# Investment Function of China

**Analyzed by Li Zhongwu**[1]

***All data are from National Bureau of Statistics,China and Federal Reserve Bank of St.Louis.**

## Definition of terms

1.**Fixed asset investment(FAI)** is meant to measure investment in long-term assets, such as buildings and equipment. However, also included in FAI are land purchases, used facilities and equipment purchases, and mergers and acquisitions. Chinese officials have long acknowledged including these items is not ideal. However, by not disaggregating they are able to produce an investment estimate with relatively high frequency and provide an important leading economic indicator.

2.**Gross fixed capital formation (GFCF)** measures how much of an economy's new output is invested, excluding purchases of land and other already-owned assets. These purchases are excluded because they don't represent new assets, just a change in ownership. Therefore they should not be considered new investment. Inventories are also excluded from GFCF.

3.**Gcapital:** annual growth rate of capital stock; **Ginvest:** annual growth rate of fixed investment; **Ggdp:** annual growth rate of gdp.

4.**The last letter f and v in aaf, aav** and remaining other pairs of terms represent **fixed investment growth rate(yearly) and value added growth rate(yearly)** ,hence, **aaf:** Agriculture Forestry Animal Husbandry and Fishery industries sector fixed investment, **aav:** Agriculture Forestry Animal Husbandry and Fishery industries sector value added;

5.**The first two letters aa and ba in aaf(v) and baf(v)** represent Agriculture Forestry Animal Husbandry and Fishery industries sector and Industry sector respectively, and **bb,ca,cb,cc,cd,ce and cf** means Construction sector,Whole sale and Retail sale sector, Transport storage and post sector, Hotel and catering services sector, Financial intermediation sector, Real estate sector and others(remaining) sectors respectively.

6.**lginvestment,lggdp,lgcapital:** logarithmic investment,gdp,capital stock; **netxm:** netx export of goods and services; **flgcapital:** one period led logarithmic capital stock; **l.lggdp:** one period lagged logarithmic gdp; **grp:** gross regional products; **lfixedinvestment:** one period lagged fixed investment.

7.**llgaaf**=l.lgaaf(one period lagged lgaaf) , **llgbaf**=l.lgbaf=(one period lagged lgbaf),**llgbbf,llgcaf,llgccf,llgcdf,llgcef,llgcff** have similar definitions; **dlgaav**=lgaav-l.lgaav(one period differenced lgaav), **dlgbav**=lgbav-l.lgbav=(one period differenced lgbav),**dlgbbv,dlgcav,dlgcbv,dlgccv,dlgcdv,dlgcev,dlgcfv** have similar definitions.

8.**Significance. codes:** '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 .

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[1] **Note:** Author is a member of investment function estimation team in Applied Macroeconomics taught by Professor Rakesh Raman.

# 1.Introduction to fixed investment of China


**Figure 1**

Total fixed investment is allocated to three fields,Construction and installation,Equipment and instrument and Others.From (**Fig 1**),total fixed investment grows at an exponential growth speed,from 96.1 billion Yuan(1981) to 51.2 trillion Yuan(2014),which is almost 533 times more than 1981's.At the same time,its three components are expanded by 507 times,451 times and 1288 respectively from 1981 to 2014.With the exponential growth rate method,total fixed investment and its three parts expand at the speed of 20.9%,20.7%,20.3% and 24.3% respectively.The share of three parts of total fixed investment is invariably changing year by year,construction and installation gets 71.87 % in 1981,then its share has been declining to 60.73% in 2008(financial crisis);but its trend is reversed,and its share is again expanded to 68.32% in 2014 because of strong stimulus packages instilled into many basic construction works.The average share of Equipment purchases and instrument( $=\sum_{1981}^{2014} Share_t / 23$ ) is about 24%,its stability implies the feature of market-driven fixed investment.

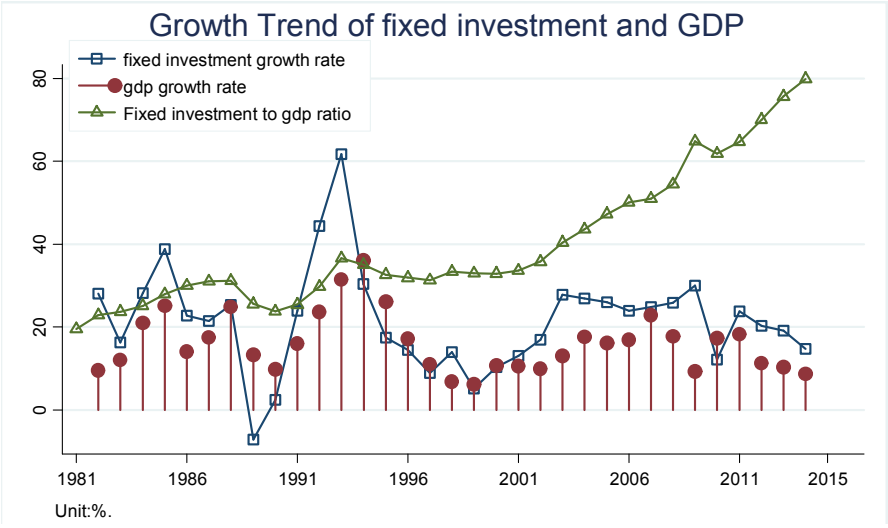


**Figure 2**

The ratio of fixed investment to GDP has increased from 19.53%(1981) to 79.92%(2014),the ratio of gross capital formation to GDP,which excludes land purchases and already owned assets,inventories investment is also just below 50%.Compared with other countries experience,this is unsustainable for Chinese economy to continue growing on the basis of investment(**Fig 2**).

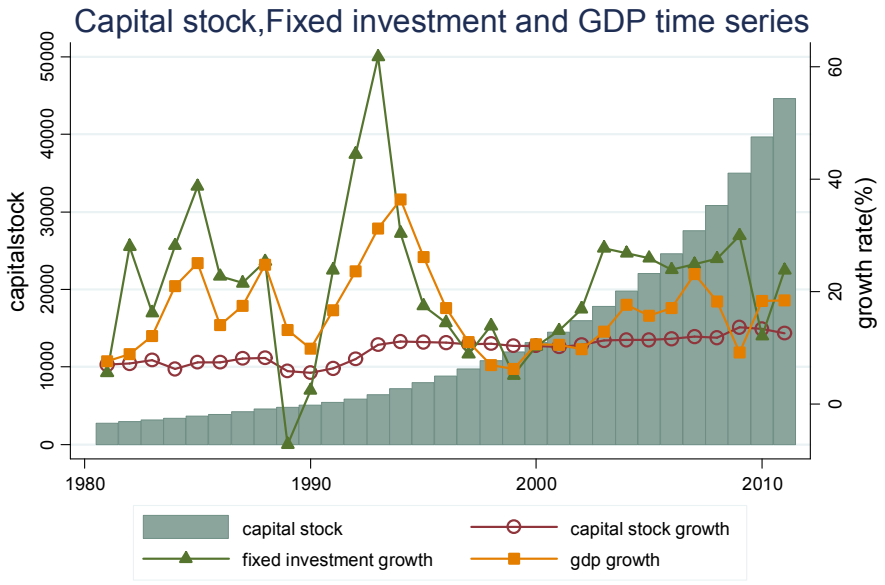


**Figure 3** Unit:billion dollar at constant price(2005).

Table 1:Pearson correlation

| | Gcapital | Ginvest | Ggdp |
|---|---|---|---|
| Gcapital | 1.0000 | | |
| Ginvest | 0.1642<br>0.3776 | 1.0000 | |
| Ggdp | 0.1048<br>0.5746 | 0.6353<br>0.0001 | 1.0000 |

Table 2:Spearman's rank correlation

| | Gcapital | Ginvest | Ggdp |
|---|---|---|---|
| Gcapital | 1.0000 | | |
| Ginvest | 0.2153<br>0.2447 | 1.0000 | |
| Ggdp | 0.2097<br>0.2576 | 0.5681<br>0.0009 | 1.0000 |

Capital stock is accumulated from the baseline of 2.7 trillion dollar(2005 constant price) in 1981 to recent 44.6 trillion dollar in 2011(data unavailability) at the annual growth rate of 9.74%.The correlation coefficient of yearly growth rates of fixed investment and GDP is 0.6353(Pearson),0.5681(Spearman).It self-justifies the close relationship between fixed investment and GDP through accelerator mechanism.

