

Regional Output Spillovers in China: Estimates from a VAR Model

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Abstract:

Interregional spillover effects are central to China's growth policy; yet relatively little is known about the strength and duration of these spillovers and whether their characteristics have changed over time. This paper examines the spillover of output between the three commonly-used regions of China: coastal, central and western regions. We find that there are strong spillovers from the coastal region to both other regions, from the central region to the western region but that shocks to the western region have no flow-on effect for the other two regions. Thus a policy of developing the coastal region is likely to indirectly benefit the other two regions.

Key words: regional spillovers, China, regional growth

JEL classifications: R11, R12

1. Introduction¹

China's emergence as a major player in the world economy in the last 25 years has been spectacular. Between 1953 and 2003 real GDP increased by an average of approximately 8.0% annually and since the beginning of reforms in 1978 the average rate has been about 10% per annum; this is an outstanding record, even by the standards of the rapid growth experienced by many countries in the 20th century.

This rapid and sustained growth has, however, been far from smooth. Growth in the often tumultuous pre-reform years fell as low as -27.3% in 1961 as a result of the disastrous Great Leap Forward from a high of 21.3% in 1958. Even the post-1978 period has seen substantial albeit smaller fluctuations in the range of 3-15% per annum. The history of recent China's growth experience is illustrated in Figure 1.

[Figure 1 near here]

Growth has fluctuated not only over time, as illustrated in Figure 1, but the spatial distribution has also been far from uniform. Figure 2 illustrates the weighted coefficient of variation as a measure of the regional (inter-provincial) distribution of growth rates over the period 1953-2003.

[Figure 2 near here]

It shows that growth rates have varied considerably across space and that this dispersion itself has fluctuated over time. Not surprisingly, the spatial distribution of economic activity and welfare has been the subject of considerable interest to both policy-makers and academic researchers.

From its inception, the government of the People's Republic of China has shown awareness of and concern for the effects of persistent regional economic disparities. At the beginning of its history, particularly during the first two Five-Year Plans (1953-57, 1958-62), the People's Republic of China emphasised industrialisation and initially favoured the north-eastern provinces which already had a relatively advanced industrial structure due to the earlier Japanese influence. However, at least from the Third Five-Year Plan covering 1966-1970, there has been a major focus on regional differences in economic policy formulation. As a result of the worsening relationships with the Soviet Union at that time, there were serious concerns for national security of inland China which, coupled with a focus on Mao's principle of industrial self-sufficiency, resulted in a strong bias in favour of western

¹ This section draws on the general discussion of regional development and policy in Wu (2004, particularly Chapters 5 and 6) and Demurger, Sachs, Woo, Bao, Chang and Mellinger (2002).

and central regions at the expense of the more prosperous coastal region. Investment allocated to interior provinces increased to 71%.

Emphasis began to shift, however, in the early 1970s with China's greater interaction with western economies and there was a gradual reduction in the discrimination in favour of the west. In the Fifth Five-Year Plan (1976-1980) there was a shift of focus back to the coast with investment in coastal provinces being the highest since 1952; not surprisingly, growth in the east began to outstrip that in the rest of the country. By the Sixth Five-Year Plan (1981-1985) there was an explicit policy of unbalanced growth, now favouring the coastal region under the argument that the limited development resources of the country should be allocated to those provinces with the natural characteristics which would benefit most from the investment. This policy of unbalanced growth continued during the currency of the Seventh Five-Year Plan (1986-1990) with an even higher proportion of government investment going to coastal provinces compared to the interior provinces. The basis of this strategy is that resources should be allocated to the region with the greatest natural advantages with the strong expectation that the faster-growing coastal region would act as a growth locomotive, taking the rest of the country with it.

More recent Plans have shifted the focus back towards the interior with growing concern about the implications for social instability of large and persistent differences in inter-provincial levels of economic welfare. In particular, in 1999 the central government announced the Great Western Experiment during the currency of the Ninth Five-Year Plan in which considerable shifts of resources to the western provinces were foreshadowed.

Notwithstanding the more recent shift in regional focus, there continues to be an expectation that the faster-growing coastal region will exert a beneficial influence on the remaining regions which depends on the existence of strong economic linkages between regions. While there has been much discussion of these inter-regional real output spillovers, there is remarkably little empirical work assessing their strength and timing. Two existing studies, Ying (2000) and Brun, Combes and Renard (2002), use annual provincial GDP data for the post-1978 period to assess the existence and strength of spillovers. Our approach in this paper is different to both existing studies in that it uses data at the regional rather than provincial level and extends the data back to 1953 and forward to 2003. Moreover, our modelling techniques differs from that in both previous studies and emphasises the analysis of

dynamic interaction between output in the three regions. In particular, the use of regional level data allows us to estimate and simulate a vector-autoregressive (VAR) model to analyse the size and timing of spillover effects without the need to decide on a specific theoretical framework.

The remainder of the paper is structured as follows. Section 2 reviews the literature on Chinese regional economic growth and, in particular, on spillover analysis with a focus on work using Chinese data and justifies our choice of modelling strategy. Section 3 describes the data. In this section we provide a careful analysis of the stationarity properties of the data, including the possibility of breaks in level and trend. These characteristics have been the subject of some controversy both for China and for other countries and, besides, they are important for the model specification. The model estimation and simulation are reported in section 4. In this section we also carry out model stability tests which are particularly important in the present case given the turbulence of recent Chinese economic history and the periodic and dramatic changes in policy direction. To anticipate our results, we find strong evidence of parameter instability in the first part of the sample (particularly surrounding the Great Leap Forward and the Cultural Revolution) and re-run our results for the period after 1982. Our conclusions are presented in the final section.

2. The Literature

There is a rapidly growing literature on regional economic growth in China. Most of this literature is, however, concerned with long-run questions which are the traditional concern of growth theory. Thus much of the literature is cast in terms of the convergence debate which focuses on whether there are persistent disparities between regions (usually provinces in China), whether these disparities will disappear of their own accord (the convergence question) and, if not, what are the factors that determine the equilibrium disparities (the conditioning variables in conditional convergence).

The convergence question has a long history that goes back at least to the work of Kuznets (1955) and the subsequent empirical work by Williamson (1965), before being labelled the “convergence” question in a path-breaking paper by Barro and Sala-i-Martin (1992). The essential idea is straightforward: in the simple neoclassical growth model steady-state income per capita is independent of the initial conditions so that, no matter what the inherited differences in capital stock are,

countries converge to the same level of income per capita. Convergence is achieved by poor countries growing more rapidly so that eventually they catch up with their richer rivals.

