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Sources of Investment Inefficiency: The Case of Fixed-Asset Investment in China

Duo Qin and Haiyan Song

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Queen Mary
University of London

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Duo QIN*

Department of Economics, Queen Mary, University of London, UK

Haiyan SONG

Public Policy Research Institute, Hong Kong Polytechnic University

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ABSTRACT

This study attempts to measure the inefficiency associated with aggregate investment in a transitional economy. The inefficiency is decomposed into allocative and production inefficiency based on standard production theory. Allocative inefficiency is measured by disequilibrium investment demand. Institutional factors are then taken into consideration as possible explanatory variables of the disequilibrium. The resulting model is applied to Chinese provincial panel data. The main findings are: Chinese investment demand is strongly receptive to expansionary fiscal policies and inter-provincial network effects; and although there are signs of increasing allocative efficiency, the tendency of over-investment remains, even with improvements in production efficiency.

JEL: E22, E62, H74, P3, C23

Keywords: over-investment, efficiency, disequilibrium, soft-budget constraint

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1. Introduction

Over-investment occurs when output growth lags behind investment growth due to lack of appropriate growth in capital productivity. Over-investment used to plague centrally planned economies (CPEs), see (Kornai, 1980) and (Begg *et al*, 1990), who refer to the phenomenon as 'investment hunger'. Clearly, large-scale over-investment is likely to occur when a well-functioning capital market in an economy is lacking, and that would incur sizeable efficiency loss. An interesting and challenging question is whether such loss could be measured and explained by certain economic factors. The present study attempts to tackle the question with a model designed for a panel data set on provincial investment in China.

Investment-driven growth remains a crucial development strategy in China although it abandoned the CPE system over two decades ago, e.g. see (Nasution, 1999). Figure 1 presents a few key aspects concerning China's fixed-asset investment since 1980.[1] The figure indicates that the growth of fixed-asset investment has been faster and more volatile than GDP growth; capital formation has risen significantly in terms of its GDP composition, from below 30% in the 1980s to above 40% since 2003; and total bank savings exceeded total bank loans in the mid 1990s for the first time since 1950, stimulating greatly the central government deficit financing activities. In fact, the sharp rise of deficits was not restricted to the central government. It also occurred widely at the provincial level (see Figure 2).

Persistent investment growth in excess of output can imply decreasing capital productivity, and volatile investment growth can result in high efficiency loss as investment normally bears high adjustment costs. Recent concerns over the banking sector reforms and economic overheating in China actually relate closely to the problems of over-

[1] For a more detailed description of the recent investment-output situation in China, see (Qin *et al*, 2006).

investment and under-utilised capital in production, e.g. see (Goldstein and Lardy, 2004). But the questions why the extensive reforms have not yet cured the investment hunger and how much and in what way the Chinese economy has suffered from the efficiency loss of over-investment remain unresolved to most researchers and practitioners.

Studies on China's aggregate investment lack conclusive views on the above questions. For example, Wang and Fan (2000) maintain that the investment hunger is not yet over on the basis of the observations that policy-induced impulsive investment behaviour is still prevalent; soft loans are still available from the banking system; and investment structure is severely unbalanced especially in view of the relatively poor performance and relatively rich capital formation in a sizeable part of the state-owned sector. However, they recognise some signs of improvement in investment efficiency since the reforms, such as rising transformation rates from investment to capital formation, and increasing shares of investments by the non-state-owned sector and the foreign sector. Zhang (2002) is very critical of the positive contribution of capital investment to China's long-term growth. He regards the overgrowth of investment versus GDP as a sign of excessive investment and deterioration in investment efficiency. By showing decelerating growth in total factor productivity and diminishing investment returns during the 1990s, Zhang suggests that China's overall fixed-asset investment has gone too far, especially with regard to its labour resource. He ascribes the problems mainly to institutional distortion, which induces a mixture of the traditional tendency of over-investment with excessive regional competition for capital as a result of fiscal decentralisation. The latter factor has attracted increasing attention in recent years. For instance, Zhang and Zou (1996) demonstrate empirically that a higher degree of fiscal decentralisation is associated with lower provincial growth. They thus infer that fiscal decentralisation must have caused severe capital shortage for infrastructure investment at the national level, which is vital for rapid economic growth. The problem is more extensively examined by Young (2000), who shows that decentralisation has resulted in significant fragmentation of internal markets that lead to inefficiency in resource allocation. But these empirical findings are somewhat at odds with Huang's detailed analysis of the political economy of central-local relations in investment controls (1996). Huang argues that China's present de facto federal system should have the merits of reducing co-ordination costs and improving economic governance. The economic role of federalism is further theorised by Qian and Roland (1998), who postulate two main effects. The first is the competitive effect of federalism, which could lead to regional investment distortion; the second is the checks-and-balances effect of federalism, which should result in hardening soft budgets for state-owned firms.

Unfortunately, there is a sizeable gap between the theoretical and empirical discussions on the possible inefficiency in China's aggregate investment. While most theories are concerned with possible misallocation of financial resources due to imperfect capital markets, empirical evidence is focused on production efficiency, such as productivity changes of capital in aggregate production functions or changing shares of capital to labour inputs.[2] The problem, we believe, lies mainly in the different economic environments in which the issue has been considered. In a market economy, investment decisions are mostly made at the firm level and therefore the issue of investment efficiency falls formally in the realm of microeconomics; whereas in a transitional economy, the market is far from perfect and micro investment decisions are still significantly affected by various institutional factors.

The present study is an attempt to fill the gap. We adopt the standard theory of capital input demand with the associated measures of investment efficiency under perfect market conditions and extend them to cover a transitional economy. This allows us to disentangle

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[2] Bai *et al* (1997) point out that improvements in production efficiency in terms of total factor productivity may not lead to more efficient resource allocation in a mixed market where firms are not solely profit maximisers.

investment efficiency into two types: efficiency in investment allocation and efficiency in capital utilisation during production. We are particularly interested in identifying and estimating how institutional factors have contributed to over-investment via investment misallocation. Our empirical model uses a panel data set of 30 provinces in China over the period 1989-2004.[3]

The rest of the paper is organised as follows: Section 2 presents a general theoretical framework for defining and measuring investment inefficiency; section 3 extends the framework to transitional economies; empirical results are presented in section 4; and the final section concludes the paper.

2. Investment Inefficiency: A Conceptual Framework

In order to define measures of inefficiency in aggregate investment, we follow convention by using the neoclassical model as the theoretical base, see (Caballero, 1999). The model defines the desired investment as the capital input demand which meets the cost-minimising or profit-maximisation condition. This enables us to define over-investment (or under-investment) as deviations of actual investment from the desired level. The theory also provides us with two measures of efficiency — production efficiency (PE),[4] which is associated with both the technological and managerial aspects of how capital assets are utilised in production, and allocative efficiency (AE), which evaluates how production decisions are made in accordance with market demand and supply conditions, see, e.g. (Färe and Primont, 1995) and (Greene, 1997).

Let us assume a homothetic production function involving only two inputs – capital and labour. Under the equilibrium state, this production function is expected to maintain

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[3] Beijing, Tianjin and Shanghai are counted as provinces, but Chongqing, the new autonomous municipality, is still regarded as part of Sichuan.

[4] We avoid the more commonly used term 'technological efficiency' because of its lack of emphasis on the managerial side, which should be more important for Chinese firms during the reforms.

constant returns to scale. Following the common practice in aggregate production function research, e.g. see (Berndt, 1991, Chapter 6), we adopt a constant-returns-to-scale CES (constant elasticity of substitution) function for the production function:

(1) $$Y^* = [\alpha K^{*\rho} + (1-\alpha)L^{*\rho}]^{1/\rho} \qquad 0 \neq \rho = 1 - \frac{1}{\sigma} < 1$$

where ρ is the *substitution* parameter mapping into σ, the elasticity of substitution. Under the condition of cost minimisation or profit maximisation:

(2) $$\min(P_k K + P_l L) \quad or \quad \max[P_y Y - (P_k K + P_l L)]$$

the desired factor input demand entails the equality between the marginal rate of technical substitution of the inputs and their price ratio at equilibrium:

(3) $$\frac{\partial Y}{\partial K} = \frac{P_k^*}{P_y^*}, \quad \frac{\partial Y}{\partial L} = \frac{P_l^*}{P_y^*}, \quad \frac{\partial Y / \partial K}{\partial Y / \partial L} = \frac{P_k^*}{P_l^*}$$

Hence, the factor input demand function for K^* can be derived by combining the first-order condition of (1) with (3) (see, e.g. Varian 2006, Chapter 20):

(4) $$K^* = \alpha^\sigma Y^* \left(\frac{P_y^*}{P_k^*} \right)^\sigma$$

Now, investment amounts to:

(5) $$I_t = K_t - (1-\delta)K_{t-1}$$

where δ is the effective depreciation rate for K. When capital stock is at its equilibrium, K^*, we should have:

(6) $$I^* = \delta K^*$$

Combining (6) and (4) and taking natural logarithms, we obtain:

(7) $$\ln I^* = A + \ln Y^* - \sigma \ln C^*, \qquad A = \ln \delta + \sigma \ln \alpha$$

where C^* denotes the standard user cost of capital:

(8) $$C^* = \frac{P_k^*}{P_y^*} = \frac{(r+\delta)}{(1-\pi)} \frac{P_I^*}{P_y^*}$$

In (8), r is the real interest rate for investment loans and π is the tax rate.

