INTERREGIONAL OUTPUT SPILLOVERS IN CHINA: DISENTANGLING NATIONAL FROM REGIONAL SHOCKS

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ABSTRACT: This paper reports an investigation of the spillover effects of output shocks between regions in China. We use a six-region classification first suggested about two decades ago which still captures relatively homogeneous regions. We start from a recent paper by Groenewold, Lee and Chen (2005) which uses the same six regions and a vector autoregressive (VAR) framework. They find that the spillover effects are crucially dependent on the order of the variables in the model due to common national influences. They overcome the "ordering problem" by using a two-step procedure. We implement an alternative solution which proceeds by including national output directly into our model. Moreover, we extend their analysis by investigating Granger-causality between regional and national output measures as well as block exogeneity. Our results confirm important conclusions of the earlier paper but also raise some interesting differences.

1. INTRODUCTION

China's economic growth in the 30 years since the beginning of economic reforms under Deng Xiaoping in 1978 has averaged 9.5 percent per annum – an outstanding record by any standards. This rapid growth has been far from smooth, however. Over time, the growth rate has fluctuated between 3 and 15 percent in the post-1978 period with fluctuations even larger if we consider the experience of the pre-reform period.

Growth has not only fluctuated over time but the spatial distribution has also been far from uniform. Moreover, this has occurred in a number of dimensions. Two of the most important arise from the urban-rural distinction and the regional disaggregation of the country. In this paper we focus on the latter with the regions based on aggregations of the provinces.

In the post-1978 period the average annual growth rate has varied from a low of 7.6 percent for Qinghai province in the north-west of China to rates over 13 percent for the south coastal provinces of Zhejiang, Fujian and Guangdong. Of greater concern than the differences in growth rates is the fact that, by and large, these differences have exacerbated already large disparities in per capita output levels. Thus in 2005 Qinghai had a per capita GDP of 10,030 yuan compared to that of Zhejiang of 27,369, Fujian of 18,613 and Guangdong of 23,674.[1]

Not surprisingly, the spatial distribution of economic activity and welfare has been the subject of considerable interest to both policy-makers and academic researchers. Policy-makers have regularly expressed concern about the adverse implications of regional disparities for national cohesion. Thus, for example, one of the key issues discussed in the context of the recent fifth plenary session of the 16th Central Committee of the Communist Party was the gap between rich and poor regions which was seen as a major potential source of political instability in a country where the difficulty of holding the empire together has always been a central challenge for the political leadership.

Moreover, this has long been recognised.[2] While the early Five-Year Plans focussed on industrialisation concentrating on the north-eastern provinces, from the mid-1960s the Five-Year Plans have regularly recognised the necessity to address the widening disparities in regional output, although policy responses have varied over time. Thus, a decade later in the Fifth Five-Year Plan (1976-1980) there was a shift of focus back to the coast and this policy of unbalanced growth was continued at least until the Seventh Five-Year Plan (1986-1990). It can be presumed that this redirection of capital to the already fast-growing coastal provinces was based on the argument that the scarce development resources of the country should be allocated to those regions likely to benefit most in terms of growth and the expectation that fast-growing coastal regions would act as a growth locomotive, taking the rest of the country with it.

As already mentioned, 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. This is evidenced by a number of special policies: 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) and the Eleventh Five-Year Plan in which there has been a major push to redress the growing regional disparities. Whether it is envisaged that greater equity will be at the cost of the national average growth rate, however, remains to be seen.

Notwithstanding the more recent shift in regional focus, there appears to be limited understanding of the linkages between regions – does the expansion of output in one region benefit or hinder output in neighbouring regions? In terms of an earlier regional development literature (see, e.g., Myrdal, 1957, and Hirschman, 1958), do “spread” or “backwash” effects dominate the economic relations between regions? Moreover, how strong are the linkages, how long do they take to work and how long do they last? Answers to questions such as these are clearly crucial to the development of policy designed to redress regional

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1 Per capita GDP data are from *China Statistical Abstract 2006.*

2 For a more extensive discussion of the regional implications of the various Five-Year Plans, see Groenewold, *et al.* (2005).

inequities. While there has been some discussion of these inter-regional real output spillovers, there is remarkably little empirical work assessing their strength, direction and timing, notwithstanding the large empirical literature on Chinese regional economic growth. Indeed, there are, to our knowledge, only a handful of papers which directly address the question of regional spillovers in China – Ying (2000), Zhang and Felmingham (2002), Brun, Combes and Renard (2002) and Groenewold, Lee and Chen (2005, 2007).

After reviewing these existing papers, we argue that, while some consensus on the strength and direction of spillovers seems to be developing, there is still much ambiguity and much work needs to be done before we have clear answers to the question of whether and how output changes in one region influence output in other regions.

It is the aim of this paper to contribute to the limited literature in this area by extending the work of Groenewold, *et al.* (2005). They use a vector-autoregressive (VAR) model with six regions as a framework for dynamic simulation of the effects of a shock to one region on the other regions.

We follow Groenewold, *et al.* (2005) in using a six-region VAR model. A VAR model is a formal method for summarising and analysing the dynamic interaction between variables without imposing prior theoretical constraints. It is ideally suited to our aim of analysing the dynamic inter-relationships between regional outputs for a country for which the more extensive data required for structural modelling are often unavailable.

It is well-known, however, that the use of a VAR model is not without its drawbacks. One of these is the "ordering problem", viz., in many applications the simulation results are sensitive to the order in which the variables are included in the model. Groenewold, *et al.* (2005) also raise this issue. They find that simulations generated by a standard VAR model are, indeed, sensitive to the ordering of the variables in the model and they attribute this to the pervasive influence of a common shock on the regional outputs. They go on to address this problem by removing the common influence using a two-step regression approach.

The contribution in the present paper is to explore an alternative method of solving "the ordering problem" which avoids the potential econometric problems of the two-step procedure.[3] This is especially important since the conclusions may depend on the method of addressing the problem and, yet, there is little guidance in the VAR literature on the appropriate procedure. Thus sensitivity analysis is vital to obtain a firmer understanding of the inter-regional forces at work.

A further contribution is that we extend their analysis to include a set of tests of Granger-causality and block exogeneity amongst the national and regional output levels.

The remainder of the paper is structured as follows. Section 2 places our work in its context by providing a brief review of the relevant literature. Section

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[3] In particular, it has long been recognised (see, e.g., Pagan, 1986) that regressors generated by an earlier regression procedure give rise to errors-in-variables problems.

3 describes the data and includes a discussion of the definition of the regions and the results of extensive stationarity tests. In section 4 we set out the VAR model and explain the process used for simulation which gives rise to the ordering problem. The model estimation and simulations are reported in section 5, in which we also present the results of our Granger-causality and block exogeneity analysis. Our conclusions are presented in the final section.

2. LITERATURE REVIEW

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).[4]

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.

To our knowledge, only five papers have explicitly examined inter-regional spillovers for China, generally using different methods of analysis. The first, by Ying (2000) using provincial output data, found the strongest significant influence being exerted by Guangdong province with which there were significant correlations with four of the five contiguous provinces although two were positive and two negative. However, his technique of spatial data analysis is essentially one of static growth correlations which does not permit the analysis of the direction, strength and timing of the relationships, questions that are central to the interest of this paper.

The pair of papers by Brun, Combes and Renard (2002) and Zhang and Felmingham (2002) both analyse inter-regional spillovers within a standard growth framework and as an aside to other questions – Brun, *et al*. to the question of growth convergence and Zhang and Felmingham to the issue of relationship between exports, FDI and growth. They both find evidence of spillovers from the coast to the centre and, in Zhang and Felmingham's case, to the west. However, in both cases their analysis is limited to testing the

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[4] The literature goes back at least to the work of Kuznets (1955) and Williamson (1965); the concept was more recently developed in Barro and Sala-i-Martin (1992). There is a vast empirical literature. Some important papers with a bias to Chinese applications are: 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) and Demurger, Sachs, Woo, Bao and Chang (2002).

significance in growth equations of spillover proxies which they treat as exogenous, thus excluding the possibility of feedback between all regions and falling short of a thorough-going dynamic analysis of the interaction between the regions.

