

Reducing Regional Disparities in China: Is Investment Allocation Policy Effective?

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Abstract:

Inter-regional disparities in China have been an important concern for central-government policy-makers for most of the past 60 years. One of the main policy instruments for redressing the balance between the prosperous coastal region and the poorer inland region has been the allocation of investment spending. Yet there is little empirical work evaluating the response of disparities to changes in the regional distribution of investment. We help fill this gap and analyse the two-way relationship between these variables within a VAR/VECM framework, the results of which we tentatively interpret in terms of a simple demand model. We find, surprisingly, that changes in the regional allocation of investment have only a modest positive effect on inter-regional output disparities while the effect in the opposite direction is also positive but much larger. The effects of investment on output are larger, though, for the post-1978 period. We find our overall results to be robust to numerous variations in variable definition.

JEL Codes: E62, O18, O23, R58

Key words: regional disparities, regional policy, China, investment allocation

1. Introduction

China has experienced a high rate of economic growth in the past 30 years. Its average growth rate in terms of real GDP has been about 9.5 per cent per annum between 1978 and 2009.¹ This rapid growth has, however, been far from evenly spread across its regions with the coastal region, for example, growing at a higher average rate than the interior region. At the provincial level, the post-1978 average annual growth rate has varied from a low of 8.4% for Qinghai province in the north-west of China to rates over 13% for the south coastal provinces of Zhejiang, Jiangsu, Fujian and Guangdong. By and large, these growth differences have exacerbated already large disparities in per capita output levels. Thus in 2009 Qinghai had a per capita GDP of 19,454 yuan compared to that of Zhejiang of 44,641, Jiangsu of 44,744, Fujian of 33,840 and Guangdong of 41,166.²

Not surprisingly, the spatial distribution of economic activity and welfare has been the subject of considerable interest to both policy-makers and academic researchers. Apart from concerns about the inequity of an uneven distribution, regional disparities have the potential to generate large inter-regional population movements as well as social unrest stemming from resentment in the poor regions at the obviously higher welfare in the richer provinces.

Beginning with the first Five-Year Plan (1953-1957), the central government attempted to “correct” the inherited imbalance between the interior and coastal

¹ The measurement of China’s economic growth has not been without controversy. See Woo(1998), Young (2003) and Bosworth and Collins (2008) for details.

² Data for per capita GDP are from State Statistical Bureau, *China Statistical Year Book 2010*. For a more extensive recent discussion of regional disparities in China, see Groenewold, Chen and Lee (2008) and for a recent econometric analysis of trends in and explanations of disparities see Lau (2010).

regions, with the allocation of investment resources being the most important instrument. The investment allocated to the interior region increased from 52% to 60% during the first Five-Year Plan. This trend continued until the end of the third Five-Year Plan by which time the proportion of investment going to the interior had increased further to 70%, although by then national security had become a major factor driving this policy since the relationship with the Soviet Union had deteriorated considerably by the mid-1960s and an important motivation for increased allocation of funds to the interior was to create several zones of economic self-sufficiency within China for strategic purposes. The allocation of investment to the interior slowed in the fourth Five-Year Plan (1971-1975) with China's greater interaction with western economies and less concern for the national security. However, the investment share of the interior was still above 50% and continued higher than that of the coastal region until 1978.

Despite the increase in investment in the interior region, inter-regional income disparities did not improve much. The ratio of GDP per capita in the interior to that in the coast was stable at about 0.7 in the 1950s and 1960s and actually fell to 0.5 by 1977 despite the biased investment allocation. Therefore, it appears that the investment allocation policy had little effect in reducing regional disparities in the pre-1978 period.

From the beginning of reforms in 1978, there was an explicit policy of unbalanced growth, favouring the coastal region under the argument that the limited resources of the country should be allocated to those provinces with higher

productivity in the expectation that the consequently higher coastal growth would pull the rest of the country behind it. As a result, the investment allocated to the coast outstripped that in the interior in 1979 for the first time since 1953 and continued to do so, rising to 65% by the end of eighth Five-Year Plan (1991-1995). Not surprisingly, the regional income gap widened during this time period – the ratio of real GDP per capita in the interior to that in the coast fell from about 0.5 in 1978 to 0.4 in 1995.

During the ninth Five-Year Plan (1996-2000), in the face of growing concern in Beijing about the unequal regional distribution of the prosperity generated by the 1978 reform and opening-up policy, a co-ordinated development strategy was advocated by the central government in which the focus shifted back to the interior region. A number of special policies, such as the Great Western Experiment (announced in 1999 during the ninth Five-Year Plan), the Resurgence of North-Eastern Old Industry Base and the Stimulation of the Central Region (both during the tenth Five-Year Plan) were implemented. The investment allocated to the interior region increased slowly in the ninth Five-Year Plan and has accelerated since 2004 with the investment share in the interior region increasing by about 10 percentage points from 1996 to 2008. However, the regional income gap has not changed much during the past decade; the ratio of real GDP per capita in the interior to that of the coast even fell from 0.4 to 0.36 from 1996 to 2004 and then rose back to 0.4 by 2008. It appears that inter-regional investment allocation policy also had little effect in reducing the regional disparities during this period. A word of warning is

needed, however. In the pre-reform period, investment consisted mainly of public investment so that the allocation of investment expenditure is clearly a reflection of government regional policy. After 1978, an increasingly important private component in investment might be considered to undermine the characterisation of investment as a policy variable. However, investment has continued to have a large public component and, besides, even private investment is importantly affected by the government, either via state-owned-bank finance or by direct government control of large projects so that the allocation of investment can still be regarded as substantially reflecting the central government's regional policy, even after 1978.

Given the importance and persistence of regional disparities in China and the long history of the use of investment policy to attempt to ameliorate them, it is surprising that this relationship has been the subject of so little empirical research. Our paper sets out to begin to fill this gap in the literature by analysing the relationship between the inter-regional allocation of investment and output disparities. It does so by distinguishing two regions – the coast and the interior. We measure investment allocation policy by the ratio of per capita investment in the interior to that in the coast while output disparities are measured by the ratio of real per capita output in the interior to that in the coast. We analyse the dynamic relationship between them in a time-series framework, using either a vector-auto-regressive (VAR) model or a vector-error-correction model (VECM), depending on the properties of the data. This modelling strategy allows us to clearly assess the effects of investment allocation on regional disparities, both the strength and timing of these effects, as well as

analysing the possibility of reverse effects running from regional inequality to investment allocation. We assess the plausibility of the magnitude of the effects generated by our empirical model by comparing them to the predictions of a simple macro model based on the relationship of total output to its components.

The remainder of the paper is structured as follows. We briefly discuss the limited literature in the area and set out a simple theoretical framework in section 2 and describe the data in section 3. Section 4 contains an outline of our empirical model and the estimation and simulation results are reported in section 5. Sensitivity tests are reported and discussed in section 6 and conclusions are drawn in section 7.

2. Literature and Theory

In this section we review such literature as there is relating to the relationship between output and investment at the regional level in China and then go on to present a simple theoretical framework which we use to assess the plausibility of the magnitude of the effects we find.

Although there is discussion in the literature of regional investment allocation policy, little empirical work has been carried out on assessing the effects of investment allocation on regional disparities. Thus, e.g., Yang (1990), Fan (1995), Wei (2000), Fujita and Hu (2001) and Yao (2003) touch on the issues but they are largely descriptive treatments of the questions of regional disparities, policy and investment. While they draw conclusions regarding investment and regional disparities, none of these papers reports a systematic evaluation of the efficacy of

investment allocation to influence regional inequalities. Other related papers focus on only a small and special component of investment, *viz.*, foreign direct investment and its effect on disparities; examples are Zhang and Kristensen (2001), Sun and Parikh (2001) and Wei, Yao and Liu (2009).

There is, therefore, little work on the effect of regional investment-allocation policy on disparities in China, although there is a substantial literature on disparities as such. Much of this literature, however, is cast in terms of the convergence debate which focuses on whether there are persistent disparities between regions, and if there are, what are the factors that determine the equilibrium disparities.³ While a few papers in this literature (Chen and Fleisher, 1996; Lin, 2000; Brun, Combes and Renard, 2002; Wang and Ge, 2004) test the role of investment in generating disparities within the convergence framework by including investment as a control variable in growth equations, their conclusions regarding investment policy are largely incidental to their main purpose. Thus, they do not consider the effect on regional disparities of the re-allocation of investment from one region to another.