The initial tests of convergence were based on estimated growth equations using cross-country data sets but recently regional data for a single country have played an important role in empirical research on this question. In this context China presents an interesting case. Data for provincial level GDP back to the early 1950s have recently been made available and they provide longer time-series data than for many cross-country studies. The overwhelming conclusion of empirical work on convergence using Chinese provincial-level data is that there is conditional convergence but not absolute convergence. Thus, provincial GDP per capita (the most commonly used variable) is converging to a steady-state level but the steady state differs across provinces.

A large number of different conditioning variables have been used including ones traditionally used in the convergence literature in general such as physical investment, human capital investment, foreign direct investment, employment growth (Chen and Fleisher, 1996), technical progress (Fleisher and Chen, 1997), trade variables (Yao and Zhang, 2001a) and infrastructure (Demurger, 2001). Other variables are more specific to China's economy such as the interaction between urban/rural and provincial disparities (Kanbur and Zhang, 1999, Chang, 2002, Lu, 2002), barriers to labour migration which have been particularly strong in China's recent history (Lu, 2002, Cai, Wang and Du, 2002), region-biased policy (Yang, 2002, Demurger, Sachs, Woo, Bao, Chang and Mellinger, 2002, and Demurger, Sachs, Woo, Bao and Chang, 2002) and geography – some form of coastal/noncoastal dummy variable has been used by many authors and geography has received specific attention in such recent papers as Yao and Zhang (2001b), Bao, Chang, Sachs and Woo (2002), Demurger, Sachs, Woo, Bao, Chang and Mellinger (2002) and Demurger, Sachs, Woo, Bao and Chang (2002). In summary, it appears that the observed disparities are likely to be a long-term feature of the Chinese economy.

While most of the discussion of Chinese regional economic activity has been in the convergence framework, little has focussed on the short-term fluctuations in output and in particular on the interaction between regional output levels which is necessary to address the spillover issue identified in the first section as the focus of

the present paper. Indeed, there is little econometric work analysing spillovers for any country.

A set of papers using a modelling approach similar to the one used in the present paper (VAR modelling) have been produced by researchers at the Federal Reserve Bank of San Francisco: Sherwood-Call (1988), Cromwell (1992) and Carlino and DeFina (1995). Of these the last is a specific analysis of the inter-regional spillover question in a model closest to ours. It applies the VAR model to eight US regions to assess the effects of shocks to income growth in one region on income growth in other regions. Carlino and DeFina use 60 years of annual per capita income growth data for eight US regions to estimate and simulate a VAR model, reporting tests of block exogeneity, impulse response functions (IRFs) and forecast error variance decompositions (FEVDs). They find significant and persistent spillover effects and suggest that an understanding of these is important to the formulation of effective regional economic policy.

Other more recent papers in the same analytical vein are by Clark (1998), Rissman (1999) and Kouparitsas (2002). Kouparitsas uses a model and data similar to that used by Carlino and DeFina but a more sophisticated decomposition of income into trend and cyclical components. In contrast to the earlier findings, he concludes that regional spillovers account for a negligible part of regional income fluctuations in the US. Thus, while the use of the VAR model is well-established in US regional research, results are far from clear.

To our knowledge, only two papers have explicitly examined inter-regional spillovers for China. The first, by Ying (2000) uses “exploratory spatial data analysis” which uses time-series data for provincial growth rates to compute (static) relationships between each province’s growth rate with those geographically near to it. Both positive and negative relationships are found with the strongest significant influence being exerted by Guangdong province which was for this reason identified as the core. Four of the five adjacent provinces showed a significant relationship to Guangdong growth: there were positive spillovers to Hainan and Guangxi but negative ones to Hunan and Jiangxi. Thus Ying has found significant growth relationships between the provinces. However, the technique of spatial data analysis is essentially one of static growth correlations which does not permit the analysis of the strength and timing of the relationships, questions that are also vital for policy-formulation and central to the interest of this paper.

The second paper to explicitly assess the nature of regional spillovers in China is by Brun, Combes and Renard (2002). They use provincial-level time series data for real per capita growth rates for the period 1981-1998 to estimate a set of conventional provincial growth equations which are modified to include the variables representing the coastal, central and western regions. This modification is designed to capture the inter-regional spillovers and allows them to test the significance of spillovers from the coastal region to the other two. They do not entertain spillovers from either of the other two regions. They find significant spillovers from the coastal region to the central region but no effect on the western region.

Our approach uses a time-series model which does not rely on theoretical priors – the VAR (or the related vector error correction model, VECM, depending on the properties of the variables). It is well known that this atheoretical approach is both a strength and a weakness of VARs – it is not restricted by (possibly competing) theories but the results can not always be unambiguously interpreted. Thus it is generally seen as a method for systematically summarising the intertemporal dynamic properties of a particular data set.² In this light it is ideally suited to our purposes since we do not wish to test alternative theories but rather to examine the dynamic inter-relationships between variables over a particular period to assess the strength and timing of these inter-relationships.

3. The Data

The data used are newly available annual series on real provincial GDP for the period 1953-2003. The sources of the data are two-fold: the early data come from Wu (2004) who obtained the 1953-1995 series from *China's GDP Data 1952-95* (State Statistical Bureau, 1997). Data for 1996-2002 come from the *Statistical Yearbook of China* (State Statistical Bureau, various years) and for 2003 from the *China Statistical Abstract* (State Statistical Bureau, 2004). In contrast to the two previous papers on inter-regional spillovers in China, we can also test the importance of the use of the longer data series and assess whether the results are stable over the whole sample.

² The debate concerning the usefulness of the VAR approach to dynamic econometric analysis is one of long standing; see, e.g., Sims (1980, 1982, 1986), Leamer (1985), Cooley and Leroy (1985) and Keating (1992).

We use the provincial real GDP series to compute three regional real GDP series for the conventionally defined coastal, central and western regions. The composition of these three regions is as follows. Coastal: Beijing, Tianjing, Hebei, Guangdong, Shandong, Fujian, Zhejiang, Jiangsu, Shanghai, Niaoning, Guangxi; Central: Shanxi, Inner Mongolia, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan; Western: Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang.³

Before specifying and estimating the model, we need to test the stationarity characteristics of the data since different model structures will be appropriate depending on the outcome of these tests – if the data are stationary we can estimate a VAR in the stationary variables while if the data are non-stationary, we need to further test for cointegration since if the data are cointegrated we should use a VECM while if they are non-stationary and not cointegrated we should estimate a VAR in the first differences (provided these are stationary).