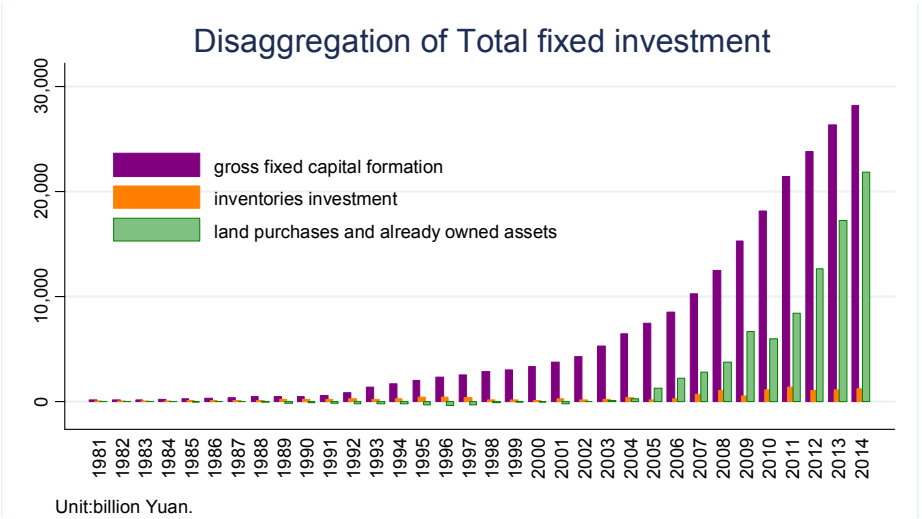


**Figure 4** Unit:billion Yuan.

According to Chinese national statistic methodology,fixed investment=gross fixed capital formation+inventories investment+land purchases and already owned assets.From (**Fig 4**),some interesting

facts can be extracted.Inventories investment is closely related to market mechanism operation and economic cycle ,the ratio of inventories investment to total fixed investment is 30.44% in 1980,reflecting serious mismatch between market demand and producer supply.Even if China is under administrative allocation of daily goods,but scarcity of those products is present together with oversupply of other government supported industries.The highest ratio of inventories investment to total fixed investment (45.20%) happens in 1989,when China suffers from world-known political crises,so,economic situation is quite bad.After 1997(14.45%),the ratio suddenly jumps down to 5.79%(1998), till the lowest level of 2.37% in 2014.With regards to land purchases and already owned assets,it is positively related to government housing policies and economic growth.The ratio of land purchases and already owned assets to total fixed investment is minus 73.42% in 1980,but strong economic growth expands the base of already owned assets in the economy,the ratio turns to be positive in 2003(1.29%).Aftereffects of market reform of real estate(commercialization of real estate) at the end of 1990s,Chinese economy follows world economy to enter into her prosperity periods up to 2008 financial crisis.At the same time,the ratio is normally going up to 21.77% in 2008,but after government's stimulus packages of 4 trillion Yuan,the ratio steeply jumps up to 29.52% in 2009.Land sales revenue has been a main contributor to local government fiscal revenue,under the context of housing market has contributed 20% share to Chinese GDP,hencewith,the ratio has the value of 42.62% in 2014.

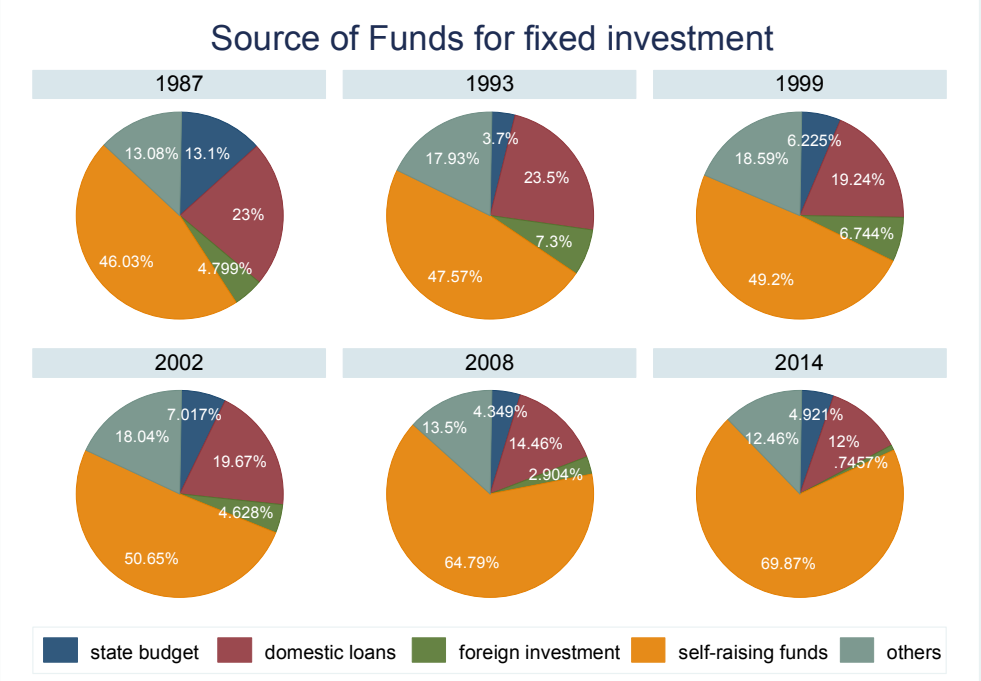


**Figure 5**

According to Chinese national statistics,there are 4 main sources of funds for fixed investment.(**Fig 5**) shows us that self-raising funds contribute most to fixed investment,then,domestic loans are ranked the second in funding investment.There is a clear trend that the importance of state budget has been declining from 12.1%(1987) to 4.92%(2014),,source of self-raising funds increases its share from 46.03%(1987) to 69.87%(2014).The possible reason is based on China's "Reform and Open up" policy,private economy gradually dominates almost all fields except energy,raw material,utility,etc which are controlled by different levels of Chinese governments.Another one trend is almost negligible share of foreign investment in fixed investment(0.7457%,2014),it indicates that the received FDI more than 120 billion dollars has a smaller role to play with comparison to huge amount of investment.

