic growth (g) to its fullest extent by redistributing resources from the youth to the elderly—utilizing policy designs such as the pay-as-you-go system (Aaron, 1966) and public debt (Diamond, 1965; Blanchard and Weil, 2001)—to ensure that, in the Pareto sense, everyone's welfare is promoted.

Dynamic efficiency is a central topic in analyses of economic growth, corporate finance, and welfare economics. Knowing the actual efficiency state is of great importance for policy implications. To address the subject empirically, one can refer to the rate-of-return criteria—which compares interest rates with the economic growth rate—to gauge whether an economy is dynamically efficient. Earlier works by Feldstein (1977), Feldstein et al. (1977), and Poterba (1998) found that in the US, the gross return on capital (above 8% on average) overwhelms the ordinary growth rate (around 3%), implying the non-existence of over-investment in the American economy. Other research that argues in favor of

[1] The theorem states that a market will tend toward a competitive equilibrium where the solution is Pareto efficient when the market maintains the following three attributes: 1. complete markets, 2. price-taking behavior, and 3. local non-satiation of preferences.

the rate-of-return criteria support this view as well (e.g., Barbie et al, 2004; Homburg, 2014; Knolle, 2014; Piketty, 2014). Therefore, it is tempting to conclude that dynamic inefficiency is merely a theoretical possibility rather than a realistic challenge to the world.

On the other hand, Mishkin (1982) estimates real interest rates for major OECD countries, and concludes that real interest rates have not consistently been above the growth rate, and in some cases, have turned out to be negative. Similarly, Von Weizsäcker (2014) revisits the public debt issue. His analysis implies that real interest rates in OECD countries and China have become negative. Are the rate-of-return criteria empirically relevant? Above all, since there are a great too many distinct "rates" to choose from, it is difficult to believe that any of the "rates" is the best overall measure of the actual interest rate, and the practical feasibility of the conventional approach is no doubt limited.

To overcome this shortcoming, Abel, Mankiw, Summers and Zeckhauser (1989, AMSZ hereafter) establish a cash-flow efficiency criterion (also known as the "net-dividend criterion"), which is considered theoretically sound as well as empirically feasible. The AMSZ criterion by its nature coincides with the conventional rate-of-return criteria, which stresses real interest rates. Yet, instead of comparing interest rates with the economic growth rate—which emphasizes the essence of dynamic efficiency, the ASMZ criterion bases its result on a comparison of cash flows generated by capital with the level of investment—which reformulates the question into observing the impact and reflection of dynamic efficiency. The cash-flow criterion helps to avoid the uncertainty of measuring interest rates, and circumvents the complexity of index selection. AMSZ's (1989) empirical applications indicate that the major OECD nations are consistently dynamically efficient[2].

For far too long, research concerning real-world dynamic efficiency has received little attention in academic circles, partly due to AMSZ's (1989) optimistic conclusions, and partly because today's

[2] Employing official statistics obtained from the Bureau of Economic Analysis (BEA) and OECD, AMSZ (1989) investigate the dynamic efficiency of the US over the period of 1929–1985, as well as that of other major OECD economies (England, France, Germany, Italy, Canada, and Japan) for the period of 1960–1984.

world indeed appears to be highly dynamically efficient[3]. On the other hand, with the remarkable progress of statistical systems achieved in the past decades, there is renewed interest in reconsidering unresolved questions in the efficiency literature, such as: 1. employing more accurate statistics to re-assesse dynamic efficiency. 2. extending the time span of the assessment, as well as using a larger range of samples; 3. correcting the biases due to the limitations of previous statistical systems; and 4. looking forward into efficiency criteria.

The arrangement of this paper is as follows. In the next section, we re-assess dynamic efficiency for major economies by employing the largest dataset assembled to date, and we further discuss the evolution of capital accumulation to derive a common pattern. In section 3, we review previous studies on statistical biases in conducting the criterion, and we present bias-corrected estimates for the representative economies. As a prime example, we investigate the dynamic inefficiency of the Chinese economy. In section 4, the paper closes with brief concluding remarks, and some concise economic implications. Discussions over unsolved data problems and the theoretical limitations of the AMSZ criterion are provided in the Addendum.

[3] In recent years, relative to the stable long-term interest rate (about 5%), the world-wide slowdown (especially for advanced economies) in both technological and demographic growth has to a certain extent contributed to the efficient status of world economies.

2. Reassessing dynamic efficiency

In this section, based on the AMSZ (1989) criterion, we investigate the dynamic efficiency of major economies and we further discuss the evolution of capital accumulation—a question that has been rarely explicitly formulated in existing literature. Assessing the evolution from an efficiency angle is more meaningful than merely studying the level and growth rate of capital accumulation, which will be brought to light in the following parts.

An efficiency criterion can be viewed from different perspectives. First, it is a benchmark for the "pie distribution" problem. That is, for social planners, it presents the welfare principle on which a Pareto-improving intertemporal redistribution is feasible. Second, it is a generalization of the golden rule condition discussed in Phelps (1961, 1965) and Diamond (1965), which suggests that efficiency status depends on the order of magnitude between interest rates and the economic growth rate. In the neo-classical concept, a dynamically inefficient economy can be labelled as "over-accumulated," since its capital stock has exceeded the optimal level for maximizing social consumption (the "welfare"). Third, it demonstrates the conditions for enterprises to enter and withdraw from markets, evaluating whether an investment should be undertaken.

Unlike the conventional rate-of-return criteria, the AMSZ (1989) criterion contends that dynamic efficiency can be assessed by observing cash flow generated in the capital sector. To be precise, an economy is deemed to be dynamically efficient if gross capital gains outweigh capital investment, and similarly, an economy is considered dynamically inefficient if capital investment exceeds gross capital gains.

2.1 Dynamic efficiency in the aggregate economy

The OECD provides the harmonized system of national accounts (SNA, hereafter) for major economies covering the period of 1970-2015. As a preliminary test, cash flow in the capital sector is calculated as the difference between gross operating surplus (GOS) and gross capital formation (GCF), displayed in Figure.1. The observed efficiency fluctuates over time and across countries, and several economies share a common upward-trend in the period of 2005-2015, implying increasing worldwide

efficiency in the last decade. More importantly, in a first approximation, as capital has consistently produced much more income than expenditure, the sufficient condition of dynamic efficiency is satisfied by a wide margin. Accordingly, efficient status holds for all samples over the 1970-2015 period.

On one hand, the analysis presented above will only take us so far due to its short time span and the restricted range of samples. For advanced economies, a time span of 45 years is far from enough to capture the historical evolution of capital accumulation, and there is need to extend the time span. However, since developed nations began their economic development much earlier than the emergence of sophisticated statistical systems[4], one might argue that there is hardly any proper empirical approach to the question.

On the other hand, longer is by no means necessarily better. As Piketty (2014) puts it, most nations were severely plagued by two world wars and the subsequent political upheavals. As a result, statistical inferences derived from long-run historical data (especially those which include the period of 1910-1950) might be misleading and ill-advised, due first and foremost to the significant shocks that were experienced[5]. As a matter of fact, during these turbulent periods, the world was so badly disrupted that, at the end of World War II, capital accumulation around the world had to start all over again (e.g., Piketty and Saez, 2003; Piketty, 2011, 2014). In the following section, we will show how these shocks contributed to the ups-and-downs, focusing on the cases of the US and China, where political and economic chaos in certain periods seriously disturbed the efficiency of capital investment. Quoting Piketty (2014, p.275): "*In the twentieth century it was war, and not harmonious democratic or economic rationality, that erased the past and enabled society to begin anew with a clean slate.*" From an economic point of view, wartime shocks to some extent help reset the on-going evolution of capital accumulation,

[4] For example, modern capital accumulation in the US generally originated in the early 1870s (after the Civil War in the 1860s); for France, it started in the 1860s (the Second Industrial Revolution).

[5] A typical example is Kuznets' celebrated article on inequality (1955). According to Kuznets' "bell curve" theory, diminished US income inequality in the period of 1913-1948 was achieved by rapid industrialization and innovations. Yet there is ample evidence (such as Elmendorf and Mankiw, 1999) suggesting that this kind of fluctuation was essentially caused by wars and violent economic and political shocks in particular periods.

providing feasible controlled experiments for learning, and make it easier for us to capture the otherwise unobservable overall process.

In this regard, 1950-2015 is not only a sufficient time span for our main objective, but also a reasonable option for assessing the past and the present. Following this idea, we begin by gathering as extensively as possible the official datasets focused on the dynamics of capital accumulation of France, the US, and Japan—which are typical advanced economies on the respective continents involved in the world wars—by exploiting statistics[6] with longer time spans.