We are now in the position of defining the two measures of efficiency. According to the established procedures, PE corresponds to the fixed individual effect decomposed from the intercept term of a regression model under a cross-section or panel setting, e.g. see (Greene, 1997). Specifically, a measure of PE, denoted by Λ_i, can be defined via extending A of (7) to a panel-data situation where i denotes the individual entry in a panel of size N:

(9) $$A_i = \ln \delta_i + \sigma \ln \alpha_i - \ln \Lambda_i \quad \Rightarrow \quad \Lambda_i = \delta_i \alpha_i^{\sigma} \exp\{-A_i\} \quad i = 1, \cdots, N$$

As for AE, it is commonly defined by the ratio of the actual price ratio to the equilibrium price ratio given in (3):[5]

(10) $$\mathrm{Z}_{kl} = \frac{P_k / P_l}{P_k^* / P_l^*} = \frac{\mathrm{Z}_k}{\mathrm{Z}_l}, \quad \mathrm{Z}_j = \frac{P_j}{P_j^*}, \quad j = l, k$$

In the present context, we are only interested in Z_k and/or Z_I. Since P_j^* is unobservable in practice, Zs are often viewed as a set of parametric correction in input factor prices. The set can be estimated either directly from the secondary price space of firms' cost-minimising function constrained by a production function, or indirectly from the primal goods space of firms' input demand function conditional on cost minimisation by means of an input distance function, see (Atkinson and Cornwell, 1994), (Atkinson and Primont, 2002).[6] If the latter route is chosen, the AE measure of Z_I becomes:

(11) $$\mathrm{Z}_I = \frac{I}{I^*} \quad \Rightarrow \quad \ln \mathrm{Z}_I = \ln I - \ln I^* = \zeta$$

Interestingly, Caballero *et al* (1995) refer to ζ as the 'mandated' investment rate and employ the cointegration approach to measure it using time-series data. The approach essentially regards ζ as a disequilibrium investment rate, where $\zeta_t > 0$ reflects over-

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[5] The actual market price ratio is more frequently used in equation (3) in the empirical literature. Under that context, firm specific shadow prices are employed in contrast with market prices, e.g. see (Baños-Pino *et al* 2001).

[6] A detailed explanation of the duality of the two approaches can be found in (Färe and Primont, 1995).

investment and $\zeta_t < 0$ under investment. This disequilibrium rate now becomes an AE measure under the assumption that perfect market equilibrium is the most efficient state. Combining (11) with (7) and writing the model in a panel model setting, we have:

(12) $$\zeta_{it} = \ln I_{it} - \left[A - \ln Y_{it} - \sigma \ln C_{it}\right] \quad i = 1, \cdots, N$$

Clearly, full efficiency implies $\zeta_{it} = 0$.

It is still premature to apply (12) directly to China's investment data. As mentioned in the previous section, most of the concerns over China's over-investment relate to financial resource misallocation due to an imperfect market environment. But model (12) does not address these concerns. When the market condition is imperfect, the investment demand of firms is expected to adapt to the imperfect market environment. Hence, ζ_{it} might not be a correct measure under such circumstances. In the next section, we shall try to extend (12) and develop suitable AE measures for a transitional economy.

3. Allocative Inefficiency under Institutional Constraints

The trait of an imperfect market is cost/price distortion. In the extreme case of a CPE, budget constraints of state-owned firms are known to be soft (Kornai, 1980) and their production objectives not aiming at profit maximisation. These characteristics have remained in spite of China's continued economic reforms, see e.g. (Liu, 2001), (Dong and Putterman, 2002). For instance, ideological concern for spatial equality and defence consideration used to be among the key objectives in state investment plans, see (Ma and Wei, 1997).

Since a mixed objective-maximising function should correspond to a cost-minimising function with soft budget constraints, a natural way to modify the investment demand function is to extend the standard cost function in (2) such that it takes into consideration those market disequilibrating institutional effects.[7] We adopt this approach and attach to the capital component a multiplicative function $Z^{\tau}(x)$ representing the institutional effects on fixed capital investment:

(13) $$\left[P_k K Z^{\tau}(\boldsymbol{x}) + P_l L\right]$$

where $\boldsymbol{x}$ denotes a set of disequilibrating soft budget indicators such that $Z^{\tau}(0) = 1$. For operational purposes, we specify $Z^{\tau}(x)$ as an exponential function:

(14) $$Z^{\tau}(\boldsymbol{x}) = \exp\left\{\sum_j \tau_j x_j\right\}$$

Substituting (14) into (13) and minimising the resultant equation subject to (1), we arrive at the following counterpart of (12) under a mixed market condition:

(15) $$\zeta_{it}^{\tau} = \ln\left(\frac{I}{Y}\right)_{it} - \left[A_i - \sigma \ln C_{it} + \sum_j \tau_j x_{jit}\right]$$

While ζ_{it} of (12) gives us a measure of AE under perfect market conditions, ζ_{it}^{τ} of (15) adapts the measure to a mixed market situation. Their difference, $\zeta_{it} - \zeta_{it}^{\tau}$, is just $Z^{\tau}(x)$ in logarithm. This demonstrates that $Z^{\tau}(x)$ is in effect an AE measure of how much the institutional factors would cause investment misallocation. This measure has the advantage of explicitly evaluating the positive and negative contribution of each of the institutional factors to AE. It indicates a way in which theories concerning efficiency-related institutional factors during reforms could be tested.[8]

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[7] Another approach is disaggregation, i.e. to formulate a two-sector model with different behavioural rules for the state-owned sector and the non-state-owned sector. However, this approach may not fully reflect the fact that it is becoming harder to differentiate firms' behaviour simply by ownership in China, since many firms suffer from incompletely specified property rights, or have their ownership diversified due to the gradual privatisation programme. Besides, disaggregation involves a substantial increase in data requirements.

[8] Theorisation of efficiency and institutional changes is still in the making, see e.g. (Yao, 2002), and desires better interactions with applied studies.

Let us now consider how to select and specify $\boldsymbol{x}$. Two general principles guide the selection. These variables must embody institutional disequilibrating effects, and they must satisfy $Z^{\tau}(0)=1$. The latter implies that the $\boldsymbol{x}$ should be ratio variables in logarithms. Taking into consideration those factors that have been suggested repeatedly in the relevant literature, such as regional factors arising from decentralisation, as well as data availability, we construct the following indicators:

a) x_1: the nation-wide effect of deficit-financing fiscal policies, which is taken as the logarithm of the ratio of the total government debt incurred to the debt payment;

b) x_{2i}: the local government expansionary fiscal policy effect, which is taken as the logarithm of the ratio of provincial government expenditure to revenue;[9]

c) x_{3i}: one period lagged deviation of provincial over-investment rate, ζ_{it-1}, from its regional average, which is intended to capture the herding effect of over-investment due to provincial competition or spill-over effect, in addition to what x_{2i} captures;

d) x_{4i}: regional growth effect, which is defined as the logarithm of the one-period lagged ratio of provincial per capita GDP to its regional average;

e) x_5: the logarithm of the bank loan-deposit ratio at the national level.

Detailed definition of these variables and the division of three regions[10] are given in the Appendix.

4. Empirical Results

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[9] The post-1994 data on x_{2i} do not represent as drastic an increase in provincial government deficit as Figure 2 suggests. This is because a new system of tax division was introduced in 1994, which entails part of the tax collected nationally to be returned to provinces by certain formulae, whereas the published local government revenue account does not contain this part. Nevertheless, local government deficit financing is mainly responsible for the nation-wide government debt, as shown in Figures 1 and 2.

[10] Here, we adopt the division of three broad regions by the Chinese National Bureau of Statistics, also see (Song *et al*, 2001).

A major issue in bridging static theories such as (12) and (15) with time-series data is how the dynamic information in data should be handled and interpreted. The key is to choose appropriate model specification and estimation methods. For model specification, we follow (Caballero *et al*, 1995) and regard ζ as the disequilibrium investment rate. In other words, we regard (12) and (15) as depicting the disequilibrium errors of the designated long-run equilibrium state which is hypothetically embedded in the dynamic data generation process. When the process is characterised by a dynamic model, the equilibrium state is expected to correspond to the long-run solution of the model, which is now commonly obtained by the cointegration technique, as the economic time series involved are normally nonstationary i.e., unit-roots feature in most of the macro economic time series.

The unit-root feature is widely observed among most of the time series in the available empirical studies on China's aggregation investment, e.g. see (Sun, 1998), (Song *et al*, 2001), (He and Qin, 2004) and (Qin *et al*, 2006). In view of this and also the very limited power of unit-root tests for panel data, we bypass the test here and adopt the panel DOLS (Dynamic Ordinary Least Squares) method to estimate the long-run parameters in (12) and (15), see (Kao *et al*, 1999) and (Kao and Chiang, 2000).[11] Taking (12) for example, the DOLS refers to the OLS estimate of σ in the following dynamic specification of (12):

$$(16) \qquad \left(\ln I_{it} - \ln Y_{it}\right) = A_i + A_{0t} - \sigma \ln C_{it} + \sum_{k=-1}^{1} \theta_k \Delta \ln C_{it-k} + e_{it}, \qquad i = 1, \cdots, n$$

where A_{0t} represents random time effect and θ_{ik} are short-run parameters. The assumption of constant return to scale is maintained in (16) without empirical testing. This is because this assumption has been verified in the above cited studies on China's aggregate investment as well as in (Qin and Song, 2003).