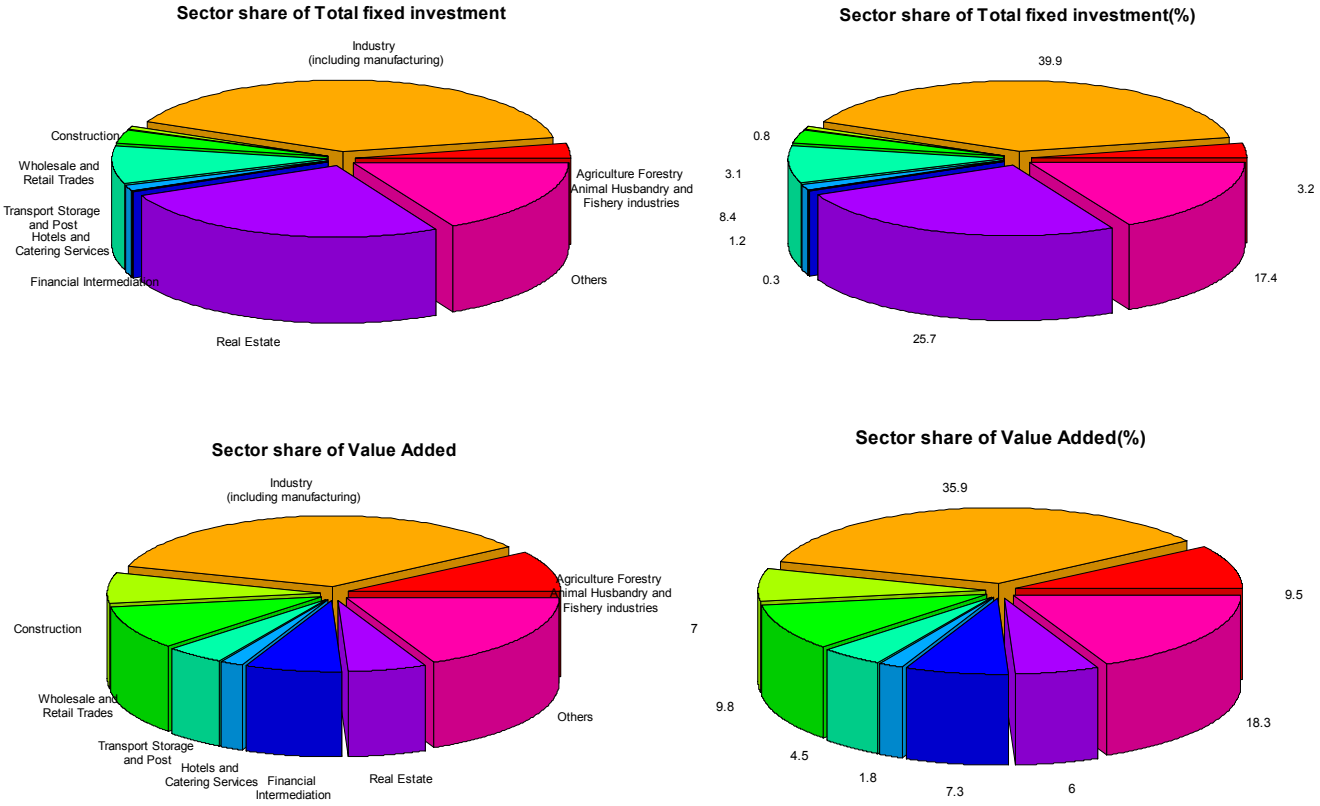


**Figure 6**

The fixed investment share of Industry sector(39.9%) is largest,the second largest fixed investment sector is Real estate(25.7%),Agriculture Forestry,Animal Husbandry and Fishery sector gets 3.2% fixed investment.The value added share of Industry sector(35.9%) is also largest,the second largest value added sector is Whole and Retail Trades(9.8%),Agriculture Forestry,Animal Husbandry and Fishery sector with 9.5% share is slightly less than commodity trade sector.However,Real Estate sector having 25.7% fixed investment share just adds 6% economic value to Chinese output.Financial Intermediation sector with merely 0.3% fixed investment produces 7.3% value added,it reflects the essential feature of financial institutions that they create value on the basis of services.

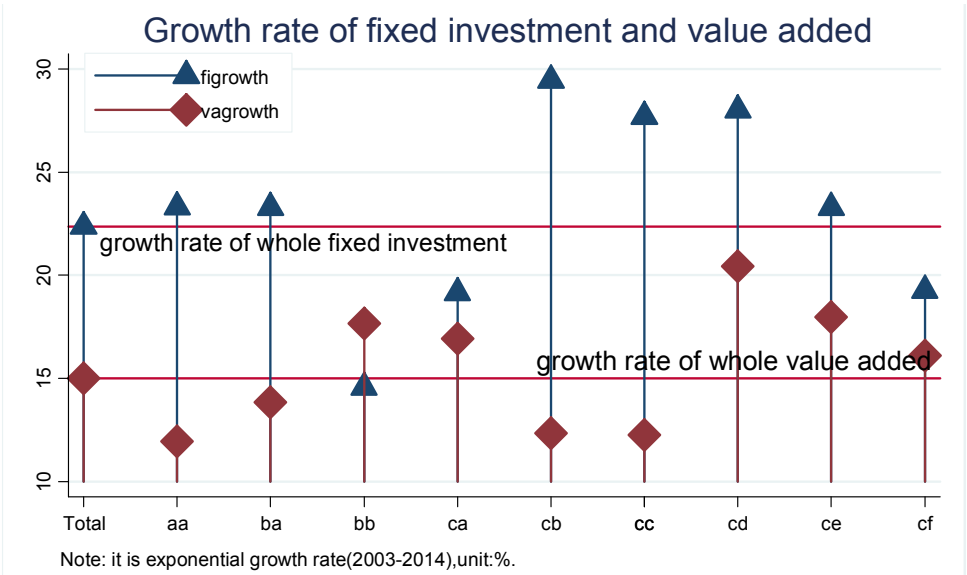


**Figure 7**

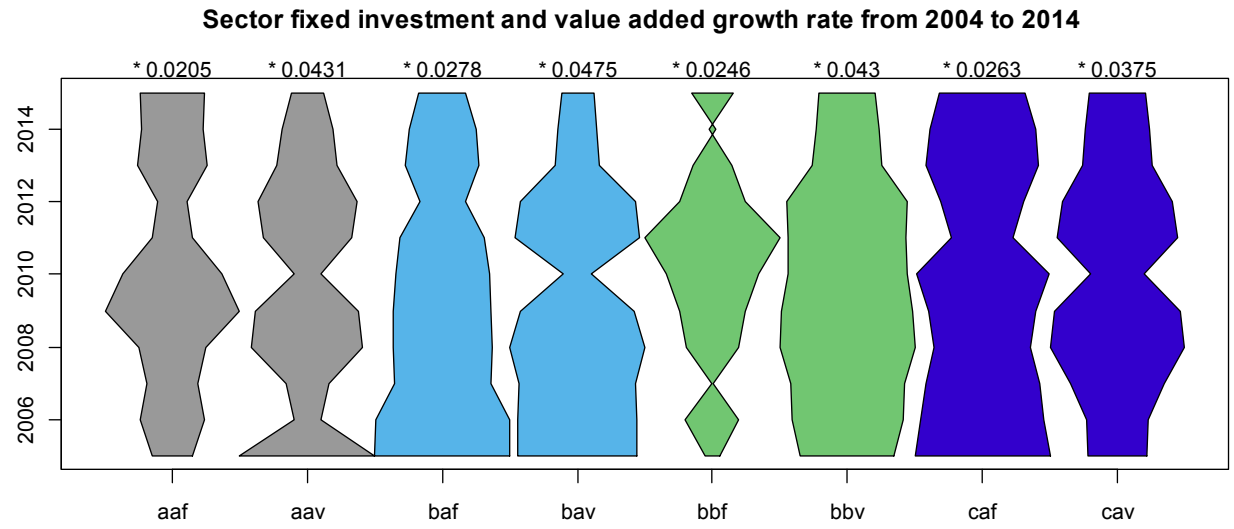


**Figure 8**

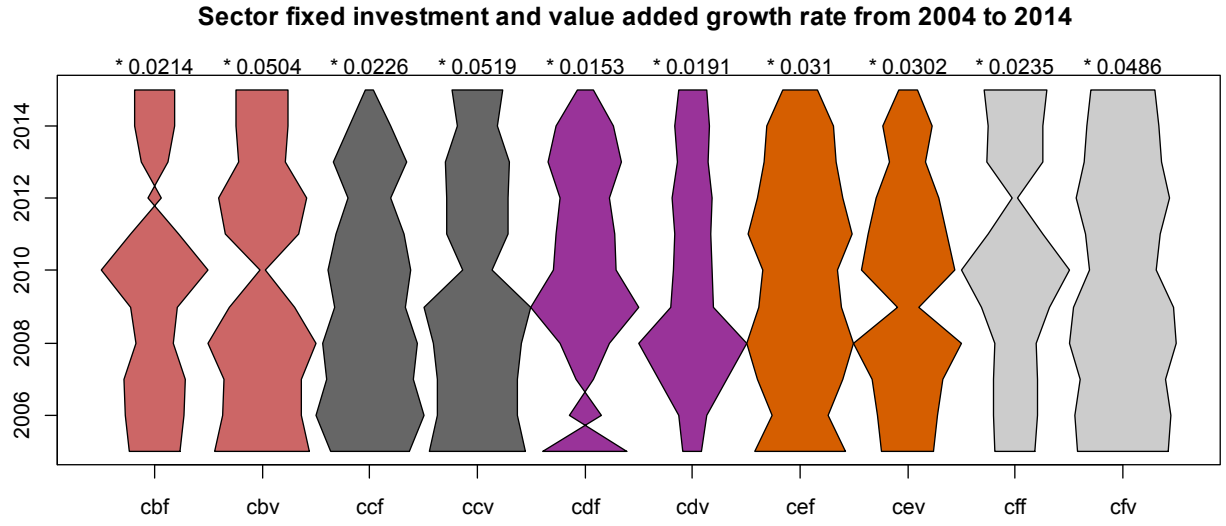


**Figure 9**

## Table 3:Sector wise correlation coefficients between yearly growth rates of fixed investment and value added(2004-2014)

