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ABSTRACT

Investment-driven growth has long been regarded as a key development strategy in China. This paper investigates empirically the validity of this view. Post-1990 data analyses and macro-econometric model simulations show that market demand has become a regular force in driving investment since reforms, that non-demand-driven investment growth contributes to increasing capital-output ratio far more than output growth, that government investment exerts a pivotal role in amplifying investment cycles, albeit effective in promoting employment, and that delayed and rising consumption from current investment surge can help sustain the impact of growth even with constant-returns-to-scale in the long-run GDP.

Key words: Investment, growth, impulse response function, cointegration, Granger non-causality

JEL classifications: E22, E62, R34, O23, P41

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By three methods we may learn wisdom: first, by reflection, which is noblest; second, imitation, which is easiest; and third by experience, which is the bitterest.

Confucius

I. Another East Asian 'Miracle'?

The spectacular growth of China over the last two decades apparently adds significant force to the East Asian 'Miracle'.[1] During the period 1990 – 2003, China's growth has been averaging 9.3% in terms of GDP per annum while the accompanying rate in gross fixed capital formation (GFCF) is 14% and the rate of the total investment in fixed assets (TIFA) is 15%.[2] Today, GFCF accounts for over 40% of nominal GDP, as compared to less than 30% in the early 1980s, see Table 1.1. These records have definitely outperformed those of Japan and the US and many other Newly Industrialized Asian Economies (NIAEs), see Table 1.2. The GFCF growth also remains high especially when compared with other Asian economies, see Figure 1.1. In 2003 alone, GFCF recorded a growth of about 20% while TIFA growth reached 25%.

In 2004, the startling acceleration of the TIFA – 43.2% growth in the 1st quarter and 33.3% in the 2nd quarter[3] before settling down to 27.6% for the full year – has led the Chinese government to curtail fixed assets investment out of the grave concern that the rising investment would overheat the economy. The rapid investment expansion has caused severe shortage in energy and raw material supplies, pushed imports to grow faster than exports, and accelerated inflation. The investment price index rose to 5.6% and the

[1] The East Asian 'Miracle' refers to the myth that the engine driving economic growth is essentially capital accumulation instead of total factor productivity growth, see e.g. (Young 1995) and (Senhadji 2000).

[2] The TIFA is more often used than the GFCF in China, as it is published monthly and more timely than GFCF. Both GFCF and TIFA are deflated by the price index of fixed assets from the China Statistical Yearbook 2004 for the period 1991-2003. The price index of raw materials and energy is used for 1990 as the price index of fixed assets is unavailable that year.

[3] All the statistics quoted are y-o-y rates.

consumer price index to 3.9% in 2004 as compared to 2.2% and 1.2% respectively in 2003. However, GDP growth ended up at about the same level as 2003 in spite of the investment fever and the tightening of investment policies.

The view that the Chinese economy is an investment-driven economy is a legacy from the old regime of a centrally planned economy (CPE), e.g. see (Kornai 1980) for a general theory of investment hunger of a CPE and see (Imai 1994) for an investment-led business cycle model of China. And in spite of regime changes since the reforms, capital investment has remained to be regarded as a vital factor to promote the economic growth, as discernible from the recent literature. For example, Goldstein and Lardy (2004) anticipate that it will take a few years for the Chinese economy to unwind the current investment boom, possibly with a down turn, on the basis of the present investment curb. This investment-driven growth view also finds support in a number of empirical studies, e.g. see (Yu 1998), (Kwan *et al* 1999), and Zhang (2003).

However, the view that investment is the main engine of growth faces several problems. Considering that the Chinese economy has undergone enormous changes since the reform, can we find enough evidence to support the assertion that the old investment-driven mechanism is still intact? If the Chinese economy has remained in an investment-led track, why is it that the rate of GDP growth has always been significantly lower than the rate of investment growth over the last 15 years?[4] Why has the volatile investment cycles not discernibly affected the GDP growth path, as shown from Figure 1.2? If one seeks support of the view from levels rather than growth rates, how can we explain the visible increasing GFCF/GDP ratio, as shown in Table 1.1? The increasing ratio actually suggests

[4] By simple growth theory, output growth is only expected to be dampened by the capital input elasticity in comparison with the capital input growth, e.g. see (Rebelo 1991). Using the estimated elasticity of 0.8, 9.3% of GDP growth should only require 11.6% growth in capital.

that the Chinese economy is another East Asian 'miracle'.[5] If that is the case, how can we reconcile the contradiction between the view of investment-driven growth and the neoclassical growth theory, which states that accelerating capital accumulation alone cannot sustain long-run economic growth in the absence of significant technical progress? If we turn to new endogenous growth models for theoretical support, what are the identifiable variables which would link investment to growth, (see George *et al* 2003)? More fundamentally, one needs first to clearly define the investment-driven growth view as the investment-output nexus is by no means a one-way causal relationship according to endogenous growth theories.

The paper makes an empirical attempt to answer the above problems using post-1990 time-series data. We try to do this first by careful data analysis, see section 2. We then try to assess empirically the magnitude and the manner by which investment drives economic growth and vice versa. This we will do using a quarterly macro-econometric model of China where both investment and GDP are endogenously determined, see Section 3. Concluding remarks are in Section 4.

II. What do data tell us about the investment-GDP nexus?

In this section, we try to find answers to the questions posed in the previous section and to examine all the possibly identifiable aspects of the investment-driven-growth view with respect to aggregate investment and GDP data. Specifically, we to try to explain why surges in investment have not been significantly transmitted into GDP surges — whether it is investment growth or GDP growth which is dynamically leading the other, whether there

[5] Evidence of overinvestment has also been presented in a number of recent publications, e.g. see (Zhang 2003), (Lin 2004) and (Wolf 2005).

exists simultaneous causality between the two aggregates in levels, and whether there has been significant technological progress underlying the long-term growth.

Let us first try to answer the question why the investment surge has not been significantly transmitted into GDP surge by analyzing the co-movement of the demand components of GDP with respect to the GFCF changes. Denote real GDP by Y, real consumption (including both private and government) by C, net exports by NX and inventory (or change in stocks) by IS. The income identity can thus be presented as $Y = C + GFCF + IS + NX$ .The corresponding growth equation is:

$$(1) \qquad \dot{Y} = \dot{C}\frac{C_{t-1}}{Y_{t-1}} + G\dot{F}CF\frac{GFCF_{t-1}}{Y_{t-1}} + \dot{NX}\frac{NX_{t-1}}{Y_{t-1}} + \dot{IS}\frac{IS_{t-1}}{Y_{t-1}}.$$

Figure 2.1 presents the weighted growth rates of the four components in the above equation alongside GDP growth rates using annual data for the period 1993-2003. It is discernible from the figure that the four component rates move in a closely substitutive manner such that their weighted average, i.e. the GDP growth rate, could remain at a relatively stable level. When GFCF accelerates, it squeezes either consumption, net exports or inventory which is very evident in recent years. There is a strong contemporaneous offsetting relationship among the GDP components to cushion the volatility impact of a single component on GDP, which is often neglected by analyses of the investment-GDP nexus based solely on the production side of the GDP.

However, the above analysis is comparative static in nature and therefore cannot answer the question of whether GDP growth is dynamically led by investment growth or vice versa. To answer this question, we employ the commonly used method of Granger causality test, e.g. see Blomström *et al* (1996) and Ball *et al* (1996). Table 2.1 shows the Granger causality test results using both the growth rate of GFCF and the growth rate of 'capital', which is the accumulated investment net of depreciation, see equation (3) in the next section and also Appendix. The test results show strong evidence that investment growth and GDP growth do not Granger-cause each other and that the capital growth does not Granger-cause GDP growth either. But there is some weak evidence showing that GDP growth has been leading capital growth (the fourth lag of GDP growth in $\triangle Kc$ equation is significant at 10%). These significantly refute the postulate that GDP growth in China has been following investment growth. Notice that our finding does not contradict the previous findings by Ball *et al* (1996) and Blomstrom *et al* (1996)[6].

Interestingly, the test results that investment growth might be led by economic growth seem corroborative to the neoclassical investment theory. This also implies that the old investment-driven-growth regime has been largely phased out at the macro level by reforms. Regrettably, the Granger-causality test only provides information concerning the sequential causal ordering of the variables. It does not tell us whether the variables are simultaneously causal. Moreover, the test disregards the possible bilateral relationship between levels of GDP and investment upon which most macroeconomic theories are based.[7] In order to examine interdependence between the levels of GDP and investment, we employ two methods. One is Johansen cointegration analysis, which will enable us to examine the long-run interdependence between nonstationary variables. The other is a comparison between maximum likelihood (ML) estimation of a simultaneous-equations model (SEM) and ordinary least squares (OLS) estimation of the single equations of the

[6] However, we are skeptical of the variable choice made by Blomstrom *et al* (1996), i.e. their choice of testing causality between real per capita income and ratio of fixed investment to GDP.

[7] Technically, Granger causality test requires the time-series variables involved to be stationary. As most of the level variables in macroeconomics exhibit strong nonstationary features, the test is commonly applied to growth rates of the variables.

model, which will enable us to examine contemporaneous interdependence, or simultaneity as commonly called in econometrics.

Dickey-Fuller unit root test is carried out on GFCF, capital and GDP before Johansen cointegration analysis is applied. There is fairly strong evidence showing that GDP and GFCF are nonstationary $I(1)$ variables from the test results (see Table 2.2). Being basically accumulated investment, capital should be an $I(2)$ variable. However, we find no adequate evidence to show capital is $I(2)$ rather than $I(1)$. As unit root tests tend to have low power when sample sizes are relatively small, we shall apply cointegration analysis on two pairs of variables respectively, i.e. GDP versus GFCF and GDP versus capital, out of the consideration that it is capital stock, rather than investment, which forms a key component of aggregate production functions. It is evident from Table 2.3 that cointegration is not rejected for either pair of variables. We can thus be fairly confident that GDP and GFCF, as well as GDP and capital, are mutually interdependent in the long run, irrespective of the difficulty in determining the exact degrees of nonstationarity of each variables involved.

