What can growth rates tell us?

A decomposition method under growth instability

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Abstract

Suppose we see time series output data for two sectors, industry and agriculture. By examining just the time series themselves, what can we say about the relative contribution of institutional/policy factors, resource constraints and intersectoral linkages to each sector's growth? Currently, the answer might be very little. Regressions on economic growth typically require additional explanatory variables specifically relating to institutions, resources, and so on. Such additional variables are drawn from candidates identified from previous studies or from *ad hoc* considerations.

But, to date, it does not appear that the explanatory variables have been derived from the algebraic definition of a growth rate itself; i.e., from the construction of a term such as $\dot{x}/x$. Our aim is twofold: first, to explain how institutional/policy, resource and other factors can be formally embedded in a growth rate term. Second, we will offer an empirical illustration of the embedding, such that just the time series output data of the two sectors *by themselves* contain enough information to decompose growth rates into the relative impacts of the institutional/policy and other factors.

Our work relates to the important literature on short-run growth instability in developing countries, and uses Chinese sectoral data as an illustration of the decomposition. Our approach allows us to address such questions such: Has volatility in China's industrial output over almost the last two decades arisen more from swings in overall institutional/policy factors, or specifically from labor supply shocks due to institutional/policy changes, or from linkages with the agricultural sector, which itself exhibits growth volatilty? We answer this question using a parsimonious data set, comprising time series of only industrial and agricultural output (over the period 1991-2007).

Key words: Short-run growth instability, growth decomposition, institutions & policies, China

JEL Classification: O, P, C.

Introduction

Recent discussions of economic growth have shifted from exploring long-run, mean determinants to investigating abrupt changes in the short-run. Pritchett (2000) notes that a single time trend fails to adequately explain the path of per capita GDP in most developing countries, given that instability in a country's growth rate over time may be very large. Yet economic development benefits from sustained, stable growth – the large economic growth literature that has focused on mean growth has mainly ignored growth rate volatility and therefore the factors that may undermine people's living standards (Mobarak 2005). Thus, research into what initiates or ends episodes of growth is likely to have high payoffs (Pritchett 2000). This point is no more stark than in the reform experience of perhaps the most important developing country today – China. Even the last 20 or so years have seen far-reaching swings in China's political and economic institutions, as well as huge transfers of labor as the rules of the game have changed. These swings have resulted in growth volatility within important sectors such as industry. Yet little research has been undertaken to answer key questions such as: Has China's industrial output volatility arisen more from changes in institutional factors, or from labor supply shocks, or from linkages with other sectors, such as agriculture, that themselves exhibit growth volatitily? What are the key broad policy areas to watch if we are to make sense of what's happening in the Chinese economy? For policy purposes the answers to these questions are pivotal, especially if we are to learn from the Chinese experience.

To address these questions we must turn to data. Yet an extensive examination of China's data sources, such as statistical yearbooks, reveals data on standard inputs and outputs, but nothing on measures of combined institutional and policy settings. Thus, researchers and policy-makers on China (and similar developing economies) face a common obstacle: if institutions and policies are important, but data on them cannot be readily found, how can they really know that institutions and policies matter? Past studies in this regard have invoked additional, complex steps. Kwan and Chow (1996) build an econometric model of growth in the Chinese economy to include major political shocks. When the shocks are removed, the hypothetical paths of the economy are derived from the model; comparing them with the actual time paths reveals the impact of adverse political institutions. But such an approach lends itself to large, discrete shocks. In contrast, reforming developing economies may be subject to numerous, continual institutional/policy changes of varying magnitude. Coping with shocks of this nature makes onerous demands on the data, especially if, alternatively, they are modelled as dummies in the regressions. Employing proxy variables may be useful, but such data are not always available and tend to be *ad hoc*.

Still, time series output of industry and agriculture are readily available. By examining just the output data themselves, could they shed much light on the relative contribution of institutional factors, resource constraints and agricultural linkages to industry's growth, say? We suggest a method by which this can be achieved, focusing on the algebraic definition of a growth rate itself. Our aim is twofold: first, to explain how institutional, resource and other factors can be formally embedded in a growth rate term; i.e., into a single equation model. Second, we will offer an empirical illustration of the embedding, such that the output data of the two sectors *solely by themselves* contain enough information to make inferences regarding the relative impacts of the institutional and other factors. This point is important, given the limited data availability that researchers and policy-makers in developing countries often face. As will become apparent, the two goals are linked – the specific, formal structure of the growth rate term to be developed is precisely that which will facilitate the extraction of information about the relative role of institutions/policy and so on from a very limited data set.

In this paper we use official Chinese data to illustrate how the informational content of limited, publicly available data can be extended. We do believe that there are data manipulations in official data, but this is beyond the scope of this paper – the point is to

reveal how standard data can offer more insights than the superficial, when the data is shocked by frequent institutional/policy changes.

Basic premises

The key to understanding our approach is to consider the implications of a statement such as: 'the growth rate of industry is 14.4%'. If M represents industrial (or manufacturing) output, the statement is equivalent to the expression:

$$\frac{dM(t)/dt}{M(t)} = 0.144$$

$$\Rightarrow \frac{dM(t)}{dt} = 0.144M(t).$$

The growth rate statement can thus be interpreted as a differential equation, where the coefficient on M (the 0.144) can be thought of as a variable that can change independently of M. For example, changes in political or economic institutions may alter industry's per unit growth rate, r (to be defined later), where:

$$\frac{dM(t)}{dt} = r(t)M(t). \tag{i}$$

It is the formal construction of r, incorporating the broad categories of labor and non-labor institutions, together with intersectoral linkages, that forms the basis of what follows.

