Trends and Cycles in China's Macroeconomy[1]

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Introduction

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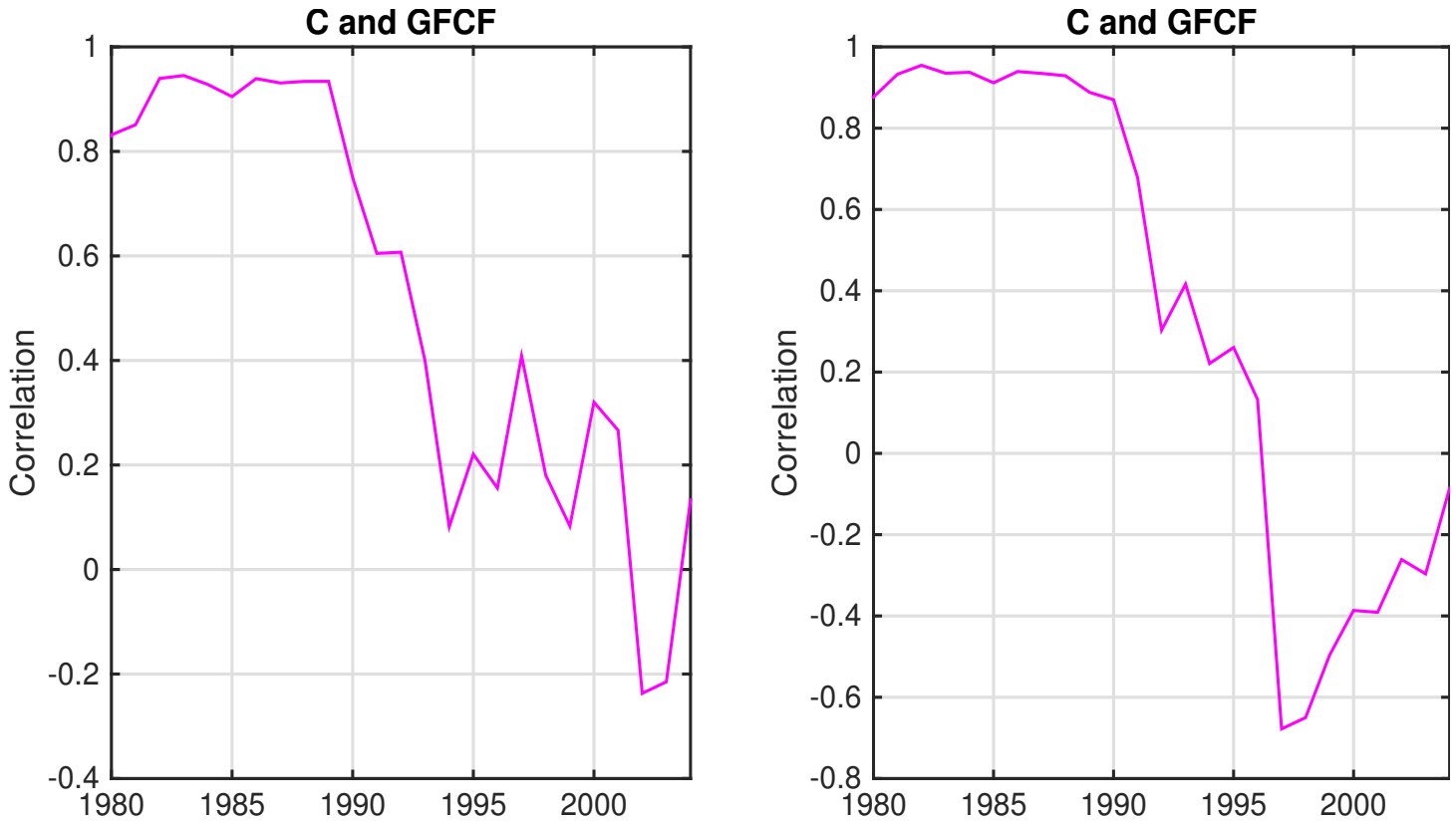
- Since the 1990s, both growth and cyclical fluctuations in China have changed their characteristics.
- The cyclical fluctuations manifest themselves after the 1997 financial crisis and most conspicuously after the 2008 financial crisis.
- Both growth and cyclical fluctuations are **deeply rooted in China's institutional arrangements**.
- Various reports from State Council, People's Bank of China, National Bureau of Statistics, and National Federation of Economic Ministry.

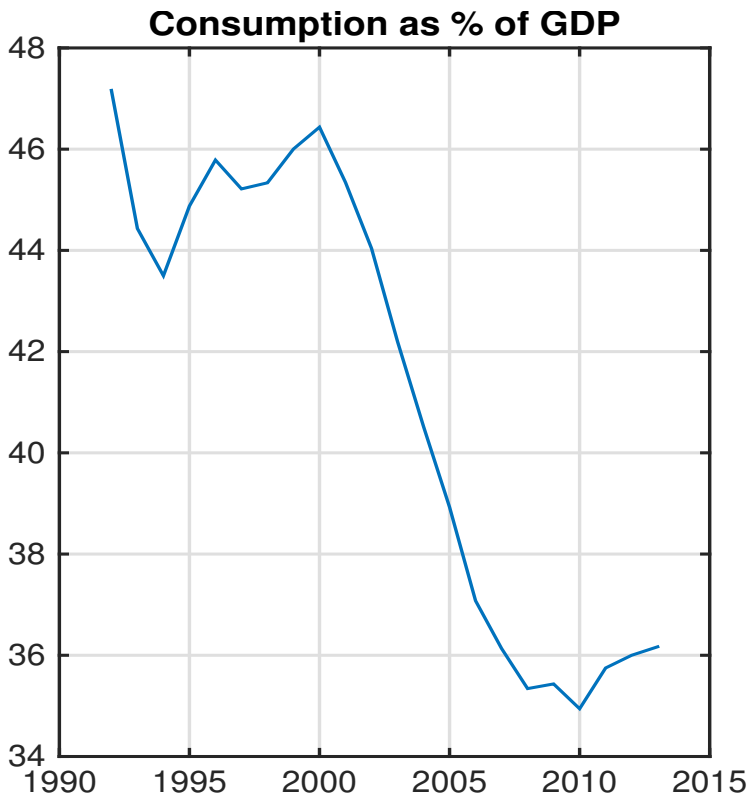
Stark cyclical patterns

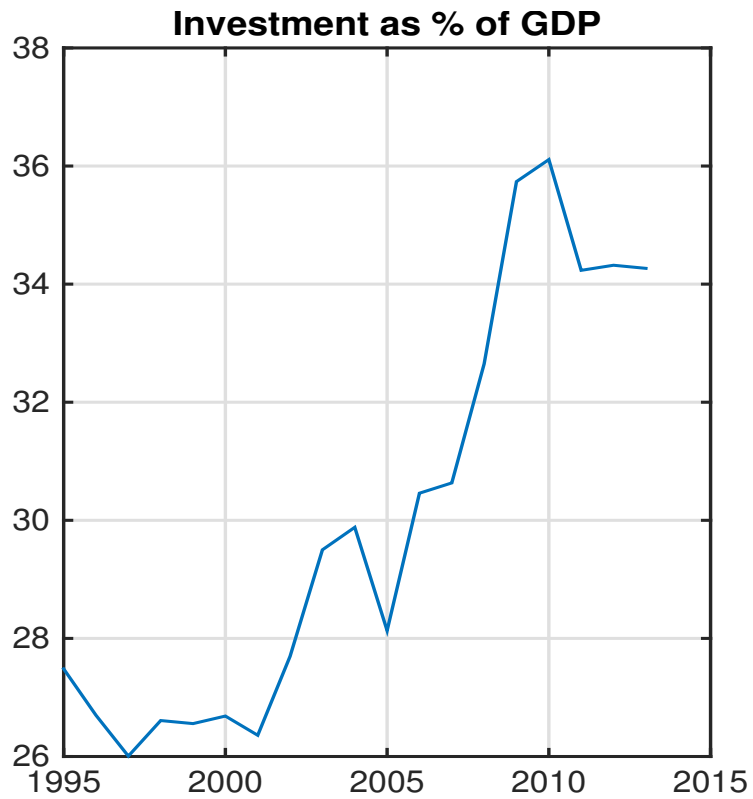


Time series of correlations with the 10-year moving window. The left-column graphs represent the correlation of annual growth rates. The right-column graphs represent the correlation of HP-filtered log annual values.

Something fundamental in China has changed since the late 1990s, but what?

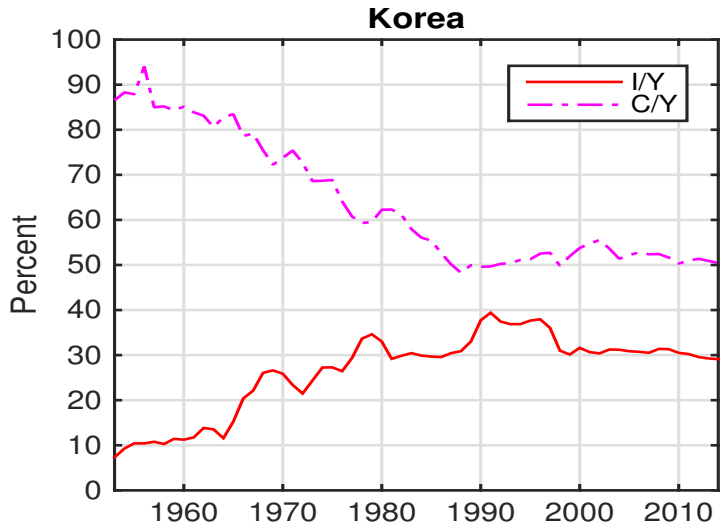
The obvious

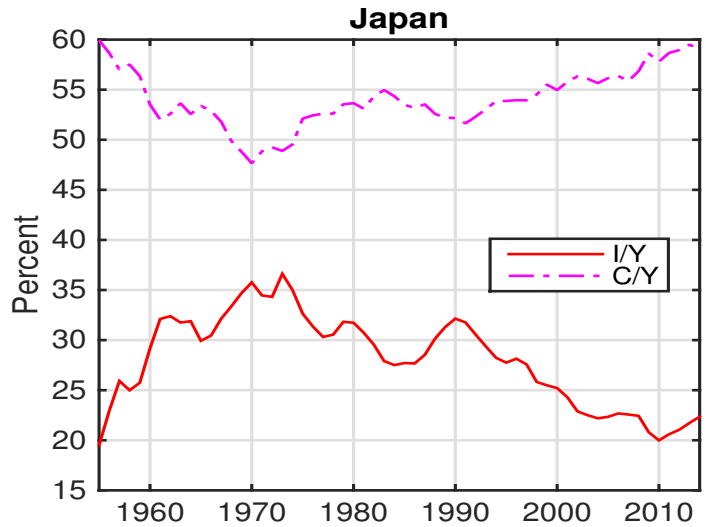


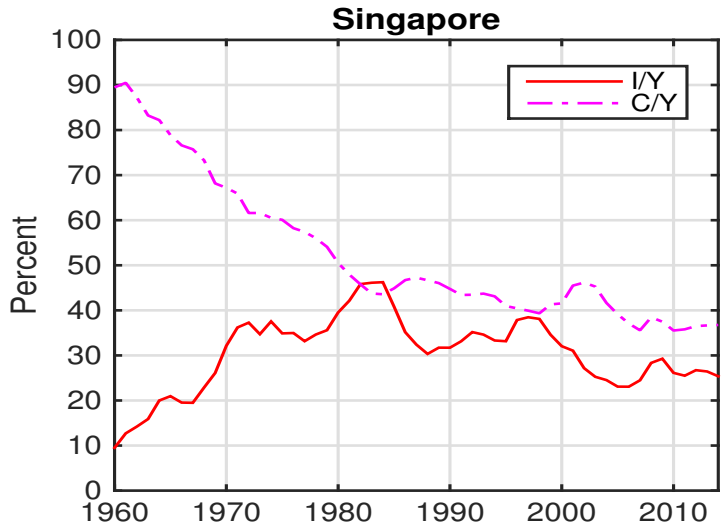


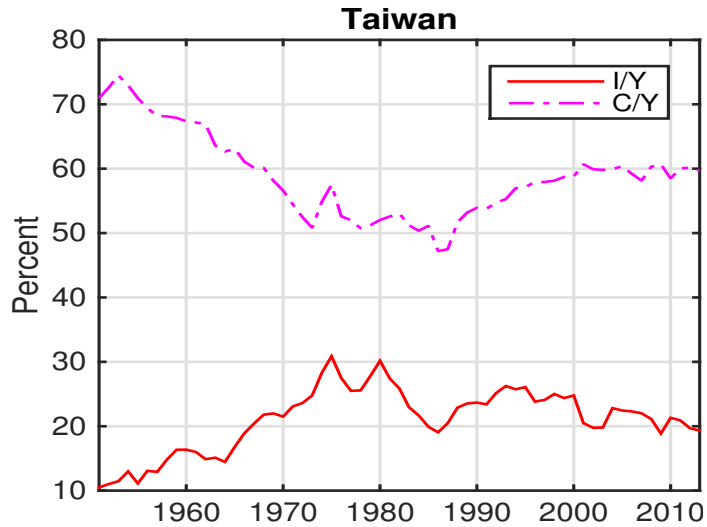
Raw annual data: trend patterns for household consumption, investment, GDP

Similar patterns in early years for Asian NICs



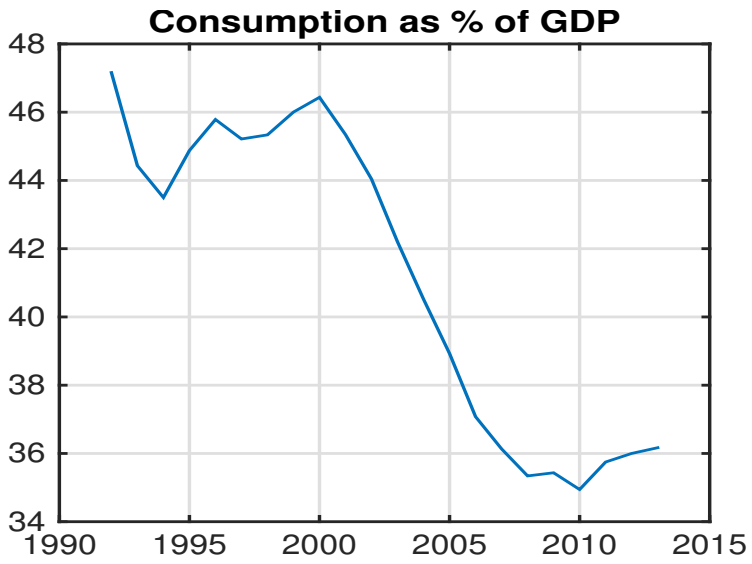


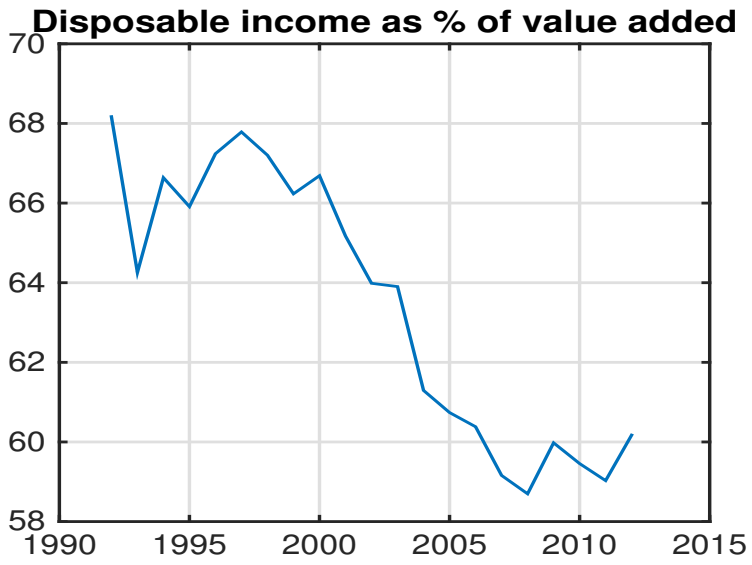




NICs: newly industrialized countries (Young 1995); C: private personal consumption; I: gross fixed domestic investment (gross fixed capital formation); Y: GDP. Source: CEIC.

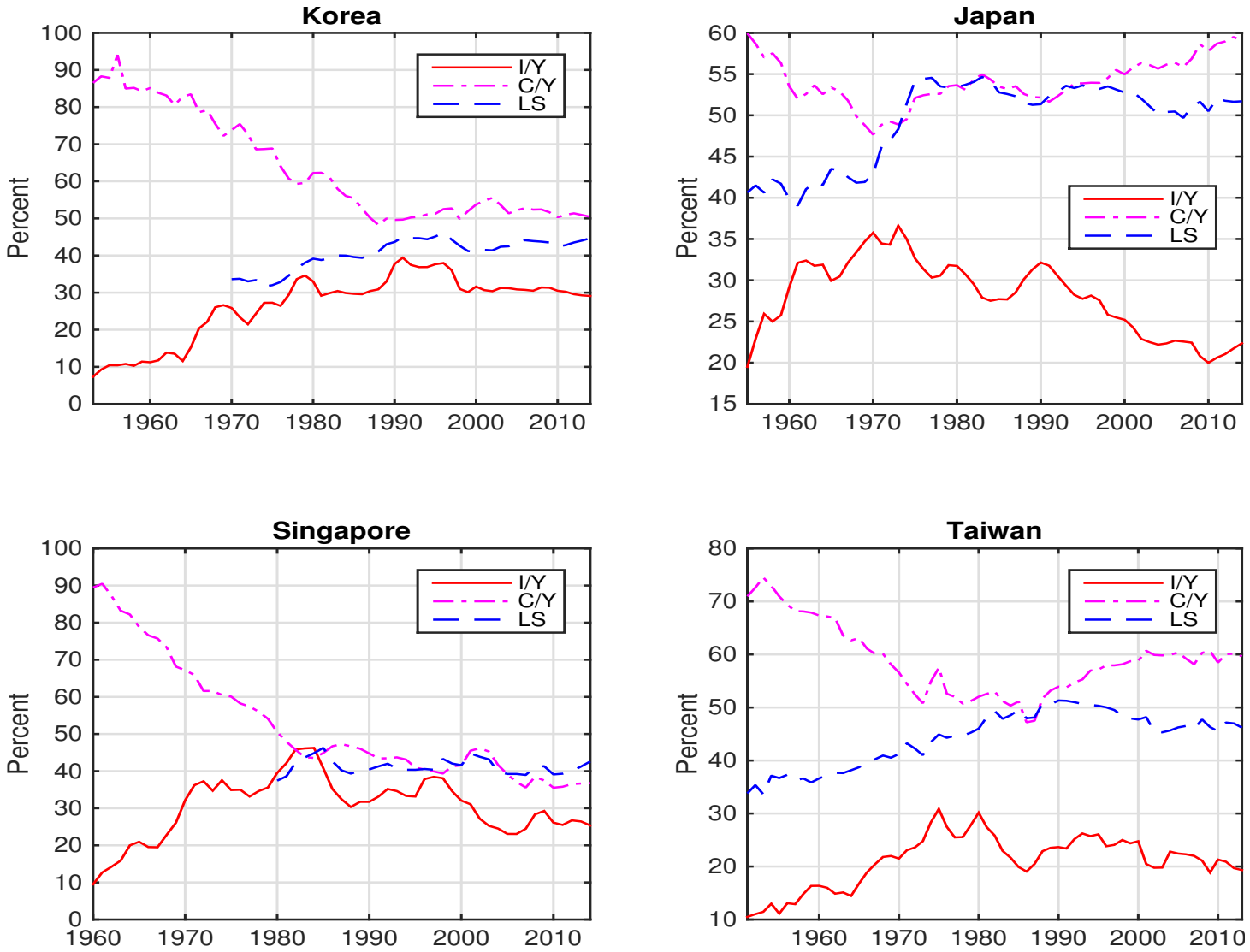
- What's so different about China?
- *Is it all about those stark cyclical fluctuations, but nothing new about trends?*





Raw annual data: trend patterns for household consumption, investment, GDP, labor share of income

International perspective



C: private personal consumption; I: gross fixed domestic investment (gross fixed capital formation); LS: labor income share; Y: GDP. Source: CEIC. Overall correlation between LS and I: 0.718 (Korea), -0.174 (Japan), 0.353 (Singapore), 0.740 (Taiwan). For labor share in Singapore in early years, see Young (1995).

Growth accounting

Growth accounting of China's economy

Growth rate (%)	1978-2011	1998-2011	1998-2007
GDP per worker	7.82	9.48	9.42
capital per worker	4.89	7.00	6.13
TFP	2.93	2.48	3.29
Contribution by capital deepening	62.3%	73.9%	65.1%

See also Brandt and Zhu (2010).

Sources of capital deepening

- Romalis (2004) finds that East Asian NIEs such as Korea, Singapore, Taiwan accumulated physical capital, their export structure also moved towards capital-intensive goods (the so-called "quasi-Rybczynski" effect in the international trade literature).
- Ventura (1997) shows how a small open economy can sustain rapid growth without a diminishing marginal product of capital by exporting capital-intensive goods.
- The disaggregate evidence of China, however, suggests the pattern of China opposite to other Asian NIEs.
- Between 1999 and 2007, according to Huang, Ju, and Yue (2015), the labor-intensive firms have increased their export shares and capital-intensive firms have reduced their export share; at the same the export share of firms has declined with their capital intensity.
- Thus, a divergence between the rising investment rate and the diminishing ability to export capital-intensive goods.

- So why has China's macroeconomy changed *so drastically* since the late 1990s for both trend and cycle?
- We need one coherent model that takes account *both growth and cyclical fluctuations*.