We begin with a standard ADF t-test which tests the significance of α_1 in the “augmented Dickey-Fuller equation”⁴:

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 t + \sum_{i=1}^k \gamma_i \Delta y_{t-i} + \varepsilon_t \quad (1)$$

where the number of lags, k , is chosen using Hall’s (1994) commonly-used “t-sig” approach; this involves starting with an initial choice of a maximum value for k , k_{\max} . k is then set at the highest value within this limit for which the last lag in the above equation is significant. Following earlier literature (see, e.g., Smyth and Inder, 2004 and references cited there), k_{\max} is chosen to be 8 even though this seems very large for annual data and the critical value for the sequential significance test is set at 1.6. We experimented with lower values of k_{\max} but found that test outcomes were not affected and report only results based on a value of 8.

For each equation estimated we also report a Ljung-Box Q-test of residual autocorrelation in the ADF equation. Following Smyth and Inder (2004) and others, we choose a lag value for the Q-test of 15 (again, rather high for annual data and

³ 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.

⁴ See Dickey and Fuller (1981). Many text-book treatments are available; e.g. Enders (1995).

likely to result in a loss of power of the test) and experiment with lower lags but find little difference. Once k has been chosen the t -statistic for α_1 is compared to the Dickey-Fuller critical values. All tests are performed with a trend term, as shown in equation (1), since given the strong growth in all of the series over the sample the most likely alternative to a non-stationary process is a stationary process about a deterministic trend.

Results for the log of real GDP for each of the three regions are reported in the first panel of Table 1, headed “No break”. In each case, we also report the lag length chosen as well as the Q -statistic for autocorrelation in the residuals of the ADF equation.

[Table 1 about here]

It is clear from the test statistics that all three series are non-stationary. The reported Ljung-Box Q -statistics indicate the absence of autocorrelation in the residuals of the ADF equations. These results are consistent with most findings for real output series both for China (both in Li, 2000, and Smyth and Inder, 2004) and for other countries.

However, other researchers, starting with Perron (1989), have pointed out the importance of allowing for a possible break (or breaks) in the data, the omission of which may well result in a finding of non-stationarity when the variable is stationary once the break is allowed for. It is possible to choose the break date exogenously or endogenously, based on the characteristics of the data. The latter approach adjusts the critical values for the ADF tests to allow for the search for the best break point as well as for the presence of the break term in the equation. In both cases it is possible to allow for level and/or trend breaks. We choose the break dates exogenously since there are dramatic historical events which suggest themselves are appropriate dates; all discussions of Chinese economic history since 1949 mention at least three momentous events which we entertain as break dates: the Great Leap Forward of 1958-61, the Cultural Revolution of 1966-76 and the opening up of China to the rest of the world under Deng Xiaoping starting in 1978. We therefore initially entertained break dates of 1958, 1966 and 1978 but discarded the first because ADF tests using long lags could not accommodate this break date, given the starting period of 1953 for our data set.

We begin by allowing just one break date, either at 1966 or 1978, in each series, first in the level, then in the trend and then in both. The results are reported in panels (b), (c) and (d) of Table 1 where the reported critical values are taken from

Perron (1989). Like the results reported for the provincial series by Smyth and Inder (2004), the results are mixed. It is clear that a break in level is not sufficient to induce stationarity in any of the three series, no matter whether it is assumed to occur at 1966 or at 1978. A break in trend at 1966 also does not induce stationarity but a single break in trend at 1978 does so for coastal and central regions and does so at 10% for the western region. If we allow for a break in both level and trend at 1966, central and western regions show stationarity while a break in level and trend at 1978 results in coast and central regions showing stationary behaviour while western does so at the 10% level. Thus, it appears that allowing a single break in trend at 1978 is sufficient to generate series which are stationary about a (broken) deterministic trend while there is also evidence for a break at 1966.

This conclusion is in some contrast to earlier work – both Li (2000) and Smyth and Inder (2004) generally require two breaks to produce stationarity in Chinese GDP data although they use tests for an endogenous break and Li tests only aggregate output while Smyth and Inder test provincial-level real output. If we extend our analysis to two breaks by combining the 1966 and 1978 breaks, we obtain the results reported in panels (e), (f) and (g). The results generally reinforce those obtained above, although those for a level and trend break at both dates are rather puzzling – it is difficult to imagine that adding level breaks, even if irrelevant, would make a previously stationary series non-stationary. An additional concern is that some of the ADF equations appear not to be free of autocorrelation judging by the reported Q-statistics. However, given the results of experimentation with alternative lag lengths reported in the footnotes to the table, we consider these few rejections to be spurious.

We conclude, therefore, that all three series are trend stationary if the trend is allowed to break at 1978. There is also a possible break in trend at 1966 and we estimate our model in (log) levels with trend and breaks in trend and level at both 1966 and 1978 before eliminating possible irrelevant break terms.

4. Results

Given our conclusions regarding the nature of the data reached in the previous section, we model the inter-relationship between the variables as a VAR in the (log) levels including a trend with breaks in level and trend at 1966 and 1978. We chose the lag length as a minimum to eliminate autocorrelation in the equation residuals. All equations had significant autocorrelation when lag length was set at 1 but this was

completely eliminated at the 5% level for all equations by extending the lags to 2. Hence a lag length of 2 was chosen and all results reported are based on two lags. Some experimentation was carried out with a longer lag length but the general shape of the IRFs to be presented below were unaffected. The estimated coefficients are reported in Table 2.

[Table 2 near here]

The degree of explanatory power of all the equations is very high which is not surprising since they are estimated in log levels and have a strong trend. The trend is significant in all equations. The level break terms are generally only of marginal significance but the trend breaks are significant in at least one equation, with the 1966 term significant in all three. We therefore retain all the break dummy variables.

We proceed now to an analysis of spillovers based on the simulation of the effects on regional output of shocks to the equation error terms. Before doing so we need to decide on the nature of the shocks. Consider a general VAR(p) model in the n-vector of variables \underline{x}_t :

$$B(0)\underline{x}_t = \underline{b}_0 + B(L)\underline{x}_{t-1} + \underline{\varepsilon}_t \quad (2)$$

where $B(0)$ is an $(n \times n)$ matrix of coefficients capturing the contemporaneous effects between the x s and $B(L)$ is a pth-order matrix polynomial in the lag operator, L :

$$B(L) \equiv B(1) + B(2)L + B(3)L^2 + \dots + B(p)L^{p-1} \quad (3)$$

and $L^j \underline{x}_t \equiv \underline{x}_{t-j}$. The ε s are the structural error terms which are mutually independent; they are the variables we wish to shock in order to examine the effects on the x s. However, the model in (2) cannot be estimated as it stands since it is not identified. Instead the (reduced-form) VAR is usually estimated. It is derived from (2) as:

$$\underline{x}_t = \underline{a}_0 + A(L)\underline{x}_{t-1} + \underline{e}_t \quad (4)$$

where $\underline{a}_0 \equiv B(0)^{-1} \underline{b}_0$, $A(L) \equiv B(0)^{-1} B(L)$ and $\underline{e}_t \equiv B(0)^{-1} \underline{\varepsilon}_t$. This system of equations can be validly estimated using OLS and, at best, we can obtain estimates of the reduced form errors (rather than the structural errors) in the form of VAR residuals.