To inform our modeling, we seek insights from actual data and events - in our illustrative case, from China. A number of significant *stylized facts* emerge from the Chinese economic literature and data. First, we note that industrial output for our sample period 1990-2007 suggests exponential, or more likely logistic, growth (Figure 1). The suggestion of logistic growth should come as little surprise. Aoki and Yoshikawa (2002) highlight the ubiquity of logistic growth functions, as a stylized fact, in industry as a whole and in specific industries within the sector. Growth may initially be exponential, but as economic activity consumes available resources, a physical limit to the number of firms that may exist and compete in the sector is approached, with the growth rate declining and eventually tending to zero.
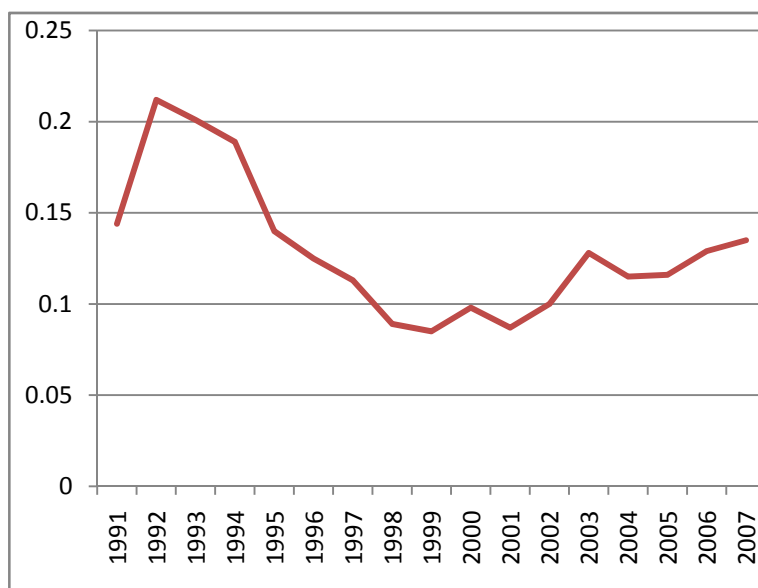
Figure 1: Industrial value added
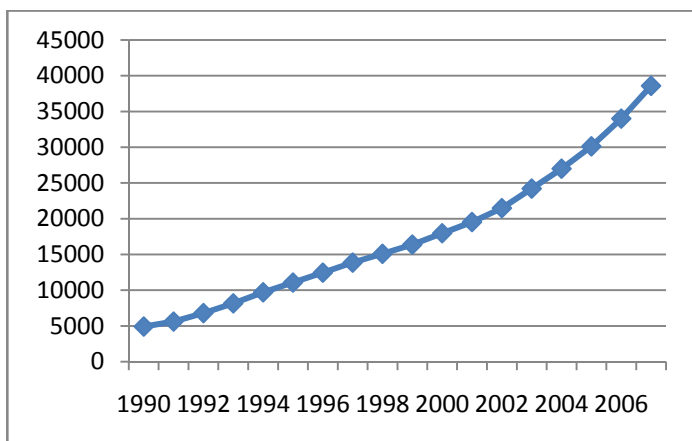
The data appear in the appendix, and are expressed in 100m yuan in 1978 prices.

Second, the data series exhibits growth volatility. Figure 2 shows the growth rates of industry over the sample period.

Figure 2: Annual industrial growth rates

Lastly, between 1990-2007 the growth rate fluctuations have come from three main sources. First, changes in institutions/policies, particularly policy settings, have been evident (see Wu, 2010). Among others, these include the post-1989 political purges, Deng Xiaoping's call in 1992 for bolder reform, the 1995 campaign to control the overheating economy, accession to the WTO in 2002 (Zheng, Bigsten and Hu, 2007), economic and administrative measures in 2004-2006 to counter the investment boom (Krueger, 2005), and the 2007 anti-corruption drive. According to Klenow (2001), '(g)rowth miracles are produced by dramatic improvements in policies, and growth disasters by deteriorating policies. China is a fast grower...because it has improved its institutions so much' (p. 222).

Second, while increases in capital and technology are likely to have contributed to increased industrial output over time, they are not responsible for the year-to-year volatility in growth rates. As Easterly and Levine (2001) point out, again as a stylized fact, '(g)rowth is not persistent over time, but capital accumulation is' – i.e., changes in the capital stock are not closely correlated with changes in economic growth (p. 179). In China the short-run volatility has come from fluctuations in labor supply to industry, as the government has either restricted labor flows or permitted rural unemployed labor to migrate to industry. Kroeber (2005) suggests that the most important contributor to China's impressive economic growth has been the shift of labor from agriculture to industry, a process that is likely to continue.

Third, of the two sectors, agriculture and services, that could conceivably influence volatility in industrial growth, the single most important one is agriculture. This follows the standard development literature, in which agriculture either contributes to or competes with the growth of industry (e.g., see Mellor (1986)).

Based on these stylized facts, we will derive an algebraic expression of industrial growth rates to help explain the relative contributions of institutions/policy broadly, institutions/policy specifically governing labor supply and inter-firm competition for labor, and the impact of agriculture-industry linkages.