| Item | Gaaf | Gbaf | Gbbf | Gcaf | Gcbf | Gccf | Gcdf | Gcef | Gcff |
|---|---|---|---|---|---|---|---|---|---|
| Gaav | -0.1569 | | | | | | | | |
| Gbav | * | 0.4810 | | | | | | | |
| Gbbv | * | * | 0.4944 | | | | | | |
| Gcav | * | * | * | -0.5791 | | | | | |
| Gcbv | * | * | * | * | -0.5419 | | | | |
| Gccv | * | * | * | * | * | 0.4377 | | | |
| Gcdv | * | * | * | * | * | * | -0.0403 | | |
| Gcev | * | * | * | * | * | * | * | 0.6317 | |
| Gcfv | * | * | * | * | * | * | * | * | -0.5410 |

**Table 4:Descriptive statistics comparisons between yearly growth rates of fixed investment and value added(2004-2014)**

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| aaf | 11 | 23.72091 | 10.75032 | 10.54 | 48.8 |
| aav | 11 | 12.12182 | 6.559867 | 4.52 | 23.19 |
| baf | 11 | 23.52455 | 7.964097 | 11.99 | 35.98 |
| bav | 11 | 14.02727 | 6.732557 | 4.56 | 21.05 |
| bbf | 11 | 15.14273 | 12.24367 | -1.85 | 40.64 |
| bbv | 11 | 17.74182 | 4.788595 | 9.76 | 23.27 |
| caf | 11 | 29.59909 | 6.210944 | 17.52 | 37.96 |
| cav | 11 | 17.08091 | 6.202026 | 10.77 | 26.66 |
| cbf | 11 | 19.75091 | 12.50807 | -5.93 | 46.7 |
| cbv | 11 | 12.46364 | 5.180228 | 0.94 | 19.85 |
| ccf | 11 | 28.20455 | 11.57568 | 3.13 | 44.22 |
| ccv | 11 | 12.33727 | 4.295938 | 5.15 | 19.25 |
| cdf | 11 | 30.07727 | 22.91219 | -19.52 | 65.37 |
| cdv | 11 | 20.93545 | 12.12127 | 9.15 | 52.47 |
| cef | 11 | 23.42545 | 6.279389 | 10.55 | 32.27 |
| cev | 11 | 18.25091 | 8.612555 | 5.59 | 33.16 |
| cff | 11 | 19.59909 | 9.389587 | 1.8 | 40.53 |
| cfv | 11 | 16.13 | 2.784744 | 12.44 | 20.58 |

We calculate the exponential growth rate of sector-wise fixed investment and value added ranging from 2003 to 2014 year.From (**Fig 7**),the average growth rates of whole fixed investment and value added are 22.37%,15.01% respectively.Whole and retail sales sector,Financial intermediation sector and Hotel and catering sector have the highest growth rates of fixed investment by order(29.46%,28.01%,27.70%),on the other hand,Financial intermediation sector,Real estate sector and Construction sector have highest growth rates of Value added by order(20.44%,17.97%,17.65%).If we calculate the pairwise correlation coefficient between sector-wise fixed investment and value added,the result with value of -0.3160 has more information to be explored.

From (**Fig 8,Fig 9**) and (**Table 3)**,we could further observe the relationship between yearly growth rates of fixed investment and value added on the basis of sectors. If two variables change in a similar proportion(no matter what direction it is),then two variables would have a high correlation coefficient.Industry sector,Construction sector,Hotel and catering sector and Real estate sector have positive correlation coefficients between yearly growth rates of fixed investment and value added;however,Agriculture,Forestry,Animal Husbandry and Fisheries sector,Whole and retail sector,Transport and storage sector,Financial intermediation sector and others (remaining) sector have negative correlation coefficients of yearly growth rates.

(**Table 4**) tells some facts about statistic features of yearly growth rates of fixed investment and value added,that yearly growth rate of fixed investment is more volatile than value added(averagely,standard error of growth rate of fixed investment in all sectors is 12.5%,value added 7.2%) in all sectors.It indirectly implicates that consumption,net export and government expenditure could smoothen value added.Fixed investment is more sensitive to other factors,like interest rate,tax rate,depreciation rate,hence,prediction of growth rate of fixed investment should not only be based on value added.

## Table 5:Sector wise correlation coefficients between fixed investment and value added

| item | aaf | baf | bbf | caf | cbf | ccf | cdf | cef | cff |
|---|---|---|---|---|---|---|---|---|---|
| aav | 0.9797 | | | | | | | | |
| bav | * | 0.9858 | | | | | | | |
| bbv | * | * | 0.9882 | | | | | | |
| cav | * | * | * | 0.9821 | | | | | |
| cbv | * | * | * | * | 0.9755 | | | | |
| ccv | * | * | * | * | * | 0.9857 | | | |
| cdv | * | * | * | * | * | * | 0.9697 | | |
| cev | * | * | * | * | * | * | * | 0.9935 | |
| cfv | * | * | * | * | * | * | * | * | 0.9893 |

The data displayed in (**Table 5**) shows the correlation relationship between sector-wise fixed investment and value added.Fixed investment and Value added in nine sectors have very high positive correlation coefficients,meaning that when fixed investment increases or Value added increases in one sector,then Value added or fixed investment would closely follow the trend to increase.At moment,we can not decide which factor affects as an exogenous variable the other factor,but the correlation coefficients demonstrate the strong relationship between the two variables.

# 2.Empirical analysis of investment function

## 2.1 Apply accelerator approach to the whole economy

To determine investment desired capital stock K* is assumed to equal a constant plus *a*Y, and actual change in capital stock $K_t - K_{t-1}$ is assumed to equal a fraction *b* of the desired change in capital stock or $b(K^*_t - K_{t-1})$. Substituting the linear function of Y for K* in this equation and solving for $K_t$ give $K_t$ = const. + $abY_t$ + (1- *b*) $K_{t-1}$. Since gross investment $I_t$ is defined as $K_t - (1- d)K_{t-1}$ where *d* is the annual rate of depreciation, one can subtract (1- *d*) times the equation for $K_{t-1}$ from the above equation for $K_t$ to obtain an equation for investment.$\mathbf{I_t = K_t - (1-}d\mathbf{)\ K_{t-1} = const. + }ab\mathbf{[Y_t - (1-}d\mathbf{)Y_{t-1}] + (1-}b\mathbf{)\ I_{t-1}}$. Given a small rate of depreciation which is equal to about 0.04 for the capital stock in China[2], investment $I_t$ depends on the rate of change in output Y according to the accelerations principle.

Table 6:Regression result of lginvestment on lggdp lag(lggdp) lag(lginvestment)

| lginvestment | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| lggdp | | | | | | |
| --. | 1.13385 | .26565 | 4.27 | 0.000 | .5905347 | 1.677165 |
| L1. | -1.005031 | .2545038 | -3.95 | 0.000 | -1.52555 | -.4845123 |
| lginvestment | | | | | | |
| L1. | .8979219 | .1088542 | 8.25 | 0.000 | .6752902 | 1.120554 |
| _cons | -.3131868 | .3555799 | -0.88 | 0.386 | -1.040429 | .4140558 |

**Investment function:** $\lg investment_t = -0.31 + 1.13\lg gdp_t - \lg gdp_{t-1} + 0.89\lg investment_{t-1}$ .The coefficient of $\lg gdp_{t-1}$ is opposite in sign and slightly less in magnitude (because of the rate of depreciation) to the coefficient of $\lg gdp_t$ . This confirms the accelerations principle that investment depends on the rate of change in income. Given the coefficients of $\lg gdp_t$ and $\lg gdp_{t-1}$ in equation above to be almost equal in magnitude. We replace these variables by the variable $\Delta\lg gdp_t = \lg gdp_t - \lg gdp_{t-1}$ to obtain following regression results and investment function:

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[2] **Note:** The estimation of depreciation rate of capital stock is from Chow (1985).