The MA form of the model is used for simulating the effects of shocks and is derived from the (reduced-form) VAR model, equation (4), as:

$$\underline{x}_t = \underline{c}_0 + C(L) \underline{e}_t \quad (5)$$

where $C(L) \equiv (I - A(L)L)^{-1}$, $\underline{c}_0 \equiv C(L) \underline{a}_0$ and I is the identity matrix of appropriate order. Since we wish to simulate the effects of shocks to the structural errors, we need to identify the ε s. There are various ways of overcoming the problem of identifying the structural errors. The standard approach is to use a Choleski decomposition of the contemporaneous covariance matrix of the VAR errors, Σ :

$$\Sigma = PP'$$

where P is a lower triangular n-matrix. The structural errors are then written as

$$\underline{\varepsilon}_t = P^{-1} \underline{e}_t \quad (6)$$

which are contemporaneously uncorrelated and have a unit variance, given the properties of the P matrix. The effect of a shock to the j th error on the i th x variable after an elapse of τ periods is given by the value of the impulse response function (IRF) at τ :

$$IRF_{ij\tau} = \underline{i}_i' C(\tau) P \underline{i}_j \quad (7)$$

where \underline{i}_k is an n-vector of zeros except for a 1 in the k th position and $C(\tau)$ is the τ th matrix in the matrix polynomial $C(L)$. Note that the P matrix is not unique and therefore the IRFs are not unique. In particular, in the standard applications of the Choleski approach the IRFs (and the corresponding FEVDs) depend on the order in which the variables are listed in the model, an ordering which often has an arbitrary

element. this weakness is mitigated where the ordering can be justified or where the contemporaneous correlation between the errors is weak.

The paper by Carlino and DeFina (1995) uses a different approach to identifying the structure errors – a version of the Bernanke-Sims structural VAR which identifies the structural errors by placing restrictions on the short-run interactions between the variables, i.e. on the matrix $B(0)$.⁵ They use a particularly simple form of the Bernanke-Sims identification scheme and assume that each structural error has a contemporaneous effect only within its own region, with effects on all other regions being lagged. This implies that the contemporaneous coefficients matrix is an identity matrix so that the structural errors are the same as the reduced-form VAR errors. This seems an extreme assumption which we find difficult to maintain when using annual data and it seems to have no great advantage over the more common identification based on the Choleski decomposition of the covariance matrix of the residuals set out above. Although the Choleski approach we use has the drawback explained above, we use this standard approach to identification on the basis that the “natural” ordering of coastal, central and western is at least as plausible as the alternative used by Carlino and DeFina. We will, however, assess the sensitivity of our finding to changes in ordering.

The IRFs for shocks to coastal, central and western are pictured in Figures 3, 4 and 5.

[Figures 3, 4, 5 near here]

The effects appear quite plausible. The shock to the coastal region has similar effects on all three regions, although it has the largest effect on the coastal region itself, followed by central and western as might be expected given the geographic relationship between them. The shock to the central region also has the largest effect on the region itself but followed in this case by the western region and with smaller repercussions for the coastal region. Finally, shocks to the western region seem to have little effect on the rest of the country, being mainly confined to itself. The greater part of the positive spillover in all three cases is completed in about 3 years although there are subsequent damped cyclical effects for a further period of up to 10 years. Thus, overall the flow of spillovers is from the coast to the centre and from the centre to the west but with little return effect of the west on the other two regions.

⁵ See Sims (1986) and Bernanke (1986).

This suggests the tentative conclusion that region-specific policy will have the greatest flow-on effects if they are applied to the coastal region but that the effects of development policies focussed on the western provinces will affect the west beneficially but have little effect on the rest of the country.

These results are reasonably consistent with those obtained by Brun *et al.* (2002), who found that coastal shocks had significant and positive flow-on effects to the central provinces but no significant effect on the western provinces. Their analysis does not allow for effects of western and central shocks and therefore throws no light on whether these will have spillover effects. Moreover, their analysis provides no information on magnitudes or timing of the spillovers.

Before drawing this conclusion too firmly, however, we should subject the model to some robustness-testing. First, we experimented with a model which omits the largely insignificant dummy variables for level breaks but this has no effect on the shape of the IRFs. Moreover, as we have already mentioned, the use of three rather than two lags in the model also leaves the broad conclusion largely unaffected. However, the results are not insensitive to the ordering of the variables in the model, a potential problem we highlighted when discussing the Choleski identification procedure above. While we have argued that there is a certain naturalness to the ordering of coastal, central and western regions which we have used, it is possible to consider alternatives. When we do this, we find that the order of the second and third variables has little effect on the nature of the IRFs but that the identity of the first-ordered variable is crucial.

If we examine the data over our sample period, we see that the three series move closely together and that they appear to be affected by several very large common shocks which are likely to swamp our attempts to accurately measure finer inter-relationships. This feature is particularly marked over the first part of the sample and we proceed to test the stability over the sample period using a test of parameter stability due to Andrews (1993). It proceeds by carrying out a Chow-type test for parameter stability at each point in the sample (although we follow Andrews' suggestion of omitting the first and last 15% of observations) and picking the break point at which the test statistic is maximised. This maximised statistic is then compared to critical values reported by Andrews which take account of the "data-mining" used to find the optimal break-point. The procedure is applicable to Likelihood-Ratio (LR), Lagrange Multiplier and Wald versions of the test for

parameter stability in a system of equations. We used the LR statistic which allowed for all parameters in the model to vary across the break-point. The value of the test statistic is pictured in Figure 6 together with its 5% critical value of 41.36.

[Figure 6 near here]

The figure clearly shows that the model parameters are highly unstable over the first part of the sample period and that only in the second part of the 1980s and 1990s can a stable model be estimated.

We therefore re-estimate the model for the period 1982-2003 which covers the period after the reforms started by Deng Xiaoping had been well-established and perhaps there was by then a reasonable certainty about the future direction of economic development. We do not re-run the stationarity tests for this shorter period since our earlier results have already shown that if we allow for a trend break at 1978, the variables are all stationary fluctuations about a trend. The estimated model for this shorter period is reported in Table 3.