Not only is there little if any systematic investigation of the effect of investment re-allocation on regional disparities, there has been no analysis of possible feedback and dynamics within this relationship. While the question that motivates the research reported in this paper is whether investment allocation affects output

³ For a selection of papers reporting research on China's regional disparities see: Chen and Fleisher (1996), Fleisher and Chen (1997), Kanbur and Zhang (1999), Yao and Zhang (2001a, 2001b), Demurger (2001), Chang (2002), Lu (2002), Cai, Wang and Du (2002), Yang (2002), Demurger, Sachs, Woo, Bao, Chang and Mellinger (2002), Bao, Chang, Sachs and Woo (2002), Demurger, Sachs, Woo, Bao and Chang (2002), Lai, Peng and Bao (2006), Yao (2006), Jin and Zou (2005), Zhang (2006), Candelaria, Daly and Hale (2009) and Fleisher, Li and Zhao (2010), Chen (2010), Chen and Groenewold (2010), Lau (2010), Zhang and Eriksson (2010) and Hao and Wei (2010).

disparities directly, it is possible that not only does investment affect disparities but the reverse may also be true in which case the simple inclusion of an investment variable in a regional growth equation will give biased results. In addition, policy-makers are likely to be interested in the dynamics of the relationship between investment and disparities – how long do changes in investment take to affect regional output disparities? What is the shape of the response? And so on. We analyse such questions within a VAR/VECM framework which is specifically designed for the analysis of the dynamic inter-relationship between variables.

Before specifying our empirical model, we consider a simple macroeconomic relationship between output and its components which we will use as a framework for thinking about the likely magnitudes of the relationship between regional output disparities and the regional allocation of investment. For region i , we have:

$$(1) \quad Y_i = C_i + I_i + G_i + NX_i, \quad \text{for } i = I, C$$

where Y , C , I , G and NX denote output, consumption, government expenditure and net exports (both inter-regional and international), all in real *per capita* terms, and the subscripts I and C denote the interior and the coastal regions respectively. Taking the ratio of Y_I to Y_C , we have:

$$(2) \quad \frac{Y_I}{Y_C} = s_C \frac{C_I}{C_C} + s_I \frac{I_I}{I_C} + s_G \frac{G_I}{G_C} + s_{NX} \frac{NX_I}{NX_C}$$

where the s_j ($j = C, I, G, NX$) are the relevant output shares in the coastal region (e.g., $s_C = C_C/Y_C$). The two variables of particular interest are the output ratio, Y_I/Y_C , and the investment ratio, I_I/I_C . From equation (2) it follows immediately that the direct effect on the output ratio of a change in the investment ratio is given by:

$$(3) \quad \frac{\partial(Y_I/Y_C)}{\partial(I_I/I_C)} = s_I$$

Thus the simple national accounting relationship between the variables suggests that the effect on the output ratio of a unit rise in the investment ratio ought to be about equal to the share of investment in total output in the coastal region, *ceteris paribus*. Naturally, in practice the relationship between the two variables will be much more complicated for at least the following reasons:

- (i) The partial derivative in (3) assumes that all the other terms in the equation are unaffected by the change in investment allocation. This is unlikely to be true in practice. Thus, for example, it is possible that there will be offsetting changes in one or more of the other variables. In particular, it may be the case that an increased government investment allocation will, in part, replace other government expenditure so that a rise in the investment ratio will be partially offset by a reduction in the government expenditure ratio. Moreover, it is likely that at least some of the inputs required for the investment will come from other provinces so that there will be an offsetting change in NX . Both of these indirect effects will serve to reduce the magnitude of the overall impact on the output ratio of the increased investment allocation.
- (ii) The expression in (3) ignores positive feedbacks via consumption, for example, that are usually captured in the multiplier process. The inclusion of these would be expected to increase the size of the effect in equation (3) since the increase in interior investment would have positive

multiplier effects while the reduction in coastal investment would have negative multiplier effects.

- (iii) Since investment adds to the capital stock, a higher level of investment in the interior will build up the capital stock there which should boost productivity, thus further increasing the output effect, although perhaps this will take longer than the traditional multiplier effect. Also, this may be offset in practice by the widely-cited inefficiency of investment in the interior region in China; see, e.g., Boyreau-Debray and Wei (2004), Dollar and Wei (2007), Bai, Hsieh and Qian (2006), Qin and Song (2007) and Wu (2009).
- (iv) Similarly, the improvement in employment opportunities expected in the interior as a result of the higher investment would likely attract labour from the coast (or slow down migration from the interior to the coast) and this will reduce output per capita if there are decreasing returns to labour.

Thus, the simple national accounting relationship between components of output which may underlie the investment allocation policy is likely to tell only a part of the story although it provides a guide to the order of magnitude of the short-run effect on output which might be expected to result from an investment re-allocation. In practice, though, the relationship between investment allocation and the per capita output ratio is likely to be much more complicated, something we will need to keep in mind when interpreting our empirical results later in the paper.

While the brief theoretical discussion above suggests that there are various

channels through which the allocation of investment might influence per capita output disparities in a regional setting, in this paper we stop well short of a full-scale structural multi-regional model. In fact, given the constraints of macro data at the regional level in China, particularly before 1978, we begin with the simplest possible structure which involves only two regions and two variables, the output ratio, Y_I/Y_C , and the investment ratio, I_I/I_C .⁴ Since the form of our empirical model (a VAR/VECM) depends on the nature of the data, we consider the data first, before returning to an exposition of the modelling framework.

3. The Data

The data employed are annual for the period 1953 to 2008. For inter-regional disparities we use the ratio of real GDP per capita in the interior to that in the coast (Y_I/Y_C). We recognise that in the analysis of distributional issues, the use of income may be more natural than GDP. We do not use income to compute the regional disparity measure, however, since the State Statistical Bureau does not provide such data at the provincial or regional level for our sample period. They do report data on per capita net income of rural households and per capita disposable income of urban households within each province and we could use these to construct a measure of provincial income but we do not proceed along this path since the definition of income for a rural household is different from that for an urban household, making any aggregation of the two difficult to interpret. Moreover, per capita GDP is by far

⁴ Since macro time-series data in China are generally available at an annual frequency except for the most recent past, it is important when using time-series models to have a reasonably long run of data which effectively means using data before 1978.

the most commonly used indicator of economic development and well-being for China and also the most commonly used variable to compute inter-regional disparities (see, e.g., Fan and Sun, 2008).

The choice of the investment allocation variable is more problematic. The main problem is the change in the nature of investment in China since economic reforms and “opening-up” began in 1978. Prior to that date, investment was a central government choice variable and can therefore be used as a policy variable. Since 1978, however, an increasing proportion of investment has been (notionally) private. To exclude the private component after 1978 would create a break in the series at that point as well as likely biasing the relationship between investment in the coast and the interior since the coastal provinces have benefited much more from the government’s opening-up policy than their inland counterparts. While the use of total investment, on the other hand, would avoid this problem, it would include investment not subject to direct government allocation policy after 1978. We opted for the use of total investment for the entire period since this provides continuity in the data coverage, there has continued to be a sizable government component of investment after 1978 and, moreover, even private investment in the second part of the sample is subject to considerable government influence through, for example, government approval and incentives for major private projects as well as directed lending by the big state-owned banks. Thus, we use the ratio of per capita total investment in the interior to that in the coast (I_I/I_C) as our investment-allocation policy variable. In contrast to the treatment of the per capita GDP ratio, we do not deflate investment

before taking the ratio for two reasons. First, we would argue that the central government allocates resources in nominal terms rather than real terms and, second, there is no consistent regional investment price index for the whole sample period which we could use as a deflator.