The final pair of extant papers is by Groenewold, Lee and Chen (2005, 2007). The second of these uses annual data for three regions (conventionally defined as coastal, central and western) for the period 1953-2003 to estimate and simulate a VAR model.[5] In that paper it is found 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. They admit, however, that their simulation results are sensitive to the order in which the variables appear in their model (the "ordering problem"), the choice of which has an arbitrary element although they argue that their order (coast, central, west) is a natural one. In the first of these two papers the authors extend the number of regions to six and explicitly address the ordering problem. They argue that it stems from a strong common component in the regional output series which they identify as the national component. Their solution to the problem is to purge the regional output series by regressing them on national output, using the residuals from these regressions as the variables in the second stage of their analysis, viz., the estimation and simulation of the VAR. They find that the severity of the ordering problem is substantially reduced in that simulation results are relatively insensitive to the order of the variables. They are able, therefore to reach firmer conclusions. They found, not surprisingly, that the Yellow River and Changjiang River regions had spillover effects although they were more extensive for the former; the South Western region had no significant spillovers effects on the rest of the country, consistently with other research results. However, in contrast to other research, shocks to the South East affect mainly the region itself with little spillover to the other regions while the North West region has general spillover effects. The unexpected nature of some of these results suggests that much more is to be learned about the direction, timing and strength of inter-regional spillovers in China.

In the present paper we contribute to the literature by a further exploration and extension of the six-region analysis in Groenewold *at al.* (2005). Like them, we use the VAR framework and within this model we propose and assess an alternative way to use national output to purge the regional outputs of their common component which does not involve the potentially problematic two-step approach. Secondly, we extend the analysis of the VAR to include tests of Granger-causality and block exogeneity.

3. DATA AND DEFINITION OF THE REGIONS

The regional output data used are based on real provincial GDP for the period 1953-2003. The sources of the data are two-fold: the early data come from Wu

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[5] A set of papers using a modelling approach similar to the one used in Groenewold *et al.* (2005, 2007) applied to the US are Sherwood-Call (1988), Cromwell (1992) and Carlino and DeFina (1995), Clark (1998), Rissman (1999) and Kouparitsas (2002).

(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* 2004 (State Statistical Bureau, 2004).

Like Groenewold, *et al.* (2005) we use six regions which include the following provinces.[6]

- The South East (SE) region: Guangdong (including Hainan), Fujian and Guangxi
- The Changjiang River (CR) region: Shanghai, Jiangsu, Zhejiang, Hubei, Hunan, Jiangxi and Anhui
- The Yellow River (YR) region: Inner Mongolia, Henan, Shanxi, Beijing, Tianjin, Shandong and Hebei
- The North East (NE) region: Heilongjiang, Jilin and Liaoning
- The South West (SW) region: Yunnan, Guizhou, Sichuan (including Chongqing)
- The North West (NW) region: Xinjiang, Gansu, Qinghai, Ningxia and Shaanxi

A map showing the six-region division of mainland China is shown in Figure 1.

Before proceeding to the specification of the model, we test the (log) real output series for stationarity. There is some disagreement in the literature as to the necessity of using stationary variables in a VAR model. We take the view that it is not important if the sole objective is to simulate the model to elucidate the dynamic patterns in the data but that we should use stationary data if we wish to engage in hypothesis-testing. In this paper we wish to use the model in both ways so we test for stationarity. Following the findings of Groenewold, *et al.* (2007) for the three-region case, we experiment with a trend with breaks in level and trend at 1966 and 1978. Table 1 shows results for the six regions as well as for the nation as a whole. National output is included in the stationarity tests since, for reasons to be explained in section 4 below, we also include national output as a variable in the VAR model.

It is clear from the table that tests with no breaks lead to a conclusion of non-stationarity for all seven variables. Moreover, a break in trend at 1978 to mark the beginning of the opening up of the Chinese economy to foreign interaction is sufficient in all but one case to produce stationarity. The one exception is the SW region which requires a break in both level and trend at 1966 to ensure stationarity. We therefore proceed to model the variables as stationary about a broken trend and intercept with breaks at both 1966 and 1978. Experimentation with omitting the breaks show that the nature of the simulation results are not affected.

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[6] For greater detail on the reasons for the definition of the regions and a general description of their characteristics see Groenewold, *et al.* (2005).

Figure 1. The Six Regions of Mainland China

Table 1. Stationarity Tests for (log) Real GDP

Region	No break	One break in level		One break in trend		One break in level and trend	
		1966	1978	1966	1978	1966	1978
NAT	-1.74	-2.48	-1.68	-2.22	-4.97***	-4.96***	-4.92***
SE	-1.30	-2.12	-1.20	-2.65	-4.11**	-3.05	-3.85
CR	-1.09	-2.44	-1.64	-3.63*	-4.49**	-3.94*	-4.45**
YR	-1.44	-2.97	-1.42	-2.94	-4.40**	-1.96	-4.37**
NE	-3.13	-2.89	-3.11	-5.03***	-4.56***	-5.04***	-4.51**
SW	-2.76	-3.29	-2.75	-3.35	-3.11	-5.77***	-3.33
NW	-1.70	-1.73	-1.68	-3.49	-4.67***	-5.62***	-4.68**

Notes: "***" indicates significance at 1%, a "**" at 5% and a "*" at 10% for the ADF test.

4. THE VAR MODEL

As indicated earlier, the framework we use for the analysis of inter-regional spillovers is a vector autoregressive (VAR) model. To clarify the nature of the ordering problem, we set out the model in some detail. It is useful to start from a general linear *p*th-order dynamic model in the n-vector of variables $\underline{x}_t$:

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

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*:

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

and $L^j \underline{x}_t \equiv \underline{x}_{t-j}$. The *ε*s are the structural error terms which are mutually independent. Our dynamic analysis consists of shocking one of these errors at a time and tracing the effects on all the *x*s over time, the results being captured in the impulse-response functions (IRFs).

The model in (1) cannot be estimated as it stands since it is not identified. Instead the (reduced-form) VAR is usually estimated. It is derived from (1) as:

$$\underline{x}_t = \underline{a}_0 + A(L)\underline{x}_{t-1} + \underline{e}_t \tag{3}$$

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. However, we can, at best, obtain estimates of the reduced form errors (rather than the structural errors) in the form of VAR residuals.

The moving-average (MA) form of the model is used for generating the IRFs and is derived from the (reduced-form) VAR model, equation (3), as:

$$\underline{x}_t = \underline{c}_0 + C(L)\underline{e}_t \tag{4}$$

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 accomplishing this but all require additional assumptions. 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:

$$\underline{\varepsilon}_t = P^{-1}\underline{e}_t \tag{5}$$

which are contemporaneously uncorrelated and have a unit variance, given the properties of the *P* matrix:

$$E(\underline{\varepsilon}_t\underline{\varepsilon}_t') = E(P^{-1}\underline{e}_t\underline{e}_t'(P^{-1})') = P^{-1}E(\underline{e}_t\underline{e}_t')(P')^{-1} = I$$

where *I* is the identity 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 relevant IRF at τ:

$$IRF_{ij\tau} = \underline{i}_i' \, C(\tau)P\underline{i}_j \tag{6}$$

where i_k is an n-vector of zeros except for a 1 in the *k*th position and $C(\tau)$ is the τth matrix in the matrix polynomial $C(L)$.

A potentially serious drawback of this approach is 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 depend on the order in which the variables are listed in the model, an ordering which often has an arbitrary element. This is easily seen from equation (5) which implies that:

$$\begin{aligned} e_{1t} &= p_{11}\varepsilon_{1t} \\ e_{2t} &= p_{21}\varepsilon_{1t} + p_{22}\varepsilon_{2t} \\ &. \\ &. \\ e_{nt} &= p_{n1}\varepsilon_{1t} + p_{n2}\varepsilon_{2t} + \ldots + p_{nn}\varepsilon_{nt} \end{aligned}$$

so that any common element to the reduced-form residuals will be attributed to the first structural shock and so on. Hence if there is a high correlation between the reduced-form residuals, a shock to the equation for the first-listed variable will be dominated by the common element, no matter what the identity of the variable is. This weakness is mitigated where a particular ordering can be justified *a priori* or where the contemporaneous correlation between the VAR errors is weak.

Groenewold *et al.* (2007) addressed the ordering problem by arguing that their ordering was a natural one so that while the IRFs were sensitive to variable order, this was not a problem since there was only a single plausible order of the variables. In their (2005) paper, however, in extending to six regions for which a natural ordering is not so obvious, they subjected their results to extensive sensitivity analysis and relied not on a natural variable ordering but on a two-stage method of reducing the residual correlation. This was based on the argument that the high residual correlation is the result of a large national shock which affects all regions. They therefore reduced the correlation by removing the effects of this national shock – they simply regressed each regional output on national output and used the residuals from these equations as the purged regional output series which they then modelled using a VAR. This method proved to be effective in reducing the high residual correlation in the VAR and the sensitivity of the IRFs to variable ordering.

In the present paper we take a different tack. We also argue that the high residual correlation is the result of the effects of a common national shock but simply include national output in the VAR. This does not remove the residual correlation but given our argument above, it is natural to list national output as the first variable in the model so that it will "absorb" the common shock. We can then experiment with variation in the ordering of the regional outputs in terms of the effects on the IRFs.

