Productivity growth of the cities of Jiangsu Province, China: A Kaldorian approach

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This paper considers the determinants of economic growth of the cities of Jiangsu Province, China, adopting a Kaldorian approach. It is found that there is a close correlation between the growth of non-industry and industry (Kaldor's first law) that provides indirect evidence for the export-base theory. The paper discusses two competing explanations of the foundations of the Verdoorn law (Kaldor's second law), which, in its simplest form, is the relationship between industrial productivity and output growth. It also considers the static-dynamic Verdoorn law paradox. This arises from the fact that estimating the Verdoorn law in log-levels often gives statistically insignificant estimates of the Verdoorn coefficient while the use of growth rates gives significant values of around one half. The results in this paper show that this does not occur when data for the cities is used. A plausible explanation for the paradox is that it results from spatial aggregation bias. It is also found that inter-province urban productivity disparities first increase, but subsequently decrease over the period considered.

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1. Introduction

In this paper, we examine the factors determining the productivity and output growth of the cities of one of China's largest and most developed regions, namely Jiangsu province. In many ways, the region is one the powerhouses behind China's fast growth over the last thirty years, or so. Consequently, the reasons behind the province's rapid growth are important for understanding China's late rapid industrialization. We examine the latter using the Kaldorian framework, the importance of which has been emphasised for understanding the rate of economic development by, for example, Mathews (2016, pp. 622-625).

Kaldor's first law is the close relationship that is found between the growth of industry and either non-industry or, alternatively, total output. The usual interpretation of this relationship is that as exports are predominantly industrial products, a faster growth of exports is closely correlated with a faster growth of industry. This, through the dynamic Harrod trade multiplier, or more generally the Hicks super-multiplier, leads to a faster growth of output.

The second, or Verdoorn's law, in its simplest form is the close relationship between industrial productivity and output growth, the statistical estimates of which are often interpreted as demonstrating the effect of induced technical progress and substantial increasing returns to scale, including agglomeration economies (Verdoorn 1949; Kaldor 1966; McCombie, Pugno and Soro 2002). We provide an alternative, although related, interpretation below. These studies using cross-regional or cross-country long-run average growth rates include McCombie and de Ridder (1984); McCombie (1985); Bernat (1996); Hansen and Zhang (1996); Fingleton and McCombie (1998); León-

Ledesma (2000); Pons-Novell and Viladecans-Marsal (1999); Angeriz, McCombie and Roberts (2008 & 2009); and Guo, Dall'erba and Le Gallo (2013).

In this approach, growth is essentially demand oriented. It is assumed that the growth of demand for labour is met by in-migration, and in the case of a rapidly developing country, such as China, migration from the rural to the urban areas. As far as the rate of capital accumulation is concerned, there are also likely to be flows of savings (and investment) to the faster growing cities. A faster growth of output will also induce a greater rate of investment. Of course, supply factors can put a break on the rapid rate of growth, either, for example, by driving up wages as labour shortages occur or by increasing prices as land rents rise. This Kaldorian approach is particularly applicable to China's rapid development over the last three decades or so. Rima (2004), for example, argues that China's growth can be best understood from a Kaldorian perspective, rather than from the traditional Ricardo-Hecksher-Ohlin approach. In particular, she argues that the former is a combination of Adam Smith's "vent for surplus" and increasing returns in manufacturing, as evidenced by the Verdoorn law.

Consequently, we estimate two of Kaldor's laws of economic growth (McCombie 1983; Thirlwall 1983).[1] The second, or Verdoorn, law, with its emphasis on the importance of demand factors driving the growth of output, stands in marked contrast to the regional neoclassical Solow and endogenous growth models.

To date, estimations of both of these Kaldorian relationships have usually been undertaken using data at the regional (or national) level. However, the spatial extent of the regions is largely determined by historical and administrative considerations and, hence, is unlikely to reflect the appropriate spatial area of production, which may be termed the Functional Economic Area (FEA). The latter is more closely approximated by the city, rather than the region, and hence we focus on the cities of Jiangsu province.

Using city-level data enables us to shed light on the "static-dynamic Verdoorn paradox", first identified by McCombie (1982). The Verdoorn law in growth-rate form can be derived from a log-level specification by differentiating the latter with respect to time and using growth rates. However, when both specifications are estimated using the same cross-regional, or cross-national, data sets, the log-level specification often finds an insignificant Verdoorn coefficient, while, paradoxically, the use of growth rates finds a significant value of around one half. The most plausible explanation of this is that as regional or national data are used when this occurs, the estimates of the static Verdoorn law are subject to greater spatial aggregation bias than are those of the dynamic version (McCombie and Roberts 2007). As the city approximates more closely to the FEA than the region, the use of city data as the unit of observation should not lead to marked differences in the estimates of the static and dynamic Verdoorn coefficient.

Consequently, using city data, we are able to test the spatial aggregation bias hypothesis and also have greater confidence in the estimates of the Verdoorn law. This is also the first time city data has been used to estimate Kaldor's laws and avoids the potential specification errors of previous studies.

We estimated the two laws for the 61 cities of Jiangsu Province which, as noted above, is one of the most developed of China's regions. It is a coastal province located along the lower reaches of the Yangtze and Huai Rivers. The province's GDP, in 2012, was 10 per cent of the national total, although its land area was about one percent. Its GDP per capita was 178 per cent of the national average, which was the fourth highest of China's provinces. It is one of the most important provinces, not least because of its contribution to national output (it is the second largest), but also because of its industrial structure and the close links with central government institutions. There are 13 prefectures in Jiangsu, with 15 prime cities and 48 county-level cities, giving a total of 61 cities. The province is divided into three regions, namely, southern Jiangsu (Sunan), central Jiangsu (Suzhong) and northern Jiangsu (Subei). Although the province is relatively developed by China's standards, it exhibits striking regional inequality with a pronounced north–south divide with the northern region, Subei, having a per capita income of 60 per cent of the province. This compares with the southern region, Sunan, where the corresponding value was 148 per cent. Thus, there is a great deal of variation in the data used to test the various hypotheses of growth.

The paper is structured as follows. In the next section we estimate the relationship between the growth of industry and non-industry for the cities. Following this, we derive the Verdoorn law and discuss two possible alternative interpretations. We next estimate the law, including a number of controlling variables in the regression. As we have noted, it is often found that when the Verdoorn law is estimated in log-level form the Verdoorn coefficient is statistically insignificant, while this is not the case using growth rates. Conventional production function studies using cross-regional or cross-country log-level data also find what are interpreted as constant, or small, returns to scale (Hildebrand, Liu and Liu 1965; Griliches and Ringstad 1971; Moroney 1972; McCombie and de Ridder 1984). We discuss this "static-dynamic Verdoorn law paradox" (McCombie, 1982) and examine whether or not it occurs at the city level. Of particular relevance is the study of Guo, Dall'erba and Le Gallo (2013) who, after controlling for spatial autocorrelation, find a significant Verdoorn coefficient for the *regions* of China. We compare our estimates of Jiangsu's cities with their results. The final section concludes.

2. Testing Kaldor's first law for Jiangsu cities

The first law is that there is a close, albeit simple, relationship between the growth of total urban output (q_{GDP}) and that of industry, or manufacturing, (q_{IND}) with the latter causing the former. This relationship is given by:

$$q_{GDPt} = c + b_1 q_{INDt} \qquad (1)$$

where *c* is used as a generic term for the constant throughout the paper. Because city total output, or GDP, definitionally includes industry as a component, this equation may be rewritten to give a preferable specification as:

$$q_{NIt} = c + b_2 q_{INDt} \qquad (2)$$

where the subscripts *IND* and *NI* denote industry and non-industry, i.e., *NI* is GDP minus industrial output. What is the interpretation of this relationship? As we have noted, a key determinant of the growth of city output is that of exports, and in developing countries and many developed countries, these are largely manufactured products. This is the basis of the export-led growth model, or export-base theory, of regional, or city, economic activity. Hence, a faster growth of exports leads to a faster growth of industrial output which, in turn, will lead to a faster growth of the rest of the economy.