Alternatively, to capture a common pattern, it is illuminating to take into account the "newly-rising" economies, such as the "four dragons of Asia." To be candid, studying the cases of developing countries might suit our purpose better, because they are late starters in economic progress as well as in capital accumulation, which means that it is unnecessary to extend the time span to certain earlier periods (note that "earlier" usually means "less reliable"), and we can make use of the harmonized system of national accounts (OECD balance sheets)—which provide better accuracy and consistency in a statistical sense—to investigate the dynamics.

Employing the same methodology, Figure 2 presents the estimates of dynamic efficiency for France, the US, Japan, South Korea, and Taiwan[7]. In every instance, at the beginning of the evolution, the net return to capital was relatively high, implying the scarcity of capital accumulation. The early stage refers to the well-known "pre-Lewis turning point" period where rural labor surplus and capital shortage coexist. As the process unfolded, the net return declined until it reached the nadir. There are

[6] As the headquarter country and one of the founding members of the OECD, France established the earliest and most complete system of national accounts in 1950. As for Japan, the cabinet office built up its national account system in 1955 in a manner corresponding to the conventional SNA68 standard, which enables us to capture the early phase of capital accumulation for post-war Japan. For the US, we employ the long-run historical data of the National Institute of Pension Administrators (NIPA), which is frequently tested and advocated by various research.

Nevertheless, one might argue that there are other alternatives (national balance sheets) which provide longer time spans than those we selected; for instance, the one Kuznets and Kendrick used in the case of the US, the one Petty estimated for France, and some early data series for the UK. The point is, many of these series cover the wartime periods, and they do not provide certain crucial elements for conducting the AMSZ criterion, such as GOS and GCF. In this regard, we base the analysis on official statistics instead.

[7] In estimates for Hong Kong and Singapore, the result is consistent, but it is not demonstrated here in the interest of space, and because the time span of both observations is limited.

roughly two explanations for the phenomenon: One obvious reason is that capital stock continued to amass over time, which lowered its marginal product (r); thus, capital became less lucrative. The other reason is that the way capital accumulated during postwar periods was always extensive and ill-deliberated. For economic stability and market expansion, most nations chose a government-led investment pattern as well as some particular anti-capital policies in their "golden ages" of economic development, such as higher upper-bracket tax rates on capital income, restrictions on house rent, economy collectivization, and financial sector constraints—which have no doubt impaired the market effectiveness and brought down investment efficiency. In the late stage, thanks to technological progress, rational bubbles (valuation effects), financial liberation, privatization of state owned enterprises (SOEs), and structural reforms, efficiency recovered and the return to capital flourished again. By and large, the estimated trajectories are in line with historical experience.

The representative nations share a similar "U-shaped pattern" in their evolution of capital accumulation, moving in a direction consistent with the economic cycle. That is, firstly the investment expands, and efficiency declines during economic booms, efficiency then reaches a lower level, and the sawtooth pattern holds for some time, finally rebounding to a higher efficiency state when a way out of low efficiency is found. Another feature worth considering is that transitions in emerging economies are much more volatile relative to those in advanced economies, both in magnitude and in direction. This insight has many profound parallels in economics; for instance, the distinctions among transitions of economic development, demographic structures, and income inequality, as discovered by numerous other authors that developing nations always "move faster".

2.2 Dynamic efficiency in the corporate sector

In subsection 2.1, we estimated the evolution of dynamic efficiency for five representative nations. Nevertheless, aggregate economy is comprised of many components; some are highly competitive sectors while others are not. In a sense, studying an economy as a whole might be inappropriate, particularly when it comes to employing an empirical approach (AMSZ criterion) that critically relies

on the assumption of completely competitive market. In an enlightening work done by Desai et al. (2011), the authors study cash flows in US investment abroad, and reveal that foreign investment sector is dynamically efficient over the 1950-2010 period, indicating that the American economy was in an efficient status. In this subsection, we turn to investigating dynamic efficiency for non-financial corporate sectors. This angle helps to shed new light on the actual efficiency, and provides suggestions about the efficiency features of aggregate economy and its competitive components.

Following the methodology and data sources used in subsection 2.1, we present the estimates of corporate-level efficiency for France, the US, and Japan. As a comparison, the estimates from both versions are demonstrated in Figure 3. The results suggest that corporate-level efficiency shares a common pattern with its aggregate-level counterpart, and in most cases, the trends lie above the critical line by a substantial margin. Hence, the corporate sector is also considered dynamically efficient.

Referring to early evidence, AMSZ (1989) conclude that the level and fluctuation of dynamic efficiency is greater for the corporate sector than it is for the aggregate economy. A similar tendency is also found in Kajitani (2012), who exploits the governmental official dataset to investigate Chinese dynamic efficiency. His analysis implies that the efficiency level and volatility are both higher in corporate sectors. However, as our estimates suggest, in the early stage of capital accumulation, corporate-sector efficiency appears to be lower than that in the aggregate economy, especially in the estimate for France—which provides better accuracy because of better data availability. The results also imply that the disparity and volatility of corporate-sector efficiency are somewhat modest in comparison. A probable explanation is that, given the competitive essence of the market economy, the net return (r) on a steady-state growth path is not supposed to be either too high or negative. That is, conditional on the effectiveness of market mechanisms, the real interest rate of capital investment ought to converge to slightly positive values or oscillate around the critical line, rather than following an opposite pattern. It is a common wisdom witnessed over a long history that the average return remains at 5% a year, approximately 1/20 of the market value of assets; thus, there seems no serious overstatement in corporate-level efficiencies.

On the other hand, dynamic efficiency also serves as an indicator of "net-profit." Enterprises

are profit-pursuing, while other sectors, such as government and financial institutions, are considered more or less "non-profitable." Then, how is it possible that the imperfectly competitive entity (aggregate economy) obtains higher returns than its highly productive component (corporate sectors)? How can the net profit of the total economy be above 25% in certain periods? The estimates clearly warn of the potential overstatement in aggregate-level efficiency, and this is exactly the reason and position—not mentioned by previous efficiency literature based on the AMSZ (1989) criterion—for looking closer into the empirical strategy. Although we believe that the biases do not disturb the order of magnitude in time-series analysis, and our main conclusion concerning efficiency evolution remains intact, to know better about the actual efficiency, we turn in the next section to the issue of empirical biases to derive more accurate estimates.

3. Bias in conducting the AMSZ criterion

In section 2, we estimated dynamic efficiencies both in the aggregate and at corporate levels for representative nations. Based on the cash-flow criterion, the estimated results support the efficient status for all samples covering overall periods. However, due to the biases arising from the defects in statistical systems, inferences derived from SNA statistics are inclined to systematically overstate actual capital gains. Recall that cash flow is calculated as the gap between capital gains and investments; the biases mislead us into becoming too sanguine about real-world dynamic efficiency. In this section, we give a brief review of the statistical biases in conducting the AMSZ criterion, what follows covers the bias-corrected estimates and Chinese dynamic inefficiency. Discussions over unsolved data problems and the theoretical limitations of the AMSZ (1989) criterion are provided in the Addendum.

3.1 Correction for bias

We summarize the typical biases and their causes below; three of them are proven not only statistically significant, but also empirically solvable.

1. Bias related to labor income: The AMSZ criterion contends that dynamic efficiency can be captured by observing cash flow generated in the capital sector, calculated as the difference between capital gains and capital investment. Employing national accounts, we measure cash flow as the difference between gross operating surplus and gross capital formation. The trouble is, as previous versions of SNA statistics have failed to distinguish between mixed income[8] and gross capital income, recorded GOS is composed of both capital income as well as labor income from proprietors, which causes an upward bias in capital returns.

In light of previous literature (AMSZ, 1989; Ahn, 2003; Kajitani, 2012; Geerolf, 2013), to cope with the SNA statistics where capital income is not properly accounted for, we take a conservative stance

[8] Mixed income is the surplus or deficit accruing from production by unincorporated enterprises owned by households, which consists of both capital income and the labor income of proprietors.

to assume the proportion of mixed income to GOS to be 10%[9], and we refer to the imputation discussed in Christensen (1971)—which reveals that labor income contributes to about 2/3 of the total mixed income in US unincorporated enterprises. Accordingly, 6.7% of the total GOS—which is by nature a kind of labor compensation—is subtracted from the conventional GOS indicators.

2. Bias related to land rents: The AMSZ criterion is a benchmark of supply-side capital accumulation. Cash flow represents profit in the production sector, calculated as the gap between input and output in the production process[10]. The problem is, GOS indicators include not only the output of "productive capital", but also the product from natural resources—such as land rents and outputs from forest resources—which is essentially the output of non-reproducible resources. In this sense, employing SNA statistics leads to overstatement of capital income because the notion of "new investment" is magnified. Particularly for nations experiencing a scarcity of land resources and real estate bubbles (such as Japan and France), land rents contribute a large percentage to aggregate capital income. As a result, ignoring the bias might seriously disturb the assessment of dynamic efficiency.