The second use we make of the VAR model is to test for Granger-causality. We carry out two types of test. The first tests for Granger-causality for each region's output in each other region's equation in the VAR. In particular, we test that output in region i is Granger-caused by output in region j if the lagged values of region j's output in region i's equation are jointly significant. Thus the null hypothesis is:

$$H_0: x_{ijt-1} = x_{ijt-2} = \ldots = x_{ijt-p} = 0$$

for a VAR with *p* lags and it is tested within the framework of the reduced-form VAR, equation (3) above. We will thus have n(n-1) test statistics. In each case we use an F-test.

The second type is a test of block-exogeneity which involves the system as a whole and uses a Lagrange Multiplier test to test the null that the lagged output variables for a particular region are jointly insignificant in the equations for all of the other regions. Thus the null for the block exogeneity of the jth region is:

$$H_0: x_{ijt-1} = x_{ijt-2} = \ldots = x_{ijt-p} = 0, \text{ for all } i \neq j.$$

In this case there are 7 statistics each of which is distributed $\chi^2_{p(n-1)}$ under H_0.

5. RESULTS

Note that the sum of regional outputs must equal national output and the imposition of restrictions at the estimation stage will improve the efficiency of the estimator. However, this restriction does not translate into a similar linear relationship between the log outputs of our model and cannot therefore be imposed in the estimation stage, each equation being estimated individually using OLS as is the usual case with VAR models. Nevertheless, the relationship between output levels implies that the differential of the log of national output is the share-weighted sum of the differentials of regional log outputs.[7] While this restriction holds only approximately for discrete changes, this constraint was imposed on the IRFs reported later in this section.

Before estimating the VAR model we consider lag length. Following Groenewold, *et al* .(2005) who found that two lags are sufficient to eliminate all autocorrelation in the equation residuals, we began with two lags. The estimated VAR(2) model in the six (log) real regional output variables, log real national

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[7] If $x = x_1 + \ldots + x_n$, and dx denotes the differential in x, we have that $dlogx = s_1 dlogx_1 + \ldots + s_n dlogx_n$ where $s_i = x_i/x$.

output, trend, intercept and breaks in intercept and trend is reported in Table 2.

The results in Table 2 show a high explanatory power for all the equations, not surprisingly given that they are specified in log levels and all include a trend as well as break variables. The autocorrelation (AC) statistics show that there is general absence of autocorrelation in the residuals using a Q(15) test. There is, however, widespread evidence of autocorrelation at shorter lags as indicated in the footnotes to the table. It is interesting, though, that this lower-order autocorrelation is not present in any of the seven equations if the lag length is restricted to 1. We generated IRFs from models with various lag lengths and found that our conclusions are not affected by varying the lag length. We, therefore, use two lags to maintain comparability to the model of Groenewold, *et al.* (2005).

The national output variable (NAT) is significant in all equations at one lag (at least) with the exception of the South West region where it is only marginally significant, suggesting that this region may be only weakly related to the national economy. Lags of the individual regional output levels are mixed as far as significance is concerned. This is not uncommon in estimated VARs and we will be more interested in the joint significance of pairs of lags which will be tested in the Granger-causality tests presented below which show that many groups of coefficients are significant. The time trend is significant in all equations, usually at the 1% level. The performance of the break variables is mixed: the trend breaks are generally insignificant but the level breaks are usually significant for the 1966 break but not for the 1978 break. We nevertheless include all the break variables in the model used to generate the IRFs. Experimentation indicates that the shape of the IRFs is unaffected by this choice.

The first use of the estimated model was to generate IRFs. They are presented in Figures 2 to 7. For each simulation we shock both the region in question as well as national output. The latter is included to incorporate the constraint that in terms of levels, the regional outputs add to national output so that it is not possible to shock one region's output, holding all other regional outputs constant, without allowing for the consequent contemporaneous effect on national output. In log terms we shock the national log output by the same as the shock to regional output multiplied by its share in national output.

We compute both the IRFs and the cumulative IRFs, the latter being simply the accumulation over time of the IRFs. In each case the IRF is derived from a model with national output included and, following the discussion above, each IRF reflects the effects of a shock to a region's output combined with a scaled shock to national output, the scale factor being the regional share in national output. In light of this and given that out focus is on regional spillovers, there is clearly no sense in reporting an IRF for a shock to national output. The order of the variables/regions underlying these IRFs is NAT, SE, CR, YR, NE, SW and NW. Experimentation with alternative ordering of the regional outputs shows that our overall conclusions are not affected.

Table 2. Estimated VAR Results

	NAT	SE	CR	YR	NE	SW	NW
	Coef	Coef	Coef	Coef	Coef	Coef	Coef
	(t-stat)	(t-stat)	(t-stat)	(t-stat)	(t-stat)	(t-stat)	(t-stat)
	2.8500	2.9940	1.6342	2.3580	3.9728	1.7018	2.3345
NAT(-1)	(3.59)	(4.23)	(2.34)	(2.39)	(2.46)	(1.59)	(2.48)
	-1.0443	-2.4986	-1.4371	-1.9044	-2.4513	-1.5474	-0.5723
NAT(-2)	(-1.14)	(-3.06)	(-1.79)	(-1.68)	(-1.32)	(-1.26)	(-0.53)
	-0.1718	0.6137	0.2511	-0.0761	-0.3953	-0.2979	-0.5861
SE(-1)	(-0.64)	(2.55)	(1.06)	(-0.23)	(-0.72)	(-0.82)	(-1.83)
	0.0836	0.1328	0.0954	0.3532	0.2814	0.1914	0.0761
SE(-2)	(0.31)	(0.56)	(0.41)	(1.07)	(0.52)	(0.54)	(0.24)
	-0.7389	-1.0191	-0.9738	-1.3489	-2.0027	-0.2958	-0.2733
CR(-1)	(-1.36)	(-2.11)	(-2.04)	(-2.00)	(-1.82)	(-0.41)	(-0.43)
	-0.6352	-0.2073	-0.2871	-0.1839	-0.1240	-0.7049	-0.7025
CR(-2)	(-1.50)	(-0.55)	(-0.77)	(-0.35)	(-0.14)	(-1.24)	(-1.40)
	0.1454	0.0744	1.0540	1.2092	0.6285	0.2697	0.1118
YR(-1)	(0.28)	(0.16)	(2.31)	(1.87)	(0.59)	(0.39)	(0.18)
	1.2557	1.3199	1.3601	1.1985	1.7268	1.6570	0.7935
YR(-2)	(1.99)	(2.34)	(2.44)	(1.53)	(1.34)	(1.95)	(1.06)
	-0.3823	-0.5319	-0.3411	-0.4545	0.1718	-0.7400	-0.2464
NE(-1)	(-1.47)	(-2.30)	(-1.49)	(-1.41)	(0.33)	(-2.12)	(0.80)
	-0.0956	0.0314	-0.0977	0.0202	-0.0840	-0.2938	-0.1145
NE(-2)	(-0.33)	(0.12)	(-0.39)	(0.06)	(-0.14)	(-0.76)	(-0.34)
	0.0993	-0.4195	0.0589	-0.0098	0.4661	0.2022	0.1711
SW(-1)	(0.32)	(-1.52)	(0.22)	(-0.03)	(0.74)	(0.49)	(0.47)
	0.2208	0.2789	0.2889	0.4409	0.4524	0.0444	0.0693
SW(-2)	(1.04)	(1.48)	(1.55)	(1.68)	(1.05)	(0.16)	(0.28)
	-0.9191	-0.7931	-0.8565	-0.7724	-2.0392	0.1120	-0.6329
NW(-1)	(-2.14)	(-2.07)	(-2.26)	(-1.45)	(-2.33)	(0.19)	(-1.24)
	-0.2904	0.4402	-0.3076	-0.4254	-0.1754	-0.0348	-0.1827
NW(-2)	(-0.62)	(1.05)	(-0.74)	(-0.73)	(0.18)	(-0.06)	(-0.33)
	-0.9218	0.0510	0.3657	0.0459	-3.1679	0.7858	-3.2028
C	(-0.59)	(0.04)	(0.27)	(0.02)	(-1.00)	(0.38)	(-1.74)
	0.0433	0.0281	0.0508	0.0418	0.0588	0.0334	0.0397
T	(3.30)	(2.40)	(4.40)	(2.56)	(2.20)	(1.89)	(2.55)
	-0.1755	-0.1458	-0.1497	-0.1209	-0.2751	-0.2475	-0.2595
DU1	(-2.43)	(2.27)	(-2.36)	(-1.35)	(-1.87)	(-2.55)	(-3.04)
	-0.1267	-0.0331	-0.0581	-0.1277	-0.3073	0.0225	-0.1970
DU2	(-1.59)	(-0.46)	(-0.83)	(-1.29)	(-1.89)	(0.21)	(-2.08)
	0.0091	0.0146	-0.0079	0.0127	0.0069	0.0205	0.0286
DT1	(0.71)	(1.28)	(-0.70)	(0.80)	(0.27)	(1.19)	(1.88)
	0.0089	0.0191	0.0020	-0.0033	-0.0078	0.0031	0.0190
DT2	(0.74)	(1.78)	(0.19)	(-0.22)	(-0.32)	(0.19)	(1.33)
AC	0.242[1]	0.959[2]	0.056[3]	0.101[4]	0.191[5]	0.150[6]	0.201[7]
$\bar{R}^2$	0.9979	0.9988	0.9986	0.9972	0.9904	0.9961	0.9971