Let us now examine whether the two pairs of variables are also contemporaneously interdependent. A simple two-equation VAR (vector autoregression) system is set up for this purpose. A SEM is then specified within the VAR and estimated first using ML estimator and then single-equation OLS estimators. Table 2.4 reports the estimation results. Set 1 in the table shows that GDP contemporaneously explains GFCF but not vice versa. In other words, GDP appears to be weakly exogenous to GFCF. Set 2 on the other hand indicates a fairly strong presence of simultaneity between capital and GDP (as ML estimates are very different from OLS estimates). Interestingly, the simultaneity in the GDP equation is essentially between GDP growth and capital growth which is roughly the GFCF (i.e. the coefficient estimates support a growth model). The OLS estimates in the capital equation of set 2 are statistically similar to those ML estimates, reinforcing the above inference that GDP is weakly exogenous to capital or GFCF rather than vice versa. These results enhance the inferences based on the Granger causality test, and provide strong support to the claim that the Chinese economy is already out of the old investment-led growth regime.

The view of investment-driven growth also faces the theoretical challenge that long-term growth is independent of capital accumulation, unless there exist either increasing returns to scale due to capital or technological progress. Empirical evidence shows that increasing returns to capital is normally long-run untenable, see e.g. (Temple 1999). To examine whether there has been significant technological progress underlying China's economic growth, we utilize the long-run GDP equation proposed by He and Qin (2004), which assumes that the long-run GDP follow a simple Cobb-Douglas production function with constant returns to scale. If there were significant technological progress, the actual GDP de-trended by this long-run GDP should carry a visible upward trend. The actual GDP, the long-run GDP and the de-trended GDP are plotted in Figure 2.2. Interestingly, the de-trended GDP shows a slow cycle, with a significant downward movement since the late 1990s, corresponding to the noticeable rise in the GFCF/GDP ratio as shown in Table 1.1. Thus, we do not reject the constant return to scale assumption — long-run economic growth may not be dependent upon investment growth.

III. What does macroeconometric model tell us about the investment-GDP nexus?

The data evidence of the previous section shows that in comparative static terms, there are counterbalancing demand factors that offset the impact of investment volatility on GDP; that, in the long run, there has not been discernable trend of long-lasting technological progress to reject the constant return to scale condition; and that there is fairly strong evidence of simultaneity between investment and GDP although the causal direction in terms of growth rates is more of GDP → investment than vice versa. However, examination of data alone is inadequate for us to synthesize the above results and to evaluate how much and in what way investment drives GDP growth both in the short run and in the long run. To achieve these, one has to resort to the use of macro models.

A common type of macro model for this purpose is the endogenous or semi-endogenous growth model, see (George *et al* 2003) for a recent survey and (Li 2000) for semi-endogenous growth models. However, most of these models are still too theoretical and too abstract to enable sound empirical inferences. For example, Agénor (2000, Chapter 13) points out how growth models are plagued by methodological problems in applications; Temple (2003) warns applied economists against taking growth models too literally. Therefore, we choose to use a full-fledged macro-econometric model of China as it is more comprehensive and closer to the Chinese economy than any growth-theory based structural models. The China model is a quarterly model built by the Economics and Research Department of Asian Development Bank jointly with the Institute of World Economics and Politics of the Chinese Academy of Social Sciences. The model contains 75 endogenous variables and 16 non-modeled variables. It is estimated based on a data sample starting from 1992Q1, see (He *et al* 2004) and (Qin *et al* 2005) for more detailed description of the model and our modeling strategy.

As the investment-GDP nexus is the present focus, this entails a brief description of the investment block and the output block of the model.[8] There are four key equations in this

[8] The basic structure of the investment block is first reported in He and Qin (2004). However, the block has been substantially revised since that paper was written, due mainly to changes in the data series used for aggregate investment. The current model uses the TIFA as the sum of government budgetary investment and business sector investment (see the Appendix). However, the sum of the TIFA and FDI is generally smaller than GFCF, though the two series have very similar dynamic patterns.

block: the first three equations explain government budgetary investment, business sector investment, and foreign direct investment (FDI) respectively, and the last equation links aggregate investment (i.e. the sum of government budgetary investment, business sector investment and FDI) to GFCF in the GDP expenditure composition. Capital stock is derived from GFCF. As for the output block, GDP is explained via its three sectors: the primary sector, the secondary sector and the tertiary sector.[9]

Theoretically, the investment-output nexus can be summarized as follows: the expected output, Y_t^e, depends on both supply and demand factors:

(2) $$Y_t^e = f\left(K_t \quad L_t \quad \Phi_t\right)$$

where K and L represent capital and labor input respectively, and Φ denotes demand factors. The expected investment, I_t^e, is dependent upon factor input demand and other institutional factors, Ψ:

(3) $$I_t^e = \Delta K_t + K_{t-1}\delta = f\left(Y_t \quad \frac{P_{Kt}}{P_{Yt}} \quad \Psi_t\right)$$

where Δ denotes difference, δ is the depreciation rate, and P_K and P_Y are the prices of capital and output respectively. Qin and Song (2003) show that (3) can be derived from minimizing the cost of an aggregate production function, where the cost function is augmented by soft-budget constraints to characterize institutional features related to government investment decisions. He and Qin (2004) find that changes in government investment exert important institutional impact on business sector investment even though the latter now follows closely the standard capital input demand theory in the long run.

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[9] The three sectors are frequently referred to as 'agriculture', 'industry' and 'services' sectors for convenience, though these names do not rigorously fit the statistical definition.

Two issues are in need of clarification with equation (2). First, it does not contain an explicit technological progress factor. This is due to two reasons. One is data evidence, i.e. the lack of observable long-run trend shown in Figure 2.2 of the previous section. The other is the lack of robust empirical evidence identifying total factor productivity, see e.g. (Chen 1997), (Easterly and Levine 2002) and (Carlaw and Lipsey 2003). One alternative is to endogenize technological progress with respect to capital, as widely adopted in endogenous growth theories. For example, King and Robson (1993) assume that it is a nonlinear function of I_t. Since the dynamics of I_t is adequately incorporated in the econometric specification of the equations corresponding to (3), our model has not ruled out the possibility of investment-led technological changes.[10] The second issue is concerned with the feasibility of a production function dominant output equation to explain the output of the three sectors individually. Apart from data unavailability with respect to disaggregate capital inputs, it is questionable whether output of services is dominantly supply driven. In the China model, only the secondary sector follows a long-run production function. The other two sectors are explained mainly from the demand side, considering that labor input does not serve as a constraint to either sector. A more detailed sketch of the output block, as well as the investment block of the China model is given in Figure 3.1.

In general, structural equations of the parsimonious error-correction model (ECM) type are obtained on the basis of (2) and (3) via the dynamic specification approach, see (Hendry 1995). Most of the variables are in natural logarithm and the variable set, $\{x\}$, is divided into endogenous variables, y, and non-modeled variables, z:

(4) $$\Delta y_t = A_0 d + \sum_{j=1}^{n} A_j \Delta y_{t-j} + \sum_{i=0}^{n} B_i \Delta z_{t-i} + \Pi x_{t-1} + u_t$$

[10] The growth rate of capital stock is found to exert a small, positive role in the secondary sector output equation of the current the China model.

where d denotes a set of dummy variables including the constant term and seasonal dummies, n denotes the minimum lag to make the residual term, u_t, white noise, and where *a priori* theory, such as (2) and (3), is embedded in the long-run error/equilibrium term, Πx.

In order to find out how investment and output drive each other dynamically within a macro model comprised of mainly estimated equations of the type like (4), we resort to the method of impulse response function (IRF) , e.g. see (Dungey and Pagan 2000). The IRF method exploits the equivalence between (4) and a moving average representation in terms of the error term, u. When an econometric model is built to comprise mainly of structural equations, the error term associated with a structural equation is often interpreted as the 'structural' shock to the endogenous variable of that equation, e.g. see (Wickens and Motto 2001). This enables applied modelers to use IRF to trace how every single endogenous variable in a model reacts to a random shock associated with one particular endogenous variable. When a macro-econometric model contains more than a few behavioral equations, it is virtually impossible to solve the IRFs analytically. It is then common to get the IRFs via model simulation. In particular, the IRF for n periods, using the estimated model, $\hat{M}$, with respect to a shock from the ith equation to the jth variable is defined as:

$$\begin{aligned} IRF\left(n \quad \delta \quad \hat{M}\right) = {} & E\left(y_{j,t+n} \mid u_{i,t} = \delta, \quad u_{i,t+1} = 0, \cdots \quad u_{i,t+n} = 0, \quad u_{k \neq i} = 0 \quad \hat{M}\right) \\ & - E\left(y_{j,t+n} \mid u_t = u_{t+1} = \cdots = u_{t+n} = 0 \quad \forall j \quad \hat{M}\right) \end{aligned} \tag{5}$$

where the impulse shock, δ, is commonly taken as the estimated standard deviation of u_i.

Two technical issues are disregarded in our IRF simulations due to model-size induced technical complexity. The first is residual orthogonalization. The structural interpretation of a shock depends on the condition that the error term concerned should be uncorrelated with the error terms of other relevant structural equations. Instead of orthogonalizing the huge residual matrix of the model, we simply check the sample covariance of those residuals relevant to our IRF simulations. In most cases, the covariance is negligibly small. The second issue is estimating confidence intervals for the IRFs. Although various methods are available, it is practically infeasible for us to implement them on a model of this size.

