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Forces Shaping China's Interprovincial Inequality

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Abstract

This paper explores the forces that shaped China's interprovincial inequality in the last five decades of communist rule. In so far as the change in interprovincial inequality is the result of differential growth in the provincial GDP per capita and provincial economic growth may be decomposed into contributions by total factor productivity and other factor inputs, a new method is introduced, breaking down the change in inequality into contributions by total factor productivity (TFP) and factor inputs. In particular, the findings suggest that TFP and factor inputs exerted different impact on interprovincial inequality in the Maoist and reform era.

Keywords: China, regional development, production

JEL classification: O4, P2, R0

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Acronyms

CPIs provincial consumer price indices

FDI foreign direct investments

GDP gross domestic product

GE generalized entropy

RPIs retail price indices

TFP total factor productivity

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1 Introduction

The unveiling of the western development programme[1] in 1999 by China's former Party Secretary, Jiang Zemin, is a reminder that notwithstanding China's spectacular economic success, the Middle Kingdom is still a country full of stark contrasts, conjuring up an image of the western periphery lagging far behind the eastern core. Uneven regional development remains a hotly debated issue half a century after Chairman Mao declared the contradictions between the coastal and inland provinces as one of the so-called ten cardinal relations (*shida guanxi*) to be addressed. There is by now a large literature on China's interprovincial inequality (Fujita and Hu 2001; Jian, Sachs and Warner 1996; Lyons 1991; Naughton 2002; Lin, Cai and Li 1998; Lin and Cai 2003; Raiser 1998; Tsui 1991, 1996; Wang and Hu 1999; the list is by no means exhaustive). This paper extends previous works along two fronts. First, in view of the problems plaguing Chinese official data, this paper tries to address seriously the problems with Chinese statistics and comes up with adjusted data for the analysis of the trend in interprovincial inequality since the 1950s. Second, and more importantly, we introduce a framework for quantitatively identifying the contributions of different forces behind the oscillation of interprovincial inequality.

With regard to the first issue, previous studies rarely treat the problem of China's data seriously, though the quality of the data has recently been the subject of much scrutiny, e.g., Rawski (2001); Young (2000); Holz (2004). Recent scepticism with Chinese official data coupled with the anomalies we have discovered in provincial statistics has prompted us to experiment with different ways of adjusting the official figures to arrive at a trend in interprovincial inequality. The results turn out to be somewhat different from those in previous studies.

The present study also fills the lacuna in existing literature by proposing a coherent framework not only to identify the forces shaping interprovincial inequality, but also to assess their relative importance by quantitatively decomposing China's interprovincial inequality into components. In this connection, a novel method building a bridge between growth accounting, often invoked to study the sources of growth, and the dynamics of regional inequality is introduced. To be more precise, let $I(\mathbf{y})$ be some measure of interprovincial inequality, where $\mathbf{y}$ is a vector of provincial GDP per capita. In so far as provincial output and factor inputs may be summarized by provincial production functions (see Equation 1), the change in interprovincial inequality, $dI(\mathbf{y})/dt$, may be expressed as a function of provincial growth rates. Employing the growth accounting technique, the latter in turn may be decomposed into contributions by the growth of total factor productivity (TFP) and such factor inputs as physical and human capital. $dI(\mathbf{y})/dt$ may thus be attributable to the changing pattern of interprovincial allocation in investment captured by the interprovincial differential growth in physical and human capital as well as the impact of institutional innovations encapsulated in the growth of TFP.

To motivate the subsequent empirical exercise, a historical sketch of the forces shaping interprovincial inequality is the subject of section 2. Experimenting with different ways of adjusting the official data, section 3 arrives at trajectories of interprovincial inequality that may be compared with the one based on official data. Section 3 introduces the

[1] For background information, see, e.g., Naughton (2004) and Goodman (2004).

conceptual framework that is employed to explain the evolution of regional disparities. The empirical results based on the conceptual framework and adjusted data are summarized in section 4. The concluding section highlights and interprets our salient findings and proposes possible extensions of the paper.

2 Background

There is a common perception that regional development strategy in the last four decades went through a number of phases, inducing different forces that impinged ultimately on interprovincial inequalities. This section is a historical synopsis of these forces that possibly might have exerted effect on the dynamics of interprovincial inequalities. These forces are incorporated in the decomposition exercise in the next section.

In the prereform era, the Chinese government saw it as one of their goals to reduce the gap between the coastal and inland provinces, a goal reinforced by defence considerations. Lardy (1978) and later Naughton (2002) have pointed out that the apparatus of central planning gave the Chinese government a handle to mobilize resources for achieving that goal, as witnessed by state appropriations as the dominant source of investment funds (see Table 1). However, the spatial allocation of investment funds often was not concerned with such efficiency considerations as comparative advantages and economies of scale. A case in point is the 'third front campaign', which was a defence-related programme to relocate industries to inland provinces in the mid 1960s and the early 1970s (Naughton 1988). With state investments pouring into some inland provinces, the campaign is often perceived as an extreme manifestation of such an apparently egalitarian development strategy. Such a massive plan to transfer industrial capacities to less-developed regions in complete disregard of their comparative advantages and their poor infrastructure turned out to be a recipe for economic waste. Inefficient regional development policies were reinforced by the need for self-reliance and the formation of a cellular economy (Donnithorne 1972) that militated against specialization and the emergence of efficient economic structures. The effect of increases in investment favouring some inland provinces was thus offset by all the other forces that undercut efficiency and productivity.

Table 1
Proportion of investment in fixed assets of state-owned units by sources of funds (10,000 yuan)

	State appropriation	Domestic loans	Foreign funds	Self-raised funds and other sources
1953-57	543.48			68.1
1958-62	956.91			350.09
1963-65	424.8	3.3		71.35
1966-70	923.86	13.4		271.83
1971-75	1,519.28	21.86		735.23
1976-80	1,831.85	142.4	111.27	1,100.68
1981-85	1,680.68	932.86	320.43	2,396.5
1986-90	2,171.19	3,095.28	1,143.29	6,932.95
1991-95	2,238.46	9,880.6	2,804.89	23,290.6
1996-2000	5,525.28	17,335.27	3,151	45,892.56

Source: NSB (2002).

Notwithstanding the political turmoil and radical economic experiments with disastrous consequences at times, the spread of basic education to less-developed provinces was a legacy of the Maoist period that has prompted some scholars, among them Bramall (2000), to argue that the investment in education in the Maoist era undergirds the rapid economic growth in the reform era. At the beginning of the reform era, China had a population that was more educated than those in countries with comparable levels of development. In so far as education boosts productivity, the spread of education may increase the productivity of labourforces in poor provinces and may help reduce gaps between rich and poor provinces.[2]

The reform era has witnessed a policy break with the past. New forces unleashed by the economic reform have fundamentally changed the spatial distribution of investment funds and induced a spatial restructuring of industries. With the retreat of central planning, the state's role in the allocation of investment has been diminishing in importance, as shown in Table 1. Fiscal decentralization has allowed local governments, administrative agencies and state-owned enterprises to retain more of the revenue generated within their jurisdictions and has opened up more opportunities to boost their fiscal intake (e.g., through township and village enterprises). In the case of Guangdong and Fujian, their high-powered fiscal contracting system (*dabaogan*) was the envy of other provinces (Wong, Heady and Woo 1995). The result was an explosion of self-raised funds, the distribution of which is highly skewed in favour of the richer coastal provinces.

Other than inducing a change in the spatial allocation of investment, productivity-boosting institutional innovations set off by reforms were often localized with spatially differentiated effects. For example, the household responsibility system had its origin in Anhui and initially spread faster in the poor provinces. Greater reliance on market forces channels industries to regions with comparative advantage and economies of scale, in contrast to politically-motivated strategies such as the 'third front' campaign that could be detrimental to economic efficiency. Richer provinces have also benefited from a faster pace of market reforms and opening up to the outside world. Guangdong and Fujian have been one step ahead of other provinces, attracting preponderant shares of foreign direct investment. The 'special economic zones' have helped some coastal provinces to attract foreign investments that not only increased physical capital for production but also introduced technology and management knowhow, boosting productivity. Some of the institutional innovations benefited the poor provinces, others boosted productivity of the richer provinces, reinforcing the effect of the new spatial pattern of investment distribution.

What emerges from the discussion is that different policy regimes emerging in the last four decades unleashed different forces with differential and, at times, opposing impacts on interprovincial inequality. Different policy regimes brought about different spatial distribution of such factors of production as human and physical capital. This translated into different rates of provincial economic growth. Furthermore, development strategies and institutional environment have also exerted spatially differential impacts on aggregate productivities of the provincial economies. The complex dynamics of interprovincial inequality by the different forces do not indicate a pattern of a monotonic change in

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2 However, the rapid expansion of basic education raises questions about the quality of prereform education.

interprovincial inequality over the last four decades. This is indeed the case, as is shown in the next section when we look into the trend of interprovincial inequality.

3 Interprovincial inequality: the trend

With the above background in mind and as a prelude to the subsequent decomposition analysis, this section turns to the historical trend in China's interprovincial inequality for the period 1952-99.[3] But first, an introduction of our notation is in order. The basic unit of our analysis is a province.[4] Following the Chinese convention, the provinces may be partitioned further into three regions: east, central and west.[5] The nominal provincial GDP of the *m*th province in the *g*th region is Y_{gm}. Let the real provincial GDP per capita, y_{gm}, be defined as $Y_{gm}/(\Pi_{gm} P_{gm})$, where P_{gm} is the total population and Π_{gm} is the GDP deflator of the *m*th province in the *g*th region.

Notwithstanding the many studies that have derived the trend in interprovincial inequality, there remains a number of nagging problems with respect to official data. It is customary to measure interprovincial inequality in terms of real provincial GDP per capita, y_{gm}.[6] There are at least two potential problems with using such a measure. With the release of provincial real growth rates (e.g., see NBS 1997), most studies have used the official growth rates for deriving provincial real GDP. However, much has been written on the defects of these growth rates, e.g., Keidel (2001); Rawski (2001); Xu (1999, 2000); Wu (2001); Young (2000). Though much less is known about the accuracy of the growth rates for the Maoist period, there is a common perception that official real growth rates for the reform era are overestimated.[7] It is also to be noted that the provincial implicit deflators derived from the growth rates seem to indicate price variability to be larger than one would expect for the Maoist period, known to be largely an era of price stability except for a period in the early 1960s after the 'great leap forward'.

The second data problem is that official population figures used to estimate the per capita GDP have become less accurate in the reform era. Post-reform figures based on household registration fail to keep track of inward or outward migration. In this paper,

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3 The period under study stops at 1999. While it is possible in theory to extend the study using more recent data, there are problems with changing definitions, especially for provincial populations after 2000, which renders some data intertemporally incomparable.

