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The effects of China's growth slowdown on its provinces: Disentangling the sources

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The effects of China's growth slowdown on its provinces: Disentangling the sources

Abstract

Since 2007 China's growth has fallen from around 10% to about 6-7% per annum. This paper investigates the experience of this slowdown at the provincial level. We use a vector-autoregressive modelling approach and annual data from 1978 to decompose each province's growth into various factors. We find that (1) all provinces experienced the slowdown; (2) there is considerable variation in this experience across provinces; (3) national factors dominate the provincial slowdown while province-specific factors explain most of the interprovincial variation; (4) when the national factor is separated into supply and demand components, the supply component dominates.

Keywords: China, growth, slowdown, provincial effects

JEL Codes: E61, R50, O53

1. Introduction

The slowdown in China's rate of economic growth since the beginning of the Global Financial Crisis (GFC) in 2008 has been the most prominent characteristic of what has come to be called China's 'New Normal'. From average growth rates of the order of 10% per annum in the three decades to 2008, growth has fallen steadily to around 6.5% recently.

There has been considerable recent empirical research on what has driven this phenomenon, focussing particularly on whether the slowdown is temporary or here to stay; see, e.g., Bai and Zhang (2017), Qian *et al.* (2017), Chen and Groenewold (2018) and Dong and Liu (2018) for general arguments. The growing consensus of this literature is that the lower growth rate will be a permanent feature of China's economic performance, although views on the precise sources of the slowdown are far from settled.¹

All of the literature mentioned above has been concerned with the issue at the national level, with no specific attention to the implications for the regions. However, given the regional diversity of the Chinese economy, it is likely that the slowdown will be experienced differently in different regions, making regionally-tailored policy desirable and, indeed, likely, given the strong incentives for provincial governments to maintain high provincial growth rates.² Thus it will be important to know something about the sources of a provincial slowdown and, in particular, whether such a slowdown is mainly a reaction to national forces or whether there are also strong province-specific influences.

We aim to make a beginning to filling this gap and, therefore, begin by considering the distribution across the provinces of the national slowdown and then go on to compute a decomposition of provincial growth rates into national and provincial components over the

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¹ Factors which have received much attention include: slowing labour-supply growth (see, e.g., Li *et al.*, 2012, but also Golley and Meng, 2011, Meng, 2012, for dissenting views), the exhaustion of the demographic dividend (see, e.g., Cai and Roberts, 2015, and Cai, 2016), a productivity slowdown (Lee and Hong, 2010, Bai and Zhang, 2017, and Lu, 2017) and a slowdown in the rate of capital accumulation (Wu, 2016 and Lu, 2017).

² There is a large literature on the nature and sources of China's regional disparities; some recent ones include Liu *et al.* (2018), Peng *et al.* (2018), Wang and Rickman (2018) and Su *et al.* (2019).

period of the slowdown since 2008. We do this using two models. The first distinguishes between national and province-specific factors as drivers of recent changes in provincial growth rates. We then extend this to further decompose the national component of provincial growth into aggregate supply and aggregate demand components. This disaggregation is chosen to reflect the importance of the debate about whether the slowdown is predominantly a demand (or cyclical) or a supply (or structural) phenomenon.³ This distinction between demand and supply as drivers of the slowdown is crucial for policy – if demand is predominant, we can expect the growth rate to revert to the long-term average and, if necessary, speed such reversion up by the use of expansionary fiscal or monetary policy. If, on the other hand, supply is the main driver, it will be necessary to implement structural reforms and other supply-side policies and, even then, it may not be possible to return the economy to its previous growth path.

The first model is a simple bivariate VAR where national and provincial shocks are identified using the standard Cholesky decomposition, following Ridhwan *et al.* (2014) and, like them, we use a sequence of models combining national variables (one in our case) and a provincial variable, each model in the sequence having a different provincial variable. In the second model we extend this analysis in two ways; first, we include an additional national variable to enable us to further decompose the national shock into two parts – a demand component and a supply component. Secondly we base our identification of the demand and supply shocks on a small macro model of the type developed by Cover, Enders and Hueng (2006) and Enders and Hurn (2007) which extend the supply-demand characterisation of Blanchard and Quah (1989) and also allow for the possibility of correlated structural errors.

Our findings may be summarised as follows. First, there has been a noticeable growth slowdown across most provinces in the period since 2008 but there are distinct differences

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³ See Chen and Groenewold (2018) and Dong and Liu (2018) for a recent discussion of this issue.

between the provinces. Second, the contribution of the national shock to the slowdown in provincial growth is quite similar across provinces, suggesting there is little inter-provincial variation in the way the common national shock is propagated at the provincial level. Third, for most provinces the national factor is the more important driver of the slowdown although province-specific factors also make a substantial contribution in some provinces and account for most of the inter-provincial differences in the slowdown. Fourth, when the national shock is divided into demand and supply components, it turns out that the national shock is driven mainly by supply factors, with the contribution of demand shocks being quite varied across provinces.