Table 1 reports the DOLS estimates of σ over various sample periods, using an annual panel data set of 30 provinces covering 1989-2004 (see the appendix for the details of data sources and definitions).[12] It is noticeable from the table that the estimates of σ are small and insignificant for sub-samples prior to 2001. This finding corroborates those reported in (Sun, 1980), (Song *et al*, 2001) and (He and Qin, 2003). It indicates that the actual C_{it} has not been widely perceived as an effective cost-minimising signal until very recent years. This is also consistent with Stigilitz's observation (1996, p97) that firms in a transition economy tend to undertake grandiose investment projects, because their decisions generally do not bear the risks or costs of mistakes that they might make, but may, however, get credit for any achievement under their direction. On the other hand, the reforms have been gradual and the cost signals have not been allowed fully effective since the 1980s. For example, the bank lending rates and investment prices were still under heavy administration during a large part of the early sample period.

To further identify the insensitivity of the cost signal, we re-estimate the model with C being decomposed into three parts:

$$\sigma \ln C_{it} = \sigma_0 \ln(r + \delta_i)_t + \sigma_1 \ln\left(\frac{P_I}{P_Y}\right)_{it} + \sigma_2 \ln(1 - \pi_{it}) \tag{17}$$

where $\sigma_0 > 0$, $\sigma_1 > 0$, and $\sigma_2 < 0$ are expected. The estimation results are reported in Table 1. The results show that the interest rate component moves from insignificant to highly significant as the sample extends and is slowly followed by the relative price component whereas the tax rate component goes in the opposite direction.

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[11] The DOLS is chosen mainly for convenience and its relatively good properties. For discussions on various panel cointegration estimating methods, see also (Phillips and Moon, 1999; 2000).

[12] Since some sample observations of the cost variable are negative because of large negative real interest rates, we shift the real interest rate net of the depreciation rate upward by adding one to the whole series before taking log transformation. This adjustment should only affect the magnitude of the constant term.

Next, we turn to the estimation of the long-run effect of the institutional variables in (15). In order to save degrees of freedom, we restrict $\sigma = 1$ in view of the full-sample result in Table 1, as well as the knowledge that most of the existing studies on China's aggregate production and investment use the Cobb-Douglas function, which implies unit elasticity of substitution. In other words, the estimation is based on the following:

$$(15') \qquad \left[\ln I_{it} - \ln\left(\frac{Y}{C}\right)_{it}\right] = A_i + \sum_j \tau_j x_{jit} + \zeta_{it}^{\tau}$$

Due to the uncertain time-series properties of the institutional variables, two methods are used: (a) DOLS and (b) feasible generalised least squares (FGLS) applied directly to (15′).[13] Variables x_{4i} and x_5 turn out to be insignificant in the estimation and thus are removed from the final version of the model. Table 2 reports the main estimation results. The results show that the estimates of τ_2 and τ_3 do not differ significantly under different methods or different sample periods, indicating that x_1 is the most likely variable containing unit roots among the three. Therefore, we choose the DOLS method and restrict $\tau_3 = -1$ to reduce the coefficient uncertainty in the estimation of ζ_{it}^{τ} (see the last column of Table 2). The overall results show that both fiscal policy variables have positively encouraged disequilibrium investment. The highly robust negative coefficient estimates for x_{i3} are confirmatory of the view that provinces have been competing with each other to invest more if they notice that they have fallen behind their neighbours in the investment race.

However, it is inadequate to infer from the long-run estimation or cointegration analysis that the disequilibrium which has been detected is actually driving the dynamic movement of the explained variable, see e.g. (Johansen, 2006). To test whether ζ_{it}^{τ} is at

[13] The ordinary least squares (OLS) residuals are used as the weights of the FGLS estimator.

work, i.e. whether it impacts on investment movements, we run the following error-correction model (ECM):

$$(18) \qquad \Delta \ln I_{it} = A_i + \theta \Delta \ln I_{it-1} + \sum_{k=0}^{1} B_k \Delta X_{it-k} + \lambda \zeta^{\tau}_{it-1} + \upsilon_{it}$$

where $\Delta X_{it} = (\Delta \ln Y_{it},\ \ \Delta \ln C_{it},\ \ \Delta x_{jit},\ \ \ j = 1,2,3)$ is a vector of all the short-run explanatory variables. A significant $\lambda < 0$ is expected if ζ^{τ}_{it} is to have its hypothetical effect on investment. The combined generalised method of moments (GMM) is used for estimation. Equation (18) is parsimoniously reduced and the final result is reported in Table 3. It is seen from Table 3 that ζ^{τ}_{it} does exhibit significant negative feedback impact, albeit quite small,[14] and that the diagnostic test statistics do not show any sign of significant mis-specification.

We can now move to the empirical interpretation of the AE measures postulated in the previous sections. The embedded long-run term in Table 3 gives us:

$$(19) \qquad \begin{aligned} \hat{\zeta}_{it} &= \ln I_{it} - \ln \frac{Y_{it}}{C_{it}} + 1.45 \\ \hat{\zeta}^{\tau}_{it} &= \hat{\zeta}_{it} - .02 x_{1t} - 0.3 x_{2it} + x_{3it} \end{aligned}$$

They correspond to ζ_{it} in (12) and ζ^{τ}_{it} in (15), respectively. The two series are plotted in Figure 3, as well as $\ln \hat{Z}^{\tau}_{it} = \hat{\zeta}_{it} - \hat{\zeta}^{\tau}_{it}$. Figure 4 gives an alternative plot of $\hat{\zeta}_{it}$ and $\hat{\zeta}^{\tau}_{it}$ by province. Several features are worthwhile noting from these figures. First, investment misallocation is more serious if judged by the perfect market condition than by the imperfect market condition, i.e. $\hat{\zeta}_{it}$ in the top panel shows greater volatility than $\hat{\zeta}^{\tau}_{it}$ in the middle panel in Figure 3, or the dotted curves are closer to the zero line than the solid curves in Figure 4. Moreover, the misallocation gets slightly worse over time under the perfect market condition, a feature due apparently to the institutional effects, as shown by

[14] This result is consistent with what Sun (1998) and Song *et al* (2001) find.

the dotted linear trends in the top and bottom panels of Figure 3. In other words, there is a slight improvement of AE in the firm behaviour of investment demand over time once the institutional effects are controlled for (see the dotted trend line in the middle panel of Figure 3). If we look at the province profile of $\hat{\zeta}_{it}^{\tau}$ in Figure 4, we see it moving closer to the zero line for many provinces, suggesting certain improvement of AE in firms' aggregate investment demand as reforms proceed. Another noticeable feature is the visible slow curvature in most of the series shown in Figure 4, indicating significant autocorrelation. Indeed, the autocorrelation test results show (see Table 4) that the majority of the series are auto-correlated in the first order, if not the second. This reflects the fact that correction of investment misallocation is normally a rather slow process because of very high adjustment costs. Finally, the major autonomous municipals, i.e. Beijing, Tianjin and Shanghai, are among the most prominent in over-investment under both conditions, though somewhat more moderate under the imperfect market condition; on the other hand, over-investment appears to be mainly a government behaviour in provinces such as Inner Mongolia (NM), Tibet (XZ), Qinghai, Ningxia and Xinjiang, as over-investment largely disappears in these provinces once the institutional effects have been accounted for, the most noticeable province being Tibet.

To further investigate the inter-province correlation in these AE measures, we apply principal component analysis (PCA) to $\hat{\zeta}_{it}$ and $\hat{\zeta}_{it}^{\tau}$, as well as to $\hat{\upsilon}_{it}$, see Tables 5, 6 and 7. Notice that $\hat{\upsilon}_{it}$ can be viewed as a broader AE measure than $\hat{\zeta}_{it}^{\tau}$ in the sense that $\hat{\upsilon}_{it}$ assumes the part of dynamic adjustment process around (15) to be part of the theory. In other words, $\hat{\upsilon}_{it}$ becomes the disequilibrium investment rate when the entire equation (18) is regarded as corresponding to the theoretical model (15). Under this broad view, the rate can be interpreted as agents' investment demand error judged by both the equilibrium demand and the dynamic adjustment costs towards the equilibrium.