Existing literature

There is a serious lack of explanations for the Chinese cyclical fluctuations.

Existing explanations for the trends

- TFP stories in two-sector models (Acemoglu and Guerrieri 2008; Fernald and Neiman, 2011): TFP growth in capital-intensive industries $>$ TFP growth in labor-intensive industries.
- Relative price of investment stories in one-sector or two-sector models (Chang and Hornstein, 2015): declining.

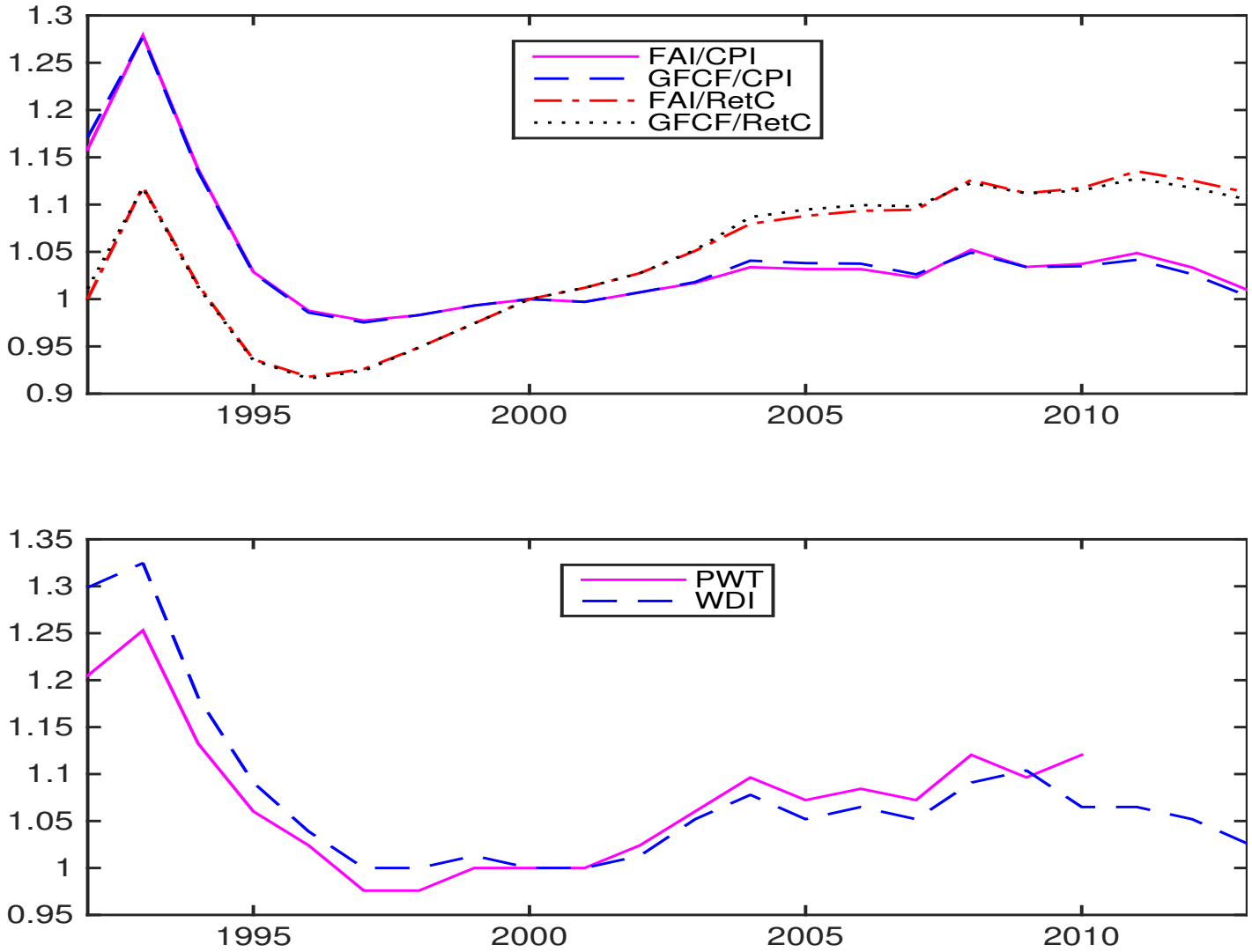
But China is different.

TFP in China

Existing evidence shows that

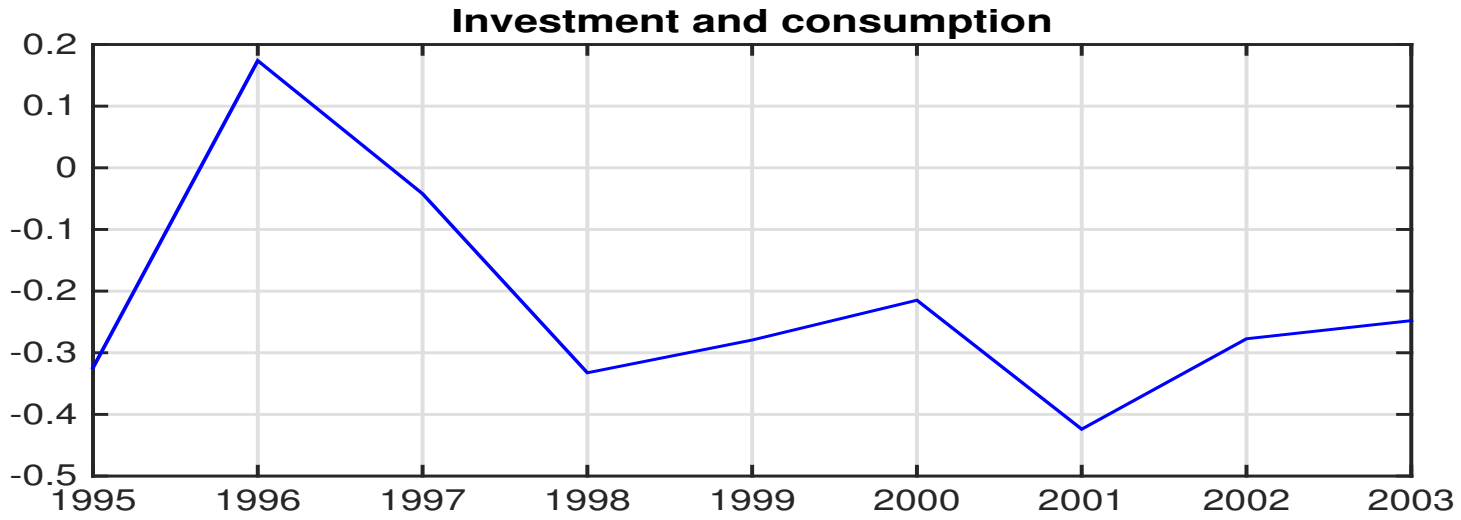
- TFP growth in the heavy sector is slower than TFP growth in the light sector (Chen, Jefferson, and Zhang, 2011; Ju, Lin, Liu, and Shi, 2015).
- Or at best, there is no clear-cut evidence.

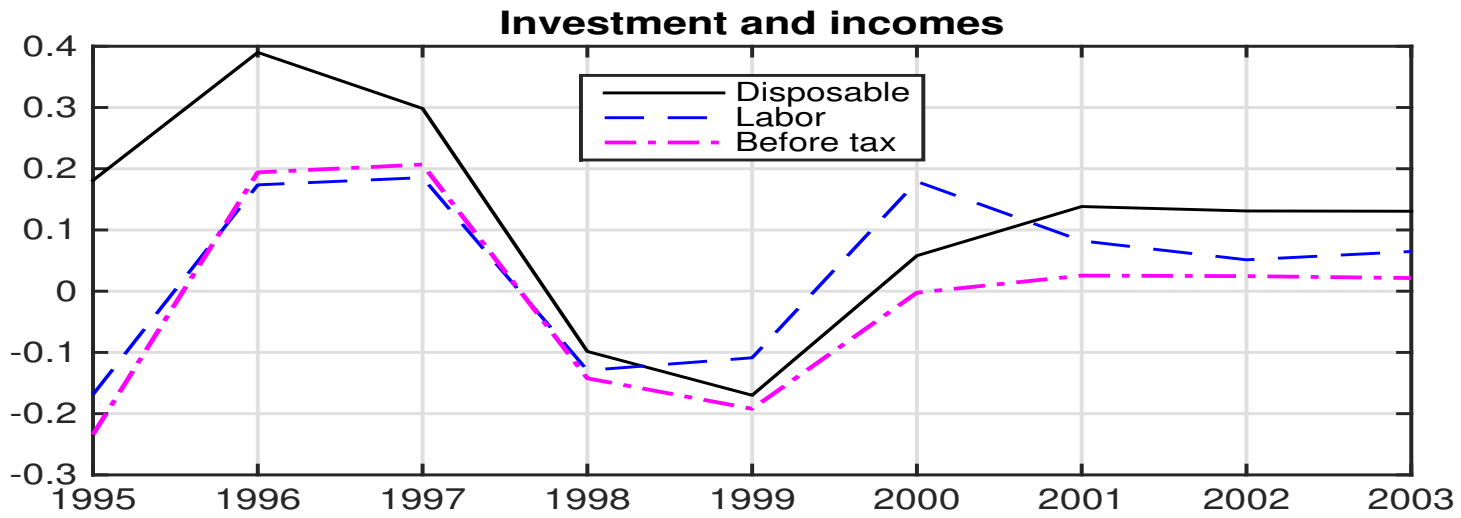
Relative prices of investment not declining in China



Various relative prices of investment goods to consumption goods, normalized to 1 for 2000. The PWT and WDI are suggested by Karabarbounis and Neiman (2014).

Striking cyclical patterns again



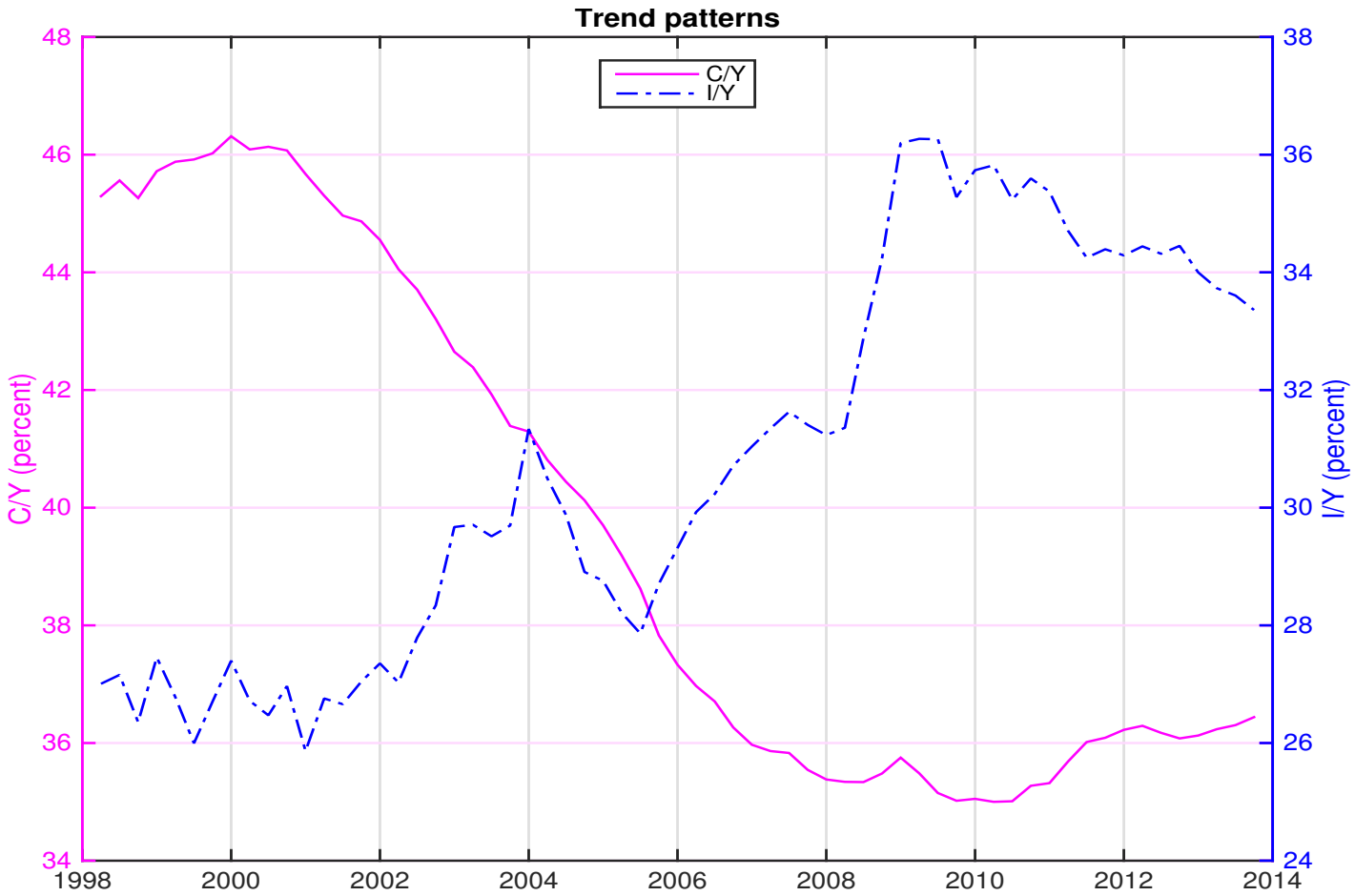


Correlations between HP-filtered log annual series with the moving window of 10 years.

Correlations between HP-filtered log quarterly series

Panel A: Real variables deflated by own price index		
	(C, I)	(I, LaborComp)
Correlation	−0.140	0.165
p-value	0.256	0.179
Panel B: Real variables deflated by GDP price deflator		
	(C, I)	(I, LaborComp)
Correlation	−0.035	0.165
p-value	0.775	0.178

Quarterly time-varying BVAR evidence



Trend patterns of household consumption and business investment, estimated from the 6-variable time-varying BVAR model, following King, Plosser, Stock, and Watson (1991). *Cyclical patterns* from various specifications: the correlation is (a) $(-0.55, -0.05)$ between investment and consumption, (b) $(-0.6, -0.23)$ between investment and labor income.

SOEs vs. POEs

- The Chinese economy has undergone two kinds of reforms in SOEs simultaneously, the so-called "grasp the large and let go of the small."
- One transition is privatization that allows many SOEs previously engaged in unproductive light industries to be privatized. This reform is the focus of Song, Storesletten, and Zilibotti (2011, SSZ).
- The other reform is a gradual concentration of SOEs in large industries, such as petroleum, commodities, electricity, water, and gas.

A different approach

- Fact 1: TFP growth in surviving SOEs has been higher than TFP growth in surviving POEs (Hsieh and Song, 2015).
- Fact 2: TFP growth in privatized firms has been higher than TFP growth in surviving POEs (Hsieh and Song, 2015).
- Discussions around SOEs vs. POEs have dominated in the literature on China.
- The SOE-POE division does not naturally lead up to
  - an explanation of the rising investment rate and the declining share of labor income;
  - or the striking patterns of cyclical fluctuations.
- We depart from the standard approach by shifting the emphasis on the heavy vs. light sectors:
  - Offers one coherent framework for analyzing both cycles and trends of China's macroeconomy.

Heavy versus light industries in transition

- Firms in the heavy sector are a mix of SOEs and POEs.
- Recent reports from China's National Federation of Economic Ministry:
  - Trend for more large private firms (whose sales are all above 500 million RMB) to engage in heavy industries.
  - Example 1: in 2007 there were only 36 large firms in the ferrous metal and processing industries; by 2011 there were 65 large firms.
  - Example 2: in 2007 there only 6 large firms in the industries of petroleum processing, coking, and nuclear fuel processing; by 2011 the number more than doubled.
  - Even there are no data for the late 1990s, other evidence and anecdotal story suggest that there were even fewer large private firms.
  - Out of 345 largest private firms in 2010, 64 (the single largest fraction of all these large firms) were in the ferrous metal and processing industries while 54 were in the wholesale and retail trade industries — heavy (capital-intensive) industries.

Key reforms

- 1995: Enacted People's Bank of China law and other banking laws with decentralization of the banking system (which ironically has led to the concentration of **large loans to large firms**).
- **March 1996** (*8th National People's Congress of China*): **Strategic plan to develop infrastructure, real estate, basic industries (metal products, autos, and high-tech machinery), and other heavy industries (petroleum and telecommunication)**.

Government policy in transition

- As China's economic reforms deepen, the government no longer adheres to the practice of favoring SOEs and bias against POEs.
- As long as firms help boost growth of the local economy and create tax revenues, the local government would support them.
- Medium&long-term bank loans treat large firms symmetrically no matter whether they are SOEs or POEs (Chinese newspaper articles by Yifu Lin — professor at Beijing University and former chief economist at the World Bank).
- Labor-intensive firms, most of which tending to be small, have a difficult time to obtain loans, especially in the last ten years.
- One of the main reasons for heavy-industry firms to gain easy access to bank loans is the firms' ability to use their fixed assets for collateralizing the loans — the key feature of our theoretical model.

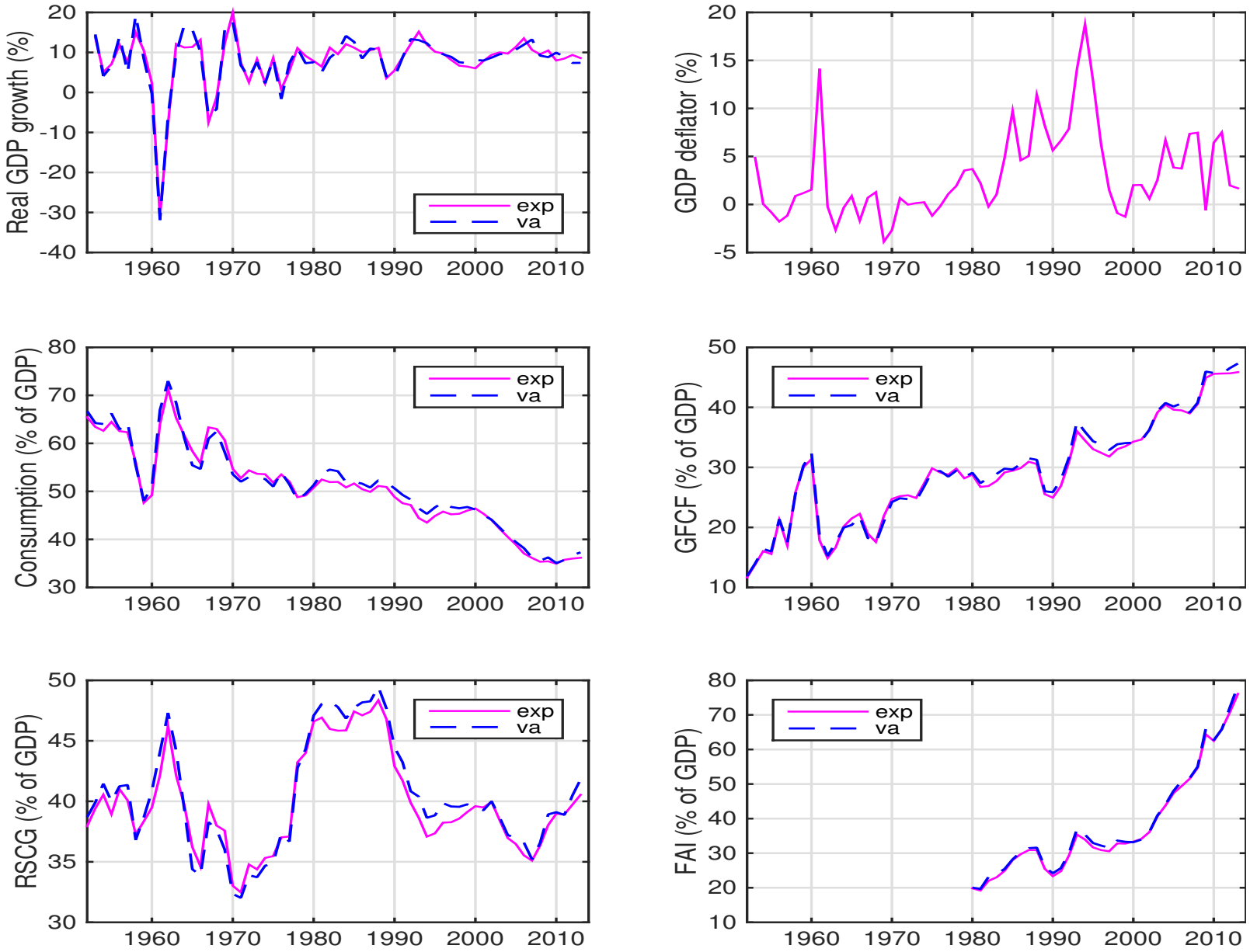
Sources of the data

- Most of our aggregate and disaggregated series are constructed based on the CEIC (China Economic Information Center, now belonging to Euromoney Institutional Investor Company) Database—one of the most comprehensive macroeconomic data sources for China.
- Two major sources of the CEIC Database are the National Bureau of Statistics (NBS) and the People's Bank of China (PBC).
- The WIND database for financial series (the Chinese version of Bloomberg).
- Disaggregated data directly from various Yearbooks published by the NBS.

