

**LABOR PRODUCTIVITY DIFFERENCE IN CHINA 1987-1997:
AN INTERREGIONAL DECOMPOSITION ANALYSIS**

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ABSTRACT: The literature on regional disparities in China is both broad and deep. Nonetheless much of its focus has been on the effects of trade liberalization and national policies toward investment in interior provinces. Few pieces have examined whether the disparities might simply be due to differences in industry mix, final demand, or even interregional trade. Using the only two newly published multiregional input-output tables and disaggregated employment data, we decompose change in labor productivity growth for seven regions of China between 1987 and 1997 into five partial effects—changes in value added coefficients, direct labor requirements, aggregate production mix, interregional trade, and final demand. Subsequently we summarize the contributions to labor productivity of the different factors at the regional level. In this way, we present a new perspective for recent causes of China's interregional disparity in GDP per capita.

Keywords: Decomposition, input-output analysis, productivity, regional disparity, China

JEL classification: C67, O40, R15

1. INTRODUCTION

As GDP has soared, interregional income disparity has become a major policy challenge in China due to increasing concerns about social stability (Démurger, 2001). From 1952 to 2007, China's GDP grew at an annual average rate of nearly 8.0 percent and even more rapidly during the last three decades—9.7 percent annually from 1978 to 2007. Along with the rapid growth, China's regional disparity reflected in labor productivity also attracts much attention. On the east coast, Shanghai's 2007 labor productivity was 139,049 RMB per worker—more than ten times that of Guizhou province, which lies far to the west and had annual productivity in 2007 of 12,010RMB per worker.¹

Some of the regional disparity seems to be a result of national economic reforms implemented since 1978. Preferential policies for coastal provinces were an initial element of the reformation programs designed to jump start China's trade with the world. During the 1980s, Shenzhen, Zhuhai, Shantou, Xiamen cities and Hainan province were designated special economic zones. Dalian, Guangzhou, Shanghai and altogether 14 other cities were designated open coastal cities. The policies were given in the form of tax abatements, infrastructure projects, and preferential foreign exchange. The overall preferential policy regime was designed to attract foreign investment and business—to develop these places as “growth poles” for China's economy. Whether or not these policies actually caused the subsequent growth remains unclear, but particularly strong growth ensued in the coastal economies nonetheless.

Of course, the strong growth also exacerbated pre-existing regional income disparities. In response to the deepening interregional income disparities, China's national government has since proposed a number of specially designed development strategies tailored to each region's history, culture, and economic conditions. In 1999, for example, the government proposed the West Development Strategy to increase capital availability in its westernmost provinces with a special interest in enhancing opportunities for foreign trade for these provinces: it included measures to improve the financial environment for infrastructure, human capital, and technology production. In 2002, China proposed a policy labeled “Revitalization of the Traditional Industrial

¹ Calculated using data from *2008 China Statistical Yearbook*.

Bases” for Northeast China. It emphasized institutional innovation in a region that was a national leader prior to the reforms, and hence, focused on restructuring state-owned enterprises, upgrading industry structure and promoting modern tertiary industry, creating jobs for the unemployed and providing social security, promoting sustainable development of resource-based cities, developing modern agriculture and so on. In 2004 Central China Rising was proposed. The policies were a mix designed to reinvigorate the region’s traditional industrial base (and hence largely followed those for the Northeast) and to get Central China’s less-developed areas better aligned with nation’s overall goal of being more engaged in international trade (and, thus also included polices applied to the West). The policies were supposed to help improve productivity in the nation’s bread basket, energy resource base, and equipment manufacturing centers: it was also hoped to expand high-tech industry into Central China.

It remains unclear exactly what set of dynamics instigated China’s large interregional productivity inequality gaps prior to enactment of the afore-mentioned policy regime of the current century. Literature investigating the causes of interregional disparity in China has cited many possibilities. Those cited have been differences in infrastructure development like transportation and telecommunications networks (Démurger, 2001); the source, size and sectoral allocation of fixed investment (Wei, 2000); the speed in the adoption of new technology, level of human capital stock (Liu and Li 2006), the accessibility to foreign direct investment and international trade (Sun and Parikh, 2001, Wei and Wu, 2001); labor market distortions like the Hukou system, which impedes labor mobility from rural to urban (Cai et al., 2002); and province-specific public policy strategies (Lin and Liu, 2008; Kanbur and Zhang, 2005; Démurger et al., 2002a,b; Yang, 2002). But none of these seems to account for more than a small measure of the interregional differences.