Three sets of IRFs are simulated to examine how much investment shocks impact on the output. The first corresponds to a government budgetary investment shock, the second to the business sector investment shock and the third to the combined shocks of the first two. The results of IRFs relating to the major variables are illustrated in Figures 3.2, 3.3 and 3.4 respectively. In these figures, all the level variables are divided by population, which is exogenous in the model to facilitate the interpretation of the simulation results with respect to growth theories.

Several interesting observations can be made out of these IRF graphs. First, there is a visible, though very small, lasting output gain from one-off investment shocks. Roughly, a 10% one-off increase in GFCF generates around 0.05% long-term GDP growth (see the average as well as the end-of-sample value of GDPc in Figure 3.4). Second, the growth is predominantly from the secondary sector (i.e. GDP growth path closely follows secondary sector growth path), followed by a rising tertiary sector output. The primary sector enjoys the least growth from the investment shocks. Third, the increase in the output of the tertiary sector is accompanied by a decline in unemployment and a subsequent rise in private consumption, implying certain long-term welfare gain of the shocks. This also shows that the long-term growth effect can be sustained by enhanced, though delayed, demand factors, even in the absence of technological progress (i.e. the graphs in the bottom right panels of these figures show no discernible upward movement to indicate technological progress)[11]. Fourth, government investment plays a pivotal role in the increase in output even though its one-off increase is roughly equivalent to 0.4% GFCF shock, its long-term output impact is as large as a 9.4% GFCF shock from the business sector investment. This is because an increase in government investment signals expansionary fiscal policy to the economy, invoking stronger growth in GFCF in the subsequent years (see Figure 3.2). Finally, there are visible lags of reaction as well as substantial dampening of the initial investment shocks (if the scales of volatility between the IRFs of GDP and GFCF are compared), which further explains why investment volatilities are not visible in the output volatilities, especially the simultaneous volatilities.

Since the increase in private consumption appears to play a crucial role in sustaining the long-term GDP growth in the above scenarios, we experiment on a scenario where the initial shock comes from private consumption in order to see if such a shock has similar growth effect, see Figure 3.5. It is discernible from the IRFs in Figure 3.5 that the answer is negative. A one-off increase in private consumption exerts no permanent effect on GDP growth. This is not very surprising though as a one-off consumption increase does not have the cumulative effect that a one-off investment increase has via capital stock.

Next, we simulate four sets of IRFs to output shocks. The first three sets correspond to an impulse shock of the primary sector, the secondary sector and the tertiary sectors respectively. The last set corresponds to combined shocks of these three sectors. The IRFs of GFCF as well as the government investment and business investment are plotted in Figure 3.6. In order to make the effects comparable across sectors, we normalized the effects of sectoral shocks in Figure 3.6 by converting each sector shock into an equivalent

[11] GDP/GDPLR in the bottom right panel is the de-trended GDP defined in Figure 2.2 and discussed in section II.

1% GDP growth shock.[12] Notice that the output shocks virtually have no permanent effect on investment. More interestingly, the volatilities that the output shocks induce on investment variables are far smaller than those induced by investment shocks on output variables. In particular, the primary sector is the sector that invokes the largest output-led temporary investment spikes among the three sectors, whereas the temporary output rise in the secondary and the tertiary sectors even results in negative investment demand in the long run. In other words, only the agricultural sector appears relatively in need of further investment. This is mainly due to the fact that nominal responses to each shock differ across sectors because of different implicit impact on the three sectoral deflators, which transmits onto various prices and interest rates. Figure 3.7 illustrates these differences embodied in inflation (both in terms of consumer price and investment price indices), nominal and real lending rates. It is discernible from the figure that agriculture is the only sector whose shock dampens the real lending rate to stimulate investment. Taken as a whole, the simulation results suggest that output-led investment is far more efficient than autonomous investment rises if judged on the basis of relative incremental changes of investment versus output growth. In other words, if investment depends purely on factor input demand as shown in equation (2), less investment would be needed to sustain the growth. The existing capacity in the economy appears to have room for further growth without investment growth, e.g. see similar views by Wolf (2005).

The IRF results clearly show why the recent investment boom in China has not been transmitted into the country's GDP growth and why GDP growth has been more or less

[12] After the normalization, the primary sector impulse shock generates roughly a 5% temporary rise and 0.25% permanent rise in GFCF; the secondary sector shock generates roughly a 2% temporary rise and 0.1% permanent fall in GFCF; the tertiary sector shock generates 2% temporary rise and 0.04% permanent fall in GFCF.

immune to investment fevers. It also substantiates the data evidences presented in the previous section.

Would the recent investment boom have occurred if the economy did not encounter any autonomous policy changes or internal shocks? To examine this we run a model forecast for the period 2002Q1 to 2004Q4 and assumed zero shocks for all equations, with the domestic and exogenous variables following their 2001 dynamics, and allowed the world exogenous variables to take their observed values. The forecasted values of key variables are plotted in Figure 3.8, together with the actual values. As seen from this figure, the economy would have run slightly smoother, the GDP would have grown at 8.4% on average instead of 9%, and the growth in GFCF would have been 18% instead of above 21% on average for the three years. It appears that GDP growth is certainly hardly affected by a much reduced investment speed (about 15% drop).

IV. Conclusions

This paper assesses empirically the validity of the belief that the Chinese economy still follows largely the investment-led growth paradigm. The paradigm is scrutinized from several aspects of the investment-output nexus: the lead-lag relationship between the growth rates of the pair, the simultaneity and long-run interdependency between the pair in levels, and the combined long-run and short-run interactions between them when both are endogenized within a macroeconometric model. The effects of investment are considered not only as GFCF flows but also as cumulated capital stock. Furthermore, the nexus is examined at a disaggregate level by means of impulse response function analysis of a macroeconometric model. Specifically, the dynamics of the nexus is examined through the impacts of random shocks via government budgetary investment, business sector investment, as well as three output sectors.

The data analyses and model simulations yield a number of interesting results with important policy implications:

1. Empirical results show the existence of a long-run positive relationship between investment and economic growth, but the causality runs from the latter to the former. In other words, the growth of capital stock and/or growth of investment does not lead or exogenously drive output growth regularly either in short run or in long run. Rather, it is output that drives investment demand in the economy. This implies the applicability of market-based growth theories.
2. Analysis of the long-run GDP trend shows that the Chinese economy has not been an exception to the East Asian 'miracle', in the sense that there lacks evidence of noticeably long-lasting technological progress to refute the constant return to scale condition in the long run. Indeed, rapid investment growth has resulted in rising capital-output ratio rather than output growth acceleration — another reason why investment is not really driving growth.
3. Rising capital-output ratio indicates the problem of overinvestment, a problem impinging on the issue of investment efficiency at a macro level. The severity of the problem is further highlighted by the model simulation results. Specifically, the investment growth to output growth ratio is significantly higher when the random shock originates from investment than when the shock originates from output; a random increase of investment leads to further rise in capital-output ratio over a long period. Overinvestment in the sense of increasing investment irrespective of output expectations would give rise to more efficiency loss and structural imbalance in the economy than to more economic growth, especially when there is surplus

capital capacity. This helps explain why investment-led overheating would heat inflation far more easily than output.

4. The model simulation results at the sectoral level shed further light to the above point. Among the three sectors, agriculture is the sector whose growth would demand the highest investment incremental. In contrast, the secondary sector can sustain further growth even with a slight reduction in investment, implying that surplus capital capacity is more prevalent in this sector.

5. Disaggregate model simulation on the investment side also shows that the government budgetary investment plays a key role in generating investment fever, i.e. overinvestment irrespective of output expectations. As government investment serves as an important signal of fiscal policy, a small increase could trigger sizeable domestic investment expansion, resulting in a much amplified investment oscillation. The ensuing long-run overcapacity in terms of GDP gap can be more severe than that induced by an increase originated from the business-sector investment. On the other hand, the positive effect of government investment on GDP growth endorses the recent theoretical studies on fiscal policy and economic growth, e.g. see (Zagler and Dürnecker 2003). It raises an importance issue of how policy makers should balance the goals of reducing unemployment and enhancing aggregate efficiency in investment and capital utilization. In principle, policy makers need to give far more attention to the efficiency/productivity of investment than to the magnitude of investment; they should provide the enabling environment that would allow the economy to take advantage of expanded opportunities. This entails sound measures to encourage technological progress and human capital improvement, to enhance existing capacity utilization and to balance development

strategies among sectors, as well as to speed up capital market and banking sector reforms.

6. Nevertheless, the view that investment drives output growth is verified in one aspect, namely that a one-off increase in aggregate investment could generate relatively long-lasting impact on the growth of output, albeit very small. More interestingly, the growth is sustained by a much lagged rising consumption response. This result reveals the long-term welfare gain that investment shocks could generate, a practically more important issue, but somewhat less investigated, than the existence of long-run balance growth, see (Temple 2003). It also shows how the consumption side of an economy can play an important role, an area not yet adequately explored in growth theories, see (George *et al* 2003). Moreover, it offers a plausible way of demystifying the East Asian 'miracle'. Therefore, it appears right to say 'yes' to the investment-led growth view under this circumstance, although such a growth strategy may not be optimal for the Chinese economy.

