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Withstanding the Great Recession like China*

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Abstract

The Great Recession was characterized by two related phenomena: (i) a jobless recovery and (ii) a permanent drop in aggregate output. Data show that the United States, Europe, and even countries with lesser ties to the international financial system have suffered large permanent losses in aggregate output and employment since the financial crisis, despite unprecedented monetary injections. However, the symptoms of the Great Recession were not observed in China, despite a 45% permanent drop in its exports—one of the largest trade collapses in world history since the Great Depression. Our empirical analysis shows that China's success in escaping the Great Recession is attributable to its bold and powerful 4 trillion renminbi stimulus package launched in late 2008. We study the precise channels through which the stimulus programs work in China. We also construct a simple model to rationalize the dramatically different impacts of stimulus programs across countries.

Keywords: Coordination Failure, Deflation, Fiscal Multiplier, Great Recession, Jobless Recovery, Liquidity Trap, State Capitalism, Quantitative Easing, Chinese Economy.

JEL Codes: E32, E58, E62, H12, H50.

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1 Introduction

Central banks and governments around the world reacted with unprecedented stimulus programs to combat the 2007-2008 global financial crisis. It was a time when bold actions and extraordinary measures were needed to prevent another Great Depression. According to the International Monetary Fund (IMF, 2009a, 2009b), the initial stimulus packages in 2008 through 2010 were as large as 5% of gross domestic product (GDP) in the United States and China, while similar-sized packages were also announced and implemented by other industrial countries.

However, the performances and effects of stimulus programs vary greatly across countries. In particular, China was the first major economy to recover from the financial tsunami. GDP growth in China rebounded to its double-digit pre-crisis rate in late 2009 (at 11.4% per year), less than one year after unveiling its stimulus package, and it rose significantly above its long-run average in the first quarter of 2010 (at 12.2% per year). In contrast, GDP growth in the United states and Europe had not recovered to pre-crisis rates as of late 2011 even though they reacted to the crisis earlier than China. Most strikingly, GDP levels in these developed countries have declined permanently since 2008 by as much as 10% below their respective long-run trends, despite more than 5 years of continuing quantitative easing after the crisis. China's GDP level, however, fully rebounded to its long-run trend in early 2010 without appealing to unconventional monetary policies. Also, total industrial production in China nearly doubled between 2007 and 2013 despite the crisis and an extremely weak international demand for Chinese goods, whereas the United States has experienced zero growth in industrial production and that in the European Union and Japan has declined by 9.3% and 17.1%, respectively. No wonder China's economic growth contributed 50% of global GDP growth during the crisis period (IMF, 2010), even though its income level accounted for less than 10% of world GDP and its total exports have remained 45% below trend since the crisis.

It thus appears that in the wake of the crisis and its aftermath, China has proved structurally and macroeconomically much stronger than developed countries in withstanding the global Great Recession. Therefore, one cannot help but wonder: What is special about China and its stimulus programs?

Obviously, China was growing much faster than Western countries before the crisis. But simply growing faster before the crisis does not make China special in withstanding the crisis (see the detailed analysis in Section 2). Many Southeast Asian countries, such as Malaysia and Thailand, were growing rapidly before the Asian financial crisis in 1997, but all plunged into deep recessions (with negative growth rates) immediately after the Asian crisis.

It is also obvious that China's financial sector is not yet fully integrated into the global financial system, which may explain China's rapid recovery. However, several major developing countries, such as Russia and South Africa, were equally disengaged from the global financial system in terms of toxic financial assets and banking scandals, yet these economies suffered large permanent losses in GDP just like in the United States and Europe (see Section 2). A key reason for this loss is the collapse of exports: Like China, these developing economies all suffered a heavy blow to their export sectors.

As did many countries, the Chinese government injected massive amounts of money into its banking system in late 2008 and 2009. Thanks to sharp increases in aggregate investment immediately following the money injection, the Chinese economy rebounded quickly to its pre-crisis level and successfully prevented a possible Great Recession and economic collapse during China's critical period of economic transition and industrialization. Consequently, China emerged after the crisis as the world's number one manufacturing powerhouse and the only significant engine of global economic growth.

How could Chinese banks find borrowers to lend a massive amount of credit so quickly to jump-start a fading economy while the U.S. and European banks were incapable of doing so?[1] Why were Chinese firms willing to borrow to invest when both domestic and international demand collapsed and the future appeared so gloomy and uncertain?

In this paper, we argue that the key to China's success is not so much that China had a double-digit growth rate before the crisis, or because Chinese banks are more solvent or more detached from the global financial system than others, but rather because China implemented bold, decisive fiscal stimulus programs that no other major nations dared to adopt. In particular, the Chinese government cleverly used its state-owned enterprises (SOEs) as a *fiscal instrument* to implement its aggressive stimulus programs in 2009, consistent with the very Keynesian notion of aggregate demand management through increased government spending and the fiscal multiplier principle.

The empirical facts provided in Section 2 show that during the 2009 stimulus period

[1] The 2007-2008 global financial collapse resulted in central banks around the world taking unprecedented action to combat weak aggregate demand in both consumption and investment. In the United States, The Federal Reserve Bank implemented a zero-interest rate policy, slashing the federal funds rate down to the range of 0-0.25 percent beginning late 2008. It was seven years later before the Fed raised rates by just 25 basis point. Today the fed funds rate stands at 1.68%, still at a historical low level. However, many industrial nations have implemented negative interest rate policies and such policies remain effective today (see, e.g., Reinbold and Wen, 2017).

when Chinese total exports collapsed, SOEs substantially expanded their credit borrowing and fixed investment. A rapid revival of private investment and GDP growth soon followed. Although the relative size of the SOE sector has declined sharply since the market-oriented reform in 1978, it still accounted for 20% of total industrial employment in 2008 when the world financial crisis started. The SOEs' actions were thus able to generate a significant countercyclical force against the meltdown of total exports and aggregate demand.

Therefore, SOEs in China acted very much like an automatic fiscal stabilizer (or market coordinator) for the Chinese economy: When the economy is in recession, the SOEs consent to boosting production and investment spending; but in normal times, they are supposed to be profit maximizers just like privately owned enterprises (POEs), albeit possibly less efficient and profitable. This ability of the public sector to move countercyclically helped insulate the Chinese economy from the global financial tsunami during the crisis period. Ex post, most of the public sector's losses resulting from inventory buildups and inefficient investment in 2009 have been repaid by the consequent continued booming economy.[2] Alternatively, had the SOEs not acted swiftly, the entire economy might have been crushed by the trade collapse and the consequent costs might have been very dear.[3]

By comparing China's economic performance during the crisis with that in the West, the effect of the stimulus package in China looks like a dream outcome of any Keynesian fiscal policy that the industrial countries' large-scale asset purchase programs had hoped to achieve. Unfortunately, the same sort of boosting effect did not happen in Western countries despite more mature and better-functioning markets and institutions. We argue that the key difference is that China's stimulus programs are fiscal in nature, whereas those in Western countries are almost purely monetary.[4]

[2] Although China's projected long-term GDP growth rate has fallen from 10% to around 7.5% or even lower since 2012, this is largely accounted for by the country's deliberate macro policy for a structural change of its growth model. Its central government acted swiftly to curtail public investment spending and luxury goods consumption in the wake of rapidly rising labor costs, corruption, and environmental problems. The structural adjustment aims to make China's economic growth more sustainable in the longer run.

[3] Our arguments in this paper do not necessarily imply that SOEs *per se* are preferable. Rather, the crucial lesson learned from China is that fiscal policies matter while purely monetary policies do not in eliminating a coordination-failure crisis.

[4] The United States adopted both fiscal and monetary stimulus programs. Its fiscal package included the Economic Stimulus Act (ESA) of 2008 and the American Recovery and Reinvestment Act (ARRA) of 2009. The ESA was $152 billion (about 1 percent of GDP) and was used mainly to provide temporary tax relief for individuals and businesses. The ARRA totaled about $862 billion and was spread over 10 years (about 0.5 percent of GDP per year). The actual increase in government purchases of goods and services was even smaller. Using data from the Bureau of Economic Analysis, Cogan and Taylor (2010) found that the government purchases through the 2nd quarter of 2010 has been only 2 percent of the ARRA (about $17 billion). They blame governments at the state and local levels for the failure to increase their purchases of goods and services (instead they reduced borrowing and increased transfer payments). Thus, the U.S. fiscal stimulus packages were effectively very small, in sharp contrast to its monetary stimulus packages: Total asset purchases were 8.7 percent of GDP between 2008 and 2010 and this value increased to about 22 percent

This paper also provides a theoretical model to rationalize the differential impacts of fiscal and monetary stimulus programs in China and other countries during the financial crisis. Our model explains not only the two symptoms of the Great Recession, but also the key features of the Great Depression in the 1930s. Our model suggests that the Roosevelt New Deal policies implemented in 1933-34 and large military spending both before and during World War II may have played a pivotal role in the U.S. economy's full recovery in the 1940s, in terms of both growth rate and GDP level.

Our model is in spirit closely related to the model of Eggertsson and Krugman (EK, 2012). EK provide a prototype dynamic stochastic general equilibrium (DSGE) model with incomplete financial markets and debt constraints to show that a sudden reduction in debt limits triggered by a credit crunch can explain the Great Depression and some long-standing puzzles, such as debt deflation and the liquidity trap, that often render monetary policies ineffective. In the EK model, because consumption demand depends on debt limits, a debt crisis can depress aggregate demand. Since debts are set in nominal terms, when the aggregate price falls, the real burden of the debt increases, further depressing consumption demand. Moving the economy away from the recessionary spiral requires a sharp reduction in the real interest rate to stimulate aggregate demand. However, if the nominal rate is already at its zero lower bound, further reduction in the real rate by expansionary monetary policies becomes impossible because of deflation, thus making fiscal policies the best alternative to reviving aggregate demand.[5]

Our model complements the EK model in several important aspects: (i) Their model focuses on debts, whereas we focus on fixed production costs as an alternative mechanism for generating the liquidity trap and market-coordination failures. The need for an alternative mechanism is obvious because not all recessions are related to debt crises (such as the one experienced in China and Russia in 2008-09). (ii) In the EK model, recessions and underemployment are highly transitory phenomena; they occur only after a sufficiently large exogenous shock to the debt limit and do not persist longer than the duration of the shocks. In contrast, recessions and underemployment in our model can be highly persistent because market-coordination failure is a Nash equilibrium in the model. Thus, our model can shed light on jobless recoveries and the persistence of recessions without relying on large exogenous and permanent shocks to debt limits, technologies, or preferences. (iii) EK do not model asset prices and capital accumulation; therefore, their model is silent on the long

in 2013 (see, e.g., Fawley and Neely, 2013).

[5]Christiano, Eichenbaum and Rebelo (2011) also argue that the government spending multiplier can be substantially larger than one at the zero lower bound.

standing puzzle of high correlation between asset price crashes and high unemployment (as well as weak investment demand), which we argue are key for Keynes's (1936) analysis of recessions and economic recoveries based on firms' animal spirits.[6] (iv) Finally, we provide an empirical case study for the effectiveness of fiscal stimulus programs in China during the worldwide Great Recession.

Most economic activities involve fixed costs and such costs are substantial. For example, admistrative costs and sales expenses alone accounted for more than 10% of firms' revenues betwen 2001 and 2010 in China, based on data of nearly 2000 listed firms.[7] Indeed, fixed costs are perhaps one of the most important sources of non-convexities and increasing returns to scale, as well as the most important rationale for the existence of markups and firms' motives for expanding market shares in a competitive world. Yet, an important but under-appreciated economic property and macroeconomic implication of fixed costs is that it can lead to market-coordination failures and multiple equilibria.

Using a simple dynamic general equilibrium model, we show that requiring at least some firms at some stages to pay for fixed costs of production is a surprisingly powerful assumption. Equilibrium with market-coordination failures, price and wage deflations, stock market crashes, the liquidity trap, and a rationale for the positive role of fiscal policies in economic crisis all emerge naturally from the model.

The intuition behind our results is simple. With fixed production costs, private firms may opt to shut down production when anticipated prices (revenues) are too low to cover the fixed operation costs, thus triggering a reduction in investment and labor demand. In particular, pessimistic expectations of future demand will induce firms to postpone investment, thus depressing demand for capital goods and forcing capital-goods producers to cut employment. A reduction in employment will in turn depress wages and weaken aggregate consumption demand, which leads to a fall in aggregate prices, thus rectifying the firms' initial pessimistic belief. At the same time, with anticipated low profits and dividends, firms' equity value in the stock market will crash. Once asset returns start to crumble, savers (consumers) opt to hoard cash instead of spending it. Monetary policies then become ineffective in boosting aggregate prices (demand). However, if there exist countercyclical fiscal instruments, such as SOEs that can lean against the wind by committing to produce in recessions even with negative profits, dramatic falls in aggregate demand and prices can be stopped. Consequently, expansionary monetary policy can start working to push up commodity and asset prices to restore the

[6] See, e.g., Farmer (2012, 2013).

[7] See Section 3 for details.

full-employment equilibrium, thanks to the initiative of counter-cyclical fiscal policies.

Thus, viewed through the lens of our model, the stubborn persistence of un(der)employment (or the jobless recoveries) in the United States and Europe during the many years after the financial crisis are attributable to market-coordination failures and the inability of their governments to implement aggressive expansionary fiscal policies. In particular, our model suggests that monetary policies alone are insufficient to end the Great Recession, thus explaining why so many European nations even today (10 years after the crisis) are still engaged in low or even negative nominal interest rates (see Dong and Wen, 2017; Reinbold and Wen, 2017).

The rest of the paper is organized as follows. Section 2 provides an empirical case study of the effects of China's stimulus package in combating the crisis. These empirical facts suggest that SOEs in China were the government's *fiscal instrument* to implement its unprecedented stimulus packages and the key for China's recovery. Sections 3 and 4 estimate the size of fixed costs in China and build simple dynamic general equilibrium models with fixed costs to generate coordination failures and explain why purely monetary policies (such as the large-scale asset purchase programs implemented by the Japanese government in the 1990s and the U.S. Federal Reserve since 2008) can fail to address a large crisis. Section 5 introduces SOEs (as an example of fiscal instruments) into the benchmark model and uses them to explain the Chinese experience. Section 6 concludes with remarks for further research.

2 Empirical Analyses

2.1 Growth Rate Recovery vs. Level Recovery

Even a temporary drop in the rate of output growth can imply a permanent loss in the output level. Thus, a full recovery in the growth rate of output is not the same thing as a full recovery in its level. Therefore, when a recession has ended as defined by the National Bureau of Economic Research (NBER), it by no means implies that the output level has fully recovered.[8] In other words, to avoid a jobless recovery or a permanent below-trend output level after a recession, an economy needs a temporary boost in growth rate, or a "growth-overshooting" period in which the growth rate of output exceeds its average long-run rate.

Consider two hypothetical output levels of two countries, say China (red solid line in

[8]Recession is defined by the NBER as at least two consecutive quarters of negative growth in aggregate output. Hence, the news media consider a recession to be ended as soon as the growth rate turns positive and remains positive thereafter.

Figure 1A) and the United States (blue solid line in Figure 1A), with the former growing faster than the latter. The slopes of the two solid lines in Figure 1A represent the growth rate of output in the two countries; these are recaptured in Figure 1B (i.e., the two lines in Figure 1B are simply the respective slopes of the two solid lines in Figure 1A). Both countries experienced an unexpected recession in period t, at which point their respective growth rate fall below their pre-crisis (long-run) growth rates—say China's growth rate falls from 10% to 6% and the U.S. growth rate falls from 2% to -2%, so both countries suffered a 4-percentage-point drop in growth rate. Also, both countries are able to resume (recover) their respective pre-crisis growth after the recession ends in period $t+1$. However, a critical difference is that the growth rate of the United States recovers through a V-shaped growth path (blue line in Figure 1B), whereas that in China recovers through an inverted Z-shaped growth path (red line in Figure 1B). That is, China's growth rate overshoots its pre-crisis growth rate temporarily during the recovery period and reaches a rate of 14% per year in period $t+1$ before resuming its 10% per year long-run rate after $t+1$. This subtle difference in the pattern of growth rate implies that the GDP level in China is able to fully revert to its long-run path (red solid line A in Figure 1A), whereas the GDP level in the United States becomes permanently lower than its original long-run path (blue solid line B in Figure 1A).