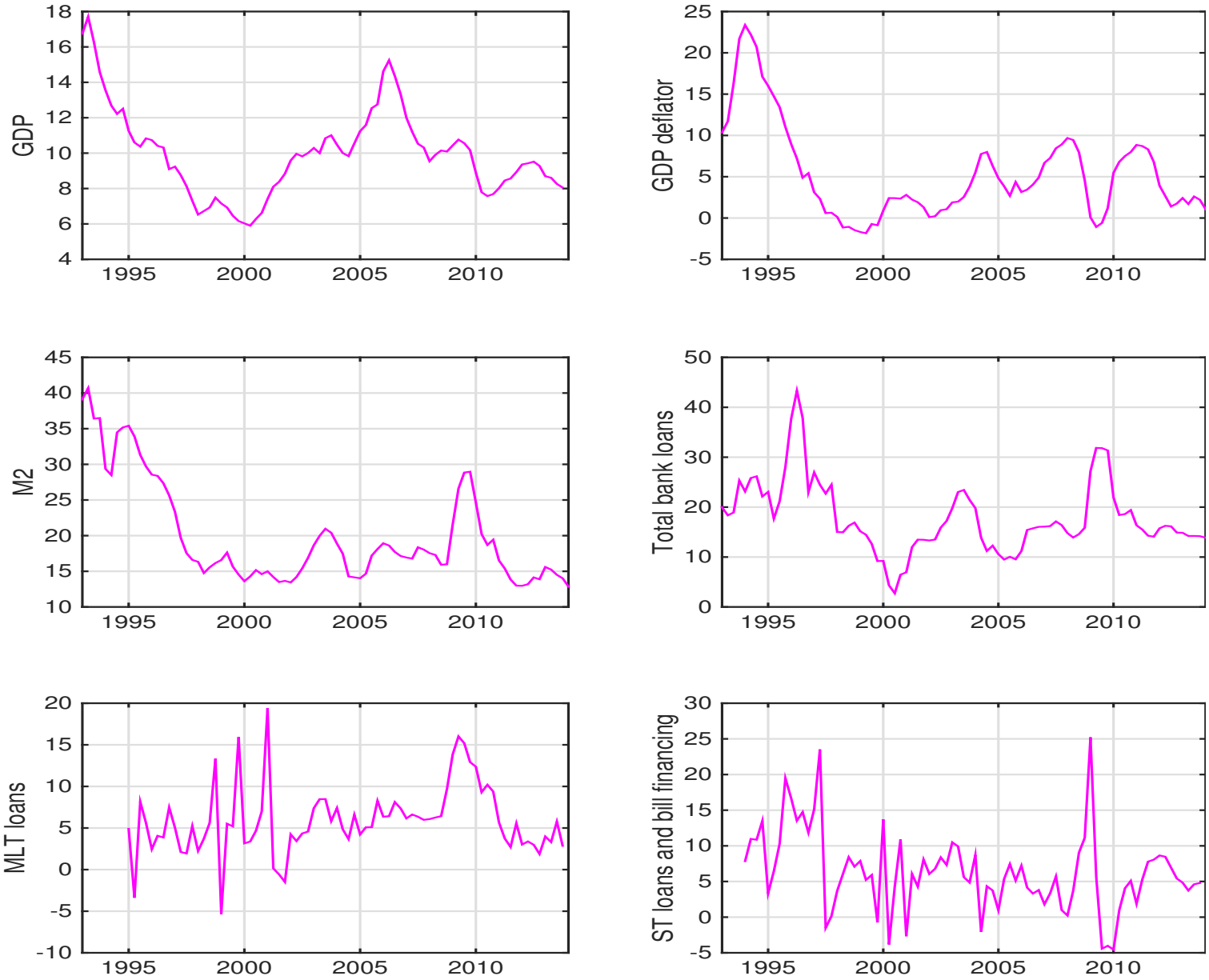
Challenge

The difficulty of constructing a standard set of annual and seasonally-adjusted quarterly time series lies in several dimensions.

- The NBS—the most authoritative source of economic data—reports only percentage changes of certain key macroeconomic variables such as real GDP.
- Many variables, such as investment and consumption, do not have quarterly data. Annual books published by the NBS, using the expenditure approach, have only annual data with continual revisions of the data from 2000 on.
- For quarterly or monthly frequencies, there are data published by the NBS, using the value-added approach (Brandt and Zhu 2010), for only subcomponents or variables with definitions different from those with the NIPA expenditure approach.
- Few seasonally adjusted data are provided by the NBS or by the PBC.
- Statistical coverage changes over time.
- Many quarterly series are interpolated using monthly and annual data. The quality of our interpolation, however, is high (Higgins and Zha, 2015).



Annual data: time-series history of trends and cycles in China's macroeconomy. The correlation between household consumption and retail sales of consumer goods (as percent of GDP by expenditure) is as low as 0.16.



Year-over-year growth rates of key quarterly time series. Total bank loans (outstanding) are delated by the GDP deflator. New long-term and short-term quarterly bank loans as percent of GDP by expenditure.

Countercyclical credit policy: examples

- In 1996, for fear of drastically slowing down the economy caused by rising counter-party risks ("Sanjiao Zhai" in Chinese), the PBC cut interest rates twice in May and August of 1996.
- While new long-term loans were held steady, short-term loans shot up in 1996 and in the first quarter of 1997 to achieve a soft landing ("Ruan Zhaolu" in Chinese).
- This increase proved to be short-lived while the decentralization of the banking system was underway.
- In subsequent years, whenever medium and long term loans increased sharply, short-term loans tended to decline.

Countercyclical credit policy: examples

- Another sharp spike of short-term loans (most of which was in the form of bill financing) took place in 2009Q1 right after the 2008 financial crisis.
- This sharp rise, however, lasted for only one quarter and was followed by sharp reversals for the rest of the year.
- By contrast, a large increase in medium and long term loans lasted for two years after 2008 as part of the government's two-year fiscal stimulus plan.
- In short, long-term and short-term loans tend *not* to move together.

Key cyclical patterns

(C1) Weak comovement or negative comovement between aggregate investment and consumption.

(C2) Weak comovement or negative comovement between aggregate investment and labor income.

(C3) A negative comovement between long-term loans and short-term loans.

Key trend facts

(T1) A simultaneous rise in the investment-to-output ratio and a fall in the consumption-to-output ratio.

(T2) A decline of the labor share of income.

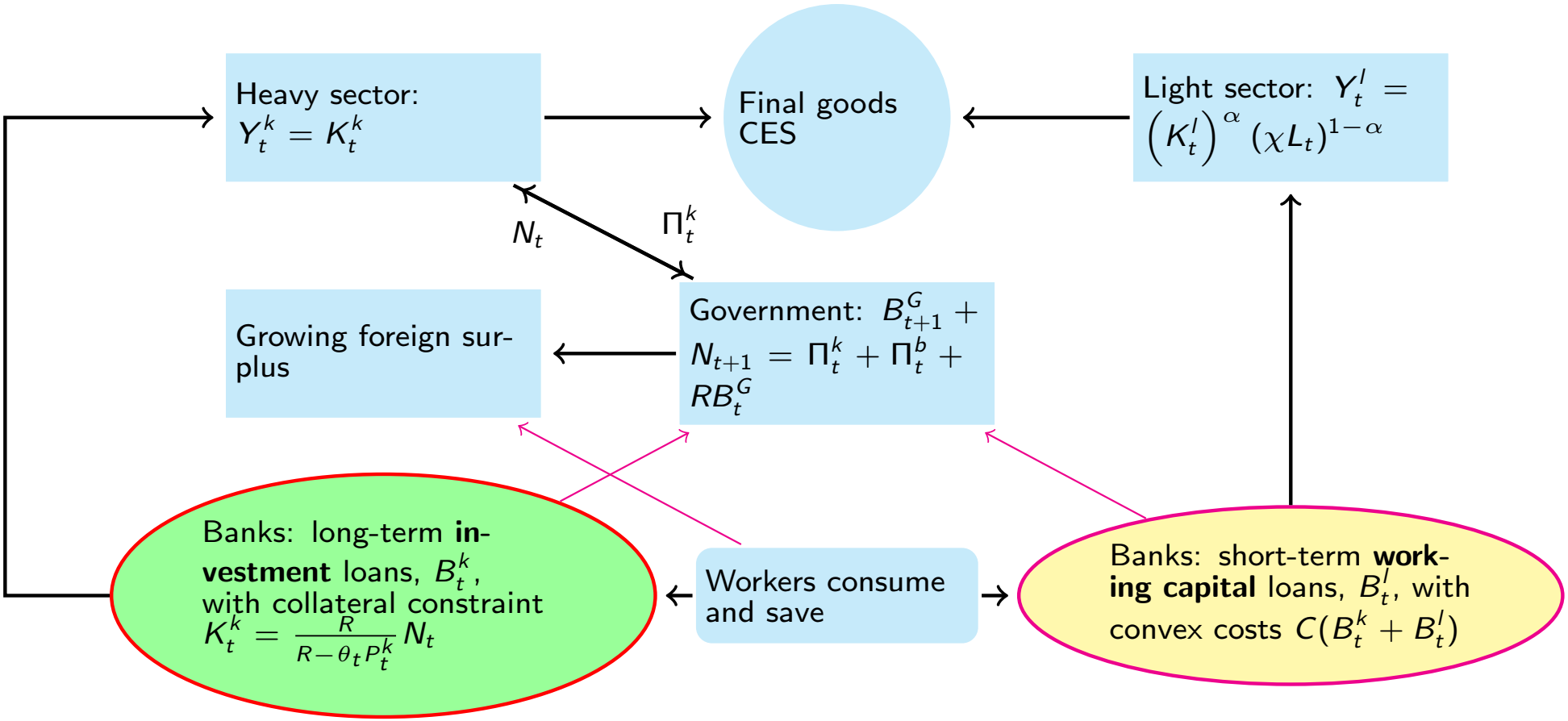
(T3) An increase in the ratio of long-term loans (for financing fixed investment) to short-term loans (for financing working capital).

(T4) A rise in the ratio of capital in the heavy sector to that in the light sector.

(T5) An increase in the ratio of total revenues in the heavy industry to those in the light sector.

- To explain both trend and cyclical patterns in one framework, we build a theoretical model on SSZ but depart from the traditional emphasis on SOEs versus POEs.
- Our driving force: macro heavy industrialization policy à la the credit channel.

Theoretical framework: an open economy with a fixed R



The model economy

- Two-period lived OLG agents: work when young and consume all their savings when old.
- Heterogeneous skills: half consists of workers without entrepreneurial skills and half entrepreneurs (born with entrepreneurial skills).
- No switching between social classes.

Technology

- Two production sectors: differ in capital intensity and *especially their access to bank loans*.
- K-firms: heavy (capital-intensive); L-firms: light (labor-intensive).
- Both types of firms have constant returns to scale:

$$Y_t^k = K_t^k, \ Y_t^l = \left(K_t^l\right)^{\alpha} (\chi L_t)^{1-\alpha},$$

- The production of final goods is a CES aggregator of the above two intermediate goods:

$$Y_t = \left[\varphi \left(Y_t^k\right)^{\frac{\sigma-1}{\sigma}} + \left(Y_t^l\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}$$

- The perfect competition in the final goods market implies:

$$\frac{Y_t^k}{Y_t^l} = \left(\varphi \frac{P_t^l}{P_t^k}\right)^{\sigma}, \left[\varphi^{\sigma} \left(P_t^k\right)^{1-\sigma} + \left(P_t^l\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} = 1.$$

K-firms

- Live for one period.
- At the beginning of each period, new born K-firms receive net worth N_t from the government.
- Can borrow from the bank at a fixed interest rate (R) to finance investment in capital.
- Have an incentive to default on loan payments and receive a fraction of output, $(1-\theta_t)P_t^k Y_t^k$.
- θ_t reflects the changing loan quota targeted by the government.
- A higher value of θ_t implies an increase of the targeted loan quota whose payment is implicitly guaranteed by the government.

K-firms

- The incentive-compatibility constraint:

$$P_t^k K_t^k - R\left(K_t^k - N_t\right) \geq (1-\theta_t) P_t^k K_t^k,$$

  where $B_t^k = K_t^k - N_t$.
- For the constraint to bind,

$$\theta_t P_t^k < R < P_t^k.$$

- The optimization problem subject to the incentive-compatibility constraint is

$$\Pi_t^k \equiv \max_{K_t^k} P_t^k K_t^k - R\left(K_t^k - N_t\right) + (1-\delta) K_t^k$$

- At the end of the period, the K-firm turns in its gross profit to the government and dies.

L-firms

- Before production takes place, L-firms must finance their working capital from intratemporal (short-term) bank loans.
- Have no access to intertemporal (long-term) bank loans to fund its fixed investment.
- Following SSZ, we assume that the old entrepreneur pays the young entrepreneur a management fee: $m_t = \psi P_t^l \left(K_t^l\right)^{\alpha} \left(\chi L_t\right)^{1-\alpha}$, where $\psi < 1$.
- The optimization problem:

$$\Pi_t^l \equiv \max_{L_t} P_t^l \left(1-\psi\right) \left(K_t^l\right)^{\alpha} \left(\chi L_t\right)^{1-\alpha} - R_t^l w_t L_t + \left(1-\delta\right) K_t^l,$$

  where R_t^l is the loan rate on the working capital $w_t L_t$.
- Old entrepreneurs do not choose K_t^l because it is determined when they are young.

Young entrepreneurs

- The gross return to the L-firm's capital is

$$\rho_t^l \equiv \Pi_t^l / K_t^l = (1-\psi)\,\alpha P_t^l \left(K_t^l / L_t\right)^{\alpha-1} (\chi)^{1-\alpha} + 1 - \delta.$$

- Since $\rho^l > R$, the young entrepreneur always prefers investing in capital to depositing in the bank:

$$\max_{s_t^E} \frac{\left(m_t - s_t^E\right)^{1-\frac{1}{\gamma}}}{1-\frac{1}{\gamma}} + \beta E_t \frac{\left(\rho_{t+1}^l s_t^E\right)^{1-\frac{1}{\gamma}}}{1-\frac{1}{\gamma}},$$

where $s_t^E = K_{t+1}^l$.

Workers

- Workers cannot lend directly to K-firms or L-firms: consistent with the fact that the banking sector in China plays a key role in intermediating business loans.
- The worker's consumption-saving problem:

$$\max_{c_{1t}^w, c_{2t+1}^w} \frac{\left(c_{1t}^w\right)^{1-\frac{1}{\gamma}}}{1-\frac{1}{\gamma}} + \beta \frac{\left(c_{2t+1}^w\right)^{1-\frac{1}{\gamma}}}{1-\frac{1}{\gamma}}$$

subject to

$$\begin{aligned} c_{1t}^w + s_t^w &= w_t, \\ c_{2t+1}^w &= s_t^w R. \end{aligned}$$

Banks

- Each period the bank receives deposits D_t from young workers and uses these deposits for long-term loans to K-firms' investment and short-term loans to L-firms's working capital.
- The bank's interest rate for investment loans is simply R (preferential lending treatment), but the loan rate for working capital is R_t^l.
- The bank is subject to a convex cost of loan processing, $C(B_t)$, which increases in the total amount of loans $B_t \equiv B_t^l + B_t^k$: $C(B_t) = B_t^\eta$ for $\eta > 1$.
- Various legislative or implicit restrictions on bank loans to small but productive firms become more severe as the loan-to-deposit ratio approaches to the official limit, making loans to productive firms exceedingly expensive (Zhou and Ren (2010).
- Reports from various Chinese financial papers confirm these institutional arrangements.

Banks

- Remaining deposits, invested in foreign bonds, earn the interest rate R.
- The bank's problem is

$$\max_{B_t^l} \Pi_t^b = R_t^l B_t^l + R B_t^k + R(D_t - B_t^k) - R D_t - C(B_t) - B_t^l.$$

- In equilibrium, $D_t = s_t^w L_t$ and $B_t^l = w_t L_t$.
- First-order condition:

$$R_t^l = 1 + C'(B_t).$$

The government

- The government lasts forever.
- At the end of each period, the government decides on how much of its revenues to be advanced to new-born K-firms as net worth in the beginning of the next period:

$$N_{t+1} = \xi K_t^k,$$

- The government's budget constraint:

$$B_{t+1}^G + N_{t+1} = \Pi_t^k + \Pi_t^b + RB_t^G.$$

Equilibrium

The resource constraint:

$$C_t + I_t + S_t^f = \text{GNP}_t = Y_t - C\left(B_t\right) + (R-1)\left(B_t^w + B_t^G\right),$$

where S_t^f stands for a current account or foreign surplus and

$$\begin{aligned} C_t &= c_{1t}^w + c_{2t}^w + c_{1t}^E + c_{2t}^E, \\ I_t &= K_{t+1} - (1-\delta) K_t, \\ K_t &= K_t^k + K_t^l, \\ S_t^f &= B_{t+1}^w + B_{t+1}^G - \left(B_t^w + B_t^G\right). \end{aligned}$$

A growing foreign surplus

- Our data show that net exports since 1997 has become large in comparison to earlier periods.
- A large current account surplus, part of the emphasis in SSZ, is a byproduct of our model but with a different mechanism.
- Workers' purchases of foreign bonds:

$$B_t^w = s_t^w - (K_t^k - N_t),$$

  where $K_t^k - N_t$ is workers' savings used for domestic capital investment.
- The net foreign surplus as a fraction of GDP is

$$\frac{B_{t+1}^w + B_{t+1}^G - (B_t^w + B_t^G)}{Y_t - C(B_t)}.$$

- Two forces drive up the net foreign surplus:
  - households' savings in foreign bonds $(B_{t+1}^w - B_t^w)$,
  - the government's savings in foreign reserves $(B_{t+1}^G - B_t^G)$.

A growing foreign surplus

- In China, although household savings is still the main component of national savings, its growth is slower than that of the government's savings between 2000 and 2012.
- According to our calculation based on the NBS annual data, government savings as percent of GDP increased by seven percentage points between 2000 and 2012, contributing to 64% of an increase of 11 percentage points in the total saving rate (from 37.5% to 48.4%) in the national saving rate of China during this period.
- In our model, the worker's saving rate is constant and all entrepreneurial savings is used to finance investment in the labor-intensive sector.
- As a result, most of the *increase* in the national saving rate and thus the net foreign surplus are driven by an increase in government savings, consistent with the aforementioned fact for China.

Estimating the elasticity of substitution

- The competitive final-goods market implies:

$$\log \frac{P_t^k Y_t^k}{P_t^l Y_t^l} = \log \varphi + \frac{\sigma - 1}{\sigma} \log \frac{Y_t^k}{Y_t^l}.$$

- Taking care of *endogeneity* between the value ratio and the quantity ratio, we have

$$A_0 y_t = a + \sum_{\ell=1}^{p} A_\ell y_{t-\ell} + \varepsilon_t,$$

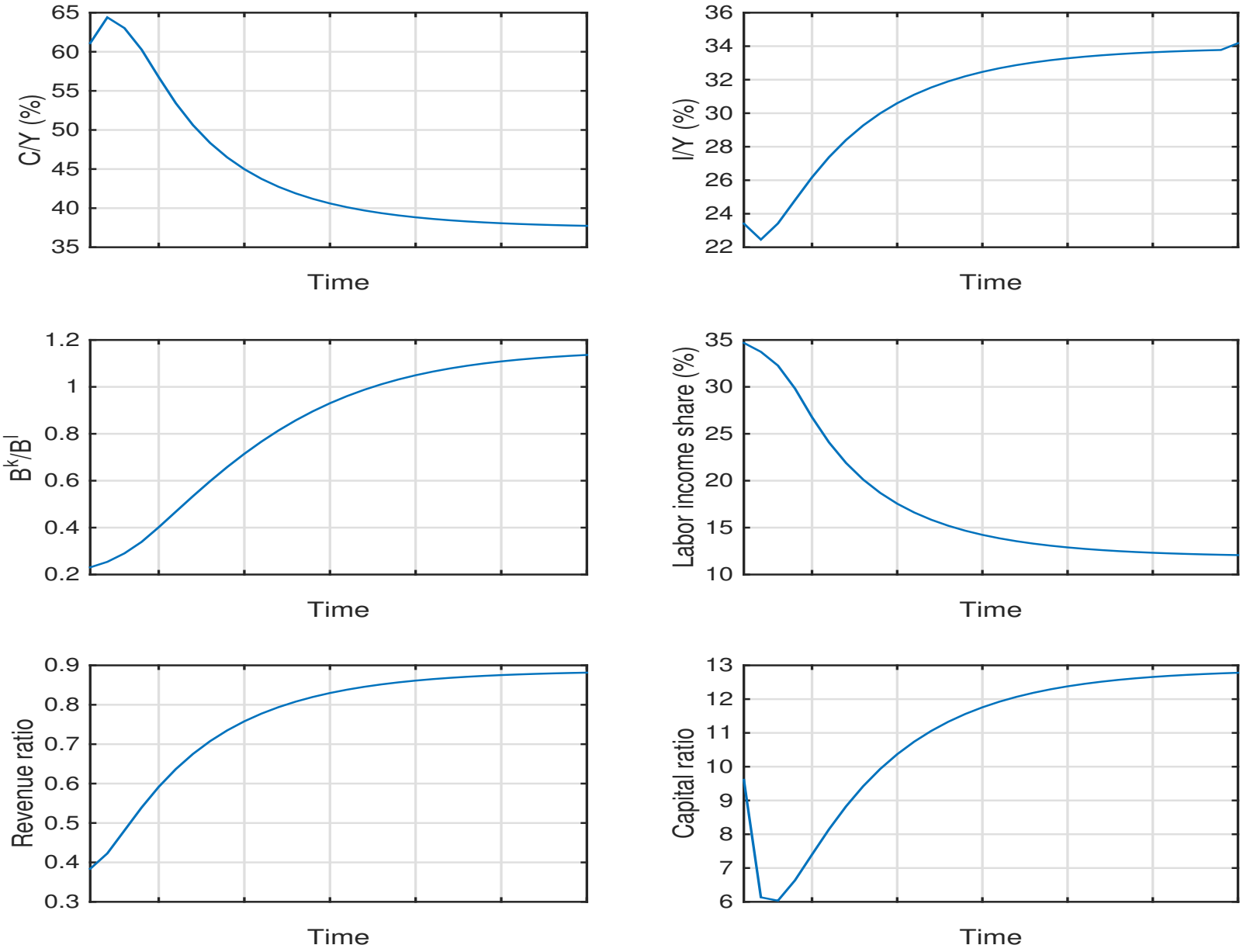
$$A_0 = \begin{bmatrix} a_{0,11} & a_{0,12} \\ a_{0,21} & a_{0,22} \end{bmatrix}, \; A_\ell = \begin{bmatrix} a_{\ell,11} & a_{\ell,12} \\ 0 & 0 \end{bmatrix}, \; y_t = \begin{bmatrix} \log \frac{P_t^k Y_t^k}{P_t^l Y_t^l} & \log \frac{Y_t^k}{Y_t^l} \end{bmatrix}'.$$

- Likelihood-based estimation of this system is analogous to utilizing a large number of lagged variables as instrumental variables (Sims 2000).