4 The directly administered municipalities are incorporated into their neighbouring provinces. Hainan and Xizang are excluded. Directly administered municipalities, i.e., Shanghai, Tianjin, Beijing and Chongqing, are merged with their neighbouring provinces.

5 The former practice was to include Guangxi in the eastern region. We follow the recent practice of assigning it to the western region. Formerly classified as a province in the central region, Neimenggu has officially been included in the west region after the introduction of the western development programme.

6 Earlier studies such as Lyons (1991) and Tsui (1991) use national income (*guomin shouru*) figures drawn from the socialist national income accounting framework that excludes the service sector.

7 In the prereform era, inflation was low except for the years surrounding the 'great leap forward' in the early 1960s.

official population data are used for the prereform era, inter-census population figures are derived based on the three censuses after 1982 (see Appendix A).

To estimate the trend in interprovincial inequality, this paper departs from previous studies by experimenting with different GDP deflators and estimates of provincial population figures. An alternative to using the official real growth rates is to deflate expenditure components by their respective price indices collected from other sources, an approach suggested by Keidel (2001). Next is a brief summary of how the data are adjusted; a detailed explanation is given in Appendix A.[8] The different expenditure categories to be individually deflated are rural consumption, urban consumption, government consumption, capital formation and net exports. For the period since the mid 1980s, provincial CPIs, together with their rural and urban counterparts, are available for all provinces and are used to deflate the various categories of consumption. For the pre-1985 period, we use provincial retail price indices (RPIs) as deflators whenever provincial consumer price indices (CPIs) are not available. The next component is gross capital formation (*ziben xingcheng zhonge*). Provincial price indices for fixed asset investment are available only for the period from 1992 to 1999. The official implicit deflators for gross capital formation are used until1984. Between 1985 and 1991, deflators based on prices of capital goods released by the National Bureau of Statistics (NBS) are constructed. Details on deriving the provincial price indices for capital formation are given in Appendix A.

The adjusted data are used to examine how interprovincial inequality changes over time. The results are then compared with those based on official data. For this purpose, we resort to a population-weighted version of Theil's entropy measure:

$$I(\mathbf{y}) = \sum_{g=1}^{G}\sum_{m=1}^{M_g} f_{gm} \ln\left(\frac{\bar{y}}{y_{gm}}\right), \quad \bar{y} = \sum_{g=1}^{G}\sum_{m=1}^{M_g} f_{gm} y_{gm} \,, \tag{1}$$

where G is the number of regions, M_g is the number of provinces in the gth region, $\mathbf{y} = (\mathbf{y}_1,...,\mathbf{y}_G)$ where $\mathbf{y}_g = (y_{g1},...,y_{gM_g})$, $f_{gm} = P_{gm} / \sum_{g=1}^{G}\sum_{k=1}^{M_g} P_{gk}$. In the present context, the provinces are categorized into the eastern, central and western regions so that G is equal to 3. Figure 1 reports three set of results. EN1 is based on unadjusted official data. EN2 and EN3 are derived using our estimates of provincial GDP deflators and population figures as detailed in Appendix A. EN3 is different from EN2 in the deflation of capital formation so as to come up with the provincial GDP deflators. While EN3 adopts the official implicit deflators for capital formation, we adjust some anomalous figures of the official deflators in arriving at EN2. This does not appear to make too great a difference. Next, we focus only on EN1 and EN2. A striking feature is that the magnitude of EN1 is distinctly higher than those of the other trend. What is even more interesting is that the two trajectories diverge in certain subperiods even though their overall oscillation patterns share certain salient features. Until 1967 and with the exception of the anomalous years of the 'great leap forward', EN1 based on official data ratchets upwards while EN2 etches downwards. Inequality shoots up in 1968, which may be due to production disruptions caused by the chaos of the Cultural Revolution. During the period between 1968 and the early 1970s, EN2 moves

8 For another approach, see Young (2000).

downwards while EN1 is almost stationary. This period coincides with the 'third front' campaign when investment funds were poured into inland provinces. But by 1973, all the trajectories move upward, reaching a peak in 1976. Start of the reform era sets off a conspicuous decline in interprovincial inequalities until the mid 1980s for both EN1 and EN2. Thereafter, the two trends initially crawl upwards, followed by sharp increases in the first half of the 1990s. Unlike the trend for EN2, which remains by and large stable from 1995, the trend using official data continues to climb upwards. This finding seems to suggest that the richer provinces underestimate their rates of inflation, thereby exaggerating the increase in inequality.

Is the trend robust with respect to the inequality indices used? The parameter-dependent class of generalized entropy (GE) measures reduces to the Theil entropy measure above when the parameter *a* equals zero.[9] We repeat the above exercise using the GE

Figure 1
Overall interprovincial inequality

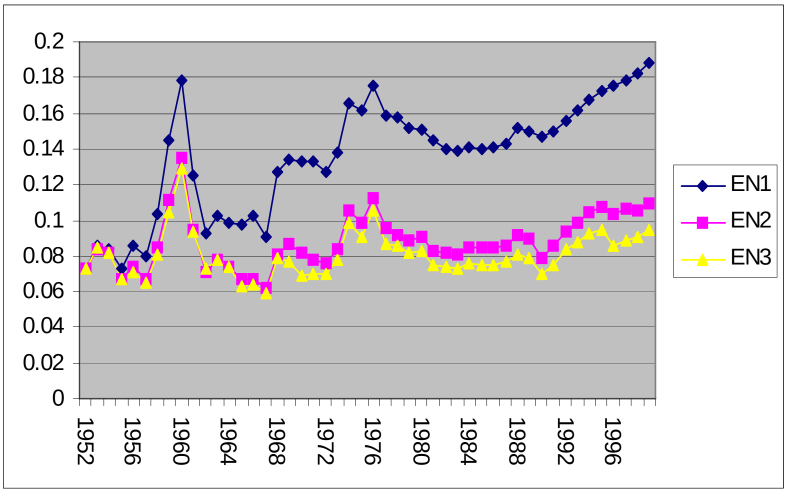
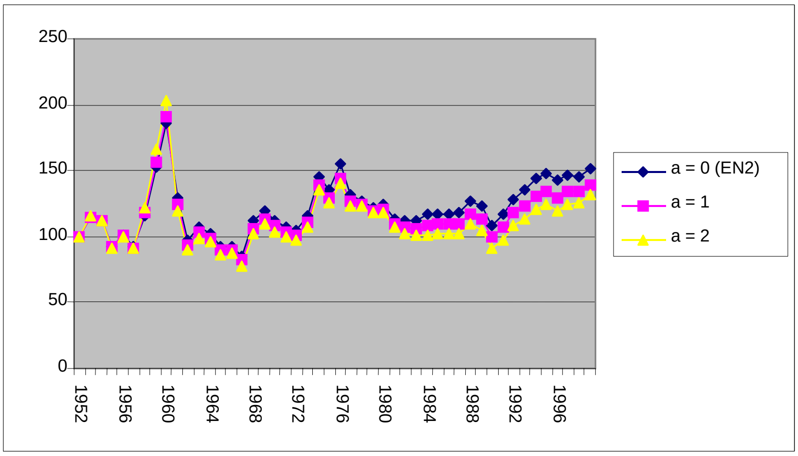


Figure 2
Trends in overall interprovincial inequality
based on official and adjusted data



Source for Figures 1 and 2: Computed by author from data sources cited in Appendix A.

9 See, for example, Shorrocks (1984).

measures when a = 1 and 2 for the case that corresponds to EN2. The case when a is equal to 2 is the square of the coefficient of variation. The smaller a, the more sensitive the measure is to transfers at the bottom of the income distribution (Shorrocks and Foster 1987). The three cases are reported in Figure 2. They are normalized to 100 in 1952. The trend of interprovincial inequality is, by and large, robust to the inequality indices used.

Since much attention has been focused on the income gap between the coastal and inland provinces, it is informative to isolate such a gap from overall inequality. The class of entropy measures is susceptible to decomposition into within-region and between-region inequality, i.e.:[10]

$$I(\mathbf{y}) = WG(\mathbf{y}) + BG(\mathbf{y}), \qquad (2)$$

where the within-region inequality is defined as:

$$WG(\mathbf{y}) = \sum_{g=1}^{G} f_g I(\mathbf{y}_g)\,,\ f_g = \sum\nolimits_{m=1}^{M_g} P_{gm} \Big/ \sum\nolimits_{g=1}^{G} \sum\nolimits_{m=1}^{M_g} P_{gm}\ ,$$

while the between-region inequality assumes the following form:

$$BG(\mathrm{y}) = \sum_{g=1}^{G} f_g \ln\left(\frac{\bar{y}}{\bar{y}_g}\right),\ \bar{y}_g = \sum\nolimits_{m=1}^{M_g} Y_{gm} \Big/ \sum\nolimits_{m=1}^{M_g} P_{gm}\ .$$

Figures 3 and 4 report the trends in the within-region inequality and between-region inequality, respectively, using different deflators, where WGi and BGi correspond to ENi, i = 1, 2, 3. Careful scrutiny suggests that the trajectories based on adjusted data differ from the one based on official data. Prereform within-region inequality, inequality based on adjusted data (i.e., $WG2$ and $WG3$) moves downward with spikes in the second half of the 1970s. This is to be contrasted with $WG1$ that seems, despite oscillations, to be on an upward trend. For all three cases, WGi, i = 1, 2, 3, decrease and then taper off in the reform era.

With regard to BGi, i =1, 2, 3, the trends based on the adjusted data fluctuate, as opposed to an increasing trend based on official data. The jumps around the early 1950s and in 1968 capture the policy shocks of those chaotic years. Then the short interlude when downward trends are discernible coincides with the 'third front campaign'. Inequality increases thereafter for all three cases, reaching a peak in 1976. The reform era introduces a period of mildly declining or almost stationary between-region inequality. From the mid 1980s, the between-region inequality for the three trends increases slowly at first and then accelerates. The three trajectories, however, diverge in the second half of the 1990s, with the trend based on official data still exhibiting a distinctly increasing trend while the other two series are much less pronounced-

What are the forces driving the aggregate trend in interprovincial inequality? The last section reviews the different forces which were created by policy-regime switching and which have shaped spatial inequalities over the last four decades. The aggregate trend in interprovincial inequality is the convergence of all these forces, some having a

10 See Shorrocks (1984).

reinforcing effect, others having a counteracting effect. However, simply observing the aggregate trend in interprovincial inequality is not enough to understand the underlying dynamics when a confluence of factors are at work. What seems missing in previous studies, e.g., Lardy (1978); Donnithorne (1972); Naughton (2002); and Tsui (1991, 1996), is a better tool for isolating the effects of these forces on interprovincial inequality. These factors include, for example, the changing spatial distribution of physical investment and the spread of basic education. But physical and human capital do not exhaust the list of factors that affect interprovincial inequality. As mentioned earlier, spatial distribution of resources induced by different institutional arrangements may have implications for comparative advantages and economies of agglomeration inducing higher or lower productivity at the aggregate level. Institutional changes were pertinent to interprovincial inequality not least because many of these changes were region-specific. Next, we introduce a framework to examine more precisely the different forces driving interprovincial inequality.