Other studies, in addition to Kaldor (1966) who used data for the advanced countries for the early postwar period, have found support for this relationship. Wells and Thirlwall (2004) confirm the first law for 45 African countries using average growth rates over the period 1980-1996. More recently, Pacheco-López and Thirlwall (2014) find a statistically significant relationship for 89 developing countries over the period 1990-2011. For our purposes, it is interesting to note that Hansen and Zhang (1996) present some early estimates for the 28 regions of China over the period 1985-1991 using cross-regional time-series data and find support for the two hypotheses. Guo, Dall'erba and Le Gallo (2013) also find the relationship holds for China's regions for a more recent period.

Equation (2) was estimated for the 61 cities of Jiangsu Province using data for 1996 to 2012. The data were taken from various editions of the *Jiangsu Statistical Yearbook*. As the boundaries of the cities change significantly over the period, they were reclassified to make them comparable over time.

One problem with the estimation using spatial data is the complication posed by the presence of spatial autocorrelation. We tested for this in all cases and used appropriate estimation techniques that corrected for the spatial autocorrelation when it is present.

Table 1 reports the results and this is the first time the relationship has been estimated using city data. As the standard diagnostic tests reject the null hypothesis of the presence of spatial autocorrelation, OLS and IV regressions were estimated. In this context, it is difficult to find an instrument that is correlated with the regressors, but uncorrelated with the error term. We, therefore, used Durbin's estimator as an appropriate IV procedure. The data are for the average growth rates over the whole of the period 1996-2012.[2] It can be seen that the OLS regression gives an estimate of the coefficient of the growth of a city's industrial output that is statistically significant at the 5 percent level. An increase in the latter variable by one-percentage point increases the growth of the rest of the city's output by about 0.26 percentage points. The IV estimates are virtually identical. The regional intercept dummies show that the cities in the more developed southern (Sunan) province have an exogenous growth of their non-industrial urban economies that is statistically significantly greater than the other two provinces. There is, however, no significant difference in the values of the slopes of the regressions between regions.

[Table 1 about here]

We considered two further specifications of the first law. The first was to estimate equation (2) using annual data in a panel auto-regressive model with spatial auto-regressive disturbances and a two-way fixed effects estimator. The estimation controlled for spatial autocorrelation, although this was again statistically insignificant. The resulting estimate of the coefficient of 0.3 is slightly higher than that obtained using average growth rates and the *t*-statistic was larger (see Table 2).

The second specification is of the first law in log-level form, which we term the static law, namely,

$$lnQ_{NIt} = c + b_3 lnQ_{INDt} \quad (3)$$

Differentiating equation (3) with respect to time gives equation (2), so theoretically the estimated coefficients should be identical.

The estimation procedure was the same as before, with annual data in a spatial panel model. This time there was statistically significant spatial autocorrelation which the estimation technique corrected for. The coefficient was 0.255 and statistically significant, again similar to the previous results, and not refuting Kaldor's first law.

[Table 2 about here]

These results confirm the importance of the growth of the industrial sector in determining the growth of the rest of the urban economy, a hypothesis, which we noted above, that may be traced back to the early export-base theory (given that most exports tend to be manufactured goods). We have also shown that the *level* of industrial output is also important in determining the value of the rest of the city's output.

3. Testing the Verdoorn law for Jiangsu cities

There are two alternative derivations of the law with very different implications. The first, following Verdoorn (1949), is to derive it from an aggregate Cobb-Douglas production function. The second is that as constant-price value data are used in the estimation of the Verdoorn law, all that the estimates are picking up by definition are an underlying accounting identity (Felipe and McCombie 2012, 2013). While the estimates do tell us something about the macroeconomy, the interpretation is very different from that of the aggregate production function.

3.1 The Verdoorn law and the aggregate production function

The Verdoorn law is at the heart of the cumulative causation model of economic growth (Dixon and Thirlwall 1975). In its simplest specification, this law is the linear relationship between productivity and output growth. One derivation of the law for a city, although we shall argue below is not the most plausible, is from a Cobb-Douglas production function, which is how Verdoorn (1949, Appendix),[3] *inter alios*, interpreted the relationship. The production function is given by:

$$Q_t = A_t K_t^{\alpha} L_t^{\beta} \qquad (4)$$

where Q, K, and L are the levels of output, capital, and labour respectively, A is the level of technology, and α and β are the output elasticities of capital and labour. It is assumed that $\alpha = \gamma\alpha'$ and $\beta = \gamma(1-\alpha')$, where γ is a measure of the degree of static returns to scale, including agglomeration economies. α' and $1-\alpha'$ are sometimes assumed to be equal to capital's and labour's share in value added. A key assumption of the Verdoorn law is that the rate of technological progress is largely induced, partly because of learning-by-doing (Arrow, 1962) and partly because a faster rate of capital accumulation is accompanied by a more rapid rate of invention (Kaldor, 1966). Technical progress can be specified as being partly endogenously determined by growth of the weighted factor inputs in the form:

$$\hat{A}_t = \bar{\lambda} + \eta(\alpha k_t + \beta l_t) \qquad (5)$$

Where $\hat{A}$ is the rate of technical progress and $\bar{\lambda}$ its exogenous component. η is the elasticity of induced technical progress with respect to the weighted growth of the inputs and k and l are the growth rates of capital and labour, respectively.

Taking logarithms of equation (4), differentiating with respect to time, using equation (5) and rearranging gives:

$$q_t = \bar{\lambda} + \gamma(\eta + 1)(\alpha' k_t + (1 - \alpha')l_t) \qquad (6)$$

where $v = \gamma(\eta + 1)$ and v is a measure of the degree of the encompassing dynamic and static returns to scale. This is assumed to be constant across regions. Re-arranging equation (6) yields the dynamic Verdoorn law using growth rates:

$$p_t = \frac{\bar{\lambda}}{v(1-\alpha')} + \left(1 - \frac{1}{v(1-\alpha')}\right) q_t + \frac{\alpha'}{(1-\alpha')} k_t \qquad (7)$$

where p is the growth of productivity. The simplest specification of the Verdoorn law assumes Kaldor's stylized fact that the growth rates of output and capital are equal and is given by $p_t = c + b_4 q_t$, where b_4 is the Verdoorn coefficient and is usually found empirically to take a value of 0.5. The Verdoorn coefficient, under these circumstances, is given by:

$$b_4 = \theta = \frac{v-1}{v(1-\alpha')} \qquad (8)$$

In practice, as we noted above, α' is taken to be equal in value to capital's factor share (*a*). In this case, if *a* equals one quarter, a Verdoorn coefficient of one half is equal to encompassing increasing returns to scale of 1.6.

Some cities may lag behind in terms of their level of technology. Therefore, part of the resultant productivity growth may be attributable to a catch-up, or convergence process, due to the diffusion of new technology from the more to the less technologically developed cities. A common practice for testing for technological diffusion is to include the initial level of the log-level of productivity as a proxy for the level of technology (Fingleton and McCombie 1998).

In the specification of Verdoorn law, output growth is assumed to be the regressor, because with factor mobility, etc., it is assumed that output growth is primarily determined by demand factors (Thirlwall 1980). These include the composition of the output of the city. Does a city, for example, have an above-average share of fast growing hi-tech industries or is production concentrated in, say, basic goods such as textiles for which world demand is growing relatively slowly? With substantial migration and the rate of capital accumulation being largely determined by the growth of output and by investment flows, city growth cannot plausibly be considered to be determined by the exogenously determined growth of the city labour force and the exogenously given savings ratio.

The above model is a highly aggregative, although no more so than those in neoclassical growth theory. However, Fingleton (2003) has derived the Verdoorn law from within the New Economic Geography framework and this can provide its microfoundations.