Estimate and probability intervals of σ using the robust econometric procedure

By Theorems 1 and 3 of Rubio-Ramirez, Waggoner, and Zha (2010), the simultaneous system is *globally identified* with $\sigma = a_{0,21}/(a_{0,21} + a_{0,22})$.

Seasonally adjusted monthly data		
Point estimate	68% interval	95% interval
2.32	(2.11, 2.54)	(1.94, 2.79)
Original (not seasonally adjusted) monthly data		
Point estimate	68% interval	95% interval
2.15	(1.96, 2.35)	(1.80, 2.57)



The trend patterns for the benchmark theoretical model.

Reallocation (between-sector) effect

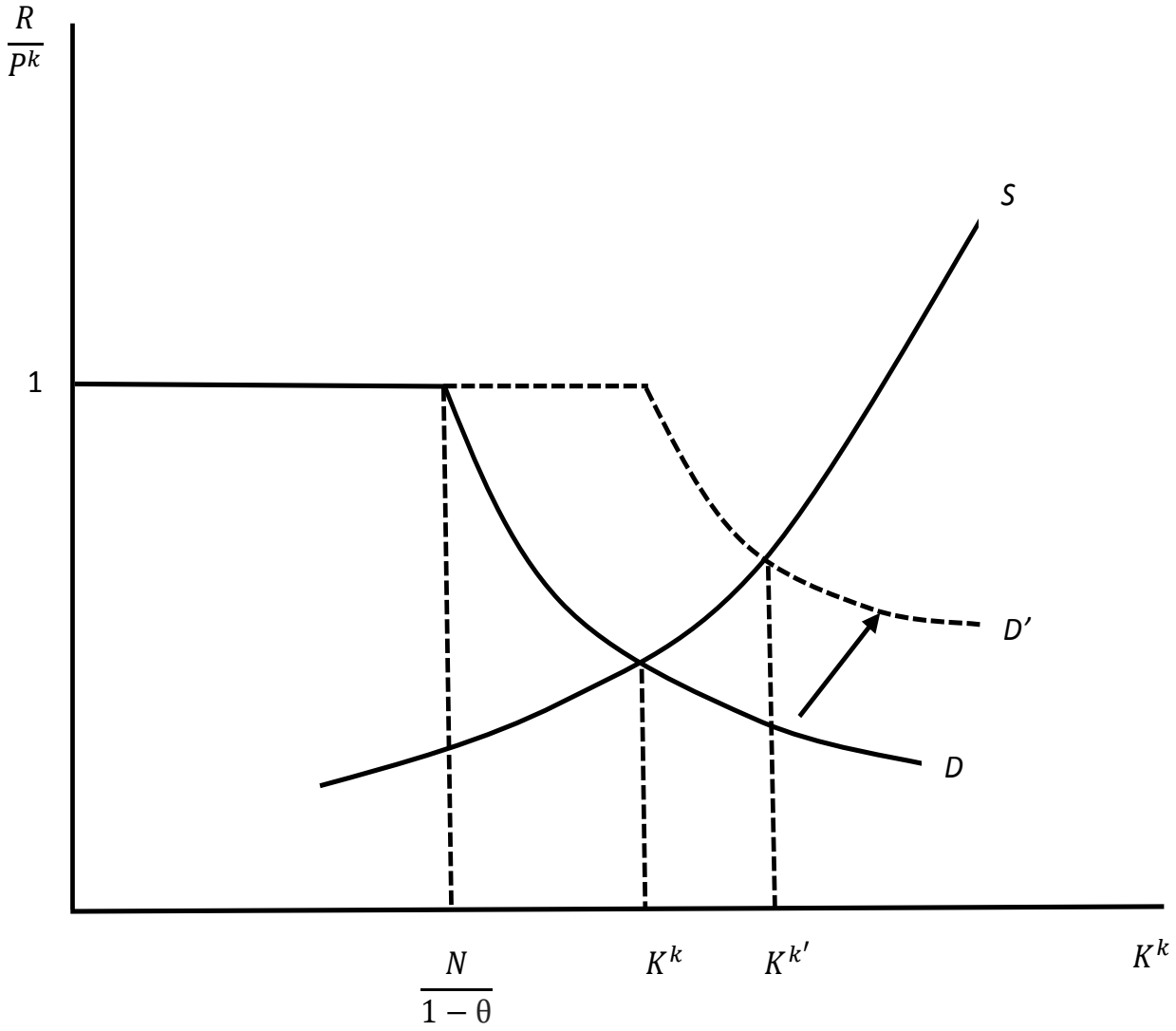
- Labor share driven by the reallocation effect:

$$\frac{w_t L_t}{Y_t} = \frac{(1-\psi)(1-\alpha)}{1 + P_t^k Y_t^k / \left(P_t^l Y_t^l\right)}.$$

- Investment rate driven by the reallocation effect:

$$\frac{I_t}{Y_t} = \frac{I_t^k}{P_t^k Y_t^k} \frac{P_t^k Y_t^k}{Y_t} + \frac{I_t^l}{P_t^l Y_t^l} \frac{P_t^l Y_t^l}{Y_t}.$$

- In the case of complete capital depreciation and the risk aversion parameter $\gamma = 1$, the investment rate in the light sector $(\frac{I_t^l}{P_t^l Y_t^l})$ is constant, while the investment rate in the heavy sector $(1/P_t^k)$ increases.



Demand and supply of K_t in responses to a long-term credit increase.

The investment rate

- The NBS provides the time series of gross output, value added, and investment for the heavy and light sectors for 2-digit industries.
- The reallocation (between-sector) effect, relative to the sector-specific (within-sector) effect, on the overall investment rate is calculated as

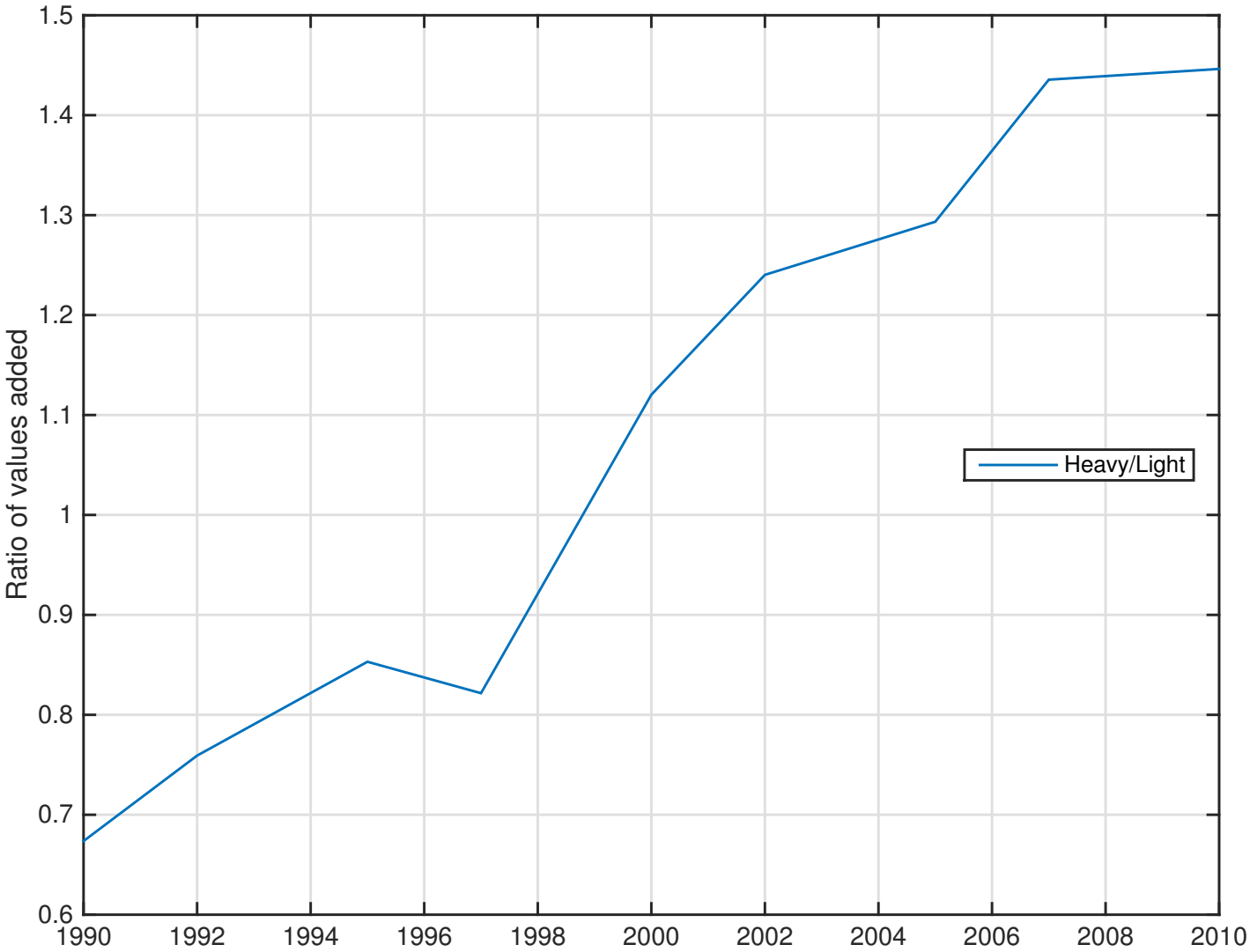
$$\frac{\bar{i}^l P_t^l Y_t^l + \bar{i}^k P_t^k Y_t^k}{P_t^l Y_t^l + P_t^k Y_t^k} - \frac{i_t^l \overline{P^l Y^l} + i_t^k \overline{P^k Y^k}}{\overline{P^l Y^l} + \overline{P^k Y^k}}.$$

- The series for value added ends in 2007 and there is no published data from the NBS for later years.
- The relative reallocation effect between 1997 and 2007 is an increase of 16.8 percentage points.
- For the series of gross output, the relative reallocation effect between 1997 and 2011 is an increase of 11.1 percentage points.

Labor income share in 17 disaggregated sectors

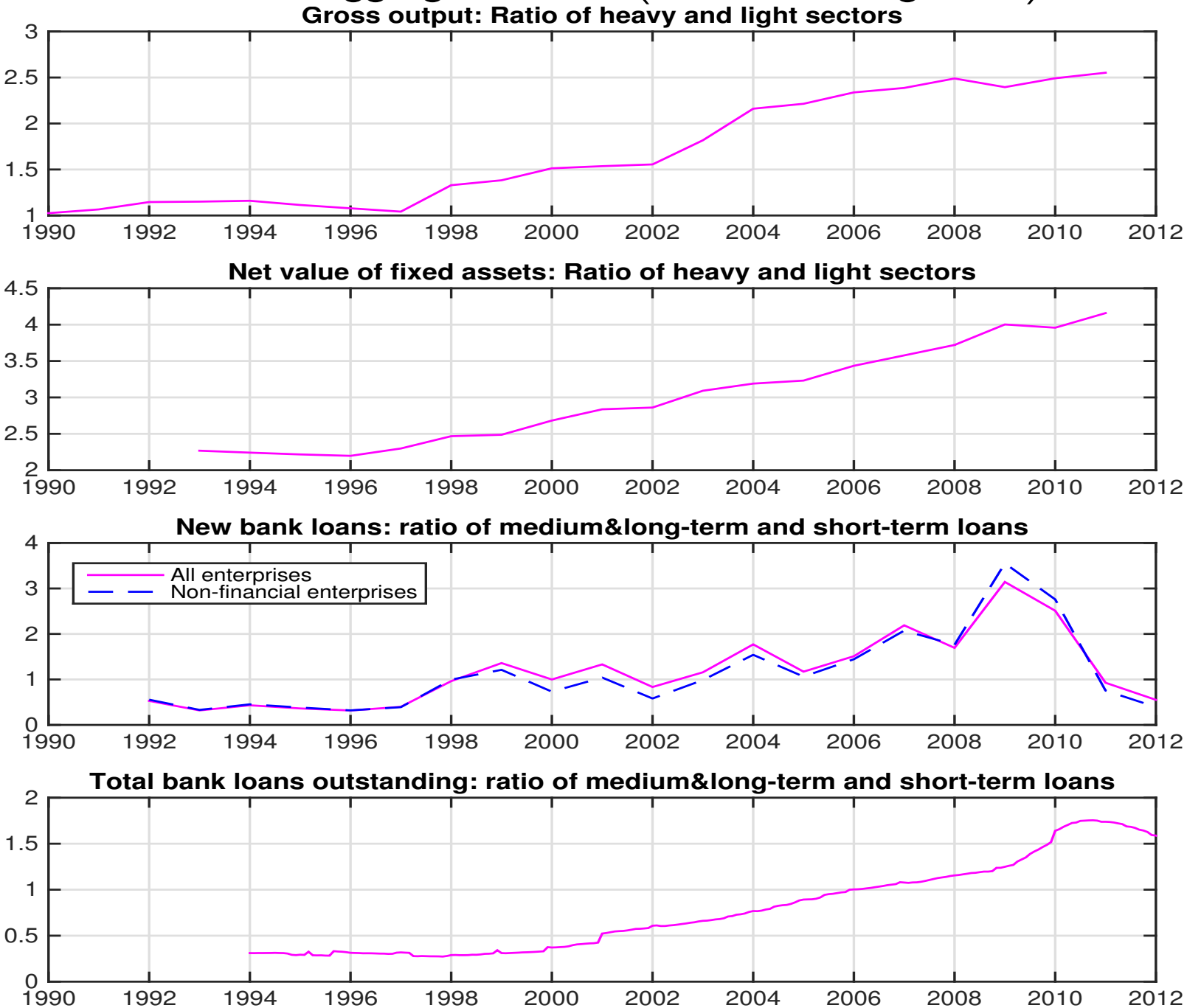
Labor share	Detailed sector	Broad sector
0.199	Real Estate, Leasing and Commercial Service	H
0.238	Electricity, Heating and Water Production and Supply	H
0.243	Coking, Coal Gas and Petroleum Processing	H
0.266	Food, Beverage and Tobacco	L
0.316	Wholesale, Retail, Accommodation and Catering	H
0.330	Banking and Insurance	H
0.335	Chemical	H
0.336	Other manufacturing	L
0.365	Mining	H
0.370	Transportation and Information Transmission	H
0.375	Metal Product	H
0.399	Machinery Equipment	H
0.414	Construction Material and Non Metallic Mineral Product	L
0.448	Textile, Garment and Leather	L
0.580	Construction	L
0.738	Other Services	L
0.886	Farming, Forestry, Animal Husbandry, Fishery	L

Corroboration from disaggregated data—the 17 sectors

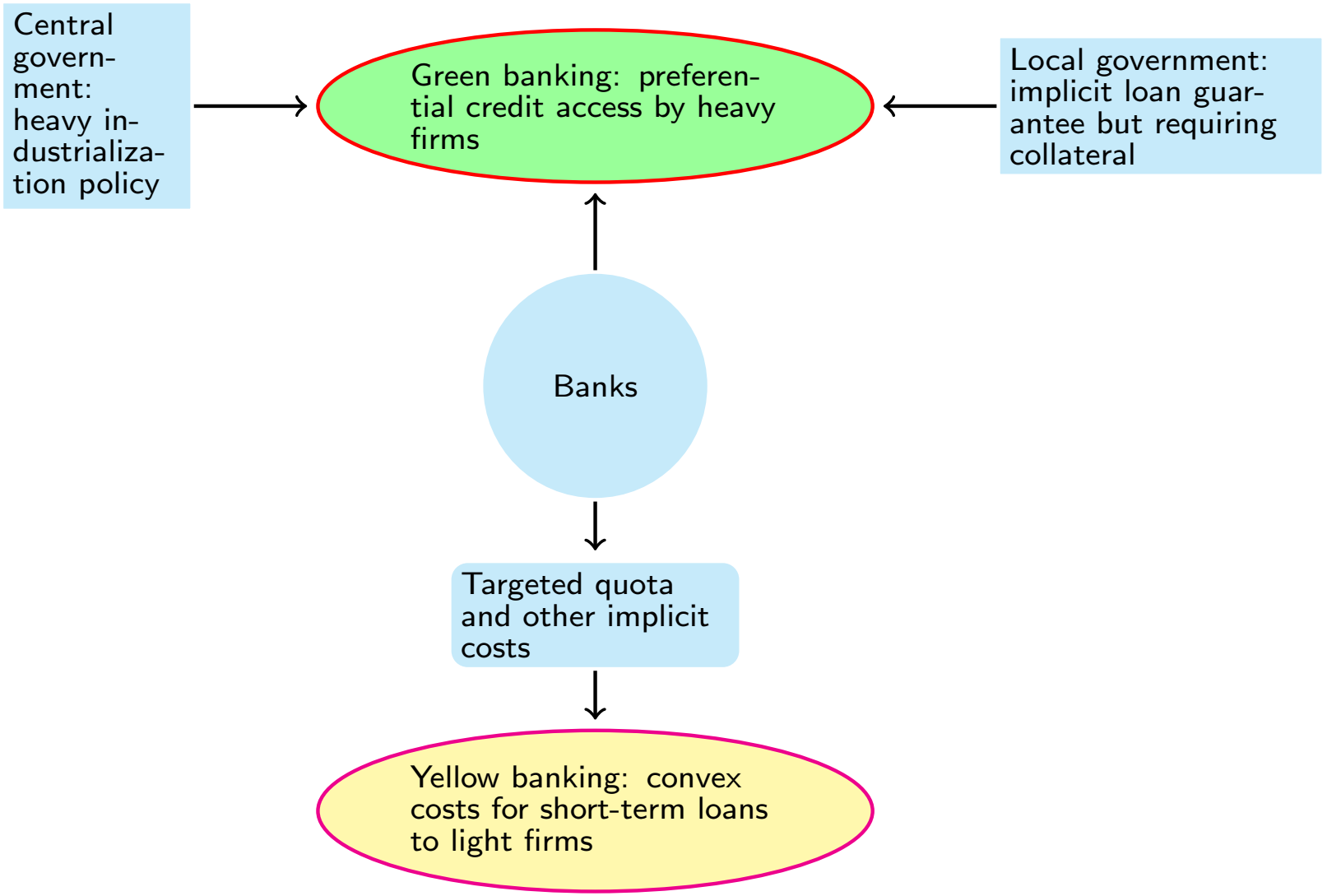


Ratio of values added in the heavy and light sectors grouped from the 17 sectors.