Figure 3
Within-region inequality

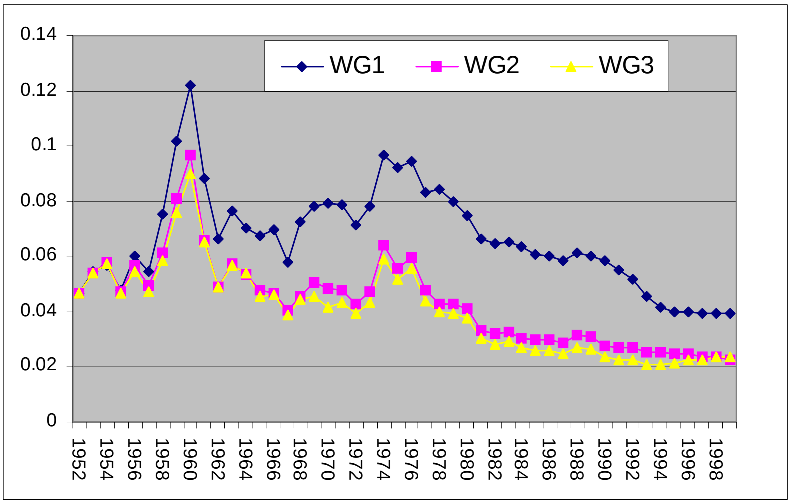
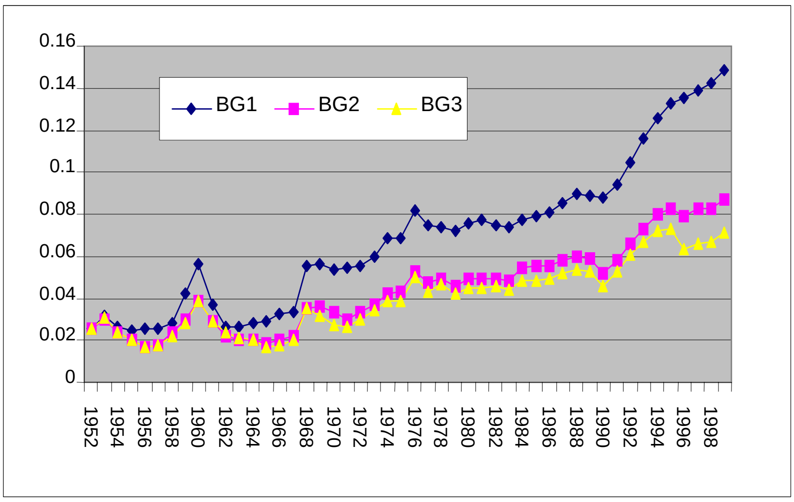


Figure 4
Between-region inequality



Source for Figures 3 and 4: Computed by author from data sources cited in Appendix A.

4 The conceptual framework: growth accounting and interprovincial inequality

This section introduces a framework for the decomposition of changes in interprovincial inequality. The discussion in section 2 highlights the links between the spatial distribution of factors of production, e.g., physical and human capital, under different policy regimes and regional inequality. No less important is the effect of policy shifts on productivity. It is convenient to think in terms of provincial production functions:

$$Y_{gm} = A_{gm}F_{gm}(K_{gm}, H_{gm}),\ H_{gm} = S_{gm}L_{gm} \tag{3}$$

where K_{gm} is the capital stock, H_{gm} is quality-adjusted labourforce being a product of an index of schooling, S_{gm} and the labourforce, L_{gm}. F_{gm} is an increasing function of K_{gm} and H_{gm}, and A_{gm} is the term capturing the total factor productivity (TFP) of the *m*th province in the *g*th region. To make our notation less cumbersome, we omit the time subscript. For each province, provincial economic growth may then be decomposed into the contribution of the growth of TFP and factor inputs:[11]

$$\frac{\dot{Y}_{gm}}{Y_{gm}} = \frac{\dot{A}_{gm}}{A_{gm}} + \left(\frac{\partial F_{gm}/\partial K_{gm}}{Y_{gm}}\right)\frac{\dot{K}_{gm}}{K_{gm}} + \left(\frac{\partial F_{gm}/\partial H_{gm}}{Y_{gm}}\right)\frac{\dot{H}_{gm}}{H_{gm}}. \tag{4}$$

Interprovincial differences in the growth of A_{gm}, K_{gm} and H_{gm} result in provincial outputs expanding at different pace, contributing ultimately to the change in interprovincial inequality. In this connection, it is to be noted that:

$$\dot{y}_{gm}/y_{gm} = (\dot{Y}_{gm}/Y_{gm}) - (\dot{P}_{gm}/P_{gm}) \tag{5}$$

Substituting (5) into (4) results in:

$$\frac{\dot{y}_{gm}}{y_{gm}} = \frac{\dot{A}_{gm}}{A_{gm}} + \alpha_{gm}^{K}\frac{\dot{K}_{gm}}{K_{gm}} + \alpha_{gm}^{L}\frac{\dot{H}_{gm}}{H_{gm}} - \frac{\dot{P}_{gm}}{P_{gm}}, \tag{6}$$

where $\alpha_{gm}^{K} = (\partial F_{gm}/\partial K_{gm})/Y_{gm}$ and $\alpha_{gm}^{L} = (\partial F_{gm}/\partial H_{gm})/Y_{gm}$. Differential growth rates in TFP, physical capital, human capital and population result in different growth rates in provincial GDP per capita. The change in inequality index $I(\mathbf{y})$ may ultimately be decomposed into contributions of A_{gm}, K_{gm}, H_{gm} and P_{gm}.

To operationalize the above intuition, the first step is to differentiate Equation (1) with respect to time:

$$\frac{dI(\mathbf{y})}{dt} = \sum_{g=1}^{G}\sum_{m=1}^{M_g}(s_{gm} - f_{gm})\frac{\dot{y}_{gm}}{y_{gm}} + \sum_{g=1}^{G}\sum_{m=1}^{M_g}(s_{gm} - f_{gm}\ln(y_{gm}))\frac{\dot{f}_{gm}}{f_{gm}}, \tag{7}$$

[11] Throughout this paper, $\dot{X}/X$ refers to the growth rate of the variable *X*.

where t is time and $s_{gm} = Y_{gm} / \sum_{g=1}^{G} \sum_{k=1}^{M_g} Y_{gk}$.[12] The first term on the right-hand side of Equation (7) captures the impact on interprovincial inequality of differential growth rates across provinces, while the second term summarizes the impact of changing population shares. It is interesting to note that the impact of $\dot{y}_{gm} / y_{gm}$ on inequality hinges on the sign of the term $(s_{gm} - f_{gm})$. Behind this term is the implicit ethical judgement that, with income share of a province, s_{gm}, falling below its population share, f_{gm}, transferring more income to that province reduces inequality. The ethical judgement is thus analogous to the Pigou-Dalton transfer principle well-known in the literature on inequality measurement.[13]

Substituting Equation (6) into Equation (7), the change in inequality then depends on the growth of TFP and factor inputs, i.e.:

$$\frac{dI(\mathbf{y})}{dt} = CA + CK + CH + CP + CF \tag{8}$$

where

$$CA = \sum_{g=1}^{G} \sum_{m=1}^{M_g} (s_{gm} - f_{gm}) \frac{\dot{A}_{gm}}{A_{gm}}, \; CK = \sum_{g=1}^{G} \sum_{m=1}^{M_g} (s_{gm} - f_{gm}) \, \alpha_{gm}^{K} \frac{\dot{K}_{gm}}{K_{gm}},$$

$$CH = \sum_{g=1}^{G} \sum_{m=1}^{M_g} (s_{gm} - f_{gm}) \, \alpha_{gm}^{L} \frac{\dot{H}_{gm}}{H_{gm}}, \; CP = -\sum_{g=1}^{G} \sum_{m=1}^{M_g} (s_{gm} - f_{gm}) \frac{\dot{P}_{gm}}{P_{gm}},$$

$$CF = \sum_{g=1}^{G} \sum_{m=1}^{M_g} (s_{gm} - f_{gm} \ln(y_{gm})) \frac{\dot{f}_{gm}}{f_{gm}},$$

Whenever any of the above components are positive, they contribute to an increase in interprovincial inequality. It is natural to interpret CA, CK, CH as the contributions of growth in TFP, physical capital and human capital to the *change* in interprovincial inequality. Capturing the effect of population growth on inequality is the term CP. Faster population growth in a poor region, *ceteris paribus*, results in an increase in interprovincial inequality. Finally, CF summarizes the effect of changing population shares on inequality.

An important dimension of interprovincial inequality that has generated a lot of debate is the gap between the coastal provinces as opposed to the central and western provinces. Indeed, as shown above, hidden behind *overall* interprovincial inequality may be divergent changes in between-region and within-region inequalities. To gain a richer picture of interprovincial inequality, the terms in Equation (8) may be further decomposed into between- and within-region contributions. Recalling Equation (2), the term $dWG(\mathrm{y})/dt$ may in turn be decomposed as in Equation (8):

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12 Details for deriving Equation (7), see Appendix B.