Our contributions are threefold. First, we examine the slowdown at the level of China's provinces. This is an important extension of the existing literature which focusses almost exclusively on the characteristics of the slowdown at the national level. Second, we distinguish between national and provincial components of provincial growth and so we can investigate whether the slowdown in the provincial economies was mainly their response to national shocks or whether there were also important province-specific factors. Third, our further decomposition of the national component into (national) supply and demand components allows us to link our work to the recent literature on the sources of the national slowdown and, in particular, to explore the question of whether national demand or supply shocks have been more important in driving the lower growth rates at the provincial level in China.

The paper is structured as follows. In the next section we report an informal analysis of provincial growth rates, comparing them to national growth rates. In section 3 we set out the two models used for the more formal analysis to follow; the first is a sequence of two-variable VAR models in which we distinguish national and provincial growth components for each province and the second is a sequence of three-variable VAR model which are identified

using a small theoretical model as well as the Blanchard-Quah supply-demand identification scheme. The following section briefly describes the data used and reports tests of stationarity of the growth rates. The modelling results are reported in section 5 which consists of two parts according to the two models used. Conclusions are drawn in section 6.

2. Provincial growth rates

Before turning to more formal econometric analysis, we look at provincial growth rates and compare them to the national growth rate. Figure 1 pictures the growth rates of the 28 provinces over our full sample of 1978 to 2016.⁴

[Figure 1 about here]

Two features stand out. First, in broad outlines, the overall shapes of the graphs are quite similar across provinces. But, second, there are also noticeable differences both in the amplitude of fluctuations and in the extent of the slowdown in the last decade or so. In Figure 2 we focus on the period since 2008 to get a closer look at the provincial growth rates during the slowdown period. We include the average national growth rate for comparison.⁵

[Figure 2 near here]

It is apparent from this figure that the slowdown has been a phenomenon that has affected all provinces although to different degrees. In particular, the fall in the growth rate has been noticeably smaller in many of the core coastal provinces such as Beijing, Guangdong, Shanghai, Fujian, Zhejiang and Jiangsu while there have been larger growth declines in the

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⁴ We use data for only 28 of China's 31 provinces: we take early province-level data from Wu (2004) who includes Chongqing in Sichuan, Hainan in Guangdong and omits Tibet, all for reasons of data availability and we follow his conventions. Scales in all multi-part graphs have been constrained to be the same so that the magnitudes are comparable across provinces.

⁵ The national growth rate in Figure 2 is the weighted average of the 28 provincial growth rates rather than the growth rate based on China's official national real GDP which is used elsewhere in this paper. The use of the weighted average of provincial growth rates ensures that the provincial graphs are reasonably evenly spread around the national graph, something that is not the case if the official national data are used due to the discrepancy between the national GDP data and the aggregate of the provincial figures, the growth rate of the latter being approximately 1.5 percentage points higher over the period 2008-2016 than that based on the official rate.

north-eastern provinces of Jilin, Heilongjiang and Liaoning as well as most of the western provinces. Moreover, most of the provinces which have seen a larger growth decline started from a level above the national growth rate and declined towards the national level by the end of the period, Shanxi and Liaoning being the main exceptions. On the other hand, provinces such as Beijing, Shanghai, Guangdong and Zhejiang which experienced relatively small growth declines began the period below the national average so that, on the whole, the growth slowdown seems to have led to a convergence of growth rates, at least on the basis of these casual empirics.

To sum up, the data show that the slowdown is not just a national phenomenon but was widely experienced by all the provinces; there are, however, significant variations across provinces which makes a closer examination of the sources of the inter-provincial differences a worthwhile exercise and one to which we now turn.

3. The model

We use time-series data and a vector-autoregressive (VAR) model as our overall framework. Including all of China's provinces simultaneously in such a model would more than exhaust the degrees of freedom even with a modest number of lags. We therefore follow existing literature in this area including Carlino and DeFina (1999), Owyang and Zubairy (2013) and Ridhwan *et al.* (2014) and estimate a sequence of smaller VAR models, one for each province – each has the same aggregate variable(s) but a different province-level variable, taking each of the provinces in turn. We then use the models to decompose the provincial growth rates into aggregate (national) and provincial components.