Corroboration from disaggregated data (manufacturing firms):



Institutional details for "Green Banking" and "Yellow Banking"



Green banking: central government's preferential policy

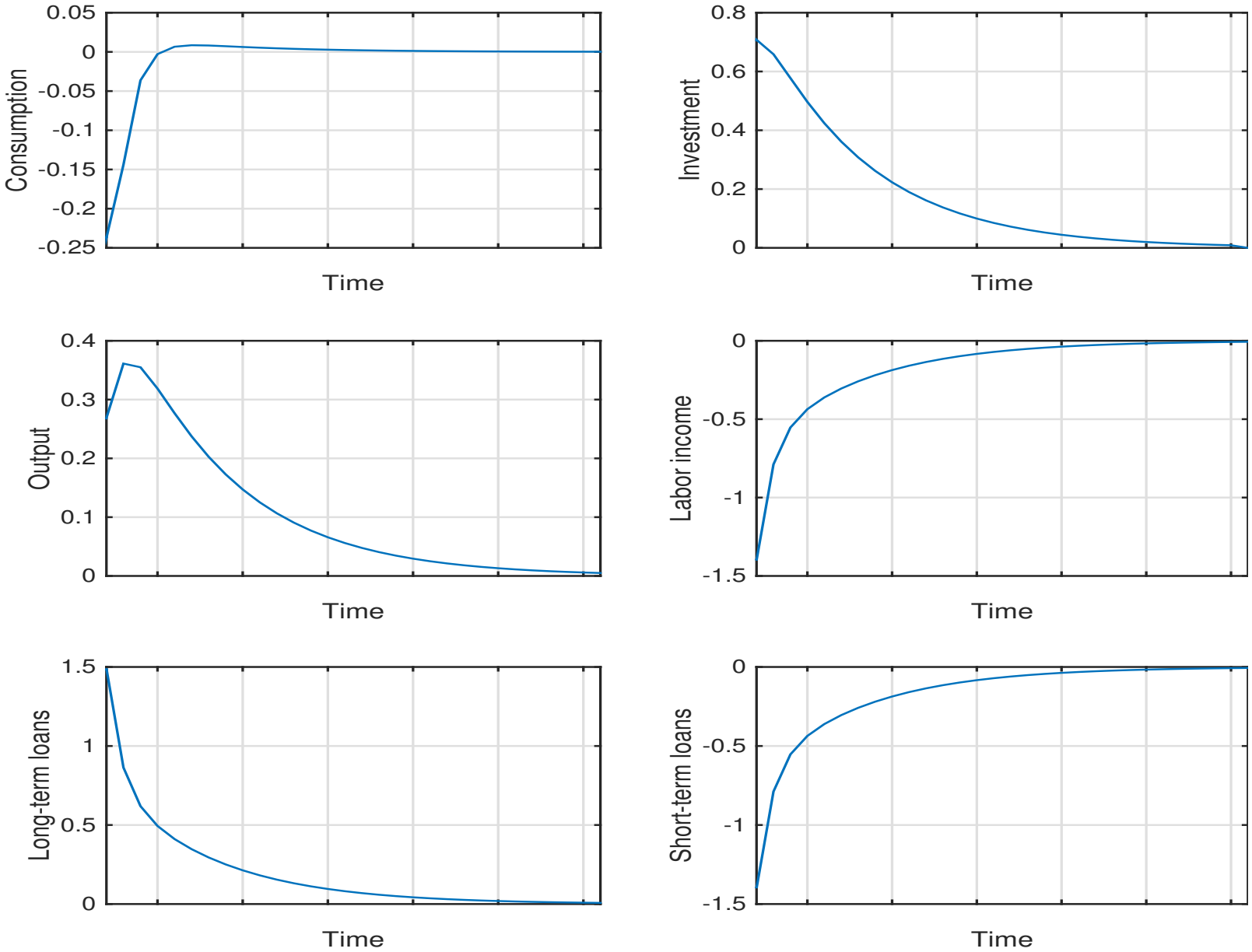
- *Large banks (most of them are state-owned)*: the persistent monopoly in the credit market $\rightarrow$ rapid increases of bank loans towards capital-intensive industries.
- *Medium and long term loans*: the share of large national banks in total bank loans is on average 75.7% between 2010 and 2014.
- *Loans to heavy industries*: 89% of medium&long-term loans is allocated on average to heavy industries and this number has been stable over the years—according to our calculation based on the 2010:1-2014:4 quarterly series of loan classifications reported by the PBC,

Green banking: local government's policy

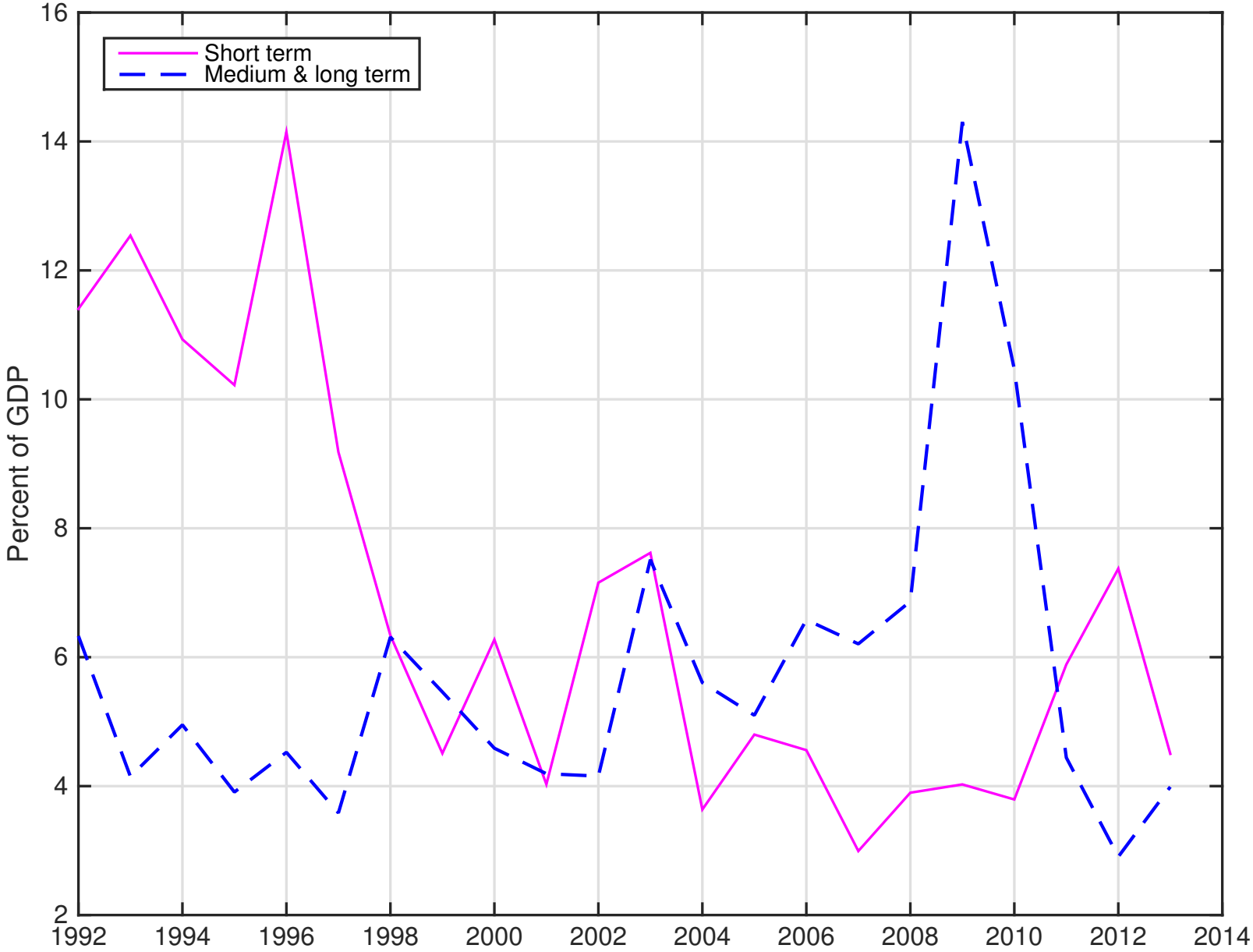
- *Implicit government guarantees*: large firms gain implicit government guarantees from local governments (Jiang, Luo, Huang, 2006).
- *Favored loans*: thus, banks favor lending to industries targeted by the state (e.g. steel and petroleum) because large firms produce more sales, provide more tax revenues, and help boost the GDP of the local economy, *an important criterion for the promotion of local government officials*.
- *Collateral*: fixed assets in large firms are used as collateral for the local government's loan guarantees.

Yellow banking: 1995 banking reform and loan quota

- Most small firms are concentrated in labor-intensive industries and have hard time to get long-term investment loans (Lin and Li, 2001).
- PBC's *China Monetary Policy Reports* reveal that the government often increases medium & long term loans at the sacrifice of short-term loans partly due to the *overall targeted loan quota*.
- The first derivative $C'\left(B_t^k + B_t^l\right)$ is designed to capture this kind of cost as well as various legislative or implicit restrictions on bank loans to small but productive firms (Zhou and Ren 2010).



Impulse responses to an expansionary credit shock θ_t in the benchmark theoretical model.



New bank loans to non-financial enterprises as percent of GDP. The correlation between the two types of loans is -0.403 for 1992-2012 and -0.405 for 2000-2012.

Correlation between short-term and long-term loans: U.S. vs. China

Start of the sample	yoy loan growth U.S.	yoy loan growth China	New loans as % of GDP China
1961:1-	0.63 (2014:3)	N/A	N/A
1997:1-	0.60 (2014:3)	-0.26 (2014:4)	-0.27 (2013:4)
2000:1-	0.59 (2014:3)	-0.40 (2014:4)	-0.27 (2013:4)

To explain striking facts, our framework

- Does *not* rely on
  - TFP assumptions between the heavy (capital-intensive) and light (labor-intensive) sectors, or
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  - *local government's implicit guarantees*: loans collateralized by fixed assets $\rightarrow$ encouraging large sales and large revenues.
- Offers a constructive framework for studying China's macroeconomy:
  - explaining both trend and cyclical patterns;
  - China's growth is not an unalloyed progress: risky policy implications.

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Detailed materials follow.

Introduction

- Yet there is a serious lack of empirical research on
  - the basic facts about trends and cycles of China's macroeconomy,
  - a theoretical framework that is capable of explaining these facts.
- This paper serves to fill this important vacuum by tackling both of these issues.

Data issues

Higgins and Zha (2015).

Specific contributions

- Provide a core of macroeconomic time series usable for systematic studies on China's macroeconomy.
- Document, through various empirical methods, the *robust* findings about the striking patterns of trend and cycle.
- Build a theoretical model that accounts for these facts.
- The model's mechanism and assumptions are corroborated by *institutional details*, disaggregated industrial data, and banking time series, all of which are distinctive of Chinese characteristics.

Broad contributions

- Departure of our theoretical model from standard ones offers a constructive framework for studying China's macroeconomy.
- Promote, among a wide research community, empirical studies on China's macroeconomy and its government policies.

Existing models

- Standard business cycle models have a number of shocks that are potentially capable of generating a negative comovement between aggregate investment and household consumption.
- Mechanism: the negative effect on consumption of rising interest rates in response to rising demand for investment.
- Examples: preference shocks, investment-specific technology shocks, and credit shocks.
- In all these models, however, an increase of investment raises household income, contradictory to fact (C2).
- What is most important: business-cycle models
  - are silent about the negative relationships between short-term and long-term loans (C3) and
  - *are not designed* to address many of the trend facts (T1)-(T5).

Existing models

- Neoclassical models predict that the investment rate falls along the transition and quickly converges to the steady state due to decreasing marginal returns to capital.
- One-sector models require a fall of the relative price of investment to explain the global decline of labor shares across a large number of countries when the elasticity of substitution between capital and labor is greater than 1 (Karabarbounis and Neiman, 2014).
- More important is that these models do not predict the rise of I/Y.
  - Intuition: measured investment is $P_I I/P_Y Y$. While I/Y increases as a result of IST increases, P_I/P_Y decreases.

Existing models

- Two-sector models of capital deepening à la Acemoglu and Guerrieri (2008) assume that
  - (labor-augmented) TFP in the capital-intensive sector grows faster than TFP in the labor-intensive sector when the elasticity of substitution between two sectors is less than 1, or
  - TFP in the capital-intensive sector grows slower than TFP in the labor-intensive sector when the elasticity of substitution between two sectors is greater than 1.
- With this assumption, the investment rate declines over time.
- For the investment rate to rise and the labor share of income to decline, it must be that
  - the elasticity of substitution between two sectors is greater than one 1, and
  - TFP in the capital-intensive sector grows faster than TFP in the labor-intensive sector.

TFP in China

Existing evidence shows that

- TFP growth in the capital-intensive sector is slower than TFP growth in the labor-intensive sector.
- Or at best, there is no clear-cut evidence.

Theoretical framework

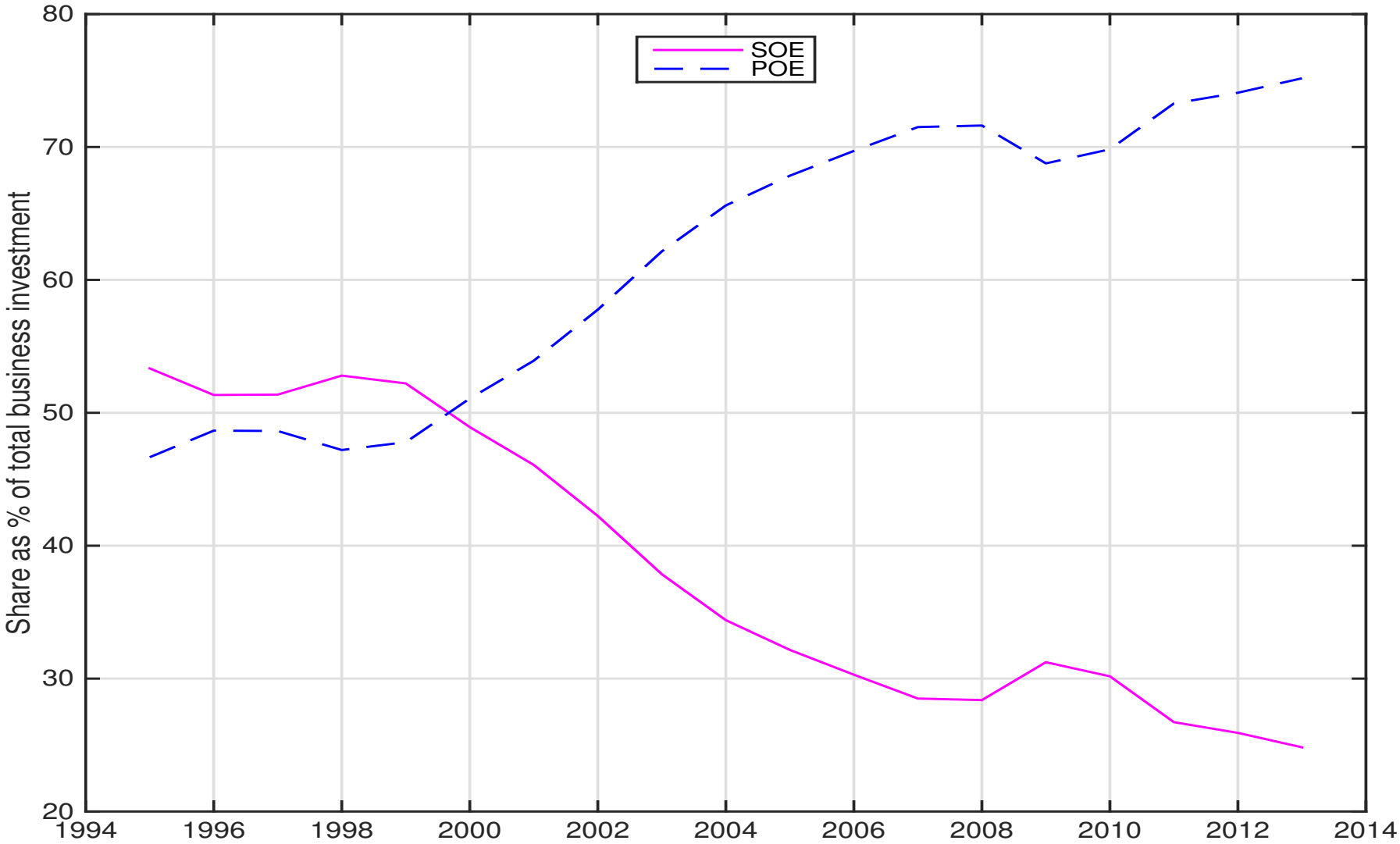
- Does *not* rest on
  - TFP assumptions between the heavy (capital-intensive) and light (labor-intensive) sectors, or
  - relative prices of investment goods.
- Does relies on institutional details by taking into account of
  - a peculiar financial arrangement for the two sectors;
  - the government's priorities and strategic plans for promotion of heavy industries.

China in transion

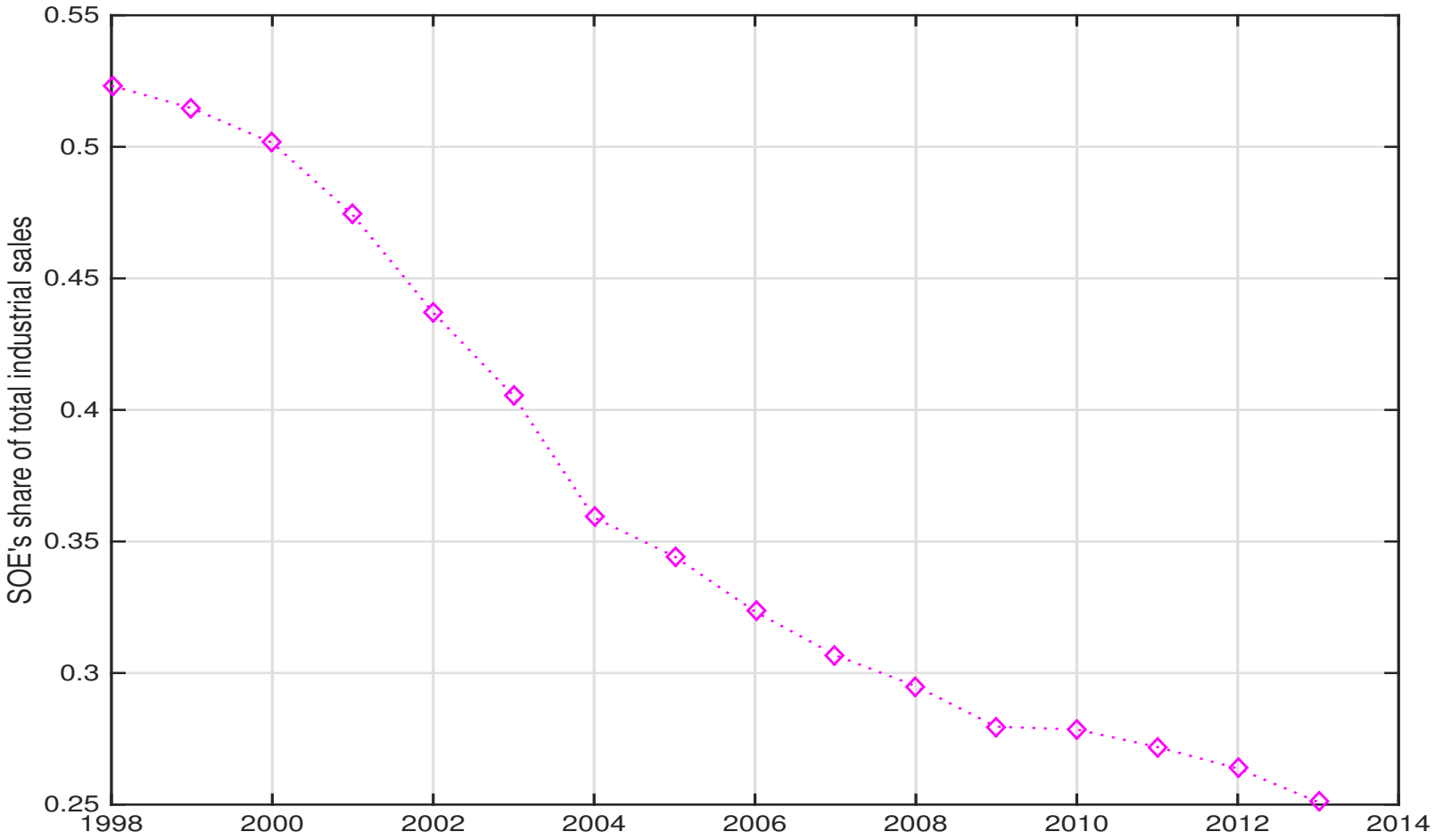
Dates	Major structural changes
December 1978	Introduction of economic reforms
Early 1990s	Price controls and rationing
Beginning of 1992	Advanced the reforms by Deng Xiaoping
January 1994	Ended the two-tiered foreign exchange system
1994	Major tax reforms and devaluation of RMB
1995-1996	Phased out price controls and rationing
1995	Enacted People's Bank of China law and other banking laws with decentralization of the banking system
March 1996	**Strategic plan to develop infrastructure and other heavy industries**
July 1997	Asian financial crises started in Thailand
November 1997	Began privatization
November 2001	Joined the WTO and trade liberalization
July 2005	Ended an explicit peg to the USD
September 2008	U.S. and world wide financial crisis
2009-2010	Fiscal stimulus of 4 trillion RMB investment

Detailed GDP subcomponents as percent of GDP

Year	C	SOE	POE	HH I	Govt C	Nex	Invty
1995	44.9	14.7	12.8	5.6	13.3	1.6	7.3
1996	45.8	13.7	13.0	5.7	13.4	2.0	6.4
1997	45.2	13.4	12.6	5.8	13.7	4.3	4.9
1998	45.3	14.0	12.6	6.4	14.3	4.2	3.2
1999	46.0	13.9	12.7	6.9	15.1	2.8	2.7
2000	46.4	13.1	13.6	7.6	15.9	2.4	1.0
2001	45.3	12.1	14.2	8.3	16.0	2.1	1.8
2002	44.0	11.7	16.0	8.5	15.6	2.6	1.6
2003	42.2	11.2	18.3	9.7	14.7	2.2	1.8
2004	40.5	10.3	19.6	10.6	13.9	2.6	2.5
2005	38.9	9.0	19.1	11.5	14.1	5.4	1.9
2006	37.1	9.2	21.2	9.0	13.7	7.5	2.2
2007	36.1	8.7	21.9	8.4	13.5	8.8	2.6
2008	35.3	9.3	23.4	7.9	13.2	7.7	3.2
2009	35.4	11.2	24.6	9.2	13.1	4.3	2.2
2010	34.9	10.9	25.2	9.5	13.2	3.7	2.5
2011	35.7	9.1	25.1	11.4	13.4	2.6	2.7
2012	36.0	8.9	25.4	11.3	13.5	2.8	2.1
2013	36.2	8.5	25.8	11.6	13.6	2.4	1.9



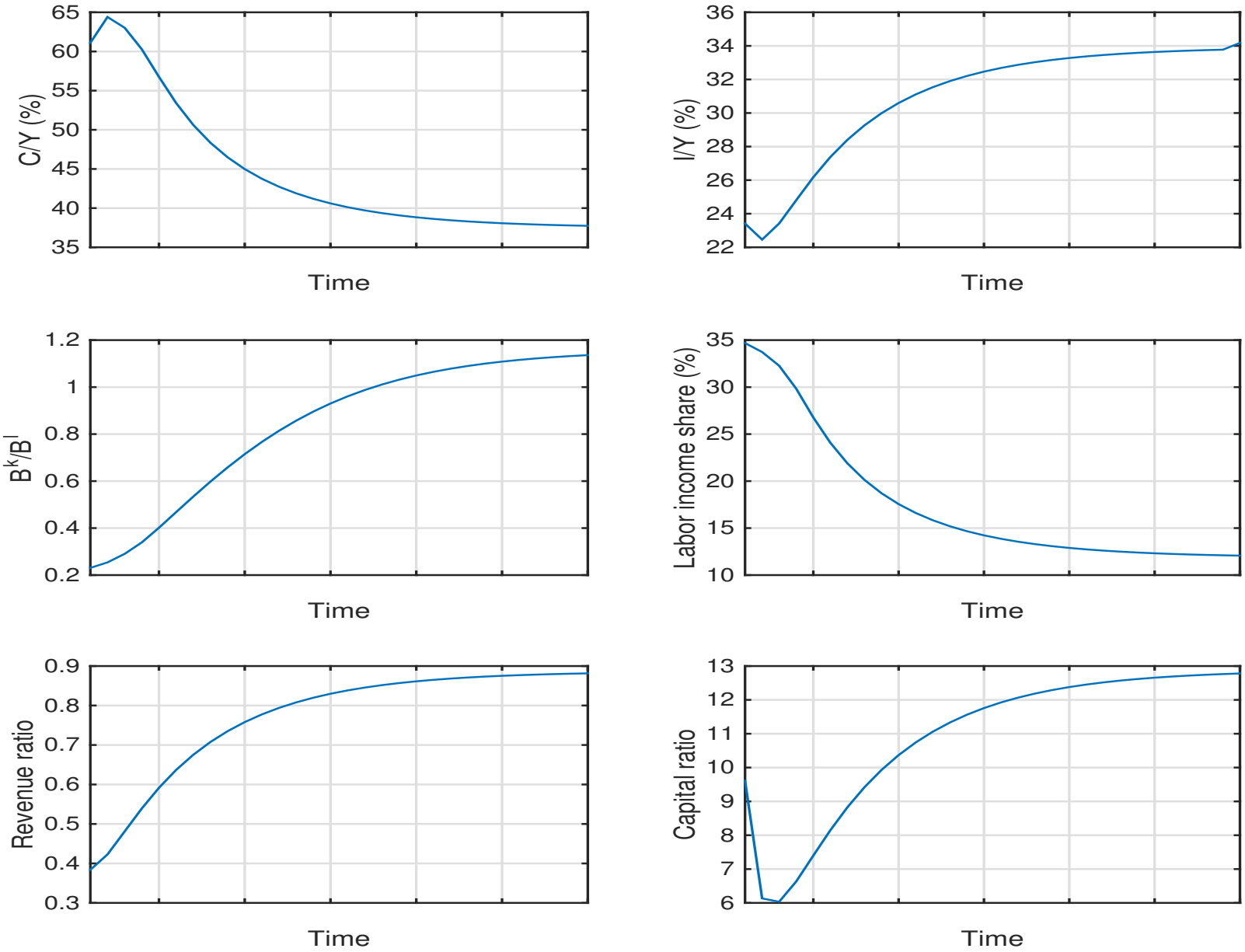
The share of SOE investment and POE investment as percent of total business investment, where total business investment equals the sum of SOE investment and POE investment.