13 An inequality measure satisfies the Pigou-Dalton principle if a transfer of a dollar from a richer to a poorer person leads, without changing their total income, to a fall in inequality; see, e.g., Sen (1997).

$$\frac{dWG(\mathbf{y})}{dt} = WCA + WCK + WCH + WCP + WCF \tag{9}$$

where

$$WCA = \sum_{g=1}^{G} f_g \left[\sum_{m=1}^{M_g} (\hat{s}_{gm} - \hat{f}_{gm}) \frac{\dot{A}_{gm}}{A_{gm}} \right], \; WCK = \sum_{g=1}^{G} f_g \left[\sum_{m=1}^{M_g} (\hat{s}_{gm} - \hat{f}_{gm}) \alpha_{gm}^{K} \frac{\dot{K}_{gm}}{K_{gm}} \right],$$

$$WCH = \sum_{g=1}^{G} f_g \left[\sum_{m=1}^{M_g} (\hat{s}_{gm} - \hat{f}_{gm}) \alpha_{gm}^{K} \frac{\dot{H}_{gm}}{H_{gm}} \right], \; WCP = -\sum_{g=1}^{G} f_g \left[\sum_{m=1}^{M_g} (\hat{s}_{gm} - \hat{f}_{gm}) \frac{\dot{P}_{gm}}{P_{gm}} \right],$$

$$WCF = \sum_{g=1}^{G} f_g \left[\sum_{m=1}^{M_g} (\hat{s}_{gm} - \hat{f}_{gm} \ln(y_{gm})) \frac{\dot{\hat{f}}_{gm}}{\hat{f}_{gm}} + I(\mathbf{y}_g) \frac{\dot{f}_g}{f_g} \right].$$

where $\hat{s}_{gm} = Y_{gm} \Big/ \sum_{k=1}^{M_j} Y_{gk}$, $\hat{f}_{gm} = P_{gm} \Big/ \sum_{k=1}^{M_g} P_{gk}$. Similarly, in the case of between-region inequality:

$$\frac{dBG(\mathbf{y})}{dt} = BCA + BCK + BCH + BCP + BCF \,, \tag{10}$$

where

$$BCA = \sum_{g=1}^{G} \sum_{m=1}^{M_g} (s_{gm} - f_g \hat{s}_{gm}) \frac{\dot{A}_{gm}}{A_{gm}}, \; BCK = \sum_{g=1}^{G} \sum_{m=1}^{M_g} (s_{gm} - f_g \hat{s}_{gm}) \frac{\dot{K}_{gm}}{K_{gm}},$$

$$BCL = \sum_{g=1}^{G} \sum_{m=1}^{M_g} (s_{gm} - f_g \hat{s}_{gm}) \frac{\dot{H}_{gm}}{H_{gm}}, \; BCP = -\sum_{g=1}^{G} \sum_{m=1}^{M_g} (s_{gm} - f_g \hat{s}_{gm}) \frac{\dot{P}_{gm}}{P_{gm}},$$

$$BCF = \sum_{g=1}^{G} \left[\sum_{m=1}^{M_g} \left(s_{gm} \frac{\dot{f}_{gm}}{f_{gm}} - f_g \hat{s}_{gm} \frac{\dot{\hat{f}}_{gm}}{\hat{f}_{gm}} \right) - f_g \ln(\bar{y}_g) \frac{\dot{f}_g}{f_g} \right], \; \bar{y}_g = \sum_{m=1}^{M_g} \hat{f}_{gm} y_{gm} .$$

Variables with '^' denote shares or averages with respect to a region. The term $(\hat{s}_{gm} - \hat{f}_{gm})$ is the difference between the income share and population share of the *m*th province *within the* g*th region* and its interpretation is similar to ($s_{gm} - f_{gm}$) discussed above. In the case of the between-region contribution, since $(s_{gm} - f_g \hat{s}_{gm}) = \hat{s}_{gm}(s_{gm} / \hat{s}_{gm} - f_g)$ and $s_{gm}/\hat{s}_{gm}$ is in fact the share of income accruing to region *g*, so that $(s_{gm} / \hat{s}_{gm} - f_g)$ turns out to be the difference between the income share and the population share of the *g*th region.

Finally, to facilitate our discussion in subsequent sections, it is helpful to derive *cumulative* changes in inequality induced by the different components above. For example, in the case of TFP, its cumulative contribution is defined as follows:

$$CCA_T = \sum_{s=T_0}^{T} CA_s \text{ , } WCCA_T = \sum_{s=T_0}^{T} WCA_s \text{ , } BCCA_T = \sum_{s=T_0}^{T} BCA_s \text{ .} \tag{11}$$

where CCA_T, $WCCA_T$ and $BCCA_T$ are the *cumulative* contribution by TFP to the *change* in overall, within-region and between-region inequality from T_0 up to the period T. Cumulative changes with respect to components other than TFP in Equations (8), (9) and (10) may be defined accordingly.

5 Estimation of provincial production functions

As a prelude to the derivation of those components in Equation (8) to Equation (10), the provincial production functions have to be estimated. To render the estimation manageable, the provincial production functions are assumed to be log-linear. Furthermore, to explore the black box of TFP, we assume that A depends on a R-vector $\mathbf{z}_{gm} = (z_{gm1},\ldots, z_{gmk})$.

$$Y_{gm} = \left(e^{\lambda_{gm} + \sum_{r=1}^{R} \lambda_{gmr} z_{gmr}} \right) K_{gm}^{\alpha_K} H_{gm}^{\alpha_H} \text{ .} \tag{12}$$

It follows that the contribution of TFP may further be decomposed:

$$CA = \Sigma_r Cz_r, Cz_r = \sum_{r=1}^{R} (s_{gm} - f_{gm}) \lambda_{mr} \frac{dz_{gmr}}{dt} \tag{13}$$

WCA and *BCA* may be decomposed analogously.

With regard to $\mathbf{z}_{gm}$, data availability has limited the factors we can include in $\mathbf{z}_{gm}$. An important dimension of China’s reform is the open-door policy as manifested in the huge influx of foreign direct investments (FDI). The spatial distribution of FDI is skewed towards the coastal provinces not only because of spatially differential policies (e.g., all the special economic zones are in the coastal region only), but possibly because coastal provinces are farther advanced with regard to reform. Therefore as a proxy for openness, we incorporate FDI as a share of GDP into $\mathbf{z}_{gm}$. In recent years, many studies have tried to establish the nexus between openness and growth. In the present context, we try to determine how differential degrees of openness impact on interprovincial inequality via their effect on provincial economic growth.

Another factor that possibly affects TFP is the spatial reshuffling of industries mentioned in section 2. With the retreat of central planning, the spatial flows of investments have conformed with comparative advantages and economies of scale. Fujita and Hu (2001) argue that industrial agglomeration in the coastal region has become stronger in the reform era and may even be a direct source of regional inequality. On the other hand, by blocking the free flow of resources between jurisdictions, local protectionism may have weakened the effect of agglomeration and comparative advantage on regional inequality. How serious market fragmentation is in the reform era is still an unsettled issue, see, e.g., Naughton (2002) and Young (2000). Empirical evidence seems to suggest that China has yet to fully exploit the effect of agglomeration on productivity (Au and Henderson 2004). It is also useful to note that the reorientation of industrial strategy from an excessive focus on heavy industries to the judicious exploitation of China's comparative advantage in labour-intensive industries has boosted some provinces, such as Guangdong and Fujian, that were lagging behind in the prereform era. This has triggered a decline in such industrial powerhouses as Liaoning. In view of these complicated dynamics, without an empirical analysis it is *a priori* difficult to ascertain how industrial restructuring affects regional inequality. In the present context, we treat the effect induced by the industrial reshuffling as among $\mathbf{z}_{gm}$ that may affect productivity. The effect is measured by the share of that province's secondary-sector output to the national total, i.e., $Y_{2k} / \Sigma_m Y_{2m}$, where Y_{2k} is the kth province's output of the secondary sector and the denominator is the national total.[14] As an illustration, Figure 10 summarizes the shares for Guangdong and Liaoning for the period under study. The underlying increase in the share of Guangdong since 1978 may expand the productivity of the province due to the exploitation of comparative advantage and economies of scale producing for the world market.

In addition to these two key variables, a dummy variable for the initial years of the Cultural Revolution and a time trend for the reform era are also included in $\mathbf{z}_{gm}$.[15] The included variables do not exhaust all the factors driving TFP growth. However, data limitations prevent us from embarking on a more comprehensive investigation. Much remains to be done in future work to explore the forces driving TFP.

6 Empirical findings

Before implementing the decomposition exercise, we first estimate Equation (12). We briefly summarize how a number of econometric issues are dealt with. Covering the period from 1964 to 1999, the provincial data are pooled to increase the degree of freedom. First, the panel unit-root test proposed by Im, Pesaran and Shin (2003) suggests that the timeseries for the regression is not stationary.[16] To avoid the potential problem of spurious correlation based on level data, we estimate the first-difference form of Equation (12). To test whether the right-hand side variables are exogenous, we apply the Wooldridge (2002) test for strict exogeneity. The test suggests that the bias induced by endogeneity of RHS variables is not serious. The above tests and procedures result in the two sets of estimates given in Table 2, one for the log-linear case and the other for the case of constant returns to scale, i.e., $\alpha_K + \alpha_H = 1$. Robust t statistics are based on variance-covariance matrices taking into account autocorrelation and heteroscedasticity proposed by Arellano (2003). Finally, using the Wald test for linear restrictions, the hypothesis of constant returns to scale is accepted.[17]

14 In the literature on agglomeration, the regional share of industry is often used as a measure for agglomeration, see, e.g., Brakman, Garretsen and van Marrewijk (2001).

15 We have also experimented with the share of primary output. The rationale is that TFP growth in many developing countries is due to structural transformation. However, in the present context, this variable does not seem to be significant.

16 Results are available on request.

17 In any case, the magnitudes of the estimates are quite similar. The Wald test is used because of the robust variance-covariance matrix.

Table 2 Regression results from production function estimation

	Log-linear		Constant returns	
Ln(K)	0.5243 (5.8585)	0.4765 (5.1743)		
Ln(H)	0.5846 (2.4991)	0.5989 (2.5311)		
Ln(K/H)			0.4884 (4.0531)	0.4513 (3.6700)
FDI	0.7087 (2.7690)	0.4525 (0.2457)	0.7236 (2.7610)	0.4606 (1.8581)
IND		7.1664 (12.2763)		7.2270 (12.8106)
CRV	-0.1017 (-6.1104)	-0.1030 (-6.8251)	-0.1032 (-9.4339)	-0.1041 (-9.5102)
TD	0.0076 (0.6008)	0.0117 (0.9156)	0.0144 (1.4702)	0.0164 (1.6503)

Notes: K = capital stock; H = quality-adjusted labourforce; FDI = share of foreign direct investment to GDP; IND = share of the secondary sector; CRV = dummy for the Cultural Revolution; TD = time trend for the reform era;

The estimates are based by pooling the provincial data and estimating the first-difference form of the log-linear production, i.e., Equation (12).

The variance-covariance matrix is robust to autocorrelation and heteroscedasticity following Arellano (2003).

Figures in parentheses are t statistics.

The results of the above regressions are summarized in Table 2. Two sets of estimates are presented, one for the panel regression without and the other with the constant returns-to-scale restriction. As suggested above, the Wald test for linear restrictions accepts the hypothesis of constant returns to scale. Estimates for λ_{gmr}, α_K and α_H are plugged into the equations for the various contributions to inequality. The contributions by the different factors are summarized in Figure 5. CCK and CCHL are the contributions of the growth in physical capital and quality-adjusted labour. Decomposing the contribution of TFP growth, CCFDI pertains to the contribution of openness and CCIND that of spatial industrial restructuring. What remains after deducting CCFDI and CCIND is CCOTH.