Few pieces have examined whether the disparities and any convergence across them might simply be due to differences and changes in industry mix, in interregional trade, or even in the composition of final demand. Li and Haynes (2008) use the shift-share method to analyze China’s regional disparity at province level from an industry structure point of view. Still, the fact that China’s industries are interdependent as expressed in input-output (I-O) parlance remains nearly completely overlooked. As a result, we take a

different tack in our analysis of Chinese interregional productivity; we use the country's 1987 and 1997 multiregional input-output (MRIO) tables with seven regions, disaggregated employment data, and a decomposition approach introduced by Dietzenbacher et al. (2000). This approach decomposes productivity into five partial effects—changes in value added coefficients, direct labor requirements, aggregate production mix, technology change, interregional trade, and final demand. Subsequently we summarize the contributions to labor productivity of the different factors at the regional level.

The paper is organized as follows. Section 2 outlines our research approach. Section 3 is a general description of data used in this paper. In Section 4, we analyze the results of our decomposition. A final section concludes the paper.

2. RESEARCH APPROACH

There are many ways to examine the likely causes of productivity change. We are particularly interested in finding out the many ways that China's economic reforms affected interregional income disparity. Was technological change a major player? How about changes in interregional trade? Perhaps the disparity was enhanced by the degree to which different sectors managed to discover ways outside of technological change to save on labor costs. How much did margin reducing pressures of interregional trade affect per capita GDP across regions? Were most of the disparities introduced via manufacturing, which is what is largely traded, or did other sectors play a role? After considering the sorts of issues we were interested in answering, it became that the multiplicative decomposition method introduced by Dietzenbacher et al. (2000) was best.

The following presents Dietzenbacher et al.'s (2000) approach, as we adopted it.² Let N be the number of industries in each region and C be the number of regions. The other definitions are as follows:

v : aggregate value added (scalar);

l : aggregate labor inputs (scalar);

π : aggregate labor productivity (v/l) (scalar);

² Dietzenbacher et al. (2000) used six factors—one more than we did. This is because they had the luxury of using data showing how interregional trade was used to meet final demand. One of the Chinese MRIO tables does not permit such an analysis. In addition, the same Chinese MRIO table lacks details on the disposition of final demand.

A: matrix with input coefficients ($NC \times NC$ matrix), with typical element α_{ij}^{rs} denoting the input of product i from region r per unit of output in industry j in region s ;

L: Leontief-inverse ($NC \times NC$ matrix), $\mathbf{L} \equiv (\mathbf{I} - \mathbf{A})^{-1}$;

x: vector with χ_i^r denotes the gross output level of industry i in region r ($NC \times 1$ vector);

f: vector with element f_i^r denotes the final demand for output of industry i in region r ($NC \times 1$ vector), which include consumption, gross fixed capital formation, changes in inventories, export and import;

λ: vector with elements λ_i^r giving the use of labor per unit of gross output in industry i in region r ($NC \times 1$ vector);

μ: vector with elements μ_i^r giving the value added per unit of gross output in industry i in region r ($NC \times 1$ vector);

A*: matrix constructed by stacking C identical $N \times NC$ matrices of aggregate intermediate inputs per unit of gross output by industry by region ($NC \times NC$ matrix),

$$\forall r : [\alpha^*]_{ij}^{rs} = \sum_{r=1}^C \alpha_{ij}^{rs} ;$$

T^A: matrix of intermediate trade coefficients, representing the shares of each region in aggregate inputs, by input by industry by region ($NC \times NC$

matrix), $[t^A]_{ij}^{rs} = \frac{\alpha_{ij}^{rs}}{[\alpha^*]_{ij}^{rs}}$, note that $\sum_r [t^A]_{ij}^{rs} = 1$;