Several features are noteworthy from Tables 5, 6 and 7. First, there appears to be a strong herding effect among provinces in investment misallocation, as shown from the strong correlation in $\hat{\zeta}_{it}$ and $\hat{\zeta}_{it}^{\tau}$ in contrast to the correlation in $\hat{\upsilon}_{it}$. For example, $\hat{\zeta}_{it}$ has the smallest numbers of principal components while $\hat{\upsilon}_{it}$ has the largest numbers to account for 90% of data variance as shown in Table 5. Clearly, the relatively stronger herding shown in $\hat{\zeta}_{it}$ as compared to $\hat{\zeta}_{it}^{\tau}$ is attributed to the institution-induced allocative inefficiency. Nevertheless, the herding effect largely remains even after the institutional effects are accounted for, as seen from comparison of $\hat{\zeta}_{it}$ and $\hat{\zeta}_{it}^{\tau}$ in Tables 6 and 7. Moreover, these tables illustrate predominantly positive principal component loadings for $\hat{\zeta}_{it}$ and $\hat{\zeta}_{it}^{\tau}$, especially in the first principal component, which accounts for the largest data variance. This suggests that firms' investment demand on the whole is still very much under the influence of the macro policies in the sense that firms across different provinces tend to herd in making investment allocation errors in the same direction. This evidence can be viewed as confirming the competitive effect postulated by Qian and Roland (1998). Finally, results from the PCA by year show that the herding effect is highly persistent, confirming again that it takes a long time to correct AE errors.[15]

Let us now turn to the estimation of the PE measure, Λ_i, in (9). Taking $\hat{\sigma} = 1$ from the above, we have to estimate α_i from the Cobb-Douglas production function in order to get an estimate of Λ_i. Due to lack of aggregate data on capital, data from the industrial sector are used here. We have to assume that the spatial pattern of the estimated α_i applies to all the other sectors. Specifically, these α_i are estimated using DOLS based on the following specification of a constant-return-to-scale Cobb-Douglas production function:

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[15] In the PCA by year, each year of the sample is defined as a variable and the 30 provinces are used as observations.

(20) $$\ln\left(\frac{YI}{LI}\right)_{it} = \lambda_0 + \sum_{i=1}^{30} \alpha_i \ln\left(\frac{KI}{LI}\right)_{it} + \sum_{k=-1}^{1} \theta_k \Delta \ln\left(\frac{KI}{LI}\right)_{it-k} + u_{it}$$

where *YI*, *LI* and *KI* denote industrial output, labour and capital respectively. Three sets of α_i are obtained, one for the full sample, another for 1989-2000 and the third for 1992-2004. Since the depreciation rate data come as time series, the sample mean $\overline{\delta}$ is used in the calculation of Λ_i. As for $\hat{\Lambda}_i$, two sets of the estimates are used: one based on model (16) which assumes the perfect market condition, and the other based on (15′) which assumes an imperfect market condition.[16] The resulting $\hat{\Lambda}_i$ are plotted in Figure 5.

We see from Figure 5 that the distribution pattern of $\hat{\Lambda}_i$ appears to be in accord with what has usually been observed by researchers, namely the coastal and southern provinces tend to be more efficient than inland and western provinces. In particular, our results do not contradict Yao's estimates of technological inefficiency using firm data (2001). Moreover, there is a certain improvement of $\hat{\Lambda}_i$ for many provinces when earlier sample estimates are compared with later sample estimates, indicating the effectiveness of the reforms. Interestingly, Beijing has a much smaller PE estimate when it is calculated assuming the perfect market condition than when it is calculated based on the imperfect market condition, whereas the opposite is observed with several of these western provinces. Finally, when the ranked PE estimates are compared with the ordered AE sample means (see Table 8), an asymmetric pattern emerges. Provinces with relatively poor PE ranking tend to suffer from under-investment in AE whereas those with strong PE ranking are prone to over-investment rather than equilibrium investment in AE. This indicates that the trend of over-investment through capital misallocation has not yet been wiped out by the reform, and the production efficiency has not necessarily led to improved

[16] Many PE indices use the negative of the fixed individual effects to reflect the degree of technological inefficiency. Our indices denote PE directly.

allocative efficiency at the macro level. This finding verifies the postulate by Bai *et al* (1997) that PE may not imply AE when firms' objectives are more complicated than profit maximisation due to imperfect market environment.

4. Concluding Remarks

Over-investment at the macro level is a key feature of CPEs. Has this feature been stamped out by the extensive economic reforms in China? This study seeks answers to this question. An aggregate investment model is developed to evaluate empirically investment inefficiency in China. The model is based on the standard capital factor input demand theory with associate measures of allocative inefficiency and production inefficiency. The model is further adapted to transitional economies where the market is far from perfect in the sense that institutional factors can exert significant impacts on investment allocation not in accordance with the optimal rules of the market. The model thus enables us to identify which institutional factors contribute to allocative inefficiency and how great the impact is.

The model is applied to China's provincial-panel data for the period 1989-2004. The main findings are:

1. Prior to 2000, investment demand hardly responded to price signals, as most capital prices were administered and not allowed freely to emit market-clearing signals until very recently. The checks-and-balances mechanism of the market for over-investment has been weak.
2. On the other hand, fiscal deficits, at both the national and provincial levels, are found to exert significant disequilibrium impacts on investment misallocation. An investment network effect is also found to exacerbate over-investment, suggesting that provinces will not curb their investment desires until they join ranks with the regional leaders of over-investment.

3. There are certain signs of gradual improvement in the provincial AE measures once the institutional factors are controlled. The significant autocorrelation found in these measures and the ECM models demonstrate that adjustments of investment misallocation have been very slow. Moreover, the strongly positive cross-correlation found in these measures suggests the presence of a broad herding tendency towards over-investment rather than under-investment.
4. The PE measures are found to be broadly in line with the pattern of regional development, with southern and coastal provinces being more efficient than western provinces. Interestingly, an asymmetric relationship is found between the PE and AE measures suggesting that provinces with relatively strong PE measures tend to be those with higher over-investment AE measures, whereas provinces with relatively lower PE measures are usually clustered at the under-investment end of the AE measures. This finding suggests that improvement in PE does not lead to improvement in AE and may even encourage over-investment at the macro level.

We must acknowledge that our efficiency measures have limitations. For example, the standard efficiency criterion underlying these measures does not take into account the possible positive externality of government non-profit-seeking investment demand, such as some infrastructural investments for poverty reduction. But efficiency is a normative concept after all. Model-based definitions and testable measures should at least help to clarify previously confused views and disorganised evidence, and hopefully to reduce the gap between theoretical and empirical studies on the welfare implications of institutional changes in transitional economies.

APPENDIX

Main data sources:

National Bureau of Statistics: *Statistical Yearbook of China* (SYC), *Industrial Economic Statistical Yearbook of China* (IESYC), *Statistics on Investment in Fixed Assets of China* (SIFAC), *Provincial Statistical Yearbook* (PSY);

China Finance Ministry: *Financial Yearbook of China* (FYC);

People's Bank of China: *Almanac of China's Finance and Banking* (ACFB).

Variable definition and source:

I: Fixed-asset investment at provincial level, SYC and SIFAC, adjusted to constant price by P_I

Y: GDP at provincial level, SYC, adjusted to constant price by P_Y

P_I: Price index of fixed-asset investment at provincial level, SYC

P_Y: Price index of GDP at provincial level, SYC

r: Real interest rate calculated by 3-5 year loan rates net of the growth rate of P_I of one-year lag (proxy for expected inflation of investment goods), SYC and ACFB

δ: Depreciation rate of fixed assets of state-owned industrial firms at provincial level, FYC and PSY (data from 1999 onwards are unavailable and are estimated using previous observations together with data of the net gross asset values of state-owned industries at provincial level from IESYC)

π: Tax is derived from total pre-tax profits minus total after-tax profits of industrial firms with independent accounting systems at provincial level, tax rate is then calculated using tax divided by value-added of the firms, SYC

x_1: Logarithm of the ratio of the total government debt incurred to the total retirement of debt and interest payments, SYC

x_{2i}: Logarithm of the ratio of provincial government expenditure to revenue, SYC

x_{3i}: One-period lagged provincial I_i/Y_i in logarithm minus its regional average I/Y in logarithm, standardised by the national average of I/Y in logarithm

x_{4i}: Logarithm of one-period lagged ratio of provincial per capita GDP to its regional per capita GDP, SYC and PSY

x_5: Logarithm of the ratio of the bank loans to bank deposits

YI: Value-added of Industry at provincial level, IESYC, 1989-1999

LI: Average employment of Industry at provincial level, IESYC, 1989-1999

KI: Net fixed assets of Industry at provincial level, IESYC, 1989-1999

Abbreviation of provinces by region:

Coastal region		Central region		Western region	
BJ	Beijing	SX	Shanxi	SC	Sichuan
TJ	Tianjin	NM	Inner Mongolia	GZ	Guizhou
HB	Hebei	JL	Jilin	YN	Yunnan
LN	Liaoning	HLJ	Heilongjiang	XZ	Tibet
SH	Shanghai	AH	Anhui	SHX	Shaanxi
JS	Jiangsu	JX	Jiangxi	GS	Gansu
ZJ	Zhejiang	HN	Henan	QH	Qinghai
FJ	Fujian	HUB	Hubei	NX	Ningxia
SD	Shandong	HUN	Hunan	XJ	Xinjiang
GD	Guangdong				
GX	Guangxi				
HAN	Hainan				

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Table 1. DOLS estimates of σ in (16)

sample	89-2000	92-2000	92-2001	92-2002	92-2003	92-2004	89-2004
σ	0.2263 (0.5690)	0.2305 (0.6687)	0.0560 (0.5015)	1.0884 (0.6244)	1.3418 (0.6319)	1.6562 (0.6459)	0.9254 (0.5531)
Coefficient estimates of the three components of the cost variable (17)							
σ_0	0.9655 (0.6508)	0.2791 (0.7773)	0.8998 (0.7532)	1.5623 (0.7573)	2.1021 (0.7724)	2.5297 (0.7876)	2.1276 (0.6695)
σ_1	-0.0049 (0.4928)	-0.1370 (0.5188)	-0.0560 (0.8998)	0.1568 (0.5102)	0.3338 (0.5228)	0.8595 (0.5291)	0.9013 (0.4957)
σ_2	-1.0519 (0.2478)	-0.8541 (0.3168)	-0.5929 (0.2923)	-0.3287 (0.2700)	-0.1477 (0.2430)	-0.0935 (0.2057)	-0.3229 (0.1827)

Note: The figures in brackets are standard errors.