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Appendix: Data Description and Sources

Variables	Description	Source[*]
BINV	Business Sector Investment	The total investment in fixed assets (TIFA) net of the government investment (see below) CMEI
FDI	Foreign Direct Investment	FDI (Actually utilized), CMEI
GCF	Gross Capital Formation	Identity: GCFC + IS
GCON	Government Consumption	Computed from nominal annual data in CSY with seasonal interpolations provided by NSBC
GDP	Gross Domestic Product	CMEI
GDPLR	Long-run GDP	Computed by Identity in the China Model
GFCF	Gross Fixed Capital Formation	Interpolated from nominal annual data in CSY using the seasonal patterns of TIFA
GINV	Government investment	Sum of expenditure for capital construction and innovation funds of enterprises from the table of the government budgetary expenditures, CMEI
IRL%	Lending Rate	PBC
IS		Computed from nominal annual data in CSY with seasonal interpolations provided by NSBC
K	Capital	Computed by equation (3); the depreciation rate is taken as 5% quarterly in the China Model
M2	Broad Money	PBC
M	Imports	Converted from nominal data in $ into *RMB* by spot exchange rate, CMEI
P#C	Consumer Price Index	Deflator for GCON and PCON, CMEI
P#GDP	GDP deflator	CMEI
P#INV	Investment Price Index	Deflator for investment series, CMEI
PCON	Private Consumption	Computed from nominal annual data in CSY with seasonal interpolations provided by NSBC
TIFA		The total investment in fixed assets, CMEI
UEMP%	Unemployment Rate	Computed from labor force and employment; these two series are computed from CSY
VA1	Value Added from the Primary Sector	CMEI
VA2	Value Added from the Secondary Sector	CMEI
VA3	Value Added from the Tertiary Sector	CMEI
X	Exports	Converted from nominal data in $ into *RMB* by spot exchange rate, CMEI

All data series are quarterly. To denote variables of constant price, a lower case 'c' is added at the end of the variable names.

[*] CMEI stands for China Monthly Economic Indicators. CSY stands for China Statistical Yearbook. NSBC stands for National Statistical Bureau of China. PBC stands for People's Bank of China.

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Table 1.1 China's Investment Ratios, 1978-2004

Year	GFCF % to GDP	GCF % to GDP	Year	GFCF% to GDP	GCF % to GDP
1978	29.8	38.2	1992	32.2	37.3
1979	28.3	36.2	1993	37.6	43.5
1980	29.0	34.9	1994	36.1	41.3
1981	25.6	32.3	1995	34.7	40.8
1982	27.2	32.1	1996	34.2	39.3
1983	28.1	33.0	1997	33.6	38.0
1984	29.7	34.5	1998	35.0	37.4
1985	30.0	38.5	1999	35.7	37.1
1986	30.6	38.0	2000	36.5	36.4
1987	31.8	36.7	2001	37.3	38.0
1988	31.4	37.4	2002	38.9	39.2
1989	26.4	37.0	2003	42.2	42.3
1990	25.8	35.2	2004 /a	44.0	44.1
1991	27.9	35.3			
AVERAGE				**32.6**	**37.5**

a/ ADB Staff Estimate
Note: GCF denotes GFCF plus inventory or change in stocks;
Source: China Statistical Yearbook, 2004; "Stable and Rapid Development of the National Economy in 2004" available at http://www/stats.gov.cn; ADB Database

Table 1.2 Average Investment Ratios for Selected Economies

	GFCF % to GDP	GCF % to GDP
	Sample: 1978—2004	
Hong Kong, China	27.2	28.4
Korea, Rep of	30.7	31.1
Singapore	35.5	36.0
Taiwan	20.0	20.6
USA	15.9	19.8
	Sample: 1980—2004	
Japan	27.7	28.0

Source: CEIC Data Company Ltd.

Table 2.1 Granger-Causality tests on GFCF & GDP and Capital & GDP

Endogenous Variable	F-statistic	Lag coefficients			
Investment and GDP growth rates (in real terms)					
		△GDPc$_{(-1)}$	**△GDPc$_{(-2)}$**	**△GDPc$_{(-3)}$**	**△GDPc$_{(-4)}$**
△GFCFc	0.9892	1.5596	-0.585	-2.2139	0.7603
	[0.4280]	(1.3950)	(1.4860)	(1.5600)	(1.4280)
		△GFCFc$_{(-1)}$	**△GFCFc$_{(-2)}$**	**△GFCFc$_{(-3)}$**	**△GFCFc$_{(-4)}$**
△GDPc	1.3944	0.0235	0.0185	-0.0056	0.0283
	[0.2589]	(0.0250)	(0.0194)	(0.0188)	(0.0186)
Capital and GDP growth rates (in real terms)					
		△GDPc$_{(-1)}$	**△GDPc$_{(-2)}$**	**△GDPc$_{(-3)}$**	**△GDPc$_{(-4)}$**
△Kc	2.6077	0.0392	-0.0337	0.0052	0.1929
	[0.0547]	(0.1004)	(0.1068)	(0.1107)	(0.0934)*
		△Kc$_{(-1)}$	**△Kc$_{(-2)}$**	**△Kc$_{(-3)}$**	**△Kc$_{(-4)}$**
△GDPc	1.3117	0.0752	-0.0233	-0.0513	-0.0733
	[0.2874]	(0.2175)	(0.3519)	(0.3302)	(0.1773)

Note: △ indicates growth rate. Statistics in parentheses are standard errors while those in brackets are probabilities. Those marked by '*' are significant at 5% level. F-statistic indicates no granger-causality between GFCF growth and GDP growth or capital growth and GDP growth. GDP growth marginally granger-causes capital growth (the significant level is 5.5%).

Table 2.2 Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) unit-root tests

	Full sample		Sub-sample	
	DF [-2.92 at 5%]	ADF(3) [-2.93 at 5%]	DF [-2.94 at 5%]	ADF(3) [-2.94 at 5%]
$\Delta_4 \ln(GDPc)$	-2.508	-2.919	-4.112	-3.601
$\Delta_4 \ln(GFCFc)$	-5.004	-3.462	-4.843	-1.95
$\Delta_4 \ln(Kc)$	-2.823	-6.368	-0.8857	-1.245
$\ln(GDPc)$	-1.423	-4.619	-0.6333	-1.071
$\ln(GFCFc)$	-1.793	-1.531	-1.366	-2.616
$\ln(Kc)$	1.889	-0.2317	-2.147	-4.791

Note: Full sample for GDPc: 1992 – 2004, for GFCFc and Kc: 1992 – 2003; Sub-sample cuts off the first three years: 1992 – 1994. Seasonal dummies are included for all the level variable tests. Critical values are in squared brackets.

Table 2.3 Cointegration Analysis

Model includes:	Constant & Seasonals	Constant, Trend & Seasonals
Set 1. GFCF and GDP		
rank = 0		
Trace test	33.16**	48.77**
Maximum Eigenvalue test	29.54**	36.44**
rank = 1		
Trace test	3.63	12.34
Maximum Eigenvalue test	3.63	12.34
Unit Root test on residuals		
Durbin-Watson	2.44	2.26
t-ADF	-8.866**	-6.528**
Set 2. Capital and GDP		
rank = 0		
Trace test	56.37	64.20**
Maximum Eigenvalue test	55.67	60.85**
rank = 1		
Trace test	0.7	3.35
Maximum Eigenvalue test	0.7	3.35
Unit Root test on residuals		
Durbin-Watson	2.41	1.92
t-ADF	7.120**	-4.763**

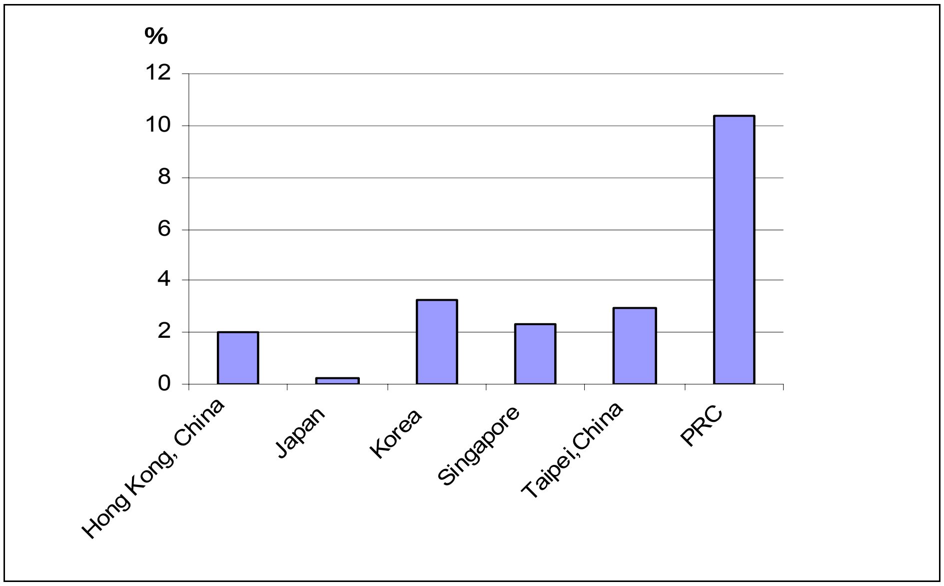
Note: There is at least one cointegrating equation for GFCF and GDP and capital and GDP. Due to small sample size, some residuals were found to be non-stationary depending on the number of lags included in the ADF test. For the purposes of this study, only the results which include lags that render the t-ADF statistics significant are reported.