The ratio of sales revenue in the SOEs to the total sales revenue in all industrial firms.

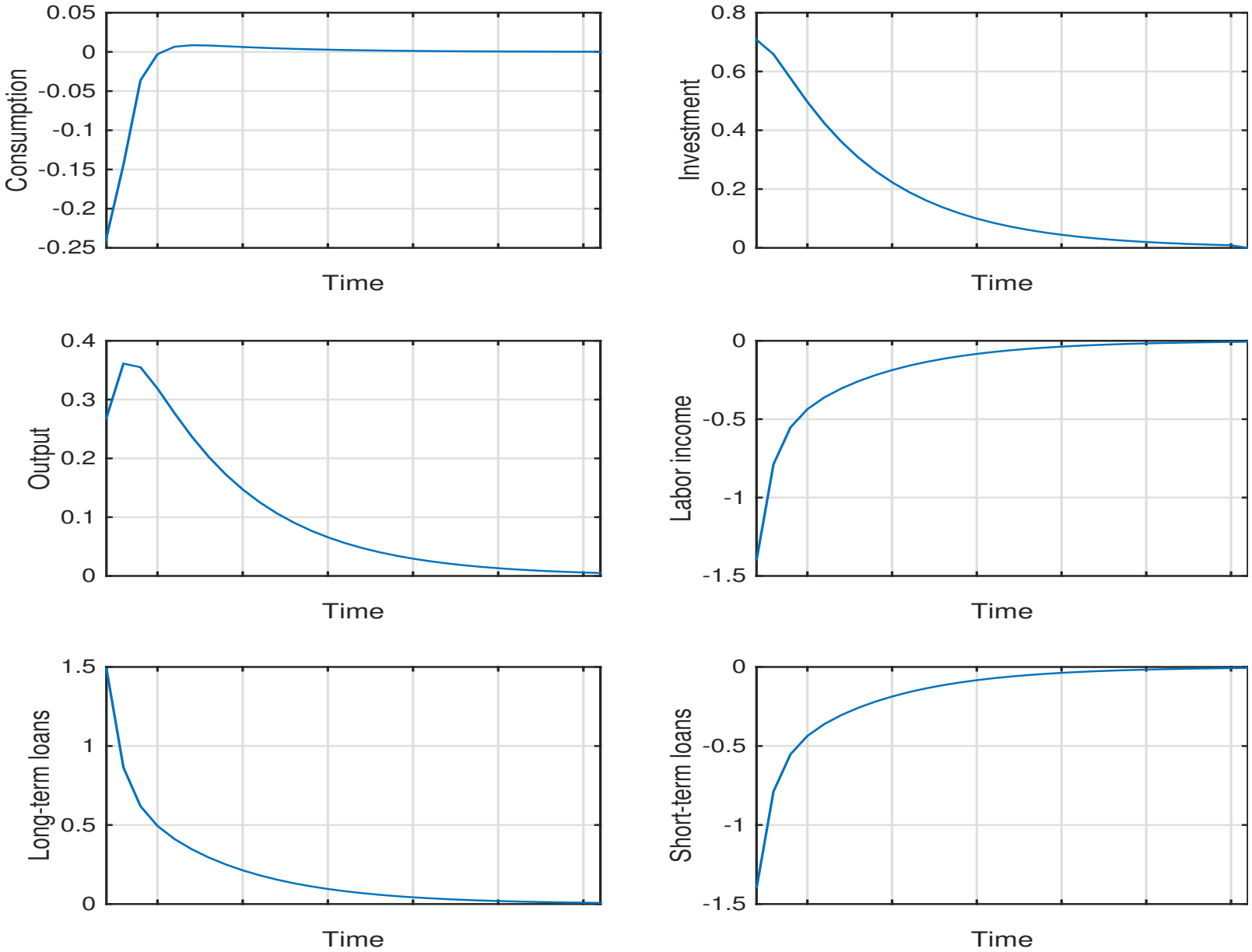
TPFs in the heavy and light sectors

- Evidence shows that the labor-intensive sector is more productive than the capital-intensive sector.
- Using the dataset of manufacturing firms by bridging the Annual Surveys of Industrial Enterprises and the Database for Chinese Customs from 2000 to 2006, Ju, Lin, Liu, and Shi (2015) find that TFP growth in the export sector (textile) was higher than that in the import sector (high technology & equipment) for the period from 2000 and 2006.
- More direct evidence from Chen, Jefferson, and Zhang (2011): the TFP in the heavy sector grew faster than that in the light sector using the disaggregate data of 2-digit industries.
- Our model reproduces the stylized Chinese facts *without relying on any TFP assumption or relative prices of investment*.



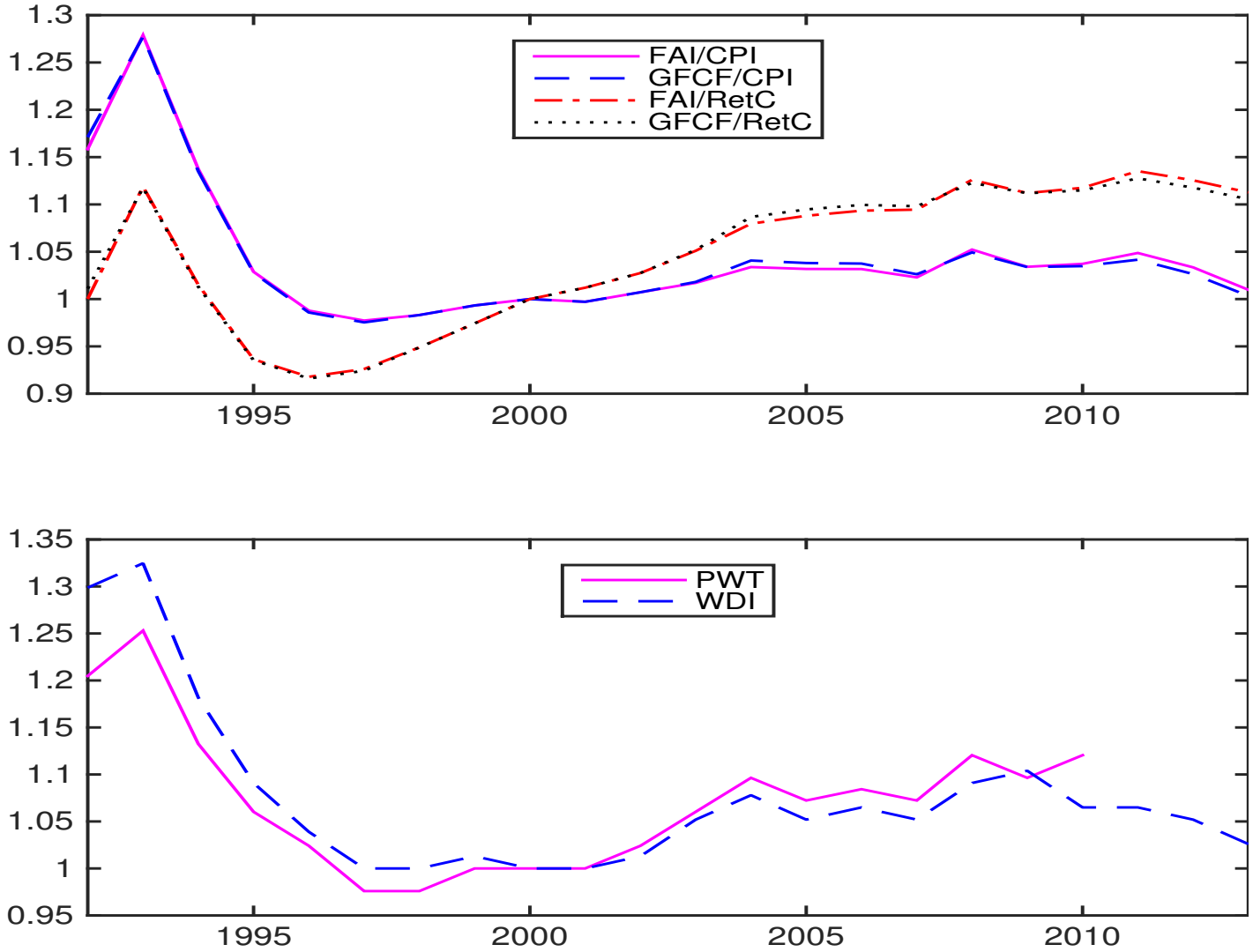
The trend patterns for the benchmark theoretical model.

▸ Parameter configuration



Impulse responses to an expansionary credit shock in the benchmark theoretical model.

The model's assumptions and mechanism: further data corroboration with institutional details.



Various relative prices of investment goods to consumption goods, normalized to 1 for 2000. The PWT and WDI are suggested by Karabarbounis and Neiman (2014).

Estimating the elasticity of substitution

- The annual data for the value and quantity ratios in the heavy and light sectors are available from 1996 to 2011.
- Following Acemoglu and Guerrieri (2008), we first HP-filter the annual data and then estimate the following relationship using the OLS:

$$\log \frac{P_t^k Y_t^k}{P_t^l Y_t^l} = \log \varphi + \frac{\sigma - 1}{\sigma} \log \frac{Y_t^k}{Y_t^l}.$$

- The regression estimate of $(\sigma - 1)/\sigma$ is 0.78 with the t-statistic 5.32, implying that the estimate of σ is 4.53 and significantly greater than 1.
- The result $\sigma > 1$ is also obtained with the annual data of sales instead of value added.

Estimating the elasticity of substitution

- Without the HP filter, we regress $\Delta \log \frac{P_t^k Y_t^k}{P_t^l Y_t^l}$ on $\Delta \log \frac{Y_t^k}{Y_t^l}$ by taking advantage of the relationship

$$\Delta \log \frac{P_t^k Y_t^k}{P_t^l Y_t^l} = \frac{\sigma - 1}{\sigma} \Delta \log \frac{Y_t^k}{Y_t^l}.$$

- The regression estimate of $(\sigma - 1)/\sigma$ is 0.74 with the t-statistic 5.65. This implies that the estimate of σ is 3.86 and it is significantly greater than 1.

Estimating the elasticity of substitution

- Monthly data for P_t^k, P_t^l, Y_t^k, and Y_t^l available:
  - from 2003:1 to 2012:5 (a total of 113 data points) when Y_t^k and Y_t^l are measured by gross output,
  - from 1996:10 to 2012:12 (a total of 195 data points) when these variables are measured by sales.
- Running simple regressions on the HP-filtered seasonally-adjusted series: $\sigma = 1.38$ for gross output and $\sigma = 1.92$ for sales.

Robust econometric procedure

- Take care of *endogeneity* between the value ratio and the quantity ratio, we model such a simultaneous relationship explicitly with the following two-variable restricted VAR:

$$A_0 y_t = a + \sum_{\ell=1}^{p} A_\ell y_{t-\ell} + \varepsilon_t,$$

where A_0 is an unrestricted 2×2 matrix allowing for full endogeneity, a is a 2×1 vector of intercept terms, ε_t is a 2×1 vector of independent standard-normal random shocks, and

$$A_0 = \begin{bmatrix} a_{0,11} & a_{0,12} \\ a_{0,21} & a_{0,22} \end{bmatrix}, \; A_\ell = \begin{bmatrix} a_{\ell,11} & a_{\ell,12} \\ 0 & 0 \end{bmatrix}, \; y_t = \begin{bmatrix} \log \frac{P_t^k Y_t^k}{P_t^l Y_t^l} & \log \frac{Y_t^k}{Y_t^l} \end{bmatrix}'.$$

- It follows that $\sigma = a_{0,21}/(a_{0,21} + a_{0,22})$.
- By Theorems 1 and 3 of Rubio-Ramirez, Waggoner, and Zha (2010), the simultaneous system is globally identified almost everywhere.

Robust econometric procedure

- Likelihood-based estimation of the two-variable system is analogous to utilizing a large number of lagged variables as instrumental variables (Sims, 2000).
- System estimation is robust to a different specification:

$$\log \frac{P_t^k Y_t^k}{P_t^l Y_t^l} = \sigma \log \varphi + (1 - \sigma) \log \frac{P_t^k}{P_t^l}.$$

Estimate and probability intervals of σ using the robust econometric procedure

Seasonally adjusted monthly data		
Point estimate	68% interval	95% interval
2.32	(2.11, 2.54)	(1.94, 2.79)
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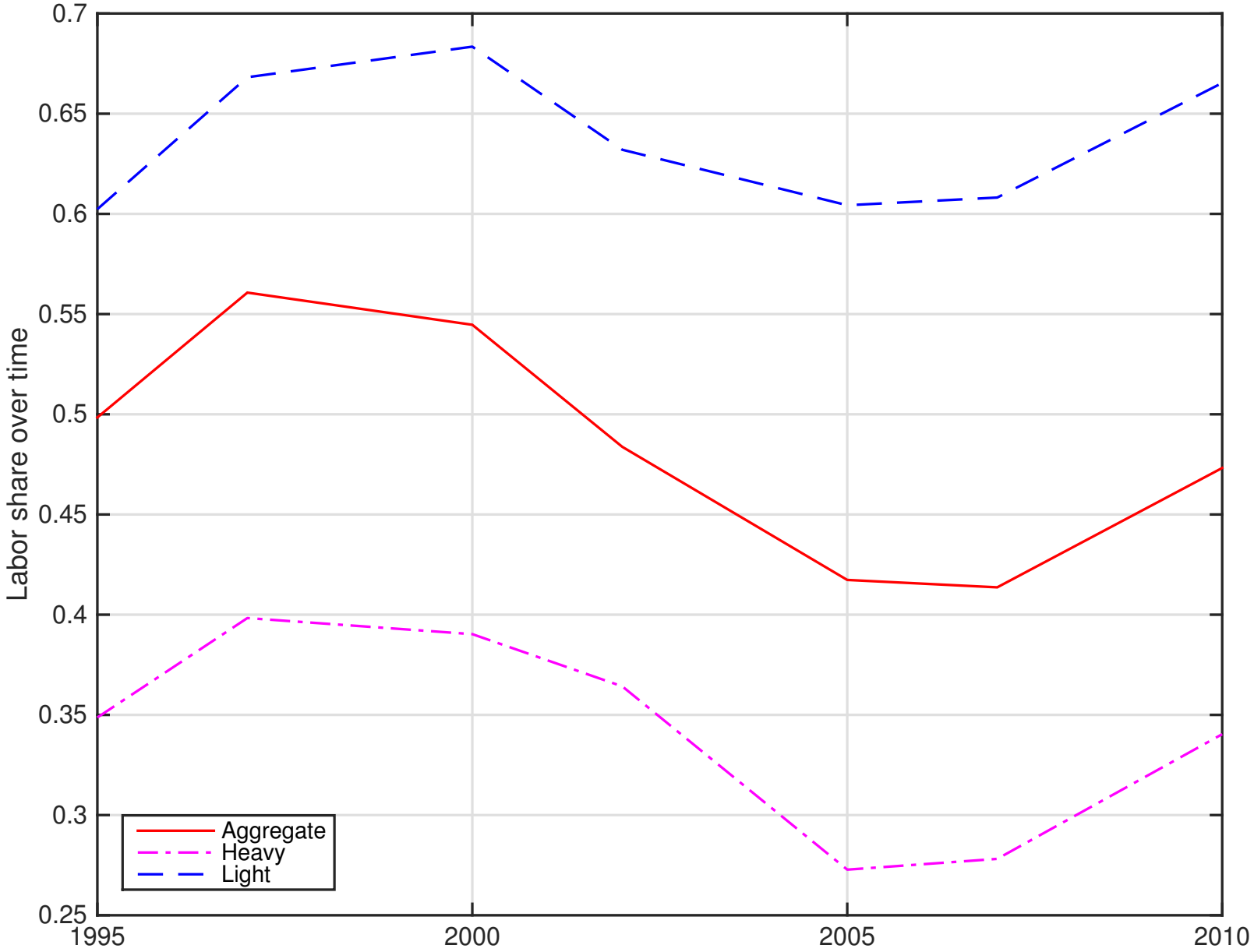


Labor shares in the heavy and light sectors. The calculation is based on the NBS disaggregated data for the 17 sectors in China.

Reallocation and sector-specific effects

All 17 sectors, ΔLS relative to the 1995 labor share					
Year	ΔLS	Between	Within	Between (%)	Within (%)
2007	-0.085	-0.048	-0.037	56.46 (−)	43.54 (−)
2010	-0.025	-0.049	0.024	67.23 (−)	32.77 (+)
All 17 sectors, ΔLS relative to the 1997 labor share					
Year	ΔLS	Between	Within	Between (%)	Within (%)
2007	-0.147	-0.046	-0.101	31.05 (−)	68.95 (−)
2010	-0.088	-0.047	-0.041	53.63 (−)	46.37 (−)
Excluding agriculture, ΔLS relative to the 1995 labor share					
Year	ΔLS	Between	Within	Between (%)	Within (%)
2007	-0.043	-0.020	-0.023	46.88 (−)	53.12 (−)
2010	0.028	-0.022	0.049	30.22 (−)	69.78 (+)
Excluding agriculture, ΔLS relative to the 1997 labor share					
Year	ΔLS	Between	Within	Between (%)	Within (%)
2007	-0.119	-0.021	-0.098	17.66 (−)	82.34 (−)
2010	-0.048	-0.022	-0.026	46.13 (−)	53.87 (−)

Short-term vs. long-term loans

- Heavy industries, given the priority by the "Five-Year Program" of the Eighth National People's Congress, have enjoyed easy access to bank loans for medium and long term investment.
- One main reason for rapid increases of bank loans towards capital-intensive industries is the persistent monopoly held by large banks (most of them are state-owned) in the credit market.