We begin with a sequence of simple two-variable VAR models and, following Ridhwan *et al.*, we use the Cholesky decomposition to identify a national and a provincial shock. We then go on to use a three-variable model which allows us to identify national

demand and supply shocks as well as a provincial shock; in this model we depart from the Cholesky identification. Instead, in the three-variable case our identification approach is grounded in a small macro model which incorporates the Blanchard-Quah definition of demand and supply shocks and, in addition, follows Cover, Enders and Hueng (2006) and Enders and Hurn (2007) in relaxing a standard VAR assumption by allowing for correlation between the structural errors.

Both models can be set out within the framework of a general VAR model as follows. Consider a (structural) VAR(p) model in, x , a vector of n variables:

$$Ax_t = A(L)x_t + \varepsilon_t \quad (1)$$

where A is an $(n \times n)$ matrix of coefficients and $A(L)$ is a p th-order matrix polynomial in L , the lag operator; $A(L) = A_1L + \dots + A_pL^p$ and $L^i z_t = z_{t-i}$. The ε_t are the (structural) error terms which have zero mean and are assumed to be uncorrelated over time and (generally) across equations. Since all the equations in (1) have the same variables, the model cannot be estimated as it stands and it is common to re-write it as a reduced-form model:

$$x_t = B(L)x_t + e_t \quad (2)$$

where $B(L) \equiv A^{-1}A(L)$ are the reduced-form coefficients and $e_t \equiv A^{-1}\varepsilon_t$ are the reduced-form errors. Here OLS can legitimately be used to estimate the reduced-form coefficients and the reduced-form residuals can be computed from the estimated model.

The estimated model will be used for decomposition of the provincial growth rates over the period 2008-2016. The decomposition is based on the MA form of the model:

$$x_t = (I - B(L))^{-1}e_t, \quad (3)$$

or, in terms of the structural errors which are of more interest,

$$x_t = (I - B(L))^{-1}A^{-1}\varepsilon_t \equiv C(L)\varepsilon_t. \quad (4)$$

This implies that each of the variables (and, in particular, the provincial growth rate) can be written as a linear combination of present and past errors where the coefficients in the linear

combination are the elements of the C matrices which are just the impulse response functions (IRFs). Then, in principle, each variable can be decomposed into the contributions of the present and past values of each of the error terms. So, for example, the j th element of x_t , x_{jt} , can be written as:

$$x_{jt} = \sum_{\tau=1}^{\infty} C_{j1}(\tau) \varepsilon_{1t-\tau} + \sum_{\tau=1}^{\infty} C_{j2}(\tau) \varepsilon_{2t-\tau} + \dots + \sum_{\tau=1}^{\infty} C_{jn}(\tau) \varepsilon_{nt-\tau} \quad (5)$$

where $C(\tau)$ is the τ th coefficient matrix in the matrix polynomial $C(L)$ ($C(0)$ being the identity matrix) and $C_{ji}(\tau)$ is its (j,i) element. Then from (5), the first term is the contribution to the value of x_j in period t of the present and past values of the first error, the second term represents the contribution of the second error and so on. In this way we can decompose the value of any x_{jt} into n components, corresponding to the n structural errors. This represents the historical decomposition (HD) of x_j and there will be n^2 HD components.⁶

The HDs will require the estimated C matrices as well as the estimated ε series (the structural residuals), all of which require us to estimate the matrix A , the matrix of contemporaneous coefficients in the SVAR model in equation (1). As things stand, this matrix is not identified and additional identification assumptions need to be made. In the two-variable model we use the commonly-used Cholesky scheme to identify two shocks (national and provincial). The order of the variables in this case is (y, y_i) , where y is the national growth rate and y_i is the provincial growth rate so that the national shock has a contemporaneous effect on the province but not *vice versa*. While this is, strictly speaking, not possible because the national growth rate is just the weighted average of the provincial growth rates, it is a common assumption (see, e.g., Ridhwan *et al.*, 2014) and usually justified on the basis that the province is small relative to the nation as a whole so that the contemporaneous feed-back can be ignored.

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⁶ In practice (i) we will use estimated coefficients and structural residuals; (ii) there will not be an infinite series of each of the error terms so the sum will be truncated at some finite feasible number; the resulting approximation error will be minimal if the IRFs die out quickly as they do in the present application; (iii) there will be an additional term capturing the deterministic components of the VAR which have been omitted above; this term is of no interest in the present application and will not be reported.