Table 2. Parameter estimates of the institutional variables in (15′)

Estimator	DOLS		FGLS		DOLS
Sample	89-2004	92-2004	89-2004	92-2004	89-2004
τ_1	0.1897 (0.042)	0.3423 (0.0523)	-0.0104 (0.0224)	0.0588 (0.0362)	0.1917 (0.0458)
τ_2	0.3012 (0.0239)	0.2908 (0.0338)	0. 2323 (0.0217)	0.2527 (0.0273)	0.2923 (0.0295)
τ_3	-1.1343 (0.0631)	-1.1284 (0.0675)	-0.9323 (0.0639)	-0.949 (0.0672)	restrict: $\tau_3 = -1$

Note: The figures in brackets are standard errors. There is no random time effect in the dynamic specification of the model.

Table 3. GMM estimation of the dynamic model (18)

Sample	
Sample 89-04	$\Delta \ln(I)_{i,t} = \underset{(0.0251)}{-0.0538} + \underset{(0.2196)}{1.81}\, \Delta \ln(Y)_{i,t} - \underset{(0.0733)}{0.1721} \Delta \ln(C)_{i,t-1} - \underset{(0.0241)}{0.0787}\, \Delta x_{2i,t-1} - \underset{(0.027)}{0.059} \zeta^{\tau}_{i,t-1} + \hat{\upsilon}_{i,t}$
	$\text{var}(\hat{\upsilon}_{i,t}) = 0.0097$; Sargan test: $\chi^2(416) = 271.5$ [1.000] AR(1): N(0, 1) = -2.324 [0.020]; AR(2): N(0, 1) = 0.4228 [0.672]
Sample: 92-04	$\Delta \ln(I)_{i,t} = \underset{(0.0398)}{-0.0361} + \underset{(0.3726)}{1.6707} \Delta \ln(Y)_{i,t} - \underset{(0.084)}{0.2617} \Delta \ln(C)_{i,t-1} - \underset{(0.0412)}{0.1362} \Delta x_{2i,t-1} - \underset{(0.0288)}{0.0789} \zeta^{\tau}_{i,t-1} + \hat{\upsilon}_{i,t}$
	$\text{var}(\hat{\upsilon}_{i,t}) = 0.0085$; Sargan test: $\chi^2(260) = 192.1$ [0.999] AR(1): N(0, 1) = 2.777 [0.000]; AR(2): N(0, 1) = 2.425 [0.015]
Embedded Long-run	$\zeta^{\tau}_{i,t} = \ln\left(\frac{I}{Y}\right)_{i,t} + \ln(C_{i,t}) + 1.45 - 0.2x_{1i,t} - 0.3x_{2i,t} + x_{3i,t}$

Note: One-step estimator is used in GMM since residual heteroscedasticity should not be a significant problem once the individual effects have been filtered out, see Arellano and Bover (1995), and also Blundell and Bond (1998). Sargan test is an over-identification test of the instrumental variables used in GMM with the null being that the instruments are valid. The significant first-order serial correlation is an expected feature of the GMM method, see Doornik and Hendry (2001, Chapter 7, vol. 3).

Table 4. Q-test of autocorrelation for $\hat{\zeta}_{it}$ and $\hat{\zeta}^{\tau}_{it}$

Null: no autocorrelation versus the alternative of 1st order autocorrelation										
	BJ	TJ	HB	SX	NM	LN	JL	HLJ	SH	JS
$\hat{\zeta}_{it}$	7.7939	0.3886	7.1105	8.0342	6.5023	0.7067	4.1638	3.8514	4.5815	2.6411
$\hat{\zeta}^{\tau}_{it}$	0.1750	2.3551	3.1031	1.3780	2.7928	1.3152	0.0589	0.7261	1.6533	0.0600
	ZJ	AH	FJ	JX	SD	HN	HUB	HUN	GD	GX
$\hat{\zeta}_{it}$	6.9760	3.9845	7.2132	7.7675	4.4321	7.4363	11.921	6.6896	5.6042	6.5267
$\hat{\zeta}^{\tau}_{it}$	1.7902	2.6061	1.4808	3.4769	2.2807	2.3363	1.8248	1.1865	1.5729	1.4002
	HAN	SC	GZ	YN	XZ	SHX	GS	QH	NX	XJ
$\hat{\zeta}_{it}$	9.5018	10.971	12.742	7.9378	5.4162	6.3655	12.255	12.513	10.392	7.8040
$\hat{\zeta}^{\tau}_{it}$	0.1228	4.3597	7.7530	1.4418	3.0528	3.3880	3.8764	1.8824	6.6262	5.9936
Null: no autocorrelation versus the alternative of 2nd order autocorrelation										
	BJ	TJ	HB	SX	NM	LN	JL	HLJ	SH	JS
$\hat{\zeta}_{it}$	8.7137	0.9943	11.243	11.336	7.2012	1.2616	5.1732	6.8278	5.2594	3.5282
$\hat{\zeta}^{\tau}_{it}$	0.1946	2.4435	3.1031	1.9419	3.3078	5.61	0.1667	1.6691	4.9618	1.558
	ZJ	AH	FJ	JX	SD	HN	HUB	HUN	GD	GX
$\hat{\zeta}_{it}$	10.272	4.2784	11.202	10.110	5.1038	9.7441	18.185	8.0697	6.7331	9.0569
$\hat{\zeta}^{\tau}_{it}$	2.0617	2.6275	1.733	3.5476	2.3306	2.543	1.9345	3.0434	6.0145	1.4017
	HAN	SC	GZ	YN	XZ	SHX	GS	QH	NX	XJ
$\hat{\zeta}_{it}$	13.807	17.463	1.2515	21.137	7.138	9.3443	19.82	21.434	15.038	11.01
$\hat{\zeta}^{\tau}_{it}$	2.4627	4.574	12.142	1.4722	3.4222	4.8743	4.581	2.2204	7.9033	6.8008

Note: The critical values at 95% for $\chi^2(1) = 3.84$ and for $\chi^2(2) = 5.99$.

Table 5. Number of principal components which account for at least 90% of data variance

sample	Full sample			1989-2000			1992-2000			1992-2004		
AE measures	$\hat{\zeta}_{it}$	$\hat{\zeta}^{\tau}_{it}$	$\hat{\upsilon}_{it}$	$\hat{\zeta}_{it}$	$\hat{\zeta}^{\tau}_{it}$	$\hat{\upsilon}_{it}$	$\hat{\zeta}_{it}$	$\hat{\zeta}^{\tau}_{it}$	$\hat{\upsilon}_{it}$	$\hat{\zeta}_{it}$	$\hat{\zeta}^{\tau}_{it}$	$\hat{\upsilon}_{it}$
By province	5	6	8	6	6	7	5	5	6	4	5	8
By year	3	4	9	2	4	8	2	3	7	3	4	8

Note: Full sample for $\hat{\zeta}_{it}$ and $\hat{\zeta}^{\tau}_{it}$ is 1989-2004, but the full sample for $\hat{\upsilon}_{it}$ is 1991-2004.

Table 6. Principal component loadings by province (the first three components only)

	1st Principal component			2nd Principal component			3rd Principal component		
	$\hat{\zeta}_{it}$	$\hat{\zeta}^{\tau}_{it}$	$\hat{\upsilon}_{it}$	$\hat{\zeta}_{it}$	$\hat{\zeta}^{\tau}_{it}$	$\hat{\upsilon}_{it}$	$\hat{\zeta}_{it}$	$\hat{\zeta}^{\tau}_{it}$	$\hat{\upsilon}_{it}$
Variance explained	(59%)	(55%)	(7.8%)	(15%)	(14%)	(4.6%)	(10%)	(8.5%)	(3.3%)
BJ	0.760	0.647	0.110	-0.182	-0.371	0.325	0.297	0.113	0.199
TJ	0.568	0.118	-0.239	-0.337	-0.679	-0.354	0.334	-0.304	-0.616
HB	0.732	0.534	-0.556	-0.503	-0.330	-0.620	-0.287	-0.601	0.048
SX	0.708	0.767	0.323	0.606	0.102	-0.684	-0.282	0.003	0.238
NM	0.821	0.881	0.735	0.322	-0.100	-0.074	0.416	0.194	-0.381
LN	0.371	0.819	0.714	0.639	-0.346	0.302	0.384	0.221	-0.317
JL	0.656	0.774	0.739	0.341	-0.143	0.028	0.403	0.061	0.264
HLJ	0.756	0.726	-0.058	-0.386	-0.467	0.490	-0.035	-0.025	-0.254
SH	-0.251	-0.396	-0.538	-0.709	-0.542	-0.187	-0.061	0.116	0.521
JS	0.566	0.738	0.538	-0.041	-0.316	0.145	0.638	0.120	-0.700
ZJ	0.905	0.402	0.644	0.217	0.020	-0.178	-0.093	0.777	0.179
AH	0.727	0.893	0.549	0.367	0.075	-0.464	-0.187	0.008	-0.166
FJ	0.582	0.749	0.476	-0.625	-0.467	0.298	0.424	-0.103	0.183
JX	0.823	0.899	0.886	0.535	0.187	-0.285	0.109	0.191	-0.031
SD	0.735	0.924	0.688	0.532	0.064	-0.502	-0.128	-0.018	0.188
HN	0.866	0.811	-0.129	-0.323	-0.109	-0.558	-0.134	-0.284	0.101
HUB	0.687	0.689	-0.101	-0.635	-0.546	0.718	0.254	-0.142	-0.127
HUN	0.879	0.865	0.352	-0.047	-0.251	0.058	0.336	-0.110	-0.569
GD	-0.491	0.594	0.773	0.350	-0.506	0.330	0.664	0.303	0.024
GX	0.807	0.598	-0.189	-0.412	-0.408	-0.091	0.260	-0.574	-0.490
HAN	-0.678	0.170	0.704	0.323	-0.583	0.232	0.590	0.619	0.481
SC	0.975	0.887	0.091	-0.159	0.294	-0.539	-0.068	-0.005	-0.549
GZ	0.950	0.791	0.241	-0.027	0.561	-0.045	-0.171	-0.095	0.334
YN	0.864	0.938	0.542	-0.384	0.139	0.195	0.208	0.260	-0.050
XZ	0.818	0.658	0.057	0.279	0.287	-0.756	-0.099	-0.501	-0.017
SHX	0.883	0.858	0.561	0.268	0.369	-0.381	-0.226	0.112	0.454
GS	0.853	0.809	0.020	0.048	0.395	-0.343	-0.465	-0.155	-0.233
QH	0.897	0.801	0.181	-0.045	0.301	0.104	-0.288	0.057	0.280
NX	0.936	0.856	0.612	0.265	0.438	-0.439	-0.047	-0.082	-0.124
XJ	0.931	0.865	0.746	0.035	0.411	0.347	0.071	0.185	0.059