Table 7:Regression result of investment on (gdp-lag(gdp)) lag(investment)

| investment | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| gdp | | | | | | |
| D1. | .2679412 | .0990118 | 2.71 | 0.011 | .0657321 | .4701503 |
| investment | | | | | | |
| L1. | 1.139666 | .0180798 | 63.04 | 0.000 | 1.102742 | 1.176589 |
| _cons | -49.26829 | 143.5449 | -0.34 | 0.734 | -342.4261 | 243.8895 |

**Investment function :** $investment_t = -49.26 + 0.26\Delta gdp_t + 1.14 investment_{t-1}$

## 2.1.a. Add Net Export to investment Function

Net export of goods and services represent extra demand for domestic products,it will have positive impact on total output through net export multiplier coefficient.If we add net export as an explanatory variable in investment function,it will possibly fit data better.

Table 8:Regression result of investment on (gdp-lag(gdp)) lag(investment) lag(netxm))

| investment | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| gdp | | | | | | |
| D1. | .0861791 | .1098697 | 0.78 | 0.439 | -.1385296 | .3108878 |
| investment | | | | | | |
| L1. | 1.135802 | .016335 | 69.53 | 0.000 | 1.102393 | 1.169211 |
| netxm | | | | | | |
| L1. | .0692158 | .0244569 | 2.83 | 0.008 | .0191959 | .1192357 |
| _cons | -32.50293 | 129.374 | -0.25 | 0.803 | -297.1025 | 232.0966 |

The regression results show that coefficients of $\Delta gdp_t$ , $investment_{t-1}$ and $netxm_{t-1}$ are significant,it is justifying the theoretical fact.Net export(total export of goods and services minus total import of goods and services) should have positive impact on fixed investment,(**Fig 3**) tells us that capital formation and net export as important parts of GDP(by expenditure) have similar patterns in terms of their values to GDP.

**Investment function:** $investment_t = -40.3 + 0.086\Delta gdp_t + 1.13 investment_{t-1} + 0.069 netxm_{t-1}$

This revised investment function is still frustrating,the coefficient of $investment_{t-1}$ is very closer to the estimated coefficient above.the role of $\Delta gdp, netxm_{t-1}$ is almost negligible.

## 2.1.b. Koyck distributed lag model for investment Function

The Koyck lag model assumes that the firm's investment level in each period is a fraction (1 − λ) of the gap between its existing level of capital and its desired level. This leads to a set of lag weights γ that decline exponentially as i increases: $\gamma_i$ is proportional to $\lambda^i$. The Koyck lag can be applied either in terms of the absolute level of **Capital stock** and **GDP**, or (as Koyck did) in proportional terms. Koyck's hypothesis was that the capital stock in year t + 1 was determined by:

$$Capital_{t+1} = \theta GDP_t^{\alpha} GDP_{t-1}^{\beta} GDP_{t-2}^{\lambda\beta} GDP_{t-3}^{\lambda^2\beta} \cdots GDP_{t-i}^{\lambda^{i-1}\beta} \cdots e^{\sigma t} \quad (1)$$

We take logarithmic form of equation(1) for simple calculation,then it will take following form:

$$\lg Capital_{t+1} = \lg\theta + \alpha \lg GDP_t + \beta \lg GDP_{t-1} + \lambda\beta \lg GDP_{t-2} + \cdots + \lambda^{i-1}\beta \lg GDP_{t-i} \cdots + \sigma t \quad (2)$$

Koyck's ingenious insight was to note that the infinite summation of lagged terms on the right-hand side of equation(2) could be eliminated by lagging equation(2) multiplying both sides by λ,then subtracting:

$$\lg Capital_{t+1} - \lambda \lg Capital_t = (1-\lambda)\lg\theta + \alpha \lg GDP_t + (\beta - \lambda\alpha)\lg GDP_{t-1} + \cdots + (1-\lambda)\sigma t + \lambda\sigma \quad (3)$$

Then,we subtract equation(3) by $(1-\lambda)\lg Capital_t$,after simple algebra arrangement:

$$\Delta \lg Capital_{t+1} = \rho + r_0 \lg GDP_t + r_1 \lg GDP_{t-1} + r_2 t + r_3 \lg Capital_t \quad (4)$$

In which, $\rho = (1-\lambda)\lg\theta + \lambda\sigma, r_0 = \alpha, r_1 = \beta - \alpha\lambda, r_2 = \sigma(1-\lambda), r_3 = \lambda - 1$.

The left-hand side of equation (4) is the growth rate of the capital stock (the difference in its logs), which is essentially the flow of investment divided by the stock of capital.The short-run, or impact, sensitivity of capital stock growth to output is measured by $r_0 = \alpha$. This is the amount that $\lg Capital_{t+1}$ would change if $\lg GDP_t$ increased by one unit, but the lagged $\lg GDP_t$ values did not change.However, the long-run sensitivity is potentially much larger as the lagged effects accumulate through φ2 and φ4. To compute the long-run effects, we must think about how $\lg Capital_{t+1}$ would change in equation (4) if all of the y terms on the right-hand side were to increase by one unit. The sum of the coefficients on the y terms is $\alpha + \beta + \lambda\beta + \lambda^2\beta + \cdots = \alpha + \frac{\beta}{1-\lambda}$.

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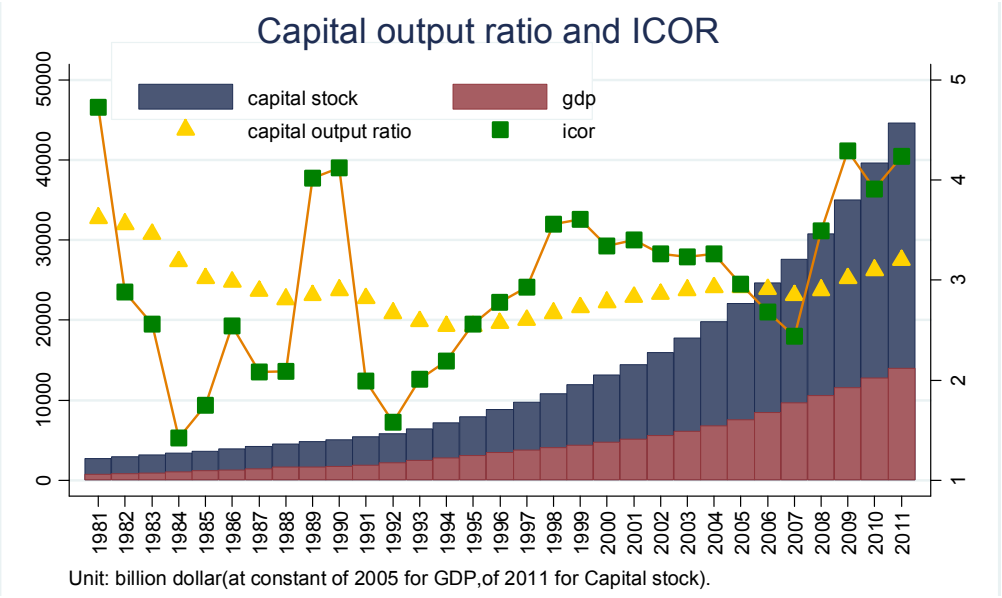



Unit: billion dollar(at constant of 2005 for GDP,of 2011 for Capital stock).