It must be noted that, when referring to the market value of vacant land, the price reflects not only the "pure land value" that represents its capacity in the production process, but also the infrastructure around it, and its geographical advantages distinguished by aggregate investments and construction, which are almost impossible to quantify. For this problem, AMSZ (1989) follow previous literature and assume that land rents contribute 6.7% to total GNP in the estimate for the US. Similarly, for lack of reliable data resources, Ahn (2003) conservatively assumes the proportion to be 2% in estimates for Asian economies, and this assumption resembles Piketty and Zucman's (2014) that the pure land value could be less than 0.5 year of national income, which infers a land rent/GNP ratio of 2.5% (if the return is 5% each year).

[9] Time series data for mixed income is only available for several economies during certain periods, according to which the ratio of mixed income to GOS ranges from 15% to 40% across countries and over time. While not determinable, these series help to draw an initial impression of the magnitude of mixed income. To avoid over-correction, the ratio is assumed to be 10% in the following estimates.

[10] This is also a merit of efficiency criteria that avoid confusing "productive capital" with "wealth," which generates profits in other ways.

On the other hand, it is more effective and meaningful to assume land rents as percentages of GOS, because the plus-minus of estimated efficiency depends on the order of magnitude between GOS and capital formation, rather than GNP or GDP. In this vein, Geerolf (2013) refers to the evaluations of Goldsmith (1985) and Davis and Heathcote (2007), which indicate that land value contributes 25% to the total value of tangible assets in the US. If land and other assets obtain identical returns, we need to subtract 25% from the GOS indicators. In our analyses, we assume the ratio to be 25% in the estimate for the US; however, the ratio is set at 20% in the estimates for Japan and France, a rather conservative stance on the question[11].

3. Bias related to production tax: As noted, GOS is pretax gross capital income which includes taxes on the production process. However, it is often neglected that production taxes defined in SNA standards are composed not only of the duties and tariffs on capital gains, but also taxes on labor income (He et al., 2007; Geerolf, 2013)[12]. Similar to the case of correcting "mixed income," as part of employee compensation is included in the reported capital gains, we need to disentangle tax on labor income from the pretax capital income. To address this issue, we follow the method presented by He et al. (2007), who assign the ratio of labor income tax to total production taxes as the ratio of total employee compensation to gross capital income. To emphasize an important point, the actual labor income tax in production processes is likely to be lower than the method derives; the reality must lie somewhere between 0 and the estimated value. Cautious readers should be aware of the potential over-correction and treat the estimate as a lower bound.

[11] According to the OECD database (SNA 2008 standard), in 2011, the land value/GDP ratio in France skyrocketed to 290 percent, and the ratio of land value to total value of nonfinancial capital is above 44 percent in France (45 percent in Japan), as revealed by Homburg (2014).

[12] According to the SNA standards established by the OECD (available on the OECD homepage), taxes on production and imports consist of taxes payable on goods and services when they are produced, delivered, sold, transferred, or otherwise disposed of by their producers, plus taxes and duties on imports that become payable when goods enter the economic territory by crossing the frontier, or when services are delivered to resident units by non-resident units. They also include other taxes on production, which consist mainly of taxes on the ownership or use of land, buildings, or other assets used in production or on the labor employed, or compensation of employees paid.

In summary, recalling the typical biases discussed above, the correction process is simplified in the following equation:

$$\text{Bias corrected GOS} = \left(\text{GOS} - \frac{2}{3}\text{Mixed income} - \text{Tax on labor income}\right) \times \left(1 - \frac{\text{Land value}}{\text{Total asset value}}\right)$$

$$\text{Level of dynamic efficiency} = \frac{\text{Bias corrected GOS}}{\text{Gross domestic product}}$$

Figure 4 presents the estimates after corrections for these biases. Among the results, the estimate for France is again superior to the others, since mixed income is directly available from the OECD database covering the 1950-2015 period. Hence, arbitrary assumptions can be avoided, which results in a more reliable assessment. In the early stage of postwar capital accumulation, un-incorporated enterprises played an important role in the French economy with "mixed income" contributing over 25% to total GDP. The correction concerning mixed income plus land rents leads to a reduction in the efficiency level of 10-20%; the correction for overall biases leads to a decrease of around 25%, large enough to overturn the previous conclusion. This result clearly points out that France has not been consistently dynamically efficient, notably during the period of 1950-1985—the postwar recovery period and the early phase of modern capital accumulation. We further conduct estimates for the US and Japan in the same manner. As expected, neither nation has consistently been in an efficient state over the observed period. Japan, in its golden periods of economic development, and the US during its economic booms might have encountered challenges from excessive investment, and the consequent inefficient status.

Are these estimates empirically relevant? Recall that for an inefficient economy, when capital has accumulated beyond the optimal level for maximizing social consumption, lowering investment today does not necessarily lead to a future decline in consumption. According to the OECD balance sheets, one can observe that the capital formation ratio (GCF/GDP) in France had been declining noticeably from 29% to 21% over the 1974-1984 period, while the consumption ratio (FCE/GDP) had been stable at around 54% throughout the 1974-2004 period. For the US and Japan, one can obtain similar tendencies from the datasets discussed above. The estimates verify the objective existence of

over-accumulation, suggesting that dynamic inefficiency is more than a theoretical possibility, and it should never be shelved in the library of impractical theories.

3.2 Dynamic inefficiency in China

In light of the analysis presented above, as a result of extensive capital accumulation, mature capitalist countries might have experienced inefficient states in their early and middle stages of economic development. On the other hand, opposite to Bernanke's caveat that a world-wide "saving glut" prevails in the 21st century, the "U-shaped curve" suggests that world economies these days appear highly dynamically efficient (even after corrections), with increasing trends[13].

Questions worth thinking about arise, such as whether there is an economy that is now experiencing the problem of dynamic inefficiency, and which of the contemporary nations suffers the most harm from over-accumulation. To have an ex ante understanding of these questions, one can refer to the causes and manifestations of dynamic inefficiency. Literature along this line recognizes that the over-accumulation issue is closely associated with: 1. a large share of monopoly enterprises, 2. a high level of government intervention, 3. market imperfections, 4. speculative bubbles, 5. excess savings and consumption stagnation, and 6. rapid economic growth. Accordingly, Asian economies stand out as potential candidates for victims of over-accumulation.

Empirical literature, such as Ahn (2003) and Geerolf (2013), reveal that Japan, South Korea, and Taiwan might have once been in an inefficient state, while little is known about other emerging economies in Asia and other regions. With the largest dataset assembled to date, based on the AMSZ criterion[14], we evaluate the 21st century dynamic efficiency of the world's top-30 largest nations ranked

[13] In a similar vein, Fischer (2017) develops a generalization of the AMSZ criterion and reveals that dynamic efficiency always prevails, and shows signs of growing in major OECD economies over the 1990-2010 period.

[14] In this part, for lack of detailed data sources, we did not conduct bias-correction. As a result, the efficiency level might be systematically overestimated, but intuitively it does not contaminate the main conclusion, since the only concern in question is the order of magnitude.

by GDP[15], and of other OECD participants, shown in Table.1. According to the estimates, recall that the bias-corrected estimate is always 15%-25% lower than the non-corrected one; therefore, it is reasonable to consider those with efficiency levels under 15% as potential victims of inefficiency. They are: China (-4.89%), India (9.72%), Sweden (10.24%), Taiwan (10.65%), Slovenia (11.34%), Iceland (11.69%), Estonia (12.42%), Denmark (12.81%), France (12.98%), Australia (14.55%), and South Korea (14.89%).

Among these observations, China is undoubtedly the one that has been experiencing a serious state of dynamic inefficiency in the past decade. Figure 5 presents the bias-corrected estimates employing OECD balance sheets—both in aggregate and at corporate levels—for China. It comes as no surprise that it turns out that even the non-corrected estimates suffice to verify Chinese inefficiency over the 1992-2014 period. The bias-corrected trajectories lie well below the critical line, which set an absolute historical record for inefficiencies obtained in the study, and there is a downward trend over the 2000-2014 period, suggesting that inefficiency might deteriorate in the near future. To trace back farther in time, we instead refer to the *estimation of historical national accounts of China*—conducted by the State Statistical Bureau of China (SSBC) and the Institute of Economic Research of Hitotsubashi University based on the *China compendium of statistics*—to extend the observation to the 1950s.