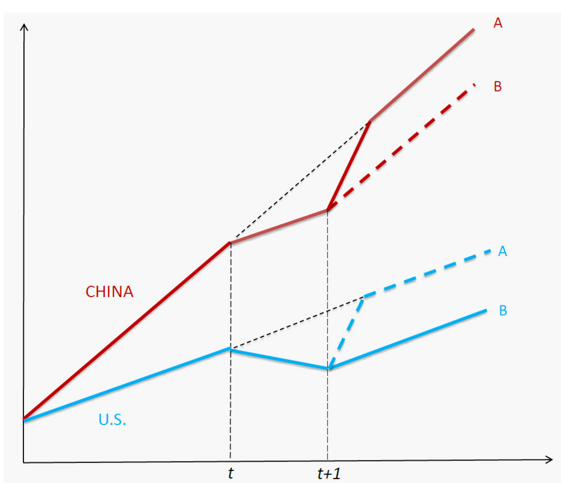


Figure 1A. Hypothetical GDP Levels.

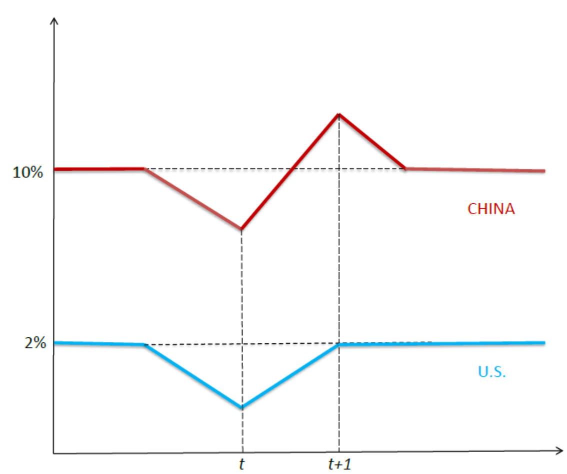


Figure 1B. Hypothetical Growth Rates.

Since output is produced by labor, a permanent loss in GDP level implies a permanently lower employment rate—or equivalently, a "jobless recovery." Thus, the two panels in Figure 1 illustrate two differences, one important and one trivial, between the U.S. experience and the Chinese experience: (i) The trivial difference is that the United States has a negative growth rate of -2% during the recession period, while China has a positive growth rate of 6% during the same period. But this difference is meaningless with regard to whether a country will experience a jobless recovery. (ii) The important difference is that the United States has taken path B (solid blue line) in Figure 1A without undergoing the Z-shaped growth-correction period. The United States could have followed a different path after the recession (as indicated by the dashed blue line A in Figure 1A), and China could have followed a jobless recovery path (as indicated by the dashed red line B in Figure 1A).

Therefore, what is important for a full recovery in the GDP level is that the economy's temporary drop in growth rate in a recession needs to be fully compensated by a temporary above-average growth rate during the recovery period, so as to fully offset the permanent loss of output caused by the slower growth in the recession period. In the figures, we assumed that China managed to temporarily overshoot its long-run growth rate during the recovery period, whereas the United States only managed to resume its long-run growth rate without such growth overshooting. Consequently, even though both countries eventually recovered their respective long-run *growth rate* after the crisis (as Figure 1B shows), only China was able to return to its long-run *output level* (the solid red line A in Figure 1A), while the United States resumed only its long-run growth rate but not its GDP level (as indicated by the solid blue line B in Figure 1A). The following subsections document that this scenario is exactly what happened in the two countries during the recent financial crisis.

2.2 Effectiveness of Stimulus Packages

As noted in the literature (e.g., IMF, 2010; International Institute for Labour Studies, 2011; Aiginger, 2011), with similar magnitude and timing the stimulus packages were much more effective in China in boosting economic performances than in the United States and Europe. The most apparent evidence comes from the direct comparison of real GDP in China with its U.S. and European Union (EU) counterparts before and after the crisis.

Figure 2 shows the real log GDP levels for the three economies (solid vertical bars in top panels) and the projected GDP long-run trends (dashed lines in top panels), which are estimated based on each economy's average growth rate in the pre-crisis period (i.e., between 1998 and 2007).[9] The lower panels in Figure 2 depict the year-over-year growth

[9] The picture is very similar regardless of how the pre-crisis average growth is estimated and the sample sizes. For example, see Wen (2013) for an estimate of the permanent GDP losses in the United States based on much longer post-war data samples.

rate in quarterly data (solid lines) and the average growth rate for the pre-crisis period (dashed horizontal lines).

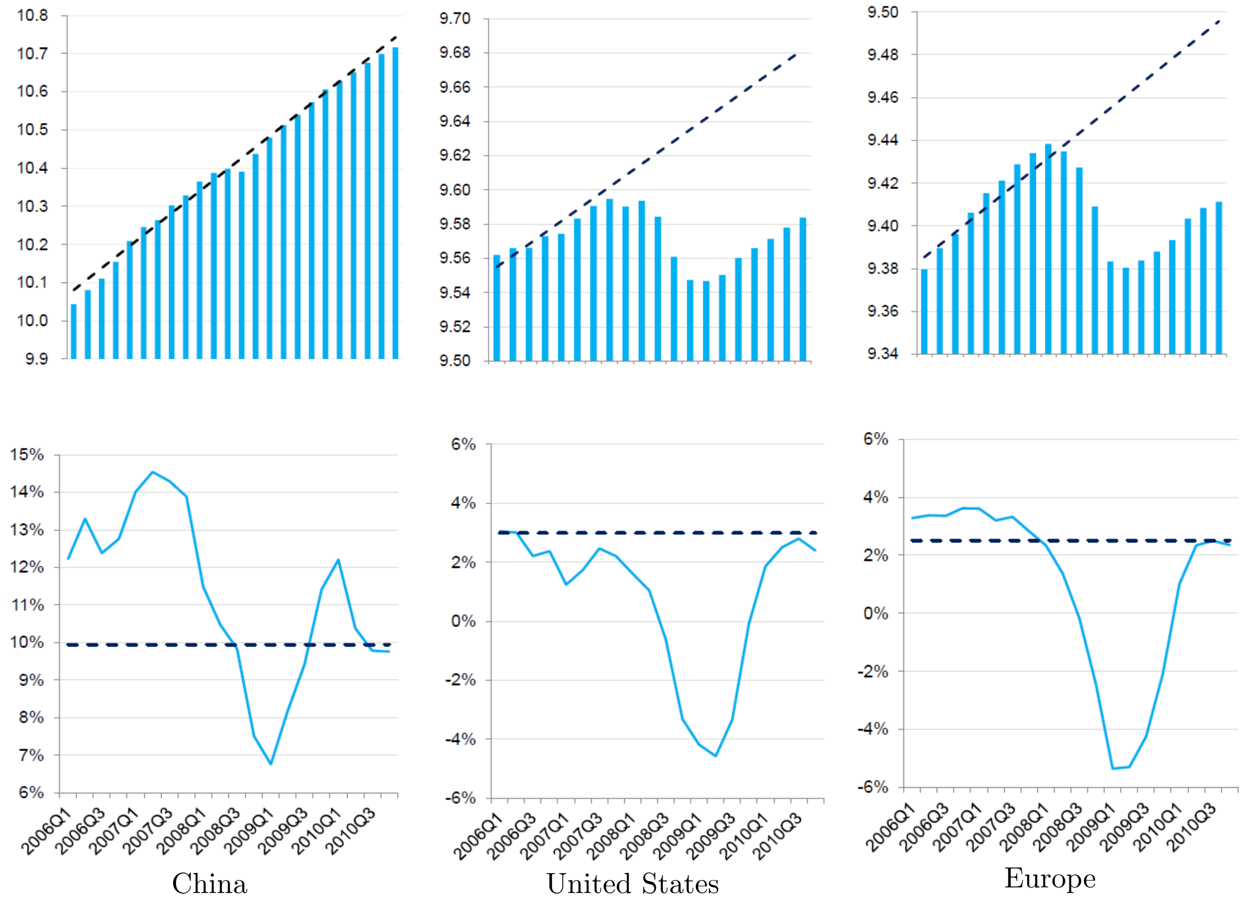


Figure 2. Log GDP Level (top row) and Growth Rate (bottom row).

The figure shows that China did not suffer a permanent loss of GDP from the financial crisis (top-left window) even though China's growth rate was substantially affected by the financial crisis (lower-left window). China's pre-crisis long-run average growth rate was about 10% per year (dashed black lines in the upper-left and lower-left windows). The actual growth rate (solid blue line in the lower-left window) was substantially above the average growth rate for several quarters before the financial crisis, but it started to fall dramatically below this long-run rate in 2008:Q3 and did not stop falling until it hit the rate of 6.6% per year in 2009:Q1. Consequently, China's growth rate dropped by 7.4 percentage points in total during the crisis period, from about 14% per year in 2008:Q1 to the 6.6% trough in 2009:Q1. However, China experienced a growth-correction period in late 2009 and early

2010 with an inverted Z-shaped growth path: It started to recover rapidly with a growth rate of 8.2% in 2009:Q2, 9.4% in 2009:Q3, and then overshot its 10% per year long-run rate in consecutive quarters (2009:Q4, 2010:Q1, and 2010:Q2) with a peak growth of 12.2% per year in 2010:Q1. After the growth-correction period, China returned to its long-run growth rate of about 10% per year in 2010:Q4. As a consequence of the temporary growth correction (over-shooting) during the recovery period, China's real GDP fluctuated only temporarily around its long-run path during the crisis and did not suffer any permanent losses after the crisis.[10]

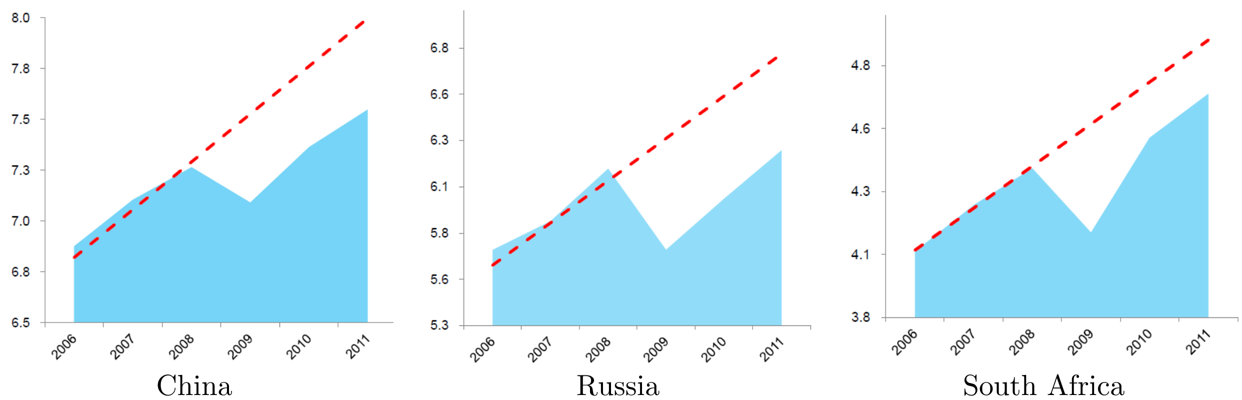


Figure 3. Real (log) Exports

In sharp contrast, real GDP levels in the United States (top-middle window in Figure 2) and Europe (top-right window) appeared to suffer permanent losses after the financial crisis, as indicated by the large and seemingly permanent gap between the actual GDP level (the solid bars) and the potential trend (the dashed line) in the top-row windows in Figure 2. The output gap is more than 10% of the potential GDP level for both economies. The lower-row windows in Figure 2 show the reason: Neither economy underwent growth correction (over-shooting) during the recovery period after their respective growth rates dropped into negative territory in 2009. Even though the growth rates for both economies eventually rebounded to their respective pre-crisis rates by 2010:Q3 through a V-shaped growth path, they never

[10]The inverted Z-shaped growth-correction pattern is even more evident and striking if we study annualized quarter-to-quarter growth rates: The Chinese economy slowed significantly in 2008:Q4 with a growth rate of only 4.4% per year, compared with 14.5% in 2008:Q2 and 9.1% in 2008:Q3. The growth rate dropped even further in 2009:Q1 to a rate of -3.2% per year. However, with the effects of the stimulus package taking place, the quarter-to-quarter growth rate jumped up to 18.7% in 2009:Q2 and 16.9% in 2009:Q3, overshooting the long-run rate by 8.7 and 6.9 percentage points respectively. It also remained about 1 to 3 percentage points above the long-run average rate for 4 more consecutive quarters between 2009:Q3 and 2010:Q3 before returning to its long-run rate in 2010:Q4.

overshot or temporarily rose above their pre-crisis rates in the recovery period. This means that the output losses caused by the slower growth rate during the financial crisis have not been fully compensated by a higher-than-normal growth rate since the crisis, leading to the permanently lower level of GDP shown in the top-middle and top-right windows in Figure 2.

One may argue that China was not hit as hard by the financial crisis as Western countries because China's financial system was not well entangled with the international financial system. However, China's economy was much less stable than those of industrial countries and depended primarily on exports for growth (in addition to domestic investment). China's total exports suffered significantly with negative growth for several quarters between 2008 and 2010: The growth rate shrank by 9 percentage points in 2008 (from 26% per year in 2007 to 17% per year in 2008) and by an additional 33 percentage points in 2009 (reaching a negative growth rate of -16% per year in that year). Even though the growth rate of total exports eventually recovered to its pre-crisis rate in 2010, China's trade sector never experienced a growth-correction (over-shooting) period. As a result, total exports in China have remained about 45% below their pre-crisis trend since 2009 (left panel in Figure 3, where the dashed line is projection based on the pre-crisis growth trend as in Figure 2). Since total exports accounted for 38% of China's GDP in early 2007, everything else equal, a permanent 45% drop in total exports would have reduced China's GDP level permanently by 17% below its potential trend.[11]

An important feature of the financial crisis is that it affected not only countries with close financial links to the United States but also countries without, such as countries that depend heavily on world trade. For example, member countries of the BRICS, such as Russia and South Africa, though not as closely linked to the U.S. financial system as Europe but have a relatively large export sector (like China), suffered large permanent losses in GDP. Specifically, in 2007, the share of exports in GDP was 30% for Russia and 31% for South Africa (compared with 38% in China). The financial crisis caused a 49% permanent drop in total exports in Russia and a 19% permanent drop in South Africa (middle and right panels in Figure 3). Consequently, these two countries also suffered large permanent GDP losses—the real GDP level has dropped 23% below potential trend for Russia and 8% for South Africa (top panels in Figure 4). The bottom panels in Figure 4 show the reason: Similar to the developed countries, neither Russia or South Africa underwent a growth-correction

[11] This value would be even higher if there was a multiplier effect (see below).

recovery period in GDP after the crisis.