We recognise that some of our choices are not incontrovertible and we carry out extensive robustness-testing to assess the impact of our assumptions on the conclusions. These include (i) the use of a GDP deflator to deflate investment instead of using nominal investment expenditure, (ii) the use of private investment only rather than total investment (although this requires restricting the sample to begin after 1978), and (iii) the use of general government expenditure as an alternative to investment as the government policy instrument. The effects of all these alternatives are reported in section 6.

All of the data we use are available disaggregated by province. We use the provincial series to compute regional equivalents for real GDP and the policy variables and then use the regional population data to compute per capita equivalents. We aggregate the provinces into two regions, conventionally defined as coastal and interior. The composition of the two regions is as follows. Coast: Beijing, Tianjin, Hebei, Guangdong, Shandong, Fujian, Zhejiang, Jiangsu, Shanghai, Liaoning, Guangxi; Interior: Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang.⁵

⁵ Note that Hainan, Chongqing and Tibet are missing. Hainan is included in Guangdong and Chongqing in Sichuan. Tibet has been omitted altogether due to missing data.

We take the GDP data from *China's GDP Data 1952-95* (State Statistical Bureau, 1997) via Wu (2004) and *Statistical Yearbook of China* (State Statistical Bureau, various years) and *China Statistical Abstract 2009* (State Statistical Bureau, 2009). The investment variable we use is "Total Investment in Fixed Assets" and data for this variable as well as for population and expenditure come from *Comprehensive Statistical Data and Materials on 55 Years of New China* (State Statistical Bureau, 2005), *Statistical Yearbook of China* (State Statistical Bureau, various years) and *China Statistical Abstract 2009* (State Statistical Bureau, 2009).

Before turning to a discussion of our empirical method, we test the stationarity of the data using the augmented Dickey-Fuller (ADF) test, the results for which are reported in Table 1.⁶ They show that the levels of the per capita GDP ratio and the per capita investment ratio are non-stationary but that their first differences are stationary; i.e., both variables are I(1). The results are clearly independent of the number of lags and the deterministic specification of the testing equation.

Table 1 near here

While both variables are non-stationary, it is possible that a linear combination of these series may exhibit stationary behaviour so that the two variables can be characterised by a long-run relationship. We test for such a cointegrating relationship using the Johansen test; see Johansen (1991, 1995). Unlike the results of the ADF test reported in the previous section, the cointegration results are not independent of the specification of the testing framework. We therefore tested various specifications and

⁶ See Dickey and Fuller (1981). Many text-book treatments are available; e.g. Enders (1995).

concluded that two lags were necessary to remove autocorrelation from the testing equations and that a trend is significant in the cointegrating vector. Therefore we report the results of the Johansen tests conducted within a VECM with a trend and intercept in the cointegrating vector and an intercept and two lags in the VAR part of the model. The results of the application of Johansen's trace and maximum eigenvalue tests within this framework are reported in Table 2.

Table 2 near here

Both statistics clearly indicate that the null of no cointegrating relationships is rejected at the 5 per cent level of significance. We conclude, therefore, that the two variables are cointegrated and that there exists a long-run equilibrium relationship between the regional output gap and regional investment allocation. The estimated cointegrating vector normalized on the per capita output ratio is:

$$(4) \quad Y_I/Y_C = 0.035 I_I/I_C - 0.006Trend + 0.658$$

(0.01) (0.001)

where standard errors are in parentheses. The estimated equation shows that there is a positive and significant relationship between regional output inequality and investment allocation. The trend is negative, which implies that, even when the investment ratio is stable, there will be a slow but gradual decline in the ratio of GDP per capita in the interior to that in the coast, i.e., a steady rise in regional income inequality.

While the cointegration results indicate a long-run relationship between our two variables of interest, they allow us to say nothing about the direction of causality or the strength and timing of the relationship, something that requires the specification

and estimation of an empirical model, a matter we now consider.

4. Empirical Model

The preliminary analysis of the data in the previous section indicates that the two ratios are I(1) and cointegrated, provided the VECM model in which the test is run has two lags, a trend and an intercept in the cointegrating regression and an intercept in the VAR part of the model. The model therefore has the form:

$$(5) \quad \Delta(Y_I/Y_C)_t = \alpha_{10} + \alpha_{11}\Delta(Y_I/Y_C)_{t-1} + \alpha_{12}\Delta(Y_I/Y_C)_{t-2} + \beta_{11}\Delta(I_I/I_C)_{t-1} + \beta_{12}\Delta(I_I/I_C)_{t-2} \\ + \delta_1 ECM_{t-1} + \varepsilon_{1t}$$

$$(6) \quad \Delta(I_I/I_C)_t = \alpha_{20} + \alpha_{21}\Delta(Y_I/Y_C)_{t-1} + \alpha_{22}\Delta(Y_I/Y_C)_{t-2} + \beta_{21}\Delta(I_I/I_C)_{t-1} + \beta_{22}\Delta(I_I/I_C)_{t-2} \\ + \delta_2 ECM_{t-1} + \varepsilon_{2t}$$

where Δ denotes the first difference operator, the α s and β s are the coefficients of lags of differenced variables, ECM_{t-1} is the (lagged) error from the cointegrating regression:

$$(7) \quad ECM_t = (Y_I/Y_C)_t - [\gamma_0 + \gamma_1 t + \gamma_2 (I_I/I_C)_t]$$

– the error-correction term – and the δ s are their coefficients; the ε s are the equation error terms. The estimated values of the γ s in equation (7) were reported earlier in equation (4).

The estimated VECM is used for two procedures (apart from testing for cointegration). First we use it as a framework to test for short-run and long-run Granger causality and then we use it to generate impulse response functions (IRFs) which picture the dynamic relationships between the variables.

Short-run Granger causality in a VECM is a straightforward extension of the common concept of Granger causality in a system of stationary variables. In a VAR in stationary variables x and y , we say that x causes y if the lagged x variables in the y equation are jointly significant and *vice versa* for the causality from y to x . In a VECM in x and y we say that there is short-run causality from x to y if the lagged Δx variables in the Δy equation are jointly significant and *vice versa* for short-run causality from y to x .

Long-run causality is a less common concept. We propose to use a definition of it and an associated test based on a recent paper by Canning and Pedroni (2008).⁷ Although they developed the tests for the case of causality in cointegrated panels, the test statistics are actually derived in a single-equation context and we follow this derivation. At present the test appears to be available for only two-variable models and we exposit it for this case.

The intuition behind the test is simple. The cointegrating vector describes the long-run relationship between the two variables and the error-correction term in the VECM consists of deviations from this long-run equilibrium relationship. If the two variables are to satisfy this equilibrium relationship in the long run, it must be the case that a change in one variable will be associated, in the long run, with a change in the other in order to keep the relationship satisfied. But this is not necessarily a causal relationship. It is possible, for example, that an exogenous change in x will be followed by a change only in y or a change only in x or, more likely, by a change in

⁷ We note that the tests published in Canning and Pedroni (2008) have circulated for some time in unpublished working papers. See Canning and Pedroni (1999, 2004).

both x and y to ensure that equilibrium is re-established. In the second of these cases there is no long-run causality running from x to y , while there is such causality in the other two. We can test which of these possibilities is valid very simply by using the significance of the coefficients of the error-correction terms in the VECM equations: if a deviation from long-run equilibrium caused by a change in x has a significant effect on Δy (that is, the error-correction term in the Δy equation is significant), x causes y in the long run and *vice versa*.