The estimates demonstrated in Figure 6 suggests that, consistent with other economies, China experienced a highly efficient status in its early stage of capital accumulation. In 1958, the strategy of "great leap forward" implemented by the Chinese government and the following "great famine" caused a drastic decline in efficiency[16]. After the recovery period of 1960-1964, efficiency began to decline as capital accumulation continued to rise. In the wake of "the cultural revolution" in 1977, efficiency showed a sign of rebounding, though transitory, as a result of restoration in production and construction.

[15] Among the Top-30, we drop the observations of Indonesia, Saudi Arabia, Argentina, Thailand, Iran, and the United Arab Emirates, as official statistics for these nations are not up to the standards for conducting the criterion.

[16] Dynamic efficiency is a steady-state notion. In a sense, although shocks like natural disasters also cause inefficiency; the mechanism is through direct economic loss and the destruction of production, rather than over-investment. This same conclusion is also applicable to the US case over the 1929-1950 period (in Figure 2), in which the "great depression" and the two world wars caused dramatic drops in aggregate-level efficiency.

China began to shift gradually from a command economy to market economy around 1980s, in 1993, when exactly Chinese SOE reform and the "opening-up" strategy were being enforced in earnest, domestic capital formation was pushed forward, and the market attracted an astronomical amount of foreign investment during its internationalization, which stimulated the first inefficient status. After the Lehman shock in 2008, to fend off the shrinking demand of the global economy, the Chinese government adopted the "4 trillion RMB" stimulus program—which boosted public investment and strengthened government intervention into market economy, resulting in massive capital formation and severe inefficiency.

If the "u-shaped curve" withstands close scrutiny, an inescapable reality is that China today is in the middle phase of capital accumulation, where substantial idle capital and an alarming level of inefficiency prevail. Chinese people today can sense the stagnation in income, rising unemployment, and increasing inequality. Faced with these challenges, the capital-extensive investment pattern is difficult to continue, and it is imperative for the Chinese government to implement reforms of the growth model to improve economic performance.

We would like to stress that studying the issues of capital accumulation from an efficiency standpoint deserves credit, because it always provides a better understanding of these questions. Mainstream analyses like Piketty and Zucman (2014) pinpoint the capital/income ratio (ratio of national capital to national income) as the standard indicator of capital accumulation. This always leads to the conclusion that the US has accumulated too much capital, since the market value of capital stock is the equivalent of 6 or 7 times the national income (also true for most European countries), while suggesting that less developed countries have invested too little because their ratio is still below 5.

On the contrary, focusing on the "level" might be misleading. Interestingly, as Piketty himself makes clear, the neoclassical doctrine *"too much capital kills its return,"* and Keynes' the *"euthanasia of rentier"* hypotheses are devalued by technological development, which brings along differentiated and multilayered opportunities for investment to sustain high returns on capital (Piketty, 2014). That is, material force (the level) is not the only concern, and sometimes not even the biggest concern in question.

In the abstract, the optimal capital stock for an economy depends to a large extent on its national characteristics. We need to weigh in institutional, political, technological, and social features to explain the distinctions among optimal capital levels across borders; thus, from the very beginning, cross-country comparisons should not be based on the "level" of capital.

As our analysis suggests, it might well be that a nation has capital stock worth 7 times its GDP, with no excessive capital, since the economy is dynamically efficient (such as the US). Yet, for an inefficient economy (such as China), a ratio of five makes us argue that the nation has accumulated too little, which is blatantly wrong. Nations differ in the causes of poor efficiency. Simply put, developing countries such as China, India, Taiwan, and South Korea obtain lower efficiencies due in large part to the way capital is accumulated (the extensive investment patterns). Poor performances of capital in Iceland, Estonia, and Slovenia are attributable to the economic and political chaos over the past decades. As a matter of fact, advanced economies—Australia, Sweden, and France—have lower capital yields because they might indeed have accumulated too much capital.

4. Concluding remarks and implications

Applying, examining, and improving the AMSZ (1989) criterion for assessing dynamic efficiency are the major goals of this study. Section 1 briefly reviews the theoretical background and previous literature pertaining to the subject of dynamic efficiency. In section 2, employing the largest dataset assembled to date, we estimate dynamic efficiency for major economies based on the cash-flow criterion. The estimated results show that the nations exhibit a similar "U-shaped order" in their evolution of capital accumulation; that is, in the early stage, dynamic efficiency swings from high-to-low, holds for some time, then rebounds from low-to-high in the late stage of capital accumulation.

In section 3, we provide a summary of the literature concerning empirical biases in conducting the criterion, followed by the presentation of bias-corrected estimates. Contrary to AMSZ (1989), the results imply that France, the US, and Japan have not been consistently dynamically efficient, especially in their early phases of capital accumulation and during the golden periods of economic development. It is worth nothing that the adjustments made to the estimates are empirically relevant, and we took no extreme stance in the computations. The following analysis suggests that China today is, at any rate, in a serious state of dynamic inefficiency, the level of excess capital is extremely high, and there is an obvious downward trend, inferring efficiency deterioration in the future. We further demonstrate the superiorities of the efficiency criteria over conventional methods in studying the subject of capital accumulation. Last but not least, we look into unsolved data problems and the theoretical limitations of AMSZ (1989) (see the Addendum). We argue that the shortcomings do not devalue its versatility, and the advantages of the approach vastly exceed its limitations. We look forward to new breakthroughs in the efficiency criterion, and the improvement of statistical methods.

This paper explores a brand-new angle for investigating the evolution of capital accumulation worldwide; some of our findings might be helpful to reconcile the diverse conclusions of recent studies. On the other hand, the efficiency literature has long been scattered without down-to-earth implications. The question is, can we draw any economic and political implications from the study?

We know that only a handful of nations (e.g., China, perhaps India, and Taiwan) currently suffer challenges from dynamic inefficiency, yet this does not mean that other economies can comfortably relax in the future. To our mind, the trade-off between economic growth (g) and interest rates (r) is a double-edged sword, as well as a dilemma.

Simply put, in a dynamically inefficient environment ($g > r$), you have a bigger "pie" (the economy grows faster), but you cannot make use of it efficiently (dynamic inefficiency). On the other hand, if growth falls short of interest rates ($r > g$), you have a smaller "pie," but you know that it can be distributed optimally (dynamic efficiency). As noted, capital saturation ($g > r$) renders further investment pointless, since capital stock has already exceeded the optimal amount for maximizing social consumption; thus, dynamic inefficiency is by nature a practice of "extravagance." Employing explicit economic models, one can roughly evaluate the welfare loss due to inefficiency by comparing optimal social consumption derived from efficient and inefficient contexts.

Another profound viewpoint suggests that the order of magnitude between r and g leads to divergence or convergence of income inequality (e.g., Piketty, 2014). The trade-off between equity and efficiency is, given that economic growth and interest rates respectively reflect the growth in labor income and the return on capital, a dynamically efficient state ($r > g$) will ultimately result in an in-egalitarian spiral between workers and capitalists, since returns on capital outweigh the growth in labor compensation in the long-run, and vice versa. This is exactly the dark prophecy made by Karl Marx that "*the bourgeoisie digs its own grave,*" and it is worth thinking that great ages of civilization and democracy in history were always accompanied by reduced interest rates and high growth (Homer and Sylla, 1996).

Moreover, it is well known that today's advanced economies have been enmeshed in interminable debt deficits, with public debts ordinarily exceeding annual GDP. To address the problem, dynamic inefficiency offers a "way out" to finance the public debt—in a $g > r$ environment, as income growth outstrips the interest rate, government can roll over the debts, and will never have to pay them

off, since there are always "emerging" investors to replace the "old"—by operating a Ponzi scheme. The mechanism applies as well to the case of "rational bubbles."

To recapitulate, dynamic inefficiency is interpreted as "the future devours the current" state, where rapid growth can be taken advantage of, while most nations are confronting "the past devours the future" state ($r > g$), where the inequality of capital ownership is becoming acute. From these vantage points, dynamic inefficiency turns out not as bad as one might imagine. The question is, if each nation were free to choose its efficiency state, which one would it prefer? This dilemma evidently depends on the pros and cons of the trade-off, which are, at this time, obscure and unanswerable questions. For dynamically inefficient nations (especially for China), although there are many underlying merits that over-accumulation brings with it, we believe that the inefficient state is pathological and unsustainable, and it will be mostly harmless and reasonable to implement reforms to stimulate consumption, lower the capital-labor ratio, raise interest rates, and reduce idle capital. The key message is that making full use of policy designs (such as pension systems and public debt, even speculative bubbles) is not only the most beneficial option to obtain "free" welfare gains, but also the ultimate solution to cope with inefficiencies.