Table 2.4 Simultaneous equations VAR model versus Single equations OLS Model

Endogenous Variable	Coefficients					
			Set 1. GFCF and GDP			
			Simultaneous equations VAR model			
	$GDPc_{(-1)}$	**GFCFc**	**$GFCFc_{(-1)}$**	**Constant**	**$Seasonal_{(1)}$**	**$Seasonal_{(3)}$**
GDPc	1.0504	-0.0481	-0.0034	-0.1943	-0.7288	-0.1503
	(0.0423)*	(0.0506)	(0.0282)	(0.2314)	(0.1037)*	(0.0283)*
	$GFCFc_{(-1)}$	**GDPc**	**$GDPc_{(-1)}$**	**Constant**	**$Seasonal_{(1)}$**	**$Seasonal_{(3)}$**
GFCFc	0.0611	4.6497	-3.3158	-6.9182	1.1044	-0.4237
	(0.1992)	(0.4800)*	(0.5658)*	(1.6240)*	(0.2937)*	(0.1335)*
			OLS model			
	$GDPc_{(-1)}$	**GFCFc**	**$GFCFc_{(-1)}$**	**Constant**	**$Seasonal_{(1)}$**	**$Seasonal_{(3)}$**
GDPc	1.0243	-0.0108	-0.0219	0.2950	-0.6528	-0.1302
	(0.0274)*	(0.0230)	(0.0168)	(0.1909)	(0.0480)*	(0.0144)*
	$INVc_{(-1)}$	**GDPc**	**$GDPc_{(-1)}$**	**Constant**	**$Seasonal_{(1)}$**	**$Seasonal_{(2)}$**
GFCFc	0.0506	4.0685	-2.7202	-6.9001	0.7702	-0.3797
	(0.1948)	(0.4390)*	(0.5265)*	(1.5880)*	(0.2708)*	(0.1300)*
			Set 2. Capital and GDP			
			Simultaneous equations VAR model			
	$GDPc_{(-1)}$	**Kc**	**$Kc_{(-1)}$**	**Constant**	**$Seasonal_{(1)}$**	**$Seasonal_{(3)}$**
GDPc	1.0842	-0.9150	0.8657	-0.1193	-0.7318	-0.1611
	(0.0985)*	(0.4679)	(0.4177)*	(0.5251)	(0.0547)*	(0.0189)*
	$Kc_{(-1)}$	**GDPc**	**$GDPc_{(-1)}$**	**Constant**	**$Seasonal_{(1)}$**	**$Seasonal_{(2)}$**
Kc	0.7924	0.1868	0.2007	-2.1100	-0.0191	0.0532
	(0.0206)*	(0.0365)*	(0.0609)*	(0.1931)*	(0.0249)	(0.0114)*
			OLS model			
	$GDPc_{(-1)}$	**Kc**	**$Kc_{(-1)}$**	**Constant**	**$Seasonal_{(1)}$**	**$Seasonal_{(3)}$**
GDPc	0.9762	-0.3871	0.3947	0.4507	-0.6710	-0.1410
	(0.0534)*	(0.2377)	(0.2125)	(0.2899)	(0.0287)*	(0.0109)*
	$Kc_{(-1)}$	**GDPc**	**$GDPc_{(-1)}$**	**Constant**	**$Seasonal_{(2)}$**	**$Seasonal_{(3)}$**
Kc	0.7863	0.1594	0.2389	-2.1594	-0.0370	0.0582
	(0.0202)*	(0.0341)*	(0.0580)*	(0.1903)*	(0.0234)	(0.0111)*

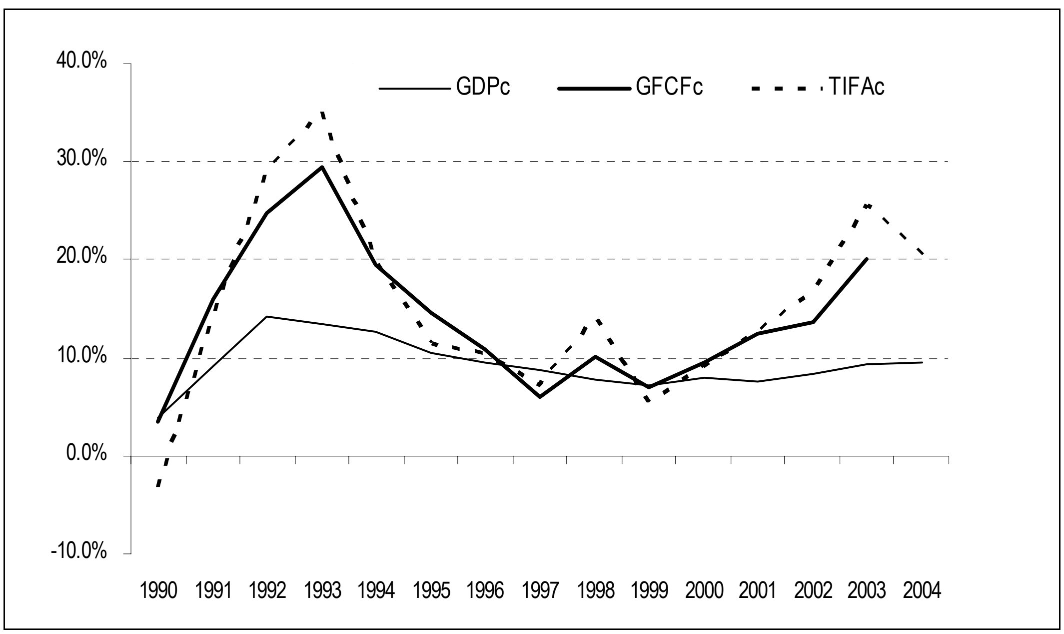
Note: Statistics in parentheses are standard errors. Those marked by '*' are significant at the 5% level. GFCF is not significant to GDP in set 1. Capital is significant to GDP in set 2 with different coefficients for the simultaneous and OLS models implying interdependence with GDP. GDP is however found to be weakly exogenous to investment (set 1) and capital (set 2).

Figure 1.1 Average Growth of Real GFCF for Selected Economies 1995-2004



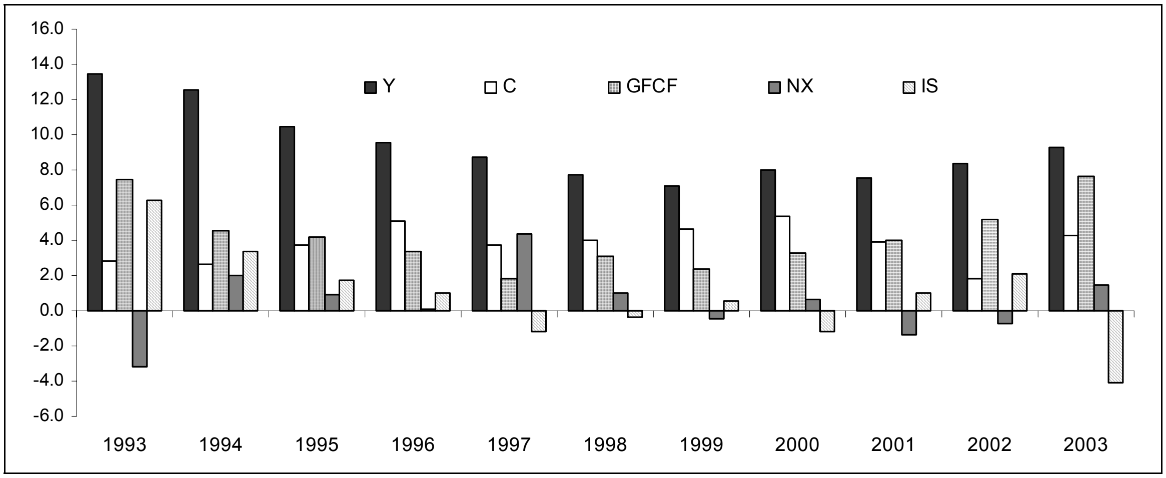
Source: CEIC Data Company Ltd.; China Statistical Yearbook, 2004

Figure 1.2 Growth rates of GDP, GFCF and TIFA (all in constant prices)



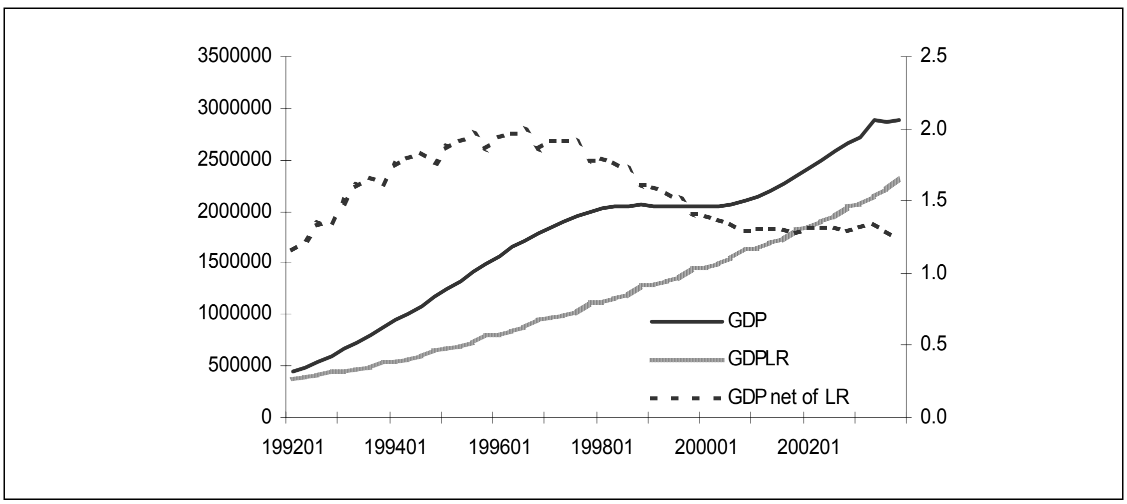
Data source: See the Appendix.

Figure 2.1 Co-movement of Growth of GDP and its components



Note: Weighted growth rates of the components are presented here alongside GDP growth.
Source: CMEI for GDP and components in levels

Figure 2.2 GDPc – Actual, Long-run and Actual net of long-run



Note: GDP net of LR refers to detrended GDP which is taken as the ratio between GDP and GDPLR.