**Figure 12**

Average capital output ratio $V = \frac{K}{Y}$ from 1981 to 2011 is 2.9,but it is in decline from 1981 to 1994(2.54),after 1995,its uptrend maintains.With the changing values of capital output ratio,we can observe the phenomenon of investment-driven growth starts to accumulate moments after Asian financial crisis.In addition,when global financial crisis hits world economy in 2008,Chinese government prescribes series of stimulus packages to recover economy,hence,V again follows upward trend.However,huge capitals installed are not fully utilized,it causes huge amount of wastage.

The incremental capital-output ratio, $ICOR = \frac{\Delta K}{\Delta Y} = \frac{\Delta K / Y}{\Delta Y / Y}$ is the ratio of investment to growth which is equal to 1 divided by themarginal product of capital. The higher the ICOR, the lower the productivity of capital or the marginal efficiency of capital.ICOR at 4.24(2011) which is far larger than 3 in most countries,shows that Chinese economy suffers from low productivity of capital.

Table 9:Regression result of d.flgcapital on lggdp l.lggdp time lgcapital

| dflgcapital | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| lggdp | .1216007 | .1218311 | 1.00 | 0.328 | -.1298463 | .3730476 |
| llggdp | -.1367885 | .1186218 | -1.15 | 0.260 | -.3816119 | .108035 |
| time | .0058995 | .0090049 | 0.66 | 0.519 | -.0126857 | .0244847 |
| lgcapital | -.0255699 | .0457801 | -0.56 | 0.582 | -.1200555 | .0689156 |
| _cons | .6313017 | 1.294184 | 0.49 | 0.630 | -2.039762 | 3.302366 |

When we apply a simple OLS regression $\Delta \lg Capital_{t+1} = \rho + r_0 \lg GDP_t + r_1 \lg GDP_{t-1} + r_2 t + r_3 \lg Capital_t$,

unfortunately,coefficients of regression are insignificant due to some reasons.It may be mis-specified econometric model,or serial correlation,here,we follow Koyck's approach to eliminate serial correlation(we find serial correlation in residual using Durbin-Watson d Test and Breusch-Godfrey Test)

with Generalized least squares regression.With calculated d=1.23299 from Durbin Watson test,we estimate coefficient of first order serial correlation $\omega \approx 1-\frac{d}{2}$ =0.38335.Then we set **y**=dflgcapital-0.38335*l.dflgcapital,**x1**=lggdp-0.38335*l.lggdp,**x2**=llggdp-0.38335*l.llggdp, **x3**=time-0.38335*l.time, **x4**=lgcapital-0.38335*l.lgcapital

Table 10:Regression result of y on x1 x2 x3 x4

| y | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| x1 | .1801171 | .1172431 | 1.54 | 0.138 | -.0624187 | .4226529 |
| x2 | -.0220809 | .1107362 | -0.20 | 0.844 | -.2511562 | .2069943 |
| x3 | .0027449 | .0110876 | 0.25 | 0.807 | -.0201916 | .0256815 |
| x4 | -.1600128 | .070808 | -2.26 | 0.034 | -.3064903 | -.0135353 |
| _cons | .150689 | .9826688 | 0.15 | 0.879 | -1.882116 | 2.183494 |

From the regression results,we find out that the coefficients of x1,x2,x3,x4 are still insignificant,then we should change our model to better reflect the relationship between output(GDP) growth rate and capital stock growth rate.

# 2.2 Applicability of accelerator approach to eight sectors

## 2.2.a. Time series regression for single sector

Table 11:Regression of aaf on (aav-lag(aav)) lag(aaf)

Coefficients:

| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| (Intercept) | 463.14006 | 399.48665 | 1.159 | 0.280 | |
| daav | -0.10775 | 0.09336 | -1.154 | 0.282 | |
| laaf | 1.22164 | 0.04321 | 28.273 | 2.65e-09 | *** |

---

Multiple R-squared: 0.991, Adjusted R-squared: 0.9887

F-statistic: 438.1 on 2 and 8 DF, p-value: 6.701e-09

Regression results show that the coefficient of daav is insignificant at 1%,5%,10% critical values,but the coefficient of laaf is significant at even 1% critical value.It means that Agriculture Forestry Animal Husbandry and Fishery industries sector fails to fit accelerator theory of investment function.

## Table 12:Regression of baf on (bav-lag(bav)) lag(baf)

Coefficients:

| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| (Intercept) | 8992.99038 | 3382.86042 | 2.658 | 0.0289 | * |
| dbav | -0.10091 | 0.16847 | -0.599 | 0.5658 | |
| lbaf | 1.10865 | 0.02232 | 49.681 | 2.98e-11 | *** |

---

Multiple R-squared: 0.9968, Adjusted R-squared: 0.996

F-statistic: 1237 on 2 and 8 DF, p-value: 1.081e-10

Regression results show that the coefficient of dbav is insignificant at 1%, 5%, 10% critical values, but the coefficient of lbaf is significant at even 1% critical value. It means that Industry sector fails to fit accelerator theory of investment function.

## Table 13:Regression of bbf on (bbv-lag(bbv)) lag(bbf)*

Coefficients:

| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| (Intercept) | -166.70886 | 165.77193 | -1.006 | 0.3440 | |
| dbbv | 0.19634 | 0.06223 | 3.155 | 0.0135 | * |
| lbbf | 0.89854 | 0.07329 | 12.260 | 1.82e-06 | *** |

---

Multiple R-squared: 0.9801, Adjusted R-squared: 0.9751

F-statistic: 196.7 on 2 and 8 DF, p-value: 1.577e-07

Regression results show that the coefficient of dbbv is significant at 5% critical value,and the coefficient of lbbf is also significant at even 1% critical value.It means that Construction sector fits accelerator theory of investment function well.Therefore,we get an fixed investment function of construction sector:

$$bbf_t = -166.7 + 0.19\Delta bbv_t + 0.89 bbf_{t-1}$$

## Table 14:Regression of caf on (cav-lag(cav)) lag(caf)

Coefficients:

| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| (Intercept) | 286.46716 | 199.74185 | 1.434 | 0.189 | |
| dcav | -0.06582 | 0.05464 | -1.205 | 0.263 | |
| lcaf | 1.27997 | 0.03278 | 39.045 | 2.03e-10 | *** |

---

Multiple R-squared: 0.9973, Adjusted R-squared: 0.9966

F-statistic: 1457 on 2 and 8 DF, p-value: 5.614e-11

Regression results show that the coefficient of dcav is insignificant at 5%,10% critical values,but coefficients of lcaf and intercept both are insignificant at even 1% critical value.It means that Whole sale and Retail sale sector fails to fit accelerator theory of investment function.

## Table 15:Regression of cbf on (cbv-lag(cbv)) lag(cbf)*

Coefficients:

| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| (Intercept) | 5304.88125 | 1543.90414 | 3.436 | 0.00888 | ** |
| dcbv | -3.13929 | 0.90786 | -3.458 | 0.00859 | ** |
| lcbf | 1.19768 | 0.06499 | 18.428 | 7.74e-08 | *** |

---

Multiple R-squared: 0.9809, Adjusted R-squared: 0.9761

F-statistic: 205 on 2 and 8 DF, p-value: 1.342e-07

Regression results show that coefficients of dcbv,lcbf and intercept all are significant at 1%,5%,10% critical values.It means that Transport storage and post sector fits accelerator theory of investment function well.Therefore,we get an fixed investment function of Transport storage and post sector:

$$cbf_t = 5304.8 - 3.14\Delta cbv_{t-1} + 1.19 cbf_{t-1}$$

## Table 16:Regression of ccf on (ccv-lag(ccv) lag(ccf)

Coefficients:

| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| (Intercept) | 299.68243 | 362.41808 | 0.827 | 0.432 | |
| dccv | 0.07009 | 0.53596 | 0.131 | 0.899 | |
| lccf | 1.07080 | 0.06108 | 17.530 | 1.14e-07 | *** |

---

Multiple R-squared: 0.98, Adjusted R-squared: 0.975

F-statistic: 196.1 on 2 and 8 DF, p-value: 1.596e-07

Regression results show that the coefficient of dccv is insignificant at 5%,10% critical values,but coefficients of lccf is significant at even 1%,5% critical values.It means that Hotel and catering services sector fails to fit accelerator theory of investment function.