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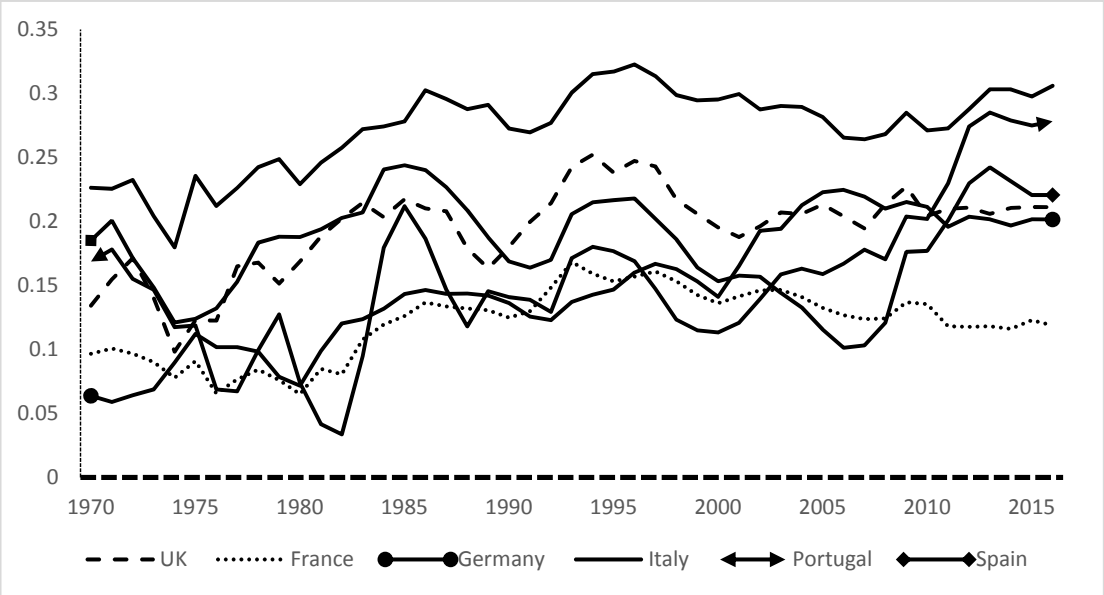
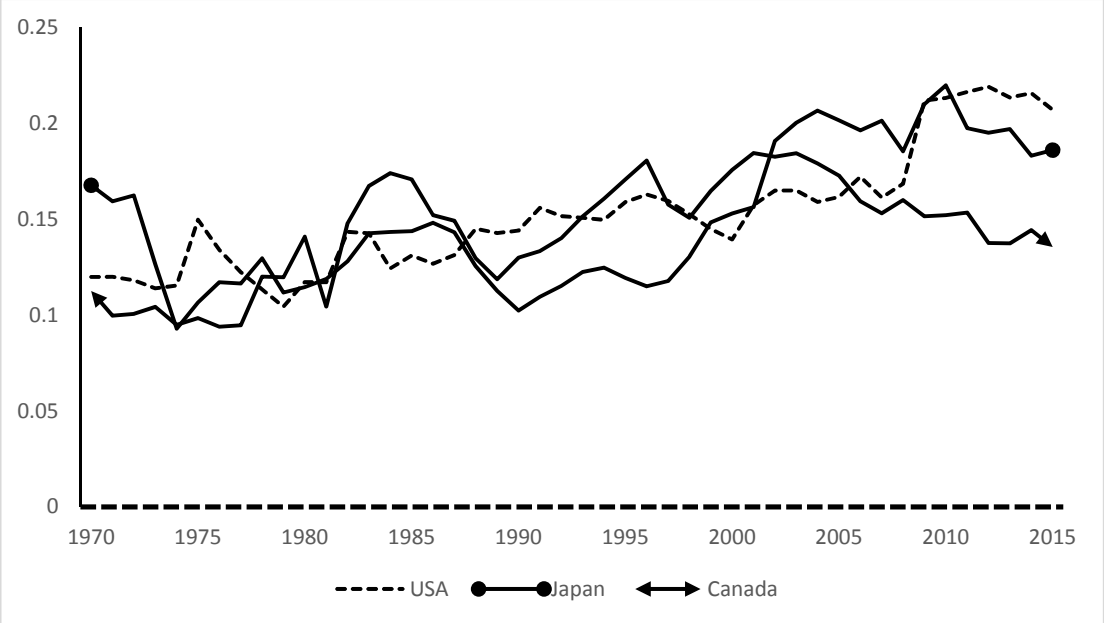
Figure 1: Dynamic efficiency (percent)

(1) European economies



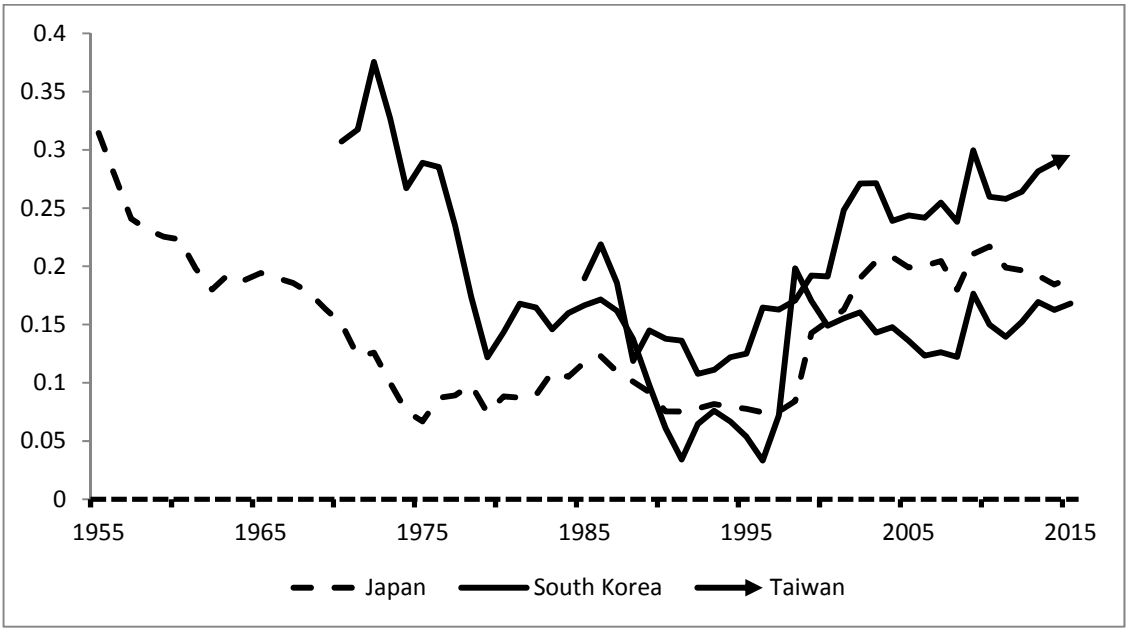
(2) Non-European economies



Source 1: Harmonized system of national accounts (OECD balance sheets).

Note 1: The cash flow in the capital sector is calculated as the difference between the gross operating surplus and the gross capital formation, demonstrated in fractions of GDP. That is, the percentage = Cash-flow/GDP.

Figure 2: Dynamic efficiency in five nations (percent)

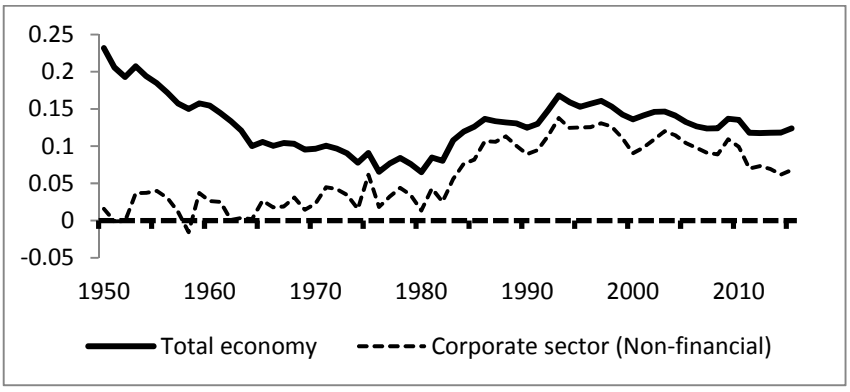


Source 2: OECD SNA statistics for estimates for France and South Korea, BEA NIPA statistics for the US, SNA68 statistics (from the Cabinet Office of Japan) for Japan, and SNA statistics (from the National Statistics of Taiwan) for Taiwan.