Short-term vs. long-term loans

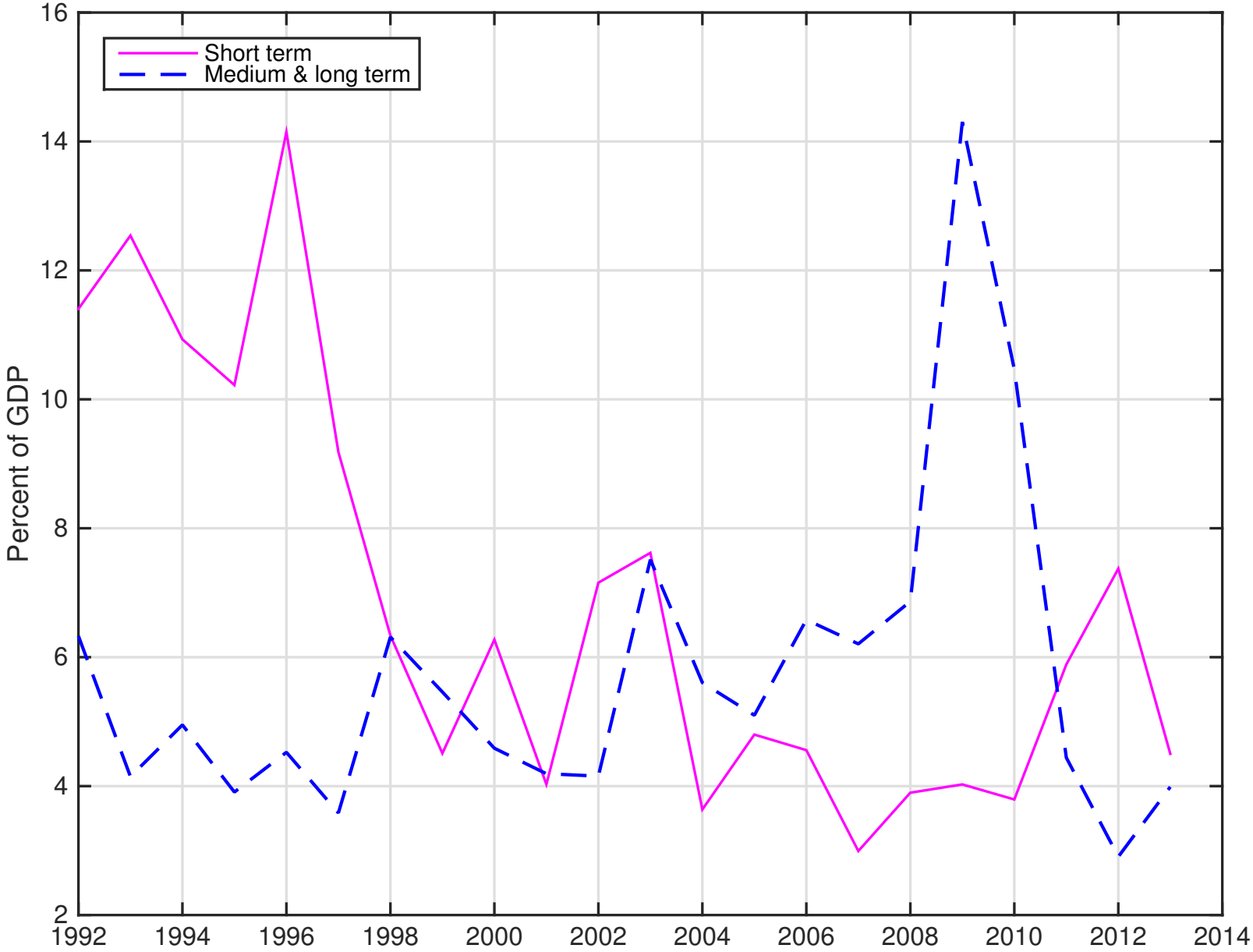
- According to Yu and Ju (1999), the share of the four largest national banks ("the Big Four") in total bank loans was 70.0% in 1997. This monopolistic power has been hardly changed ever since.
- According to our calculation using the monthly data from 2010:1 to 2014:12 published by the PBC, the share of large national banks in total bank loans was on average 67.4% (with a share of 51.2% for the Big Four).
- This monopoly is more severe for *medium and long term loans*, with an average share of 75.7% between 2010 and 2014 (55.2% for the Big Four).

Short-term vs. long-term loans

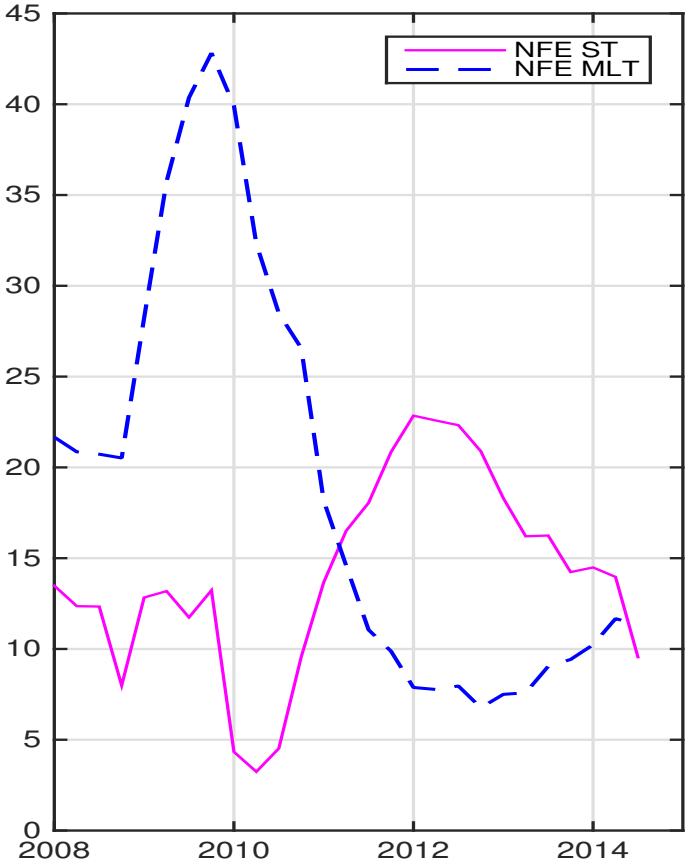
- When assessing loan applications, these large national banks favor loans to large firms and are biased against small firms.
- This practice is not only because of the asymmetric information problem for small firms when banks assess loan applications, but also because large firms *gain implicit government guarantees from local governments* (Jiang, Luo, Huang, 2006).
- Banks favor lending to industries targeted by the state (e.g. steel and petroleum) because large firms produce more sales, provide more tax revenues, and help boost the GDP of the local economy, *an important criterion for the promotion of local government officials*.

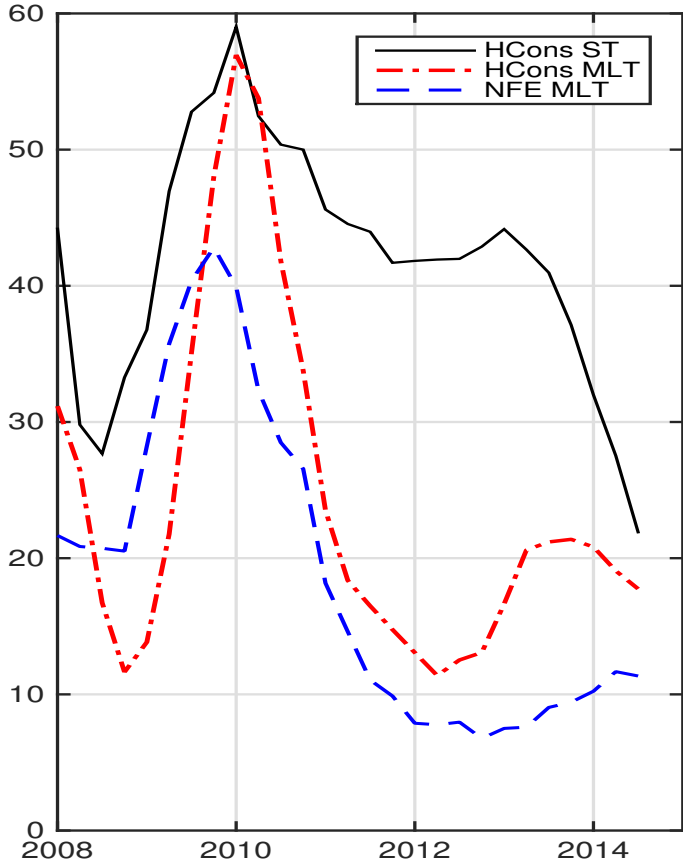
Short-term vs. long-term loans

- Most small firms are concentrated in labor-intensive industries (Lin and Li, 2001).
- Given the monopoly of large banks in the credit market, their preferential loan advances to large firms in the heavy industry, often in the form of "medium & long term loans," take priority over other loans to small firms in the light industry, often in the form of "short-term loans and bill financing."
- PBC's *China Monetary Policy Reports* reveal that the government often increases medium & long term loans at the sacrifice of short-term loans.
- From our calculation based on the 2010:1-2014:4 quarterly series of loan classifications reported by the PBC, 89% of medium&long-term loans is allocated on average to heavy industries and this number has been stable over the years.



New bank loans to non-financial enterprises as percent of GDP. The correlation between the two types of loans is -0.403 for 1992-2012 and -0.405 for 2000-2012.

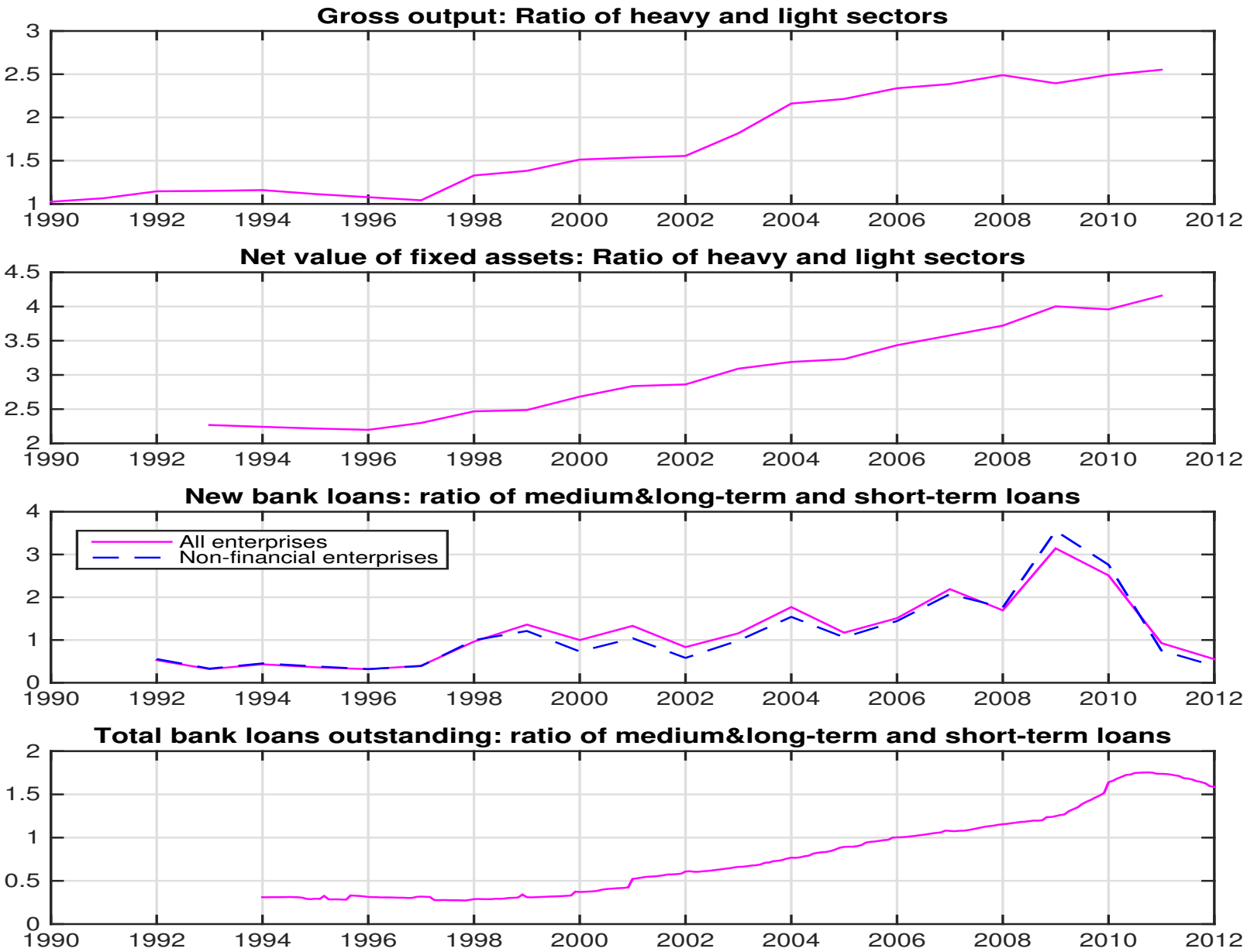




Year-over-year growth rates of short term (ST) and medium and long term (MLT) bank loans (outstanding) to household consumption (HCons) and non-financial enterprises (NFE) from 2008Q1 to 2014Q3. The correlation is -0.744 between short-term and medium&long-term NFE loans, 0.725 between short-term and medium&long-term household consumption loans, and 0.769 between medium&long-term NFE and household consumption loans.

Correlation between short-term and long-term loans (quarterly data)

art of sample	Loan growth (yoy) U.S.	Loan growth (yoy) China	New loans as % of GDP China
61:1-	0.63 (2014:3)	N/A	N/A
97:1-	0.60 (2014:3)	-0.26 (2014:4)	-0.27 (2013:4)
00:1-	0.59 (2014:3)	-0.40 (2014:4)	-0.27 (2013:4)



Secular patterns for heavy vs light sectors and for medium and long term bank loans vs. short term bank loans.

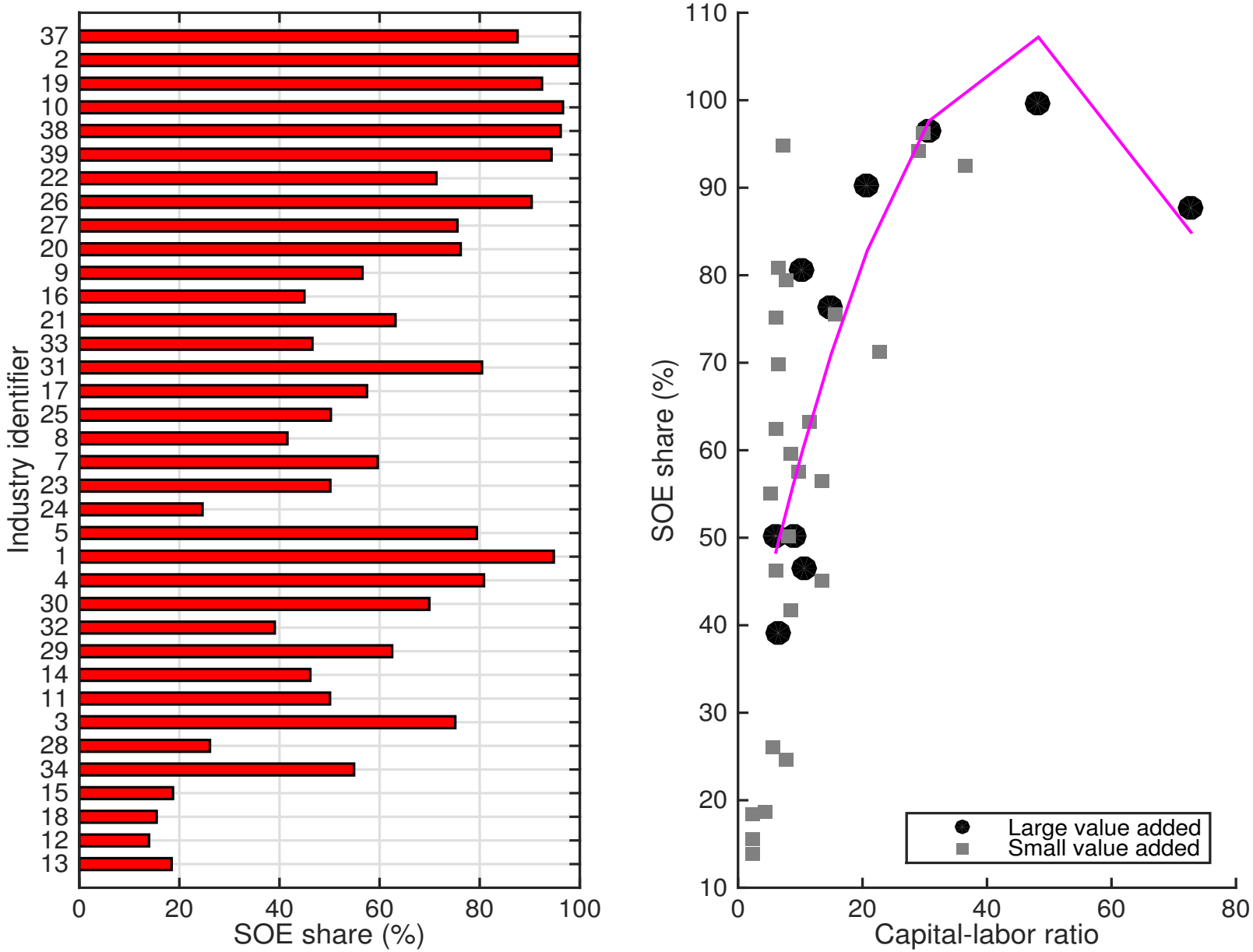
Conclusion

- Refine and enrich the model for day-to-day policy analysis, an analysis much needed by the People's Bank of China—in the spirit of the CEE and SW tradition.
- Perhaps the most relevant extension is to explore policy implications and banking reforms.
- The twin first-order problems facing China's macroeconomy today: (a) low consumption growth and (b) overcapacity of heavy industries with rising debt risks.
- Our paper suggests that both problems have stemmed from preferential credit policy for promoting the heavy industrialization since the late 1990s.
- Going forward, effective policy would aim at reducing the *preferential* credit access given to large firms and especially those in the heavy sector.

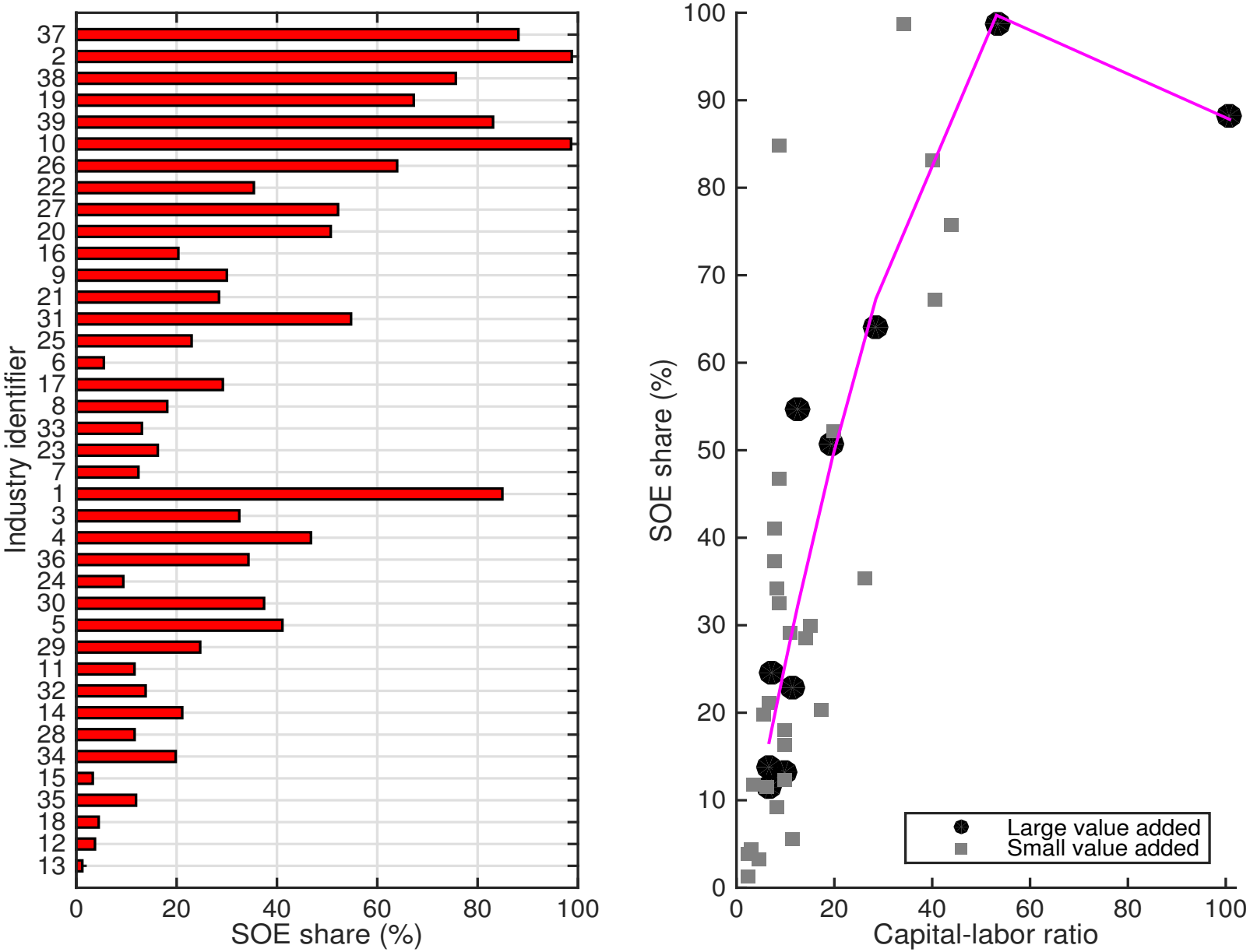
Supplemental Materails

ntifier	Industry
1	Mining and Washing of Coal
2	Extraction of Petroleum and Natural Gas
3	Mining and Processing of Ferrous Metal Ores
4	Mining and Processing of Non-Ferrous Metal Ores
5	Mining and Processing of Nonmetal Ores
6	Mining of Other Ores
7	Processing of Food from Agricultural Products
8	Food
9	Wine, Beverage & Refined Tea
10	Tobacco
11	Textile
12	Textile Product, Garment, Shoes & Hat
13	Leather, Fur, Feather & Its Product
14	Wood Processing, Wood, Bamboo, Rattan, Palm & Grass Product
15	Manufacture of Furniture
16	Manufacture of Paper and Paper Products
17	Printing, Reproduction of Recording Media
18	Cultural, Education & Sport
19	Processing of Petroleum, Coking, Processing of Nuclear Fuel
20	Chemical Material & Product