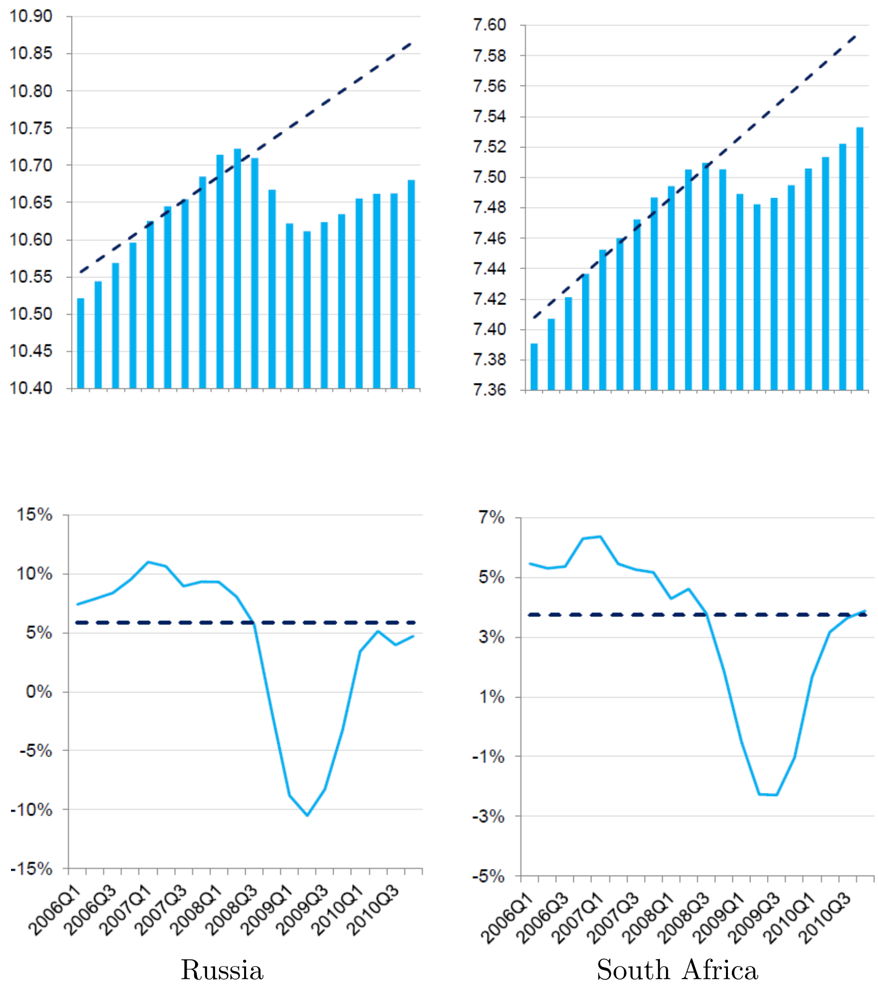


Figure 4. Log GDP Level (top row) and Growth Rate (lower row).

The economic performances in BRICS countries during the financial crisis are consistent with the prediction of the textbook Keynesian multiplier theory. In 2007, the share of total exports in GDP was 13% for Brazil, 30% for Russia, 20% for India, 38% for China, and 31% for South Africa. All of these countries have suffered sharp declines in real exports since the crisis—by 2011, real exports in these countries still stood at 17%, 49%, 6.5%, 44% and 19%, respectively, below their respective long-run trends. Suppose the demand multiplier is 1.5 for each country, then without government interventions such sharp and permanent declines in exports would have caused a permanent drop in the GDP level of 3.4% for Brazil, 22.3% for Russia, 2% for India, 25.3% for China, and 9% for South Africa. In fact, the actual GDP gap by the end of 2011 was 2.9% in Brazil, 23.1% in Russia, 0.8% in India, 2.7% in China, and 8.3% in South Africa. Therefore, except for China, the predicted GDP gaps based on the multiplier principle are consistent with the actual estimated GDP gaps (Table 1).

Table 1. Export and GDP Gaps in BRICS Countries

Country	$\frac{\text{Export}}{\text{GDP}}$ Ratio (2007)	Export Gap (2011)	GDP Gap (2011)	*Predicted* GDP Gap* (2011)
Brazil	13.36%	17.2%	2.9%	3.4%
Russia	30.16%	49.2%	23.1%	22.3%
India	20.45%	6.5%	0.8%	2.0%
China	38.3%	44%	2.7%	25.3%
Souch Africa	31.48%	19%	8.3%	9.0%

*Note: Predicted GDP gap is calculated as $1.5\times(\frac{\text{Export}}{\text{GDP}}$ ratio$)\times$(Export gap).

Figure 5 visualizes the information in Table 1. It shows that the predicted GDP gaps based on the multiplier principle match the data quite well for Brazil, Russia, India, and South Africa. The predicted gap (horizontal axes) and the actual gap (vertical axes) form almost a 45-degree line for these countries, suggesting that even without tight financial links to the United States, a developing country's decline in GDP after the crisis is closely linked to its decline in exports multiplied by the initial share of exports in GDP before the crisis. The multiplier of 1.5 simply suggests that the demand-side effect of trade collapse is amplified universally across these developing countries with a similar multiplier.

China is a surprising outlier in Figure 5. The multiplier principle predicts that China's GDP level would be 25% below potential trend, given its large (nearly 40%) export share in GDP and nearly 45% permanent decline in total exports (i.e., $0.38 \times 0.44 \times 1.5 = 0.25$). However, the actual GDP level in China was only slightly (-2.7%) below trend in 2011, suggesting that China's aggregate output level had essentially completely recovered from the crisis and was back on its long-run trend despite the catastrophic 44% permanent drop in export demand.

Some may argue that because China was growing so much faster than the United States and the other BRICS countries before the crisis, a temporarily slower growth matters much less for China than for the other nations. This view is incorrect, as already shown in Figures 1A and 1B. Regardless of how fast China was growing before the crisis, it still could have suffered large permanent losses in GDP level had the growth-correction recovery period in 2009-10 not occurred.

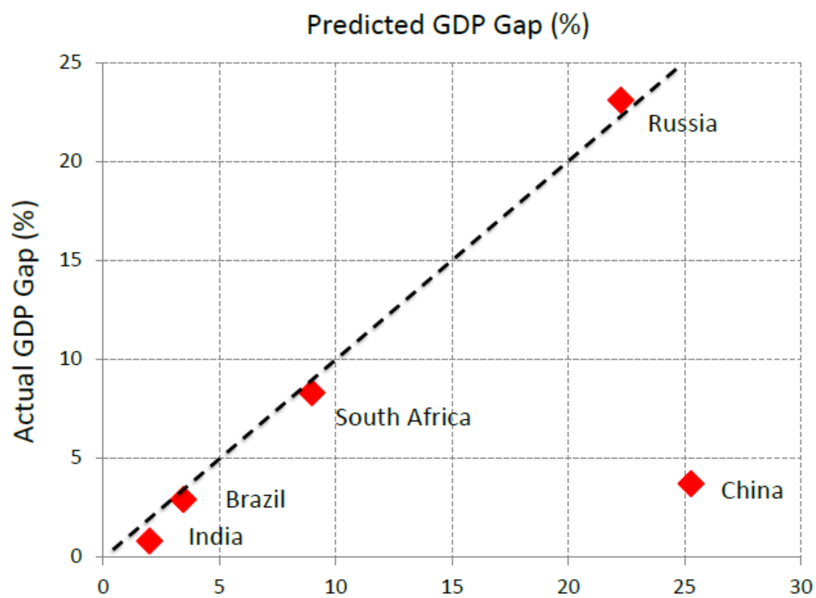


Figure 5. Export-Driven GDP Gap

Therefore, the only important and relevant question is "why did a growth-correction (or growth-overshooting) recovery period occur in China but not in the United States, Europe, Russia, and South Africa?" Table 2 sheds some light on this question by looking at the decomposed contributions of the four major components of aggregate demand (private consumption, government spending, aggregate fixed investment of private and public sectors, and net exports) to GDP growth in China, the United States, and Europe.

Table 2 reveals that a large surge in total fixed investment in 2009 was the pillar for sustaining China's phenomenal GDP growth and the growth correction during its recovery period. The Chinese government announced a 4 trillion RMB (US \$586 billion) stimulus package in November 2008 and implemented it immediately in December 2008 and throughout 2009. Directly after the unveiling of the stimulus package, the year-over-year growth rate of fixed asset investment in China jumped 9 percentage points from 2008:Q4 to 2009:Q1 and accelerated further to 38% per year in 2009:Q2. So for the entire year of 2009 the yearly growth rate of fixed investment reached 30.9%—almost twice as high as its average pre-crisis growth rate. As a result, gross fixed capital formation contributed a phenomenal 8.06 percentage points to China's 9.1% per year real GDP growth in 2009. In other words, investment alone was responsible for nearly 90% of the robust GDP growth in 2009 when Chinese exports collapsed and shrank by nearly 45%.

Table 2. Percentage-Point Contribution to Real GDP Growth in 2009

Component	China	United States	Europe
Private consumption	3.44 (37.8%)	-1.06 (−37.9%)	-0.87 (−20%)
Government consumption	1.14 (12.5%)	0.64 (22.9%)	0.46 (10.6%)
Total fixed investment	8.06 (88.6%)	-3.52 (−125.7%)	-3.77 (−87.1%)
Net exports	-3.54 (−38.9%)	1.14 (40.7%)	-0.15 (−3.5%)
Total GDP growth	9.10 (100%)	-2.80 (100%)	-4.33 (100%)

In contrast, total private investment in the United States collapsed in 2009 with a negative growth rate of -21.62%, further down from -9.38% per year in 2008, making it the largest drop since the end of WWII. The sharp drop in investment lowered U.S. GDP growth by 3.52 percentage points in 2009, contributing more than 125% of the negative GDP growth in that year, far larger than the negative contribution from private consumption. In fact, weak investment demand was not only the culprit in the Great Recession but also key in the U.S. jobless recovery in the post-crisis period. The situation in Europe was quite similar: The sharp decline in fixed investment was the single most important contributor to Europe's negative GDP growth during the crisis period, representing more than 87% of the negative income growth in 2009, which was more than 4 times the negative contribution from private consumption (see Table 2).

Therefore, the effectiveness of monetary policy was dramatically different between China and the industrial economies. As the first central bank reacting to the financial crisis, the Fed started massive monetary injection as early as 2008:Q3. The total monetary base has more than doubled within two years, making it the single most aggressive monetary injection in U.S. history. In addition, the Fed conducted unconventional monetary policies through large-scale asset purchases to lower the longer-term interest rate. By 2013, total long-term asset purchases reached $3.5 trillion, equivalent to 21% of U.S. GDP. However, banks responded by increasing excess reserves rather than increasing bank loans, and the public responded with a substantial flight to liquidity in the form of currency and demand deposits. So the dramatic monetary easing did not translate into increases in credit expansion in the United States; instead, the real growth rate of outstanding loan balances was negative in 2009 and 2010. As a result, the growth rate of credit lending was 15 percentage points below its pre-crisis average level despite the unprecedented monetary injections (left panel in Figure 6). Europe faced a similar dilemma (middle panel in Figure 6), although the magnitudes of both monetary injection and loan balance shrinkage were relatively smaller than those in the United States.

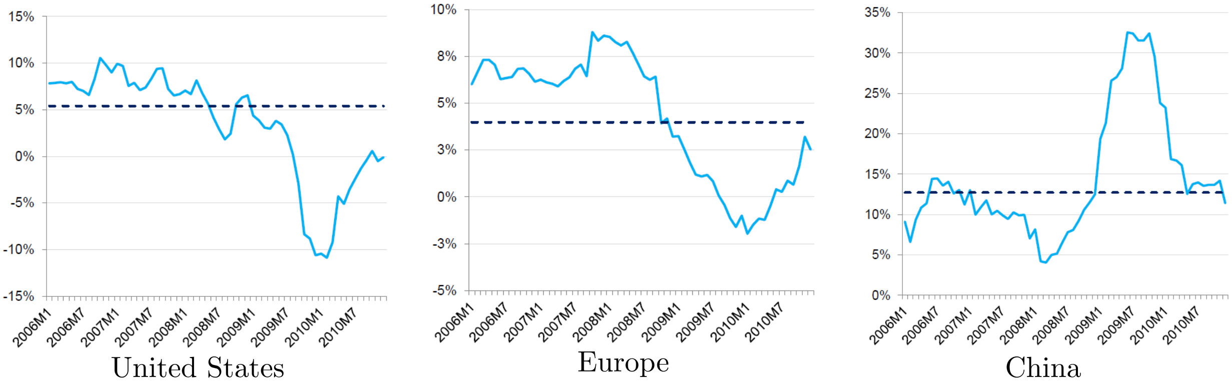


Figure 6. Outstanding Loan Growth Before and During the Financial Crisis

However, the situation in China was quite different. Following the lead of the Federal Reserve, the People's Bank of China (PBOC) started to expand money supply by the end of 2008. The monetary injection immediately led to sharp increases in credit lending at nearly the same speed and magnitude. Despite positive inflation, the real growth rate of outstanding loan balances increased from 5% per year in mid-2008 to 12.49% per year in December 2008, and further up to 32.5% per year in June 2009—a historical peak during the entire reform era since 1978 (right panel in Figure 6).

As a result of the credit boom in China, total industrial production nearly doubled between 2007 and 2013, whereas that in industrial countries (such as the United States, Europe, and Japan) remained below the 2007 level until 2013. More specifically, before the crisis (in 2007), China's industrial production was only about 60% of the U.S. level, but by 2012 it was already 126% of the U.S. level, making China the world's largest manufacturing giant and ending the U.S. dominance it enjoyed for a century.

The comparisons above provide two textbook examples of the potential outcomes of expansionary monetary policies in recessions. In China, everything worked just fine: A sharp increase in money supply expanded credit lending, which thereby boosted aggregate investment and finally resulted in full recovery and new economic growth. The United States and European experiences, however, were just the opposite: Despite unprecedented, astronomical monetary injections through both conventional and unconventional quantitative easing, these economies still remain weak. The reasons for this persistent weakness are simple: (i) Firms are unwilling to borrow and invest when aggregate consumption demand remains low, and (ii) consumers are not willing to spend when firms are not hiring—a classic market-coordination failure problem identified by Keynes.

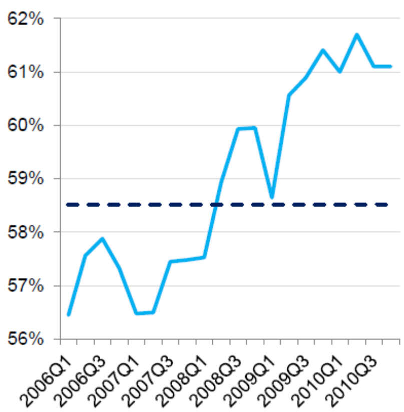
Why did monetary policies fail in boosting aggregate demand in the United States and Europe while they succeeded in China? The next section reveals the answers.

2.3 Contribution of SOEs to China's Economic Recovery

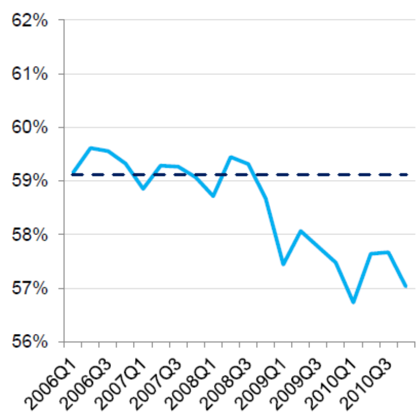
Further investigation shows that the effectiveness of China's stimulus packages is derived from the contribution of the public sector (SOEs). We start with firms' borrowing behaviors, which is essential in understanding the effectiveness of China's fiscal/monetary policies. Since information on the breakdown of outstanding loan balances according to borrowers' ownership is currently unavailable, we choose to explore the issue indirectly by focusing on the manufacturing firms' average leverage ratio published by the National Bureau of Statistics of China (NBSC). Although the leverage ratio in the pre-crisis period was similar between SOEs (58.5%) and POEs (59.1%), the dynamic paths during the stimulus period were quite different for these two groups (Figure 7A, where the dashed lines represents the pre-crisis average levels in each panel). On the one hand, the average leverage ratio of state-owned manufacturing firms increased steadily: from 57.5% in 2008:Q1 to 59.9% in 2008:Q3, reached 60.6% in 2009:Q2, and finally peaking at 61.4% in 2009:Q4. On the other hand, during the same period between mid-2008 and 2010, the average leverage ratio of privately owned manufacturing firms dropped continuously from the pre-crisis level of 59% to 57%, which is quite similar to what we observe in the industrial countries. The sharp difference in the leverage ratio demonstrates that only SOEs were willing to expand their debts during the crisis, which provides one major clue as to why the money injected by the central bank could be effectively translated into new loans in China.