[Table 3 near here]

To preserve comparability with the previous model, we estimate the model with two lags. Diagnostics show that all three equations are free of residual autocorrelation at 5%. The trend term is again significant in all equations and given the shorter sample period, the break dummy variables are not applicable.

The IRFs from this model are shown in Figures 7, 8 and 9.

[Figures 7, 8 and 9 about here]

The shock to the coastal region has much the same effect as for the full sample in terms of pattern although the magnitude is smaller and the cyclical fluctuations are also smaller. The timing is similar to that for the full sample. The smaller magnitude of the spillovers is not surprising in view of the smaller volatility in the second part of the sample and the correspondingly smaller s.e.'s and therefore smaller initial shocks. Thus the coastal region continues to have substantial spillovers to the other two regions, only slightly smaller than the effects on itself. The effects of a shock to the

central region are also much smaller for the sub-sample than they were for the full sample and surprisingly, the effect on the western region is slightly larger than on itself. Moreover, subsequent fluctuations are more violent than for the full sample. The IRF for the western region has undergone the greatest change but still indicates that the western region has little effect on the rest of the country. Thus overall, the greatest spillover effects emanate from the coastal region which influences both other regions, shocks to the central region spillover to the western region and shocks to the western region are felt only in that region itself.

5. Conclusions

This paper has focussed on the strength, direction and timing of spillover effects among the three traditionally-defined regions in China: coastal, central and western regions. We used annual data for the period 1953-2003 and conducted our analysis within the framework of a vector-autoregressive model which allows us to analyse the dynamic inter-relationships between variables without the need to impose a prior theoretical structure. We found that there are strong spillovers from the coastal region to the other two regions while shocks to the central region spillover only to the west while western shocks affect only that region itself. The initial positive spillovers lasted about 3 years but there were subsequent cyclical fluctuations which went on for a further 8-10 years although these were progressively damped.

The model was tested for structural stability which is particularly important given the momentous changes in economic policy and development on China over the last 50 years. We found considerable evidence of instability in the first part of the sample period and re-estimated the model over the more stable second part of the sample. The dynamic effects, however, were little different over this shorter period although shocks were smaller.

It appears, therefore, that a policy favouring the coastal region will have benefits for the whole country while development in the central provinces will have more limited general effects and western development will benefit only that region. An important caveat to these conclusions is the dependence of the simulation results on the ordering of the variables in the VAR model. While this is a matter of modelling choice, we feel that the order of coastal, central, western which we used is a natural one although alternatives are possible. Since this feature is a consequence of

the limited information in the data, we conjecture that further spatial disaggregation of the data may be useful in disentangling the separate effects more clearly.

References

- Andrews, D.W.K. (1993), 'Tests for Parameter Stability and Structural Change with Unknown Change Point', *Econometrica*, 61, pp. 821-856.
- Barro, R. J. and X. Sala-i-Martin (1992), "Convergence", *Journal of Political Economy*, 100, 223-251.
- Bernanke, B. (1986), 'Alternative Explanations of the Money-Income Correlation', *Carnegie-Rochester Conference Series on Public Policy*, 25, pp. 49-100.
- 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, pp. 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.
- Carlino, G. and R. DeFina (1995), "regional Income Dynamics", *Journal of Urban Economics*, 37, pp 88-106.
- Chang, G. H. (2002), "The cause and Cure of China's Widening Income Disparity", *China Economic Review*, 13, 335-340.
- Chen, J. and B. M. Fleisher (1996), "Regional Inequality and Economics Growth in China", *Journal of Comparative Economics*, 22, 141-164.
- Clark, T. E. (1998), "Employment Fluctuations in the U.S. Regions and Industries: The Roles of National, Region-Specific and Industry-Specific Shocks", *Journal of Labor Economics*, 16, 202-229.
- Cooley, T. F. and S. F. Leroy (1985), "Atheoretical Macroeconomics: A Critique", *Journal of Monetary Economics*, 16, 283-308.
- Cromwell, A.B. (1992), "Does California Drive the West? An Econometric Investigation of Regional Spillovers", Federal Reserve Bank of San Francisco *Economic Review*, 2, pp.15-25.
- 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, G. Chang and A. Mellinger. (2002). "Geography, Economic Policy and Regional Development in China", NBER Working Paper 8897, April 2002.

- 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.
- Dickey, D.A. and W. A Fuller (1981), ‘Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root’, *Econometrica*, 49, pp. 1057-1072.
- Enders, W. (1995), *Applied Econometric Time Series*, Wiley, New York.
- 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.
- Hall, A.D. (1994), “Testing for a Unit Root in Time Series with Pretest Data Based Model Selection”, *Journal of Business and Economic Statistics*, 12, pp. 461-470.
- 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.
- Keating, J. W. (1992), “Structural Approaches to Vector Autoregressions”, *Federal Reserve Bank of St Louis Review*, 37-57.
- Kouparitsas, M. A. (2002), “Understanding US Regional Cyclical Comovement: How Important Are Spillovers and Common Shocks?”, *Federal Reserve Bank of Chicago Economic Perspectives*, 4th quarter, 30-41.
- Kuznets, S. (1955), “Economic Growth and Income Inequality”, *American Economic Review*, 45, 1-28.
- Leamer, E. E. (1985), “Vector Autoregressions for Causal Inference?”, *Carnegie-Rochester Conference Series on Public Policy*, 22, 255-304.
- Li, X.-M. (2000), “The Great Leap Forward, Economic Reforms and the Unit Root Hypothesis: Testing for Breaking Trend Functions in China’s GDP Data”, *Journal of Comparative Economics*, 28, pp.814-827.
- Liu, X. and Y. Wei (2003), “Convergence or Divergence? Debate on China’s Regional Development”, Conference on Openness, Competition and Economic Growth in China, Xi’an Jiaotong University, Xi’an, China, September, 2003.
- Lu, D. (2002), “Rural-Urban Income Disparity: Impact of Growth, Allocative Efficiency and Local Growth Welfare”, *China Economic Review*, 13, 419-429.