Notes: NAT, SE, CR, YR, NE, SW and NW are the logs of output of the nation, and the South East, Changjiang River, Yellow River, North East, South West and North West regions. The deterministic variables, in addition to the trend, are DU1, DU2 which are the level breaks at 1966 &1978 and DT1, DT2 which are the corresponding trend breaks. AC reports the p-value for the Ljung-Box test for residual autocorrelation with 15 lags. [1]Q(2)-Q(8) are significant at the 10% level; [2]Q(1) is significant at the 5% level; [3]Q(1)-Q(8) are significant at the 10% level; [4]Q(1)-Q(-9) and Q(14) are significant at the 10% level; [5] Q(1) and Q(3)-Q(11) are significant at the 10% level: [6]Q(1)-Q(4) are significant at the 10% level;[7]Q(1)-Q(8) are significant at the 10% level.

Figures 2(a) and 2(b) show the effects of a shock to the South East region on all the regions. In the short run the strongest effect is on SE itself even though the model permits direct effects to on all the regions (SE is the first-ordered of the six regions). Over time there is also a substantial effect on CR and YR and these effects actually overshadow that on SE itself after seven or eight years. There are effectively no spillovers to NE and SW and the overall effects on NW are actually negative. These results seem plausible. The larger effect on the CR region no doubt reflects the fact that this region is contiguous with SE and likely to be linked industrially. The YR region is not adjacent to SE, however, although it is likely to be linked by level of industrial development to SE and this may explain the spillovers. It is *prima facie* surprising that there seems little evidence of a spillover to the other regions adjoining SE, *viz*, SW; the lack of a connection here may simply reflect the quite different structure of the two regions and shows that contiguity does not guarantee spillovers. The lack of effect on the NE region is not a surprise given the large distance and the fact that the NE region has a relatively obsolete industrial structure and few resources. An overall negative spillover might normally be explained as evidence that a boost to one region attracts resources which would otherwise have gone to the other region and therefore shows a decline in the output of the second region. In the case of the relationship between the SE and NW regions, it might reflect the reallocation of public investment resources away from the coastal regions to the inland regions and *vice versa* at times during the sample period as outlined briefly in section 1 above.

The effects of a shock to the Changjiang River region are shown in the IRFs in Figures 3(a) and 3(b). They show that initially there are positive effects on all regions although the effects on CR itself and on the NE region dominate. The effects on the SE and SW regions are the smallest. Thus it would appear that the NE region is more closely related to CR than to SE which is not unexpected. The subsequent effects are quite puzzling, though. These are particularly clear in the cumulative IRFs shown in Figure 3(b) which show that the overall effects on all regions, including CR itself, are negative after three years. Thus shocks to the CR region have at best short positive spillovers, particularly on the NE and, to a lesser extent, on the NW and YR regions.

Next we turn to the effects of a shock to the Yellow River region shown in Figures 4(a) and 4(b). There are initial positive effects on all regions but particularly on YR itself and on NE, showing that NE is also positively related in the short run to YR as it is to CR. Over time the positive spillovers to CR grows as would be expected given the contiguity of the regions and their similar industrial structure. Not surprisingly, there are effectively no long-term spillovers to the SW region, while the NW and SE regions are negatively affected after a short-term positive effect. This large negative effect on the SE is somewhat surprising although it may be that these regions compete for resources in a broad sense so that an expansion of one has generally proceeded at the expense of the other.