More formally, Canning and Pedroni say that x causes y in the long run if a permanent shock to the x structural error has a permanent effect on y . In terms of the earlier explanation: if a permanent shock to the x structural error is adjusted to in the long run at least partly by a change in y then x causes y in the long run. As already explained, the Canning-Pedroni test for this is based on the significance of the error-correction term in the VECM equations but requires an additional restriction which is that a shock to the y innovation has a permanent effect on y itself. In Canning and Pedroni's application, they derive this supplementary condition from the theory underlying their model while we check that it holds empirically.⁸

Finally, the IRFs measure the dynamic effect on each of the endogenous variables of a shock to an equation error term. There are various ways of computing the IRFs. The most straightforward is simply to shock one of the ε s in equations (5) and (6). However, in practice these errors are correlated and shocking them independently would violate this relationship. For this reason it is common to transform the model

⁸ This additional restriction appears to be ignored in many applications of the Canning-Pedroni procedure, as does the restriction to two variables; see, for example, Basu, Chakraborty and Reagle (2003), Christopoulos and Tsionas (2005), Narayan and Smyth (2008) and Lee and Chang (2008).

errors into independent innovations using the Choleski decomposition of the model's covariance matrix, Σ , as

$$(8) \quad \Sigma = PP^{tr}$$

where P is a lower triangular matrix and P^{tr} is its transpose. Using this, the model errors can be transposed as:

$$(9) \quad u_t = P^{-1}\varepsilon_t$$

where ε_t is the vector of model error terms, $(\varepsilon_Y, \varepsilon_I)^{tr}$ and the elements of u_t are independent.⁹ This has the advantage that the errors can be shocked independently and interpreted as structural shocks but the disadvantage that, since the Choleski matrix is not unique, neither are the resulting IRFs. In particular, the IRFs are dependent on the order in which the variables are included in the model; the transformation implies that the first-listed error has a contemporaneous effect on both variables whereas the second-listed has a contemporaneous effect only on itself. In this sense it is assumed that the first-listed variable is causally prior to the second. The seriousness of the "ordering problem" is mitigated when the correlation of the model errors is low.

5. Results

We turn first to the estimated VECM which is reported in Table 3.

Table 3 near here

In terms of specification, the LM test for autocorrelation shows that the two lags used

⁹ See Enders (1995) for a text-book discussion of this and related points.

are sufficient to remove serial correlation from the residuals. The estimation results show that the coefficient of the error-correction term in the regional disparity $\Delta(Y_I/Y_C)$ equation is negative and significant and that in the investment allocation $\Delta(I_I/I_C)$ equation it is positive and significant. Given that the coefficient of Y_I/Y_C is normalized in the error-correction term, these coefficients show that both variables significantly contribute to moving the system back to long-run equilibrium (captured by the cointegrating relationship) after a shock.

In the $\Delta(Y_I/Y_C)$ equation, the first lags of the regional inequality and investment allocation variables are both positive and significant. Therefore, it appears that output inequality has autoregressive characteristics and is also (positively) influenced by the investment allocation as we would expect from our theoretical priors. In the $\Delta(I_I/I_C)$ equation, its own lags and the first lag of $\Delta(Y_I/Y_C)$ are significant. Thus regional income inequality has significant reverse effects on investment allocation.

These results are suggestive of both long-run and short-run causality between the two variables. The results for a test of short-run Granger causality are reported in the second part of Table 3. Clearly, the null hypothesis that I_I/I_C does not cause Y_I/Y_C in the short run can be rejected at the 5% level of significance. Similarly, the hypothesis that Y_I/Y_C does not cause I_I/I_C in the short run can be rejected, although only at the 10% level of significance and, in this sense, the evidence for causality running in the reverse direction (from Y_I/Y_C to I_I/I_C) is less strong than that running in the expected direction from investment allocation to output disparities.

Statistics for testing long-run causality between the two variables in our model

are also set out in the second part of Table 3. Clearly, long-run causality runs in both directions. The short-run and long-run causality from the investment ratio to the GDP ratio are consistent with the basic assumption underlying the use of investment as a policy instrument to influence the regional output distribution, although from the Granger causality tests we cannot tell what the sign and magnitude of the effects are which therefore need to be further investigated. The causality in the opposite direction is more surprising. Indeed, our simple theory in section 2 is not informative about this since it assumes that investment is an exogenous policy variable. But the estimation results make it clear that, not only does investment allocation affect output disparities but changes in output disparities lead to changes in the government's investment allocation. Thus, analysis which looks at the effects in only one direction misses half the story.

However, given that the Granger causality results show only the joint significance and not the magnitude or the sign of the coefficients and so tell us nothing about the dynamics of the interaction between the variables of interest, not a great deal can be learned from these results. Thus, for example, if coefficients of successive lags more or less cancel each other out, there may be little effect of a shock even if there is strongly significant causality. In our estimation results, the first lag always has the opposite sign to the second lag, in all but one case, and the (absolute) value of coefficients of $\Delta(Y_I/Y_C)$ lags is much larger than that of $\Delta(I_I/I_C)$ lags in each of the equations. Therefore, we should be cautious in our interpretation of the causality test results and we now turn to impulse response functions (IRFs) for more information

about magnitude and dynamics.

The IRFs show the dynamic interaction between the output gap and investment allocation. In particular, they show the effect over time on the levels of each of the two endogenous variables of a shock to each of the (VECM) equation error terms. They reflect the whole model (both equations and the short-run adjustment mechanism as well as the long-term adjustment through the error-correction term) and the size and sign of the coefficients rather than their significance. Given that the variables are non-stationary but cointegrated, the effects of a shock are permanent but should converge and this is reflected in the long-run behaviour of the IRFs. As mentioned in the previous section, we use the IRFs based on the Choleski decomposition and it is well known that the results using the Choleski decomposition are sensitive to the order in which the variables appear in the model. However, given that the contemporaneous correlation of the error terms in our model is relatively low (0.29), this is not likely to be a serious problem. Besides, we order investment allocation first on the view that I_t/I_C is more likely to affect Y_t/Y_C within the period than *vice versa*.¹⁰ We report the first IRFs in Figure 1. The response of the regional output gap to a one-standard-error shock to investment allocation is denoted by Y_t/Y_C and the response of investment allocation to a shock of one standard error to regional disparities is denoted by I_t/I_C .¹¹

Figure 1 near here

¹⁰ As part of our robustness tests, we also generated IRFs using the reverse variable ordering as well as those using the generalized version of IRFs following Pesaran and Shin (1998) which are derived from shocks which incorporate their historical correlation. The resulting IRFs do not change our overall conclusions.

¹¹ To minimise clutter in the diagram, we do not include the response of a variable to its own shock since they are of no immediate interest.

Recall that both variables are ratios of the interior to the coast. Following our simple theory in section 2, we would expect a rise in the interior's share in investment to improve its output position relative to the coast so that a positive shock to I_I/I_C should lead to a positive effect on Y_I/Y_C . Our priors regarding the reverse effect are ambiguous; indeed, our theory assumes that the investment ratio is exogenous and therefore is unaffected by the output ratio. In practice it is possible that the investment ratio is governed by a policy rule so that a fall, say, in Y_I/Y_C will stimulate the central government to increase its allocation of investment to the interior, so producing a negative effect. On the other hand, a rise in Y_I/Y_C might generate expectations of further development in the interior and so draw more investment to the interior, resulting in a positive effect. Inspection of the IRFs in Figure 1 shows that, clearly, an increased allocation of investment from the coast to the interior region has a positive effect on reducing the regional output gap but the effect appears small. A shock to the output gap, on the other hand, has substantial positive effects on the investment allocation between the two regions. In both cases the effects are more or less monotonic and are felt relatively quickly – most of the adjustment to the new long-run equilibrium are completed within the first three or four years.

Our simple theoretical framework in section 2 suggests that the short-run effect of a unit change in the investment ratio on the output ratio should be about the share of investment in total output in the coastal region which averages about 0.22 over our sample period. Whether the IRFs are consistent with this prediction is difficult to see since they result from a one-standard-error shock rather than a unit shock.

Moreover, the relative magnitudes of the two effects may also simply reflect differences in the size of the relevant standard errors. This difficulty in interpretation is easily overcome by computing the implied effects for a unit shock and, rather than reporting adjusted IRFs, we simply report the short-run and long-run figures for a unit shock in Table 4.

Table 4 about here

The full-sample effects in both directions are given in the first two columns of figures and we see, first, that the relative effects of the two shocks are little changed – the effect on the output ratio is much smaller than that in the opposite direction. Second, the maximum effect of investment on output is approximately 0.14 which occurs two periods after the shock with a long-run effect of about 0.05. The short-run effect therefore falls somewhat short of the prediction of our simple model, even at its maximum impact. Clearly some of the offsetting factors mentioned in section 2 must come into play in practice in the short run and, more strongly, in the long run. Thus, it is possible that government investment allocations are to some extent offset by opposite changes in other categories of government expenditure. Secondly, it is possible that net exports also fall when investment rises; this would happen, for example, if the investment goods are "imported" from the other region. In the longer term, an additional explanation is that the investment in the interior region is inefficient relative to that in the coastal provinces, as pointed out in a previous section. Finally, it is likely that in the long run the migration of labour also plays a part – the greater the allocation of capital to the interior the greater will wages be since the

marginal productivity of labour is increasing in the capital stock in a standard production function.¹² Thus, while initially per capita output rises in the interior relative to the coast, labour is attracted over time which results in the dissipation of the advantage, making it only temporary.