In our three-variable model we derive the additional restrictions needed to identify the structural effects from a three-equation macro model based on Cover, Enders and Hueng (2006) and Enders and Hurn (2007):

$$y_{it} = E_{t-1} y_{it} + \beta \varepsilon_{st} + r \varepsilon_{dt} + \varepsilon_{pt}, \quad (6)$$

$$y_t = E_{t-1} y_t + \alpha(p_t - E_{t-1} p_t) + \varepsilon_{st}, \quad (7)$$

$$(y_t + p_t) = E_{t-1}(y_t + p_t) + \varepsilon_{dt}. \quad (8)$$

Here equations (7) and (8) constitute a simple aggregate-supply/aggregate-demand model in aggregate real output, y_t , and the price level, p_t . E_{t-1} represents expectations conditional on the previous period's information. Equation (6) is a simple equation for real output for province i which assumes that provincial real GDP is affected just by its expectation as well as all three structural shocks. The ε_{jt} terms ($j = p, s, d$) are the structural errors for the province-specific shock, the aggregate supply shock and the aggregate demand shocks respectively. The model embodies the assumption that the aggregate shocks have a contemporaneous effect on provincial output but that the provincial shock does not have an effect within the period on aggregate output or price.⁷ The absence of a contemporaneous effect of the provincial shock on national variables is consistent with that of the Cholesky identification in the two-variable model.

To solve the model, we follow the assumption made in Enders and Hurn that the expectations terms are all determined by (vector) autoregressive processes so that we can represent the model by a VAR model of the form of equation (2) above in the variables y_i , y , and p where e_t , the vector of reduced-form errors is related to the structural errors by $e_t = D\varepsilon_t$ and

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⁷ An alternative assumption to that of the direct effects of both aggregate shocks on provincial output is to assume that these two shocks feed through to the province only through the dependence of provincial output on aggregate output, an alternative we considered but found did not affect the solution of the model and therefore did not change the identification restrictions.

$$e_t = \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix}, \varepsilon_t = \begin{bmatrix} \varepsilon_{pt} \\ \varepsilon_{st} \\ \varepsilon_{dt} \end{bmatrix}, \text{ and } D_t = \begin{bmatrix} 1 & \beta & r \\ 0 & \frac{1}{1+\alpha} & \frac{\alpha}{1+\alpha} \\ 0 & \frac{-1}{1+\alpha} & \frac{1}{1+\alpha} \end{bmatrix}. \quad (9)$$

To proceed with identification, we distinguish between national demand and supply shocks in the manner of Blanchard and Quah (1989): the demand shock has no long-run effect on aggregate real output but may affect the price level in the long run while the supply shock may affect both real output and the price level in the long run. We extend this in the present model to include the restriction that the demand shocks also has no long-run effect on provincial real output. These two long-run restrictions may be used to solve for the parameters α and γ in terms of the estimated coefficients of the reduced form model, equation (2). The remaining parameters may be computed from the usual restrictions: normalisation restrictions, independence of the structural errors and the equivalence between the estimated covariance matrix of the reduced-form VAR and covariance matrix of the structural errors implied by equation (9).

Cover, Enders and Hueng (2006) and Enders and Hurn (2007) have shown that the standard assumption in the Blanchard-Quah procedure that the structural errors are uncorrelated is often violated in practice and they have proposed a method for relaxing this assumption. Before deriving the remaining parameters in our model we extend our analysis, following Enders and Hurn, by allowing for possible correlation between the structural errors since, to anticipate our results, we find significant evidence of correlated structural errors. To enable such correlation to be estimated we need to restrict its form. In particular, we make the demand-prior assumption of Enders and Hurn:

$$\varepsilon_{pt} = \delta_{pt} + c_1 \delta_{dt}, \quad (10)$$

$$\varepsilon_{st} = \delta_{st} + c_2 \delta_{dt}, \quad (11)$$

$$\varepsilon_{dt} = \delta_{dt}. \quad (12)$$

Here the δ_{jt} ($j = p, s, d$) terms are “pure” provincial, supply and demand shocks (which are assumed mutually independent) and demand is said to be prior in that the pure demand shock directly affects both the (structural) provincial shock and the supply shock. Thus, in the spirit of simple Keynesian macroeconomics, an unexpected increase in demand is initially met (partially, at least) by a temporary increase in supply, i.e., (partially) matched by a supply shock. This counts for both aggregate and provincial output. Given these assumptions, the relationship between the reduced form errors and the pure shocks is given by:

$$e_t = \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix} = D\varepsilon_t = \begin{bmatrix} 1 & \beta & r \\ 0 & \frac{1}{1+\alpha} & \frac{\alpha}{1+\alpha} \\ 0 & \frac{-1}{1+\alpha} & \frac{1}{1+\alpha} \end{bmatrix} \begin{bmatrix} \varepsilon_{pt} \\ \varepsilon_{st} \\ \varepsilon_{dt} \end{bmatrix} = \begin{bmatrix} 1 & \beta & r \\ 0 & \frac{1}{1+\alpha} & \frac{\alpha}{1+\alpha} \\ 0 & \frac{-1}{1+\alpha} & \frac{1}{1+\alpha} \end{bmatrix} \begin{bmatrix} 1 & 0 & c1 \\ 0 & 1 & c2 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \delta_{pt} \\ \delta_{st} \\ \delta_{dt} \end{bmatrix} = G\delta_t \quad (13)$$

where δ_t is the vector of pure shocks and

$$G = \begin{bmatrix} 1 & \beta & c_1 + c_2\beta + r \\ 0 & \frac{1}{1+\alpha} & \frac{c_2+\alpha}{1+\alpha} \\ 0 & \frac{-1}{1+\alpha} & \frac{-c_2+1}{1+\alpha} \end{bmatrix} \quad (14)$$

The parameters α and γ can be estimated from the two long-run restrictions as explained above and the remaining parameters (c_1, c_2, β and the variances of the pure shocks) can be estimated from the six restrictions implied by the relationship between the covariance matrix of the structural and reduced-form errors, the normalisation assumptions and the independence assumptions regarding the pure shocks.

4. Data

We require data for two types of variables: national and regional. All data are annual from 1978 to 2016. The national variables are real output growth and inflation. Real output is measured by real GDP (RGDP) and the inflation rate is computed from the CPI. Both of these series were taken from the *China Statistical Yearbook* (NSB, various issues).

The regional variables are real provincial GDP data for which were taken from Wu (2004) and the *China Statistical Yearbook* (NSB, various issues). We used data for 28 of China's 31 provinces: we included the "city-provinces" of Beijing, Shanghai and Tianjin and, following Wu (2004), we included Chongqing in Sichuan, Hainan in Guangdong and omit Tibet.

Before proceeding to our empirical results, we report tests of stationarity of the data in Table 1.

[Table 1 about here]

In each case the lag length for the ADF tests was chosen using the SIC with a maximum number of lags of 9. Generally the logs of the variables are $I(1)$ so that the levels are non-stationary and the growth rates and the inflation rate (log difference) are stationary as we would expect. There are a few exceptions but an inspection of the IRFs in the three-variable model does not suggest any non-convergence problems and we therefore proceed on the assumption that all the variables are stationary in the first-differences of the logs.

5. Results

In this section we present the results of our two models, starting with those generated by the two-variable model and then going on to the three-variable extension. These allow us to distinguish between national and provincial components in the first case and between (national) supply and demand as well as provincial components in the second.

5.1 *The two-variable model: National v. provincial contributions to the provincial slowdown*

We begin by addressing the question: what are the relative contributions of national and provincial factors to the widespread slowdown in the growth rate which we observed at the provincial level in section 2? We address this question by estimating and simulating a

sequence of simple two-variable VAR models, each with the national growth rate and one of the provincial growth rates. In this case we identify the structural shocks using the Cholesky approach, assuming that the national shock (N) may affect both national and provincial growth rates contemporaneously but that the provincial shock (P) affects only the provincial growth rate within the period (although it will, generally, affect the nation with a lag through the model dynamics). This is similar to the assumption made by Ridhwan *et al.* (2014) in their analysis of the regional impact of monetary policy on the provinces in Indonesia.

Before estimating the model we need to decide on lag length which we based on standard information criteria: the SBC and the AIC, the results for which are reported in Table 2.

[Table 2 near here]

It is clear from the table that the maximum lag for any model is 2 and while one lag is sufficient for many cases, we estimate all models with two lags to ensure comparability across models.

The basis of the analysis is a set of historical decompositions (HDs) of the provincial growth rates over the period 2008 to 2016. In each case there are two components, a national and a provincial one. The results are pictured in Figure 3.

[Figure 3 about here]

There are various features of the results that are worth noting. First, with the exception of Xinjiang province, the contribution of the national factor is always negative at the end of the sample period. Second, in most cases the national component has been negative for more than half the period from 2008 to 2016 so that national factors have been having a negative impact on provincial growth for at least half the period. Third, in all cases (again, with the possible exception of Xinjiang) the national component has, on average, declined over the period. Fourth, for most of the provinces (exceptions being Shanxi, Inner Mongolia, Jilin and

Xinjiang) national shocks have generated most of the overall decline in provincial growth rates. Fifth, there is much greater variation across provinces in the contribution of the province-specific factor than in that of the national factor. This suggests that the differential growth experience of the provinces in the past decade results not so much from differences in the mechanism through which national shocks are propagated in the provinces as from province-specific shocks.⁸

It has been noted earlier that it is a weakness of the sequence-of-models approach that the aggregate shocks are not constrained to be equal across the sequence and this could affect the inter-province comparisons. Thus the inter-provincial differences in the national components might importantly reflect differences in the national shocks which ought to be identical rather than differences in the way the common national shocks are propagated. We can throw some light on this possibility by examining the national structural errors generated by the 28 model and we do this in Figure 4 where each series for 2008 to 2016 is compared to the average across all provinces.