It follows that

$$v = \boldsymbol{\mu}' \mathbf{x} \text{ and } l = \boldsymbol{\lambda}' \mathbf{x}$$

$$\mathbf{x} = \mathbf{Ax} + \mathbf{f} = (\mathbf{I} - \mathbf{A})^{-1} \mathbf{f} = \mathbf{Lf},$$

and, thus

$$v = \boldsymbol{\mu}' \mathbf{Lf} \text{ and } l = \boldsymbol{\lambda}' \mathbf{Lf}$$

in which primes indicating transposed vectors. The aggregate labor productivity change can be written as:

$$\frac{\pi_1}{\pi_0} = \frac{v_1}{v_0} \div \frac{l_1}{l_0} = \frac{\boldsymbol{\mu}'_1 \mathbf{L}_1 \mathbf{f}_1}{\boldsymbol{\mu}'_0 \mathbf{L}_0 \mathbf{f}_0} \div \frac{\boldsymbol{\lambda}'_1 \mathbf{L}_1 \mathbf{f}_1}{\boldsymbol{\lambda}'_0 \mathbf{L}_0 \mathbf{f}_0}$$

$$= \left(\frac{\mu'_1 \mathbf{L}_1 \mathbf{f}_1}{\mu'_0 \mathbf{L}_1 \mathbf{f}_1} \right) \left(\frac{\lambda'_0 \mathbf{L}_1 \mathbf{f}_1}{\lambda'_1 \mathbf{L}_1 \mathbf{f}_1} \right) \left(\frac{\mu'_0 \mathbf{L}_1 \mathbf{f}_1}{\mu'_0 \mathbf{L}_0 \mathbf{f}_1} \times \frac{\lambda'_0 \mathbf{L}_0 \mathbf{f}_1}{\lambda'_0 \mathbf{L}_1 \mathbf{f}_1} \right) \left(\frac{\mu'_0 \mathbf{L}_0 \mathbf{f}_1}{\mu'_0 \mathbf{L}_0 \mathbf{f}_0} \times \frac{\lambda'_0 \mathbf{L}_0 \mathbf{f}_0}{\lambda'_0 \mathbf{L}_0 \mathbf{f}_1} \right)$$

By using $L = (\mathbf{I} - \mathbf{A}^* \circ \mathbf{T}^A)^{-1}$ (\circ represents elementwise multiplication), we can get the final decomposition of labor productivity change:

$$(1) \quad \frac{\pi_1}{\pi_0} = (1.1) \times (1.2) \times (1.3) \times (1.4) \times (1.5)$$

with

$$(1.1) = \left(\frac{\mu'_1 \mathbf{L}_1 \mathbf{f}_1}{\mu'_0 \mathbf{L}_1 \mathbf{f}_1} \right)$$

$$(1.2) = \left(\frac{\lambda'_0 \mathbf{L}_1 \mathbf{f}_1}{\lambda'_1 \mathbf{L}_1 \mathbf{f}_1} \right)$$

$$(1.3) = \left\{ \frac{\mu'_0 [\mathbf{I} - (\mathbf{A}_1^* \circ \mathbf{T}_1^A)]^{-1} \mathbf{f}_1}{\mu'_0 [\mathbf{I} - (\mathbf{A}_0^* \circ \mathbf{T}_1^A)]^{-1} \mathbf{f}_1} \times \frac{\lambda'_0 [\mathbf{I} - (\mathbf{A}_0^* \circ \mathbf{T}_1^A)]^{-1} \mathbf{f}_1}{\lambda'_0 [\mathbf{I} - (\mathbf{A}_1^* \circ \mathbf{T}_1^A)]^{-1} \mathbf{f}_1} \right\}$$

$$(1.4) = \left\{ \frac{\mu'_0 [\mathbf{I} - (\mathbf{A}_0^* \circ \mathbf{T}_1^A)]^{-1} \mathbf{f}_1}{\mu'_0 [\mathbf{I} - (\mathbf{A}_0^* \circ \mathbf{T}_0^A)]^{-1} \mathbf{f}_1} \times \frac{\lambda'_0 [\mathbf{I} - (\mathbf{A}_0^* \circ \mathbf{T}_0^A)]^{-1} \mathbf{f}_1}{\lambda'_0 [\mathbf{I} - (\mathbf{A}_0^* \circ \mathbf{T}_1^A)]^{-1} \mathbf{f}_1} \right\}$$

$$(1.5) = \left(\frac{\mu'_0 \mathbf{L}_0 \mathbf{f}_1 \times \lambda'_0 \mathbf{L}_0 \mathbf{f}_0}{\mu'_0 \mathbf{L}_0 \mathbf{f}_0 \quad \lambda'_0 \mathbf{L}_0 \mathbf{f}_1} \right)$$

in which indices are time indicators, $\mathbf{0}$ denoting 1987 and $\mathbf{1}$ denoting 1997.