Our work fits strongly within the important, emerging literature on short-run growth instability in developing countries. For example, growth instability has been shown to be

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strongly linked with changes in political leadership, particularly in autocratic countries. Among autocratic regimes, the impact of leadership change on growth rates is negatively correlated with constraints on the autocrats' power, which may depend on the constitutional framework (Jones and Olken 2005). Political institutions matter (Mobarak (2005). Jerzmanowski (2006) highlights the relationship between growth and the quality of economic institutions, including the rule of law and the protection of property rights. Institutions affect the interactions between economic shocks and growth rates, and the likelihood and duration of high growth episodes. A mixture of political and economic institutions may be captured by special groups, resulting in extractive, economic distortionary policies that lead to growth instability and downturns (Acemoglu et al. 2003). Jones and Olken (2008) find that monetary instability influences growth collapses. More broadly, Hausmann, Pritchett and Rodrik (2005) include economic reforms as a significant contributor to sustained growth accelerations. The foregoing may be broadly categorized as political or economic *institutional factors* impacting on short-run growth, many of which affect incentives to produce. For our purposes we define institutions as the rules of the game that influence the size of profit and the willingness to reinvest profit (where the profits are not related to the size of the sector, a point that will become apparent later).

Institutional change not only affects incentives, but can release resources from one sector to another. China's stop-go economy of the 1990s illustrates this point dramatically. Labor supply fluctuations resulting from swings in economic or political institutions, because of their importance, should be included explicitly as a second broad category influencing short-run growth. This is especially relevant for developing economies, like China, that rely to a large extent on labor-intensive production processes. Here we emphasize *the impact of intra-sectoral competition for labor,* as increases in the number of firms puts upward pressure on labor costs and reduce growth rates. Still, institutional changes such as permitting labor to migrate to industry reduce intra-sectoral competition and increase growth rates - fluctuations in labor market institutions can translate into growth rate volatility.

Mobarak (2005) also identifies a sectoral shift from agriculture to manufacturing in searching for a priori determinants of a growth takeoff. The interactions between the sectors introduce additional empirical insights, since the sectoral composition of an economy is important for economic growth rates (Echevarria 1997). We treat the *interaction between agriculture and industry* as the third determinant of growth rate volatility.

Individually, the papers cited above yield important insights into the determinants of short-run growth fluctuations. But collectively there is currently no framework that unifies the disparate growth determinants or allows their relative importance to be measured. As mentioned earlier, we need to ascertain how important intersectoral linkages have been in explaining the growth volatility of industry, relative to the incentives to reinvest in industry that have been unleashed by institutional/policy changes in that sector, versus the role that intra-sectoral competition for labor, labor migration and controls thereof have had.

Deriving a per unit growth rate

We emphasize at the outset that it is not our aim to formalize a theory of how institutions/policy affect incentives. Nor do we offer a new model of economic growth or a story of total factor productivity. Rather our objective is to derive an algebraic derivation of a growth rate term, a derivation that will allow an empirical decomposition of industrial growth rates into the contribution of institutions/policy, labor constraints and agricultural linkages using very limited data. That is, consistent with the stylized facts in the previous section, we seek a fuller expression for r in equation (i), where $\frac{dM}{dt}/M$ is the fractional growth rate of industry and r is the per unit growth rate in the sector.

To this end, the stylized facts inform the structure of our model. While it is apparent that there is exponential growth in manufacturing output in Figure 1, there must be an

upper limit to manufacturing output implied by resource constraints (Aoki and Yoshikawa, 2002). This suggests a logistic curve as the eventual form of Figure 1, as illustrated in Figure 3. The form of the equation is given by:

$$\frac{dM}{dt} = r_M \left(1 - \frac{M}{K_M}\right) M,$$

where r_M is the 'intrinsic' growth rate and K_M is the upper limit to manufacturing output defined by existing resources and technology in the sector. Hence, our search for r leads us to consider $r = r_M(1 - \frac{M}{K_M})$. The $-M/K_M$ term indicates intra-sectoral competition; as firms compete for fixed resources, the per unit growth rate eventually falls.

Employing similar logistic functions to formalize economic growth has been undertaken elsewhere in the literature. Clark *et al.* (1993) use logistic functions to model the share of manufacturing value added in GDP over time, as do Balance *et al.* (1982). Day (1982) posits a neoclassical one-sector model with a production function given by $y = Bk^\beta(m-k)^\gamma$, where y is output, k is the capital/labor ratio and m, B, β and γ are parameters. It is this modelling tradition that we follow. For our empirical work, we will modify Day's (1982) production function to give output of the industrial sector. Instead of a capital/labor ratio, we focus on a single input, labor, and will incorporate simple linkages with agriculture, given the stylized facts above.

We begin with a one-sector model of economic growth, that of industry. To enhance the theoretical and intuitive value of what follows, we define M as the number of firms within industry. (Rather than growth in output, the relevant growth concept in this section will be growth in the number of firms that produce the output). Suppose all firms are identical. Let $C(q, M)$ be the cost per unit of a firm's output, q, when the number of firms in industry is M. Let $R(q, M)$ be the firm's revenue per unit of output. Total profit of a firm is $\pi(q, M) = (R-C)q$. If profits facilitate growth in the number of firms, the growth rate of M is:

$$\frac{dM}{dt} = \beta \pi(q, M) M, \tag{ii}$$

where $\beta > 0$ represents the proportion of profits that is converted into or attracts new firms each period. Here we have a preliminary link with Hausmann, Pritchett and Rodrik (2005), Jerzmanowski (2006), Acemoglu et al. (2003) and others, where economic policy and the political environment influence the willingness of firms to reinvest. We restrict these institutions to non-labor-related institutions, since we want to capture a separate role for institutions that impact specifically on labor flows.