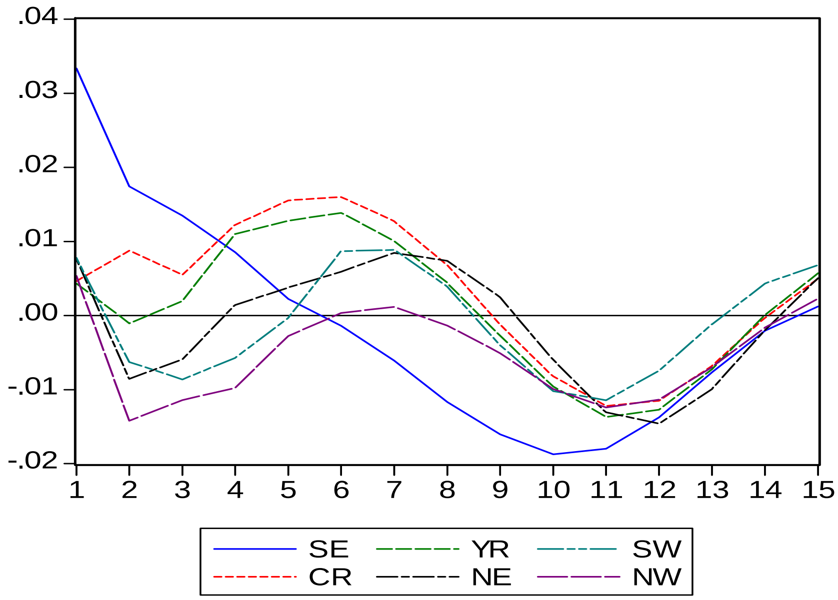

Figure 2 (a). IRFs for a Shock to SE

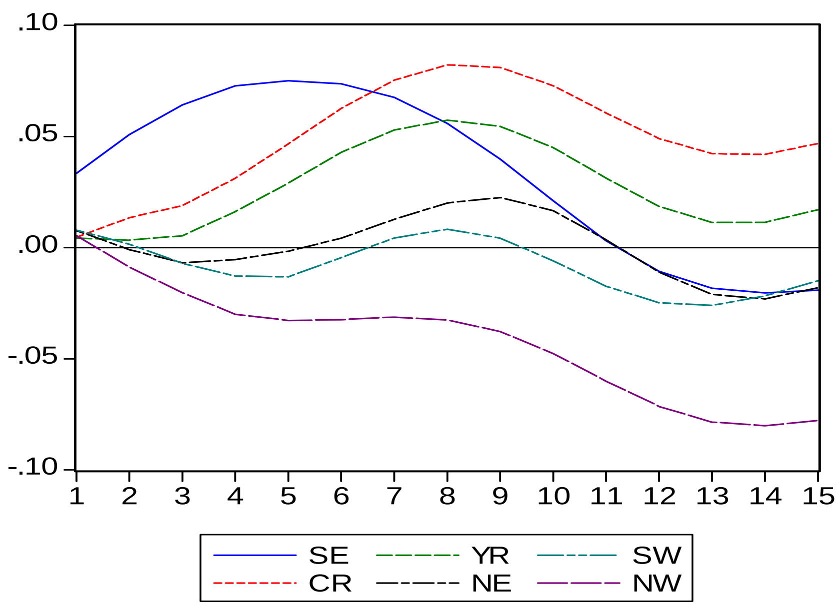

Figure 2 (b). Cumulative IRFs for a Shock to SE

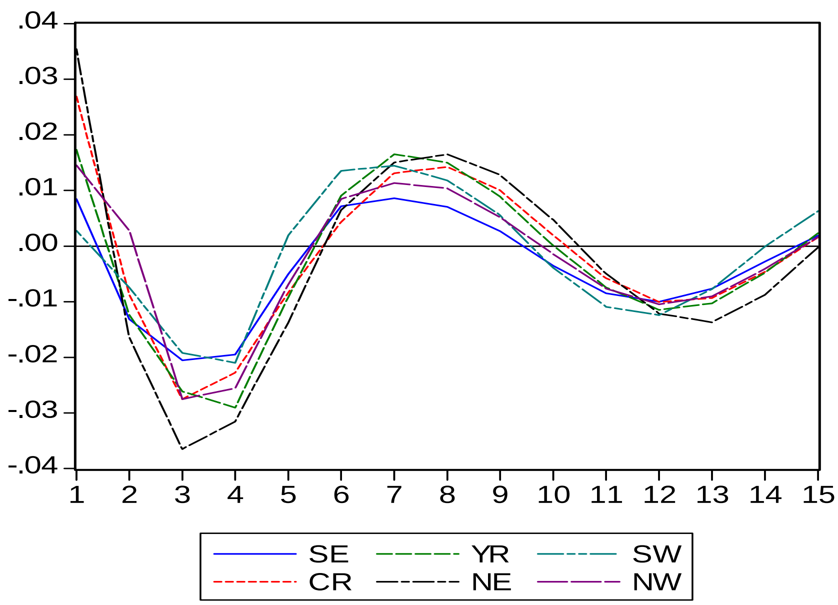

Figure 3 (a). IRFs for a Shock to CR

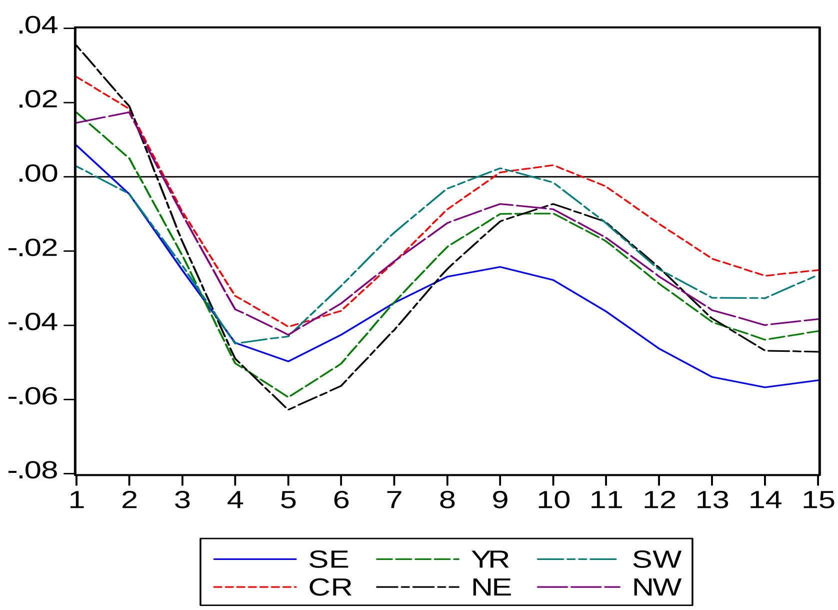

Figure 3 (b). Cumulative IRFs for a Shock to CR

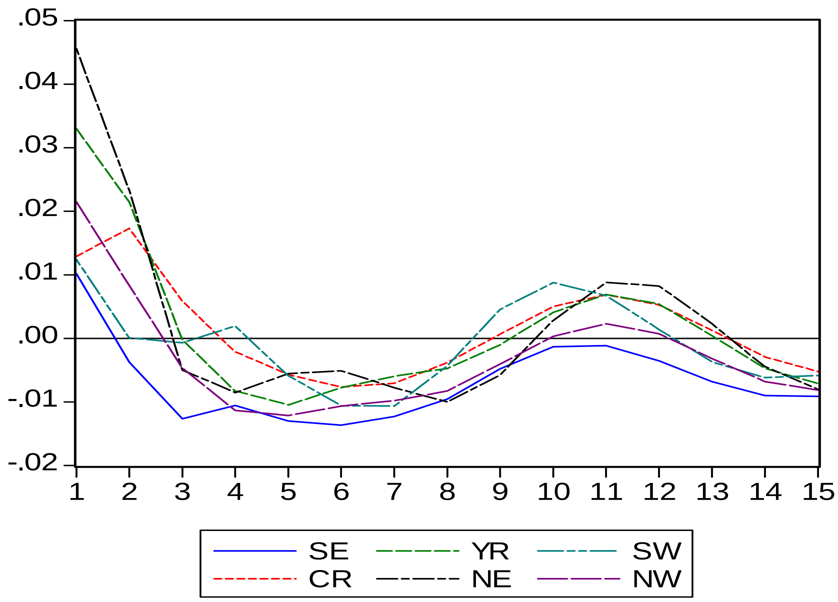

Figure 4 (a). IRFs for a Shock to YR

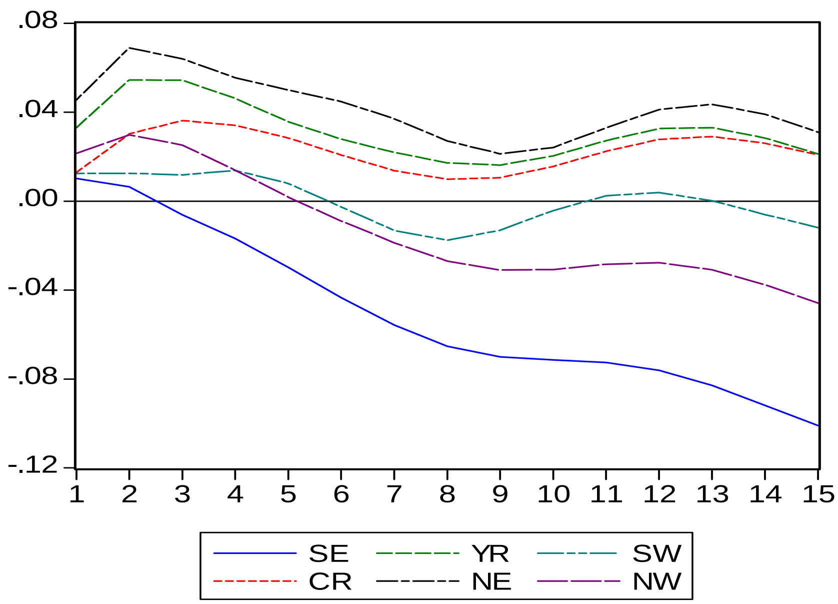

Figure 4 (b). Cumulative IRFs for a Shock to YR

The IRFs showing the effects of a shock to the NE region are shown in Figure 5(a) and 5(b). The short-run effect of a shock to NE is dominated by the effect on the region itself. The effects on all other regions apart from SW are small and positive in the short-term and all IRFs fluctuate widely over time. Thus we must conclude that shocks to the NE region have effectively no positive spillovers on any region which suggests that it is relatively economically isolated from the rest of the country, perhaps handicapped by its increasingly outmoded industrial base as recognised by the recent policy of the "Resurgence of North-Eastern Old Industry Base".

The results for shocks to the SW region are shown in Figure 6(a) and 6(b). Focussing on the cumulative IRFs, they show that the SW region has small positive short-term spillovers to the NW and NE regions which increase over a period of about 4 years before subsiding, with the effect on the NE being larger. The spillover on NW is no doubt explained by its close proximity but this can not explain the effect on NE which is at the opposite corner of the country. There is a small positive spillover to the other regions but this quickly becomes zero and then negative.

Finally consider the IRFs showing the impact of a shock to the NW region which are reported in Figures 7(a) and 7(b). Their shape is similar to those for SW but the spillover implications differ. Initially the main effect is on NW itself with small positive effects on all other regions. But only the spillover on SW is maintained; indeed it grows to eclipse the effect on NW itself within two years, perhaps reflecting the contiguity of the SW region. In general, however, the NW region is relatively isolated from the rest of the country, not surprisingly, perhaps, in light of its geography.

To sum up the implication of the IRFs, overall spillovers are relatively weak. Not unexpectedly in light of earlier literature, the SE region has spillovers to both CR and YR and YR also has spillovers to CR. Thus, these core industrial regions of China appear to be relatively well integrated. Spillovers to NE from SW and YR are weak and not sustained so that, as has been recognised recently, the older NE region is not well integrated with the rest of the coastal region. Finally, there are effectively no spillovers from the rest of the country to the two western regions although there are weak interrelationships between SW and NW. These effect are not sensitive to re-ordering the variables in the model as long as the national output level occupies the first position.

Overall, these results are similar but not identical to those in Groenewold *et al.* (2005). The comparison is summarized in Figures 8(a) and 8(b), the first of which shows the spillovers in the Groenewold, *et al.* (2005) paper and the second captures those described above.