[Figure 4 near here]

An inspection of the national error series from each of the models in Figure 4 shows them to be very similar to the average in all cases so that the variation in the N shocks across models is not likely to have a substantial effect on the differences in the N components. This is borne out by the correlations: the average correlation coefficient between the individual N shocks and their average across all models is 98% for the period 2008 to 2016. The individual correlations are reported in the appendix in Table A1.

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⁸ Indeed, the correlation coefficient across provinces in 2016 between the province-specific contribution and the deviation of growth from the national average is 83%.

5.2 The three-variable model: Supply, demand and provincial contributions to provincial growth rates

We now turn to the results from the model in which the national component is further divided into (national) supply and (national) demand components. In this model we have two national variables (real GDP growth and inflation) and one provincial variable (provincial real GDP growth). The addition of the national inflation rate allows us to break up the national component of the previous mode. into national demand and supply components using an identification scheme based on Blanchard and Quah (1989) as modified by Cover, Enders and Hueng (2006) and Enders and Hurn (2007). The results of the resulting decomposition of each province's growth rate over the period 2008 to 2016 are pictured in Figure 5.

[Figure 5 about here]

Each graph shows the decomposition of the particular province's growth rate into three components: supply, demand and province-specific. It seems clear that the supply component closely resembles the national component in the previous model, suggesting that not only is the national component the major driver of the slowdown at the provincial level but that supply forces are the main systematic part of the national factor.⁹ It is also interesting that the supply component of each province's growth rate is similar in shape to the supply component of the national growth rate as derived in Chen and Groenewold (2018). Thus nation-wide supply forces are mainly responsible for the slowdown for China as a whole and flow through consistently to the provincial growth rates. There are exceptions, however: in some provinces such as the north-eastern provinces of Jilin, Liaoning and Heilongjiang the supply effects are more deeply negative whereas other provinces such as the

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⁹ The correlation in 2016 across provinces between the national contribution in the two-variable model and the supply contribution in the three-variable model is 88%.

western province of Xinjiang have experienced a relatively modest negative impact of supply factors.

The province-specific component also remains relatively stable between the two models, which gives us confidence that this variable really is capturing provincial effects.¹⁰ Demand forces are much more variable across provinces than are supply factors, although there does seem to be a common large positive “hump” around 2010 which we take to reflect the national government’s extraordinary fiscal expansion in response to the collapse in world trade following the onset of the GFC, a policy which seems to have delayed the onset of the growth decline to around 2012 for many provinces.

Finally, we check the similarity of the national supply and demand shocks across the provinces to ensure that differences in the supply and demand components did not result from (spurious) differences in the shocks. In Figure 6 we report the supply shocks for each model and compare it to the average across models and in Figure 7 we do the same for the demand shocks.

[Figures 6 and 7 about here]

In each case the shock series are very close to the average for most provinces; the average correlations are 97% and 96% for the supply and demand shocks respectively. The correlations for each model are reported in the appendix in Tables A2 and A3. Clearly the criticism of the sequence-of-models approach that they do not constrain the common shocks to be identical, while true, is not likely to have important practical consequences in our case.

In summary, the similarity in provincial experience in the period after the onset of the GFC in 2008 clearly stems from a fairly uniform provincial reaction to a national growth contraction driven by supply factors. National demand forces seem to have made a positive contribution to provincial growth early in the period, coinciding with the national

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¹⁰ The correlation between the provincial effects in the two models in 2016 is 96%.

government's fiscal stimulus following the GFC contraction but demand has not played any consistent role in the slowdown overall. Finally, provincial effects vary considerably across provinces, as might be expected, and are the main explanation of the variation of provincial growth experience around the national average.

6. Conclusions

The slowdown in China's growth rate over the period since the onset of the GFC is widely believed to be a long-term phenomenon rather than merely a temporary departure from historically high growth rates. In this paper we investigated the slowdown at the provincial level. We began by comparing the provincial growth rates to the national growth, after which we proceeded to our econometric analysis. We first used a sequence of simple bivariate VAR models in which we distinguished national from provincial shocks and used it to decompose the time-path of each province's growth rate over the period 2008-2016 into national and provincial components. We then went on to a three-variable model in which we divided the national shock into national supply and demand shocks and used it to decompose provincial growth rates into three components: national supply, national demand and provincial.