Being a dominating factor and the focus of many previous studies (e.g., Naughton 2002), the cumulative contribution of physical capital (CCK) unambiguously declines until 1972 and then starts to climb until the end of period under review. As shown in Figure 6, the initial decline is attributable to the fall in both with-region contribution of capital (WCCK) and between-region contribution of capital (BCCK), though the magnitude of the latter is much larger. The decline in BCCK coincides with the 'third front' campaign, a period when massive state investments were directed to the inland provinces.

The increasing trajectory of CCK after 1973 is largely explained by the widening gap among the coastal, central and western regions, so much so that by the 1990s, the upward trend in CCK is entirely propelled by BCCK. The peak of the 'third front' campaign was over in the 1970s (Naughton 1988, 2002) and the result is captured by CCK moving upward again. As shown in Figure 6, the sharp increase in CCK progressively driven by the between-region contribution of capital (BCCK) is the major force in the reform era pushing interprovincial inequality upwards. The reform brings in a period of investment funds from new sources such as self-raised funds and foreign capital, the allocation of which is not in the hands of the central government, (recall Table 1). Administrative decentralization has put more extrabudgetary funds at the disposal of the state-owned enterprises, administrative agencies and local governments. Fiscal devolution has opened up opportunities for local governments to venture into profitable businesses such as township and village enterprises, resulting in an explosion of self-raised funds. Large shares of these funds have accrued to richer provinces and have been targeted to investment projects to fuel local economic development. The open-door and the preferential policies granted to the coastal provinces of Guangdong and Fujian attracted preponderant shares of FDI into the richer coastal provinces. Departing from the egalitarian investment strategy of central planning, the spatial distribution of investment funds in the reform era has thus been increasingly skewed in favour of richer provinces, explaining the increase in BCCK.

Even though the above discussion has confirmed that contribution of physical capital is, *ceter paribus*, important in explaining interprovincial inequality, it is interesting to note that changes in CCK do not always track the trend in overall interprovincial inequality.

Figure 5
Contributions to interprovincial inequality

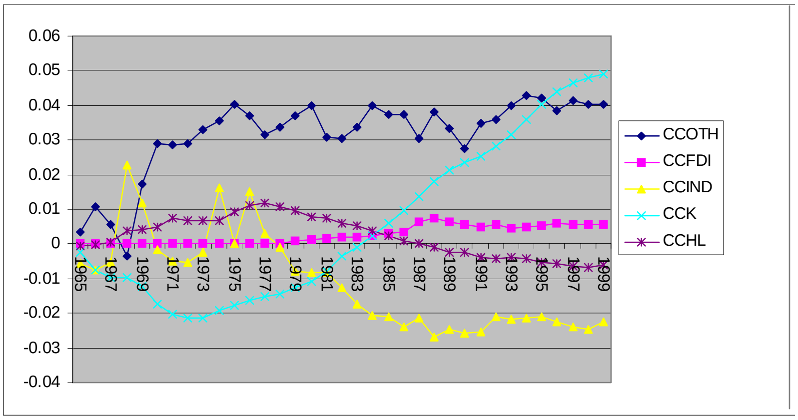
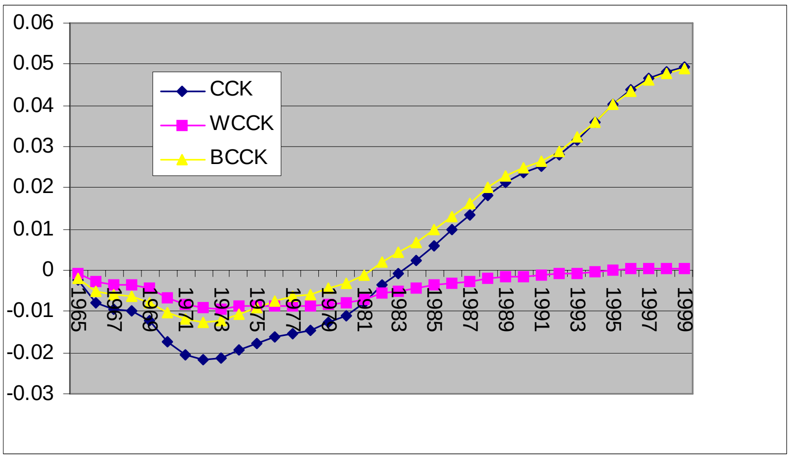


Figure 6
Overall, between-regional and within-region contributions of capital



Source for Figures 5 and 6: Computed by author from data sources cited in Appendix A.

Figure 7
Total factor productivity (before deducting the effects of FDI and agglomerative effects

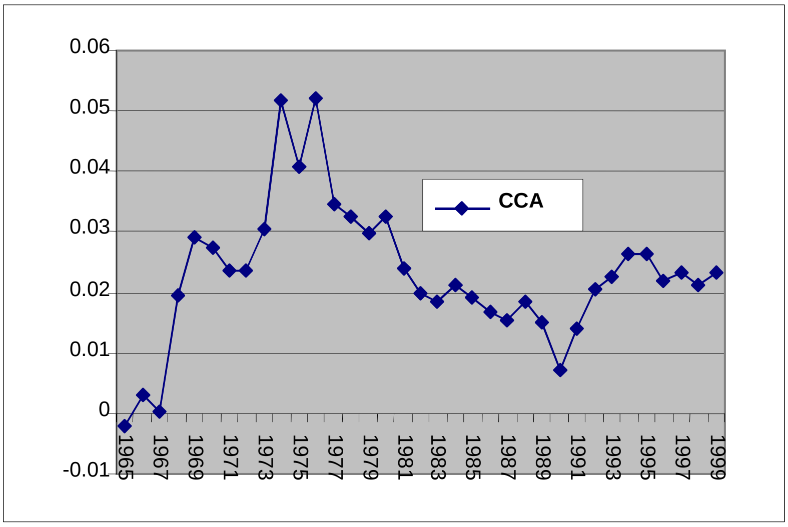


Figure 8
Contribution of FDI

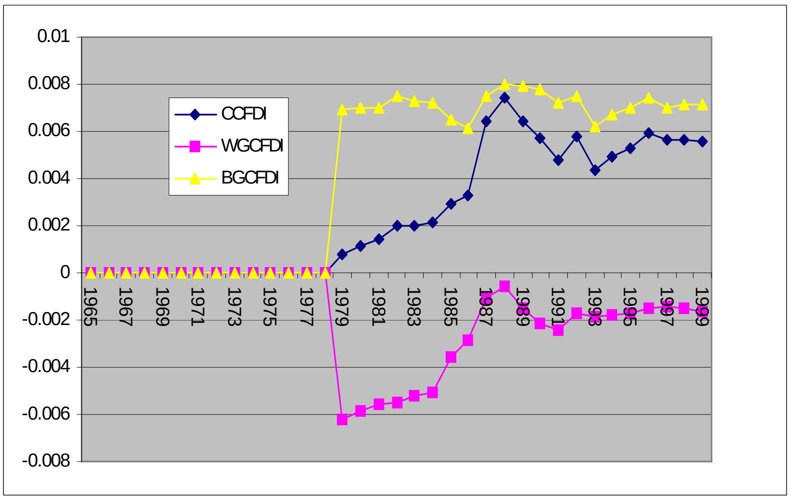
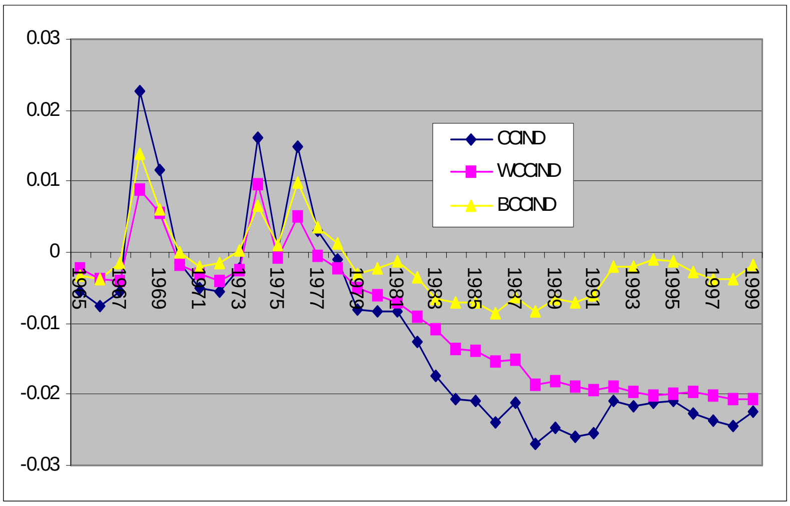


Figure 9
Contributions of agglomeration



Source for Figures 7, 8, and 9: Computed by author from data sources cited in Appendix A.

Our results suggest that the cumulative contribution to inequality of TFP growth before deducting the impact of FDI and industrial restructuring, i.e., CCA, is equally if not more important in certain subperiods and has a trajectory that is divergent from that of CCK. Figure 7 summarizes the contribution of TFP (CCA) based on Equation (13). During the Cultural Revolution (1967-77), the magnitude of the upward trend in CCA is so large that it surpasses CCK so that overall inequality increases. Decomposing CCA using Equation (13), and the proxy for the distribution of industries exhibits some spikes but no discernible trajectory. CCOTH (equal to CCA-CCFDI-CCIND) in Figure 5 is the remainder after the contributions of FDI and IND are deduced and exhibits, by and large, an increasing trend up to the mid 1970s.

Using Equation (13), the effects of FDI and industrial restructuring may be extracted from CCA. There was no FDI in the prereform era. FDI initially contributes to an increase in inequality but the effect tapers off from the mid 1980s onwards. After a jump induced by initial FDI flows into the coastal provinces (such as Guangdong), the between-region contribution of FDI (BCCFDI) does not exhibit a discernible trend. The trajectory of the within-region contribution (WCCFDI) exhibits a one-off decrease, followed by an upward trend. This is consistent with the fact that the initial beneficiaries of FDI are the poorer coastal provinces, such as Guangdong and Fujian which constitute the special economic zones. Foreign capital subsequently spread to other coastal provinces. On the whole, these contributions are relatively small in magnitude.

Figure 9 summarizes the overall (CCIND), between- (BCCIND) and within-region contributions (WCCIND) of industrial restructuring. In the prereform era, there are a number of inequality-increasing spikes but no discernible trends are detected. Since the late 1970s, CCIND contributes to a reduction in overall interprovincial inequality, though its inequality-reducing effect tapers off in the 1990s. In decomposing CCIND further into between- and within-region contributions, the declining trend is largely attributable to WCCIND and, to a much smaller extent, to BCCIND. In the latter case, the trend of BCCIND seems to have become modest in the 1990s. In a further breakdown of WCCIND into contributions by the three regions, the decline is concentrated largely within the eastern region.[18] The reform period has witnessed the decline of such industrial powerhouses as Liaoning that relied on heavy industries. In their place are new industrial-growth poles such as Guangdong, translating their comparative advantage and economies of scale in labour-intensive industries (see Figure 10) into faster TFP growth. As these newly industrializing provinces were less developed in the initial stages of the reform era, industrial restructuring has thus reduced interprovincial inequality.