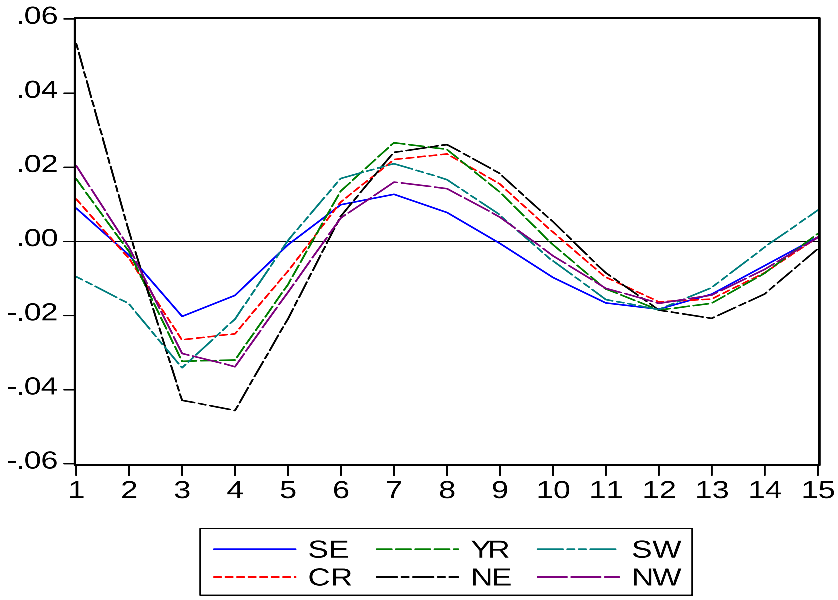

Figure 5 (a). IRFs for a Shock to NE

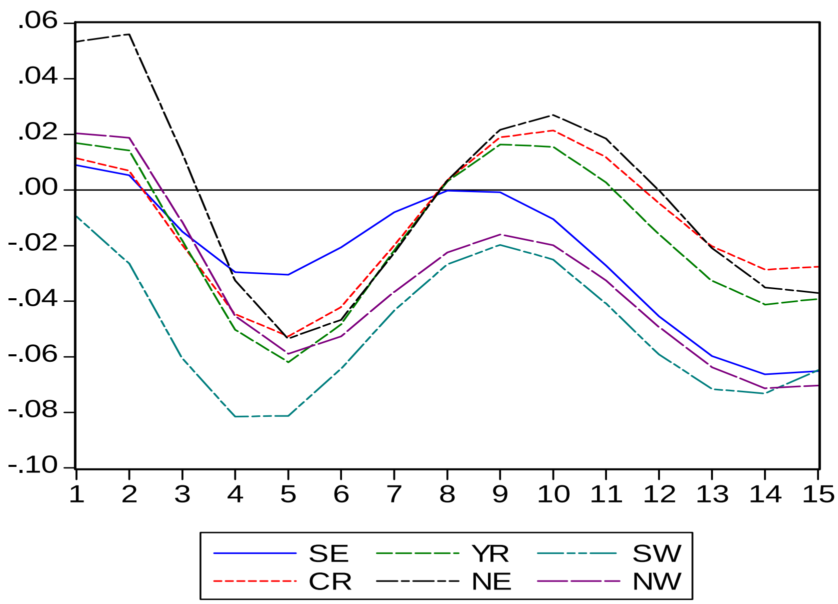

Figure 5 (b). Cumulative IRFs for a Shock to NE

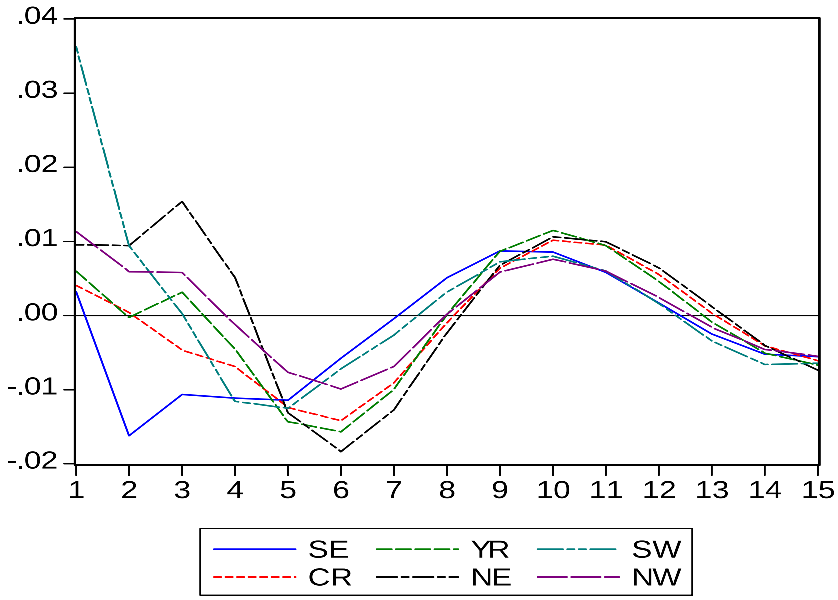

Figure 6 (a). IRFs for a Shock to SW

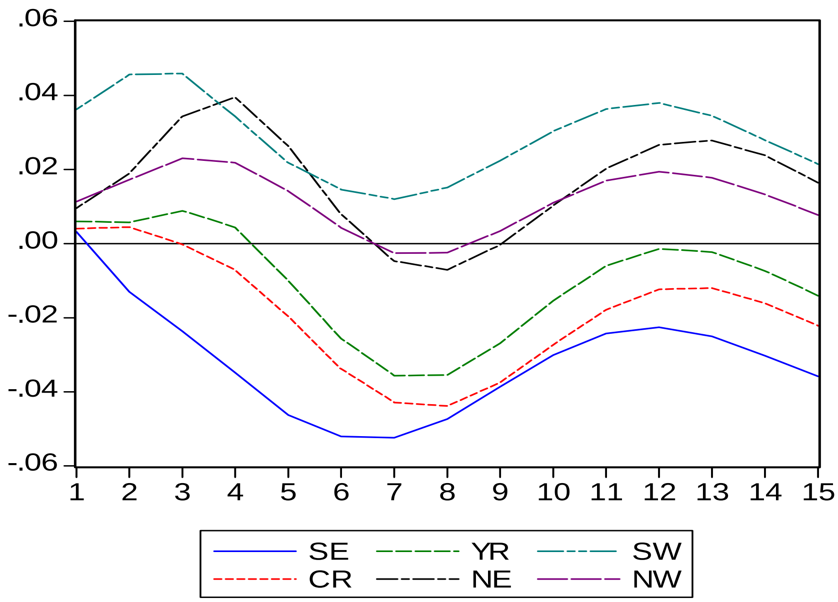

Figure 6 (b). Cumulative IRFs for a Shock to SW

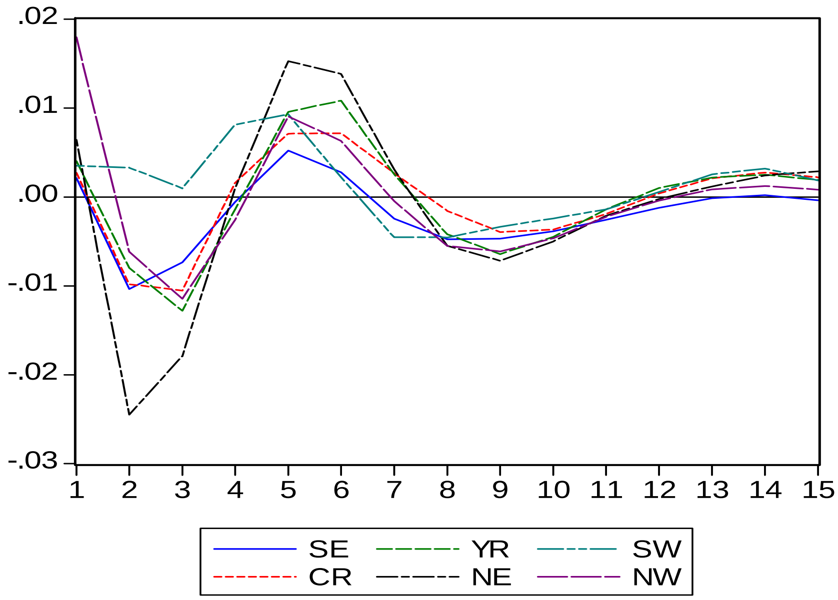

Figure 7 (a). IRFs for a Shock to NW

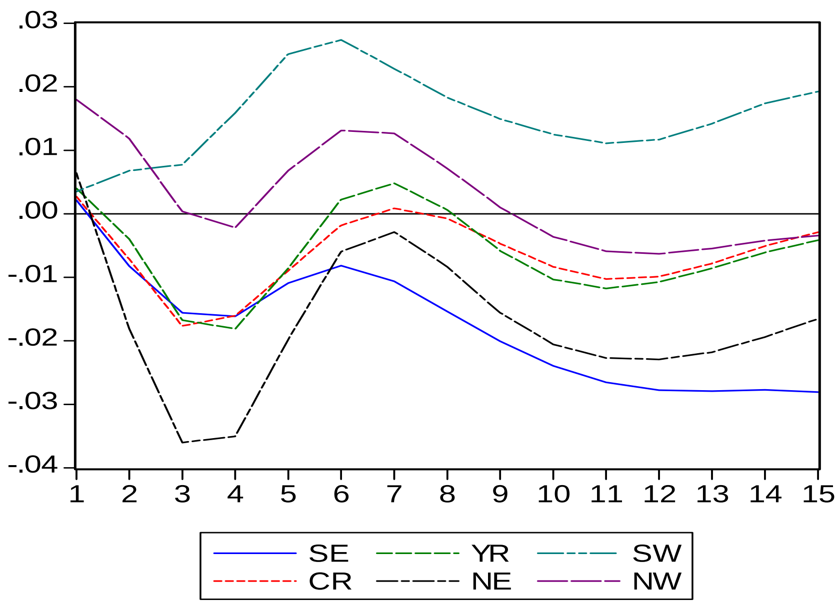

Figure 7 (b). Cumulative IRFs for a Shock to NW

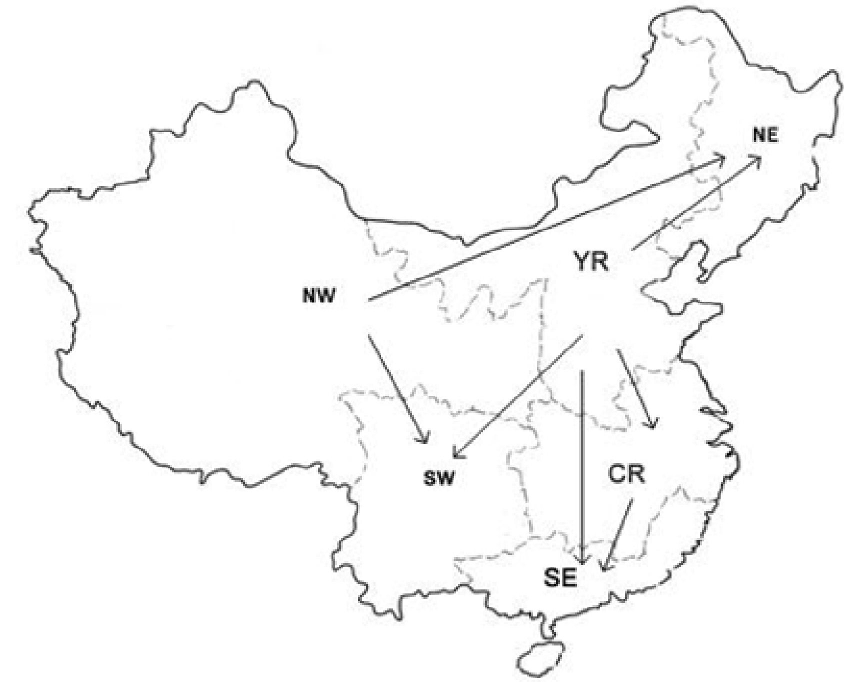

Figure 8 (a). Spillovers of Six Regions in Groenewold, et al (2005) paper.

The IRFs for NE and SW are almost the same, showing that the two regions are relatively isolated from the rest of the country. As we have mentioned above, the NE region was, for historical reasons, relatively industrially advanced when Mao took control of China in 1949. There were early policies to capitalise on this development to build China's industrial capacity but subsequent events led to a gradual running-down of this capacity so that more recently the NE industry base has become obsolete and the region economically isolated. In contrast, the SW region (which includes Sichuan province) has always been populous but with a low productivity (its share of GDP was 8.4 percent in 2004 but its population share almost twice that at 15.6 percent). It has a high dependence on agriculture matched by a relatively low share of secondary and tertiary industries thus providing little opportunities to develop channels of spillover to the rest of the country, a situation which may improve as its industrial development proceeds.

We also obtained similar results for the shock to YR which indicate that the Yellow River region has general effects on other regions. This is not surprising. While the YR region has a number of provinces with a modest level of industrial development (such as Inner Mongolia, Shanxi, Hebei and Henan), it also contains three of the advanced coastal provinces of Beijing, Tianjin and Shandong all of which have relatively large secondary industries which would be expected to draw materials from the surrounding provinces thus creating a spillover mechanism.

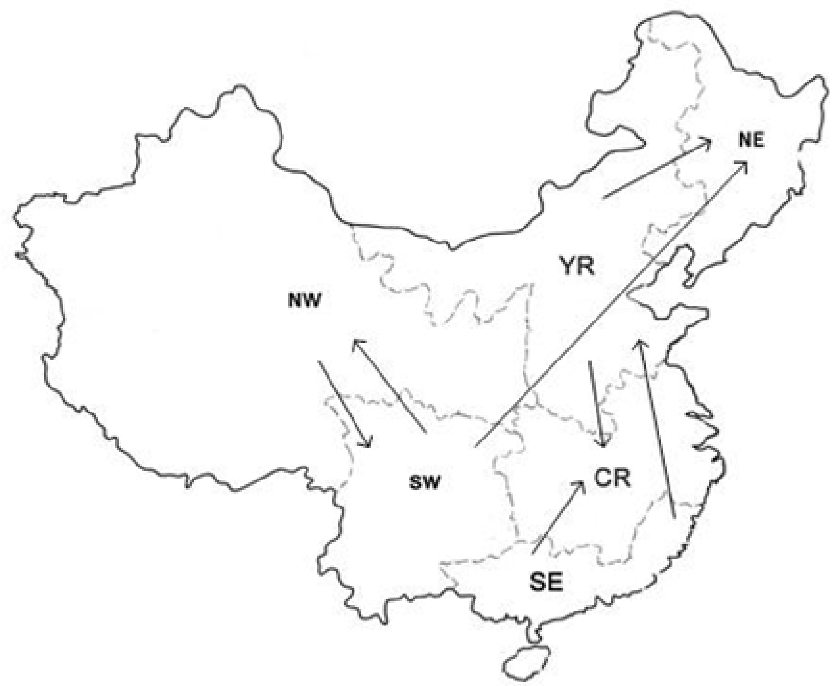

Figure 8 (b). Spillovers of Six Regions (in this paper)

However, compared to the earlier paper, in the present case the SE appears to have more positive spillovers. This is clearly in line with the general conception that the SE has been one of the main sources of growth in the country. There is evidence that its contribution to international exports is high but that it is a net importer from the rest of the country which should provide strong spillover channels, thus making the results in the present paper more plausible than those reported in Groenewold *et al.* (2005).