Equation (1.1) represents the productivity effects of changes in the value added figures per unit of gross output by industry; Equation (1.2) represents the effects of changed labor requirement per unit of gross output by industry; Equation (1.3) represents the effects of changes in the interindustry structure (due to technological change, factor substitution, changing output compositions within industries, etc.); Equation (1.4) is the productivity effects of changed structures with respect to commodities and services used as intermediate inputs; Equation (1.5) is the effects of changes in the final demand.

There is an obvious index-number problem here, so the other polar decomposition is expressed as follows:

$$(2) \quad \frac{\pi_1}{\pi_0} = (2.1) \times (2.2) \times (2.3) \times (2.4) \times (2.5)$$

with

$$(2.1) = \begin{pmatrix} \boldsymbol{\mu}'_1 \mathbf{L}_0 \mathbf{f}_0 \\ \boldsymbol{\mu}'_0 \mathbf{L}_0 \mathbf{f}_0 \end{pmatrix}$$

$$(2.2) = \begin{pmatrix} \boldsymbol{\lambda}'_0 \mathbf{L}_0 \mathbf{f}_0 \\ \boldsymbol{\lambda}'_1 \mathbf{L}_0 \mathbf{f}_0 \end{pmatrix}$$

$$(2.3) = \left\{ \frac{\boldsymbol{\mu}'_1 [\mathbf{I} - (\mathbf{A}_1^* \circ \mathbf{T}_0^A)]^{-1} \mathbf{f}_0}{\boldsymbol{\mu}'_1 [\mathbf{I} - (\mathbf{A}_0^* \circ \mathbf{T}_0^A)]^{-1} \mathbf{f}_0} \times \frac{\boldsymbol{\lambda}'_1 [\mathbf{I} - (\mathbf{A}_0^* \circ \mathbf{T}_0^A)]^{-1} \mathbf{f}_0}{\boldsymbol{\lambda}'_1 [\mathbf{I} - (\mathbf{A}_1^* \circ \mathbf{T}_0^A)]^{-1} \mathbf{f}_0} \right\}$$

$$(2.4) = \left\{ \frac{\boldsymbol{\mu}'_1 [\mathbf{I} - (\mathbf{A}_1^* \circ \mathbf{T}_1^A)]^{-1} \mathbf{f}_0}{\boldsymbol{\mu}'_1 [\mathbf{I} - (\mathbf{A}_1^* \circ \mathbf{T}_0^A)]^{-1} \mathbf{f}_0} \times \frac{\boldsymbol{\lambda}'_1 [\mathbf{I} - (\mathbf{A}_1^* \circ \mathbf{T}_0^A)]^{-1} \mathbf{f}_0}{\boldsymbol{\lambda}'_1 [\mathbf{I} - (\mathbf{A}_1^* \circ \mathbf{T}_1^A)]^{-1} \mathbf{f}_0} \right\}$$

$$(2.5) = \begin{pmatrix} \boldsymbol{\mu}'_1 \mathbf{L}_1 \mathbf{f}_1 \times \boldsymbol{\lambda}'_1 \mathbf{L}_1 \mathbf{f}_0 \\ \boldsymbol{\mu}'_1 \mathbf{L}_1 \mathbf{f}_0 \quad \boldsymbol{\lambda}'_1 \mathbf{L}_1 \mathbf{f}_1 \end{pmatrix}$$

When we decompose for each region and industry, we replace the vectors $\boldsymbol{\lambda}$ and $\boldsymbol{\mu}$ in Equations (1) and (2) by diagonal matrices with the same elements on the main diagonal and zeroes elsewhere, and premultiply all numerators and denominators with $(1 \times NC)$ aggregation vectors, one for each region or industry.