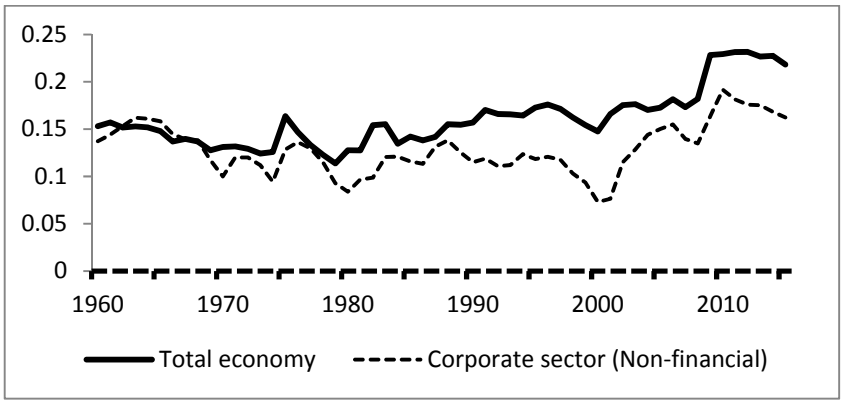
Note 2: In estimates for France, Japan, South Korea, and Taiwan, cash flow in the capital sector is calculated as the difference between the gross operating surplus and the gross capital formation, shown as a percentage of GDP. In estimates for the US, the conventional GOS indicator is not available in NIPA statistics until 1952, and the GCF indicator is not recorded until 1960. To extend this time span, we follow the method presented by AMSZ (1989), which calculates the gross capital flow as national income plus capital consumption allowance, less employee compensation and 67% of proprietors' income.

Figure 3: Dynamics in the aggregate economy and corporate sector (percent)

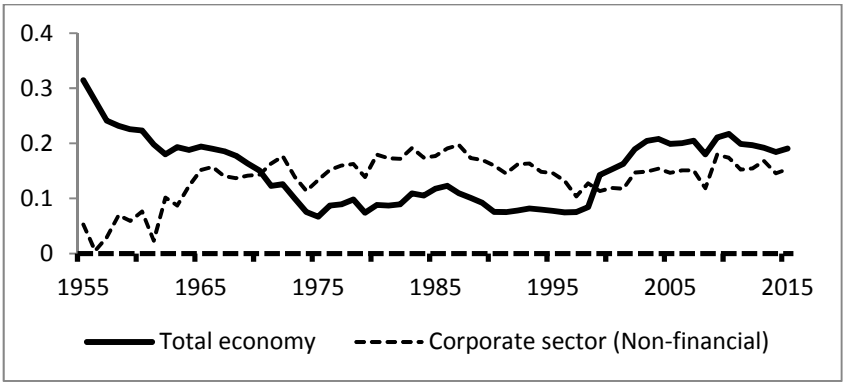
(1) France



(2) US



(3) Japan

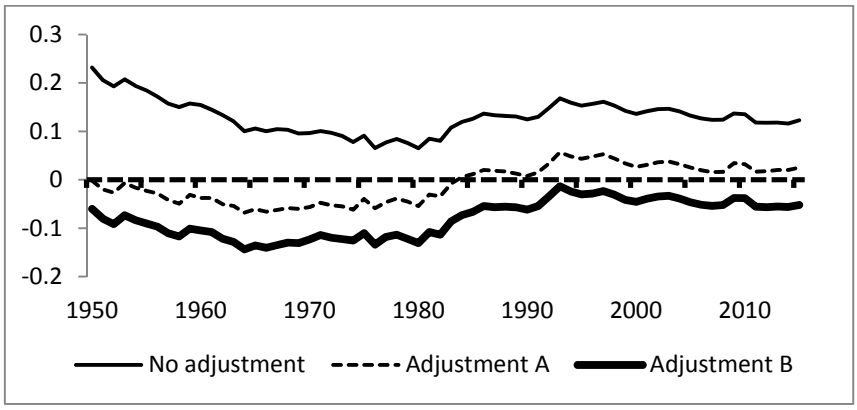


Source 3: Consistent with Figure.2.

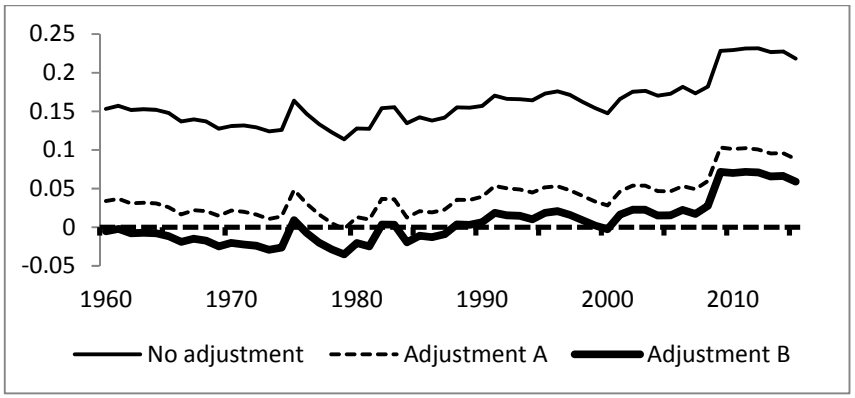
Note 3: Since the SNA statistics (from the Cabinet Office of Japan) did not record the GDP of the corporate sector, we assume the portion of GDP in the corporate sector to total GDP is 0.6 in the estimate for Japan. For the US corporate sector, the GOS indicator is not available in NIPA statistics. We calculate the cash flow as the gross value added, less indirect tax paid by producers, which is reduced by producer subsidies received, less compensation of employees. In short, GOS= GV-(IT-SU)-CE.

Figure 4: Bias-corrected estimates for the aggregate economy (percent)

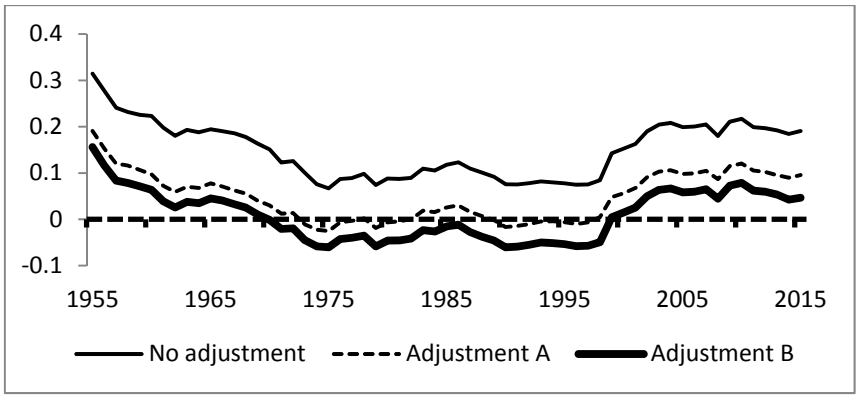
(1) France



(2) US



(3) Japan



Source 4: Consistent with Figure.2 and Figure.3.

Note 4: "No adjustment" represents the aggregate-level estimates obtained from Figure.3. "Adjustment A" represents the estimates after correction for biases related to labor income and land rents. "Adjustment B" represents the estimates after correction for biases related to labor income, land rents, and production taxes.

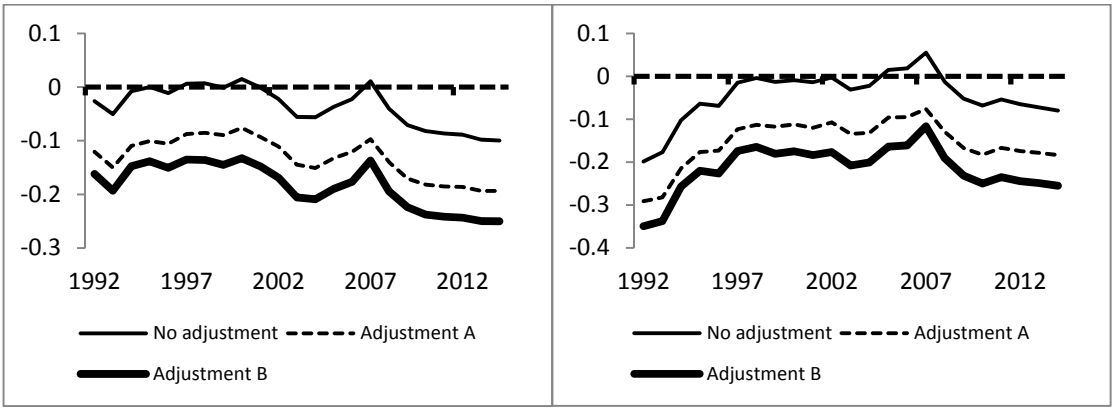
Table 1: 21st century dynamic efficiency (percent)