Our findings may be summarised as follows. First, there has been a noticeable growth slowdown in most provinces in the period since 2008 but there are distinct differences across provinces. Second, the contribution of the national shock to the slowdown in provincial growth is quite similar across provinces. Third, for most provinces the national factor is the more important driver of the slowdown although province-specific factors also make a substantial contribution in some provinces and account for most of the inter-provincial differences in the slowdown. Fourth, when the national shock is divided into demand and supply components, it turns out that the national shocks are driven mainly by

supply factors, with the contribution of demand shocks being quite varied across provinces, despite the shock being common to all provinces. This is consistent with the consensus view that the growth slowdown at the national level is mainly driven by supply factors.

The empirical disentangling of different sources of provincial slowdowns is potentially an important one from a policy perspective. Most of what the provinces have experienced since 2008 is the result of national supply forces and the reactions are fairly uniform across provinces. This suggests that a common national policy will be valuable and that such policy should, in the first place, be supply-focussed. But, for some provinces at least, there will be scope for policy tailored to the province's specific needs which might be seen as the responsibility of the relevant provincial government.

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Table 1: Stationarity tests, provincial RGDP, national RGDP and CPI

Variable	log level		log difference	
	no trend	trend	no intercept	intercept
Beijing	0.9023	0.2222	0.2007	0.0012
Tianjin	0.6759	0.5052	0.7841	0.2051
Hebei	0.5239	0.9125	0.5709	0.2342
Guangdong	0.1515	0.9919	0.1888	0.0385
Shandong	0.9004	0.2287	0.3507	0.0124
Fujian	0.7705	0.6392	0.4124	0.1558
Zhejiang	0.3102	0.9889	0.1351	0.0076
Jiangsu	0.8696	0.1442	0.1997	0.0031
Shanghai	0.9190	0.5286	0.3439	0.0379
Liaoning	0.8987	0.0005	0.2804	0.6297
Guangxi	0.9841	0.1828	0.3873	0.0522
Shanxi	0.9302	0.1273	0.1269	0.0067
Inner Mongolia	0.9687	0.6344	0.2563	0.0569
Jilin	0.9548	0.3204	0.1760	0.0030
Heilongjiang	0.9840	0.3036	0.5862	0.2776
Anhui	0.9858	0.2346	0.1748	0.0046
Jiangxi	0.9936	0.0218	0.1929	0.0232
Henan	0.9963	0.4026	0.3995	0.0001
Hubei	1.0000	0.1914	0.1657	0.0401
Hunan	0.9930	0.6956	0.5820	0.0591
Sichuan	0.9993	0.3573	0.1437	0.0046
Guizhou	0.9978	0.9384	0.3327	0.0074
Yunnan	0.9601	0.6948	0.4889	0.0000
Shaanxi	0.9987	0.8238	0.5437	0.0020
Gansu	0.9914	0.0452	0.1546	0.0001
Qinghai	1.0000	0.1265	0.8008	0.0000
Ningxia	0.9708	0.5862	0.2968	0.0010
Xinjiang	0.8843	0.5082	0.2447	0.0047
China RGDP	0.7372	0.0213	0.5242	0.0169
China CPI	0.5586	0.9467	0.1354	0.0221

Notes: lag lengths for the tests were chosen using the SIC with a maximum number of lags of 9.

Table 2: Optimum lag length for the two-variable model

Model	SBC	AIC
Beijing	1	2
Tianjin	1	1
Hebei	1	2
Guangdong	2	2
Shandong	1	1
Fujian	1	2
Zhejiang	1	1
Jiangsu	1	1
Shanghai	2	2
Liaoning	1	1
Guangxi	1	1
Shanxi	1	2
Inner Mongolia	1	2
Jilin	2	2
Heilongjiang	1	2
Anhui	1	1
Jiangxi	1	1
Henan	1	1
Hubei	1	1
Hunan	1	1
Sichuan	1	1
Guizhou	1	2
Yunnan	2	2
Shaanxi	1	1
Gansu	1	1
Qinghai	2	2
Ningxia	1	1
Xinjiang	1	1

Note: the optimal lags are chosen based on the AIC and SBC.

Figure 1. Provincial growth rates, China, 1979 to 2016

Figure 2. Provincial and national growth rates, China, 2008 to 2016

Notes: red = growth rate of national real GDP, blue = growth rate of provincial real GDP.