## Table 17:Regression of lgcdf on (cdv-lag(cdv) lag(cdf)

Coefficients:

| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| (Intercept) | -91.86272 | 204.85089 | -0.448 | 0.6657 | |
| dcdv | 0.09620 | 0.06677 | 1.441 | 0.1876 | |
| lcdf | 2.28149 | 1.13498 | 2.010 | 0.0793 | . |

---

Multiple R-squared:0.6943, Adjusted R-squared:0.6179

F-statistic: 9.085 on 2 and 8 DF, p-value: 0.008733

Regression results show that the coefficient of dccv is insignificant at 5%,10% critical values,but the coefficient of lcdf is significant at even 10% critical value.It means that the financial intermediation sector fails to fit accelerator theory of investment function.

## Table 18:Regression of cef on (cev-lag(cev) lag(cef)*

Coefficients:

| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| (Intercept) | -57.33909 | 1780.34503 | -0.032 | 0.97510 | |
| dcev | 2.00090 | 0.57170 | 3.500 | 0.00808 | ** |
| lcef | 1.09837 | 0.02425 | 45.301 | 6.23e-11 | *** |

---

Multiple R-squared: 0.997, Adjusted R-squared: 0.9962

F-statistic: 1315 on 2 and 8 DF, p-value: 8.461e-11

Regression results show that the coefficient of dcev is significant at 5%,10% critical values,and the coefficient of lcef is also significant at even 1% critical value.It means that Real estate sector fits accelerator theory of investment function well.Therefore,we get an fixed investment function of Real estate sector:

$$cef_t = -57.3 + 2\Delta cev_{t-1} + 1.1cef_{t-1}$$

## Table 19:Regression of cff on (cfv-lag(cfv)) lag(cff)

Coefficients:

| | Estimate | Std. Error | t value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| (Intercept) | 4960.5623 | 3777.5213 | 1.313 | 0.226 | |
| dcfv | -1.4488 | 0.9277 | -1.562 | 0.157 | |
| lcff | 1.4237 | 0.1499 | 9.498 | 1.24e-05 | *** |

---

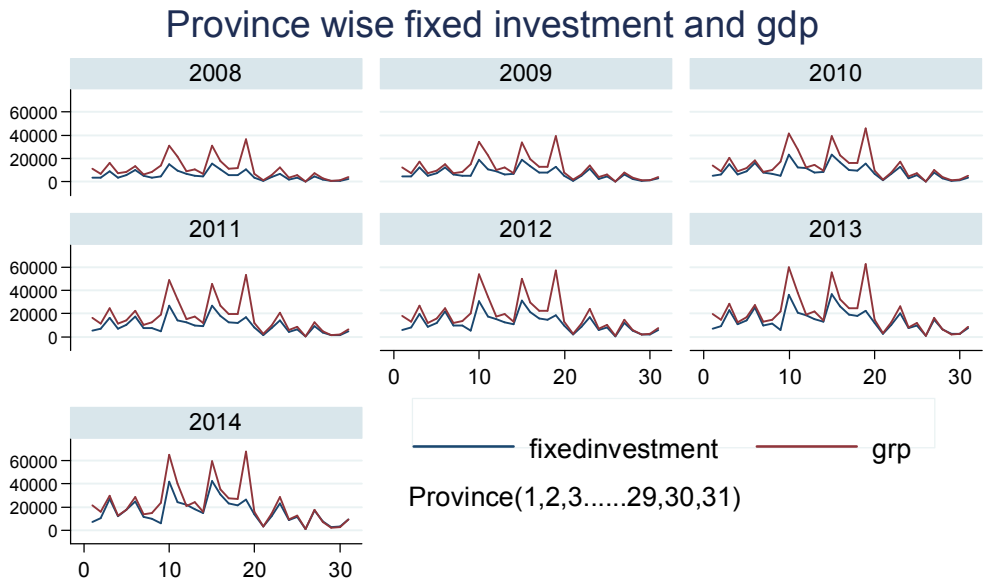
Multiple R-squared:0.9845,Adjusted R-squared: 0.9806

F-statistic: 253.4 on 2 and 8 DF, p-value: 5.834e-08

Regression results show that coefficient of lcff is significant at 1% critical value,but the coefficient of dcff is insignificant at 5%,10% critical values.It means that Othe**rs(remaining) se**ctor fails to fit accelerator theory of investment function.

**Continuing**

## 2.2.b. Panel regression for eight sectors




Note: grp means gross regional product; unit:billion Yuan.

**Figure 13**

Table 20:Panel regression of fixedinvestment on grp lfixedinvestment(FE)

Oneway (individual) effect Within Model
Balanced Panel: n=31, T=21, N=651
Coefficients :

| | Estimate | Std. Error | t-value | Pr(>\|t\|) |
|---|---|---|---|---|
| dgrp | 0.1824386 | 0.0299466 | 6.0921 | 1.96e-09 *** |
| lfixedinvestment | 1.1416393 | 0.0057481 | 198.6132 | < 2.2e-16 *** |

Total Sum of Squares:2.1052e+10, Residual Sum of Squares:129030000
R-Squared: 0.99387, Adj. R-Squared: 0.94349
F-statistic: 50107.2 on 2 and 618 DF, p-value: < 2.22e-16

Investment function: $fixedinvestment_{it} = 0.18\Delta gdp_{i,t} + 1.14lag(fixedinvestment_{i,t})$.

Continuing

Continuing

## Table 21:Individual specific effects in regression(FE)

| | Estimate | Std. Error | t-value | Pr(>\|t\|) | |
|---|---|---|---|---|---|
| 1 | -291.2033 | 101.6645 | -2.8644 | 0.004179 | ** |
| 2 | -24.5521 | 100.7064 | -0.2438 | 0.807387 | |
| 3 | 81.3292 | 103.0530 | 0.7892 | 0.429996 | |
| 4 | 62.4867 | 100.3424 | 0.6227 | 0.533459 | |
| 5 | 136.1919 | 100.9670 | 1.3489 | 0.177377 | |
| 6 | -40.8249 | 102.9732 | -0.3965 | 0.691765 | |
| 7 | -32.3409 | 100.4574 | -0.3219 | 0.747501 | |
| 8 | -109.3058 | 100.5228 | -1.0874 | 0.276872 | |
| 9 | -411.0557 | 101.9252 | -4.0329 | 5.509e-05 | *** |
| 10 | -86.0265 | 115.1263 | -0.7472 | 0.454921 | |
| 11 | -167.2000 | 105.7738 | -1.5807 | 0.113939 | |
| 12 | 178.8679 | 101.4418 | 1.7633 | 0.077857 | . |
| 13 | 79.8502 | 101.9566 | 0.7832 | 0.433523 | |
| 14 | 83.2824 | 100.6785 | 0.8272 | 0.408118 | |
| 15 | -11.9640 | 112.4308 | -0.1064 | 0.915255 | |
| 16 | 170.6876 | 104.2878 | 1.6367 | 0.101694 | |
| 17 | 162.3920 | 102.5477 | 1.5836 | 0.113290 | |
| 18 | 140.0423 | 102.5462 | 1.3657 | 0.172048 | |
| 19 | -493.1359 | 118.8670 | -4.1486 | 3.345e-05 | *** |
| 20 | 79.0303 | 100.6281 | 0.7854 | 0.432237 | |
| 21 | -13.5035 | 99.7548 | -0.1354 | 0.892322 | |
| 22 | 37.6873 | 100.4944 | 0.3750 | 0.707646 | |
| 23 | 58.5074 | 102.7507 | 0.5694 | 0.569077 | |
| 24 | 90.6020 | 100.0413 | 0.9056 | 0.365124 | |
| 25 | 45.7535 | 100.3235 | 0.4561 | 0.648347 | |
| 26 | -23.6344 | 99.7143 | -0.2370 | 0.812640 | |
| 27 | 148.3754 | 100.9235 | 1.4702 | 0.141514 | |
| 28 | 73.8738 | 99.8941 | 0.7395 | 0.459591 | |
| 29 | 6.6384 | 99.7326 | 0.0666 | 0.946930 | |
| 30 | 2.5887 | 99.7425 | 0.0260 | 0.979294 | |
| 31 | 66.5601 | 100.0391 | 0.6653 | 0.505832 | |

**Note: Estimate column** shows individual effects (in deviation from the overall mean), **second column** their standard errors and **third and fourth column** the test of equality to the overall intercept.