Bolstered by new loans, Chinese SOEs promptly expanded their fixed assets investment. Figure 7B (where the dashed line in each panel represents pre-crisis average) shows that before the crisis POEs were clearly the major force behind aggregate investment spending in China. Between 2004:Q1 (when the disaggregated statistics of fixed asset investment became available) and 2007:Q4, the real year-over-year growth rate of POEs' total investment in fixed assets was remarkably high, at 35.15% per year (dashed line), almost three times as fast as that of SOEs (12.88% per year). But this pattern changed dramatically during the crisis period. From a normal growth rate of 11.59% per year in 2008:Q2, the real growth rate of SOEs' fixed investment spending increased rapidly to 21.09% per year in 2008:Q4 and reached an astonishing 45.3% per year in 2009:Q2. This was not only more than 33 percentage points higher than its pre-crisis level in 2008:Q2, but also about 10 percentage points higher than the pre-crisis average growth rate of POEs' investment. Thus, the actual investment growth rate of SOEs stayed at 20 percentage points above its pre-crisis average rate for several quarters between 2008:Q4 and 2010:Q1. Meanwhile, the investment growth of POEs decreased sharply from 30% per year in 2007:Q3 to 20% per year in 2008:Q4. However, following the lead of SOEs, a rapid revival of private investment also followed: The real growth rate of POEs' fixed investment recovered from a trough of 20% per year in 2008:Q4 to about 33% per year in 2009:Q2 and 2009:Q3, even though these rates fluctuated between 24% to 30% per year after the stimulus program ended in 2010:Q4.

A. Leverage Ratio

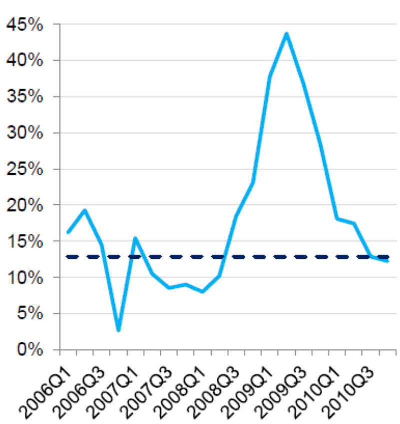


SOEs

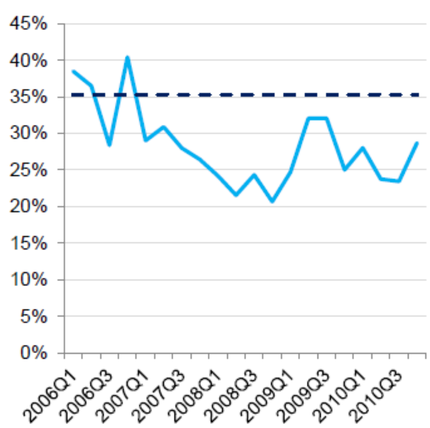


POEs

B. Fixed Investment Growth



SOEs



POEs

Figure 7. Behaviors of Chinese Manufacturing Firms

2.4 Evidence from Panel Studies

These stylized facts point to a critical role of SOEs in China's dramatic recovery in GDP and employment levels during the crisis. We can further support this conclusion by using panel data at the province level. First, we use a simple difference-in-differences econometric model based on data from 31 provinces in China between 2001 and 2010. The underlying logic of our analysis is fairly straightforward: If the effectiveness of China's stimulus package did indeed rely mainly on the public sector, we should expect regions with more SOEs or higher SOE shares in total regional output (or employment) to suffer less and recover faster from the crisis.

To confirm this conjecture, we run the following regression:

$$\Delta GDP_{j,t} = \alpha X_t + \beta \left(X_t \times Z_{j,t} \right) + \gamma_j + e_{j,t}, \quad (1)$$

where Δ denotes the first-difference operator; $GDP_{j,t}$ is the provincial output level (in logarithm) in province j and period t; X_t is the STIMULUS dummy variable for the stimulus period (i.e., 2009 and 2010); $Z_{j,t}$ is a proxy of the share of SOEs in province j in period t; and $e_{j,t}$ is an error term. The province fixed effects ($\gamma_{j,t}$) are introduced to capture any unobserved attributes such as natural resource endowments across provinces, with the assumption that these factors would not substantially change within a short time period (such as the stimulus period). If SOEs have made major contributions to the effectiveness of the stimulus package, the coefficient β should be positive and statistically significant.

Table 3. Effects of SOEs in the Stimulus Period (a)

Dependent Variable: dlog(*GDP*)

	(1)	(2)	(3)	(4)	(5)	(6)
*STIMULUS * SOE*	0.031	0.031	0.031	0.032	0.029	0.031
	(1.95)*	(2.47)**	(1.85)*	(2.16)**	(2.34)**	(1.85)*
STIMULUS	-0.014	-	-	-0.029	-	-
	(-1.82)*	-	-	(-3.75)***	-	-
SOE	-	-	-0.019	-	-	-0.014
	-	-	(-2.40)**	-	-	(-1.37)
log(*GDP*) (-1)	-	-	-	0.026	-0.050	0.001
	-	-	-	(6.24)***	(-2.37)**	(0.89)
Province Fixed Effect	Yes	Yes	No	Yes	Yes	No
Year Fixed Effect	No	Yes	Yes	No	Yes	Yes
N	279	279	279	279	279	279
R^2	0.388	0.628	0.258	0.471	0.636	0.260

(1) t statistics in parentheses

(2) * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4. Effects of SOEs in the Stimulus Period (b)

Dependent Variable: dlog(*INV*)

	(1)	(2)	(3)	(4)	(5)	(6)
STIMULUS * *SOE*	0.149	0.149	0.149	0.159	0.186	0.143
	(2.25)**	(2.42)**	(2.05)**	(2.44)**	(3.08)***	(1.99)**
STIMULUS	-0.032	-	-	-0.010	-	-
	(-0.97)	-	-	(-0.29)	-	-
SOE	-	-	0.025	-	-	0.095
	-	-	(0.72)	-	-	(2.26)**
log(*INV*) (-1)	-	-	-	-0.030	-0.107	0.018
	-	-	-	(-2.92)***	(-4.11)***	(2.80)***
Province Fixed Effect	Yes	Yes	No	Yes	Yes	No
Year Fixed Effect	No	Yes	Yes	No	Yes	Yes
N	279	279	279	279	279	279
R^2	0.364	0.467	0.169	0.385	0.502	0.193

(1) t statistics in parentheses

(2) * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

While variables such as GDP can be directly derived from the official statistics published by NBSC, the information on SOE shares in provincial GDP is not readily available. Here we choose to use SOEs' shares in provincial employment as a proxy, calculated based on the 2001 National Population Census data. We choose this time-invariant variable instead of a time-varying indicator for two reasons. First, if the employment of either SOEs or POEs is more sensitive to the shock, introducing a time-varying measurement of employment should lead to the endogeneity problem and a biased estimation of β. We can avoid such a bias in the estimation by focusing on the conditions at the very beginning of the sample period. Second, an alternative data source—the Annual Statistics of Employment—includes all SOEs but only large POEs above a certain size; thus, the SOE share in employment is not comparable across different provinces. The National Census data, by contrast, cover all SOEs and POEs. According to the census, on average SOEs accounted for 47.54% of total employment in 2001, while the variance between different provinces was huge—the highest value was 73.9% in Xinjiang and the lowest was only 14.2% in Zhejiang—one of the richest provinces in China.[12]

Bear in mind that our model does not capture any cross-border spillover effects—because of input-output and trade linkages across provinces, a higher SOE share in province A may also boost output in province B. Thus, there may be downward bias in the estimated β coefficient.

The estimation results are listed in Table 3. As a benchmark specification, column (1) strictly follows equation (1). The α coefficient of the STIMULUS dummy X is significantly

[12] As a robustness check, we also used employment share based on the 2004 National Economic Census and the results are similar.

negative, while the β coefficient of the cross term between X and the SOE share variable Z is positive and significant at the 10% level. These two coefficients together suggest that while the economic growth in all provinces was significantly negatively affected by the crisis, provinces with more SOEs suffered less and recovered faster from the crisis, which is consistent with our expectation. Calculating based on the coefficients and controlling for other factors, during the stimulus period the real annual GDP growth rate (at the province level) with the highest SOE share would be about 1.87 percentage points higher than that in the province with the lowest SOE share.

The following columns in Table 3 use several other specifications to test the robustness of the results. In column (2) we replace the STIMULUS dummy with year fixed effects (i.e., the cross term becomes a term between the SOE proxy and the sum of the year dummies of 2009 and 2010). This specification significantly improves the overall explanatory power of the model and the coefficient β now becomes more significant. In column (3) we replace the province fixed effects with the SOE proxy as the control variable. One interesting result is that the coefficient of the SOE proxy is significantly negative in the model, which is consistent with the argument that SOEs are less efficient during a normal period but more efficient during a crisis period. The coefficient β remains unchanged in this specification. Finally, in the last three columns we introduce the lagged level of GDP as an additional control variable for each of the three cases, which does not affect the results significantly.

In Table 4 we adopt the growth rate of total fixed investment in each province as the dependent variable, with the explanatory variables identical to those in Table 3. Again, the interaction term between the SOE proxy and the STIMULUS dummy is significantly positive in the model, suggesting that provinces with a higher SOE shares also experienced a larger expansion in fixed investment during the stimulus period. According to the coefficients in column (1), during the stimulus period the real annual growth rate of fixed investment is about 9.3 percentage points higher in the province with the highest SOE share than that in the province with the lowest SOE share. The results are also robust if we (i) replace the STIMULUS dummy with year fixed effects, (ii) replace the province fixed effects with the SOE proxy, or (iii) add the lagged investment level as an additional control variable.

Next, to further support our arguments, we use firm-level panel data from China Annual Survey of Industrial Firms (CASIF), covering the period between 2001 and 2010. CASIF is conducted annually by National Bureau of Statistics of China, which covers all state-owned industrial enterprises in the nation, as well as non-SOE industrial firms with annual sales at or above 2 million yuan RMB.[13] We exclude from our sample all the SOEs with annual sales lower than 2 million yuan RMB to make the two types of firms comparable. As a result, we have a total of 328,236 firms (including 8,011 SOEs and 320,225 non-SOEs) with 871,913 firm-year observations.

We run the following regressions to investigate SOEs' responses to the stimulus package in terms of the changes in their fixed investment and debts during the crisis period:

$$\Delta PPE_{i,t} = \alpha \left(X_t \times SOE_i \right) + \eta_i + \delta_t + \varphi Z_{i,t} + \varepsilon_{i,t} \tag{2}$$

$$\Delta DEBT_{i,t} = \alpha \left(X_t \times SOE_i \right) + \eta_i + \delta_t + \varphi Z_{i,t} + \varepsilon_{i,t} \tag{3}$$

where Δ denotes the first-difference operator; $PPE_{i,t}$ is the book value of plant, property and equipment (or the so-called fixed assets according to China's accounting code) owned by firm i at the end of year t (normalized by the firm's total asset in the same point), $DEBT_{i,t}$ is the book value of debt held by firm i at the end of year t (again normalized by the total asset); X_t is the dummy variable for the stimulus period (i.e., 2009 and 2010), and SOE_i is the dummy variable for SOEs; η_i and δ_t are the firm- and year fixed effects, respectively, which are introduced to capture any unobserved firm attributes or macro conditions; $Z_{i,t}$ refer to other control variables such as profitability; and $\varepsilon_{i,t}$ is an error term. All variables are winsorized at 1% in order to exclude the effect of outliers. The summary statistics of the variables are listed in Table 5.

Everything else equal, if SOEs have made major contributions to the effectiveness of the aggregate stimulus package, the coefficient α should be positive and statistically significant in the above two models. The estimation results are presented in Table 6. Regarding the firms' fixed asset investment growth, column (1) shows that α is positive and significant at the 1% level. The magnitude of α suggests that the normalized growth rate of fixed asset investment of the state-owned industrial enterprises is about 1.5 percentage points higher than the non-SOE counterparts during the stimulus period. This suggests that, while firms were reluctant to invest in fixed assets during the crisis, the SOEs did the opposite and invested significantly more than private firms, which is consistent with our expectation.

[13] See Brandt, Biesebroeck and Zhang (2012) and Cai and Liu (2009) for more details on CASIF.

Table 5. Summary Statistics

Variables	Mean	Std. Dev.	Min	Max
D. Fixed Assets / Total Assets (in %)	4.08	22.78	-106.65	125.84
D. Total Liabilities / Total Assets (in %)	-1.19	24.01	-268.93	268.93
Fixed Assets / Total Assets (in %)	31.83	24.01	0	103.27
Total Liabilities / Total Assets (in %)	55.41	31.89	0	268.93
Total Profit / Average Total Assets (in %)	13.68	26.31	-40.58	150.91

A similar pattern is also found in firms' borrowing behaviors. Column (2) shows that the interaction term between STIMULUS and SOEs (α) is again significantly positive, suggesting that SOEs did tend to borrow significantly more than private firms during the stimulus period.[14]

Table 6. Estimation Results Based on CASIF Panel Data

VARIABLES	(1) D. Fixed Assets / Total Assets (in %)	(2) D. Total Liabilities / Total Assets (in %)
Stimulate * SOE	1.904***	2.055***
	(0.240)	(0.223)
L. Fixed Assets / Total Assets (in percent)	-0.656***	
	(0.00141)	
L. Total Liabilities / Total Assets (in percent)	0.00850***	-0.774***
	(0.00107)	(0.000994)
L. Total Profit / Average Total Assets (in percent)	0.105***	-0.104***
	(0.00149)	(0.00139)
Year Fixed Effects	Yes	Yes
Firm Fixed Effects	Yes	Yes
Observations	1,425,729	1,431,640
R-squared	0.374	0.495

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0

In summary, SOEs were the pivotal force behind China's rapid economic recovery in 2009 and 2010. During the most difficult and crucial period in early 2009 when China's total exports collapsed, SOEs in China borrowed more, invested more, and produced more, which revived the private sector and generated a sharp and prompt recovery of aggregate demand.

[14] The results are consistent in a series of robustness checks, although we do not report them here to conserve space. First, instead of using the whole decade between 2001 and 2010, we tried using the period of 2007-2010 only (i.e., with two years before the stimulus period and two years during the stimulus period), and the results are robust. Second, instead of using all non-SOEs as the control group, we tried narrowing down to the firms which are explicitly labelled as private firms (i.e., we exclude the joint ventures whose ownership structures are not clear). Again the results are consistent. We also tried adopting a strictly balanced panel, which does not quantitatively affect the results either.

These findings naturally lead to the question of why SOEs could play such a critical role, given that SOEs are generally considered or perceived as highly inefficient. We answer this question with a theoretical model developed in the next section.

3 The Benchmark Model

We present first some empirical evidence on fixed costs and then a simple benchmark model without labor (and with a constant aggregate supply of capital) to illustrate several key properties of our model. These key properties include: (i) stock market crashes and high unemployment can go hand in hand (see Farmer, 2012 and 2013); (ii) a jobless recovery with permanently lower output level can be a self-fulfilling market-coordination-failure equilibrium; (iii) monetary policies alone are insufficient to lift the economy out of the market-coordination-failure trap; and (iv) fiscal policies are a powerful tool to address the coordination-failure problem. We then extend the simple model to a more general setting with active capital accumulation, endogenous labor supply, and SOE firms to show how SOEs can help withstand the market-coordination-failure trap.