Our results in this paper that the SW and NW regions interact mainly with each other and little with the rest of the country are also consistent with earlier three-region results that the western region is relatively isolated from the rest of the economy. Both regions are relatively poor and the NW has the added disadvantage of substantial minority groups which make economic integration less likely.

A surprising finding both in terms of our priors and in the light of earlier work concerns CR which shows that the stimulation of economies in this region has a negligible positive effect on the rest of the country. This finding appears to undermine the recent regional development policy which emphasises the development of the Changjiang River region. It may be that the explanation lies in the reprocessing nature of much of the economic activity in this region – both input and output relations are dominated by international trade so that channels for spillovers are limited. The composition of this regions is also quite varied (it includes prosperous coastal provinces such as Zhejiang, Shanghai and Jiangsu as well as relatively less developed interior provinces such as Hunan and Hubei) so that the analysis of more disaggregated data may pay off in terms of the resolution of some of these puzzles. This will have to await further data, however, since it is our view that the data we have is already stretched to provide a reasonable analysis of a six-region model.

The second use we make of the estimated model is to conduct tests of Granger-causality. We do this at two levels. In the first place we consider all possible pairs of regions and test for causality in both directions between output in one region and that in the other. In the second test we look at block exogeneity and test for the joint significance of the two lags of a variable in all equations of the model. The results are reported in Table 3.

Table 3. Granger-Causality Test Results

Region	NAT F-stat	SE F-stat	CR F-stat	YR F-stat	NE F-stat	SW F-stat	NW F-stat
NAT		8.94	2.73	2.87	3.31	1.28	5.02
SE	0.20		1.29	0.67	0.27	0.34	2.13
CR	2.78	2.87		2.41	1.85	1.05	1.32
YR	2.52	3.29	8.71		1.55	2.56	0.74
NE	1.42	2.83	1.50	1.07		3.34	0.51
SW	0.84	1.63	1.58	1.62	1.31		0.23
NW	3.19	2.24	3.71	1.81	3.16	0.02	
χ^2	40.76	49.49	41.97	41.27	16.42	26.99	30.87

Notes: The critical value of the F-statistic for rejection of the non-Granger-causality null is 3.32 at the 5% level and 2.49 at the 10% level. The critical value of the χ^2 statistic for rejection of the block-exogeneity null is 21.03 at the 5% level.