Figure 3.1 Framework of output and investment blocks of the China Model

$$\text{GDPc} = \text{VA1c} + \text{VA2c} + \text{VA3c}$$

(Agriculture) (Industry) (Services)

where:

$$\text{VA1c} = f\,(\text{Income, Relative Prices, Sector Structural Shifts})$$

(demand side function) (additional short-run factor)

$$\text{VA2c} = f\,(\text{Capital, Labor, Sector Structural Shifts})$$

(supply side function) (additional short-run factor)

$$\text{VA3c} = f\,(\text{Income, Relative Prices, Sector Structural Shifts})$$

(supply side function) (additional short-run factor)

$$\text{GFCFc} = f\,(\text{BINVc} + \text{GINVc} + \text{FDIc})$$

(Business investment) (Government investment) (Foreign direct investment)

where:

$$\text{BINVc} = f\,(\text{GDP, User cost of capital, Government investment})$$

(additional short-run factor)

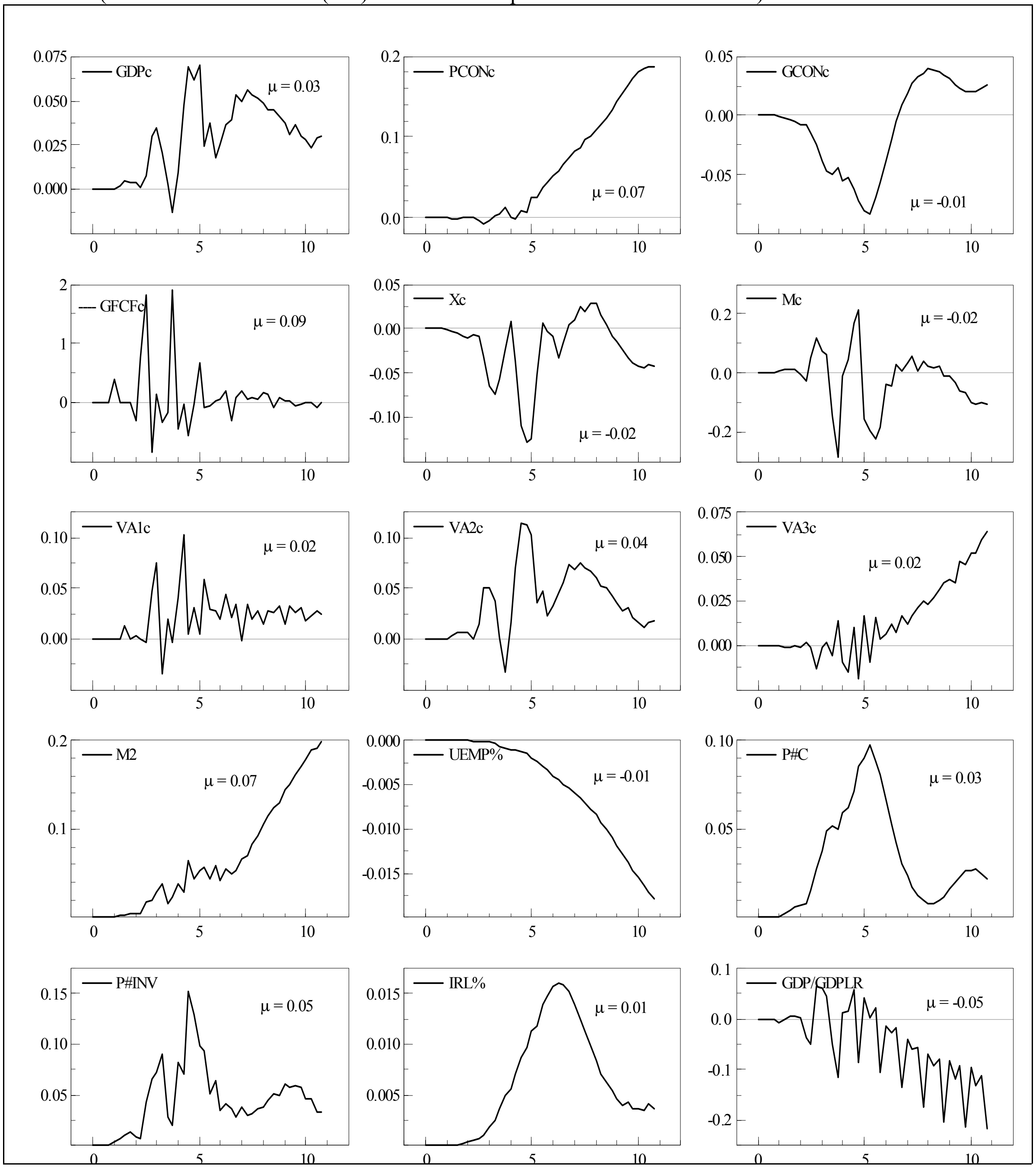
$$\text{GINVc} = f\,(\text{Revenue, Policy targets})$$

(unemployment rate, GDP gap)

$$\text{FDI} = f\,(\text{Differential interest rates, Trade openness, Relative prices})$$

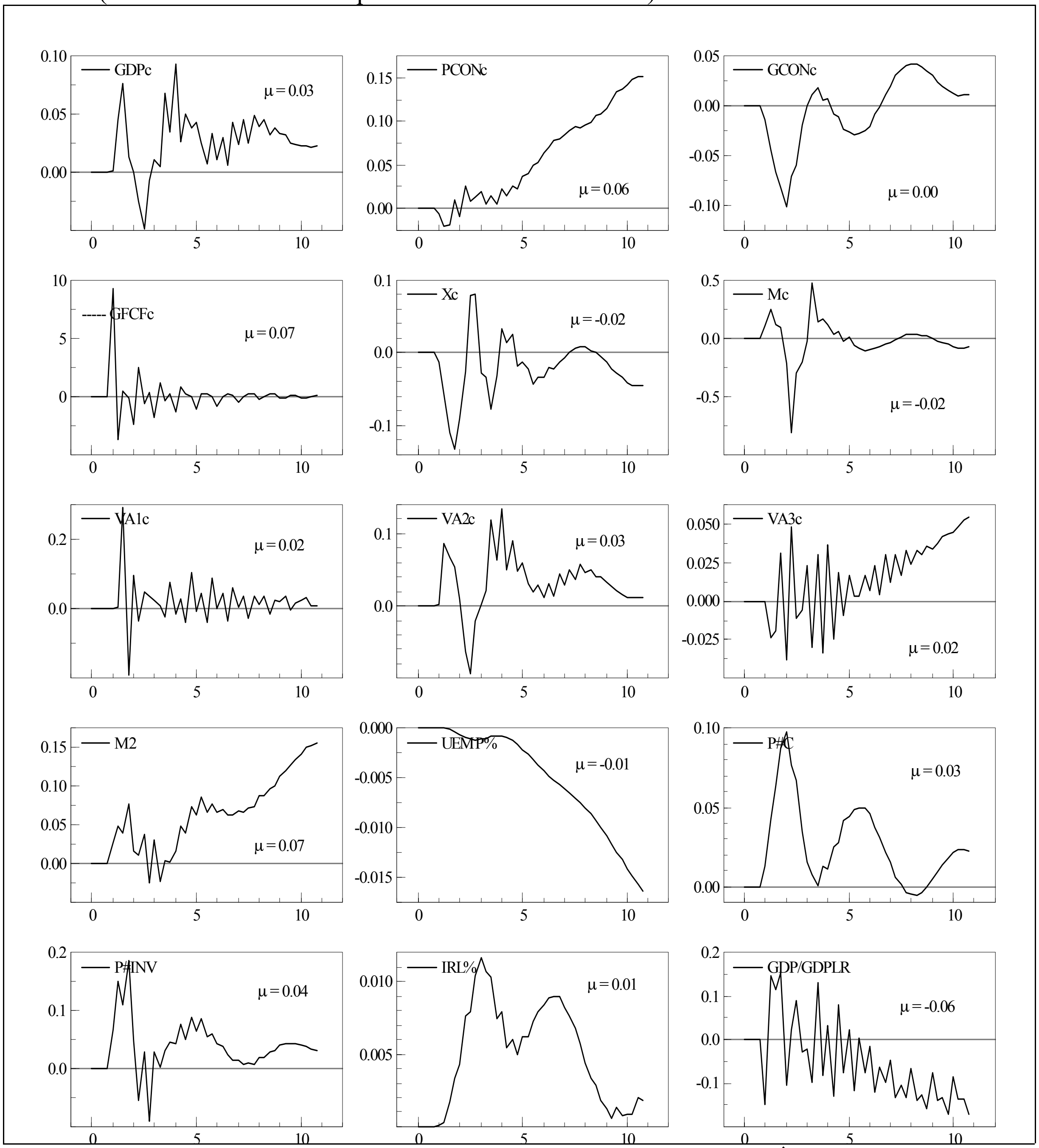
Figure 3.2 Impulse response function to government investment (GINVc) shock

(one standard deviation (s.d.) of GINVc is equivalent to a 10% ↑ shock)