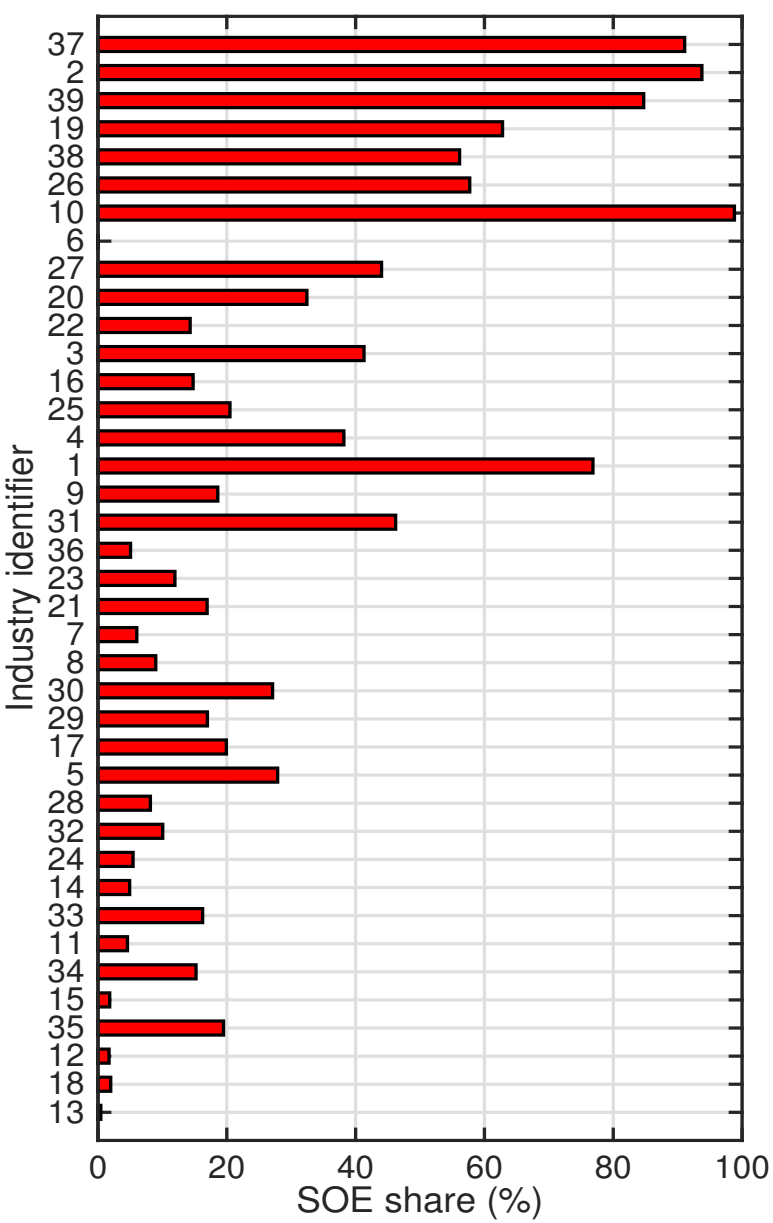
ntifier	Industry
21	Manufacture of Medicines (Pharmaceutical)
22	Manufacture of Chemical Fibers
23	Manufacture of Rubber
24	Manufacture of Plastics
25	Manufacture of Non-metallic Mineral Products
26	Smelting and Pressing of Ferrous Metals
27	Smelting and Pressing of Non-ferrous Metals
28	Manufacture of Metal Products
29	Manufacture of General Purpose Machinery
30	Manufacture of Special Purpose Machinery
31	Manufacture of Transport Equipment
32	Manufacture of Electrical Machinery and Equipment
33	Computer, Communication & Other Electronic Equipment
34	Instrument, Meter, Culture & Office Machinery
35	Manufacture of Artwork and Other Manufacturing
36	Recycling and Disposal of Waste
37	Electricity, Heat Production & Supply
38	Gas Production & Supply
39	Water Production & Supply

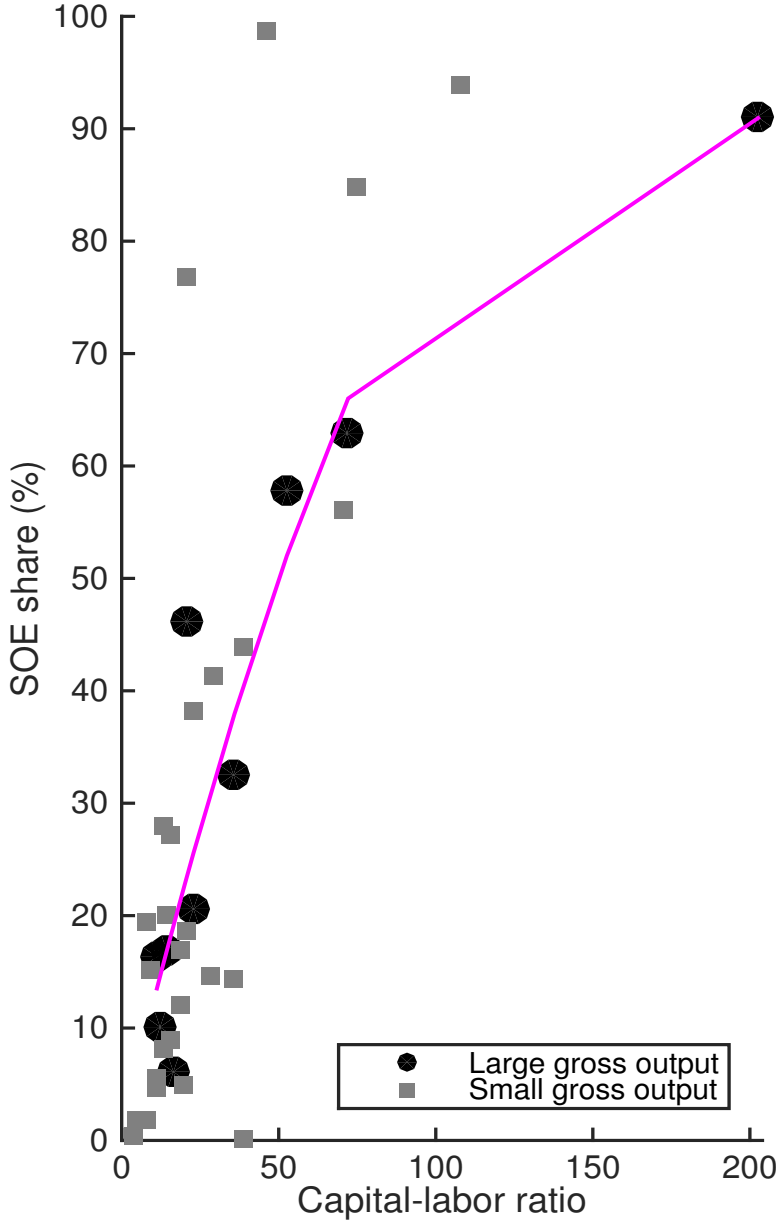


The 1999 characteristics of various industries in China.



The 2006 characteristics of various industries in China.





The 2011 characteristics of various industries in China.

Key transition paths

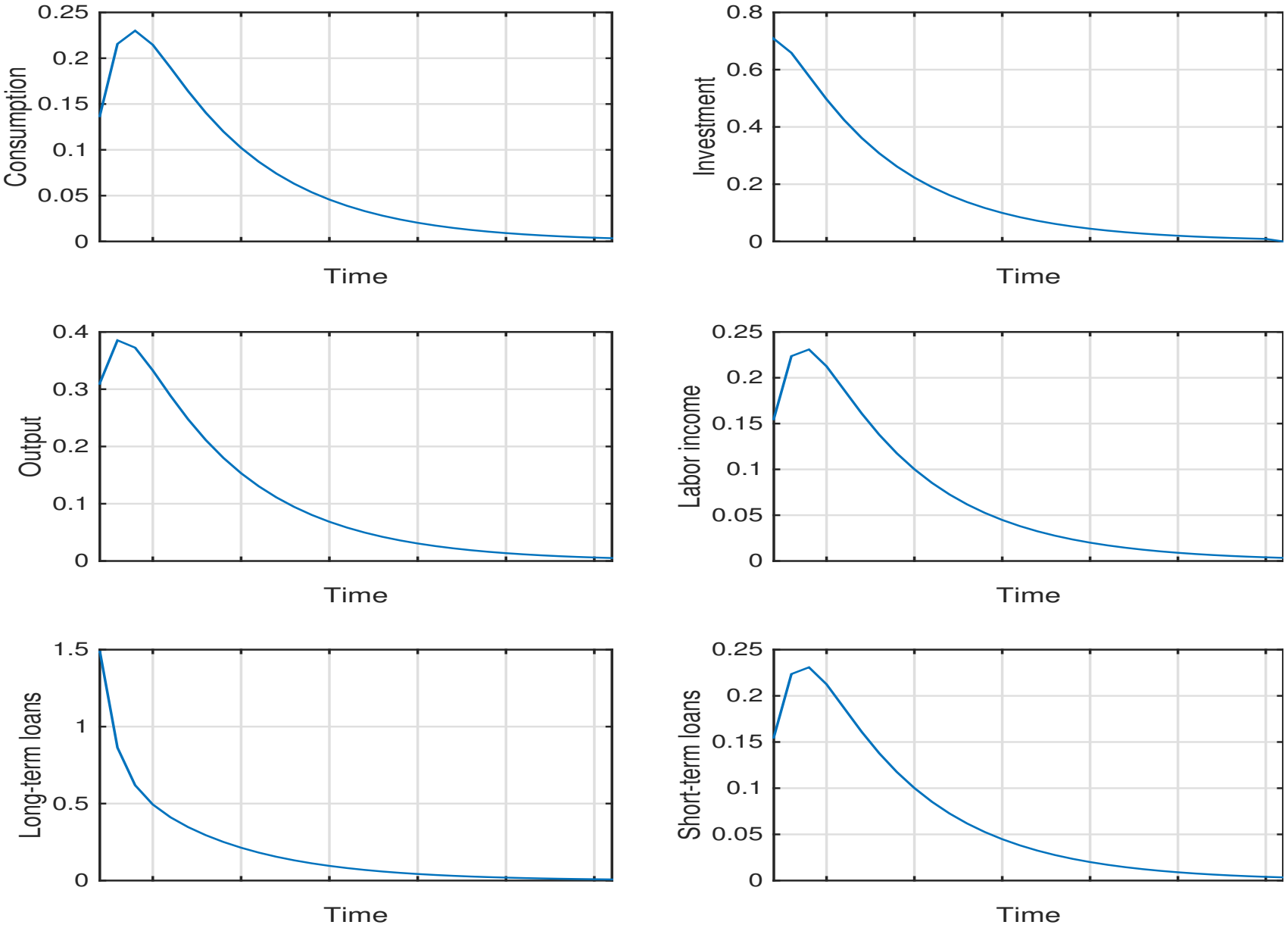
Proposition Given that $\sigma > 1$, during the transition the ratio of revenue in the capital-intensive sector to that in the labor-intensive sector increases monotonically towards the steady state.

- Note

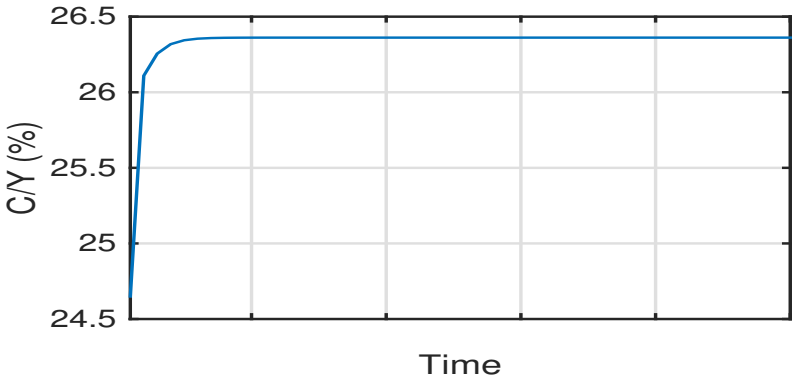
$$\Delta \log \frac{P_t^k Y_t^k}{P_t^l Y_t^l} = \left(1 - \frac{1}{\sigma}\right) \Delta \log \frac{Y_t^k}{Y_t^l}; \quad \frac{Y_t^k}{Y_t^l} = \left(\frac{\varphi \left(1 - \varphi^\sigma \left(P_t^k\right)^{1-\sigma}\right)^{\frac{1}{1-\sigma}}}{P_t^k} \right)^\sigma .$$

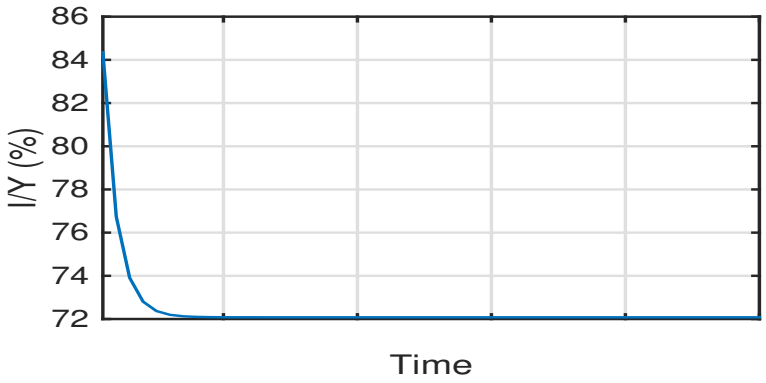
- As net worth of the capital-intensive sector increases, the collateral constraint becomes less binding, which reduces the price of capital-intensive goods towards the first-best level R.
- The ratio Y_t^k / Y_t^l increases monotonically during the transition path.
- Given $\sigma > 1$, the ratio $P_t^k Y_t^k / \left(P_t^l Y_t^l\right)$ increases along the transition path.

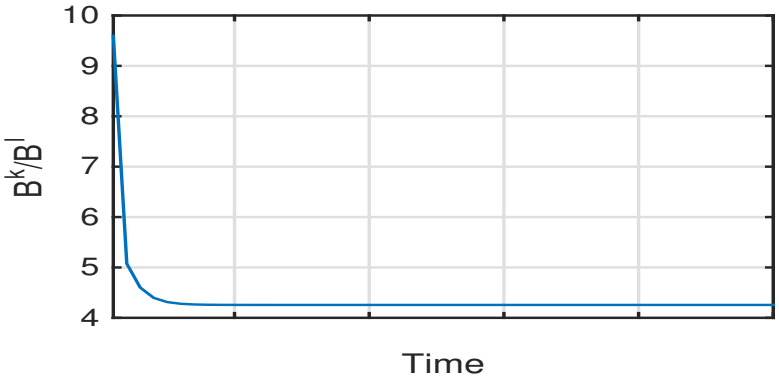
Impulse responses to an expansionary credit shock in an economy without the bank-lending friction:

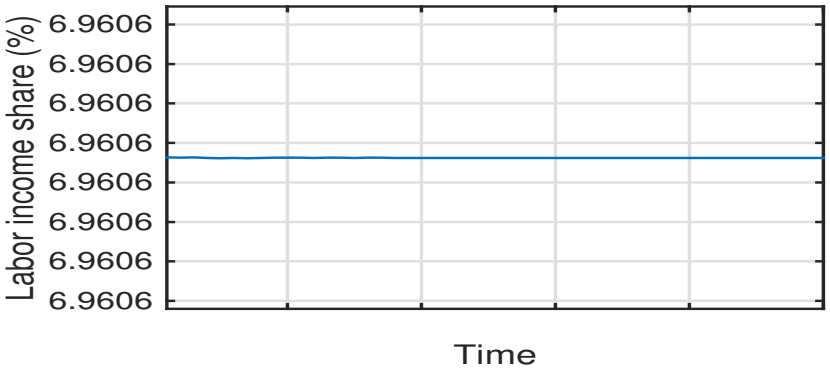


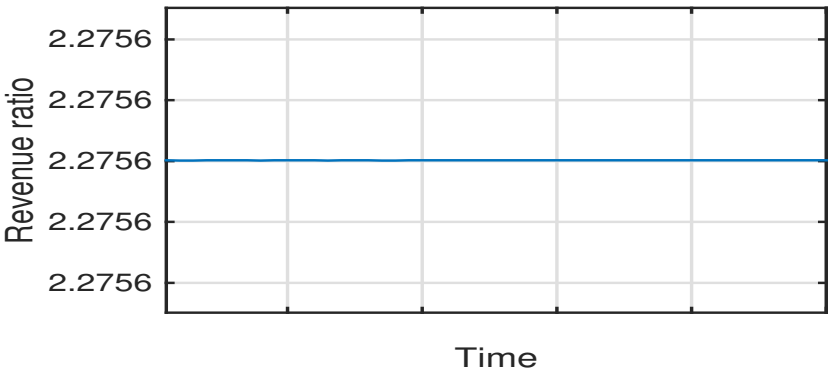
The trend patterns for an economy without lending frictions and collateral constraints:

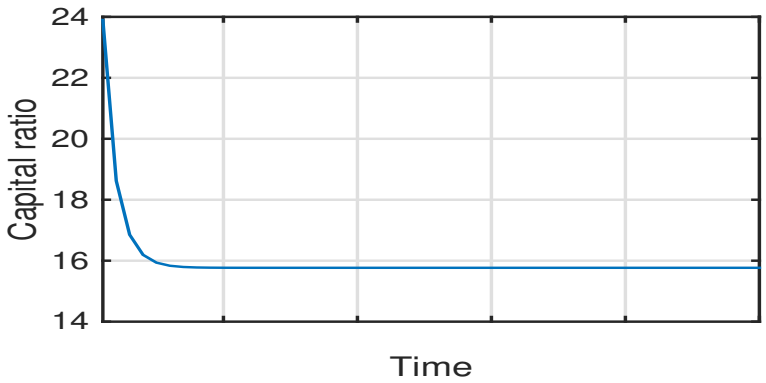












Economy with no collateral constraints

- Consider the complete capital depreciation and the risk-aversion parameter $\gamma = 1$.
- Because there there is no collateral constraint on capital-intensive firms, we have $P_t^k = R$ and consequently P_t^l is constant.
- The investment rate in the capital-intensive sector becomes

$$\frac{K_{t+1}^k}{P_t^k Y_t^k} = \frac{K_{t+1}^k}{P_{t+1}^k Y_{t+1}^k} \frac{P_{t+1}^k Y_{t+1}^k}{P_t^k Y_t^k} = \frac{1}{R} \frac{Y_{t+1}^l}{Y_t^l}.$$

- $\frac{Y_{t+1}^l}{Y_t^l}$ declines dues to the diminishing returns to capital in the labor-intensive sector.
- Even though the investment rate in the labor-intensive sector remains constant, because $\frac{P_t^l Y_t^l}{P_t^k Y_t^k}$ is constant, the investment rate in the capital-intensive sector $\downarrow \longrightarrow$ the aggregate investment rate $\downarrow$ and the consumption-output ratio $\uparrow$.

Parameter figuration:

Parameter	Definition	Value
α	Capital Income Share in L-Sector	0.40
β	Utility Discount Factor	$(0.96)^{30}$
γ	Speed of Net Worth Accumulation for K-sector	0.56
θ	Leverage Ratio for K-Sector	0.30
ω	Fraction of L-sector Revenue to Young Entrepreneurs	0.20
δ	Capital Depreciate Rate	1
χ	Relative TFP of L-sector	4.98
σ	Elasticity of Substitution Between K and L Sectors	2
R	Interest Rate for K-sector Investment Loan	1.04
ϕ	Share of K-sector output in Final Output Production	0.85
η	Curvature Parameter in Banking Cost of Borrowing	20
ν	Intertemporal Elasticity of Substitution	1

Back to benchmark model

Equilibrium

$$
\begin{aligned}
1 &= n_t = \left[\frac{(1-\psi)(1-\alpha)P_t^l\chi}{R_t^l w_t}\right]^{\frac{1}{\alpha}} K_t^l/\chi, \\
\Pi_t^l &= \rho_t^l K_t^l, \\
\rho_t^l &= (1-\psi)\alpha P_t^l \left(K_t^l\right)^{\alpha-1}\chi^{1-\alpha} + 1 - \delta, \\
R_t^l &= 1 + C'(B_t), \\
\Pi_t^k &= P_t^k K_t^k - R\left(K_t^k - N_t\right) + (1-\delta)K_t^k, \\
\Pi_t^B &= \left(R_t^l - 1\right)B_t^l - C(B_t), \\
m_t &= \psi P_t^l \left(K_t^l\right)^{\alpha}(\chi L_t)^{1-\alpha}, \\
s_t^E &= m_t / \left(1 + \beta^{-\gamma}\left(E_t\rho_{t+1}^l\right)^{1-\gamma}\right), \\
c_{1t}^E &= m_t - s_t^E,\ c_{2t}^E = \rho_t^l s_{t-1}^E, \\
B_t^k &= K_t^k - N_t, \\
B_t^l &= w_t L_t,
\end{aligned}
$$

Equilibrium

$$
\begin{aligned}
N_{t+1} &= \xi K_t^k, \\
Y_t &= \left[\varphi\left(Y_t^k\right)^{\frac{\sigma-1}{\sigma}} + \left(Y_t^l\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}, \\
Y_t^k &= K_t^k, \\
Y_t^l &= Y_t^l = \left(K_t^l\right)^{\alpha}\left(\chi L_t\right)^{1-\alpha}, \\
1 &= \left[\varphi^{\sigma}\left(P_t^k\right)^{1-\sigma} + \left(P_t^l\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \\
K_t^k &= \frac{R}{R-\theta_t P_t^k} N_t, \\
B_{t+1}^G &= \Pi_t^k + \Pi_t^b + RB_t^G - N_{t+1}, \\
P_t^l &= \frac{P_t^k}{\varphi}\left(\frac{Y_t^l}{Y_t^k}\right)^{\frac{1}{\sigma}}, \\
s_t^w &= w_t / \left(1 + \beta^{-\gamma} R^{1-\gamma}\right), \\
c_{1t}^w &= w_t - s_t^w,\ c_{2t}^w = s_t^w R, \\
B_t^w &= s_t^w - B_t^k.
\end{aligned}
$$