Empirical Evidence. Since the key assumption in our model to deliver the essential results is fixed cost in production, we first provide some evidence on the size of fixed costs in China to support our model. Following the influential work of Melitz (2003), we use firms' fixed overhead (operation) costs as a proxy for fixed production costs.

According to the accounting code in China, fixed overhead costs include four major components reported in firms' income statements, namely, (i) depreciation costs of fixed assets, (ii) fixed financial costs, (iii) administrative expenses, and (iv) sales expenses. Unlike the variable costs of raw materials and labor, these costs do not vary with the amount of output produced each period on a daily basis.

Table 7 reports the share of the 4 types of fixed costs in firms' total assets, based on the annual financial statements, where the last column is firm's asset returns. The upper panel (A) reports results based total of 2952 firms listed in mainland China. During the decade of 2001-2010, the total value of these four components, normalized by each firm's total assets, fluctuated around 15%. Even if we take out capital depreciation (first column), the reaming fixed costs still account for more than 12% of firms' total assets on average.

The results are similar if we focus on the 1777 listed firms in the manufacturing industry only (Panel B). The lower panel in Table 7 shows that the average fixed costs are about 15%-18% of firms assets. Taking out depreciation cost, the remaining fixed costs still account for

11%-15% of firm assets. Since in China the average asset-to-output ratio is around 1, these values reported in Table 7 also reflect the ratio of fixed costs-to-output (annual sales).

Hence, the share of fixed costs in firms' output (revenue) is substantial, much higher than the average rate of return to assets (the last column in Table 7 indicates a 4%-5% rate of return on average). Hence, when market demand is in slump, sales would be too low to cover these fixed costs of operations, firms may opt to shut down production, as formally shown in our model.

Table 7. Fixed Costs of Listed Firms in China

A. All Listed Non-financial Firms (normalized by total assets)						
	Depreciation Cost	Financial Cost	Administrative Expenses	Sales Expenses	Total Fixed Costs	Return on Asset
2001	3.26%	1.27%	3.72%	5.72%	13.79%	3.56%
2002	3.32%	1.32%	4.03%	6.02%	14.50%	3.13%
2003	3.51%	1.37%	4.17%	6.17%	15.23%	2.90%
2004	3.65%	1.47%	4.18%	6.43%	15.42%	2.38%
2005	3.23%	1.50%	4.07%	6.12%	14.33%	1.25%
2006	3.41%	1.64%	4.55%	5.75%	14.98%	3.76%
2007	3.16%	1.86%	5.15%	6.05%	15.29%	7.86%
2008	2.84%	1.76%	5.50%	6.58%	14.26%	5.70%
2009	2.71%	1.20%	6.04%	7.37%	15.30%	8.45%
2010	2.66%	1.05%	6.29%	8.28%	17.24%	10.35%
B. All Listed Manufacturing Firms (normalized by total assets)						
	Depreciation Cost	Financial Cost	Administrative Expenses	Sales Expenses	Total Fixed Costs	Return on Asset
2001	3.53%	1.27%	4.21%	6.07%	14.92%	3.94%
2002	3.57%	1.34%	4.74%	6.36%	15.67%	3.90%
2003	3.79%	1.34%	4.85%	6.40%	16.56%	4.11%
2004	3.83%	1.40%	4.80%	6.62%	16.46%	3.55%
2005	3.44%	1.48%	4.60%	6.19%	15.03%	2.14%
2006	3.75%	1.67%	5.16%	6.03%	16.24%	5.06%
2007	3.50%	1.81%	5.68%	6.10%	15.84%	8.02%
2008	3.16%	1.86%	6.16%	6.64%	14.92%	5.99%
2009	3.00%	1.22%	6.62%	7.30%	15.70%	9.23%
2010	2.94%	1.06%	6.60%	8.00%	17.75%	11.14%

Households. There is a representative household that chooses consumption and firm equity shares to solve

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log \left(C_t + \Delta \right) \right\} \tag{4}$$

such that

$$P_t C_t + \int Q_{it} s_{it+1} di \leq \int \left(Q_{it} + d_{it} \right) s_{it} di + \Pi_t \tag{5}$$

$$C_t \geq 0, \tag{6}$$

where the constant $\Delta > 0$ in the utility function represents consumption of non-market goods, which serves to bound the marginal utility of consumption away from negative infinity when the consumption for market goods collapses to $C_t = 0$.[15] P_t is the final good price, Q_{it} is the competitive price of intermediate-goods firm i's equity, s_{it} is the equity share of firm i held by the household, d_{it} is dividends of firm i, and Π_t is total profit income of the final-good firm. Denoting $\{\Lambda_t, \mu_t^c\}$ as the Lagrangian multipliers for equations (5) and (6), the first-order conditions (FOCs) for $\{C_t, s_{it+1}\}$ are given by

$$\frac{1}{C_t + \Delta} = P_t \Lambda_t - \mu_t^c \tag{7}$$

$$Q_{it} \Lambda_t = \beta E_t \left(Q_{it+1} + d_{it+1} \right) \Lambda_{t+1}. \tag{8}$$

Equation (8) implies that the equity price Q_{it} is simply the present value of discounted future dividends:

$$Q_{it} = E_t \sum_{j=1}^{\infty} \beta^j \frac{\Lambda_{t+j}}{\Lambda_t} d_{it+j}. \tag{9}$$

The Final-Good Firm. There is a representative final-good producer that produces the final consumption good Y_t by combining intermediate goods Y_{it}:

$$Y_t = \left[\int_0^1 Y_{it}^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}}, \tag{10}$$

where $\sigma > 1$ is the elasticity of substitution across intermediate goods. Denoting the price of the final good by P_t and that of intermediate goods by P_{it}, profit maximization leads to the following demand function for intermediate good i:

$$P_{it} = P_t \left(\frac{Y_t}{Y_{it}} \right)^{\frac{1}{\sigma}}. \tag{11}$$

We choose the final good price as the numeraire; thus,

$$P_t = 1. \tag{12}$$

[15] Alternatively, we can assume that each household receives an endowment or home goods Δ each period in addition to market income, but the results would be the same (see the next section).

Intermediate-Goods Producers. There is a continuum of monopolistic firms indexed by $i \in [0,1]$. Firm i produces intermediate good i using capital only, and the production technology is given by

$$Y_{it} = e_{it} K_{it}, \tag{13}$$

where $e_{it} \in [0,1]$ denotes the rate of capacity utilization. Assume that in each period there exist fixed costs of production $\Phi > 0$, measured in terms of the final good, and that the fixed cost is identical across firms.[16] The revenue of an intermediate-good firm is then given by

$$P_t(i)\, e_t(i)\, K_t(i) - \mathbf{1}_{it}\Phi, \tag{14}$$

where $\mathbf{1}_{it}$ is an indicator function that takes the value of 1 if $e_{it} > 0$ and 0 if $e_{it} = 0$.[17]

Each intermediate-good firm i chooses capacity utilization rate $e_t(i)$ and investment $I_t(i)$ to maximize the value of the firm (the present value of discounted future dividends), $V(K_{it}) = \max E_t \sum_{j=0}^{\infty} \beta^j \frac{\Lambda_{t+j}}{\Lambda_t} \left[P_{it+j} e_{it+j} K_{it+j} - \mathbf{1}_{it+j}\Phi - P^I_{t+j} I_{it+j} \right]$, or solve the following recursive problem:

$$V(K_{it}) = \max_{\{I_{it}, K_{it+1}\}} \left\{ \left[\max_{\{e_{it}\}} \{P_{it} e_{it} K_{it} - \mathbf{1}_{it}\Phi, 0\} - P^I_t I_{it} \right] + \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t} V(K_{it+1}) \right\} \tag{15}$$

subject to

$$P_{it} = \left(\frac{Y_t}{e_{it} K_{it}} \right)^{\frac{1}{\sigma}} \tag{16}$$

$$K_{it+1} = K_{it} + I_{it}, \tag{17}$$

and $e_{it} \in [0,1]$, with $K_{i0} > 0$ given.

Denoting q_{it} as the Lagrangian multiplier for equation (17), the FOCs for $\{I_{it}, e_{it}, K_{it+1}\}$ are given by

$$P^I_t = q_{it} \tag{18}$$

$$e_{it} = \begin{cases} 1, & \text{if } P_{it}(Y_t)\, K_{it} > \Phi \\ 0, & \text{if } P_{it}(Y_t)\, K_{it} < \Phi \end{cases} \tag{19}$$

$$\begin{aligned} q_{it} &= \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t} \left\{ \frac{\partial P_{it+1}}{\partial K_{it+1}} e_{it+1} K_{it+1} + P_{it+1} e_{it+1} + q_{it+1} \right\} \qquad (20) \\ &= \left(1 - \frac{1}{\sigma}\right) E_t \sum_{j=1}^{\infty} \beta^j \frac{\Lambda_{t+j}}{\Lambda_t} \left[Y_{t+j}^{\frac{1}{\sigma}} K_{it+j}^{-\frac{1}{\sigma}} \right] e_{it+j}^{1-\frac{1}{\sigma}}. \end{aligned}$$

[16] Making the fixed cost heterogeneous does not change our results.

[17] Firms do not incur the fixed costs if they do not produce in period t.

Tobin's q is given by $\frac{q_{it}}{P_t^I}$, so the firm will invest if $\frac{q_{it}}{P_t^I} \geq 1$ and not invest if $\frac{q_{it}}{P_t^I} < 1$. Note that (i) the capacity utilization rate is positive if and only if the revenue can cover the fixed production cost and (ii) investment is forward looking—firms opt to invest now only if $q_{it} > 0$ or future capacity utilization rates are positive in some periods.

The aggregate supply of capital is fixed: $\int K_{it}di = \bar{K}$. We can interpret the capital as Lucas trees. Firms can purchase Lucas trees to yield fruits and accumulate more trees from the asset market if profitable. It takes one period to yield fruits after purchase. However, operating Lucas trees is costly: The cost is $\Phi > 0$. An immediate implication of this fixed cost is that even if the Lucas trees are free (i.e., $P_t^I = 0$), the market demand for such assets can still be zero ($I_{it} = 0$ for all i) if the expected profits (under full-capacity utilization) are negative: $E_t\left[P_{it+1}K_{it+1} - \Phi\right] < 0$.

Rational Expectations Equilibrium. We consider symmetric equilibrium with $K_{it} = \bar{K}$, $I_{it} = I_t$, $e_{it} = e_t$, $d_{it} = D_t$, $q_{it} = q_t$, $Q_{it} = Q_t$, and $P_{it} = P_t = 1$. A rational expectations equilibrium is defined as the sequence of asset prices $\left\{q_t, Q_t, P_t^I\right\}_{t=0}^{\infty}$ and quantities $\{Y_t, e_t, C_t\}_{t=0}^{\infty}$ such that given prices and the initial distribution of capital stocks $K_{i0} = K_0 > 0$, the quantities maximize household utilities and firms' profits in all sectors, all markets clear, and standard transversality conditions hold. A steady state is a situation where all aggregate endogenous variables are constant, and all distributions for individual variables are time invariant.

Proposition 1 *For a sufficiently high aggregate capital stock $\bar{K} > \Phi$, the model has at least two rational expectations equilibria: (i) a Keynesian equilibrium with market-coordination failures, where the quantities for market activities $\{Y_t, e_t, C_t\} = 0$ and prices $\left\{q_t, Q_t, P_t^I\right\} = 0$; and (ii) a classic equilibrium with full-capacity utilization $e = 1$, positive quantities $\{Y, C\} > 0$, and positive prices $\left\{q, Q, P^I\right\} > 0$. For convenience, we call the classical equilibrium a "full-employment equilibrium" even though there is no labor in the model yet.*

Proof. See Appendix I. ■

In the Keynesian equilibrium, every market participant is worse off than in the classical equilibrium; however, no individuals have incentives to deviate away from the coordination-failure equilibrium because (i) it is not optimal for any single intermediate-good firm to produce when other intermediate-goods firms are not producing; (ii) it is impossible for consumers to increase consumption when their wealth income (stock price and equity value) is zero; and (iii) it is not optimal for firms to increase asset demand when there is no demand for their output and households do not consume. Therefore, consumers and producers are trapped in the coordination-failure equilibrium because none of them has the incentive to increase efforts to boost demand/supply on their part even though they have the ability to do so collectively through coordinated actions. Suppose all producers could act together to increase capital investment with "animal spirits"; asset prices and household wealth would go up and consequently consumption would also go up, so the economy could escape from the coordination-failure equilibrium. Alternatively, suppose all consumers would increase consumption; intermediate-goods prices P_{it} would go up and it would then become profitable for firms to produce and invest. But individual consumers and firms, by rationally making decisions based on their own self-interests, are unable to coordinate their actions to end the recession.

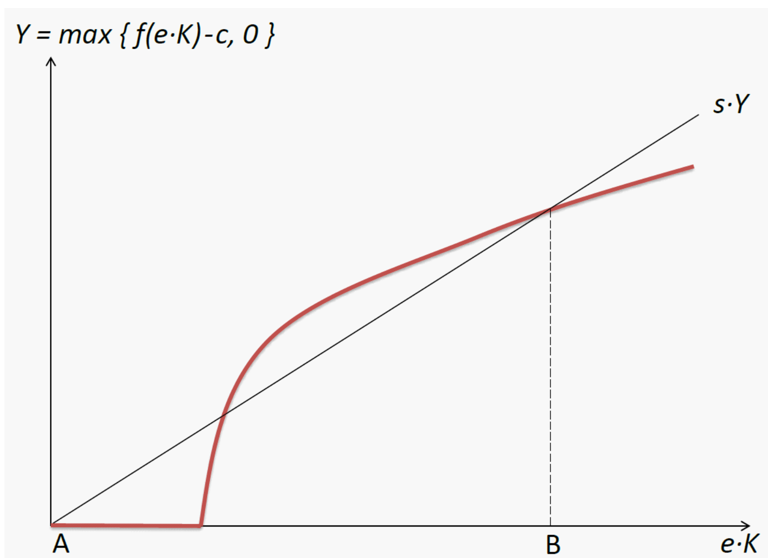


Figure 8. Solow Growth Model with Capacity Utilization (e) and Fixed Cost (c).

Figure 8 illustrates the intuition behind a coordination-failure equilibrium in a typical Solow growth model with fixed production cost in the Y-K plan, where $Y = f(e \cdot K) - c$ denotes output, c denotes fixed cost, K denotes the capital stock, $e \in [0, 1]$ denotes capacity utilization rate, and s denotes the saving rate. Since output cannot be negative, the production frontier is $Y = \max\{f(e \cdot K) - c, 0\}$. As Figure 8 shows, the fixed cost of production (c) makes the zero-output steady state (point A) a stable steady state since firms will opt not to produce if $K < f^{-1}(c)$. But this zero-output steady state is not yet a Nash equilibrium since the economy can growth out of it once the capital stock is large enough. However, with variable capacity utilization, forward-looking investment decisions and a wealth effect from dynamic asset prices, the zero-output steady state with $e = 0$ can become a self-fulfilling Nash equilibrium even if the economy is already at point B or the capital stock is already sufficiently large with $K > f^{-1}(c)$. That is, a market economy operating at the full-capacity utilization equilibrium B may suddenly collapse to equilibrium A with permanently lower output and employment.

4 A More General Model

This section introduces labor, money, and reproducible capital into the benchmark model. For simplicity, we use the money-in-the-utility model (as in Lucas, 2000). However, since money is a veil (without sticky prices), it has no effects on equilibrium allocations and the results would thus be identical regardless of money. To make the monetary model more interesting, we assume that the fixed costs of production are in nominal terms so that money is not neutral. We show that even with monetary non-neutrality, expansionary monetary policy cannot by itself be effective in preventing recessions or resolving coordination failures. Instead, fiscal policies matter.