The large and positive effect in the reverse direction (from output inequality to investment allocation) is more difficult to explain. The positive sign suggests that it does not reflect a policy reaction since we would then expect a negative sign – a fall in the output ratio would call forth more investment in the interior relative to the coast. A possible explanation is that a rise in the output ratio is taken as a sign by the private sector of improvements in investment returns in the future, thus attracting more investment. This is plausible only after the dismantling of central planning from the late 1970s onwards. Before that it is well-known (see the brief discussion in section 1) that much investment allocation to the interior during Mao's time was motivated by security considerations rather than by the desire to reduce disparities so that the positive sign of the IRF is due to the fact that investment allocation continued to favour the interior even as its relative output position was improving while later investment allocation favoured the coast even as it was increasing in prosperity. The magnitude of the effect of Y_I/Y_C on I_I/I_C , though, is difficult to explain since, as shown in Table 4, the long-run effect of a unit shock is almost 7. While this is not beyond the bounds of possibility it seems very large. A numerical example might clarify this.

¹² This effect is more likely to operate in the post-1978 period when labour movement was increasingly less restricted. Nevertheless, during the Mao period, while internal migration restrictions were severe, there was a general encouragement to move to the interior, in line with national security objectives and this may have had a similar effect of diluting the *per capita* improvements in output resulting from the systematic bias of investment allocation in favour of the interior.

Suppose that initially Y_I/Y_C is $100/200 = 0.5$ and that the I_I/I_C ratio is $22/44 = 0.50$ (corresponding to an average investment share in output of 22%). Suppose the output ratio increases by 10% to $110/200$. Then a 7-fold effect of the 10% increase in Y_I/Y_C would require the I_I/I_C ratio to rise to 0.85 which would require a re-allocation of investment from the coast to the interior of about 8 units to make the new I_I/I_C ratio equal to $30/36$ which is about 0.83; not impossible but very large.¹³

Thus, all in all, the results from the main simulations show that the effects from investment to output, although somewhat small, are plausible but those in the opposite direction are of a quite unexpected magnitude. We go on, in the next section to consider the robustness of our results before drawing conclusions.

6. Robustness tests

In this section, we subject the main findings to greater scrutiny by presenting the results of some robustness tests.

6.1 *Splitting the sample at 1978*

Our first robustness test involves splitting the full sample into two sub-samples at 1978 and re-running the simulations for the pre- and post-1978 periods separately, given that there is a possibility of structural change in 1978 when economic reforms began and the investment variable became increasingly private as discussed in the previous section. The effects of a shock to investment allocation in the sub-samples

¹³ From a purely mechanical point of view, of course, if the model associates an increase of 0.22 in Y_I/Y_C with a unit increase in I_I/I_C then a unit increase in Y_I/Y_C is associated with an increase in I_I/I_C of $1/0.22$ which is about 4.5.

are reported in Figure 2 and those of a shock to the output ratio are pictured in Figure 3. We also include the results for the full sample in the two figures for the purpose of comparison.¹⁴

Figures 2 and 3 near here

In terms of overall pattern, there is no difference between the two sub-samples: a change to the investment allocation has a relatively small positive effect on output inequality while the regional output shock has a larger reverse effect on investment allocation, just as we found for the full sample.

Nevertheless, there are interesting and substantial differences between the two sub-samples and these are highlighted by the multipliers reported in Table 4. In particular, the change in the investment ratio has a much stronger effect on the output ratio in the post-1978 period than in pre-1978 period. The multiplier calculations show that the short-run effect of investment on output is about 0.45 and in the long run it rises to 0.53, both considerably in excess of the prediction of 0.22 based on the simple macro model of section 2.¹⁵ Following on from our earlier conjectures about the reasons for the relatively small effect for the full sample, the larger post-1978 effects might reflect smaller offsetting changes in government expenditure and net exports as well as reinforcing effects of induced increases in consumption. Since investment was increasingly private during this period, it is less likely that an increase in investment would be substituted for current government expenditure and it is also possible that, with the greater technical capabilities of the interior provinces, less

¹⁴ To make the effects comparable over the sub-periods, we scale all shocks to 0.01 which is about the order of magnitude of the shock to the output ratio for the full sample.

¹⁵ Although it should be noted that the relevant investment share in the post-1978 period was 0.33.

investment goods needed to be “imported” from the coast. Moreover, the fact that after 1978 investment was increasingly private and so was more likely to be allocated according to market principles means that it is more likely to go to a use with a high marginal product thus boosting output in the longer term. Finally, the greater effectiveness of investment allocation in the post-Mao period might also reflect the fact that investment increasingly went to the coast during this period.

In contrast, the income gap has larger effects on investment allocation in the pre-1978 period than in the post-1978 period. This might simply reflect the fact that investment re-allocations to the interior region were much larger in Maoist period so that relatively small changes in the output ratio were associated with large change in the investment ratio.

In summary, although the relative magnitudes of the two IRFs of interest has not changed, the effects of investment re-allocation after 1978 are considerably larger and much more in line with our theoretical priors.

6.2 Using the ratio of real investment

Recall that we use nominal investment to compute the investment ratio variable, I_t/I_C , in the base case since there was no suitable investment deflator. We can, however, deflate investment using the GDP deflator and we now use this to compute real investment which we then use to compute the ratio of investment per capita and then re-run the simulations. We report the IRFs in Figure 4 and, again, they do not change much from the base case and certainly do not change our overall conclusions.

Figure 4 near here*6.3 Excluding outliers in the sample*

For most of our sample period China had a household registration or *hukou* system under which permission to migrate to another location to work was seriously restricted, although enforcement has slackened progressively since reforms began in 1978. Official population data which are used in our measures of per capita output and investment are based on official registered population but it is well-known that there has been very substantial unregistered migration from the inland to the coastal provinces so that the population data in some of the provinces are overestimated and others are underestimated (Cai and Wang, 2010). This problem obviously affects the accuracy of our measures of GDP per capita and investment per capita and so that of regional disparities and investment allocation¹⁶. Population data adjusted for this problem are not available but we conjecture that this problem is most serious for four provinces, Guangdong, Shanghai, Sichuan and Chongqing. The former two underestimate their population since many of their residents are without Shanghai and Guangdong *hukou* and so are not included in the population data. The latter two overestimate their population since many people with Sichuan and Chongqing *hukou* do not live in these two provinces but are still included in the population data. We attempt to get some idea of how this might affect our results by excluding these four provinces from the sample and re-running the simulations. We find that the results

¹⁶ However, these floating workers usually send money back home, to some extent reducing the income bias resulting from the official population data (Kanbur and Zhang, 2005).

do not change much except that the responses convergence more quickly. The IRFs are reported in Figure 5.

Figure 5 near here

6.4 Using investment by SOEs

As we discussed in the previous section, investment in China became increasingly private after 1978 so that there must be some doubt as to the extent to which investment can be considered a policy instrument in the latter part of the sample period. As a fourth robustness test, we replace total investment by investment by the state-owned enterprises (SOEs), which is more likely to have been influenced by the government. We use SOE investment to re-compute the investment ratio variable. Unfortunately such data are available only for the post-1978 period so that we estimate a model for the period from 1978 to 2008 and re-compute the IRFs which we report in Figure 6. We compare these to the effects in Figures 2 and 3 for the post-1978 sample and find that investment allocation now has a smaller effect on regional income inequality, the output ratio also has a smaller effect on the investment ratio but their relative magnitudes have not changed so that our overall conclusions are not affected.¹⁷ In broad terms, the magnitudes of the effects are consistent with those in post 1978 sub-sample period with the original investment variable reported in Figures 2 and 3 so that our original results are not importantly driven by our choice of investment data..