Next, as depicted in Figure 11, quality-adjusted labour (H) contributes to an increase in interprovincial inequality until the mid 1970s, after which the trend is reversed. The trajectories of between-region (BCCHL) and within-region contributions (WCCHL) are similar, with the inequality-reducing effect of the between-region contributions being more prominent. Two forces are at work. First, growth of the labourforce is faster in poor provinces. The second factor is the spread of education. As better-educated children in the poor provinces gradually entered the labourforce in the 1960s and 1970s, the rapid improvement in labour quality S leads to a faster growth in H. Our empirical

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18 Recall (9); the figures are not reported but available on request.

findings suggest that this translates into a decline in interprovincial inequality but the impact is small relative to the contributions of TFP and physical capital (see Figure 5).

Figure 10
Shares of secondary sectors in Liaoning and Guangdong

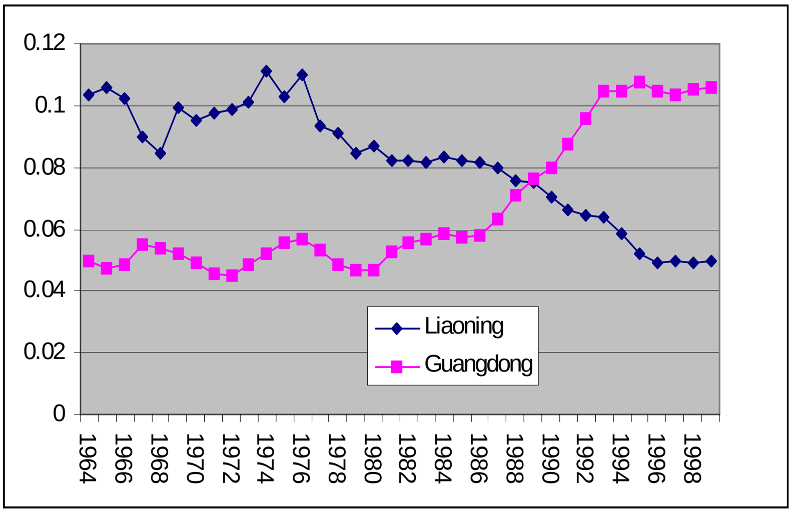
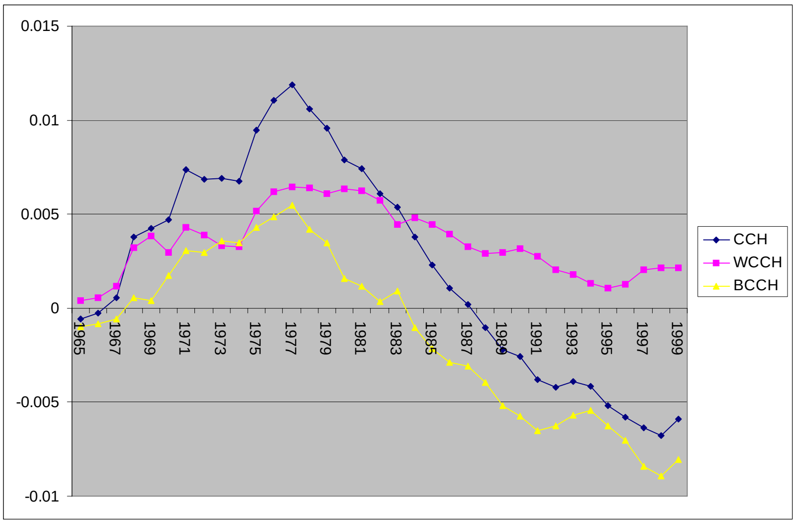


Figure 11
Contribution by quality-adjusted labour



Source for Figures 10 and 11: Computed by author from data sources cited in Appendix A.

7 Salient findings and concluding remarks

The main objective of this paper is to better link the forces induced by policy regime switching to the fluctuation in interprovincial inequality. This is done with the help of data that have been adjusted to hopefully take into account the data problems that are of concern to many experts on China. As our empirical results suggest, the vicissitude of interprovincial inequality reflects the paradigm shifts in China's development strategies over the last four decades that reshuffled resources and induced spatially differential impacts. The rest of this section highlights three major clusters of results. The first pertains to the contribution of capital vis-a-vis TFP growth. Our findings seem to suggest that the different policy environments of the Maoist and of the reform era induced differential changes in the spatial distribution of capital and TFP growth, at times with opposing effects on interprovincial inequality. The second set of results indicates a more complex picture than can be captured by the coastal-inland divide in explaining interprovincial inequality. The final set of results sheds light on the effect of prereform spread of education on growth in the reform era.

Regime switching in the mid 1970s leaves a permanent imprint with regard to the contribution of physical capital to inequality, with its trajectory reversing from a downward to an upward direction. However, the changing locations of investment allocation does not fully explain the interprovincial inequality trends. Indeed, the contribution of physical capital has a trajectory that, at times, is divergent from that of TFP. In the prereform era, especially during the ten-year period of the Cultural Revolution, the contribution of TFP growth surpasses that of physical investment, and seems to coincide with the shocks induced by political turmoil as well as the policy environment in the prereform era. As pointed out by Donnithorne (1972), the ‘cellular economy’ induced by a policy of self-reliance militated against the convergence of TFP, in so far as the interjurisdictional flow of resources, ranging from factors of production to ideas and knowledge, was discouraged. The roles of TFP growth and of investment have been reversed since the late 1970s; the decreasing contribution of TFP more than offsets the increasing contribution of capital, accounting for the decline in interprovincial inequality in the 1980s. The inequality-decreasing contribution of TFP fades in the 1990s, with the trajectory of the contribution of capital becoming dominant.

Spatial industrial restructuring, with the evolution of provincial shares of secondary-sector output as a proxy, turns out to be important in explaining much of the decline in the contribution of TFP in the post-Mao era. Relinquishing the policy of self-reliance, industrial decisions have become oriented towards comparative and agglomeration advantages. As summarized by our empirical results, industrial reshuffling in the 1980s probably had the effect of rectifying a distorted spatial industrial structure and induced a decline both in within-region and between-region inequality. This effect is so powerful that it overrides the other inequality-increasing forces, leading to an overall decrease in interprovincial inequality. Once the spatial restructuring of industries was complete and the effect exhausted, our findings seem to suggest that the spatial distribution of TFP growth contributes to an increase in between-region inequality in the 1990s. Institutional changes seem to be moving at a much faster pace in the coastal provinces, probably reinforced by agglomeration economies.

In so far as the coastal-inland divide is in the limelight and such government initiatives as the ‘western development programme’ are an attempt to address the imbalance, highlighting some salient findings along this line seems warranted. In this study, changes in the overall between-region contribution reported in Figure 4 are decomposed into the contributions by TFP, physical capital and human capital (recall Equation 10). In the prereform era, the inequality-reducing between-region contribution of capital (CCK) is more than offset by the increase in the between-region contribution of TFP. Since the mid 1970s, changing spatial patterns of investment are the major factor behind the between-region inequality. However, other forces at times counteract this tendency. Among these are the investments in education in the prereform period, the effect of which began to show up in the late 1970s, and industrial restructuring in the 1980s. Their impact, however, is modest in comparison with the contribution of capital. The sharp increase in overall interprovincial inequality in the early 1990s is largely due to the increase in between-region contribution of physical capital.

Nevertheless, there is more to interprovincial inequality than the coastal-inland dichotomy. As shown in Figure 3, there is a sustained decline in the within-region inequality. Careful scrutiny suggests that the fluctuation of provinces within the coastal region can, at times, be the dominant force behind the trajectory of overall interprovincial inequality. Worthy of particular mention is the industrial restructuring among the coastal provinces that triggers a fall in interprovincial inequality in the 1980s. The emerging new growth poles in the eastern region have capitalized on the development of non-state industrial enterprises (e.g., township and village enterprises) and the open-door policy. In sharp contrast is the decline in the old industrial centres (especially those in the northeast) as their moribund state-owned enterprises failed to meet the competition brought about by market reform. The above transformation translates into a decline in overall interprovincial inequality in the 1980s, with the within-region contribution of industrial restructuring exhibiting a downward trend.

Last but not least, the effect of schooling on China's interprovincial inequality is discussed much less, although human capital is often in the limelight in connection with economic growth. Notwithstanding the political calamities communism inflicted on the people, there is no denying that much had been done before 1978 in spreading education to the less developed provinces. Some scholars, e.g., Bramall (2000), have even gone so far as to argue that the prereform investment in education laid the foundation for the spectacular growth of the reform era. This paper is a preliminary attempt to incorporate this issue into the analysis of interprovincial inequalities, though much remains to be done to improve the measure of schooling. The empirical results suggest that contribution of schooling first increases and then reduces interprovincial inequality. In so far as school-aged children in less developed provinces entered the labourforce in the 1970s only gradually, our interpretation is that the inequality-reducing effect of schooling is a consequence of the prereform expansion of basic education. The contribution of quality-adjusted labour to growth is, however, small relative to capital and TFP.

This paper attempts to extend the research on China's regional inequality first by resorting to a more careful use of China's data and then introducing a framework that enhances our understanding of the forces behind the changes in the country's interprovincial inequality. In particular, quantitative estimates of the contributions of factors affecting inequality are presented. Much, however, remains to be done. The experimentation with adjusting official data leaves room for improvement. Nor is our method of adjustment the only one conceivable. For example, Young (2000) tackles the problem by first coming up with deflators for different sectors of the national economy, an approach that may be applied to provincial data. Another potential extension of our study is to experiment with different ways to construct provincial indices for human capital, a subject too complex to be elaborated in this paper.[19] Finally, our study of the factors behind TFP growth is crude and tentative. There are certainly other important

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19 The Appendix has a discussion on the derivation of provincial average years of schooling. In this paper, we have mainly used age-specific data from censuses to estimate the average years of schooling of the labourforce for each province. Another way is to integrate census figures with the annual enrolment data.

variables in the equation. Among them are the effects of interprovincial migration, local protectionism and improvement in transportation network, etc. All these extensions may be topics for future research.

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Appendix A

A1 Real provincial GDP

The nominal GDP for the period 1952 to 1998 are from NBS (2001a). Data for 1999 are collected from the provincial yearbooks.[20] Care has been exercised in ensuring that the 1999 data are consistent with those of previous years because provincial statistical bureaux periodically update the GDP figures. In case of a province update on its GDP series, we use the new series (this involves very few cases). Details are available on request.