Figure 3. The contributions of national and provincial shocks to provincial growth, 2008 to 2016
Notes: red = national contribution, blue = provincial contribution

Figure 4. Actual and average national shocks for each of the 28 two-variable VAR models
Notes: black=actual, blue=average

Figure 5. The contributions of supply, demand and provincial shocks to provincial growth, 2008 to 2016

Notes: purple = supply contribution, green = demand contribution, blue = provincial contribution

Figure 6. Actual and average supply shocks for each of the 28 three-variable VAR models
Notes: blue=actual, black=average

Figure 7. Actual and average demand shocks for each of the 28 three-variable VAR models
Notes: blue=actual, black=average

Appendix

Table A1. Correlations between actual and average national shocks, two-variable model

Model	1978-2016	2008-2016
Beijing	0.99375	0.99766
Tianjin	0.98270	0.98945
Hebei	0.99355	0.99569
Guangdong	0.90546	0.99600
Shandong	0.97897	0.99168
Fujian	0.95171	0.99592
Zhejiang	0.98777	0.99676
Jiangsu	0.99666	0.99900
Shanghai	0.83177	0.90848
Liaoning	0.98172	0.97620
Guangxi	0.96840	0.98484
Shanxi	0.98193	0.97571
Inner Mongolia	0.95182	0.97173
Jilin	0.91249	0.95328
Heilongjiang	0.98721	0.98761
Anhui	0.97115	0.97690
Jiangxi	0.99097	0.99299
Henan	0.98919	0.99818
Hubei	0.98875	0.99552
Hunan	0.98128	0.99219
Sichuan	0.98262	0.97945
Guizhou	0.96642	0.96661
Yunnan	0.90626	0.95611
Shaanxi	0.89259	0.98616
Gansu	0.96365	0.99771
Qinghai	0.91278	0.98507
Ningxia	0.97074	0.99215
Xinjiang	0.93878	0.94101
Average	0.95930	0.98140

Notes: each figure is the correlation coefficient between the structural errors and the average of the structural errors across all provinces for the period at the head of the column.

Table A2. Correlations between actual and average supply shocks, three-variable model

Model	1978-2016	2008-2016
Beijing	0.98779	0.99125
Tianjin	0.98918	0.99008
Hebei	0.98325	0.99157
Guangdong	0.90910	0.97176
Shandong	0.93934	0.95631
Fujian	0.95186	0.99564
Zhejiang	0.96599	0.99544
Jiangsu	0.97515	0.99686
Shanghai	0.88794	0.94971
Liaoning	0.96569	0.92463
Guangxi	0.97596	0.98998
Shanxi	0.93692	0.87138
Inner Mongolia	0.87341	0.89626
Jilin	0.96632	0.95674
Heilongjiang	0.99650	0.99678
Anhui	0.99468	0.99331
Jiangxi	0.99695	0.99922
Henan	0.97732	0.99748
Hubei	0.98588	0.99451
Hunan	0.98767	0.9938
Sichuan	0.98726	0.98339
Guizhou	0.99742	0.99784
Yunnan	0.88632	0.94732
Shaanxi	0.88073	0.9536
Gansu	0.98588	0.98279
Qinghai	0.98257	0.99422
Ningxia	0.98622	0.97991
Xinjiang	0.94559	0.95105
Average	0.96010	0.9730

Notes: each figure is the correlation coefficient between the structural supply errors and the average of the structural supply errors across all provinces for the period at the head of the column.

Table A3. Correlations between actual and average demand shocks, three-variable model

Model	1978-2016	2008-2016
Beijing	0.94401	0.97965
Tianjin	0.95256	0.97759
Hebei	0.96045	0.98166
Guangdong	0.91785	0.98849
Shandong	0.93128	0.97702
Fujian	0.97847	0.98481
Zhejiang	0.98583	0.98795
Jiangsu	0.93131	0.94656
Shanghai	0.90719	0.968
Liaoning	0.97659	0.93937
Guangxi	0.99078	0.98932
Shanxi	0.90789	0.76077
Inner Mongolia	0.9188	0.93857
Jilin	0.96573	0.98894
Heilongjiang	0.92277	0.81941
Anhui	0.97246	0.99611
Jiangxi	0.94622	0.97664
Henan	0.96546	0.99713
Hubei	0.92567	0.9728
Hunan	0.99185	0.9967
Sichuan	0.98965	0.99377
Guizhou	0.94079	0.93881
Yunnan	0.97297	0.98363
Shaanxi	0.99336	0.99534
Gansu	0.92823	0.96206
Qinghai	0.92369	0.9469
Ningxia	0.93715	0.98209
Xinjiang	0.97739	0.96773
Average	0.9520	0.9621

Notes: each figure is the correlation coefficient between the structural demand errors and the average of the structural demand errors across all provinces for the period at the head of the column.

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