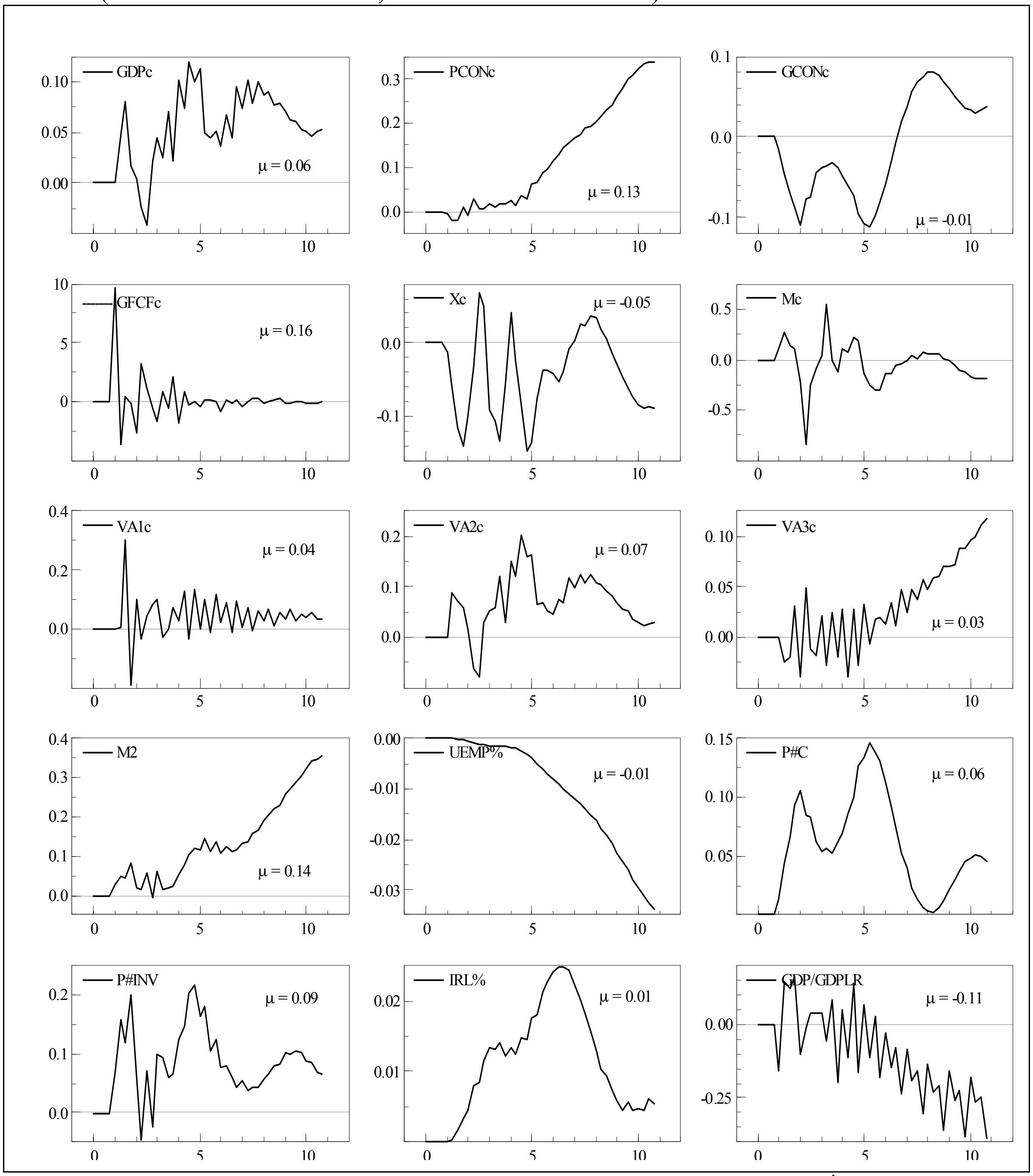
Note: The experiment is carried out for an 11-year (44 quarters) period. The impulse is imposed at quarter 5 and there are 40 quarters of response time. The unit of the vertical axis is in percentage. All the level variables are divided by population. The curves capture the difference of annual growth rates of the variables concerned and the μ's are estimated average values. See the appendix for detailed definitions of the variables. The current impulse generates roughly a 0.4%↑ GFCFc shock.

Figure 3.3 Impulse response function to the business sector investment (BINVc) shock
(one s.d. of BINVc is equivalent to a 17% ↑ shock)



Note: Refer to the note of Figure 3.2. The current impulse generates roughly a 9.4%↑ GFCFc shock.

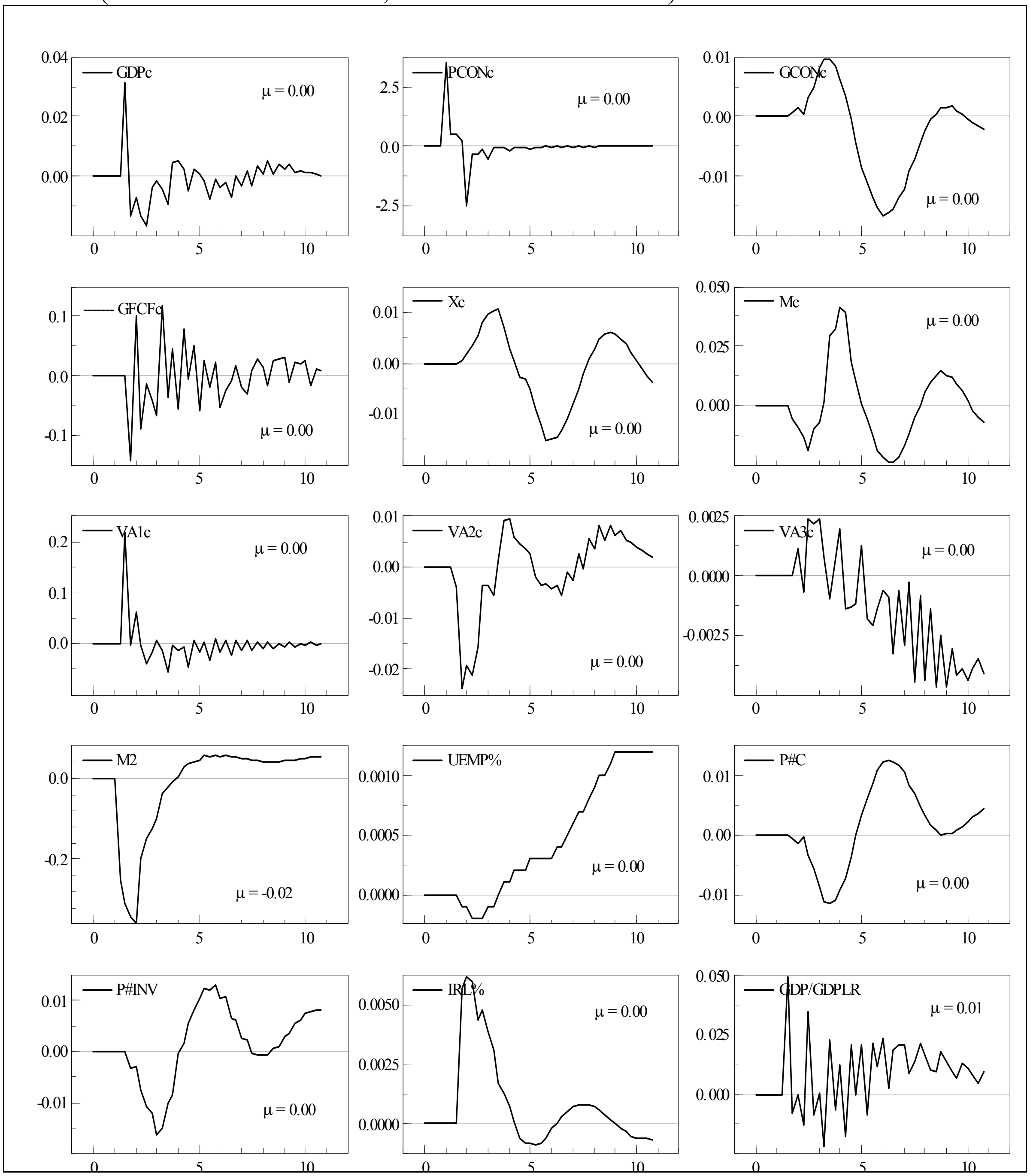
Figure 3.4 Impulse response function to the combined investment shocks
(10% ↑ shock in GINVc; 17% ↑ shock in BINVc)



Note: The same as the note of Figure 3.2. The current impulse generates roughly a 9.8%↑ GFCFc shock.

Figure 3.5 Impulse response function to the private consumption shocks

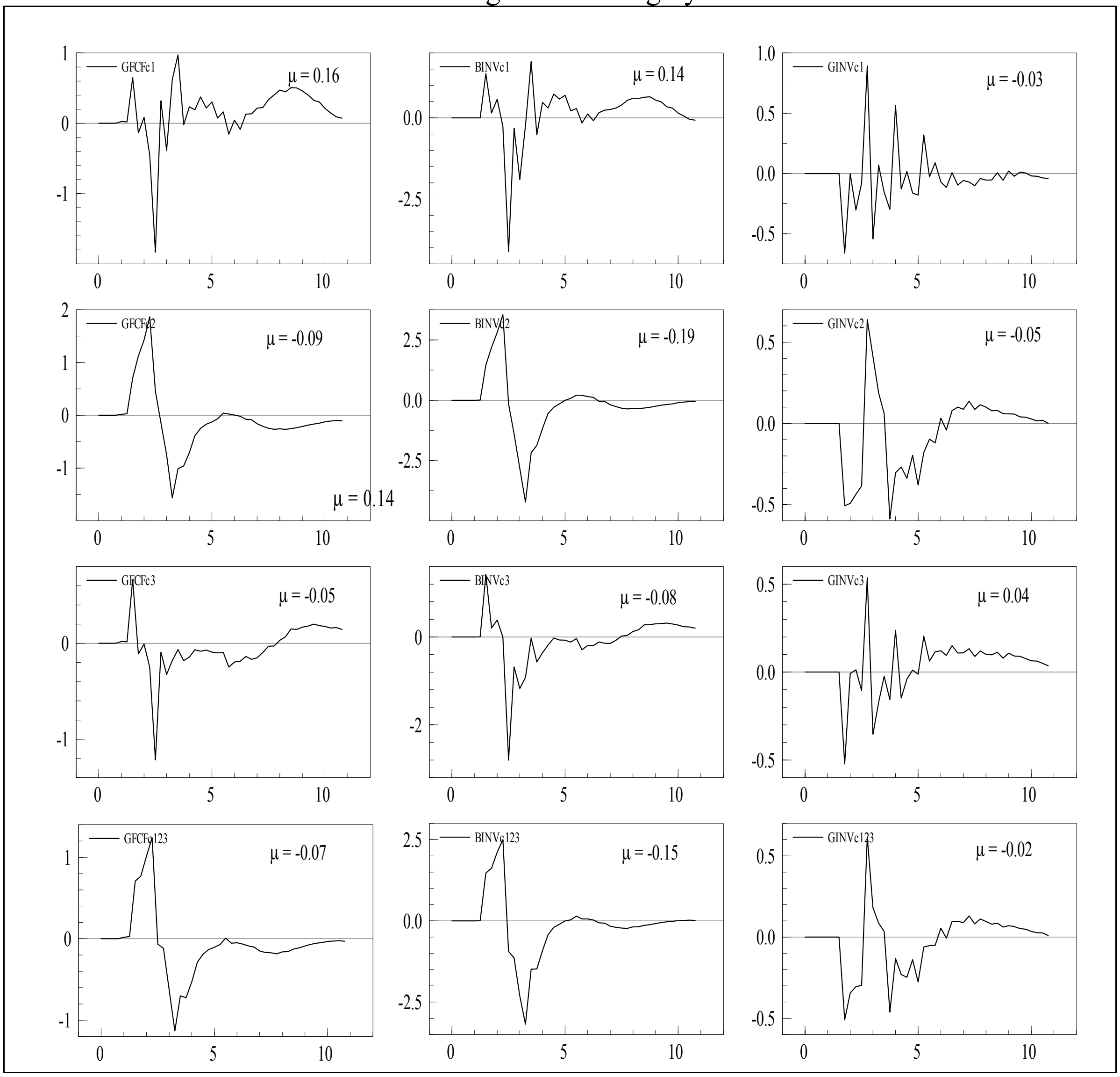
(4% ↑ shock in PCCONr; 3% ↑ shock in PCCONu)