GDP Ranking	Country	Dynamic efficiency	Averaged over	GDP Ranking	Country	Dynamic efficiency	Averaged over
1	USA	18.41%	2000-2015	28	Austria	16.42%	2000-2015
2	China	**-4.89%**	2000-2014	31	Norway	21.02%	2000-2016
3	Japan	19.23%	2000-2015	34	Israel	19.55%	2000-2015
4	Germany	20.05%	2000-2015	35	Denmark	12.81%	2000-2016
5	UK	20.57%	2000-2016	39	South Africa	23.59%	2008-2014
6	France	12.98%	2000-2016	40	Ireland	27.62%	2000-2015
7	India*	9.72%	2011-2014	43	Columbia	35.50%	2000-2015
8	Italy	28.63%	2000-2016	44	Chile	32.52%	2003-2015
9	Brazil*	21.12%	2010-2014	45	Finland	17.34%	2000-2016
10	Canada	15.93%	2000-2016	47	Portugal	19.98%	2000-2016
11	Korea	14.89%	2000-2015	50	Greece	25.13%	2000-2016
12	Russia	17.66%	2011-2015	51	Czech Republic	22.77%	2000-2016
13	Australia	14.55%	2000-2015	53	New Zealand	22.45%	2010-2015
14	Spain	16.65%	2000-2015	58	Hungary	18.52%	2000-2015
15	Mexico	44.63%	2003-2015	66	Slovak Republic	27.13%	2000-2015
17	Turkey	32.15%	2009-2015	76	Luxembourg	20.36%	2010-2015
18	Netherlands	19.74%	2000-2016	77	Costa Rica	22.10%	2012-2014
19	Switzerland	15.56%	2000-2015	86	Slovenia	11.34%	2000-2015
22	Taiwan*	10.65%	2000-2015	88	Lithuania	26.77%	2004-2015
23	Sweden	10.24%	2000-2016	100	Latvia	19.15%	2000-2015
24	Poland	28.35%	2000-2015	105	Estonia	12.42%	2000-2015
25	Belgium	16.34%	2000-2015	112	Iceland	11.69%	2000-2015

Source 5: SNA (2008) statistics (from the National Statistics of Taiwan) for Taiwan; statistics on employee compensation used to compute GOS are not available for India at the aggregate level, we instead use the statistics on the non-financial corporate sector as an alternative, obtained from the Ministry of Statistics and Program Implementation of India; data for other nations is directly obtained from the OECD database. For Brazil, statistics on acquisitions less disposals of valuables used to compute gross capital formation are not available in the OECD database; we instead use the statistics on gross fixed capital formation as an alternative, which might to some extent overstate the efficiency level.

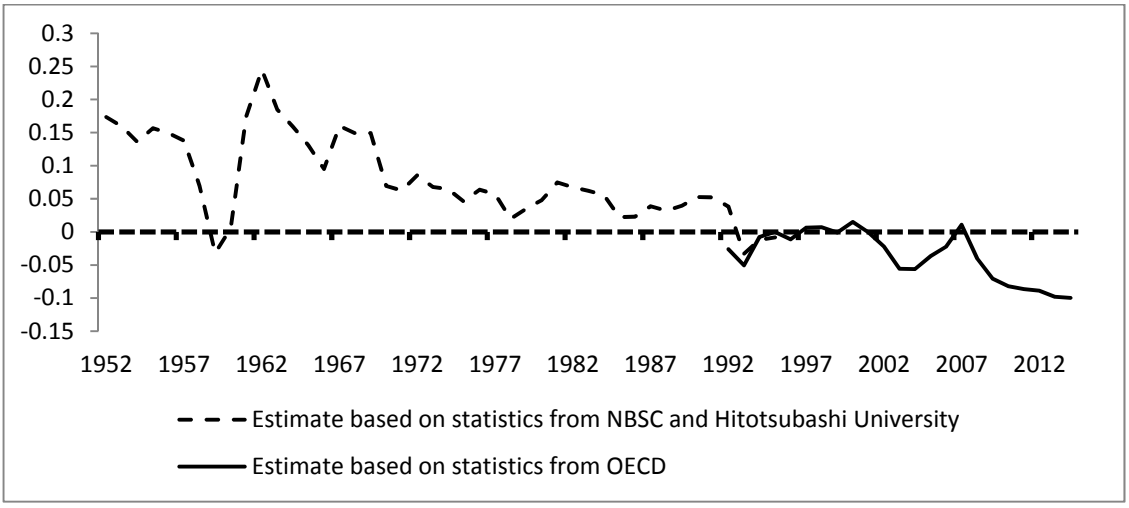
Figure 5: Bias-corrected estimates for China (percent)

(1) Aggregate economy *(2) Corporate sector*



Source 6: Harmonized system of national accounts (OECD balance sheets).

Figure 6: Dynamics in the Chinese economy (percent, no adjustment)



Source 7: OECD balance sheets for estimates over the period of 1992-2014. To extend the time span, we refer to the historical national accounts of China, conducted by State Statistical Bureau of China (SSBC) and the Institute of Economic Research of Hitotsubashi University, for the period of 1952-1995. Two trends overlap in the period of 1992-1995, and the fit is good.

Note 5: The GOS indicator is not available in statistics from the SSBC or Hitotsubashi University; we calculate the GOS/GDP ratio using OECD statistics. The result suggests that the ratio fluctuates from 36% to 40% during the period of 1992-2014. For the sake of being conservative, we assume the ratio as 40% in the estimates covering the 1952-1995 period.

Addendum

A.1 Unresolved statistical biases

Except for the previously noted factors, some causes of biases are of the utmost importance, but remain unresolved due to the limitations of statistical methods. We provide a brief review below to call attention to them for further research.

1. **Bias related to monopoly rents:** As noted, the AMSZ (1989) criterion pivots on the assumptions of perfect competition and capital to obtain its marginal returns. In the real world, there are monopoly rents, decreasing returns, market failures, and other distortions which lead to overestimation of the marginal return on capital. For this problem, considering Tobin's q (Tobin, 1969)—the ratio of a firm's market value to its book value—as a potential proxy for the degree of monopoly might be practical[17]. However, in assessing efficiency, referring to Tobin's q only helps to qualitatively render a verdict about whether there is an upward bias resulting from monopoly rents; it does not mean that one can quantitatively measure the bias.

Previous studies on Tobin's q provide divergent insights. Some estimate that the corporate-level Tobin's q is lower in advanced economies than in emerging economies, yet some provide the opposite results. Some argue the law of diminishing Tobin's q over time, while others support the contrary. Above all, although many questions remain unsolved, there does appear to be a consensus among academicians that the economy-level Tobin's q is generally greater than unity in today's world, which manifests the objective existence of monopoly rents and market distortions. That is, it is unquestionable that the efficiency level derived from empirical approaches is overestimated due to monopoly issues, yet as a consequence of the limitations of statistical methods and insufficient theoretical research, we are still not able to answer the questions of "how much" and "to what extent". To be clear, since market distortions are multi-dimensional issues that are rather complicated to deal with, it is unlikely that these factors can be summed up by any single unidimensional index; thus, it would not be a good idea to devote too much to measuring Tobin's q.

2. **Biases related to capital formation, adjustment cost, and tax evasion:** In assessing dynamic efficiency, the minuend is gross capital formation, which in principle represents immediately available capital

[17] As a precedent, by referring to estimated values of Tobin's average q, Geerolf (2013) has explicitly made attempts to correct for the monopoly bias.

("productive capital") in the production sector. The trouble is, on one hand, the assumption of full depreciation adopted in AMSZ (1989) is empirically irrelevant, since capital is also comprised of other crucial elements, such as vantage capital. On the other hand, it aggravates matters when it comes to the empirical assessment. As numerous studies have revealed, most statistical systems do not properly account for capital depreciation, even those established in the 21st century. Setting the depreciation issue aside, capital formation itself is suspect in the statistical sense for focusing mainly on the supply side, and there is ample evidence indicating that it takes some time for formed capital to be "operative" (Anderson, 1993; Fakin, 1998). In other words, there is time asymmetry between recorded capital formation and actual capital formation (also known as "time adjustment" and "gestation period"). In this case, for economies where the production sector is expanding, accounting capital formation will be above actual capital formation, resulting in understating efficiency.

Current statistical systems provide lackluster assessments of actual capital formation, casting doubts on the conventional observation frequency (annually) widely used by economists. Under the circumstances, we are not certain how much of the capital is left in a certain year (depreciation); more importantly, it is not clear how capital is formed (formation), making it hard to "trace back," thus impairing the reliability of the conventional perpetual inventory methods in measuring capital stocks.

Moreover, the notion of "investment" also includes informal financial services and intermediations. In current statistical standards, ignoring these elements tends to overestimate capital return by 2%-5% of GDP (Bullard and Russell, 1999; Geerolf, 2013; Piketty, 2014), a non-negligible bias in assessing efficiency. Also, some immature statistical systems in developing economies, such as those in China and South Korea, appear to overstate capital formation due to artificial errors[18]. In this sense, although official statistics are not directly employed in our study, our conclusion concerning Chinese inefficiency should be treated cautiously.