4.1 Firms' Problem

The Capital-Good Producer. There is a representative capital-goods supplier that uses labor only to produce capital, which is sold to intermediate-goods producers as inputs. The production technology is given by

$$I_t = N_t^{\alpha}, \quad a \in (0,1), \tag{21}$$

so a representative firm solves

$$\max_{N_t} \frac{1}{P_t} \left\{ P_t^I N_t^a - W_t N_t \right\}, \tag{22}$$

where P^I denotes the nominal price of the capital good. Optimal production (supply of capital good I_t^s) and demand for labor are given, respectively, by

$$I_t^s = \min \left\{ \int I_{it}^d di, \left(\alpha \frac{P_t^I}{W_t} \right)^{\frac{\alpha}{1-\alpha}} \right\} \tag{23}$$

$$N_t = \left(I_t^s \right)^{\frac{1}{\alpha}}, \tag{24}$$

where I_{it}^{d} denotes total demand for capital good from all downstream firms $i \in [0,1]$.

The Final-Good Firm. There is a representative final-good producer as in the benchmark model, which produces the final consumption good by combining intermediate goods. Profit maximization leads to the same demand function for intermediate good i as in equation (11).

Intermediate-Goods Producers. As in the benchmark model, there is a continuum of monopolistic firms indexed by $i \in [0,1]$. Firm i produces intermediate good i using technology in equation (13). The nominal fixed cost of production is denoted by $\Phi > 0$. An intermediate-goods firm chooses capacity utilization rate $e_t(i)$ and investment in fixed capital $I_t(i)$ to maximize the value of the firm:

$$V(K_{it}) = \max_{\{I_{it},K_{it+1}\}} \left\{ \left[\max_{\{e_{it}\}} \left\{ \frac{P_{it}}{P_t} e_{it} K_{it} - \mathbf{1}_{it} \frac{\Phi}{P_t}, 0 \right\} - \frac{P_t^I}{P_t} I_{it} \right] + \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t} V(K_{it+1}) \right\} \tag{25}$$

subject to the demand function (16) and

$$K_{it+1} = (1-\delta) K_{it} + I_{it} \tag{26}$$

$$I_{it} \geq 0, \tag{27}$$

$e_{it} \in [0,1]$, and $K_{i0} > 0$ given, where the constraint (27) reflects the assumption that investment is irreversible.

Irreversible investment simplifies our analysis by increasing the tractability of the general model. It also reinforces the stability of the Keynesian equilibrium. The intuition is that investment by nature is a forward-looking behavior, whereas capacity utilization is not, and irreversible investment creates a state of rational inaction when the future is uncertain and gloomy. Because waiting has positive option value when firms are uncertain about future demand, they opt not to undertake investment under pessimistic expectations even though the current demand may be high, so a wait-and-see position or strategy becomes optimal. Low investment demand imposes a negative demand externality on capital-goods producers and their employment decisions, reinforcing any pessimistic expectations about aggregate demand.

Denoting $\{q_{it}, \pi_{it}\}$ as the Lagrangian multipliers for equations (26) and (27), respectively, the FOCs for $\{I_{it}, e_{it}, K_{it+1}\}$ are given by

$$\frac{P_t^I}{P_t} = q_{it} + \pi_{it} \tag{28}$$

$$e_{it} = \begin{cases} 1, & \text{if } P_{it}K_{it} > \Phi \\ 0, & \text{if } P_{it}K_{it} < \Phi \end{cases} \tag{29}$$

$$q_{it} = \beta E_t \frac{\Lambda_{t+1}}{\Lambda_t} \left\{ \frac{1}{P_{t+1}} \frac{\partial P_{it+1}}{\partial K_{it+1}} e_{it+1} K_{it+1} + \frac{P_{it+1}}{P_{t+1}} e_{it+1} + (1-\delta)\, q_{it+1} \right\}, \tag{30}$$

which are analogous to those in the benchmark model. Because producing investment goods is subject to diminishing returns to scale in the capital-good-producing sector, the equilibrium investment in the intermediate-goods sector is always finite (bounded above) for any bounded prices $\frac{P_{it}}{P_t} \in [0, \infty)$ despite the linear technology in the final-good sector. However, investment remains a jump variable except that it is bound below by zero as a result of the irreversibility assumption.

4.2 Household Problem

With labor and money added into the general model, the household problem becomes[18]

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log (C_t + \Delta) + \gamma \log \frac{M_t}{P_t} - N_t \right\} \tag{31}$$

such that

$$C_t + \int Q_{it} s_{it+1} di + \frac{M_{t+1}}{P_t} \leq \frac{M_t}{P_t} + \frac{W_t}{P_t} N_t + \int (Q_{it} + d_{it})\, s_{it} + \frac{\Pi_t}{P_t} \tag{32}$$

$$C_t \geq 0 \tag{33}$$

$$N_t \geq 0, \tag{34}$$

where Π_t is nominal profit income from capital-good-producing firms.[19] Denoting μ_t^N as the Lagrangian multiplier for equation (34) and keeping the same notations for the remaining Lagrangian multipliers as in the benchmark model, the FOCs of the household become

$$\frac{1}{C_t + \Delta} = \Lambda_t - \mu_t^c \tag{35}$$

$$1 - \mu_t^N = \frac{W_t}{P_t} \Lambda_t \tag{36}$$

[18] Adopting a more general leisure cost function, such as $-a\frac{N^{1+\gamma_n}}{1+\gamma_n}$, has no qualitative effects on our results.

[19] The profit of the final-good sector is zero and is thus not included to simplify notations.

$$Q_{it}\Lambda_t = \beta E_t \left(Q_{it+1} + d_{it+1}\right) \Lambda_{t+1} \tag{37}$$

$$\frac{\Lambda_t}{P_t} = \beta \frac{\Lambda_{t+1}}{P_{t+1}} + \beta\gamma \frac{1}{M_{t+1}}. \tag{38}$$

Proposition 2 *Given any positive initial capital stock* $K_{i0} = K_0 \in (0, K^*]$, *for a sufficiently high level of money supply* $\bar{M} > M^* = \frac{\beta\gamma}{1-\beta}\frac{\Delta}{K_0}\Phi$, *there exist at least two symmetric equilibria: (i) a full-employment equilibrium with allocations* $e = 1$ *and* $\left\{C, Y, I, N, K, P, P^I, W\right\} > 0$; *and (ii) a Keynesian coordination-failure equilibrium with the allocation* $\{e, C, Y, I, N\} = 0$ *and relative prices* $\lim_{t\to\infty} \frac{W_t}{P_t} = 0$,$\lim_{t\to\infty} \frac{P_t^I}{P_t} = 0$, *and* $\frac{P_{t+1}}{P_t} = \beta$.

Proof. See Appendix II. ■

Note that in the Keynesian equilibrium, there is negative inflation, so the real rate of return to money is strictly positive. As a result, the real money demand $\lim_{t\to\infty} \frac{M_{t+1}}{P_t} = \infty$, which is the liquidity trap equilibrium. Also note that even if the nominal wage is sticky such that $\frac{W_t}{P_t}$ does not approach zero, the Keynesian equilibrium still exists because capital producers have no incentive to hire labor when the real wage $\frac{W}{P}$ is high yet the output (investment good) price $\frac{P^I}{P}$ is zero. Thus, consumers' labor income remains zero regardless of sticky wages. In this sticky wage case, we may have involuntary unemployment with $N^s \geq N^d = 0$.

Carollary 1 *In normal times, money is a lubricant of the economy and is non-neutral. First, because the fixed cost* Φ *is nominal, the higher the price level, the lower the real fixed cost. Second, and more importantly, if the aggregate stock of money supply* $\bar{M}$ *is too low* ($\bar{M} < \frac{\beta\gamma}{1-\beta}\frac{\Delta}{K}\Phi \equiv M^*$), *then it cannot support a full-employment equilibrium; instead the Keynesian equilibrium is the only equilibrium. Thus, a sharp contraction in the money supply from a level above* M^* *to a level below* M^* *can push the economy from the full-employment equilibrium to the Keynesian equilibrium (i.e., monetary contraction and deflation are bad and dangerous). The reverse, however, is not true. Expansionary monetary policy cannot automatically shift the economy from the Keynesian equilibrium to the classical equilibrium because restoring the full-employment equilibrium also requires a shift of expectations (coordination by all economic agents).*

Corollary 1 provides a theoretical rationale for the Friedman-Schwartz (1963) hypothesis that monetary contraction by the Fed during the early 1930s caused the Great Depression.

Note that deflation exacerbates the fixed cost problem because the real fixed cost $\frac{\Phi}{P_t}$ goes to infinity over time as the aggregate price level falls. This situation is similar to the Fisherian debt-deflation problem studied by Eggertson and Krugman (2012).

When aggregate demand collapses, the price system collapses too—welcome to the Keynesian world where classical theory is turned upside down and no longer applies. In other words, despite zero prices with unemployed resources, no market mechanisms can help re-establish trade. Therefore, traditional monetary injection cannot eliminate the market-coordination failure equilibrium even if money supply is plentiful. The large-scale asset purchase programs conducted by the Fed since the financial crisis cannot do the job either because merely preventing asset prices (or the price of Lucas trees) from falling does not help when nobody wants to hold the assets that are no longer productive. Preventing the nominal wage from falling (such as the policy adopted by the Hoover administration during the Great Depression) does not help either because the problem is not the lack of labor supply but the lack of labor demand. The best hope to solve the coordination-failure problem with a collapsed aggregate demand, as Keynes (1936) argued, is to use government spending to support aggregate demand, thus restoring the price system and reviving the aggregate supply.[20]

5 Withstanding Coordination Failures: Keynesianism, Chinese Style

China has a dual-track system that features the co-existence of SOEs and POEs. The dual-track system was originally designed by the Chinese government in the early stage of economic reform to provide two important functions:

(i) to prevent a sharp rise in unemployment caused by the reform by maintaining a stable labor demand in the public sector (Lin et al., 1998), which is equivalent to an implicit lump-sum transfer from the winners (beneficiaries) of the reform (workers in the private sector) to the losers of the reform (workers in the public sector) so as to avoid social instability (Lau, Qian, and Roland, 2000); and

[20] Our model thus also implies that fiscal stimulus programs that rely heavily on tax reliefs and transfer payments to households (such as the ESA in 2008 and ARRA in 2009) are not as effective as direct increases in government spending on goods and services due to the Ricardian equivalence principle. In addition, a tax cut is equivalent to an increase in firms' output price, while transfer payments to households are equivalent to decreases in consumption-goods price (or increases in workers' wage). According to our theoretical model, these measures cannot insulate the economy from the Keynesian equilibrium because they tend to work through the price system, but the price system has already collapsed in a coordination-failure equilibrium. The key, therefore, is to use government spending to support quantities (aggregate demand) instead of prices.

(ii) to provide economic and political insurance against possible failures of the reform under epic uncertainty of the outcome of the reform.[21]

The basic motive for the reform was clearly to address the inefficiency problem of SOEs. But the private sector's ability to absorb surplus labor is limited by its finite rate of growth. Hence, China's gradualist reform through the dual-track system is coined "a reform without losers" (Lau, Qian, and Roland, 2000).

When the financial crisis hit the Chinese economy in 2008 and 2009, China's SOE sector still accounted for about 20% of real GDP and total employment. Therefore, this sector became the natural instrument (or "shovel-ready" projects) of the Chinese government for implementing its aggressive stimulus program. To avoid a possible Great Depression and economic collapse in the middle of its epic economic transition, the Chinese government not only implemented a 4 trillion RBM fiscal stimulus package to boost aggregate demand, but the central bank of China also simultaneously increased monetary supply to prevent deflation. The growth rate of money (M1) in China increased sharply over the entire year in 2009, from a growth rate of 5% per year at the end of 2008 to 20% per year in mid-2009, and further to 36% per year at the end of 2009.

Our model shows that this type of fiscal-plus-monetary policy mix or "dual-dose" stimulus package is a desirable policy combination that can provide not only a precautionary double insurance of success, but also a necessary and sufficient condition for avoiding a deflationary deep recession.

The intuition is that on the one hand, without encouraging the SOEs to continue to operate under negative profits (the fiscal package), a monetary injection would be impossible or insufficient to address the coordination-failure problem. Ironically, such a policy cannot stop deflation despite unprecedented monetary injections. On the other hand, without an expansionary monetary policy to accompany the fiscal stimulus package, SOEs may continue to operate under negative profits with the fiscal stimulus program in place (due to insufficiently high aggregate price levels), which is not optimal and is unsustainable.

This section introduces a public sector into the benchmark model to support these arguments. We study how the dual-dose government stimulus program, which requires (i) the public track to expand production and increase investment on the one hand and (ii) the

[21] Economic reform or transition from central planning to a market economy is like repairing a decrepit ship offshore in the open ocean: One must be careful not to sink the ship while tearing its body apart and repairing its crumbling foundation. The natural way to proceed is not to tear everything apart at the same time, but instead to keep some old parts as a support while repairing other parts.

central bank to increase money supply on the other hand, can prevent a severe coordination failure and a deep recession when hit by a unprecedented negative shock to aggregate demand (say net exports).

The Final-Good Producer. There are two types of firms in the economy, SOEs and POEs, denoted by $h = \{POE, SOE\}$. A representative firm produces the final consumption good Y_t by combining intermediate goods Y_{it} produced by POEs and SOEs:

$$Y_t = \left[\int_0^\theta \left(Y_{it}{}^{SOE}\right)^{\frac{\sigma-1}{\sigma}} di + \int_\theta^1 \left(Y_{it}{}^{POE}\right)^{\frac{\sigma-1}{\sigma}} di\right]^{\frac{\sigma}{\sigma-1}}, \tag{39}$$

where Y_i^{POE} denotes the good produced by POE firm i, Y_i^{SOE} denotes the good produced by SOE firm i, $\theta \in [0,1]$ is the share of SOEs in aggregate output, and $\sigma > 1$ is the elasticity of substitution across intermediate goods. Notice that we can rewrite the above aggregator as

$$Y_t = \left[\left(Y_t^{SOE}\right)^{\frac{\sigma-1}{\sigma}} + \left(Y_t^{POE}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}, \tag{40}$$

where $Y_t^{SOE} \equiv \left[\int_0^\theta \left(Y_{it}{}^{SOE}\right)^{\frac{\sigma-1}{\sigma}} di\right]^{\frac{\sigma}{\sigma-1}}$ and $Y_t^{POE} \equiv \left[\int_0^\theta \left(Y_{it}{}^{POE}\right)^{\frac{\sigma-1}{\sigma}} di\right]^{\frac{\sigma}{\sigma-1}}$. Since $\sigma > 1$, the aggregate output can be positive even if only SOEs remain active; namely, $Y_t = Y_t^{SOE}$ if $Y_{it}^{POE} = 0$ for all $i \in [\theta, 1]$.