To deflate the provincial GDP, we experiment with different methods (recall Figure 1). Official real growth rates are available in NBS (1997). Provincial yearbooks may be used to deflate nominal GDP. However, as pointed earlier, many China experts suspect that official data underestimate inflation in the reform period. This paper follows the suggestion of Keidel (2001) by deflating the different categories of expenditure by their respective price indices. Specifically:

$$Y_{gm} = CR_{,gm} + CU_{gm} + CG_{,gm} + CF_{gm} + NX_{gm}$$

where the subscript *gm* refers to the *m*th province in the *g*th region, Y_{gm} = GDP CR_{gm} = rural consumption, CU_{gm} = urban consumption, CG_{gm} = government consumption, CF_{gm} = capital formation and NX_{gm} = net export. The data are from NBS (2001).[21] These expenditure components can be found in NBS (2001). For the period from the mid 1980s onwards, provincial rural and urban CPIs are used to deflate CR_{gm} and CU_{gm}, respectively, because better alternatives are hard to come by. Provincial CPI indices are used to deflate CG_{gm}. For the preceding period, only provincial cost-of-living indices for staff and workers are available for deflating CU_{gm} (NBS 2001). We have no choice but to resort to provincial retail price indices (RPIs). Theoretically, the biases with this expediency are twofold. First, changes in the prices of services are not taken into account. Second, RPIs reflect changes in both rural and urban prices. However, casual comparisons of RPIs and CPIs for a few provinces when both indices are available seem to suggest that their movements are very similar for the prereform period (with the possible exception of the years surrounding the 'great leap forward'). This, in fact, is not surprising because the shares of urban and rural expenditures on services might be relatively insignificant. In any case, prices were administratively fixed and rarely changed.

Ideally, provincial capital formation should be deflated using price indices for capital goods. This is the case when provincial price indices for fixed asset investment are available for the period from 1992 to 1999. For the period 1985-91, the price indices for

20 Another source of national income data is from NSB (1997). However, the data cover the period until 1995. A crosscheck of our data with this source of data shows that they are approximately the same.

21 Jiangxi and Guangdong do not have data for the prereform period. However, information is available for these provinces on consumption (*xiaofei*) and accumulation (*jilei*) under the socialist material product system (MPS); see NBS (1987). To derive deflators for these provinces, the best option is to deflate consumption and accumulation as defined in the MPS by their respective price indices. The national implicit deflator for capital formation is used to deflate accumulation. The implicit deflators so derived are then used to deflate the prereform GDP series for these two provinces. Details are available on request (NSB 2001a).

capital goods recently released by NBS (2001b) are used to estimate the price indices for construction (*jianzhu anzhuang*) and equipment (*shebi*). Then, we derive an overall price index for capital investment by weighting the indices for construction and equipment (*shebi*) by their respective shares in total investment.[22] From 1964 to 1984, owing to data limitations, two sets of deflators are used for the period until the mid 1980s. One set involves using official implicit deflators for capital formation without adjustments.[23] Using the official implicit deflators for gross capital formation, we can derive provincial real GDP per capita series that are used to estimate EN3 in Figure 1. Another set includes adjusted official implicit deflators for capital formation that takes into account data anomalies. Specifically, there are some years when the implicit rates of changes in the prices of capital goods are incredibly high even though the prereform era is known to be a period of price stability. Our rule of thumb is to replace price increase rates exceeding 20 per cent with the national rates for the same year. For the years around the 'great leap forward' that were affected by high price increases, we refrain from such adjustments. The use of these adjusted deflators corresponds to EN2 in Figure 1.

Finally, provincial RPIs are used to deflate net exports.

A2 Real capital stock

The main difficulty with the estimation of provincial physical capital stock is to derive at the initial capital stock for each of the provinces. We follow the procedure proposed by Nehru and Dhareshwar (1993). If, as a first approximation, the capital-output ratio is constant, then it can easily be shown that $K_{gm,t-1} = FA_{gmt}/(g+\delta)$, where K is capital stock, FA_{gmt} is *real* fixed asset investment, δ is the depreciation rate and g is the output growth rate. We assume that $\delta = 0.05$. To smooth out fluctuations, a three-year average growth rate (the three years being 1953, 1954 and 1955), and the corresponding three-year average investment level are used to estimate the 1954 capital stock. Then, the capital stock figures for 1953 and 1952 can be derived recursively. To arrive at the real provincial capital stock series, the perpetual inventory approach is used:

$$K_{gmt} = (1 - \delta)K_{gm,\, t-1} + FA_{gmt}.$$

To arrive at the real fixed asset investment, the nominal data used are those of capital formation in fixed assets (*guding zichan xingcheng zonge*) from NBS (2001). The same method for the deflation of capital formation (see above) is also applied to arrive at FA_{gmt}. Since the sample period of our econometric estimation is 1964-99, whatever biases are embedded in the initial capital stocks are hopefully ameliorated after twelve years.

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22 The publication consists of *national* price indices for specific capital goods classified under construction and equipment. For each category, we take the average of the price increases of the specific capital goods to arrive at the price indices for construction and equipment, respectively. To arrive at the province-specific indices, the two indices are weighted by the respective shares of construction and equipment in total fixed asset investment.

23 Prereform provincial real growth rates are from NBS (1997).

Prereform data on fixed-asset capital formation are not available for Guangdong and Jiangxi. We use an admittedly crude method to estimate the prereform data utilizing the fixed-asset accumulation figures under the socialist material product system from NSB (1987). First, ratios of fixed-asset capital formation under the current national accounting system (i.e., SNA) and fixed-asset accumulation under MPS are derived for the period 1978-85. The averages of these ratios are then applied to the fixed-asset accumulation data for the prereform period to arrive at estimates of fixed-asset capital formation under SNA.

A3 Quality-adjusted labourforce

Quality-adjusted provincial labourforce is the product of the labourforce (*congye renyuan*) multiplied by the average year of schooling. Provincial labourforce statistics are found in NSB (1999) and provincial yearbooks. For a few provinces where data are missing for a few years, estimates for those years are derived by using linear extrapolations. Details are available on request. One problem with the labourforce statistics is that workers on leave (*xiagang*) were included before 1998. The problem of *xiagang* began in the early 1990s and reached a peak in the late 1990s. Provincial *xiagang* figures can be obtained from various issues of NBS's Department of Population, Social and Technological Statistics. *Xiagang* workers were subtracted from total labourforce for the post-1994 period based on the assumption that these figures are relatively small before 1994.

To arrive at provincial estimates of years of schooling, we utilize information from the 1982, 1990 and 2000 censuses on the working-aged population with different levels of education, viz., primary (*xiaoxue*), junior high (*chuzhong*), senior high (*gaozhong*) and university (*daxue*). For any period between two censuses, age-specific population for a given level of education is projected forward using the survival rate of that age group. For example, let $x(a, e, T)$ be the population at age a with the eth level of education derived from the population census in year T (e.g., 1982) for a given province (to ease exposition, subscripts for provinces are omitted). In theory, the population at age a+1 in year T+1 with the eth level of education is:

$$x(a+1, e, T+1) = x(a, e, T)\times s(a,T) + d(a+1, T+1),$$

where $s(a,T)$ is the rate of those surviving in T+1 and $d(a+1, T+1)$ is the volume of net migration between T and T+1. Then, the following recursive formula can be used to

$$x(a+k, e, T+k) = x(a+k-1, e, T+k-1)\times s(a, T+k-1) + d(a+k, t+k), \qquad \text{(A1)}$$

Survival rates from provincial life tables, $\hat{s}(a)$, can be used to approximate $s(a,t)$.[24] Annual information on age-specific net migration data is, however, hard to obtain. Thus, we have made use of the figures from two consecutive censuses to arrive at the total volume of net migration for each age group for the intervening period as a whole. Then, the total volume of net migration is evenly distributed among the intervening years. To be precise, we first assume that $d(a+k, t) = d(a)$ for the period between the census in year T

24 $\hat{s}(a)$ is equal to $L(a+1)/L(a)$, where $L(a)$ is the population surviving to age a in a life table.

and the next census K year from T. Then, using the recursive formula above, the estimate of $x(a+K, e, T+K)$, denoted by $\hat{x}$ $(a+K, e, T+K, d(a))$, is an unknown function of $d(a)$. In theory, if our assumption that $d(a+k, t)$ is equal to $d(a)$ were correct, then $x(a+K, e, t+K) = \hat{x}(a+K, e, T+K, d(a))$. Since $x(a+K, e, t+K)$ is a figure that may be derived from the census in $T+K$, we can solve the equation for some *implicit* net migration figure $\hat{d}(a)$, which can be substituted into (A1) to arrive at estimates of $x(a+k, e, t+k)$ between the two censuses:

$$\hat{x}(a+k, e, t+k) = x(a, e, t) \times \hat{s}(a) + \hat{d}(a).$$

The above method is used to arrive at the estimates for different education levels for the period after 1982 making use of data from the 1982, 1990 and 2000 censuses. The number of years of schooling for the working-aged population is then equal to:

$$\hat{X}(t+k) = \sum_e \sum_{a=15}^{60} w_e \hat{x}(a+k, e, t+k),\ k = 0,1,\ldots,K, \quad \text{(A2)}$$

where w_e is the number of years of schooling for the eth level of education. The years for primary, junior high, senior high and university education are 6, 9, 12 and 16, respectively.

For the period before 1982, age-specific data required for implementing the above method are not available.[25] To arrive at estimates before 1982, $x(a, e, t)$ may, in theory, be projected recursively backward, i.e.:

$$\hat{x}(a\text{-}k, e, 1982\text{-}k)$$

$$= [\hat{x}(a\text{-}k+1, 1982\text{-}k+1) - d(a\text{-}k+1, 1982\text{-}k+1)]/\hat{s}(a\text{-}k)$$

$$= f(a,e, k, 1982) - g(a,k)$$

where

$$f(a,e, k, 1982) = x(a, e, 1982)/\left(\prod_{j=1}^{k} \hat{s}(a-j)\right),\ g(a,k) = \left(\sum_{j=0}^{k-1} \frac{d(a-j)}{\prod_{i=j}^{k-1} \hat{s}(a-i)}\right)$$

$f(a,e, k, 1982)$ may be derived using the 1982 census data and survival rates from life tables. The figures for each level of education are then multiplied by their respective years of schooling, w_e, to arrive at the total years of schooling before deducting the second term, i.e., $F(k,1982) = \sum_e \sum_{a=15}^{60} w_e f(a,e,k,1982)$.