Note: These are results based on the full sample.

Table 7. Principal component loadings by year (the first three components only)

	1st Principal component			2nd Principal component			3rd Principal component		
Variation explained	$\hat{\zeta}_{it}$ (75%)	$\hat{\zeta}^{\tau}_{it}$ (73%)	$\hat{\upsilon}_{it}$ (24%)	$\hat{\zeta}_{it}$ (13%)	$\hat{\zeta}^{\tau}_{it}$ (12%)	$\hat{\upsilon}_{it}$ (16%)	$\hat{\zeta}_{it}$ (5.9%)	$\hat{\zeta}^{\tau}_{it}$ (4%)	$\hat{\upsilon}_{it}$ (14%)
1989	0.849	0.882		0.285	0.212		-0.088	-0.222	
1990	0.892	0.881		0.257	0.246		-0.146	-0.214	
1991	0.895	0.875	0.017	0.192	0.247	-0.062	-0.187	0.047	0.749
1992	0.816	0.790	0.282	0.318	0.169	-0.259	-0.342	-0.280	-0.235
1993	0.785	0.840	-0.340	0.405	0.283	-0.229	-0.365	-0.329	-0.639
1994	0.871	0.760	-0.470	0.407	0.510	0.493	-0.085	0.309	0.224
1995	0.910	0.820	-0.137	0.268	0.395	0.499	0.096	0.194	0.546
1996	0.892	0.891	-0.227	0.251	0.259	0.568	0.317	-0.081	-0.260
1997	0.909	0.934	0.345	0.108	0.121	0.481	0.367	0.080	0.374
1998	0.924	0.972	0.618	-0.046	-0.066	0.499	0.357	0.132	-0.189
1999	0.943	0.899	0.628	-0.127	-0.176	-0.047	0.257	0.264	-0.150
2000	0.932	0.889	0.750	-0.301	-0.319	0.301	0.150	0.204	-0.211
2001	0.881	0.877	0.796	-0.432	-0.363	0.375	0.070	0.167	-0.156
2002	0.827	0.820	0.760	-0.541	-0.515	-0.310	-0.077	-0.021	0.209
2003	0.766	0.734	0.471	-0.575	-0.587	-0.621	-0.254	-0.178	0.319
2004	0.696	0.811	0.043	-0.616	-0.508	-0.375	-0.295	-0.139	0.277

Note: These are results based on the full sample.

Table 8. Ordered AE measures versus PE ranks

Perfect market model				Imperfect market model			
1989-2004		1992-2004		1989-2004		1992-2004	
Ordered AE & sample mean	PE rank	Ordered AE & sample mean	PE rank	Ordered AE & sample mean	PE rank	Ordered AE & sample mean	PE rank
SH **0.50**	1	SH **0.49**	1	SH **0.36**	1	SH **0.31**	1
QH **0.39**	4	QH **0.44**	3	ZJ **0.24**	2	BJ **0.25**	7
XZ **0.37**	23	XZ **0.40**	23	BJ **0.23**	7	ZJ **0.23**	2
BJ **0.33**	30	BJ **0.36**	30	TJ **0.23**	11	TJ **0.22**	13
XJ **0.32**	9	XJ **0.35**	7	GD **0.18**	5	GD **0.20**	4
TJ **0.28**	6	TJ **0.31**	11	FJ **0.13**	6	JS **0.17**	5
HAN **0.26**	5	NX **0.28**	14	SC **0.12**	14	FJ **0.16**	6
NX **0.23**	18	HAN **0.24**	5	HAN **0.12**	13	SC **0.16**	17
ZJ **0.20**	2	ZJ **0.22**	2	JS **0.12**	3	SD **0.14**	3
GD **0.10**	3	SC **0.14**	19	SD **0.11**	4	HAN **0.13**	10
SC **0.07**	17	NM **0.14**	18	HB **0.08**	9	HB **0.11**	9
NM **0.06**	21	GD **0.10**	4	LN **0.06**	8	GX **0.09**	15
SX **0.04**	8	SX **0.04**	8	GX **0.05**	15	LN **0.09**	8
YN -0.05	10	YN **0.01**	6	XJ **0.04**	23	XJ **0.08**	23
HLJ -0.06	16	HUB **0.01**	15	YN **0.03**	10	YN **0.06**	11
HUB -0.07	14	FJ -0.03	9	SHX **0.00**	19	GZ **0.04**	21
FJ -0.08	11	HLJ -0.04	17	NX -0.01	28	NX **0.04**	26
HN -0.10	12	GX -0.06	22	GZ -0.01	22	SHX **0.03**	19
HB -0.11	15	HB -0.08	16	QH -0.05	25	QH -0.01	28
GX -0.12	22	HN -0.08	10	GS -0.08	27	GS -0.05	27
SD -0.14	7	GZ -0.12	26	SX -0.08	16	HUB -0.07	18
SHX -0.17	25	JS -0.13	13	HUB -0.10	18	SX -0.08	14
GZ -0.20	27	SD -0.14	12	HN -0.10	12	HN -0.09	12
JS -0.20	13	SHX -0.17	25	HLJ -0.13	20	HLJ -0.12	20
GS -0.25	29	HUN -0.20	27	NM -0.16	29	NM -0.13	29
HUN -0.25	26	GS -0.23	28	HUN -0.17	24	HUN -0.14	24
LN -0.26	19	JL -0.24	24	JX -0.20	26	JX -0.16	25
JL -0.28	24	LN -0.25	20	AH -0.22	17	AH -0.19	16
JX -0.33	28	JX -0.30	29	JL -0.24	21	JL -0.21	22
AH -0.50	20	AH -0.50	21	XZ -0.54	30	XZ -0.43	30

Note: The positive AE measures indicate over-investment allocation and the negative measures indicate under-investment allocation. Hence, the order sequence cannot be regarded as AE ranking.