We give (ii) a more concrete form, now emphasizing the role of institutions on resource flows, by deriving a specific cost function. First, assume that a firm's output is a function only of its labor, l. Here we follow the short-run growth literature, which typically omits the role of technological change and capital accumulation in growth instability. But we extend the literature by allowing labor to impact on growth rates, for the reasons outlined above. Let the number of workers required to give output q be given by an inverse function:

$$l = f^{-1}(q) = g(q).$$

Hence unit cost is:

$$C(q) = \frac{wg(q)}{q},$$

where w is the wage rate. Assume that this unit cost has some minimum when quantity

$q=q^*$, the competitive equilibrium for the firm. Assume further that the total number of people able and prepared to work in the sector is:

$$lM = aw,$$

where a is a constant relating to labor institutions, determined initially by government administrative mechanisms that relax or constrain workers' ability to work in the manufacturing given sector (for example by influencing labor migration flows) and subsequently by the work-leisure choice of the workers that have been permitted to work in manufacturing, or even by work-leisure choices to flout the administrative restrictions. Hence, labor is proportional to the prevailing wage rate, w, and w is positively related to M.

At $q=q^*$:

$$g(q^*)M = aw.$$

Now take the first three terms of the Taylor expansion of $C(q)$ near q^*:

$$C(q) \approx C(q^*) + C'(q^*)(q - q^*) + \frac{C''(q^*)}{2}(q - q^*)^2.$$

Noting that since q^* is the competitive equilibrium for the firm, $C'(q^*) = 0$:

$$C(q) \approx \frac{wg(q^*)}{q^*} + \frac{C''(q^*)}{2}(q - q^*)^2$$

$$= \frac{C''(q^*)}{2}(q - q^*)^2 + \frac{g(q^*)^2}{aq^*}M$$

$$= \gamma(q - q^*)^2 + \phi M, \tag{iii}$$

where the constants of the unit cost equation are $\gamma = C''(q^*)/2$ and $\phi = g(q^*)^2/aq^*$. The term ϕM represents additional costs proportional to the size of the sector, where increases in the number of firms, M, drive up resource costs. Note, however, that if a increases, perhaps due to administrative relaxation of controls restricting the flow of labor to manufacturing, then costs fall.

Assume that the price of manufactured goods, p, decreases linearly with M, such that $p = p_0 - \alpha M$, where α is a positive constant. Thus, profit per firm is given by:

$$\pi = (p_0 - \alpha M - \gamma(q - q^*) - \phi M)q. \tag{iv}$$

From (ii):

$$\frac{dM}{dt} = \beta q(p_0 - \alpha M - \gamma(q - q^*) - \phi M)M. \tag{v}$$

We can think of $\beta q(p_0 - \alpha M - \gamma(q - q^*) - \phi M)$ as the individual firm's contribution to the growth rate of M, ie, as a per unit growth rate. Defining the constants

$r_M = \beta q(p_0 - \gamma(q - q^*))$ and $K_M = (p_0 - \gamma(q - q^*))/(\alpha + \phi)$, and with the dot indicating the time derivative, we have (Turner and Rapport 1974):

$$\dot{M} = (r_M - \frac{r_M}{K_M}M)M \qquad\qquad (vi)$$

$$= r_M(1 - \frac{M}{K_M})M, \text{ as required above.}$$

Equation (vi) represents a simple logistic model describing the growth in the number of firms in industry, as required by the first stylized fact in the previous section. The bracketed term is the per unit growth rate, and, as defined above, relates to the impact of institutions in inducing firms to convert profits into the creation of new firms. The first component of this term is the intrinsic rate, r_M, defined as the rate at which M would grow without the inhibiting effects of resource scarcity. r_M does not contain the term M; therefore it excludes a, the constant reflecting institutions that govern labor supply. Thus r_M may be thought of as representing non-labor institutions, such as political stability, property rights allocation, operational autonomy, and other incentives to reinvest profits into firms. We also note the role of international trade in explaining growth accelerations (eg, see Jones and Olken (2008)), here acting through prices and profits.

Now consider the second term in brackets, $(r_M M/K_M)$. Define K_M as the maximum number of firms that labor resources in the sector may support indefinitely. As M approaches K_M, the per unit growth rate tends to zero. Thus, we can think of $(r_M M/K_M)$ as the impact of resource scarcity on the per unit growth rate. To see why K_M is the limit to the number of firms that may exist, consider equation (v). For dM/dt to equal zero, i.e., there is no further growth in the number of firms, it is sufficient that $p_0 - \alpha M - \gamma(q - q^*) - \phi M = 0$. In other words, $M = (p_0 - \gamma(q - q^*))/(\alpha + \phi) \equiv K_M$. (And in (v), when $M = K_M$, $dM/dt = 0$.) Thus we have introduced intrasectoral competition to the model, i.e., the competition for labor between firms within industry. Note that K_M may change over time if the parameters determining K_M change. For example, from $K_M = (p_0 - \gamma(q - q^*))/(\alpha + \phi)$ and $\phi = g(q^*)^2/aq^*$, an increase in a, a determinant of labor supply, raises K_M and reduces the growth-inhibiting effect of intra-sectoral competition between firms. If p_0, γ, q^* and α are all constant, then K_M varies only with a. That is, labor supply determines K_M. Thus, we have derived a labor constraint determinant of growth volatility. Recalling that a relates to government policies relaxing or constraining workers' ability to work in a sector, we have a term that reflects administrative interventions in labor markets.