However, information again on $d(a)$ is not available. There are only provincial figures on the total volume of net migration, denoted by $m(t)$, each year. We apply a rule to apportion the total to different levels of education. First, we decompose net migration in year t, $m(t)$, into different education levels. We assume that the share of net migration with working ages is equal to the share of the labourforce of the population of the

25 The census prior to 1982 was undertaken in 1964. However, age-specific figures by education levels are not available.

province in question, denoted by $r(t)$. Next, we assume that the share of migrants with the eth level of education is the same as that of the share of $f(a,e, k, 1982)$ in the workforce, denoted by s_e. Then, $r(t)m(t)s_e$ is the component of $m(t)$ with the eth level of education. Finally the total number of years of schooling with respect to net migration is $\sum_e w_e r(t)m(t)s_e$. This term is then subtracted from $F(k,1982)$ to arrive at the total number of years of schooling $\hat{X}(1982-k)$. This method is applied to recover the total number of years of schooling only up to 1964. One reason is that the 'great leap forward' had a great impact on population figures and large margins of errors may result if $\hat{X}(t)$ is projected back into the 1950s. Second, frequent changes in provincial boundaries and large-scale population migration in the 1950s may further reduce the accuracy of the estimation.

There are, no doubt, weak spots in constructing $\hat{X}(t)$, t = 1964, …, 1999, using the method delineated above. However, given the data available, this is the best we can do. There is much room for further fine-tuning of the method and experimenting with other methods (e.g., using enrolment data). To arrive at the average years of schooling S, $\hat{X}(t)$ is divided by the working-aged population (estimated based on census data)

A4 Population

Population data used to derive provincial GDP per capita, especially figures based on household registration in the reform era, are not without problems because of the failure to take proper account of inward or outward migration. In so far as the data problems created by migration are not so serious for the prereform period, the official population figures from NBS (1999) and from provincial yearbooks are used. From 1982 onwards, we extrapolate population figures made up of age-specific data from the 1982, 1990 and 2000 population censuses. Essentially, we have age-specific populations for all the provinces from the 1982, 1990 and 2000 censuses. Using the survival rates from the provincial life tables, we project the age-specific population groups forward from one census to the next. The difference between the projected and actual figures of the next census is assumed to be due to net migration. Such differences are allocated evenly to the inter-census years as in the case of schooling.[26]

[26] Details available on request.

Appendix B

This appendix illustrates how the equations in the text are derived. The population-weighted version of Theil's entropy measure is as follows:

$$I(\mathbf{y}) = \sum_{g=1}^{G}\sum_{m=1}^{M_g} f_{gm} \ln\left(\frac{\bar{y}}{y_{gm}}\right) = \ln(\bar{y}) - \sum_{g=1}^{G}\sum_{m=1}^{M_g} f_{gm} y_{gm} \quad \text{(B1)}$$

where $\bar{y} = \sum_{g=1}^{G} \sum_{m=1}^{M_g} f_{gm}\, y_{gm}$.

Differentiate Equation (B1):

$$\frac{dI}{dt} = \frac{\dot{\bar{y}}}{\bar{y}} - \sum_{g=1}^{G} \sum_{m=1}^{M_g} \left(f_{gm} \frac{\dot{y}_{gm}}{y_{gm}} + \dot{f}_{gm} \ln(y_{gm}) \right) \quad \text{(B2)}$$

where, for any variable *x*, $\dot{x}$ = *dx/dt.* It is to be noted that:

$$\frac{\dot{\bar{y}}}{\bar{y}} = \sum_{g}^{G} \sum_{m}^{M_g} \left(\frac{\dot{f}_{gm} y_{gm} + f_{gm} \dot{y}_{gm}}{\bar{y}} \right) = \sum_{g}^{G} \sum_{m}^{M_g} \left(\frac{f_{gm} y_{gm}}{\bar{y}} \frac{\dot{f}_{gm} y_{gm} + f_{gm} \dot{y}_{gm}}{f_{gm} y_{gm}} \right) \quad \text{(B3)}$$

Since

$$s_{gm} = \frac{f_{gm} y_{gm}}{\bar{y}} = \frac{P f_{gm} y_{gm}}{P \bar{y}},$$

P being the total population. It follows that the term is equal the share of GDP accruing to the *m* province in the *g*th region. Thus Equation (B3) becomes:

$$\frac{\dot{\bar{y}}}{\bar{y}} = \sum_{g}^{G} \sum_{m}^{M_g} \left(\frac{f_{gm} y_{gm}}{\bar{y}} \frac{\dot{f}_{gm} y_{gm} + f_{gm} \dot{y}_{gm}}{f_{gm} y_{gm}} \right) = \sum_{g}^{G} \sum_{m}^{M_g} s_{gm} \left(\frac{\dot{f}_{gm}}{f_{gm}} + \frac{\dot{y}_{gm}}{y_{gm}} \right)$$

Thus, Equation (B2) becomes:

$$\frac{dI}{dt} = \sum_{g}^{G} \sum_{m}^{M_g} s_{gm} \left(\frac{\dot{f}_{gm}}{f_{gm}} + \frac{\dot{y}_{gm}}{y_{gm}} \right) - \sum_{g=1}^{G} \sum_{m=1}^{M_g} \left(f_{gm} \frac{\dot{y}_{gm}}{y_{gm}} + \dot{f}_{gm} \ln(y_{gm}) \right)$$

Regrouping the terms:

$$\frac{dI}{dt} = \sum_{g}^{G} \sum_{m}^{M_g} \left((s_{gm} - f_{gm}) \frac{\dot{y}_{gm}}{y_{gm}} \right) - \sum_{g=1}^{G} \sum_{m=1}^{M_g} \left((s_{gm} - f_{gm} \ln(y_{gm})) \frac{\dot{f}_{gm}}{f_{gm}} \right).$$

Since

$$\dot{y}_{gm} / y_{gm} = (\dot{Y}_{gm} / Y_{gm}) - (\dot{P}_{gm} / P_{gm}) \text{ and} \quad \text{(B4)}$$

$$\frac{\dot{Y}_{gm}}{Y_{gm}} = \frac{\dot{A}_{gm}}{A_{gm}} + \left(\frac{\partial F_{gm} / \partial K_{gm}}{Y_{gm}}\right)\frac{\dot{K}_{gm}}{K_{gm}} + \left(\frac{\partial F_{gm} / \partial L_{gm}}{Y_{gm}}\right)\frac{\dot{L}_{gm}}{L_{gm}} \tag{B5}$$

dI/dt may easily be rewritten as Equation (7) in the text.

The within-region component is

$$WG(\mathbf{y}) = \sum_g^G f_g I(\mathbf{y}_g)\,,\ f_g = \sum_m^{M_g} f_{gm}$$

$$\frac{WG(\mathbf{y})}{dt} = \sum_g^G \left(f_g \frac{dI_g}{dt} + I_g \dot{f}_g \right),\ I_g = I(\mathbf{y}_g).$$

Using the results above:

$$\frac{dI_g}{dt} = \sum_m^{M_g} \left[(\hat{s}_{gm} - \hat{f}_{gm}) \frac{\dot{y}_{gm}}{y_{gm}} \right] + \sum_m^{M_g} \left[(\hat{s}_{gm} - \hat{f}_{gm} \ln(y_{gm})) \frac{\dot{\hat{f}}_{gm}}{\hat{f}_{gm}} \right].$$

where the notation is the same as in the text. Thus,

$$\frac{WG(\mathbf{y})}{dt} = \sum_g f_g \sum_m \left[(\hat{s}_{gm} - \hat{f}_{gm}) \frac{\dot{y}_{gm}}{y_{gm}} \right] + \sum_g \left\{ I_g \dot{f}_g + f_g \sum_m \left[(\hat{s}_{gm} - \hat{f}_{gm}) \ln(y_{gm}) \frac{\dot{\hat{f}}_{gm}}{\hat{f}_{gm}} \right] \right\}$$

$$= \sum_g f_g \sum_m \left[(\hat{s}_{gm} - \hat{f}_{gm}) \frac{\dot{y}_{gm}}{y_{gm}} \right] + \sum_g f_g \left\{ I_g \frac{\dot{f}_g}{f_g} + \sum_m \left[(\hat{s}_{gm} - \hat{f}_{gm}) \ln(y_{gm}) \frac{\dot{\hat{f}}_{gm}}{\hat{f}_{gm}} \right] \right\}$$

Again, using (B4) and (B5), the above expression is reduced to Equation (9).

The between-region component is:

$$BG(\mathbf{y}) = \sum_g^G f_g (\ln(\bar{y}) - \ln(\bar{y}_g)).$$

Thus,

$$\frac{BG(\mathbf{y})}{dt} = \sum_g^G \left[f_g \left(\frac{\dot{\bar{y}}}{\bar{y}} - \frac{\dot{\bar{y}}_g}{\bar{y}_g} \right) + \dot{f}_g (\ln(\bar{y}) - \ln(\bar{y}_g)) \right]$$

$$= \frac{\dot{\bar{y}}}{\bar{y}} - \sum_g^G f_g \frac{\dot{\bar{y}}_g}{\bar{y}_g} + \left(\sum_g^G \dot{f}_g (\ln(\bar{y}) - \ln(\bar{y}_g)) \right)$$

$$= \frac{\dot{\bar{y}}}{\bar{y}} - \sum_g^G f_g \frac{\dot{\bar{y}}_g}{\bar{y}_g} + \left(\sum_g^G \dot{f}_g \ln(\bar{y}_g) \right),$$

where $\sum_g^G \dot{f}_g = 0$.

Since

$$\frac{\dot{\bar{y}}_g}{\bar{y}_g} = \sum_m^{M_g} \hat{s}_{gm}\left(\frac{\dot{\hat{f}}_{gm}}{\hat{f}_{gm}} + \frac{\dot{y}_{gm}}{y_{gm}}\right)$$

$$\frac{BG(\mathbf{y})}{dt} = \sum_g^G \sum_m^{M_g} s_{gm}\left(\frac{\dot{f}_{gm}}{f_{gm}} + \frac{\dot{y}_{gm}}{y_{gm}}\right) - \sum_g^G f_g \sum_m^{M_g} \hat{s}_{gm}\left(\frac{\dot{\hat{f}}_{gm}}{\hat{f}_{gm}} + \frac{\dot{y}_{gm}}{y_{gm}}\right) - \left(\sum_g^G \dot{f}_g \ln(\bar{y}_g)\right)$$

$$= \sum_g^G \sum_m^{M_g}\left[(s_{gm} - f_g \hat{s}_{gm})\frac{\dot{y}_{gm}}{y_{gm}}\right] + \sum_g^G \left\{\sum_m^{M_g}\left[s_{gm}\frac{\dot{f}_{gm}}{f_{gm}} - f_g \hat{s}_{gm}\frac{\dot{\hat{f}}_{gm}}{\hat{f}_{gm}}\right] - \dot{f}_g \ln(\bar{y}_g)\right\}$$

where the notation as the same as in the text. Using (B4) and (B5), the above expression is reduced to Equation 10.