The appropriate method of estimating the Verdoorn law is to use cross-regional or cross-country data. Estimating the Verdoorn law using, say quarterly or annual time-series data, will often give a significant “Verdoorn” coefficient, but this has no implications for whether or not there are increasing returns to scale. This is because the estimate is merely capturing the Okun (1962) effect. Okun’s law results from the fact that over the business cycle, in a downturn, changes in total hours worked underestimate the decline in both the flow of labour services and the intensity of the hours worked, because of labour hoarding and labour contractual issues. Labour is a “quasi-fixed factor of production”, as Oi (1962**)** puts it. Also the flow of capital services declines more than the observed change in the capital stock (Lucas, 1970). See, for example, McCombie and Thirlwall (1994, pp.197-200).

Okun’s law (1962) can be expressed in a number of ways, the most common of which is to relate the change in unemployment to the growth of output, usually, GDP. As employment changes are related to changes in unemployment, Okun’s law can be re-specified as the cyclical relationship between employment, productivity and output growth. Ball, Leigh and Lougani (2012 p.11) find that an increase in output growth in the upswing is accompanied by a growth in employment of about half-a-percentage point and in productivity growth of a similar magnitude. This provides no unambiguous evidence of the degree of returns to scale, as the relationships are associated with short-run labour market adjustments and changes in capacity utilisation. The growth of the inputs of labour and capital have serious systematic measurement errors.

Consequently, because of this, productivity growth tends to move procyclically and be positively correlated with output growth. Attempts to correct for changes in the utilization rates by, say using unemployment rates or the interpolations from the trend growth rates of output (or capital) are crude and far from satisfactory. McCombie and de Ridder (1983) estimated the Verdoorn law using time-series data for the US, but concluded that all that the statistically significant Verdoorn coefficient was picking up was, indeed, the Okun effect and this had no implications for the degree of returns to scale.

3.2 The Verdoorn law and the accounting identity

A serious problem with the above derivation of the Verdoorn law is that it is based on an aggregate production function. The difficulty is that, as Fisher (1992, 2005) has formally proved, the aggregation problems are "so very stringent as to make the existence of aggregate production functions in real economies a non-event" (Fisher, 2005, p 490). The defence is that nevertheless estimations of aggregate production functions give good fits to the data, with plausible values of the estimates.

But this is solely due to the fact that constant-price monetary values are used for output and capital in their estimation, together with the existence of an underlying accounting identity derived from the national accounts, namely, $Q_t \equiv W_t L_t + R_t K_t$, where W is the wage rate and R the rate of profit. Expressing this identity in growth rates gives:

$$q_t \equiv a_t r_t + (1 - a_t) w_t + a_t k_t + (1 - a_t) l_t \qquad (9)$$

where a and $(1\text{-}a)$ are the factor shares of capital and labour and r and w are the growth rates of the rate of profit and the real wage rate.

Rearranging equation (9) we obtain:

$$p_t \equiv \frac{\lambda_t}{(1-a_t)} + \left(1 - \frac{1}{(1-a_t)}\right) q_t + \left(\frac{a_t}{(1-a_t)}\right) k_t \qquad (10)$$

where $\lambda_t \equiv a_t r_t + (1-a_t) w_t$. It should be emphasised that as equations (9) and (10) are nothing more than an accounting identity, they must *always* hold and, consequently, give a perfect fit to the data. This is irrespective of the degree of competition in factor and product markets, whether there are constant or increasing returns to scale or, indeed, whether or not an aggregate production function exists. If factor shares do not vary greatly over time, equation (10) may be mistaken for a Cobb-Douglas aggregate production function.[4]

Equation (9) may also be written as:

$$tfp_t \equiv q_t - a_t k_t - (1-a_t) l_t \equiv \lambda_t + 0.q_t \qquad (11)$$

where the $tfp_t \equiv a_t r + (1-a_t) w_t$. The variable *tfp* is often termed the growth of total factor productivity and is used in preference to the growth of labour productivity. But it should be emphasised that here it is merely derived from the accounting identity and does not involve any further implicit neoclassical assumptions. If the growth of capital is equal to the growth of the capital stock (one of Kaldor's stylised facts), then equation (10) can be expressed as:

$$p_t \equiv \frac{\lambda_t}{(1-a_t)} + 0.q_t \qquad (12)$$

The Verdoorn coefficient must always equal zero because in equations (9), (10) and (11), the sum of the coefficients of *l* and *k* must equal unity, as they are simply the respective factor shares.

As all we are estimating is an identity in, say, equations (10) and (12), problems of, for example, lags and cointegration of the variables when time-series data are used do not arise. This argument concerning the accounting identity, as it applies to the aggregate production function has been extensively discussed by Felipe and McCombie (2014), and Herbert Simon (1979) thought it of sufficient importance to discuss it in his Nobel Prize lecture.

What then are the implications for the Verdoorn law? Suppose, using cross-regional data, we have a number of regions where those regions with a faster growth of output have a faster growth of productivity. If we estimate

$$p_{it} = c_{it} + b_5 q_{it} \quad (13)$$

(where *i* denotes the region), and allow the intercepts to vary by using, say, fixed-effects panel data estimation, then this will give a perfect fit to the data (an R^2 equal to unity) and the estimate of b_5 will be equal to zero. This is because we are merely estimating the identity, given by equation (12).

However, the traditional specification of the Verdoorn law assumes a constant intercept across regions (countries) is given by:

$$p_{it} = c + b_6 q_{it} \quad (14)$$

where the estimate of b_6 usually takes a value of around 0.5. It could correctly be argued that this is just an estimation of a misspecified identity and the R^2 will be less than unity.

However, equation (14) does tell us something empirically. A positive and statistically significant Verdoorn coefficient in this cross-sectional context implies that those individual regions with a faster growth of output also have a faster growth of productivity. The converse is also true; slower growing regions have a slower growth of productivity. Notwithstanding the identity, this is a behavioural relationship. It is possible when we compare the experience of different regions that there is no correspondence between a faster growth of productivity and that of output growth. Consequently, estimating equation (14) will give an estimate of b_6 that is not statistically greater than zero and the equation will fail the usual tests of statistical significance. (It is important not to confuse this with estimating equation (13).)

However, we cannot give equation (14), even with a statistically significant Verdoorn law, any interpretation in terms of an aggregate production function, which includes a measurement of the separate contribution of rate of technical change, increasing returns and the growth of factor inputs to productivity growth, etc. All that can be said is that a faster growth of output causes a faster growth of productivity and interpret this broadly as increasing the growth of "technical efficiency" very broadly defined, of a region.

This is discussed in greater detail in McCombie and Spreafico (2016, and, especially, section 5, Figure 2 and the simulation results). It should be noted that their argument depends upon the use of cross-sectional data and average growth rates calculated over a period of, say, five or more years. (These are almost always used in studies of the Verdoorn law.) As we discussed above, estimating the Verdoorn law using time-series data tells us nothing about any structural relationship between productivity and output growth. As we have seen, the short-term relationship in fluctuations between productivity and output growth merely reflects Okun's law and measurement errors. Moreover, as it is based on the accounting identity, statistical issues of cointegration, etc., are irrelevant.

For expositional ease, it is sometimes convenient to refer to a significant Verdoorn coefficient as indicating 'encompassing increasing returns to scale', although it should be remembered that generally it reflects anything that causes either the sum of the weighted growth of the real wage rate and the rate of profit or productivity growth to increase with the growth of output.

The two explanations do not, however, stand on an equal footing as the accounting identity must always hold whereas there are very strong reasons for doubting the existence of the aggregate production function.

3.3 The Verdoorn Law: regression results

We estimated the Verdoorn law for the 61 cities of Jiangsu province initially using cross-city data and average growth rates over the period 1996-2012 for total output and over the period 1999-2012 for industry. The data are again taken from various years of the *Jiangsu Statistical Yearbook*. The labour input is the numbers employed. The periods were determined by the availability of data. We also split the sample into two sub-periods where the break point was 2005/2006 and also estimated the regressions using these data. (This was done because structural breaks in exogenous productivity growth were found at this point in time.) Total output was used as well as industry, as the service sector may also exhibit a statistically significant Verdoorn coefficient.