The term $(-)r_M$ plays two roles. In the absence of resource scarcity, r_M increases the overall growth of M exponentially; but as M grows, for a fixed K_M, it is the very increase in M, and the attendant competition for resources, that reduces growth as M approaches K_M. K_M is the size of the manufacturing sector where r_M is cancelled by intra-sectoral resource competition. But a change in labor-related institutions, α, can raise the growth rate by raising K_M; ie, by shifting the logistic curve upwards. In other words, an increase in K_M increases the slope of the M function, and thus raises the per unit growth rate at any given value of t by an amount $r_M M/K_M'$. It is in this sense that we claim that the term $r_M M/K_M$ partially reflects the impact of changes in labor supply institutions on growth rates.[1]

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[1] As simple numerical example illustrates the point. Suppose $r_M = 0.5$, $M = 1$, $K_M = 100$; then the per unit growth rate is 0.495. If $K_M' = 200$, then the growth rate is 0.4975. The growth rate increases by 0.0025 (= $r_M M/K_M'$).

Now also suppose that agricultural output influences the growth rate of industrial firms (Mobarak 2005), initially by assisting industry to expand beyond its normal carrying capacity. Firms not only compete for factors of production within their sector, but may compete with, or contribute to, firms outside their sector. Models of structural change, such as in Mellor (1986), incorporate a system of intersectoral linkages. The linkages come about for a variety of reasons: one sector pays factor incomes, which consumers use to purchase the other sector's goods; one sector produces intermediate goods and services used by other sectors; and so on.

Here we consider the case where agriculture decreases per unit manufacturing costs, for example by increasing the supply of agricultural products used as inputs by industry. The cost function for industry can be rewritten:

$$C(q, M, A) = \gamma(q - q^*)^2 + \phi M - \delta A. \tag{vii}$$

Thus, equation (v) becomes:

$$\frac{dM}{dt} = \beta q (p_0 - \alpha M - \gamma(q - q^*) - \phi M + \delta A) M$$

$$= (r_M - \frac{r_M}{K_M} M + \delta A) M, \tag{viii}$$

where $\delta = r_M \tau$ and τ is a constant. If δ is positive, agriculture supports manufacturing – a mutualistic relationship; a negative δ indicates a competitive relationship between the two sectors. Again, we can think of the term $(r_M - \frac{r_M}{K_M} M + \delta A)$, or $r_M(1 - {M}/{K_M} - \tau A)$, as a per unit growth rate. It is the comparison of the size of each term in the per unit growth rate that reveals the relative contributions of institutions (labor and non-labor) and that of agriculture-manufacturing linkages to manufacturing growth rates.

Finally:

$$\frac{\dot{M}}{M} = r_M - \frac{r_M}{K_M} M + \delta A. \tag{ix}$$

Equation (ix) models the growth rate of manufacturing as depending on the intrinsic growth rate, r_M, which captures institutional/policy determinants of the sector's growth (via incentives for firms to invest their profits in the production of new firms); on competition between firms for labor (at the sectoral level); and on the impact of another sector, agriculture (an intersectoral effect). The model is flexible enough to encompass aspects of international trade (through the impact of changing demand and supply on prices), and political and economic institutions, such as a kleptocracy and property rights (that affect the proportion of profits that becomes new firms each period, β.)

The differential equation explains the growth rate of the sector in terms of its present size and the size of the other sector. The sector initially grows exponentially, but its growth slows under increasing intrasectoral competition, eventually falling to zero. However, if the sectors support one other, they are able to become larger than without mutualistic linkages.

While it may seem intuitively obvious that the growth rate of manufacturing will depend, at least, on institutions, labor supply and the linkages with agriculture, our pursuit of a formal model offers a very significant advantage. Concretely, the (per unit) growth rates include the variables M and A (the RHS of equation (ix)). This allows empirical

estimation to proceed with minimal data requirements, as will be explained in the next section.

An Illustration

Our theoretical derivation of a growth rate lends itself to empirical analysis with parsimonious data requirements. We demonstrate how a time series solely comprising agricultural and manufacturing value added, for example, can yield insights into the relative impacts of institutional factors, market competition for resources, and intersectoral linkages in explaining the growth rates of the two sectors.