Note: The same as the note of Figure 3.2.

Figure 3.6 Impulse response function to GDPc impulse shock

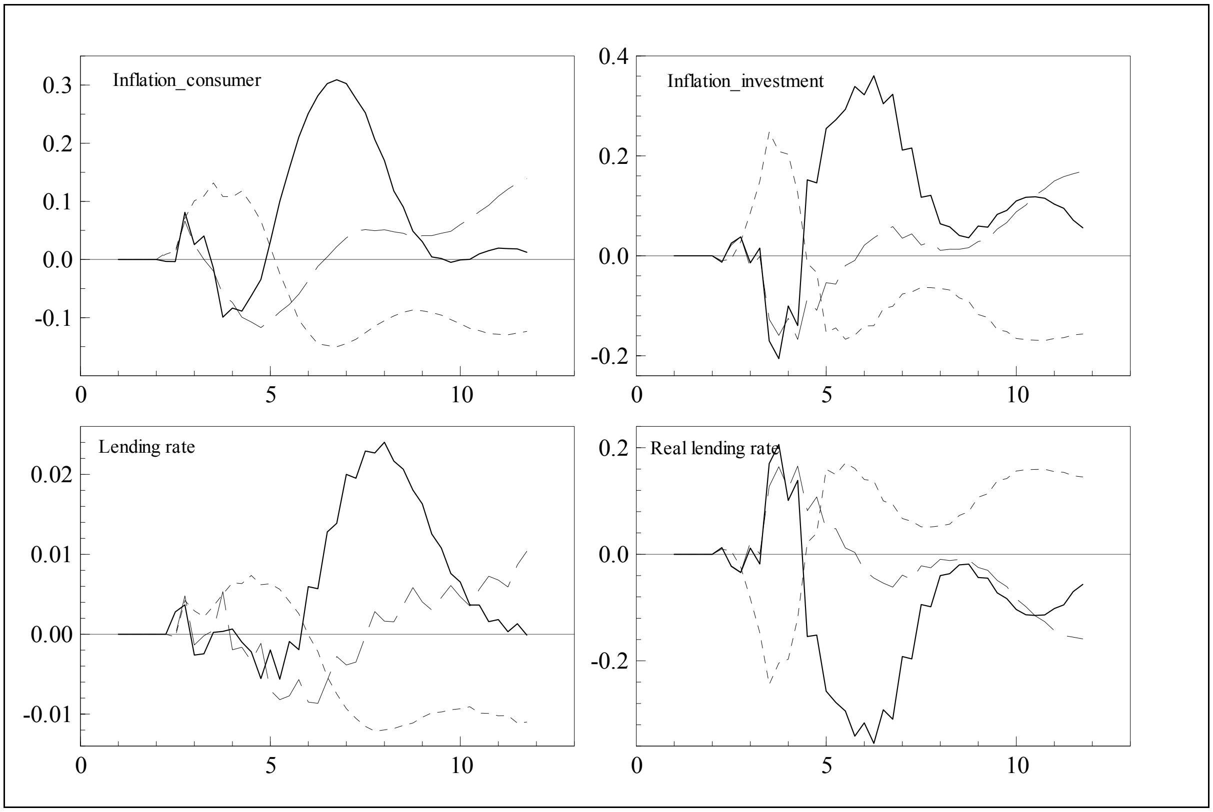
1st row: 1 s.d. shock from VA1c generates roughly 0.044% ↑ GDP shock
2nd row: 1 s.d. shock from VA2c generates roughly 1.17% ↑ GDP shock
3rd row: 1 s.d. shock from VA3c generates roughly 0.45% ↑ GDP shock
4th row: combination of the three generates roughly 1.68% ↑ GDP shock



Note: Refer to the note of Figure 3.2. The number added to the variable notation indicates the sector where shock is originated. To make the three sector shocks comparable, all the IRFs are rescaled to correspond to 1% of GDPc growth.

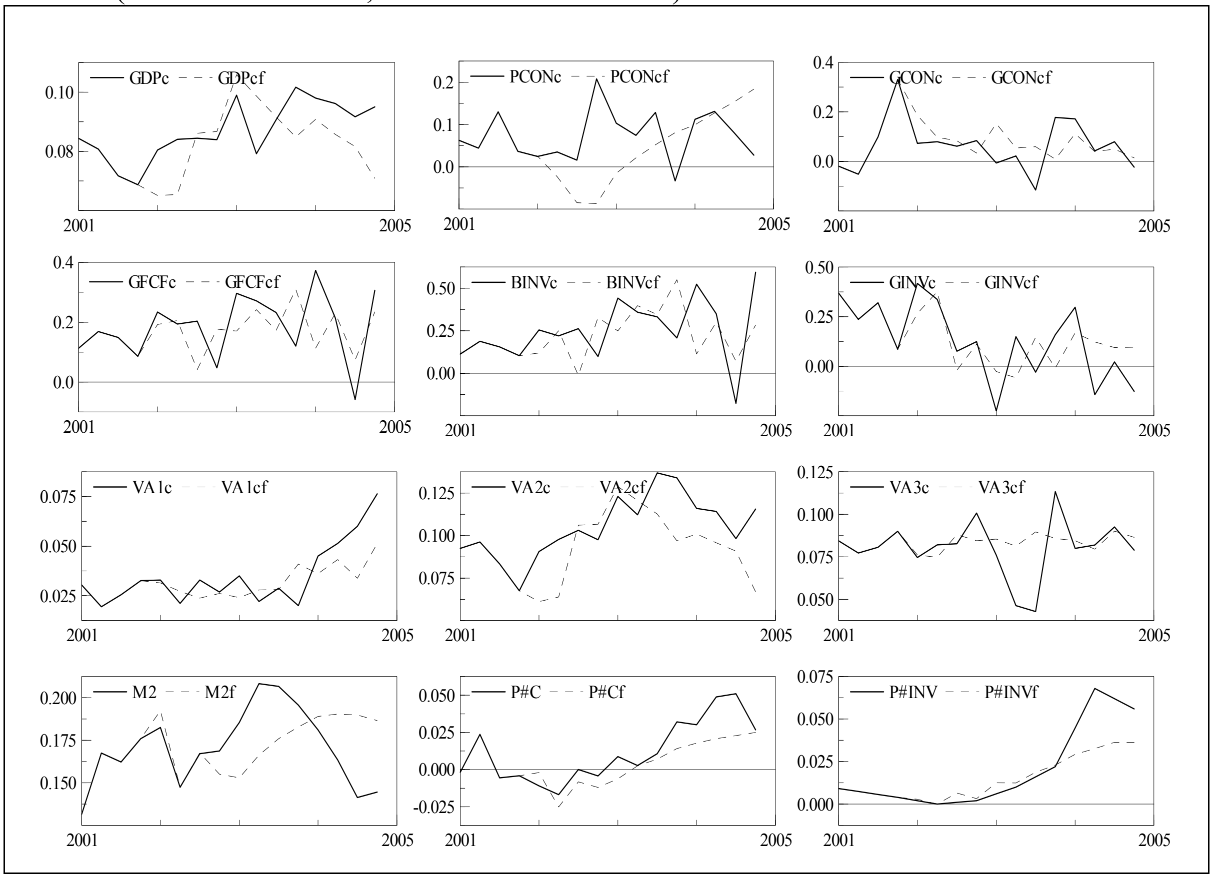
Figure 3.7 Nominal response to impulse shocks of the three sectors

(solid curve: by VA1c; dotted curve: by VA2c; dashed curve: by VA3c)



Note: The unit of the vertical axis is in percentage. Inflation is calculated as y-o-y growth rates. See Figure 3.6 for the details of the impulse shock scenarios.

Figure 3.8 Forecasted versus actual growth for 2002Q1 – 2004Q4
(Solid curve: actual; dotted curve: forecasts)



Note: For the growth rates of PCONc, GCONc and INVc, the 2004 actual values are not yet available. These values are forecasted using the full sample information.

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