Average growth rates over both these periods were used in the regression to minimize the short-run fluctuations in productivity due to labour hording and variations in capacity utilization that occur when annual, or quarterly, data are used and which is discussed above. The specification of Verdoorn law that we used, apart from including lnP_0, which is the log-level of productivity at the beginning of the period, also included the ratio of fixed assets investment to GDP (*FAI*) to capture the growth of the capital stock,[5] the ratio of foreign direct investment to GDP (*FDI*), and the share of public infrastructure as a share of total public spending (*IE*). The last three are average values for the whole period.[6] *lnTE*, which is the logarithm of output of the township enterprises expressed as a share of the output of total industry, is also included as a control.[7] All four variables are expected to have a positive effect on the growth of a city's productivity within the Verdoorn law framework. *lnPOP* is the population of each city at the beginning of the period and is included to capture the effect of city size on productivity growth, via agglomeration effects. Intercept dummies were also included for the southern and central regions. Preliminary specifications included also the logarithm of public education expenditure (as a percentage of total public spending). However, to construct a more reliable model, this regressor was dropped as it is strongly correlated with the level of productivity at the beginning of the period (the degree of correlation is greater than 0.70 with the VIF greater than 5).

Moran's I suggests that there is no statistically significant spatial autocorrelation in the estimates discussed below and so the results reported below are for OLS and IV, the latter regression used again Durbin's estimator. We also used the estimation procedure discussed in endnote 2, but again it made little difference to the results. The absence of spatial autocorrelation suggests that the city may be the appropriate unit of observation, i.e., there is no "nuisance" spatial autocorrelation. We also report the results for the two sub-periods separately. This is discussed further below when we consider spatial productivity convergence and divergence.

The results are reported in Table 3 for total output and Table 4 for industry. (Verdoorn's law has been traditionally specified for industry, but developments in technology, in, for example, the retail and wholesale trade, suggest services may also now be subject to encompassing increasing returns to scale and other related factors.) Taking both tables together, can be seen that the Verdoorn coefficient is statistically significantly greater than zero in all the periods for both total output and industry. The values for total output range from about 0.54 to 0.83, depending upon the time period and the estimation procedure. The estimates for industry are very similar, ranging from roughly 0.41 to 0.88. City size (the logarithm of city population) has a positive effect on industrial productivity growth in the period 2006-2012, although surprisingly not for the earlier period (1999-2005). The logarithm of the level of initial level of productivity is statistically significant in the regression for total output and industry in the last sub-period (2006/2007 to 2012), suggesting that the less technologically advanced cities benefit from the diffusion of innovations from the more advanced cities. Perhaps surprisingly, the variable was not statistically significant in the first sub-period.

[Table 3 about here]

[Table 4 immediately following]

The regional intercept dummies are statistically significant both for total output and industry over the whole period with exogenous productivity in the more developed South and the Central regions growing faster than in the North. There was no statistically significant difference in the estimate of the Verdoorn law between the regions. The other controlling variables, perhaps surprisingly, are all statistically insignificant. Overall, these results suggest that a faster growth of output of the Jiangsu cities leads to a faster growth of productivity and technical efficiency, the latter broadly defined.

It is interesting to note that Guo, Dall'erba and Le Gallo (2013), also controlling for spatial autocorrelation, find values for the Verdoorn coefficient of between 0.45 and 0.37, depending upon the precise specification of the model, for China's *regions* over the period 1996 to 2006.

3.4 The static-dynamic Verdoorn Law paradox

The Verdoorn law in its simplest form, using regional data over a period of T years, is given in log-level form by;

$$lnP_{it} = c + b_7D + b_8lnQ_{it} \qquad (15)$$

where i is the spatial unit of observation and $t = T, 0,$ *i.e.,* the initial and terminal years. c, it will be recalled, denotes a generic constant. (Differentiating this equation with respect to time gives the traditional, or "dynamic" Verdoorn law.) If we estimate this equation using a period-dummy, D, to capture any exogenous increase in productivity over the period of T years, the estimate of the Verdoorn coefficient is given by b_8. It is notable that Verdoorn (1949) himself derives the Verdoorn law from a static (i.e., expressed in levels) Cobb-Douglas aggregate production function. Suppose, following Kaldor (1966), *inter alios*, we estimate the law using long-run average cross-country (or cross-regional) growth rates calculated over the single period of length T, i.e.,

$$ln(P_{iT}/P_{i0}) = c + b_9(lnQ_{iT}/Q_{i0}), \qquad (16)$$

then we should expect the estimates of the two Verdoorn coefficients, namely b_8 and b_9, to be equal.

But this does not prove to be the case (McCombie 1982). When this was done in other studies for the OECD countries, the US states or the EU regions, a paradox arose. Using the same data set, when exponential growth rates are used, a significant Verdoorn coefficient is found, whereas using the log-level specification gives small and often insignificant values for the Verdoorn coefficient. Hildebrand and Liu (1965) and Moroney (1972), for example, estimate traditional Cobb-Douglas aggregate production functions in log-level form for the US states using cross-sectional (regional) data and find estimates of what they interpret as degree of returns to scale that nearly always do not differ significantly from unity. Angeriz, McCombie and Roberts (2008, 2009) confirm the static-dynamic paradox for total manufacturing and individual industries for the EU regions as do McCombie and de Ridder (1984) using US state data for manufacturing.

The ratio of the levels of productivity of two regions, *i* and *j*, the sizes of which are administratively determined, using the estimates of the Verdoorn coefficient from the dynamic Verdoorn law is given by:

$$\frac{P_i}{P_j} = \frac{A_i}{A_j}\left(\frac{Q_i}{Q_j}\right)^{0.5} \quad (17)$$

If we assume that region *i* is one-tenth the size of region *j* (and such differences are common in the EU NUTS2 regions, the US states and the advanced countries) and both have the same level of technology ($A_i = A_j$), then the level of productivity of region *i* will always be less than one-third that of region *j*. However, the regions of the advanced countries, and the advanced countries themselves, empirically do not differ greatly in their levels of productivity. Consequently, the only way this can occur is if the log-level cross-sectional estimates of the Verdoorn law give a Verdoorn coefficient of zero, i.e., the level of productivity is independent of the size of the region, which, as we have noted, has been empirically confirmed.[8] But this contradicts the results of estimating the Verdoorn law using average growth rates. McCombie (1982) examined a number of possible examinations for this paradox, ranging from measurement errors to differences in the constant of integration if the dynamic law is integrated to give the static specification. However, he concluded none of them was convincing.

However, McCombie and Roberts (2007) put forward a new plausible explanation. They have shown both theoretically, and using simulation analysis, that, at the *regional* level, the paradox is likely to be due to "spatial aggregation bias". This arises because the boundaries of spatial units of observation, if they are regions, are determined by administrative, rather than by economic, considerations. This bias results when variables measured at a low-order spatial level are aggregated to make observations at a higher-order spatial level. City data may be aggregated to the country or region/state level and these may be the only statistics available to the researcher.

McCombie and Roberts (2007) argue that the correct spatial unit of observation at which to observe the production relations should be what may be termed the Functional Economic Area (FEA), which is the area over which agglomeration economies occur and the dimensions of which are possibly related to journey-to-work distances, i.e., the city. Other studies of the determinants of spatial productivity likewise focus on the city (e.g. Glaeser, Kallal, Scheinkman and Schleifer 1992; Glaeser, Scheinkman and Schleifer 1995). In this light, as far as Verdoorn's law is concerned, the bias using log-levels occurs because the region is not usually an FEA. Consequently, all that the researcher may have access to is the aggregate data for each region, which are the values of the various variables of the regions' FEAs summed by the statistical authorities. The values of the inputs and outputs of each FEA within a region are aggregated arithmetically, while the true relationship in level form takes a power relationship, $P_{ij} = AQ_{ij}^{\theta}$ or, equivalently, $L_{ij} = A'Q_{ij}^{(1-\theta)}$, as $P_{ij} \equiv Q_{ij} / L_{ij}$ where i denotes the FEA (City) and j the region, using the simple Verdoorn law as an example, for expositional ease. A is a constant.