We illustrate our model with a case study of China. The Chinese reforms in agriculture and industry offer a potentially rich dataset that reflects the impacts of institutional change and autocratic policy-making (eg., Islam and Jin (1994), Woo, Hsueh, Shi and Zhang (1993), Zweig (1992), Sicular (1992), Wu (1992), Findlay and Watson (1992), Islam (1991)), interactions between the agriculture and manufacturing (B. Lin (1995a), Findlay, Watson and Wu (1994a), and intrasectoral competition for resources, as labor was freed labor to shift from agriculture to rural industry, for example (Islam & Jin, 1994). Specifically, a mutualistic relationship emerged between agriculture and the newly-liberalized TVEs. The initial government decollectivization of agriculture facilitated the growth of a virtuous circle of higher farm incomes, more farm investment, higher incomes, and so on. The labor-saving farm investments released labor from agriculture, allowing their transfer to rural manufacturing enterprises. Agriculture also provided demand linkages with rural enterprises, which supplied farmers with, among other things, farm implements, simple consumer goods, and construction and transport services. As manufacturing grew, it generated more employment, drawn from agriculture (Findlay, Watson and Wu 1994), and raised off-farm incomes. Part of the rising incomes were spent on or remitted to the agricultural sector. Farm incomes rose and farmers were able to increase their expenditures on inputs provided by manufacturing. A further virtuous circle emerged in which manufacturing and agriculture expanded in tandem (eg, see Byrd and Lin 1990; Findlay and Watson 1992; Sicular 1992; Ratha, Singh and Xiao 1994; Islam and Jin 1994; Lin 1995).

Note that our case study is solely intended as an illustration of the basic model. We make a number of modifications to equation (ix) due to data limitations. In particular, since we opt for a model of industrial-manufacturing interactions, we must redefine our industrial and manufacturing growth rates. Equation (viii) referred to the growth rate of the number of manufacturing firms. While this may be appropriate for the formal modelling, it may prove problematic when actually illustrating or testing the model. The observed increase in the number of manufacturing firms in China may reflect entrepreneurial activity and firm entry, as implied by the formal model. This is especially the case for private firms, and is likely to be applicable to small-scale township and village enterprises also. Nevertheless, the size of Chinese enterprises is approximately distributed according to the simplified canonical law (or perhaps even Zipf over large, noncensored samples) rather than anything resembling constant (Ramsden & Kiss-Haypl, 2000). Thus, the relationship between the number of firms and any other measure of sector size (output, value-added, employment, and so on) will be nonlinear (Axtell, 2001).

A way to resolve the problem of defining the 'size' of each sector is to take M and A as outputs, value-added, total assets or employment. Since sector profit is proportional to size, in our regression we choose value-added over the other measures. Data are taken from the National Bureau of Statistics (2009). The data provided in the Statistical Yearbook of China have been used in landmark studies of Chinese economic growth, e.g., Kwan and Chow (1996). Examining the data in the Appendix reveals an interesting divergence in growth - real industrial value added increased almost eight-fold over the sample period, while agricultural output only doubled.

In terms of estimating the relative contributions of institutions, competition for labor between firms, and agricultural linkages to industry's per unit growth rate, take equation

(ix) as an example. The left hand side is the annual fractional change in real manufacturing output. Regressing this on M and A, the coefficients will be r_M/K_M (relating to intrasectoral competition for labor) and δ (relating to the intersectoral impact between agriculture and industry), respectively, with the constant equivalent to the intrinsic rate of growth, r_M, relating to non-labor-related institutions and policies.

The constant in the regression could be a 'black box', but the key to thinking about it is to consider the causes of growth volatility, not the level of output. Output levels could depend on many things, including institutions, capital, technology, scale, externalities, labor supply, and so on. But we are examining only a subset of these – those that vary enough to shock growth rates on a year-to-year basis. This rules out technology, capital (as discussed earlier), scale, and externalities, leaving only economic and political institutions, the policies that result from them.

A clear problem is that the variables in the formal model are instantaneous quantities, whereas the available data is annual. The growth rates refer to the growth over a given calendar year, and the values added/outputs of the sectors are available at the beginning and end of this interval. It seems logical to take the mean (or some other weighted average) of the terminal points, but all variables in the above regressions turn out insignificant. Using the initial points (in fact, the lag of value added/output, since the corresponding initial output for growth in 1991 is the output at the end of 1990) yields better results:

Dependent variable, $\dfrac{\dot{M}}{M}$, using total industrial value-added, 1991-2007

Model: OLS

	coefficient	t-ratio
Const	0.640982	6.350 ***
A (lagged)	-0.0002701	-5.228 ***
M (lagged)	0.00001806	5.196 ***

*** 1% significance

R-squared   0.68
Durbin-Watson 1.88

Quandt likelihood ratio tests suggest no structural breaks in either manufacturing or agriculture in the sample period. Tests on a wider sample (1979-2007) indicate a structural break in industrial value added in 1990; thus, we restrict our sample to 1991 onwards.

In the 1991-2007 sample period, total industry exhibits a very high r_M of 0.641. r_M/K_M is positive at 0.00001806, indicating a relaxation of labor constraints to industry, while the coefficient determining the relationship between agriculture on industry is negative ($\delta = -0.0002701$). The negative coefficient suggests that agriculture and competed competed with one another.

In this illustration, to find the relative contribution of each growth determinant, we now multiply r_M/K_M by the mean of annual manufacturing value added over the period 1991-2007, i.e. by 18351.37, giving a value of 0.331. Similarly, for δ we multiply by mean agricultural output, 3114.293, giving a value of -0.841. Thus, the estimated per unit growth rate has a value of 0.641 + 0.331 - 0.841 = 0.131. (Alternatively: 0.641 + 0.296 - 0.806)/0.641 = 1 + 0.462 – 1.257 constitute the relative contributions.)