¹⁷ For this case we estimated a VAR in the first differences of the two variables and report accumulated IRFs since there is no cointegrating relationship between the levels. We used a common shock size of 0.01.

Figure 6 near here

6.5 Using the government expenditure ratio

Government expenditure is under the control of government in the entire sample period and is clearly a policy variable. To assess the possible weakness of using investment which was not wholly policy-controlled in the second part of the sample, we used the ratio of government expenditure in the interior region to that in the coastal region, G_I/G_C , to measure the government allocation of resources¹⁸. The IRFs, reported in Figure 7, indicate that, as was the case for investment, the effect of government expenditure on output is smaller than the effect in the opposite direction. Converting the effects to those of unit Choleski shocks shows that the short-run effect of a change in the expenditure ratio is approximately 0.47, falling to 0.44 in the long run, both of which are plausible in terms of our simple framework. The effects of a unit shock in the opposite direction are smaller than they were for investment: 0.68 in the short run and 1.1899 in the long run, suggesting that government expenditure as a whole is “more exogenous” than (government) investment.

Figure 7 near here

All in all, the sensitivity tests above support our main findings that a policy of inter-regional resource re-allocation generally has a relatively modest effect on regional output inequality while output inequality has a substantial effect on resource allocation. This conclusion is robust to choice of sample and to various alternative

¹⁸ It should be noted that government expenditure includes not only investment but also other non-investment spending such as education, health care, etc. The expenditure ratio and the output ratio were found to be I(1) and cointegrated and we generated the IRFs from a VECM with one lag and a trend in the cointegrating error.

measures of the two variables in the model.

7. Conclusions

This paper has addressed the important policy question: has the regional re-allocation of resources by the government in China had an appreciable effect on the distribution of output across the regions? We analysed this for two regions (the interior and the coast) within the context of a vector-error-correction model (VECM) in two variables: the ratio of real per capita GDP in the interior to that in the coast and the ratio of per capita investment in the interior to that in the coast. Our surprising finding is that, for our full sample of 1953-2008, the effect has been relatively modest: a unit change in the investment ratio has led to a change in the output ratio of about 0.14 after two years which falls to 0.05 in the long run. This is considerably smaller than what we would expect even on the basis of our simple model based on the application of the national accounting identity at the regional level so that we conclude that there must have been significant offsetting changes in other variables such as net exports and government expenditure.

When we re-examined the relationship for the latter part of the sample (1979-2008), however, the effect is much stronger and quite consistent with our model, suggesting that smaller offsetting changes in other variables and, perhaps, greater investment efficiency.

A second surprising finding is that the reverse effect of the output ratio on the investment ratio is much larger, in both the short run and the long run, than the

influence of investment on output.

Our overall results are found to be robust to a number of variations in the definition of the variables. In particular, we assess the sensitivity of the results to both choice of sample and choice of investment variable and find the broad conclusions to be surprisingly robust.

References

- Bai, C., C. Hsieh and Y. Qian (2006), “The Return to Capital in China”, NBER Working Paper 12755, National Bureau of Economic Research.
- Bao, S., G. H. Chang, J. D. Sachs and W. T. Woo (2002), “Geographic Factors and China's Regional Development under Market Reforms, 1978–1998”, *China Economic Review*, 13, 89-111.
- Basu, P., C. Chakraborty and D. Reagle (2003), “Liberalization, FDI and Growth in Developing Countries: A Panel Cointegration Approach”, *Economic Inquiry*, 41, 510-516.
- Bosworth, B. and S. M. Collins (2008), “Accounting for Growth: Comparing China and India”, *Journal of Economic Perspectives*, 22, 45-66.
- Boyreau-Debray, G. and S. Wei (2004), “Can China Grow Faster? A Diagnosis of the Fragmentation of Its Domestic Capital Market”, IMF Working Paper WP/04/76, International Monetary Fund.
- Brun, J.F., J. L. Combes and M. F. Renard (2002), “Are there Spillover Effects between the Coastal and Noncoastal Regions in China”, *China Economic Review*, 13, 161-169.
- Cai, F., D. Wang and Y. Du (2002), “Regional Disparity and Economic Growth in China: The Impact of Labor Market Distortions”, *China Economic Review*, 13, 197-212.
- Cai, F. and M. Wang (2010), “Growth and Structural Change in Employment in

- Transition China”, *Journal of Comparative Economics*, 38, 71-81.
- Canning, D and P. Pedroni (1999), “Infrastructure and Long-Run Economic Growth”, Working Paper 99-09, Center for Analytical Economics, Cornell University
- Canning, D. and P. Pedroni (2004), ‘The Effect of Infrastructure on Long Run Economic Growth’, Discussion Paper, Williams College.
- Canning, D. and P. Pedroni (2008), “Infrastructure , Long-Run Economic Growth and Causality Tests for Cointegrated Panels”, *The Manchester School (Special Issue)*, 76, 504-527.
- Candelaria, C., M. Daly and G. Hale (2009), “Beyond Kuznets: Persistent Regional Inequality in China”, Federal Reserve Bank of San Francisco Working Paper 2009-07.
- Chang, G. H. (2002), “The Cause and Cure of China’s Widening Income Disparity”, *China Economic Review*, 13, 335-340.
- Chen, A. (2010), “Reducing China's Regional Disparities: Is There a Growth Cost?”, *China Economic Review*, 21, 2-13.
- Chen, A. and N. Groenewold (2010), “Reducing Regional Disparities in China: An Evaluation of Alternative Policies”, *Journal of Comparative Economics*, 38, 189-198.
- Chen, J. and B. M. Fleisher (1996), “Regional Inequality and Economic Growth in China”, *Journal of Comparative Economics*, 22, 141-164.
- Christopoulos, D. K. and E. G. Tsionas (2005), “Productivity Growth and Inflation in Europe: Evidence from Panel Cointegration Tests”, *Empirical Economics*, 30, 137-150.
- Demurger, S. (2001), “Infrastructure Development and Economic Growth: An Explanation for Regional Disparities in China”, *Journal of Comparative Economics*, 29, 95-117.
- Demurger, S., J. D. Sachs, W. T. Woo, S. Bao and G. Chang (2002), “The Relative Contributions of Location and Preferential Policies in China’s Regional Development: Being in the Right Place and Having the Right Incentives”, *China Economic Review*, 13, 444-465.

- Demurger, S., J. D. Sachs, W. T. Woo, S. Bao, G. Chang and A. Mellinger (2002). "Geography, Economic Policy and Regional Development in China", NBER Working Paper 8897, April 2002.
- Dickey, D.A. and W. A Fuller (1981), 'Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root', *Econometrica*, 49, 1057-1072.
- Dollar, D. and S. Wei (2007), "Das (Wasted) Kapital: Firm Ownership and Fixed-Asset Investment in China", Working Paper No.584, Department of Economics, Queen Mary College, University of London.
- Enders, W. (1995), *Applied Econometric Time Series*, Wiley, New York.
- Fan, C. C. (1995), "Of Belts and Ladders: State Policy and Uneven Regional Development in Post-Mao China", *Annals of Association of American Geographers*, 85, 421-49.
- Fan C. C. and M. Sun (2008), "Regional Inequality in China, 1978-2006", *Eurasian Geography and Economics*, 49, 1-20.
- Fleisher, B. M and J. Chen (1997), "The Coast-Noncoast Income Gap, Productivity and Regional Economic Policy in China", *Journal of Comparative Economics*, 25, 220-236.
- Fleisher, B., H. Li and M. Zhao (2010), "Human Capital, Economic Growth, and Regional Inequality in China", *Journal of Development Economics*, 92, 215-231.
- Fujita, M. and D. Hu (2001), "Regional Disparity in China 1985-1994: The Effects of Globalization and Liberalization", *Annals of Regional Science*, 35, 3-37.
- Groenewold, N., A. Chen and G. Lee (2008), *Linkages between China's Regions: Measurement and Policy*, Edward Elgar, Cheltenham, UK.
- Hao, R. and Z. Wei (2010), "Fundamental Causes of Inland-Coastal Income Inequality in Post-Reform China", *Annals of Regional Science*, 45, 181-206.
- Jin, J. and H. Zou (2005), "Fiscal Decentralization, Revenue and Expenditure Assignments and Growth in China", *Journal of Asian Economics*, 16, 1047-1064.
- Johansen, S. (1991). "Estimation and Hypothesis Testing of Cointegration Vectors in