To illustrate this, let us assume that there are three regions, the first region consists of one FEA, the second region, two FEAs and the third region, three FEAs. Let us assume that the size of all the FEAs are the same, with L equal to 10 and Q equal to 100 implying that $(1-\theta) = 0.5$, given that the true production relationship is $L_{iJ} = A'Q_{iJ}^{(1-\theta)}$, with A' normalised to unity. On aggregating the FEAs, we have Region One with total employment and output equal to 10 and 100 respectively, Region Two (20, 200) and Region Three (30, 300). It can be seen that if we estimate the static Verdoorn law using these cross-sectional data as $lnL_j = c + b_{10}lnQ_j$, we will find the estimate of $b_{10,}$ which equals $(1-\theta)$, to be unity, which suggests there are constant returns to scale. These results suggest that doubling the labour input merely doubles the output. However, if we use data for the individual cities (i), then we will obtain an unbiased estimate of the Verdoorn coefficient.

What about the case where we use the aggregated regional data in the dynamic Verdoorn law? The growth rates of L and Q for region j are given by:

$$l_j = \sum_i \psi_{ij} l_{ij} \quad \text{and} \quad q_j = \sum_i \varphi_{ij} q_{ij} \tag{18}$$

where i denotes the FEA and j the region. ψ and φ are the FEA's share of employment and output in the regional total. Consequently, if we were to estimate the Verdoorn law using the aggregate regional data, namely, $l_j = c + b_{11} q_j$ (given that $l_j \equiv p_j - q_j$), we would obtain a relatively unbiased estimate of θ if the shares ψ_i and φ_i are roughly equal to each other for a particular region and/or the variation in growth rates between FEAs *within* a region are relatively small compared with the variation *between* regions. See the discussion and simulations in McCombie and Roberts (2007). They show that the use of two-way fixed effects panel data estimation using log-level data should resolve the paradox, which empirically proves to be the case (Angeriz, McCombie and Roberts 2008, 2009). Consequently, the use of average regional growth rates is providing a relatively unbiased estimate of the Verdoorn coefficient.

If the correct spatial unit of observation is the city, the use of log-levels and average growth rates should give the same results. Consequently, we estimated the static Verdoorn law in the conventional form regressing *lnP* on *lnQ* for the 61 cities and the results are reported in Table 5. Annual data were used for both GDP and industry, with time dummies included to allow for any increases in exogenous productivity. The static law was estimated using a spatial panel auto-regressive model with spatially auto-regressive disturbances. The estimates are controlled for spatial autocorrelation, which is now found to be present. The results are reported in Table 5.

[Table 5 about here]

It should be noted that similar results are obtained if we just use data for the initial and terminal years. However, interestingly and as hypothesised, no static-dynamic paradox arises. The estimates demonstrate a statistical significant and large Verdoorn coefficient for both industry and total output. The estimated values of the Verdoorn coefficients are approximately equal to the average of the estimates found using exponential growth rates. The fact that the paradox is not found in this case is plausibly explained by the fact that each city corresponds approximately to a single FEA, which differs in magnitude with the city's population size or level of output. Consequently, both the static and dynamic estimates of the Verdoorn coefficient should be of a similar magnitude, which, in fact, turns out to be the case.

Nevertheless, as noted above, McCombie and Roberts (2007) have shown, we should still obtain relatively unbiased estimates of the regional Verdoorn law using average regional growth rates, notwithstanding the potential problems of using administratively-determined regions. This is confirmed by our results above and suggested by the similar estimates of the Verdoorn coefficient of Guo, Dall'erba and Le Gallo (2013) using regional data. However, Guo, Dall'erba, and Le Gallo (2013) do not estimate the Verdoorn law using log-level data and they do not discuss the static-dynamic Verdoorn law paradox. Angeriz, McCombie and Roberts. (2008) also find similar significant estimates of the Verdoorn coefficient using EU regional growth-rate data, which also are likely to reflect the value for the FEAs.

4. Changes in city and regional productivity disparities

The cumulative causation model does not necessarily mean that city productivity inequalities will either indefinitely increase or decline, whereas the Solow growth model predicts convergence. To determine what has happened to city productivities over the period under consideration, we calculated the coefficient of variation of the logarithm of productivity for total output and industry over the period. The two series were very close and Figure 1 reports the coefficient of variation for industry of the 61 cities over the period. It can be seen that the disparity increased up until about 2005 and then fell sharply.

[Figure 1 about here]

This picture is confirmed using Theil's entropy index (TI). This may be decomposed as follows:

$$TI = TI_{br} + TI_{wr} = \sum_{i=1}^{3} \Xi_{Q_i} ln\frac{\Xi_{Q_i}}{\Xi_{POP_i}} + \sum_{i=1}^{3} \Xi_{Q_i}\left[\sum_j \Xi_{Q_{ij}} \ln\frac{\Xi_{Q_{ij}}}{\Xi_{POP_{ij}}}\right] \quad (19)$$

where TI_{br} is the between-region inequality index, TI_{wr} measures the within-region disparity for each region, 3 is the number of regions in Jiangsu, $\Xi_{Q_{ij}}$ is the share of the *j*th city's GDP in the *i*th region, and $\Xi_{POP_{ij}}$ is the share of its population.

Theil indices are calculated for using GDP and population shares at different levels of aggregation. The results are reported in Table 5 and Figures 2 and 3 show the results in graph form.

[Table 6 about here]

[Figure 2 about here]

[Figure 3 about here]

These results confirm, and extend the picture, shown by the coefficients of variation. First, the overall productivity disparities given by TI first increase and then decrease. Secondly, the between-regional disparity has been greater than the within-regional disparity. On average, 70 percent of the inter-city disparity is explained by the disparity between the southern, central and northern regions. Finally, the lagging northern region (Subei) has the highest degree of disparity across its cities, although this has been declining rapidly since 2004. In comparison, the most prosperous southern region, Sunan, had the lowest disparity before 2007. The Theil index of Sunan has been rising since 2001. Suzhong outperformed other regions in terms of equality across cities, and there is a clear trend of declining disparity.

These results also contradict the neoclassical explanation of city growth disparities. We also estimated the Solow growth model, conditional on the investment-output ratio and other control variables.[9] In this approach, it is assumed that there is a common technology. Cities differ temporarily in their productivity growth rates according to how far away they are from their steady-state capital-labour ratios. The estimation over the full period suggests conditional beta convergence, but with convergence in the first part of the period and divergence in the second part. This latter result presents problems for this growth model, as do the assumptions of constant returns to scale given the results of both the Verdoorn law and widespread microeconomic evidence to the contrary (World Bank, 2009, Chapter 4). Moreover, the model is silent on the reasons for why regions differ to varying degrees from their steady-state levels in the first place. Nevertheless, there are numerous studies estimating regional absolute and conditional beta convergence, but the theoretical and empirical rationales for this approach are not compelling, and are contradicted by the results estimating the Verdoorn law.

5. Conclusions

This paper has adopted a Kaldorian approach to explaining the growth of the cities of Jiangsu province. It is found that the Kaldor's first law holds, which provides indirect evidence of the export-base theory. A faster growth of industry, which is correlated with the growth of a city's, increases the growth of the city's output, even allowing for the fact that industry accounts for about 40 percent of urban production.

We discussed two alternative explanations of the Verdoorn law. The first was based on standard aggregate production function theory, whereas the second involved an underlying accounting identity that, *inter alia*, vitiates the former. However, following McCombie and Spreafico (2016), it was shown that the cross-sectional estimates of the Verdoorn law do show that a faster long-run growth rate of output increases the growth of productivity or, more generally, the sum of weighted growth of the real wage rate and the rate of profit. In other words, a faster growth of output leads to an increasing efficiency in production, broadly defined.

Estimation of the Verdoorn law for the Jiangsu province using average growth rates, or in log-level form, find a statistically significant and large Verdoorn coefficient. This stands in marked contrast to the standard neoclassical approach using the regional

Solow growth model that assumes constant returns to scale (or there is insignificant Verdoorn coefficient). It was shown that time-series estimation of the law is merely capturing the short-run cyclical effect of Okun's law.