Over the 1991-2007 period, non-labor institutions appear to have contributed around twice as much as the relaxation of labor constraints to the growth rate of manufacturing, while the adverse impact of agriculture on manufacturing was less than the combined

positive impact of institutions (labor and non-labor-related). Note that M/K_M is positive – the 0.462 value is probably an underestimate of labor flow relaxation (relating to a change in K_M), since M rose over the sample period (contributing *ceteris paribus* to a decline in the growth rate). Thus K_M has had an even bigger impact than that suggested by the coefficient 0.462.

Still, a question remains: does our model measure the impact of institutions as claimed? That is, does the constant in the regression reflect the impact of institutions and policies? To determine the role of our constant, we employ a proxy for institutions/policies in the regression to see how much the constant falls. The proxy we use is agricultural employment. Figure 3 shows how agricultural employment has responded to institutional and policy changes over time. For example, the initial rise in agricultural employment at the beginning of the series reflects the political swing post-Tiananmen 1989. Deng's tour of Southern China in 1992 resulted in growth of manufacturing, with the privatization of state and collective firms, inflows of foreign direct investment, and acceleration of exports (Zheng *et al.* 2007). But in the face of an overheating economy, economic and administrative counter-measures were introduced to cool investment, reflected in labor shifting back into agriculture.
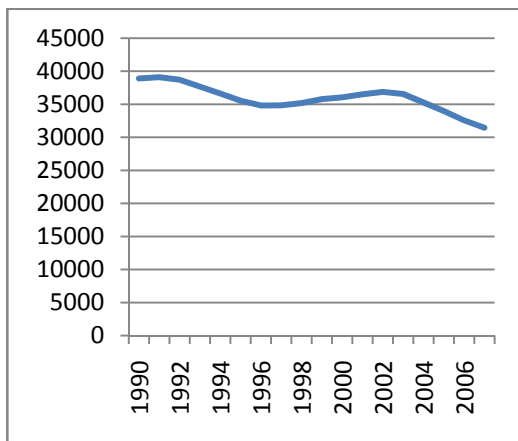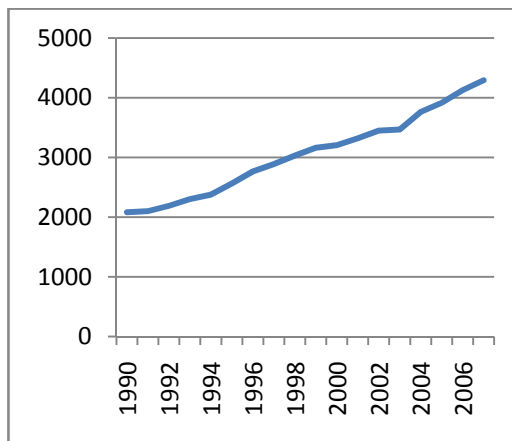
Figure 3: Agricultural employment   Figure 4: Agricultural output

Dependent variable, $\dfrac{\dot{M}}{M}$, using total industrial value-added, 1991-2007

Model: OLS

	coefficient	t-ratio
Const	0.0078256	0.0305
A (lagged)	-0.0001956	-3.6567***
M (lagged)	0.0000141	3.7996***
N (lagged)	0.0000013	2.5403 **

*** 1% significance

R-squared   0.79
Durbin-Watson   2.01

The correlation coefficient between agricultural employment and agricultural output is -0.82. So agricultural employment captures much more than agricultural output. But note that it also captures the impact of labor-related institutions/policies, so it is at best an imperfect proxy for r_M. Still, employing our proxy for institutions/policies has all but removed the constant, providing strong empirical support for the claim that the constant captures institutions and policies.

Conclusion

We have a method that uses very limited data to extract information about the relative sizes of key factors that influence the growth rates of a sector. Note that, because of our grouping of factors into three broad areas, identification of the key specific factors within each group lies outside the scope of this paper. Our approach obscures further detail that we leave to further research. An example is the labor supply equation that might explicitly model workers' preferences and wages outside the sectors examined. Lastly, for developing countries, on which the short-run growth literature currently focuses, the transition from agriculture to industry justifies our focus on the agricultural sector, rather than services, as a key growth determinant of manufacturing. For more developed countries the impact of the service sector might also be a useful addition.

Appendix: Manufacturing and Agricultural Outputs

(100m yuan, 1978 prices)

Year	Manufacturing	Agriculture
(1990)	(4899.7)	
1991	5605.2	2101.9
1992	6791.2	2190.1
1993	8155.5	2304.0
1994	9698.2	2377.8
1995	11059.4	2565.6
1996	12443.0	2765.7
1997	13850.7	2890.2
1998	15083.3	3031.8
1999	16368.9	3162.2
2000	17971.1	3206.4
2001	19528.3	3321.9
2002	21476.0	3451.4
2003	24214.3	3468.7
2004	27000.8	3763.5
2005	30126.4	3917.8
2006	34005.7	4129.4
2007	38595.3	4294.6

References

Acemoglu, Daron, Simon Johnson, James Robinson, and Yunyong Thaicharoen (2003), Institutional Causes, Macroeconomic Symptoms: Volatility, Crisis, and Growth," *Journal of Monetary Economics* 50, 49–123.

Aoki, M. And Yoshikawa, H. (2002), Demand saturation-creation and economic growth, Journal of Economic Behavior & Organization, 48 127–154.