- Perron. P. (1989), ‘The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis’, *Econometrica*, 57, pp. 1361-1401.
- Rissman, E. R. (1999), ‘Regional Employment Growth and the Business Cycle’, Federal Reserve Bank of Chicago *Economic Perspectives*, 4th quarter, 21-39.
- Sherwood-Call, C. (1988), ‘Exploring the Relationship between National and Economic Fluctuations’, Federal Reserve Bank of San Francisco *Economic Review*, summer, 15-25.
- Sims, C. A. (1980), ‘Macroeconomics and Reality’, *Econometrica*, 48, 1-48.
- Sims, C. A. (1982), ‘Policy Analysis with Econometric Models’, *Brookings Papers on Economic Activity*, 1, 107-152.
- Sims, C.A. (1986), ‘Are Forecasting Models Usable for Policy Analysis?’, Federal Reserve Bank of Minneapolis *Quarterly Review*, 3-16.
- Smyth, R. and B. Inder (2004), ‘Is Chinese Provincial Real GDP per capita Nonstationary? Evidence from Multiple Trend Break Unit Root Tests’, *China Economic Review*, 15, pp. 1-24.
- State Statistical Bureau (2004), *China Statistical Abstract*, Statistical Publishing House of China, Beijing.
- State Statistical Bureau (various issues), *Statistical Yearbook of China*, Statistical Publishing House of China, Beijing.
- Williamson, J. (1965), ‘Regional Inequality in the Process of National Development’, *Economic Development and Cultural Change*, 17, 3-84.
- Wu, Y. (2004), *China’s Economic Growth: A Miracle with Chinese Characteristics*, London: Routledge Curzon.
- Yang, D. T. (2002), ‘What Has Caused Regional Inequality in China?’, *China Economic Review*, 13, 331-334.
- Yao. S. and Z. Zhang (2001a), ‘Regional Growth in China Under Economic Reforms’, *Journal of Development Studies*, 38, 167-186.
- Yao, S. and Z. Zhang (2001b), ‘On Regional Inequality and Diverging Clubs: A Case Study of Contemporary China’, *Journal of Comparative Economics*, 29, 466-484.
- Ying, L. G. (2000), ‘Measuring the Spillover Effects: Some Chinese Evidence’, *Papers in Regional Science*, 79, pp. 75-89.

Table 1
Stationary tests: log real GDP

Region	TB	ADF statistic	test lags	Ljung-Box statistic	Q-	P-value
(a)No break						
Coastal		-1.45	8	15.96		0.39
Central		-1.21	3	9.28		0.86
Western		-1.88	3	12.19		0.67
(b)One break in the level						
Coastal	1966	-1.77	8	16.89		0.32
Coastal	1978	-1.61	8	15.8		0.39
Central	1966	-2.86	1	13.01		0.60
Central	1978	-1.16	3	9.38		0.86
Western	1966	-3.37	1	14.88		0.46
Western	1978	-1.90	3	12.81		0.61
(c)One break in the trend						
Coastal	1966	-1.61	8	17.14		0.31
Coastal	1978	-4.47	1	10.49		0.79
Central	1966	-2.97	3	8.74		0.89
Central	1978	-4.64	1	10.98		0.75
Western	1966	-3.52	5	12.33		0.35
Western	1978	-3.75	1	11.08		0.75
(d)One break in the level and trend						
Coastal	1966	-1.74	8	16.98		0.32
Coastal	1978	-4.42	1	10.58		0.78
Central	1966	-4.26	1	9.80		0.83
Central	1978	-7.15	7	29.28		0.02 ¹
Western	1966	-5.96	1	14.46		0.49
Western	1978	-4.08	1	11.58		0.71
(e)Two breaks in the level						
Coastal	1966 1978	-2.52	8	22.93		0.08 ²
Central	1966 1978	-2.80	1	13.17		0.59
Western	1966 1978	-3.33	1	15.06		0.45
(f)Two breaks in the trend						
Coastal	1966 1978	-5.57	1	9.72		0.84
Central	1966 1978	-4.44	7	26.12		0.04 ³
Western	1966 1978	-6.62	2	12.44		0.65
(g)Two breaks in the level and trend						
Coastal	1966 1978	-3.19	8	18.25		0.25
Central	1966 1978	-3.28	7	23.89		0.07 ⁴
Western	1966 1978	-3.36	8	16.68		0.34

TB is the break date. The Ljung-Box Q-statistic is for 15 lags. The p-values in the last column refer to the Ljung-Box Q-test. The 5% ADF critical value without break is -3.51. The 5% ADF critical value with one break (1966 or 1978) in the level is -3.76. The 5% ADF critical value with one break in trend at 1966 is -3.87 and at 1978 is -3.96. The 10% ADF critical value with one break in trend at 1966 (1978) is -3.58 (-3.68). The 5% ADF critical value with one break in level at 1966 (1978) is -4.17 (-4.24). The 10% ADF critical value with one break in level and trend at 1966 (1978) is -3.87 (-3.96).

Notes:

1. When the maximum of lags is 5, the ADF statistic value is -4.63 (lag equals to 1 and the P-value of Q-statistic for 15 lags is 0.75)
2. When the maximum of lags is 5, the ADF statistic value is -2.75 (lag equals to 1 and the P-value of Q-statistic for 15 lags is 0.82)
3. When the maximum of lags is 5, the ADF statistic value is -5.92 (lag equals to 2 and the P-value of Q-statistic for 15 lags is 0.83)
4. When the maximum of lags is 5, the ADF statistic value is -6.05 (lag equals to 2 and the P-value of Q-statistic for 15 lags is 0.68).

Table2
 VAR for full sample (1953-2003)

Regressor	<u>Coastal</u>		<u>Central</u>		<u>Western</u>	
	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat
Lco(-1)	0.4164	0.9836	-0.3479	-0.8338	-0.0744	-0.1915
Lco(-2)	-0.3722	-0.9881	-0.1680	-0.4523	-0.4566	-1.3196
Lce(-1)	0.7067	1.4432	1.0905	2.2591	0.3406	0.7574
Lce(-2)	-0.2226	-0.4802	-0.0845	-0.1848	0.0995	0.2338
Lwe(-1)	-0.1259	-0.4561	0.1855	0.6815	0.5901	2.3267
Lwe(-2)	0.0396	0.1462	-0.2410	-0.9019	-0.2493	-1.0010
Constant	2.2766	5.3824	2.1079	5.0551	2.3051	5.9332
Trend	0.0168	2.4131	0.0153	2.2343	0.0181	2.8273
DU2	-0.0440	-0.6905	-0.0247	-0.3941	-0.1093	-1.8659
DU3	-0.1045	-1.7170	-0.0604	-1.0070	-0.0472	-0.8453
DT2	0.0372	3.1732	0.0289	2.5041	0.0480	4.4541
DT3	0.0128	1.5800	0.0165	2.0528	0.0100	1.3414
\bar{R}^2	0.9967		0.9956		0.9964	
P-value	0.7560		0.3920		0.063 ¹	

Lco is the log of real GDP for the coastal region, Lce is the log of real GDP for the central region and Lwe is the log of real GDP for the western region. The p-value is that of Q(15) .