## Table 22:Panel regression of fixedinvestment on grp lfixedinvestment(RE)

Oneway (individual) effect Random Effect Model
Balanced Panel: n=31, T=21, N=651
Effects:

| | var | std.dev | share |
|---|---|---|---|
| idiosyncratic | 208786.06 | 456.93 | 0.985 |
| individual | 3127.42 | 55.92 | 0.015 |
| theta: 0.1278 | | | |

Coefficients :

| | Estimate | Std. Error | t-value | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | 59.5088060 | 26.2876810 | 2.2638 | 0.02392 * |
| dgrp | 0.1291670 | 0.0264075 | 4.8913 | 1.265e-06 *** |
| lfixedinvestment | 1.1489916 | 0.0056512 | 203.3174 | < 2.2e-16 *** |

Total Sum of Squares:2.5548e+10,Residual Sum of Squares:140100000
R-Squared: 0.99452, Adj. R-Squared: 0.98993
F-statistic: 58761.4 on 2 and 648 DF, p-value: < 2.22e-16

Investment function: $fixedinvestment_{it} = 59.5 + 0.13\Delta gdp_{i,t} + 1.15 lag(fixedinvestment_{i,t})$.

## Table 23:Dynamic Panel regression of fixedinvestment on diff(grp)lag(fixedinvestment)

Oneway (individual) effect Two steps model
Balanced Panel: n=31, T=22, N=682
Coefficients

| | Estimate | Std. Error | z-value | Pr(>\|z\|) |
|---|---|---|---|---|
| diff(grp) | 0.167044 | 0.074582 | 2.2397 | 0.02511 * |
| lag(fixedinvestment, 1) | 1.139792 | 0.015522 | 73.4313 | < 2e-16 *** |

Sargan Test: chisq(229) = 27.76605 (p.value=1)
Autocorrelation test (1): normal = -2.809768 (p.value=0.0049577)
Autocorrelation test (2): normal = -2.804038 (p.value=0.0050467)
Wald test for coefficients: chisq(2) = 50395.34 (p.value=< 2.22e-16)
Signif. codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

Investment function: $fixedinvestment_{it} = 0.16\Delta gdp_{i,t} + 1.14\, fixedinvestment_{i,t-1}$.

# 3. Conclusion

Through our series of regression estimations of investment function,we obtain the following outcomes.

**A. Investment function(Whole economy):**

$$investment_t = -49.26 + 0.26\Delta gdp_t + 1.14 investment_{t-1}$$

**B. Investment function(Whole economy (netxm)):**

$$investment_t = -40.3 + 0.086\Delta gdp_t + 1.13 investment_{t-1} + 0.069 netxm_{t-1}$$

**C. Investment function(Construction sector):**

$$bbf_t = -166.7 + 0.19\Delta bbv_t + 0.89 bbf_{t-1}$$

**D. Investment function(Transport and Storage sector):**

$$cbf_t = 5304.8 - 3.14\Delta cbv_{t-1} + 1.19 cbf_{t-1}$$ [3]

**E. Investment function(Real estate sector):**

$$cef_t = -57.3 + 2\Delta cev_{t-1} + 1.1 cef_{t-1}$$

**F. Investment function(Province wise panel data with fixed effects):**

$$fixedinvestment_{it} = 0.18\Delta gdp_{i,t} + 1.14 lag(fixedinvestment_{i,t}).$$

**G. Investment function(Province wise panel data with random effects):**

$$fixedinvestment_{it} = 59.5 + 0.13\Delta gdp_{i,t} + 1.15 lag(fixedinvestment_{i,t}).$$

**H. Investment function(Province wise dynamic panel data by GMM):**

$$fixedinvestment_{it} = 0.16\Delta gdp_{i,t} + 1.14\, fixedinvestment_{i,t-1}.$$

For the whole economy,output growth $\Delta gdp_t$ will demand for investment,and its marginal effect of output growth $\Delta gdp_t$ on $investment_t$ is 0.26,meaning $\frac{\Delta investment}{\Delta(\Delta gdp)} = 0.26$ .The result indicates that when output growth $\Delta gdp_t$ increases by 1 billion Yuan , $investment_t$ will be induced to have an increase of 26 million Yuan.The output growth elasticity of investment is around 0.05,meaning that when output growth goes up by 1%,fixed investment will go up by 0.05%.Real estate sector will have larger impact of output growth $\Delta gdp_t$ on $investment_t$ ,its marginal effect is 2.Regarding province wise dynamic panel data

[3] **Note:** The equation is unreasonable,given the coefficient of $\Delta cbv_t$ has a negative sign.

regression,the marginal effect of output growth $\Delta gdp_{i,t}$ on $investment_{i,t}$ is 0.16,meaning

$$\frac{\Delta investment_{i,t}}{\Delta(\Delta gdp_{i,t})} = 0.16$$

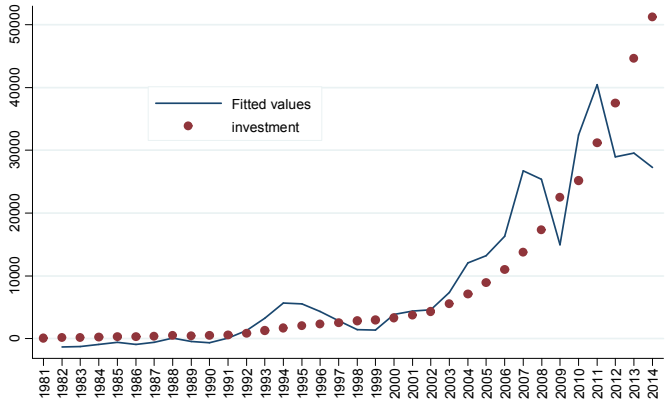



**Figure10**

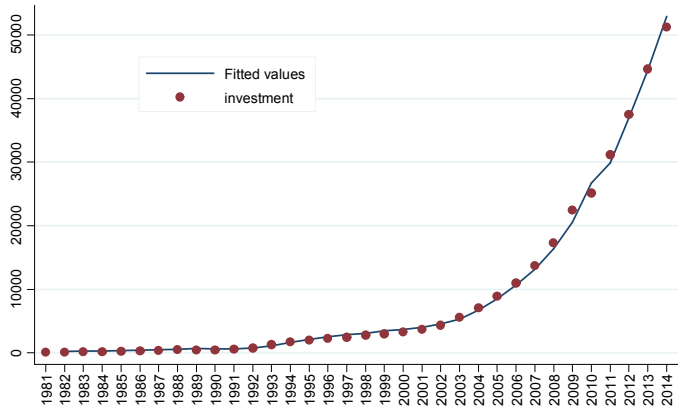



**Figure 11**

However,It is not satisfactory for that investment at time period of t is explained well by previous period of investment(**Fig 1**),investment function obtaining by regression investment on output(GDP) growth is not fit well to actual data(**Fig 10**).That our investment function estimated above is fit well to actual data is just because lagged investment is put into the equation.

The empirical analysis of aggregate investment spending has been one of the great frustrations of postwar macroeconomics. Unlike most of the other behavioral functions of the basic Keynesian system, the investment function has not fit the aggregate data for most countries well.Of course failing to find a significant relationship in aggregate data does not necessarily imply that the theory is wrong. Measurement error, biases associated with reverse causality, and the effects of omitted variables—those ubiquitous nemeses of econometric analysis—may prevent our econometric tests from finding the true underlying relationship among the variables.

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