[18] According to Xu (2008), Chinese statistical systems record the capital investment of "big projects"—which are generally operated for more than 5 years—as capital formation in the starting year of the project. In this regard, efficiency during economic transitions and expansion periods might be heavily underestimated. There is other evidence indicating that Chinese statistical systems substantially overstated investment because of the understatement of social consumption (Garner and Qiao, 2013; Zhang and Zhu, 2015; Liu et al., 2016). This kind of bias prevailing in less developed countries might not be a coincidence, but rather the consequence of common tricks used by local governments to manipulate GDP accounting—in order to "improve" their political achievements.

In recent years, the increasing problems of "tax evasion" and wealth concealment have become a major factor in understatement of capital returns. The core concept for tax avoidance is the strategy of "transfer pricing;" for example, consider the case of "tax havens." A large multinational company reports most of its profits as earned by its subsidiaries located in the Cayman Islands (tax haven), rather than by its European subsidiaries, which actually produce the profits (where statutory rates are higher). Zucman (2013) reveals that in 2010, about 8% of global private capital was held in tax havens, most of which was owned by Europeans and Americans. Thus, actual efficiency might be relatively higher than the national balance sheets suggest, especially for advanced economies.

Yet, due to the deficiency of statistical methods, correction for these biases remains a difficult enterprise. Note that the defects discussed above are far from enough to cover the overall biases concerning capital formation and its returns. Economists have long been assessing capital stocks based on SNA flows statistics. Only recently have balance sheets recording stocks been gradually embedded in SNA standards (SNA 2008); thus, we must admit that statistical systems today are still in their infancy. As we are entering the era of "Big Data," the center of empirical research should be focused on the improvement of statistical approaches to enrich and supplement our attempts to answer real-world problems, rather than trying to reach definitive conclusions without solid data support.

A.2 Theoretical limitations of ASMZ (1989)

Empirical literature—primarily preoccupied with dynamic efficiencies both in aggregate and at corporate levels—has shown potential explanatory power and the versatility of the cash-flow criterion[19]. In the foregoing sections, we presented meticulous assessments of dynamic efficiencies in both dimensions. An important reason to take a further look at the AMSZ (1989) criterion is that the theoretical basis of the methodology is not without its limitations[20]; as a result, the cash-flow criterion has never put the debate within efficiency literature to rest. In this subsection, we briefly review the existing theoretical limitations of AMSZ (1989), and we look forward to the prospect of efficiency criteria.

As a major critique, the AMSZ (1989) criterion virtually underlies a sufficient condition for (interim) Pareto optimality, for which the required assumptions are far stronger than those for assessing dynamic efficiency (e.g., Zilcha, 1990, 1991; Barbie et al., 2004), although AMSZ's (1989) conclusion remains intact, since Pareto optimality also verifies dynamic efficiency. Empirically, the discrepancy between the nature of the methodology and its interpretation is likely to misrepresent our understanding of real-world efficiency. As several counter-examples in Chattopadhyay (2008) have suggested, there is a possibility that employing the AMSZ (1989) criterion misreads an efficient economy as "inefficient".

In addition, the AMSZ criterion is frequently challenged for its much more demanding assumptions concerning uncertainty, as it requires the "net dividend" to hold positive on all paths (including the future) to make an evaluation—which is almost impossible to test. As a matter of fact, the cash-flow criterion is intrinsically equivalent to many others, besides the fact that other benchmarks (rate-of-return criteria) also confront the same limitation—the interest rate must be evaluated over the "entire horizon." The only distinction is that the AMSZ criterion investigates the "average" dividend, while others focus on marginal product and real interest rates.

[19] Indeed, similar to the rate-of-return criteria, the AMSZ (1989) criterion is not immune to data problems in assessing efficiency.

[20] In fact, the limitations of the cash-flow criterion ex post criticized by others are more or less mentioned in AMSZ (1989), including some of the potential empirical biases, as well as the shortcomings of the mathematical proof.

The critique reminds us of the "Cambridge capital controversy," one of the most influential debates in the 20th century. At the time, the offensive side (UK economists) questioned neo-classical economics, and made it clear that it is impossible to aggregate heterogeneous capital, because the market value of capital is partly determined by its future profits (which is also the focus in the "efficiency criteria debate," noted above), while profits depend on the marginal product of aggregate capital (in the neo-classical concept). Obviously, the up-to-now notion of capital is circular and contradictory; it is illogical to measure something in terms of itself. However, accepting this idea means that it no longer makes sense to talk about the concepts of "macro," "capital returns," and even capital itself, which arbitrarily denies the wisdom gathered by the pioneers, and leaves behind an empty shell in macroeconomics. The defensive side (mostly US economists) openly admitted this shortcoming, but insisted on developing neo-classical economics, which flourished and become the mainstream theories today, while the capital controversy appears as though it had never occurred before. What is the message of this story? Quoting Piketty (2014, p.16): "*Their answers were not always satisfactory, but at least they were asking the right questions*." From a less pedantic viewpoint, similar to the capital controversy, the critique on AMSZ's (1989) definition of "future earnings" is immaterial, and the question is merely a theoretical limitation rather than a reason to turn a blind eye to the advantages and versatilities of the methodology. Economists should never let pretty mathematical problems prevent them from asking the "right questions."

What is the "right question" for the subject? To our mind, the actual limitation of the cash-flow criterion to be perfected is that it needs more bridges to connect the "macro" with the "micro." According to AMSZ (1989), as a typical planners' problem, the proofs followed conventional methods in discussing social welfare; they incorporated an implicit utility function in computing the first order conditions, while the derived propositions literally do not rely on them, because allocations and market prices in equilibrium are *assumed* to satisfy the individual constraints, as well as the first order conditions. That is, as the studies presented by Barbie et al. (2001), Chattopadhyay (2008), Weil (2008) and Schoonbroodt and Tertilt (2010)—which question the underpinnings of AMSZ (1989)—have implied, the cash-flow criterion does not seem to necessarily obtain its most essential micro foundations—the generalities of consumer preferences, intergenerational risk-sharing, and existing transfer mechanisms. Nevertheless, one might argue that the traditional

concept of dynamic efficiency has long been focused on macroscopic manifestations (Zilcha, 1990, 1991), why is it necessary to sketch the microcosmic features?

Some stylized facts are: the world economy is comprised of government, corporate sectors, and individuals (households); in a sense, it is of equal importance to understand the efficiency implication in household levels. In fact, individuals play substantially important roles in the real-world economy, and most enterprises are privately or collectively owned. All signs are that aggregate capital today consists almost entirely of private capital, if aggregate wealth is divided into public wealth and private wealth (Piketty, 2014). All in all, the reason people choose to hold capital matters.

As Weil (2008, p.11) puts it, "*to cure inefficiency in low interest rate, Saumuelson economies*[21]*, one needs a way to implement perpetual transfer from young to old that will reduce the desire of consumers to transfer goods from youth the old age (remember that it is that desire that drives down the interest rate).* " In a nutshell, to fundamentally investigate the inefficiency which mostly comes from over-savings, a basic approach is to re-consider the subject from the individual standpoint. In an informative line of literature, Feldstein (1985) and Fischer (2017) infer that consumers should save and invest more if the interest rate overwhelms the *marginal substitution rate* between present and future consumption. What the inference actually stresses is the fact that individuals as market participants do not invest just for profits, but rather invest to promote life-time utility as a household per se. Households behave differently from corporations and the aggregate economy in many ways; they are more complicated and their incentives are also driven by factors that cancel out at the aggregate level (such as transfer mechanisms), and by those regarded as "unconventional" elements, such as preferences, time discount rates, and cultural features.

Take the Chinese economy as an example, plausible and empirically relevant; all signs are that Chinese inefficiency owes much to the extensive investment patterns. However, overstating the aggregate behaviors blinds us to the details; there is ample evidence on Chinese saving behaviors that the main determinants for arguably the highest saving rates are the cultural features—such as the bequest motives and the

[21] "*Saumuelson economies"* refers to economies where the interest rate falls below the growth rate (dynamically inefficient). On the other hand, dynamically efficient ($r > g$) is a more conventional and "classical" feature embedded in most macroeconomic models with standard welfare properties.

"patience" (lower time preference)—rather than conventional factors, like economic growth and demographic structures, which cannot distinguish China from other emerging economies with lower saving rates.

To a certain extent, the characterization of aggregate-level efficiency cannot provide complete answers; we need a further look at the "right questions," to which previous literature gave little attention. These questions are: what observable characteristics signal efficiency for household investment? Can we use the efficiency criterion to guide household decisions? Does dynamic efficiency lead to income inequality? We will focus on these subjects in the future, and we look forward to new breakthroughs.