¹ Only the Q-statistics at lags 1 and 15 have p-values less than 0.1.

Table3
 VAR for the subsample (1982-2003)

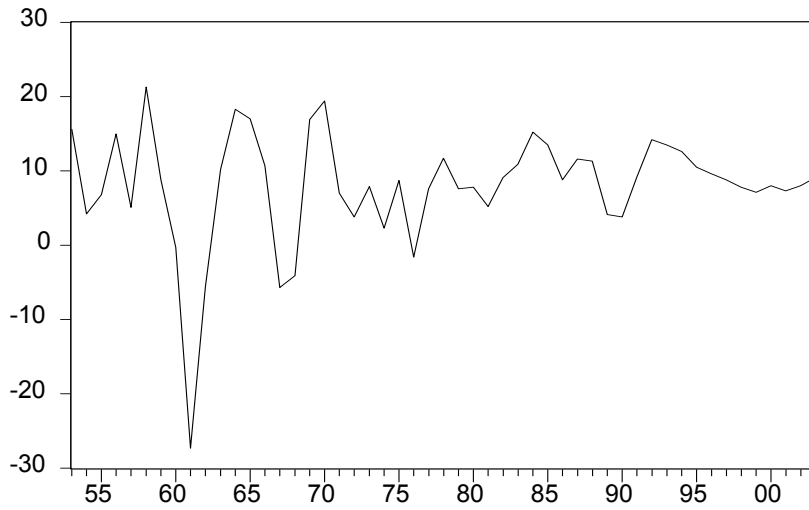
Regressor	<u>Coastal</u>		<u>Central</u>		<u>Western</u>	
	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat
Lco(-1)	0.8996	1.7853	0.1004	0.2647	-0.1329	-0.3284
Lco(-2)	-0.3893	-0.8843	0.0138	0.0417	-0.5488	-1.5521
Lce(-1)	0.8417	1.2466	1.3363	2.6281	1.5385	2.8370
Lce(-2)	-0.7828	-1.2835	-0.6159	-1.3412	-0.8745	-1.7853
Lwe(-1)	-0.4527	-1.2970	-0.2639	-1.0041	-0.1165	-0.4158
Lwe(-2)	0.2932	0.7382	-0.0667	-0.2230	0.8378	2.6259
Constant	1.1323	4.1658	0.7638	3.7315	0.6254	2.8646
Trend	0.0627	3.7808	0.0432	3.4595	0.0368	2.7637
\bar{R}^2	0.9990		0.9991		0.9990	
P-value	0.879 ¹		0.8650		0.024 ²	

Lco is the log of real GDP for the coastal region, Lce is the log of real GDP for the central region and Lwe is the log of real GDP for the western region. The p-value is that of Q(15) .

¹ Only the Q-statistic at lag 2 has p-values less than 0.1.

² Only the Q-statistics at lags 13, 14 and 15 have p-values less than 0.1.

Figure 1: Growth Rate



Source: State Statistical Bureau (various issues) and Wu (2004)

Figure 2: Standard Deviation

(growth rates of provinces)



Source: State Statistical Bureau (various issues) and Wu (2004)

Figure 3:

Response to one s.e. shock to coastal

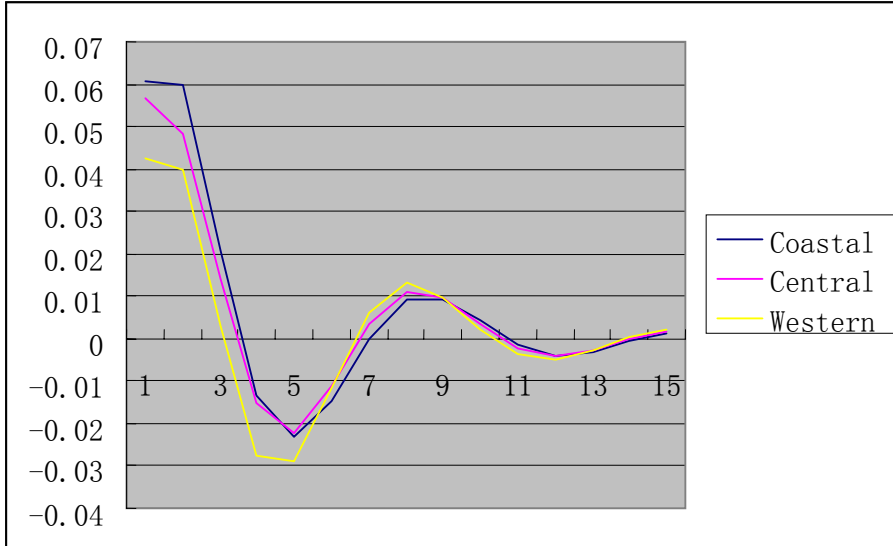


Figure 4:

Response to one s.e. shock to central

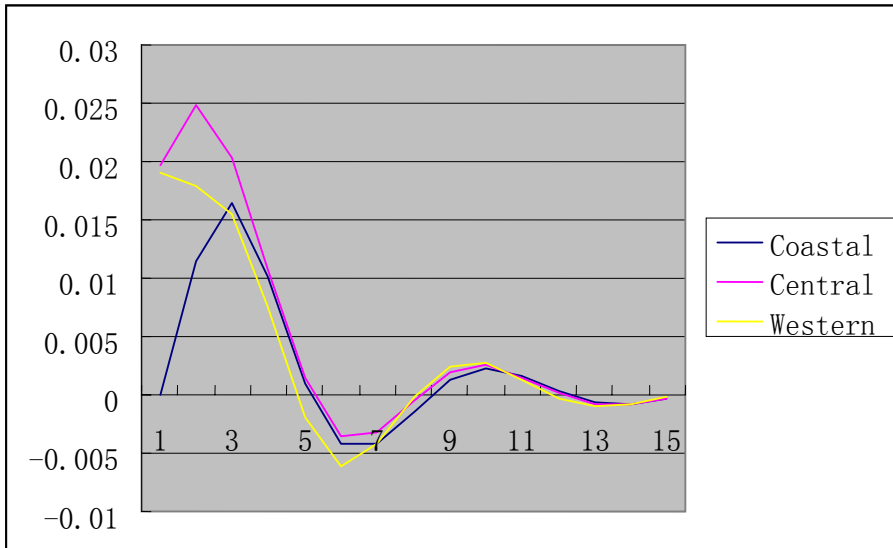


Figure 5:

Response to one s.e. shock to Western

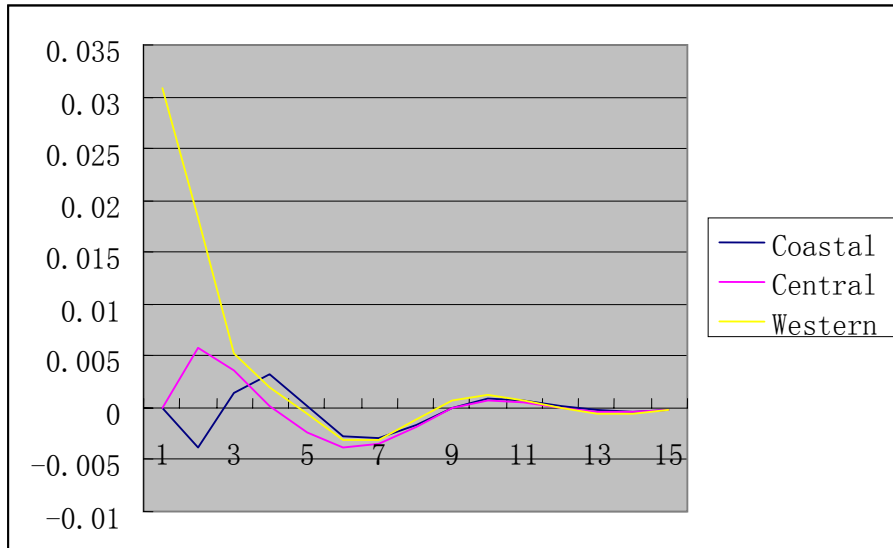


Figure 6: Andrews Test

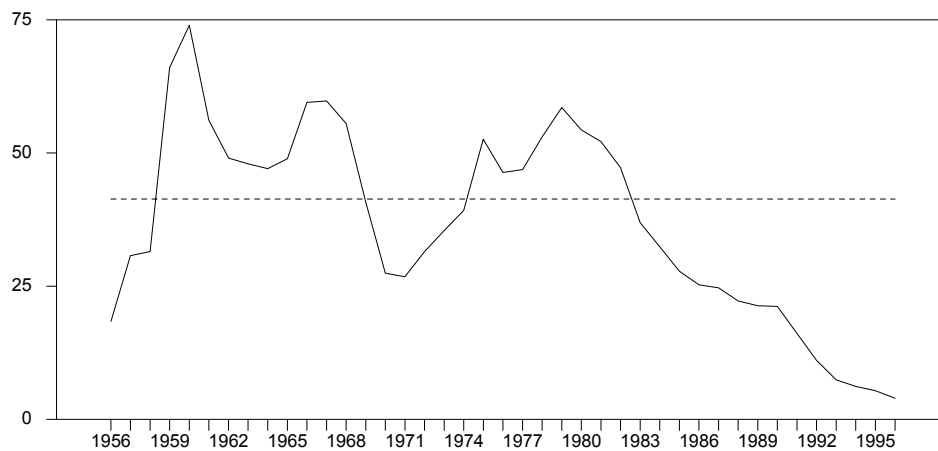


Figure 7:

Response to one s. e. shock to coastal

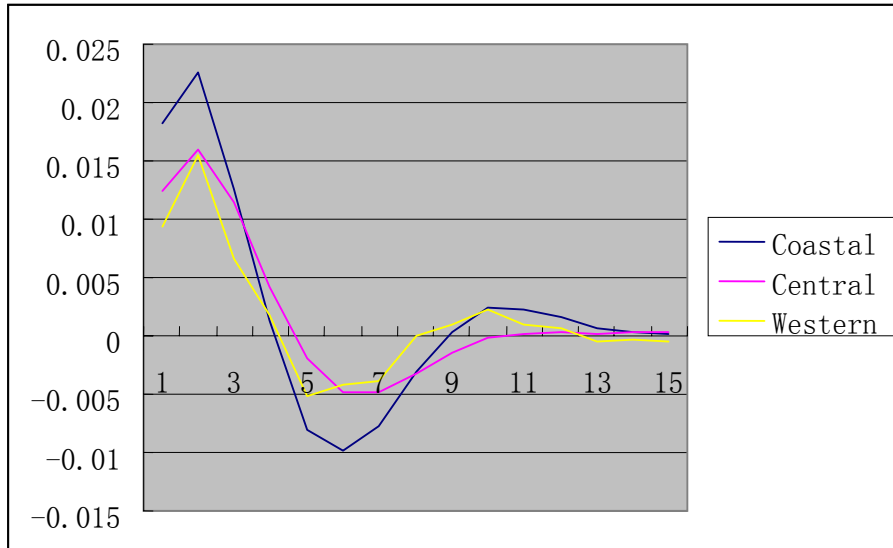


Figure 8:

Response to one s. e. shock to central

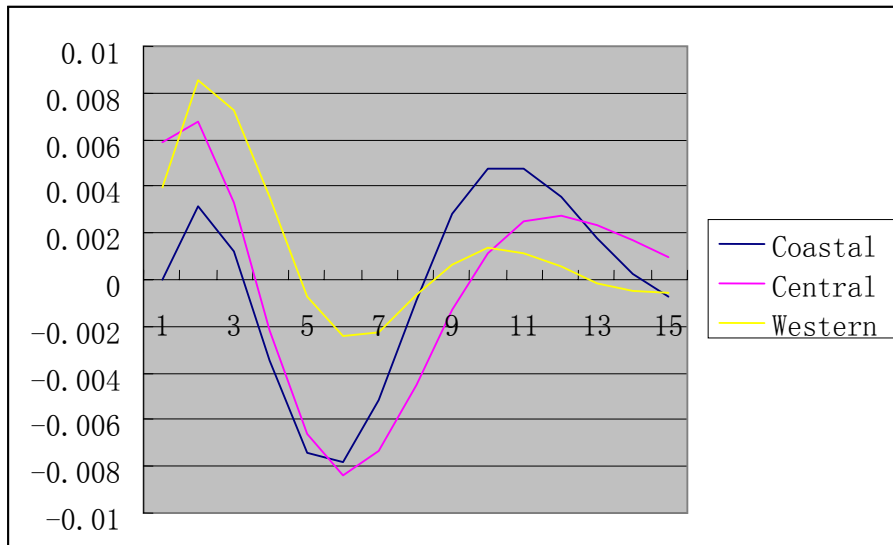


Figure 9:

Response to one s.e. shock to Western