The figures in the body of the table are F-statistics for the test that the row variable Granger-causes the column variable; thus, e.g. the value of 0.20 in the first column of figures is the statistic for the null hypothesis that the two lagged SE variables in the NAT equation are jointly zero, i.e., that SE does not Granger-cause NAT. The figures in the last row of the table are derived from a Lagrange Multiplier test of the joint significance of all the two lags of the column variable in the model as a whole; so, 40.76 is the result of a test that the two lagged NAT variables are jointly zero in all six equations of the model other than the NAT equation itself. The relevant critical values for each of the two tests are given in the notes to the table.

Several interesting causal relations are shown. In the first place, the first row of statistics shows that the national output variable Granger-causes all others except for SW. This is as expected and consistent with our earlier observation on the basis of the results in Table 2. Looking next at the causality between regions, we see that SE causes no other regions; CR causes SE and YR (marginally); YR causes SE, CR and SW; NE causes SE and SW; SW causes no other regions and NW causes NE. These results call for the following comments.

First, they confirm our earlier results reported in Table 2 – by and large, the cases where there is Granger-causality are those where at least one individual coefficient is significant in the relevant equation. Second, many of the causal relationships appear to be at odds with the implications drawn from the IRFs above. However, before discarding one or the other (or, indeed, both!), it should be noted that Granger-causality analysis throws only limited light on spillovers. First, Granger-causality is based on a single equation and not on the system as a whole as the IRFs are. Second, Granger-causality is a short-run phenomenon, being based on only two lags, whereas we saw on the basis of the IRFs that spillovers may take some time to become apparent. Thirdly, Granger-causality does not distinguish between positive and negative effects. In IRFs these may offset each other so showing no spillover but in Granger-causality analysis the pair would be jointly significant even if their sum is not. Moreover, we have generally discarded negative spillovers in the discussion of the IRFs but these will be picked up in the causality analysis which is concerned only with significance. Thus, the Granger-causality analysis can only be supplementary to results obtained from the model as a whole.

The final row of Table 3 shows the Lagrange Multiplier statistics for the block exogeneity tests. The results of the test show that all regions except NE are integrated in the economy and that, judging by the magnitude of the test statistics, the strongest trio is SE, CR and YR. These results are much more closely consistent with the IRF results reported earlier in this section, something which is not surprising since the Lagrange Multiplier tests are based on the model as a whole.

6. CONCLUSIONS

In this paper we have extended earlier work by Groenewold *et al.* (2005) on inter-regional spillovers in China. Like them, we used a six-region VAR model as the framework for our analysis. They found that the order in which the regional output variables appear in the model has an important effect on the simulation outcomes and therefore on their conclusions regarding the nature of inter-regional spillovers. They proposed a particular solution to this “ordering problem” using a two-stage regression approach.

We argued that while this was a plausible approach, other solutions are possible and that, given the importance of knowledge of spillovers for policy-formulation, it is necessary to assess the sensitivity of the results to the solution method. We therefore suggested an alternative which is equally plausible but avoids certain econometric problems. We found a great deal of support for their conclusions but also some important differences. Our overall conclusions are that the three core regions that form the Chinese industrial heartland – the South East, the Changjiang River region and the Yellow River region – are relatively well interconnected. However, even for these regions the spillovers are not pervasive and strong. Thus, the SE region has positive spillover effects on both the CR and YR regions and YR affects CR but CR, in turn, affects neither of its neighbouring regions.

On the other hand, the North East region is only weakly related to the neighbouring regions – it receives spillovers from both SW and YR, but has itself no positive effects on any regions. The South West and North West are weakly related to each other but not to the rest of the country.

The contrast to the earlier conclusion in Groenewold *et al.* (2005) centres particularly on the role of the SE region. Their simulations show that it has little spillover effects on the rest of the country. This is surely counter to the conventional wisdom that the SE has been one the prime movers of Chinese economic development and should therefore be treated with some caution, a caution reinforced by our results that the SE region has larger effects than they measure, particularly on the CR and YR regions, as might be expected. There is, therefore definite value in the sort of sensitivity analysis reported in this paper and, no doubt, others will find aspects of our analysis which they will want to test for robustness.

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REFERENCES

Bao, S., Chang, G. H., Sachs, J. D. and Woo, W. T. (2002) Geographic factors and China's regional development under market reforms, 1978–1998. *China Economic Review,* 13, pp. 89-111.

Barro, R. J. and Sala-i-Martin, X. (1992) Convergence. *Journal of Political Economy*, 100, pp. 223-251.

Brun, J.F., Combes, J. L. and Renard, M. F. (2002) Are there spillover effects between the coastal and noncoastal regions in China? *China Economic Review*, 13, pp. 161-169.

Cai, F., Wang, D. and Du, Y. (2002) Regional disparity and economic growth in China: the impact of labor market distortions. *China Economic Review*, 13, pp. 197-212.

Carlino, G. and DeFina, R. (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, pp. 335-340.

Chen, J. and Fleisher, B. M. (1996) Regional inequality and economic growth in China. *Journal of Comparative Economics*, 22, pp. 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, pp. 202-229.

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, pp. 95-117.

Demurger, S., Sachs, J. D., Woo, W. T., Bao, S., Chang, G. and Mellinger, A. (2002) Geography, economic policy and regional development in China. NBER Working Paper 8897, April 2002.

Demurger, S., Sachs, J. D., Woo, W. T., Bao, S. and Chang, G. (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, pp. 444-465.

Estima (2004) *RATS Version 6.0 User's Guide*, Evanston, Ill.

Fleisher, B. M and Chen, J. (1997) The coast-noncoast income gap, productivity and regional economic policy in China. *Journal of Comparative Economics*, 25, pp. 220-236.

Groenewold, N., Lee, G and Chen, A. (2005) Inter-regional spillovers in China: the importance of common shocks and the definition of the regions. Discussion Paper No. 05-19, Department of Economics, University of Western Australia. Available at: http://www.biz.uwa.edu.au/home/research/discussionworking_papers/economics/2005 A revised version with the same title is forthcoming in *China Economic Review*.

Groenewold, N., Lee, G. and Chen, A. (2007) Regional output spillovers in China: estimates from a VAR model. *Papers in Regional Science* 86, pp. 101-122.

Hirschman, A. (1958) *The Strategy of Economic Development*. Yale University Press: New Haven.

Kanbur, R. and Zhang, X. (1999) Which regional inequality? The evolution of rural-urban and inland-coastal inequality in China from 1983 to 1995. *Journal of Comparative Economics*, 27, pp. 686-701.

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, pp. 30-41.

Kuznets, S. (1955) Economic growth and income inequality. *American Economic Review*, 45, pp. 1-28.

Liu, X. and Wei, Y. (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.

Liu Z. (1985) Some issues of comprehensive economic administrative divisions (Zong He Jing Ji Qu Hua De Ji Ge Wen Ti). *Economic Theory and Business Management*.(*Jing Ji Li Lun Yu Jing Ji Guan Li*), 30, pp. 45-49.

Lu, D. (2002) Rural-urban income disparity: impact of growth, allocative efficiency and local growth welfare. *China Economic Review*, 13, pp. 419-429.

Myrdal, G. (1957) *Economic Theory and Underdeveloped Regions*. Gerald Duckworth: Essex.

Pagan, A. (1986) Two stage and related estimators and their applications. *Review of Economic Studies*, 53, pp. 517–538.

Rissman, E. R. (1999) Regional employment growth and the business cycle. Federal Reserve Bank of Chicago. *Economic Perspectives*, 4th quarter, pp. 21-39.

Sherwood-Call, C. (1988) Exploring the relationship between national and economic fluctuations. Federal Reserve Bank of San Francisco *Economic Review*, Summer, pp. 15-25.

Sims, C.A. (1986) Are forecasting models usable for policy analysis? Federal Reserve Bank of Minneapolis *Quarterly Review*, pp. 3-16.

State Statistical Bureau (2004) *China Statistical Abstract* 2004. Statistical Publishing House of China: Beijing.

State Statistical Bureau (2006) *China Statistical Abstract* 2006. 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, pp. 3-84.

Wu, Y. (2004) *China's Economic Growth: A Miracle with Chinese Characteristics*. Routledge Curzon: London.

Yang, D. T. (2002) What has caused regional inequality in China? *China Economic Review*, 13, pp. 331-334.

Yao. S. and Zhang, Z. (2001a) Regional growth in China under economic reforms. *Journal of Development Studies*, 38, pp. 167-186.

Yao, S. and Zhang, Z. (2001b) On regional inequality and diverging clubs: a case study of contemporary China. *Journal of Comparative Economics*, 29, pp. 466-484.

Ying, L. G. (2000) Measuring the spillover effects: some Chinese evidence. *Papers in Regional Science*, 79, pp. pp. 75-89.

Zhang Q. and Felmingham, B. S. (2002) The role of FDI, exports and spillover effects in the regional development of China. *Journal of Development Studies,* 38, pp. 157- 178.