- Gaussian Vector Autoregressive Models”, *Econometrica*, 59, 1551–1580.
- Johansen, S. (1995), *Likelihood-based Inference in Cointegrated Vector Autoregressive Models*, Oxford: Oxford University Press.
- Kanbur, R. and X. Zhang (1999), “Which Regional Inequality? The Evolution of Rural-Urban and Inland-Coastal Inequality in China from 1983 to 1995”, *Journal of Comparative Economics*, 27, 686-701.
- Kanbur, R. and X. Zhang (2005), “Fifty Years of Regional Inequality in China: a Journey Through Central Planning, Reform, and Openness”, *Review of Development Economics*, 9, 87-106.
- Lai, M., S. Peng and Q. Bao (2006), “Technology Spillovers, Absorptive Capacity and Economic Growth”, *China Economic Review*, 17, 300–20.
- Lau, C.K.M. (2010), “New Evidence about Regional Income Divergence in China”, *China Economic Review*, 21, 293-309.
- Lee, C. and C. Chang (2008), “Energy Consumption and Economic Growth in Asian Economies: A More Comprehensive Analysis Using Panel Data”, *Resource and Energy Economics*, 30, 50-65
- Lin S. (2000), “Resource Allocation and Economic Growth in China”, *Economic Inquiry*, 38, 515-526.
- Lu, D. (2002), “Rural-Urban Income Disparity: Impact of Growth, Allocative Efficiency and Local Growth Welfare”, *China Economic Review*, 13, 419-429.
- Narayan, P. K. and R. Smyth (2008), “Energy Consumption and Real GDP in G7 Countries: New Evidence from Panel Cointegration with Structural Breaks”, *Energy Economics*, 30, 2331-2341.
- Qin, D. and H. Song (2007), “Sources of Investment Inefficiency: The Case of Investment Efficiency in China”, NBER Working Paper 584 and Department of Economics, Queen Mary College, University of London.
- Pesaran, M. H. and Y. Shin (1998). “Impulse Response Analysis in Linear Multivariate Models,” *Economics Letters*, 58, 17-29.
- State Statistical Bureau (1997), *China’s GDP Data 1952-95*, Beijing: Statistical Publishing House of China.

- State Statistical Bureau (2005), *Comprehensive Statistical Data and Materials on 55 Years of New China*, Beijing: Statistical Publishing House of China.
- State Statistical Bureau (2009), *China Statistical Abstract 2009*, Beijing: Statistical Publishing House of China.
- State Statistical Bureau (various issues), *Statistical Yearbook of China*, Beijing: Statistical Publishing House of China.
- Sun, H and A. Parikh (2001), “Exports, Inward Foreign Direct Investment (FDI) and Regional Economic Growth in China”, *Regional Studies*, 35, 187-196.
- Wang, Z. and Z. Ge (2004), “Convergence and Transition Auspice of Chinese Regional Growth”, *Annals of Regional Science*, 38, 727-739.
- Wei, K., S. Yao and A. Liu (2009), “Foreign Direct Investment and Regional Inequality in China”, *Review of Development Economics*, 13, 778-791.
- Wei Y.D. (2000), “Investment and Regional Development in Post-Mao China”, *Geojournal*, 51, 169-179.
- Woo, W. T. (1998), “Chinese Economic Growth: Sources and Prospects”, in Michel Fouquin and Francoise Lemoine (eds.), *The Chinese Economy*, Economica, London.
- Wu, Y. (2004), *China's Economic Growth: A Miracle with Chinese Characteristics*, London: Routledge Curzon.
- Wu, Y. (2009), “Investment Efficiency and Its Determinants in China's Regional Economies”, UWA discussion paper.
- Yang, D. (1990), “Patterns of China's Regional Development Strategy”, *The China Quarterly*, 122, 203-57.
- Yang, D. T. (2002), “What Has Caused Regional Inequality in China?”, *China Economic Review*, 13, 331-334.
- Yao, S. (2006), “On Economic Growth: FDI and Exports in China”, *Applied Economics*, 38, 339–51.
- Yao, S. and Z. Zhang (2001a), “On Regional Inequality and Diverging Clubs: A Case Study of Contemporary China”, *Journal of Comparative Economics*, 29, 466-484.

- Yao, S. and Z. Zhang (2001b), “Regional Growth in China Under Economic Reforms”, *Journal of Development Studies*, 38, 167-186.
- Yao, Y. (2003), “The Impact of Investment Policy on Regional Economic Patterns in China”, *Journal of the Asia Pacific Economy*, 8, 327-353.
- Young, A. (2003), “Gold into Base Metals: Productivity Growth in the People’s Republic of China during the Reform Period”, *Journal of Political Economy*, 111, 1221-1261.
- Zhang, J. and G. Kristensen (2001), “The Paradox of Unequal Regional Investment and Equal Regional Economic Growth in China”, *Annals of Regional Science*, 35, 637-655.
- Zhang, X. (2006), “Fiscal Decentralization and Political Centralization in China: Implications for Growth and Inequality”, *Journal of Comparative Economics*, 34, 713-726.
- Zhang, Y. and T. Eriksson (2010), “Inequality of Opportunity and Income Inequality in Nine Chinese Provinces, 1989–2006”, *China Economic Review*, 21, 607-616.

Table 1 ADF Test Results

A. Per Capita Real GDP Ratio (Y_I/Y_C)

Lags	Level		First difference	
	With constant		With constant	
	With constant	and trend	With constant	and trend
1	-1.24	-3.12	-6.37***	-6.41***
2	-1.32	-2.10	-4.58***	-4.61***
3	-1.13	-2.26	-3.99***	-4.10**

B. Per Capita Investment Ratio (I_I/I_C)

Lags	Level		First difference	
	With constant		With constant	
	With constant	and trend	With constant	and trend
1	-1.72	-2.54	-6.26***	-6.19***
2	-1.04	-1.67	-3.72***	-3.64**
3	-1.52	-1.81	-2.65*	-2.61

Note: *, ** and *** denote rejection of the null at 10%, 5% and 1% significance levels respectively.

Table 2 Johansen Tests for Cointegration Between Y_I/Y_C and I_I/I_C

Hypothesis	Trace statistic	Maximum eigenvalue statistic
$r=0$	26.09**	21.46**
$r \leq 1$	4.63	4.63

Note: r denotes the number of cointegrating vectors and ** denotes rejection of the null at a 5% significance level.

Table 3 Vector Error-Correction Model Estimates

	$\Delta Y_I/Y_C$ equation		$\Delta I_I/I_C$ equation	
	Coefficient	t-Value	Coefficient	t-Value
ECM_{t-1}	-0.311	2.55	1.989	3.21
$\Delta (Y_I/Y_C)_{t-1}$	0.319	2.34	-1.456	-2.10
$\Delta (Y_I/Y_C)_{t-2}$	-0.040	-0.25	-0.530	-0.67
$\Delta (I_I/I_C)_{t-1}$	0.061	2.55	0.545	4.45
$\Delta (I_I/I_C)_{t-2}$	-0.016	-0.67	-0.511	-4.15
Constant	-0.004	-1.44	-0.017	-1.26

Autocorrelation (LM Test):

Lag 1, (p-value) 0.273

Lag 2 (p-value) 0.821

Short-run causality:

I_I/I_C does not cause Y_I/Y_C (p-value) 0.037

Y_I/Y_C does not cause I_I/I_C (p-value) 0.092

Long-run causality

I_I/I_C does not cause Y_I/Y_C (p-value) 0.014

Y_I/Y_C does not cause I_I/I_C (p-value) 0.002

Table 4 Multipliers

Direction	1953-2008		1953-1978		1979-2008	
	SR	LR	SR	LR	SR	LR
I_I/I_C to Y_I/Y_C	0.1409	0.0530	0.1573	0.0855	0.4532	0.5355
Y_I/Y_C to I_I/I_C	2.1609	6.7414	4.4230	7.2577	3.0787	2.2472

Notes: The numbers in the table are the effects of Choleski unit shocks to the first-listed variable in the first column. "SR" denotes the short-run effects (two periods after the shock) and "LR" denotes the long-run effects (after 30 periods).