Axtell, R. L. (2001). Zipf distribution of U.S. firm sizes. *Science, 293*, 1818–1820.

Byrd, W. and Q. Lin (1990), *China's Rural Industry: Structure, Development and Reform*, NY: Oxford U.P.

Clark, D., Kaserman, D. and Anantanasuwong, D. (1993), A diffusion model of industrial sector growth in developing countries, World Development, 21(2):421-428.

Day, R. (1982), Irregular growth cycles, *American Economic Review*, 72(3):406-414.

Echevarria, C. (1997) Changes in sectoral composition associated with economic growth, The International Economic Review, 38(2):431-452.

Easterly, W. and Levine, R. (2001), It's not factor accumulation: Stylized facts and growth models, World Bank Economic Review, 15(2):177-219.

Findlay, C. and A. Watson (1992), "Surrounding the Cities from the Countryside", in R. Garnaut and Liu Guoguang (eds.), *Economic Reform and Internationalisation: China and the Pacific Region*, St Leonard's, NSW: Allen and Unwin.

Findlay, C., A. Watson and H. Wu (1994a), *Rural Enterprises in China*, manuscript version, London: Macmillan.

Hausmann, R., Pritchett, L., and Rodrik, D. (2005) Growth accelerations, Journal of Economic Growth 10(4):303-329

Henisz, W. (2000) The institutional environment for economic growth, Economics and Politics 12(1):1-31

Islam, R. (1991), "Growth of Rural Industries in Post-Reform China: Patterns, Determinants and Consequences", *Development and Change*, 22(4):687-719.

Islam, R. and H. Jin (1994), "Rural Industrialization: An Engine of Prosperity in Postreform rural China", *World Development*, 22(11):1643-1662.

Jerzmanowski, M. (2006) Empirics of hills, plateaus, mountains and plains: A Markov-switching approach to growth, Journal of Development Economics 81, 357-385

Jones, B. & Olken, B., (2005), Do leaders matter? National leadership and growth since World War II," *Quarterly Journal of Economics* 120, 835–864.

Jones, B. and Olken, B. (2008) The anatomy of start-stop growth, *The Review of Economics and Statistics* 90(3): 582–587

Klenow, P. (2001), Comment on "It's not factor accumulation: Stylized facts and growth models," by William Easterly and Ross Levine, *World Bank Economic Review*, 15(2):221-224.

Kroeber, A. (2005), China as Employer and Consumer: Economic Outlook for the 11th Five-Year Plan (2006-2010). Conference Paper presented at the China and the World Economy Workshop, December 2005, The Atlantic Council of the United States, Asia Programs.

Kwan, Y. and Chow, G. (1996), Estimating economic effects of political movements in China, Journal of Comparative Economics, 23(2):192-208

Lin, J. (1995), "Can China's 'Mini-Bang' Succeed?", *Contemporary Economic Policy*, XIII(1):10-14.

Mellor, J. (1986), "Agriculture on the Road to Industrialization", in J. Lewis and V. Kallab (eds.), *Development Strategies Reconsidered*, New Brunswick: Transaction Books.

Mellor, J. (1984), "Manufacturing Development and the Intersectoral Transfer of Resources", in C. Eicher and J. Staatz (eds.), *Manufacturing Development in the Third World*, Baltimore: Johns Hopkins University Press.

Mobarak, A. (2005), Democracy, volatility, and economic development, The Review of Economics and Statistics 87(2): 348-361

National Bureau of Statistics of China. (2009). *China Statistical Yearbook 2009*. Hong Kong: International Centre for the Advancement of Science and Technology.

Pritchett, L. (2000), Understanding patterns of economic growth: Searching for hills among plateaus, mountains, and plains, The World Bank Economic Review 14(2):221-250

Ramsden, J. J., & Kiss-Haypl, G. (2000). Company size distribution in different countries. *Physica A*, *277*, 220–227.

Ratha, D., I. Singh and G. Xiao (1994), "Non-State Enterprises as an Engine of Growth: An Analysis of Provincial Industrial Growth in Post-Reform China", Transition Economics Division, The World Bank (mimeo).

Sicular, T. (1992), "China's Manufacturing Policy During the Reform Period", in Joint Economic Committee, Congress of the United States (ed.), *China's Economic Dilemmas in the 1990s: The Problems of Reforms, Modernization, and Interdependence*, NY: M.E. Sharpe.

Turner, J. and D. Rapport (1974), An Economic Model of Population Growth and Competition in Natural Communities, in S. Levin (ed.), *Lecture Notes in Biomathematics 2: Mathematical Problems in Biology*, Berlin: Springer-Verlag.

Woo, T., T. Hsueh, R. Shi and Y. Zhang (1993),　Impact of the Development of China's Rural Non-Manufacturing Sector on the National Economy, in T. Hsueh, Y. Sung and J. Wu (eds.), *Studies on Economic Reforms and Development in the People's Republic of China*, Hong Kong: The Chinese University Press.

Wu, H. (1992),　"The Industrialisation of China's Rural Labor Force since the Economic Reform", *CERU Working Paper* No. 92/6, Adelaide: Chinese Economic Research Unit, University of Adelaide.

Wu, H. (2010), Political incentives and mismatch of Chinese growth rate, Asian Economic Panel Meeting, March 22-23.

Zheng, J., Bigsten, A. and Hu, A. (2007), Can China's growth be sustained? A productivity perspective , World Development