Past estimations of the Verdoorn law using cross-sectional log-levels of regional and country data finds an insignificant Verdoorn coefficient, while using growth rates finds a value typically around one half. This is known as the static-dynamic Verdoorn law paradox. It is shown that the correct delineation of the spatial area of each unit of observation is important in explaining this paradox. The Functional Economic Area is the most appropriate spatial level at which to estimate the Verdoorn law and it is shown that the paradox results from spatial aggregation bias. This bias does not occur with the use of city data as both the static and dynamic Verdoorn law give approximately the same statistically significant estimates of the Verdoorn coefficient. This reflects the fact that the city is the FEA. McCombie and Roberts (2007) show that the use of *regional* growth rates, as opposed to log-levels, will give relatively unbiased estimates of the Verdoorn coefficient. Thus, the city estimates of the Verdoorn coefficient found in this paper are reassuringly similar to those found by Guo, Dall'erba, and Le Gallo (2013) using regional growth rates.

Although the Verdoorn law is at the heart of the cumulative causation model of economic growth, this does not preclude city disparities decreasing if other increasing costs more than offset the gains from faster productivity growth and the growth of those cities with faster growth decline. It is found that disparities in city productivity levels first increase and then decline over the sample period and that the disparities between the three regions also follow a similar pattern.

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[1] Kaldor's third law of economic growth (Kaldor 1975), namely, the regression of aggregate productivity growth on that of both industrial output and non-industrial employment, is merely derived from an identity and the other two laws of growth. As it consequently conveys no more information than implied by the first two laws, we do not discuss it (see McCombie 1981).

[2] We also split the sample into two periods, namely, 1996-2004 and 2005-2012 and estimated the equations using for the second period, with the variables from the first period acting as instruments. It did not make any significant differences to the results, which are not reported here.

[3] Verdoorn did not include technical progress in his specification.

[4] Note that integrating equation (9) at time *t* gives $Q_t \equiv CR_t^a W_t^{(1-a)} K_t^a L_t^{(1-a)}$, where C is the constant of integration. This equation is an exact isomorphism of the accounting identity and holds even though the aggregate production function does not exist. If we assume the stylized facts that the rare of profit does not grow over time and the trend rate of growth of wages is given by $w = \rho$, then $Q_t = Be^{(1-a)\rho t} K_t^a L_t^{(1-a)}$, if factor shares do not change over time. Although the equation looks like a Cobb-Douglas production function, it merely reflects the accounting identity.

[5] As $I/Y = (Y/K)(\Delta K/K)$, where I is investment, I/Y approximates to the growth of the capital stock provided that the output-capital ratio does not greatly vary (one of Kaldor's stylized facts). However, Scott (1991) provides a theoretical argument that I/Y is the correct measure.

[6] As FDI and FAI are related to total GDP, they are dropped for industry.

[7] Due to missing data, it is expressed as the average of the 1996 and 1997 observations.

[8] Harris and Liu (1999, p.29), however, argue that "this apparent static-dynamic paradox can also be related more generally to the dynamic specification of the empirical model to be estimated when time series data are used". But this misunderstands the nature of the paradox,

even if one assumes that there is an underlying aggregate production function. Harris and Liu estimate the Verdoorn law using time-series data (notwithstanding the serious problems outlined in the text) and a VECM for a large number of countries separately. The estimates display large putative increasing returns to scale. For example, for Belgium and the US the sum of the output elasticities are 1.96 and 2.07 respectively (Harris *et al*., Table 1). The observed ratio of the level of productivity of Belgium to that of the US is 0.977. However, the output of Belgium is only 3 per cent that of the US. This implies that Belgium should have a *level* of productivity that is only a small fraction of that of the US, if the correct unit of observation was the country and if (implausibly) the time-series estimates of the parameters are unbiased and were applied to the levels of output. But under these circumstances the only way Belgium could have a *level* of productivity that is equal to that of the US is if the sum of the output elasticities were equal to unity for both countries, as we have noted above. Hence, it is this that is the nature of the paradox, as described in the text and in McCombie (1982), and it has nothing to do with time-series estimations. Harris and Lau (1998) also make the same misinterpretation.

[9] The results are available on request from the authors.

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Table 1. Kaldor's First Law. OLS and IV regressions.

	Dependent variable: *Growth of Non-Industry* (q_{NI})	
	OLS	IV
q_{IND}	0.257** (2.50)	0.240** (2.13)
South dummy	0.025*** (4.27)	0.024*** (4.20)
Central dummy	0.006 (1.07)	0.006 (1.04)
constant	0.083** (4.71)	0.086** (4.53)
No. of obs	61	61
F test p-value	0.0008	0.0009
R^2	0.303	n.a.

Notes: Superscripts */**/*** denote significant at 10, 5, and 1 percent confidence levels. Period is 1996-2012. Figures in brackets are the t-statistics. n.a. denotes not applicable. OLS and IV are ordinary least squares and instrumental variables (GMM) regressions. These regressions are controlled for heteroscedasticity. Moran's I (p-value = 0.143), LM (error, p-value = 0.345), Robust LM (error, p-value = 0.291), LM (lag, p-value = 0.52) and Robust LM (lag, p-value = 0.423) cannot reject the null that there is no spatial autocorrelation in the data. With respect to the IV estimator, the Anderson canonical correlations likelihood-ratio test rejects the null of under-identification (135.778, p-value = 0.00) and the F-statistic form of the Cragg-Donald statistic (470.90) shows that the instruments are not weak.

Sources: Jiangsu Statistical Yearbook (various years)

Table 2. Static and Dynamic Kaldor's First Law. Spatial Panel Data Autocorrelation Model

	Dependent Variable: q_{NI}	Dependent Variable: $ln\ Q_{NI}$
$ln\ Q_{IND}$	n.a.	0.255*** (2.97)
q_{IND}	0.303*** (6.86)	n.a.
ρ	0.111 (0.48)	0.345** (1.96)
μ	0.168 (1.35)	0.563** (4.45)
Time dummies	yes	yes
No. of obs	976	1037
No. of cities	61	61
Panel length	16	17
R^2 Within Between Overall	 0.2643 0.0185 0.2395	 0.9511 0.8789 0.8979

Notes: [§] Estimation is a spatial panel auto-regressive model with spatially auto-regressive disturbances (two-way fixed effects). n.a. denotes not applicable.
Superscripts */**/*** denote significant at the 10, 5, and 1 percent confidence levels.
Period is 1996-2012. ρ is the spatial autocorrelation coefficient; μ is the spatial error term coefficient. Figures in brackets are the t-statistics.
All the estimation results are controlled for heteroskedasticity.

Sources: Jiangsu Statistical Yearbook (various years)

Table 3. Dynamic Verdoorn Law. Total Output, OLS and IV regressions.

	Dependent Variable: *Productivity Growth, p*					
	Total Output					
	1996-2012		1996-2004		2005-2012	
	OLS	IV	OLS	IV	OLS	IV
Output growth, q	0.578*** (7.18)	0.537*** (6.62)	0.725*** (8.19)	0.534** (2.27)	0.826*** (8.21)	0.820*** (7.23)
ln P_0	-0.016*** (-4.12)	-0.020*** (-4.22)	0.000 (0.01)	-0.032 (-1.66)	-0.035*** (-5.95)	-0.038*** (-5.88)
FDI	-0.159*** (-2.95)	-0.063*** (-0.85)	-0.117 (-1.47)	0.651* (1.76)	-0.184 (-1.21)	-0.064 (-0.49)
FAI	0.039** (2.28)	0.013 (0.81)	0.125*** (3.08)	-0.128 (-1.03)	0.018 (0.91)	0.003 (0.15)
IE	-0.109** (-2.18)	-0.056 (-0.91)	-0.260** (-2.22)	0.318 (0.76)	-0.045 (-0.69)	-0.021 (-0.29)
lnTE_0	0.010** (2.34)	0.007 (1.71)	0.023*** (3.34)	-0.002 (-0.09)	-	-
lnPOP	0.004 (1.38)	0.004 (1.18)	0.001 (0.15)	-0.002 (-0.18)	0.009 (1.48)	0.009 (1.44)
Southern dummy	0.015*** (3.84)	0.013*** (2.98)	0.007 (0.94)	-0.011 (-0.56)	0.026*** (3.01)	0.023** (2.50)
Central dummy	0.018*** (6.41)	0.015*** (5.05)	0.009* (1.82)	0.010 (1.19)	0.032*** (3.82)	0.027*** (3.52)
constant	0.181*** (3.99)	0.226*** (4.42)	0.035 (0.51)	0.359* (1.77)	0.317*** (4.43)	0.345*** (4.12)
Anderson canon. corr. LR stat.	n.a.	31.061 (0.00)	n.a.	15.51 (0.00)	n.a.	58.213 (0.00)
Cragg-Donald F-stat	n.a.	28.47	n.a.	21.21	n.a.	20.76
No. of obs	61	61	61	61	61	61
F test p-value	0.000	0.000	0.000	0.007	0.000	0.000
R^2	0.803	n.a.	0.722	n.a.	0.851	n.a.