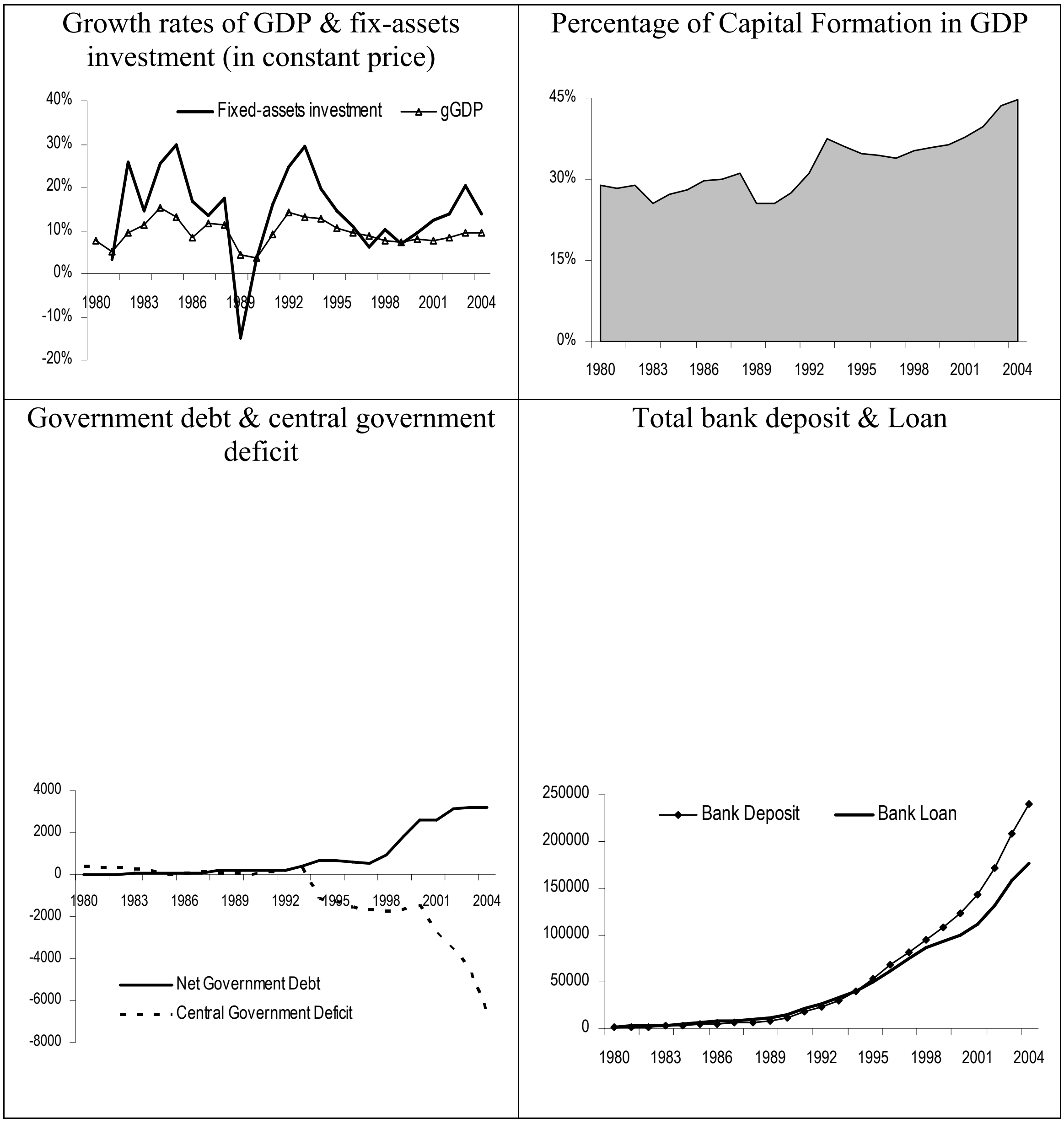
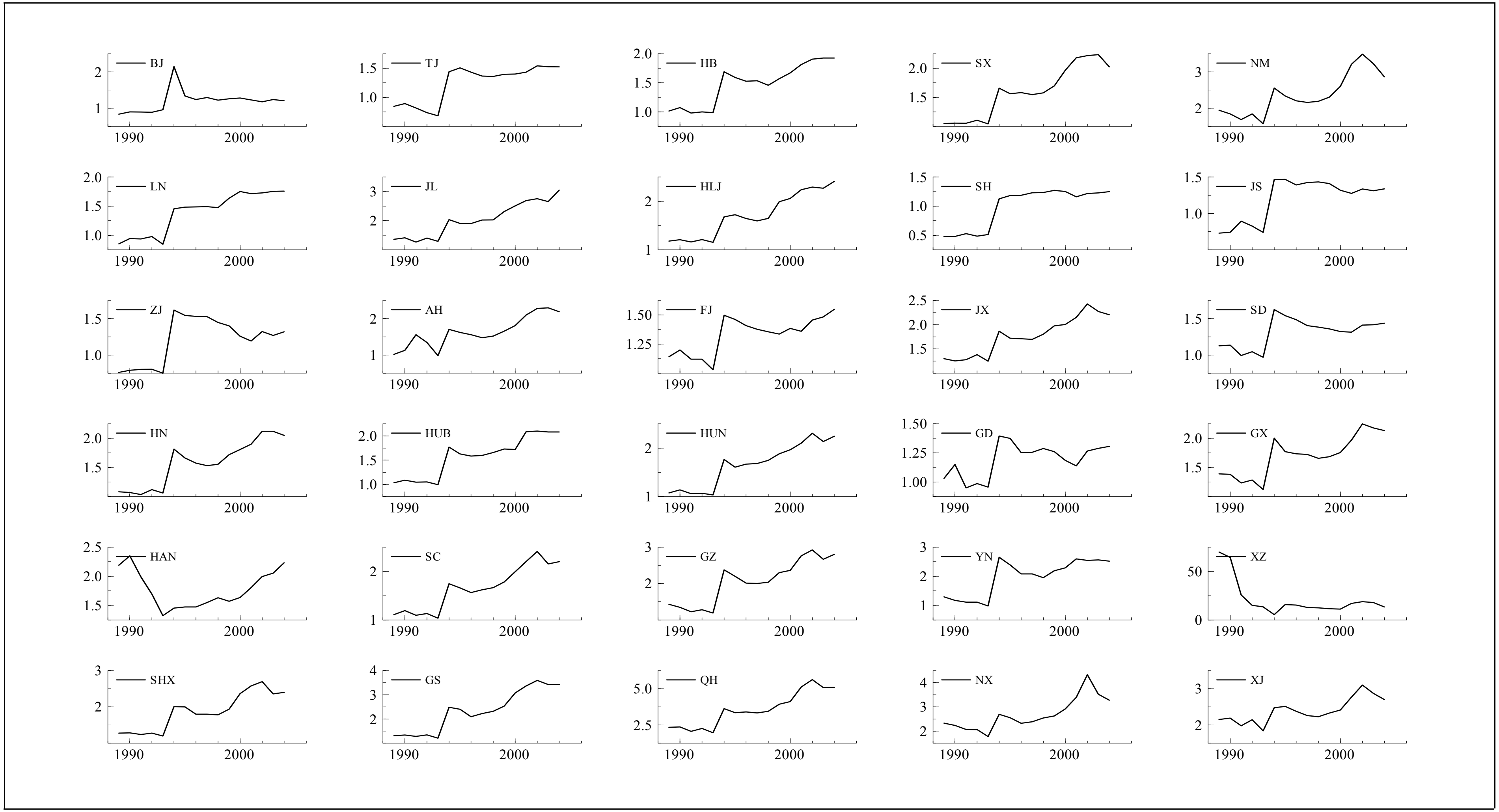


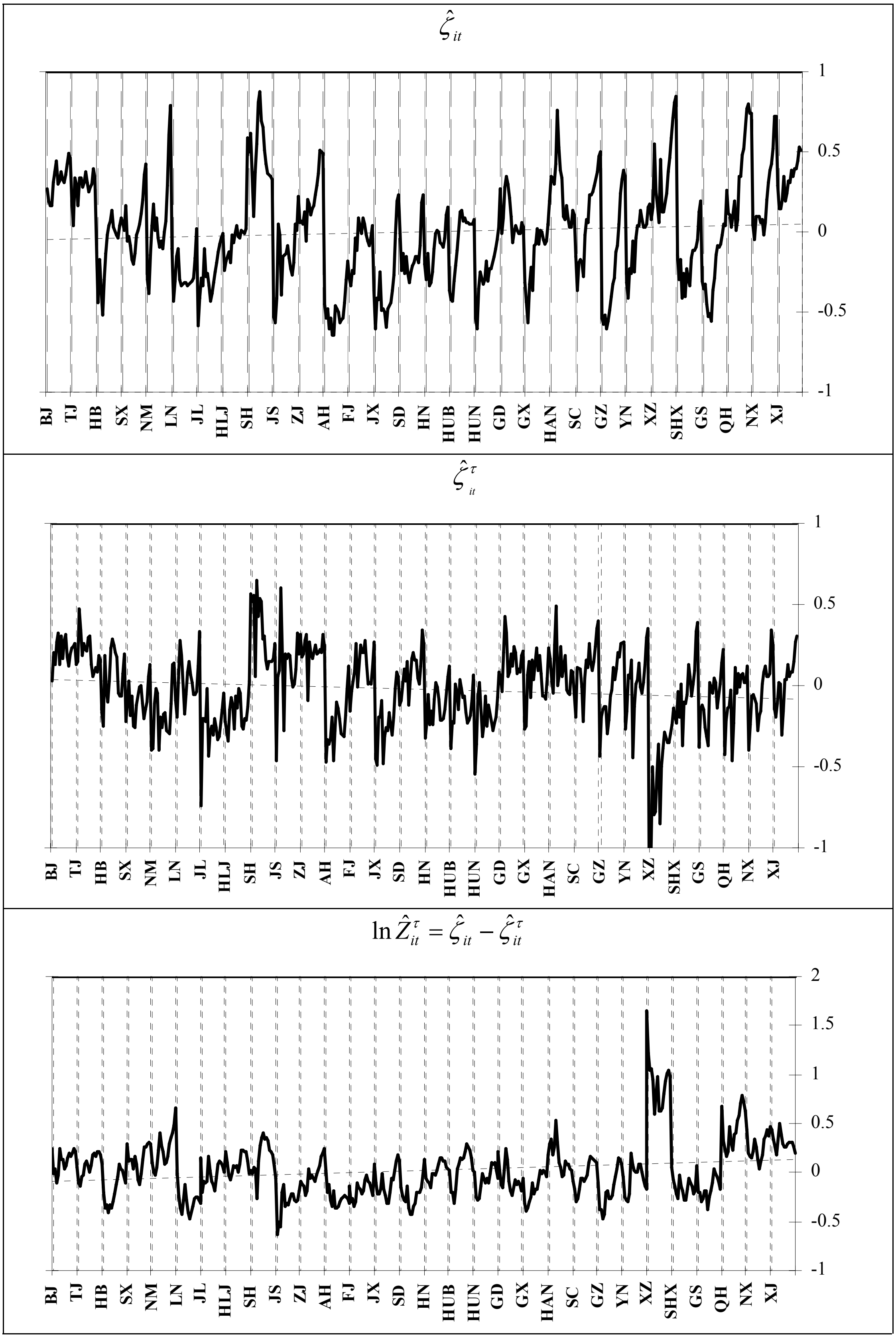
Figure 1. Capital investment, GDP, and other aggregate series (in 100 million yuan)

Figure 2. Ratio of provincial government expenditure to revenue



Note: Due to the introduction of a new system of tax division in 1994, post-1994 data on local government revenue do not necessarily reflect the actual income of local governments, since the central government returns part of the tax collected nationally to provincial governments. Hence the above graphs can only represent trends of local government deficit financing rather than actual degrees of deficit.