Denoting the price of the final good by P_t and that of intermediate goods by P_{it}^h, where $h = \{POE, SOE\}$, profit maximization leads to the following demand function for intermediate good i:

$$P_{it}^h = P_t \left(\frac{Y_t}{Y_{it}^h}\right)^{\frac{1}{\sigma}}, \quad h = \{POE, SOE\}. \tag{41}$$

Intermediate-Goods Firms. There are two types of firms in the intermediate-goods sector indexed by $h \in \{SOE, POE\}$. Part of the production technology is identical for the two types of firms, $Y_{it}^h = e_{it}^h K_{it}^h$. However, assume that the fixed cost of production is higher for SOEs than for POEs with

$$\Phi^{SOE} > \Phi^{POE} > 0. \tag{42}$$

This assumption implies that SOEs are less efficient than POEs. Firm i of type h solves

$$V_t^h\left(K_{it}^h\right) = \max\left\{\max\left\{\frac{P_{it}^h}{P_t} e_{it}^h K_{it}^h - \frac{\Phi^j}{P_t}, 0\right\} - \frac{P_t^I}{P_t} I_{it}^h + E_t \beta \frac{\Lambda_{t+1}}{\Lambda_t} V_{t+1}^h\left(K_{it+1}^h\right)\right\} \tag{43}$$

subject to

$$P_{it}^{h}=P_{t}\left(\frac{Y_{t}}{Y_{it}^{h}}\right)^{\frac{1}{\sigma}} \tag{44}$$

$$K_{it+1}^{h}=(1-\delta)\,K_{it}^{h}+I_{it}^{h} \tag{45}$$

$$I_{it}^{h}\geq 0, \tag{46}$$

and $e_{it}^{h}\in[0,1]$, with $K_{i0}^{h}>0$ given. The FOCs for $\left\{I_{it}^{h},e_{it}^{h},K_{it+1}^{h}\right\}$ are given by

$$\frac{P_{t}^{I}}{P_{t}}=q_{it}^{h}+\pi_{it}^{h} \tag{47}$$

$$e_{it}^{h}=\begin{cases}1, & \text{if } P_{it}^{h}K_{it}^{h}>\Phi^{h}\\ 0, & \text{if } P_{it}^{h}K_{it}^{h}<\Phi^{h}\end{cases} \tag{48}$$

$$q_{it}^{h}=\beta E_{t}\frac{\Lambda_{t+1}}{\Lambda_{t}}\left\{\frac{1}{P_{t+1}}\frac{\partial P_{it+1}^{h}}{\partial K_{it+1}^{h}}e_{it+1}^{h}K_{it+1}^{h}+\frac{P_{it+1}^{h}}{P_{t+1}}e_{it+1}^{h}+(1-\delta)\,q_{it+1}^{h}\right\}. \tag{49}$$

The Capital-Good Firm. A representative capital-good producer chooses employment to maximize profits $\left\{P_{t}^{I}I_{t}-W_{t}N_{t}\right\}$ subject to $I_{t}=N_{t}^{\alpha}$. The optimal labor demand and capital-good supply are given by $N_{t}=\left(\alpha\frac{P_{t}^{I}}{W_{t}}\right)^{\frac{1}{1-\alpha}}$ and $I_{t}=\left(\alpha\frac{P_{t}^{I}}{W_{t}}\right)^{\frac{\alpha}{1-\alpha}}$. Market clearing for the capital good implies $I_{t}=\int_{0}^{\theta}I_{it}^{SOE}di+\int_{\theta}^{1}I_{it}^{POE}di$.

The Household. A representative household solves

$$\max E_{0}\sum_{t=0}^{\infty}\beta^{t}\left\{\left[\log\left(C_{t}+\Delta\right)+\gamma\log\frac{M_{t}}{P_{t}}-N_{t}\right]\right\} \tag{50}$$

such that

$$C_{t}+\sum_{h}\left(\frac{1}{P_{t}}\int Q_{it}^{h}s_{it+1}^{h}di\right)+\frac{M_{t+1}}{P_{t}}\leq\frac{M_{t}}{P_{t}}+\frac{W_{t}}{P_{t}}N_{t}+\sum_{h}\left(\int\frac{\left(Q_{it}^{h}+d_{it}^{h}\right)}{P_{t}}s_{it}^{h}di\right)+\frac{\Pi_{t}}{P_{t}} \tag{51}$$

$$C_{t}\geq\Delta \tag{52}$$

$$N_{t}\geq 0. \tag{53}$$

The first-order conditions are given by

$$\frac{1}{C_{t}+\Delta}+\mu_{t}^{c}=\Lambda_{t} \tag{54}$$

$$\frac{\Lambda_t}{P_t} = \beta \frac{\Lambda_{t+1}}{P_{t+1}} + \beta\gamma \frac{1}{M_{t+1}} \tag{55}$$

$$1 = \frac{W_t}{P_t}\Lambda_t + \mu_t^N \tag{56}$$

$$\frac{Q_{it}^h}{P_t} = \beta \frac{Q_{it+1}^h + d_{it+1}^h}{P_{t+1}}, \quad h = \{SOE, POE\}. \tag{57}$$

Note that if SOEs are less efficient because of higher fixed production costs, they will pay lower dividends to households than POEs. However, this does not necessarily imply that the demand for equity shares of SOEs is zero, because a lower dividend does not imply a lower rate of return to equities, which is given by the dividend-to-price ratio $\frac{Q_{t+1}^h + d_{t+1}^h}{Q_t^h}$. In particular, the dividend-to-price ratio $\frac{Q_{t+1}^h + d_{t+1}^h}{Q_t^h} = \frac{\frac{1}{1-\beta}d^h + d^h}{\frac{1}{1-\beta}d^h} = 2 - \beta = 1 + r$ in the steady state, so it is independent of dividends and firm types in this model. Therefore, as long as SOEs can pay positive dividends, households will hold the equities of both SOEs and POEs.

Proposition 3 *Assume $K_{i0}^h = K_0 \in (0, K^*]$ for all intermediate-goods firms and $\bar{M} > \frac{\beta\gamma\Delta}{1-\beta}\frac{\Phi^{SOE}}{K_0}$. Suppose that the SOE sector can commit to producing output regardless of profits and that monetary policy is accommodative with an adequate money supply; then the full-employment equilibrium is the only equilibrium and, at this equilibrium, both SOEs and POEs can make positive profits.*

Proof. See Appendix III. ■

The key intuition is that the existence of SOEs can prevent aggregate demand from collapsing, thereby making money injections effective in raising aggregate prices, and thus not only preventing economic meltdown but also keeping all firms profitable. The public sector is profit-driven in normal times when the private sector (market) is functioning properly, albeit less efficiently than the private sector. But when the private sector is about to collapse (or has collapsed) due to pessimistic expectations of future market sales, the public sector can maintain its operations and defy the self-fulfilling expectations of the private sector (or revive the private sector even if it has collapsed). This means that as long as the public sector is in operation, the Keynesian equilibrium can no longer be possible or self-fulfilling despite large exogenous shocks to the economy.

6 Conclusion

This paper provides a case study for the sharp differences in the effectiveness of stimulus packages in combating the financial crisis in the industrial world and in China. We attempt to explain why the industrial world entered a long period of recession (jobless recovery) with large permanent losses in GDP following the crisis, whereas China resumed its long-run growth path shortly after the shock with only minor and temporary losses in GDP despite the global trade collapse. We argue that a key difference between China's stimulus package and the Western stimulus packages is that the Chinese package is fiscal in nature whereas those in industrial countries are monetary in nature. We then also provide a theoretical model to rationalize the empirical evidence and support our arguments.

China may be lucky to have had a large enough SOE sector available at the onset of the financial crisis to help defend its economy from a crushing slowdown.[22] Although there is evidence that part of the 4 trillion RMB stimulus package in China was directed to the real estate property market instead of infrastructure and the manufacturing sector (Deng et. al., 2011), the policy is considered a success as long as it stimulated aggregate demand and prevented a Western-style Great Recession or jobless recovery. No one knew what would happen if China had not acted decisively in a countercyclical manner by using fiscal policies. For a massive developing country with more than 1.3 billion mouths to feed in the middle of an uphill great transition, China cannot afford a Latin-American-style or Japanese-style "Lost Decade." A great recession with jobless recovery in China would be catastrophic and could push China forever into a low-middle-income trap that many Latin American and South-East Asian countries have experienced during their industrialization (transition) process. Despite the unpleasant housing bubble (see Chen and Wen, 2017), at least now China can have a better chance to continue growing at a high speed (projected as around 7% per year) for another couple of decades to come. Compared with the worst possibility of a lost decade without the decisive countercyclical stimulus packages carried through by the SOEs, the cost of the housing bubble may be minor as long as China can manage to achieve a soft landing in controlling the bubble (see Chen and Wen, 2017).

The crucial lesson learned from China is not necessarily that SOEs *per se* are desirable, but rather that credible fiscal policies matter in eliminating a coordination-failure crisis,

[22] In industrial countries, even if governments are willing and able to increase expenditures to stimulate the economy, it takes time and effort to identify shovel-ready projects at a critical moment when immediate actions are needed. The Chinese government solved the identification problem of finding immediate shovel-ready projects by using the SOEs. That is, because SOEs exist, identifying shovel-ready projects is not an issue in China.

whereas purely monetary (or half-hearted fiscal) policies do not. We believe that the inability to implement aggressive and decisive fiscal policies in Western countries explains the stubborn persistence of the Great Recession in the United States and jobless recoveries in Europe, in contrast to the rapid economic recovery in China after the global financial crisis as well as the Great Recovery in the United States (in the 1930s-40s) following the Great Depression.

References

[1] Aiginger, K. 2011. Why Performance Differed Across Countries in the Recent Crisis. WIFO Working Paper No. 2011-387.

[2] Chen, Kaiji and Yi Wen, 2017, The Great Housing Boom in China, *American Economic Journal: Macroeconomics*, 9(2), pp. 73-114, April 2017.

[3] Christiano, Lawrence, Martin Eichenbaum and Sergio Rebelo, 2011, When is the Government Spending Multiplier Large? Journal of Political Economy 119(2), 78-121.

[4] Cogan, John F. and John B. Taylor, 2010, "What the government purchases multiplier actually multiplied in the 2009 Stimulus Package." Working Paper, http://www.stanford.edu/~johntayl/Cogan%20Taylor%20multiplicand%2010-25.pdf.

[5] Deng, Y., R. Mock, J. Wu, and B. Yeung. 2011. Monetary and Fiscal Stimuli, Ownership Structure, and China's Housing Market. NBER Working Paper No. w16871.

[6] Dong, Feng and Yi Wen, 2017, Optimal Monetary Policies under Negative Interest Rate, Federal Reserve Bank of St. Louis, Working Paper 2017-019A, May 2017.

[7] Eggertsson, G. and P. Krugman. 2012. Debt, Deleveraging, and the Liquidity Trap: A Fisher-Minsky-Koo Approach. Quarterly Journal of Economics 127(3): 1469-1513.

[8] Farmer, Roger, 2012, The Stock Market Crash of 2008 Caused the Great Recession: Theory and Evidence. Journal of Economic Dynamics and Control 36, 697-707.

[9] Farmer, Roger, 2013, Animal Spirits, Financial Crises and Persistent Unemployment. Economic Journal 23(568): 317-340.

[10] Fawley, B. and C. Neely. 2013. Four Stories of Quantitative Easing. Federal Reserve Bank of St. Louis Review 95 (1): 51-88.

[11] Fisher, I. 1933. The Debt-Deflation Theory of Great Depressions. Econometrica 1(4): 337-357.

[12] Friedman, M. and A. Schwartz, 1963. A Monetary History of the United States, 1867-1960. Princeton University Press, Princeton, NS.

[13] International Institute for Labour Studies. 2011. A Review of Global Fiscal Stimulus. EC-IILS Joint Discussion Paper Series No. 5.

[14] IMF. 2009a. Group of Tewnty: Meeting of the Ministers and Central Bank Governors, March 13-14, 2009. London, U.K. http://www.imf.org/external/np/g20/pdf/031909a.pdf.

[15] IMF. 2009b. The Size of the Fiscal Expansion: An Analysis for the Largest Countries. http://www.imf.org/external/np/pp/eng/2009/020109.pdf.

[16] IMF. 2010. World Economic Outlook April 2010: Rebalancing Growth. International Monetary Fund, Washington, DC.

[17] Keynes, J. 1936. The General Theory of Interest, Employment and Money. Macmillan, New York.

[18] Krugman, P. 1998. It's Baaack: Japan's Slump and the Return of the Liquidity Trap. Brookings Papers on Economic Activity 29(2): 137-206.

[19] Lau, L., Y. Qian, and G. Roland. 2000. Reform without Losers: An Interpretation of China's Dual-Track Approach to Transition. Journal of Political Economy 108(1): 120-143.

[20] Lin, J., F. Cai, and Z. Li. 1998. Competition, Policy Burdens, and State-owned Enterprise Reform. American Economic Review 88(2): 422-27.

[21] Melitz, Marc. The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. Econometrica, 2003, 71(6): 1695-1725.

[22] Lucas, R.E. Jr., 2000. Inflation and Welfare. Econometrica 68, 247-274.

[23] Reinbold, Brian and Yi Wen, 2017, Negative Interest Rates, manuscript, Federal Reserve Bank of St. Louis

[24] Wen, Yi, 2013, Evaluating Unconventional Monetary Policies—Why Aren't They More Effective? Federal Reserve Bank of St. Louis Working Paper No.2013-028B.

Appendix I. Proof of Proposition 1.

Proof. First, consider the full-employment equilibrium.

Suppose the demand for intermediate goods is expected to be sufficiently high that revenues can cover the fixed costs of production under full capacity utilization, $P_{it}K_{it} > \Phi$; then the FOCs of the intermediate-goods firms imply $e_{it} = 1$. The marginal product of capital is given by $\left(\frac{\partial P_{it+1}}{\partial K_{it+1}} e_{it+1} K_{it+1} + P_{it+1} e_{it+1}\right) = \left(1 - \frac{1}{\sigma}\right)$ in the steady state. Equation (20) implies that the asset price of Lucas trees is $P^I = q = \frac{\beta\left(1-\frac{1}{\sigma}\right)}{1-\beta} > 0$. The aggregate dividends of the intermediate-goods firms are $D_t = \bar{K} - \Phi > 0$, the household's share of firms' equity $s_{it} = 1$ for all i in equilibrium, so the household budget constraint becomes (note aggregate investment $I_t = K_{t+1} - K_t = 0$)

$$\begin{aligned} C_t &= \int \left(Q_{it} + d_{it}\right) s_{it} di - \int Q_{it} s_{it+1} di + \Pi_t && (58) \\ &= \int \left(p_{it} y_{it} - \mathbf{1}_{it}\Phi - P_t^I I_{it}\right) di + \left[Y_t - \int p_{it} y_{it}\right] \\ &= Y_t - \Phi \int \mathbf{1}_{it} di - P_t^I I_t = \left[\int \left(e_{it} K_{it}\right)^{\frac{\sigma-1}{\sigma}} di\right]^{\frac{\sigma}{\sigma-1}} - \Phi \int \mathbf{1}_{it} di \\ &= \bar{K} - \Phi > 0. \end{aligned}$$

The steady-state value of the firm is given by

$$V(K) = \frac{1}{1-\beta} D = \frac{1}{1-\beta}\left(\bar{K} - \Phi\right) > 0, \quad (59)$$

which is also the share price Q.

Now consider the coordination-failure Keynesian equilibrium.

Suppose that the intermediate-goods firms are pessimistic about their future demand because consumption demand on the final good Y is sufficiently low, and thus they expect the revenue to be unable to cover the fixed cost of production and investment expenditures from period t on (even at full-capacity utilization): $P_{it+j}K_{it+j} < \Phi$ for $j \geq 0$.[23] This means that the value of the firm would be negative if it continues to operate, thus setting $e_{it+j} = 0$ and $I_{it+j} = 0$ for all periods $j \geq 0$ is optimal. Equation (20) can be written as

$$q_{it} = \beta E_t \sum_{j=0}^{\infty} \beta^j \frac{\Lambda_{t+1+j}}{\Lambda_t} P_{it+1+j} e_{it+1+j} = 0, \quad (60)$$

[23] We treat the equality $P_i K_i = \Phi$ as a borderline case.

which implies that all firms' asset prices q_{it} collapse to zero immediately in period t when the expected flow of future dividends is choked off, $P_{it+j}e_{it+j}K_{it+j} - \mathbf{1}_{it+j}\Phi = 0$ for all $j > 0$. Namely, given any price of investment good P_t^I, the value of newly installed capital is given by $q_t = 0$; hence, the intermediate-goods firms will not undertake any investment, thus opting to set $I_{t+j} = 0$ for all $j \geq 0$. Without effective investment demand in the present and the future, the asset price P_t^I will decrease to zero.[24]

Since the firm value (stock price) collapses to zero with

$$Q_t = V(K_t) = E_t \sum_{j=0}^{\infty} \beta^j \frac{\Lambda_{t+j}}{\Lambda_t} \left\{ P_{t+j}e_{t+j}K_{t+j} - \mathbf{1}_{t+j}\Phi - P_{t+j}^I I_{t+j} \right\} = 0, \tag{61}$$

the household's budget constraint then implies that aggregate consumption demand is zero from period t on. Thus, firms' initial pessimistic expectation about consumption demand is self-fulfilled. That is, not undertaking any investment on the firm side (because of a pessimistic view of the future) can crash consumption demand by choking off household wealth. Thus, the household budge constraint collapses to zero:

$$C_t = \left[\int (e_{it}K_{it})^{\frac{\sigma-1}{\sigma}} di \right]^{\frac{\sigma}{\sigma-1}} - \Phi \int \mathbf{1}_{it} di = 0, \tag{62}$$

which is consistent with the goods-market clearing condition: $C_t = Y_t - \mathbf{1}_t\Phi = 0$. ■

Appendix II. Proof of Proposition 2.