Figure 1 Cross Effects, Base Case, Full Sample (1953-2008)

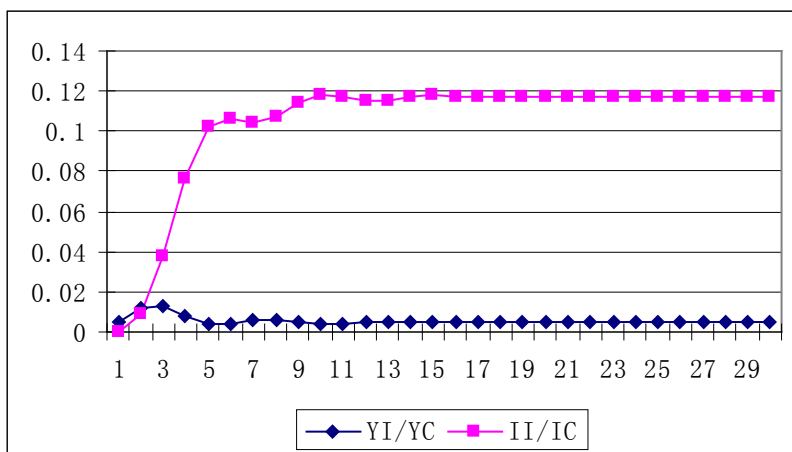


Figure 2 Effects of Shock to I_t/I_C

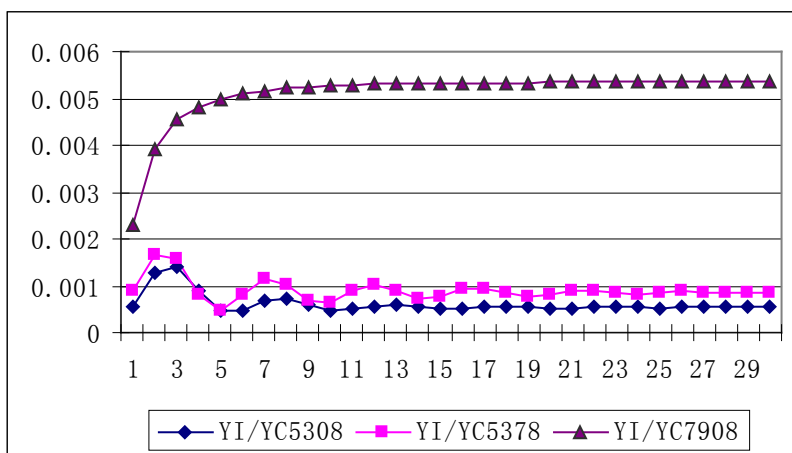


Figure 3 Effects of Shock to Y_t/Y_C

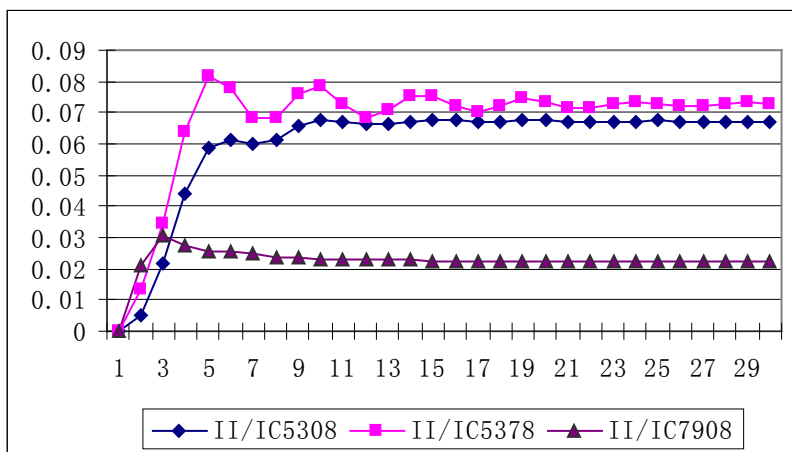


Figure 4 Cross Effects, with Real Investment Ratio

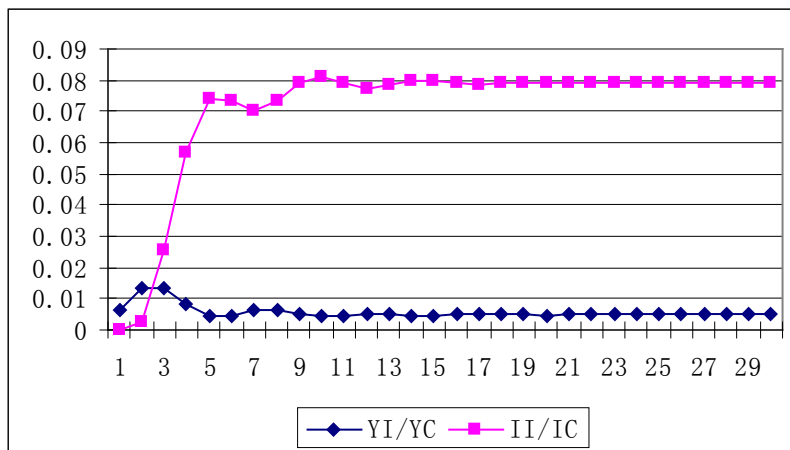


Figure 5 Cross Effects, Excluding Outliers

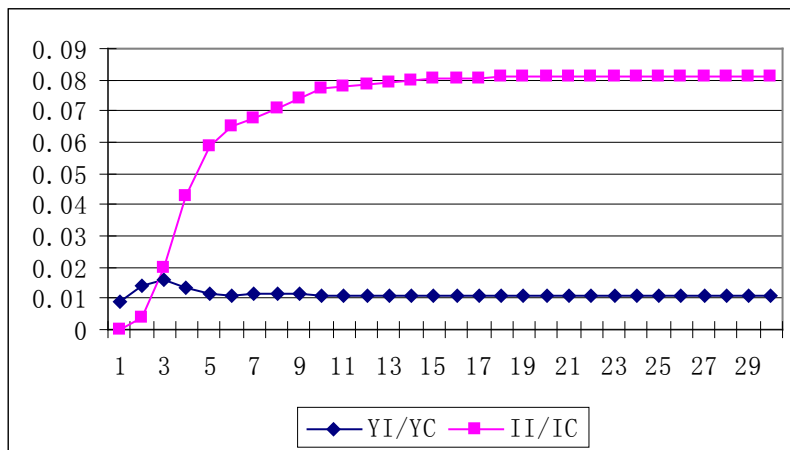


Figure 6 Cross Effects, with Investment by SOEs

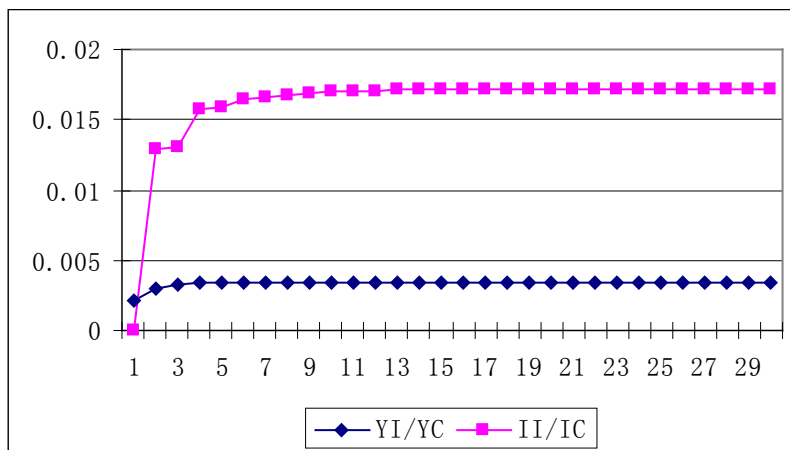


Figure 7 Cross Effects, with Expenditure Ratio Variables