Notes: Superscripts */**/*** denote significance at the 10, 5, and 1 percent confidence levels. n.a. denotes not applicable. The dependent variable is the exponential growth rate of real productivity over the 1996-2012 period in case of total GDP.
Figures in parentheses are the t-statistics, except for Anderson canonical correlations likelihood-ratio test where they are p-values. OLS and IV are ordinary least squares and instrumental variables (GMM) regressions. Where necessary, the regressions are controlled for heteroskedasticity. In case of IV regressions, the instruments are defined following the Durbin's method. The Anderson canonical correlations likelihood-ratio test rejects the null of under-identification and the F-stat form of the Cragg-Donald statistic shows that the instruments are not weak. For total GDP, Moran's I (p-value = 1.174), LM (error, p-value = 0.290), Robust LM (error, p-value = 0.207), LM (lag, p-value = 0.622) and Robust LM (lag, p-value =0 .397) cannot reject the null that there is zero spatial autocorrelation.

Source: Jiangsu Statistical Yearbook (various years)

Table 4. Dynamic Verdoorn Law. Industry, OLS and IV regressions.

	Dependent Variable: ***Productivity Growth, p***					
	Industry					
	1999-2012		1999-2005		2006-2012	
	OLS	IV	OLS	IV	OLS	IV
Output growth, q	.0440*** (3.15)	0.406*** (2.83)	0.879*** (5.42)	0.853*** (4.83)	0.727*** (3.77)	.6045*** (2.91)
ln P_0	-0.021*** (-2.14)	-0.024** (-2.55)	0.026 (1.72)	0.027 (1.56)	-0.052*** (-3.28)	-.0588*** (-3.58)
FDI	-	-	-	-	-	-
FAI	-	-	-	-	-	-
IE	-0.098 (-1.12)	-0.047 (-0.44)	-0.150 (-0.93)	-0.194 (-0.77)	-0.002 (-0.02)	0.002 (0.02)
$lnTE_0$	-	-	-	-	-	-
lnPOP	0.014*** (2.77)	0.013** (2.01)	-0.001 (-0.09)	0.000 (0.03)	0.029*** (2.71)	0.028** (2.39)
Southern dummy	0.014* (1.78)	0.015 (1.63)	-0.006 (-0.39)	-0.004 (-0.26)	0.033** (2.03)	0.032* (1.97)
Central dummy	0.017** (2.57)	0.016*** (3.02)	0.013 (1.26)	0.014 (1.28)	0.027*** (2.27)	0.024** (2.06)
constant	0.185 (1.57)	0.225* (1.91)	-0.298* (-1.75)	-0.307 (-1.60)	0.426** (2.17)	0.524** (2.49)
Anderson canon. corr. LR stat.	n.a.	59.676 (0.00)	n.a.	50.015 (0.00)	n.a.	72.630 (0.00)
Cragg-Donald F-stat	n.a.	44.82	n.a.	34.30	n.a.	61.81
No. of obs	61	61	61	61	61	61
F test p-value	0.000	0.000	0.000	0.000	0.000	0.000
R^2	0.535	n.a.	0.615	n.a.	0.678	n.a.

Notes: Superscripts */**/*** denote significance at the 10, 5, and 1 percent confidence levels. n.a. denotes not applicable. The dependent variable is the exponential growth rate of real productivity over the 1999-2012 period for industry because of missing data. Figures in parentheses are the t-statistics, except for Anderson canonical correlations likelihood-ratio test where they are p-values. OLS and IV are ordinary least squares and instrumental variables (GMM) regressions. Where necessary, the regressions are controlled for heteroskedasticity. In case of IV regressions, the instruments are defined following the Durbin's method. The Anderson canonical correlations likelihood-ratio test rejects the null of under-identification and the F-stat form of the Cragg-Donald statistic shows that the instruments are not weak. Moran's I (p-value = 0.654), LM (error, p-value = 0.517), Robust LM (error, p-value = 0.482), LM (lag, p-value = 0.647) and Robust LM (lag, p-value = 0.595) cannot reject the null that there is zero spatial autocorrelation. See also notes for Table 3.

Source: Jiangsu Statistical Yearbook (various years)

Table 5. Static Verdoorn Law. Spatial Panel Autocorrelation Model

	Dependent Variable: The log of productivity, *ln P*	
	Output	Industry
ln Q	0.423*** (9.17)	0.346*** (9.44)
ρ	0.833*** (11.59)	0.464** (2.31)
μ	0.270* (1.11)	0.444*** (3.13)
Time Dummies	yes	yes
No. of obs	1037	854
No. of cities	61	61
Panel length	17	14
R^2		
Within	0.953	0.871
Between	0.754	0.662
Overall	0.697	0.761

Notes: Spatial panel auto-regressive model with spatially auto-regressive disturbances. Superscripts */**/*** denote significant at 10, 5, and 1 percent confidence levels. ρ is the spatial autocorrelation coefficient and μ is the spatial error term coefficient. The sample covers the 1996-2012 period in case of total output and the 1999-2012 period in case of industry, because of missing data. The figures in brackets are the t-statistics. All the estimation results are controlled for heteroskedasticity.

Sources: Jiangsu Statistical Yearbook (various years)

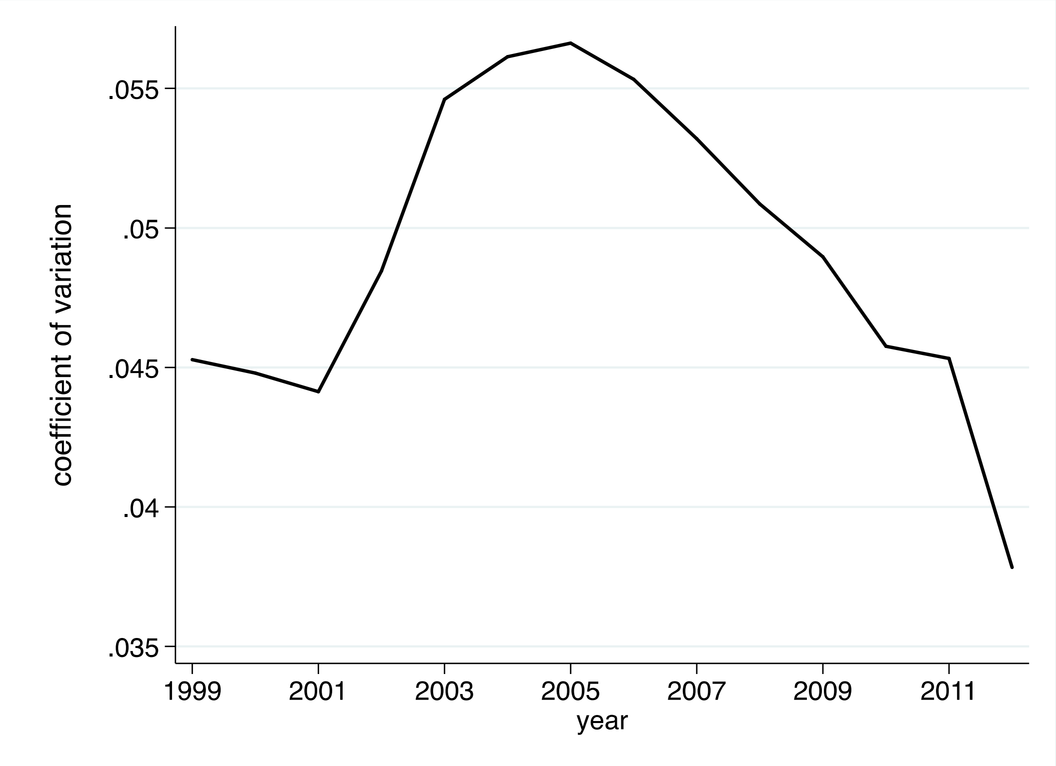
Table 6. Theil Indices for the Regions and Cities of Jiangsu Province