Proof. Consider the full-employment equilibrium first. Suppose $P_{it}K_{it} = P_t Y_t^{\frac{1}{\sigma}} K_{it}^{1-\frac{1}{\sigma}} > \Phi$ or equivalently $P_t = P^* > \frac{\Phi}{K}$ for all t, then $e = 1$, $\frac{P^I}{P^*} = q = \frac{\beta\left(1-\frac{1}{\sigma}\right)}{1-\beta(1-\delta)}$, $\delta K = I = \left(\alpha \frac{P^I}{W}\right)^{\frac{\alpha}{1-\alpha}}$, and $C = K - \frac{\Phi}{P^*}$. Since $C > 0$ and $N > 0$, we must have $\mu^c = \mu^N = 0$. Equation (38) implies $(1-\beta)\frac{1}{P^*(C+\Delta)} = \frac{\beta\gamma}{\bar{M}}$, so $P^* = \frac{1-\beta}{\beta\gamma}\frac{\bar{M}}{C+\Delta} = \frac{1-\beta}{\beta\gamma}\frac{\bar{M}}{K+\Delta-\frac{\Phi}{P^*}}$, which implies

$$P^* = \frac{\frac{1-\beta}{\beta\gamma}\bar{M} + \Phi}{K + \Delta} \tag{63}$$

Equations (35) and (36) imply $\frac{1}{C+\Delta} = \Lambda = \frac{P^*}{W}$, or

$$C + \Delta = \frac{W}{P^*}. \tag{64}$$

[24] Since the zero investment demand is caused by $q_t = 0$, we have that q_t approaches zero before (or faster than) P_t^I; thus, we have the limiting properties $\lim_{t\to\infty} \frac{q_t}{P_t^I} = 0$ and $\lim_{t\to\infty} P_t^I = 0$.

The steady-state capital stock K is determined by the following equation:

$$\delta K^{*}=I=\left(\alpha\frac{P^{I}}{W}\right)^{\frac{\alpha}{1-\alpha}}=\left(\alpha\frac{P^{I}/P^{*}}{\left[K^{*}-\frac{\Phi}{P^{*}}+\Delta\right]}\right)^{\frac{\alpha}{1-\alpha}}=\left(\frac{\alpha\beta\left(1-\frac{1}{\sigma}\right)}{1-\beta\left(1-\delta\right)}\frac{\frac{\frac{1-\beta}{\beta\gamma}\bar{M}+\Phi}{\frac{1-\beta}{\beta\gamma}\bar{M}}}{\left(K^{*}+\Delta\right)}\right)^{\frac{\alpha}{1-\alpha}}, \quad (65)$$

where the last equality is obtained by using equation (63). Equation (65) solves uniquely for $K^{*}>0$ as a function of money supply $\bar{M}$. Given K^{*}, equation (63) determines $P^{*}>0$. Equation (63) also implies $P^{*}>\frac{\Phi}{K^{*}}$ since by assumption $\bar{M}>\frac{\beta\gamma}{1-\beta}\frac{\Delta}{K_{0}}\Phi\geq\frac{\beta\gamma}{1-\beta}\frac{\Delta}{K^{*}}\Phi$.

Now consider the Keynesian equilibrium. Suppose that the intermediate-goods firms are pessimistic about current and future aggregate consumption demand, e.g., Y is sufficiently low, and thus they expect the revenue $P_{i}\left(Y\right)Y_{i}=PY^{\frac{1}{\sigma}}Y_{i}^{1-\frac{1}{\sigma}}$ is not able to cover the fixed cost of production and investment expenditures from period t on (even at full-capacity utilization): $P_{it+j}K_{it+j}<\Phi$ for $j\geq 0$. This means that the value of the firm would be negative if it continues to operate, thus setting $e_{it+j}=0$ and $I_{it+j}=0$ for all future periods $j\geq 0$ is optimal. Equation (30) can be written as

$$q_{it}=\beta E_{t}\sum_{j=0}^{\infty}\left[\beta\left(1-\delta\right)\right]^{j}\frac{\Lambda_{t+1+j}}{\Lambda_{t}}P_{it+1+j}e_{it+1+j}=0 \quad (66)$$

which implies that the firm asset prices q_{it} collapse to zero immediately in period t when expected flow of future dividends is choked off. Namely, given any real price of investment good $\frac{P_{t}^{I}}{P_{t}}$, the real value of newly installed capital is given by $q_{t}=0$. Hence, the intermediate-goods firms will not undertake any investment, thus opting to set $I_{t+j}=0$ for all $j\geq 0$. Without effective investment demand in the present and the future, the real capital-goods price $\frac{P_{t}^{I}}{P_{t}}$ will collapse too.[25] With the asset prices $q_{t+j}=0$ for all $j\geq 0$, equation (18) implies that the multiplier π_{t+j} approaches zero from above: $\lim_{j\to\infty}\pi_{t+j}=\lim_{j\to\infty}\frac{P_{t+j}^{I}}{P_{t+j}}=0$, which is consistent with $I_{t+j}=0$ even in the limit as $j\to\infty$.

Given that the demand for investment good is zero, the capital-good producer opts to shut down production immediately regardless of the price of capital good and the wage rate, so the demand for labor $N_{t+j}=0$ for all $j\geq 0$. Notice that even if prices are such

[25]Since the zero-investment demand is caused by $q_{t}=0$, we have that q_{t} approaches zero before (or faster than) $\frac{P_{t}^{I}}{P_{t}}$ does; thus, we have the limiting properties $\lim_{t\to\infty}\frac{q_{t}}{P_{t}^{I}/P_{t}}=0$ and $\lim_{t\to\infty}\frac{P_{t}^{I}}{P_{t}}=0$.

that production is profitable for the capital-good producer (i.e., $\frac{P_t^I}{P_t}$ is high and $\frac{W_t}{P_t}$ is low), the supply of capital good is still zero because the zero demand for the capital good by intermediate-goods firms does not hinge on $\frac{P_t^I}{P_t}$. A zero labor demand in the capital-good sector means that (i) the household real wage income is zero from period t on, $\frac{W_{t+j}}{P_{t+1}} N_{t+j} = 0$ for all $j \geq 0$, and (ii) the real wage rate also fall continuously to clear the labor market, so in the steady state we must have $\lim_{t \to \infty} \frac{W_t}{P_t} = 0$.[26] Notice that even if the nominal wage is sticky so that $\lim_{t \to \infty} \frac{W_t}{P_t} > 0$, our results continue to hold because with positive wage costs, the capital-good producer has even less incentive to hire. Hence, equation (23) remains valid.

Since the firm value (stock price) collapses to zero with

$$Q_t = V(K_t) = E_t \sum_{j=0}^{\infty} \beta^j \frac{\Lambda_{t+j}}{\Lambda_t} \frac{1}{P_{t+j}} \left\{ P_{t+j} e_{t+j} K_{t+j} - \mathbf{1}_{t+j} \Phi - P_{t+j}^I I_{t+j} \right\} = 0, \tag{67}$$

and (with zero labor demand) the household's budget constraint then implies that aggregate consumption demand is zero from period t on, then firms' initial pessimistic expectations about future consumption demand are self-fulfilled. Thus, the household budge constraint collapses to zero:

$$C_t = \frac{W_t}{P_t} N_t + \left(\frac{P_t^I}{P_t} I_t - \frac{W_t}{P_t} N_t \right) + \left[\int \left(e_{it} K_{it} - \mathbf{1}_{it} \frac{\Phi}{P_t} - \frac{P_t^I}{P_t} I_{it} \right) di \right] = e_t K_t - \mathbf{1}_t \frac{\Phi}{P_t} = 0, \tag{68}$$

which is consistent with the goods-market clearing condition: $C_t = Y_t - \mathbf{1}_t \frac{\Phi}{P_t} = 0$.

By the household FOC in equations (35) and (36),

$$\left(\frac{1}{C_t + \Delta} + \mu_t^c \right) \frac{W_t}{P_t} = 1 - \mu_t^N, \tag{69}$$

where $\mu_t^c \geq 0$, $C_t = 0$ and $\lim_{t \to \infty} \frac{W_t}{P_t} = 0$ together imply $\lim_{t \to \infty} \mu_t^N = 1$, which is consistent with $N = 0$. The allocation $\{Y, e, I, C, N\} = 0$ with $\lim_{t \to \infty} \frac{P_t^I}{P_t} = \lim_{t \to \infty} \frac{W_t}{P_t} = 0$ is therefore indeed a self-fulfilling equilibrium. Equation (38) implies $\Lambda = \beta \frac{P_t}{P_{t+1}} \Lambda + \beta \gamma \frac{P_t}{P_{t+1}} \frac{1}{m_{t+1}}$, where m_t denotes real money demand. Note that $\frac{P_t}{P_{t+1}} = \frac{1}{\beta}$ and $\lim_{t \to \infty} m_{t+1} = \infty$ are consistent with the Keynesian (the liquidity trap) equilibrium. ■

[26] Since the collapse of the labor market (demand side) is caused by the collapse of the capital-goods market (demand side), P_t^I approaches zero before W_t does; thus, we have the limiting property $\lim_{t \to \infty} \frac{P_t^I}{W_t} = 0$, which is consistent with equation (23).

Appendix III. Proof of Proposition 3.

Proof. When the SOE sector can commit to produce output and undertake investment even at negative profits, then the aggregate consumption demand (or final-good demand) will be strictly positive. In this case, the revenues of intermediate-goods firms $P_t Y_t^{\frac{1}{\sigma}} \left(e_{it}^h K_{it}^h\right)^{1-\frac{1}{\sigma}}$ will be strictly positive even if POEs do not produce; therefore, the central bank can use monetary policies to support a high enough aggregate price level P_t at which both POEs and SOEs are profitable (i.e., with revenues exceeding fixed costs for both types of firms).

The details of the proof are as follows. First, suppose in equilibrium $P_t = P^* > \frac{\Phi^{SOE}}{K}$ for all t, then since $\Phi^{SOE} > \Phi^{POE}$, we have $e^{SOE} = e^{POE} = 1$, $\frac{P^I}{P^*} = \frac{q}{P^*} = \frac{\beta\left(1-\frac{1}{\sigma}\right)}{1-\beta(1-\delta)}$, and $\delta K^h = I^h = \left(\alpha \frac{P^I}{W}\right)^{\frac{\alpha}{1-\alpha}}$. Clearly, since the two types of firms face the same competitive prices P^I and nominal wage W, the desired investment rate and steady-state capital stock are identical, $K^{POE} = K^{SOE}$; consequently, the output levels Y_{it}^h are also identical: $Y_{it}^{POE} = Y_{it}^{SOE} = Y_t$. Equations (54) and (56) imply

$$C + \Delta = \frac{W}{P^*}. \tag{70}$$

Equation (55) implies $P^* = \frac{1-\beta}{\beta\gamma} \frac{\bar{M}}{K - \frac{\Phi}{P^*} + \Delta}$, which implies

$$P^* = \frac{\frac{1-\beta}{\beta\gamma}\bar{M} + \Phi}{K^* + \Delta}, \tag{71}$$

where the steady-state optimal capital stock K^* is determined by the following equation:

$$\delta K^* = \left(\frac{\alpha\beta\left(1-\frac{1}{\sigma}\right)}{1-\beta\left(1-\delta\right)} \frac{\frac{\frac{1-\beta}{\beta\gamma}\bar{M}+\Phi}{\frac{1-\beta}{\beta\gamma}\bar{M}}}{\left(K^* + \Delta\right)} \right)^{\frac{\alpha}{1-\alpha}}, \tag{72}$$

which is identical to equation (65). Given K^*, equation (71) implies that $P^* > \frac{\Phi^{SOE}}{K^*}$ since $\bar{M} > \frac{\beta\gamma\Delta}{1-\beta}\frac{\Phi^{SOE}}{K_0}$ by assumption. Therefore, it is profitable for both POEs and SOEs to produce.

Second, we show that as long as SOE firms commit to operating (producing and investing) regardless of profits, then the allocation at which POEs do not operate (produce and invest) is not an equilibrium. We prove this by contradiction.

(i) Suppose $K^{POE} = K^{SOE} = K^*$ and $P_t < \frac{\Phi^{POE}}{K^*}$ for all t such that it is not profitable for either POEs or SOEs to produce, but by assumption SOEs will always operate despite negative profits. Since SOEs can invest at the otherwise optimal rate $I = \left(\alpha \frac{P^I}{W}\right)^{\frac{\alpha}{1-\alpha}}$ and consequently the capital-goods firm can hire workers at the nominal wage W, the representative household can sustain consumption at least at the level of $C = K^{SOE} - \frac{\Phi^{SOE}}{P^*}$. If $\bar{M} > \frac{\beta\gamma\Delta}{1-\beta}\frac{\Phi^{SOE}}{K^{SOE}}$ by assumption, then $C > 0$ and $P_i = P^* \left(Y^{SOE}\right)^{\frac{1}{\sigma}} \left(Y_i^{SOE}\right)^{1-\frac{1}{\sigma}} = P^* > \frac{\Phi^{SOE}}{K^{SOE}} = \frac{\Phi^{SOE}}{K^*}$. But $P^* > \frac{\Phi^{SOE}}{K^*}$ implies $P^* > \frac{\Phi^{POE}}{K^*}$, which is a contradiction to our initial hypothesis that $P_t < \frac{\Phi^{POE}}{K^*}$. The intuition is that as long as some intermediate-goods firms are producing, the aggregate output Y_t will be positive. Thus, with a sufficiently high level of the money supply, aggregate price level $P_t = \frac{\frac{1-\beta}{\beta\gamma}\bar{M} + \Phi^{SOE}}{K^* + \Delta} > \frac{\Phi^{SOE}}{K^*}$, so SOEs are profitable. Given that $\Phi^{SOE} > \Phi^{POE}$ by assumption, if the price level is high enough to profit SOE firms, it must also be high enough for the POE firms to make positive profits provided that the capital stock of POEs K_t^{POE} is no less than that of the SOEs, $K_t^{POE} \geq K_t^{SOE}$.

(ii) Suppose $K_t^{POE} < K_t^{SOE} = K^*$. Since investment is a jump variable, given the prospect of positive revenue in the SOE sector, the price level should be high enough to motivate POE firms to invest to the desired level K^* such that $P_t K^* > \Phi^{POE}$. Thus $P_t K^{POE} < \Phi^{POE}$ can never be an equilibrium.

(iii) Suppose $K_t^{POE} < K_t^{SOE} = K^*$ and that POE firms are borrowing constrained such that their capital stock cannot reach the desired level K^* instantaneously. In this case, the monetary authority can always inject enough money into the SOE sector to raise the price level so that POEs are profitable for arbitrarily low capital stock K_t^{POE}. Since capital K_t^{POE} will depreciate over time without investment, the longer the government waits after a recession shock to the private sector, the larger the money injection needed to raise the price level and make firms profitable. Thus, in this last case (with borrowing constraints), expansionary monetary policy and expansionary fiscal policy (keeping SOEs operative) must be combined to restore the full-employment equilibrium. This combined stimulus package or policy mix is exactly what was observed in China during the financial crisis. ■