Figure 3. Estimated AE measures from (19)



Note: each bar section contains 16 observations of the period 1989-2004.

Figure 4. Estimated AE measures by province

Solid curve: AE of standard theory; dotted curve: AE of mixed theory

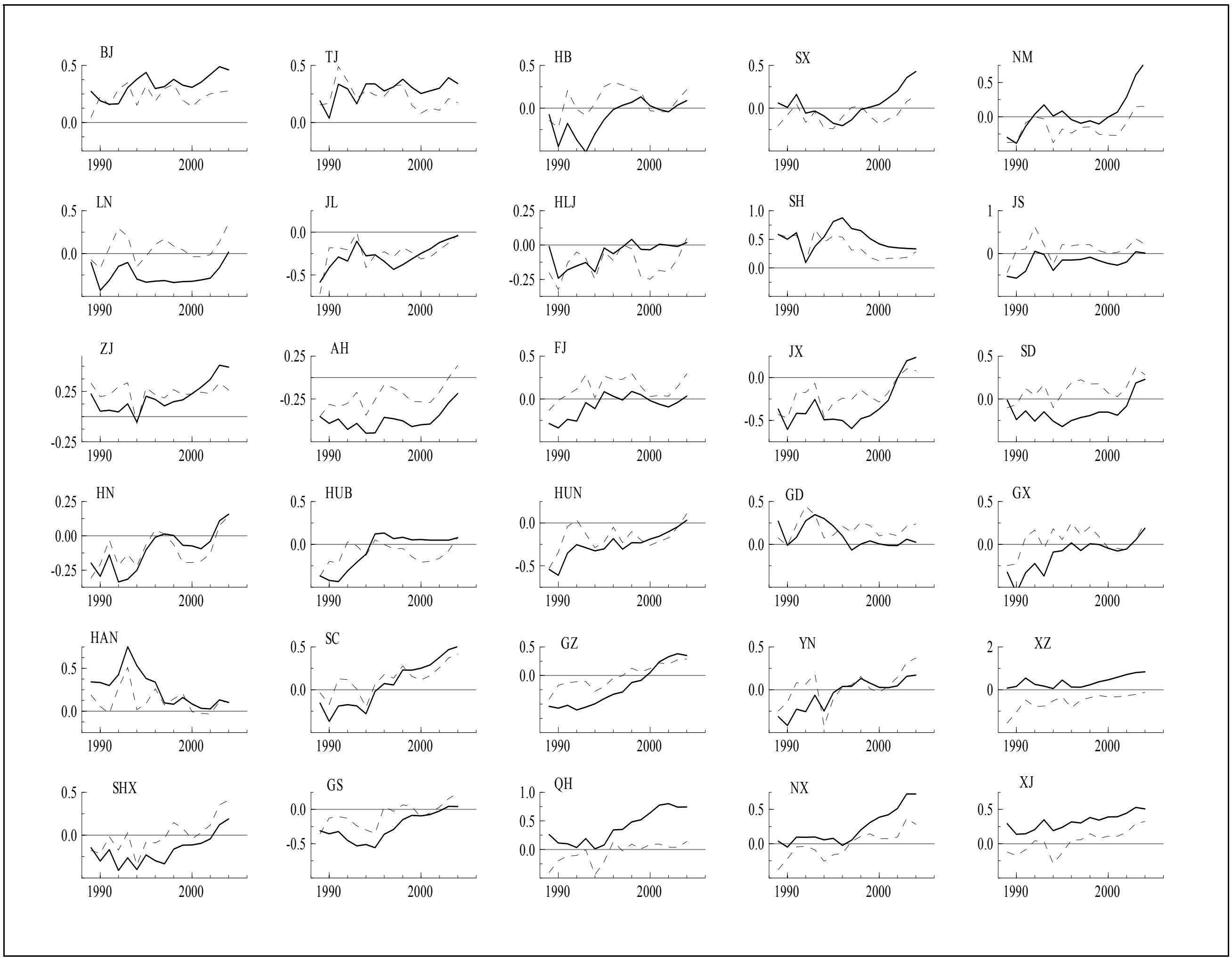
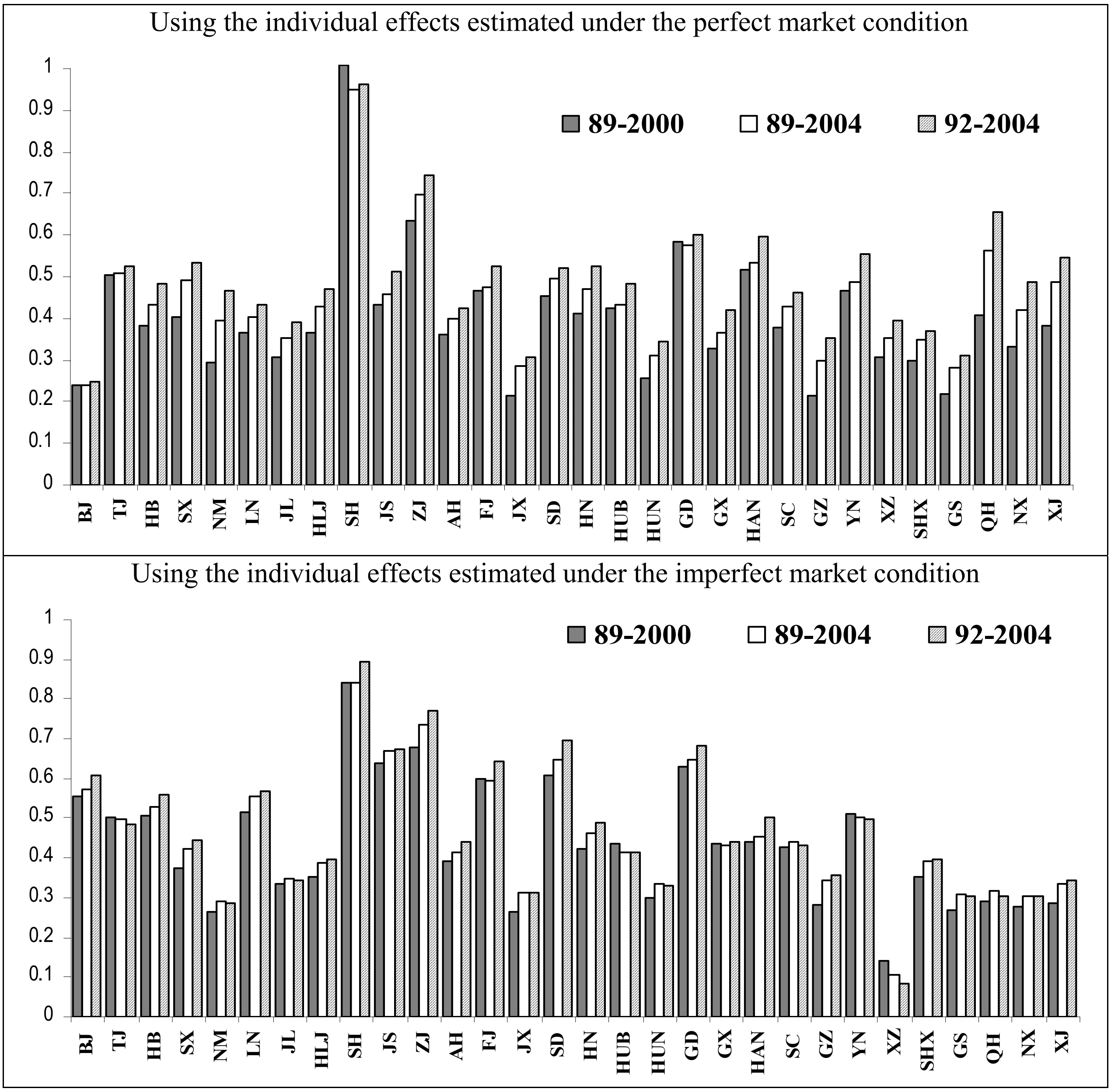


Figure 5. Estimated PE measures: $\hat{\Lambda}_i$



Note: All the measures are standardised to make them comparable.

Queen Mary
University of London

This working paper has been produced by
the Department of Economics at
Queen Mary, University of London

Department of Economics
Queen Mary, University of London
Mile End Road
London E1 4NS
Tel: +44 (0)20 7882 5096
Fax: +44 (0)20 8983 3580
Web: www.econ.qmul.ac.uk/papers/wp.htm