Year	TI	TI_{br}	TI_{wr}	Sunan*	Suzhong*	Subei*
1999	0.2252	0.1542	0.0710	0.0489	0.0732	0.1199
2000	0.2304	0.1594	0.0710	0.0482	0.0799	0.1193
2001	0.2375	0.1661	0.0714	0.0487	0.0834	0.1183
2002	0.2499	0.1747	0.0752	0.0562	0.0846	0.1167
2003	0.2863	0.2021	0.0842	0.0646	0.0841	0.1407
2004	0.2972	0.2072	0.0900	0.0673	0.0849	0.1621
2005	0.3046	0.2173	0.0873	0.0686	0.0797	0.1532
2006	0.3046	0.2159	0.0887	0.0725	0.0817	0.1466
2007	0.3008	0.2136	0.0871	0.0744	0.0737	0.1405
2008	0.2933	0.2061	0.0873	0.0839	0.0579	0.1248
2009	0.2731	0.1921	0.0810	0.0827	0.0569	0.0973
2010	0.2625	0.1842	0.0783	0.0790	0.0582	0.0940
2011	0.2530	0.179	0.0730	0.0757	0.0542	0.0815
2012	0.2479	0.1800	0.0678	0.0700	0.0530	0.0742

Notes: *Theil indices within each region, namely inequality between the cities of each region. The sum of Theil indices of Sunan, Suzhong and Subei do not equal TI_{wr}. TI_{wr} is the GDP-weighted sum of Theil indices of each region.

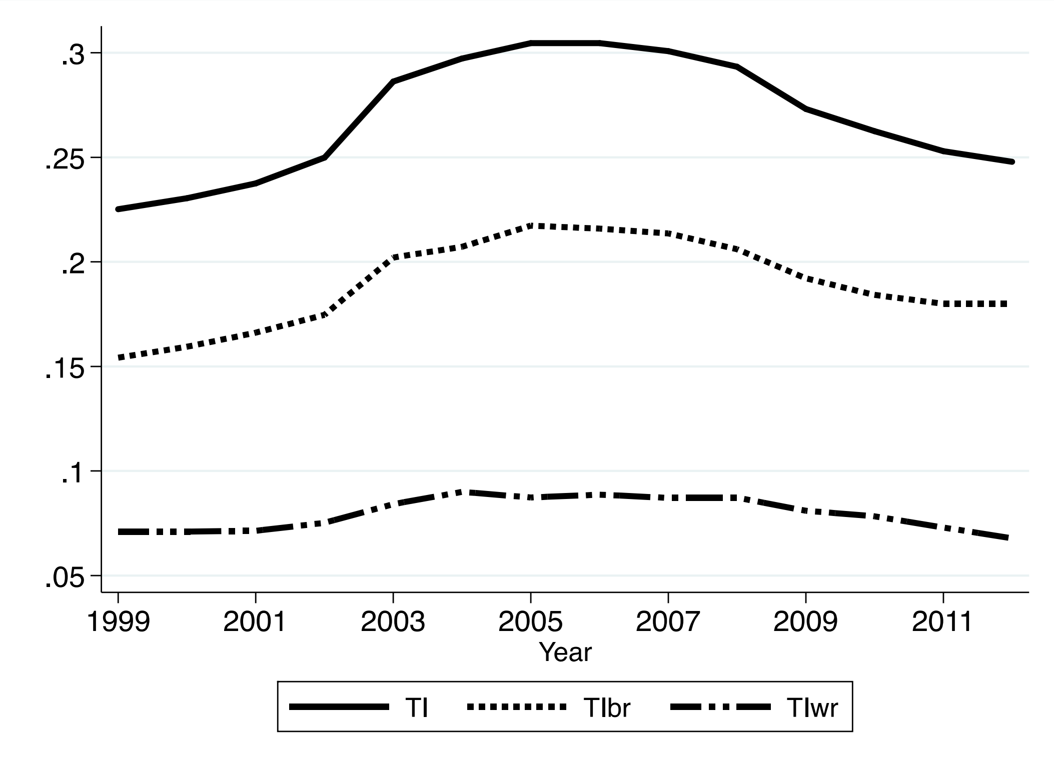
Sources: *Jiangsu Statistical Yearbook* (various years)

Figure 1. Coefficient of Variation for City Industrial Productivity



Source: Jiangsu Statistical Yearbooks (various years)

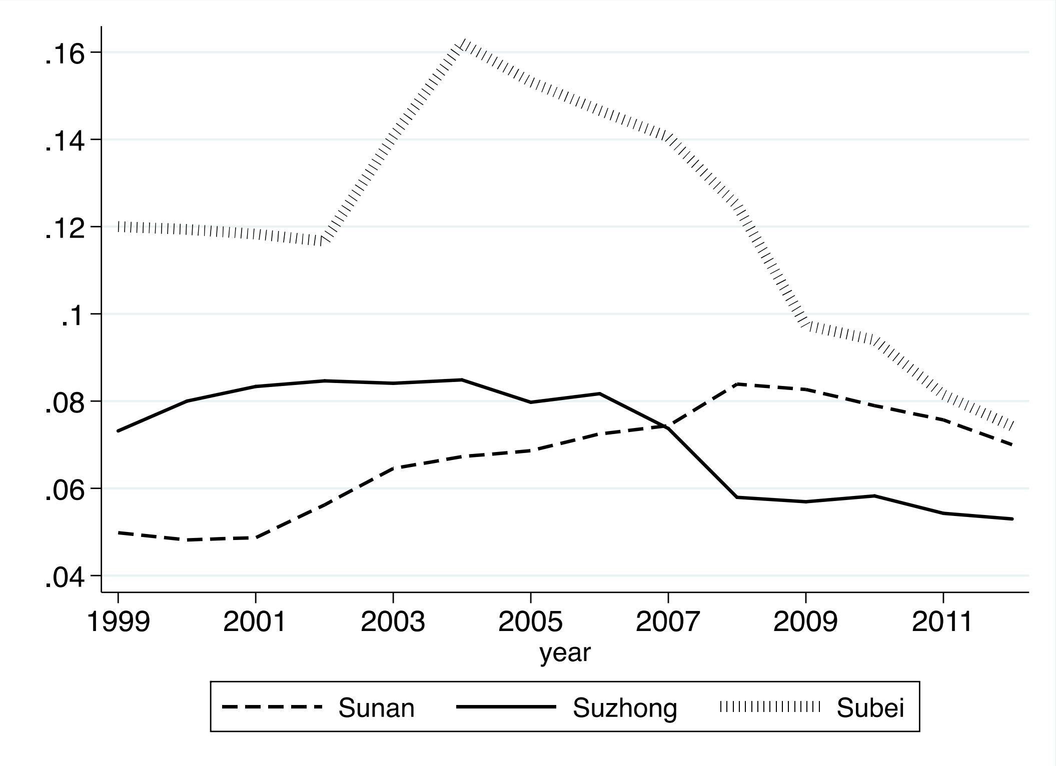
Figure 2. Decomposition of the Theil Indices



Notes: TI is the total inequality index; TI_{br} is the between-region inequality index; TI_{wr} the within-region inequality.

Source: *Jiangsu Statistical Yearbook* (various years)

Figure 3. Within-region Theil Indices



Source: Jiangsu Statistical Yearbook (various years)