3. DATA

The data used in our paper are multiregional input-output (MRIO) tables of China in 1987 (Ichimura and Wang, 2003) and 1997 (China's State Information Center, 2005). MRIO tables are much more complex: they capture the interregional linkages as well as the aspects of production. That is, the economic system is described in terms of interdependent industries and interrelated regions. Few countries have official MRIO tables because of difficulty in generating interregional flow data as well as official survey-based regional tables. Unfortunately, China's two MRIO tables are not perfectly consistent. The main source of data for the 1987 MRIO is a set of 30 regional I-O tables produced by the country's various provinces, autonomous regions, and municipalities. The MRIO table for 1997 was produced using hybrid techniques with interregional trade

flows based on survey data.³ We were forced to undertake some procedures to make them comparable.

Prior to the present paper, Meng and Qu (2007) have used the two Chinese MRIO tables to decompose *gross output* growth, rather than labor productivity change. They focused upon the nature of interregional relationships, however. They highlighted the performance of China's industrial and regional development policies on the magnitudes of interregional spillovers and feedbacks, which is a rather different focus from that we present here. Hioki and Okamoto (2009) also use the same tables, but they applied a qualitative input-output approach to identify changes in the largest spatial linkages among China's main regions since undertaking reforms. In sum, while the two tables have some compatibility problems, these two research groups showed that the worst of them can be overcome in a satisfactory manner.

To make some limitations to our study clear, we start by explaining how we dealt with differences in region definitions across the two MRIO tables. There were altogether seven regions in 1987 and eight in 1997 (see Figure 1). Thus, in the 1997 accounts we aggregated the North Municipalities with North Coast, the result of which conformed to the North China region in the geography of the 1987 MRIO accounts (see Table 1 for details). Another change between 1987 and 1997 in Chinese political geography was that in 1987 Chongqing was included within Sichuan province, while in 1997 it was a separate municipality directly under the central government. Fortunately within the I-O accounts this was not an issue since both are assigned to the Southwest region in both years. But a discrepancy does arise in the assignment of Inner Mongolia to regions in the MRIO accounts: it belongs to North China in 1987 but to the Northwest in 1997. Unfortunately, we have no way to correct for this problem since more detailed region classifications are lacking. We proceeded as if this was not an issue since Inner Mongolia

³ There are other critical differences in the accounting schemes that undoubtedly make interpretation of decomposition results difficult regardless of the technique that is applied. For example, the 1997 table includes interregional trade of final demand, but the 1987 does not. Moreover, the 1987 MRIO table is influenced by the MPS statistical system: thus, welfare is included in value added accounts and social consumption in final demand accounts. Intermediate deliveries among regions in the service sector are reported in 1987 MRIO table while service demands are assumed to be met by local supply only in the 1997 MRIO table.

is economically rather small.⁴ Of course, there was the prospect that it could produce some bias in our results.

As for the sector classification, there were 9 industries in 1987 MRIO table and 17 in 1997 MRIO table. We were able to aggregate them into 7 consistent sectors in both 1987 and 1997 MRIO tables (see Table 2). We also faced the additional constraint of needing employment counts in order to measure labor productivity by industry and region in both 1987 and 1997. Industry-level labor counts by hours worked are not available by sector for China's provinces and regions. The employment data are from *China Statistical Yearbook*.^{5,6,7} Unfortunately, we could only get labor data for five more aggregated industries by region over the period of study. Therefore, to preserve as much information as possible, we first aggregate all the vectors or matrices (except those with labor input involved) into seven sectors, continue calculation and then aggregate them to 5 sectors when confronted with labor input vectors.

⁴ We found that Inner Mongolia comprised 23.5 percent of the Northwest's GDP in 1997 and 8 percent of North China's GNI in 1987. Thus the shift in Inner Mongolia's economic alliance is more likely to lead to bias in the analysis of the Northwest than it is to our analysis of North China. However, the bias is not expected to be so large since much of difference made by the different scheme of regional (sectoral) aggregation are averaged out when we work with input-output coefficients (Hioki and Okamoto, 2009).

⁵ The employees refer to all the persons working in government agencies of various levels, political and party organizations, social organizations, enterprises and institutions, and receiving wages or other forms of payment. They include fully employed staff and workers, re-employed retirees, teachers in schools run by the local people, foreigners and Chinese compatriots from Hong Kong, Macao, and Taiwan working in various units, part-time employees, employees of other units working temporarily at current posts, and employees holding the second job, but exclude staff and workers who have left their working units while keeping their labor contract (employment relation) unchanged. This indicator reflects the total number of laborers actually engaged in production or other operations in various units.

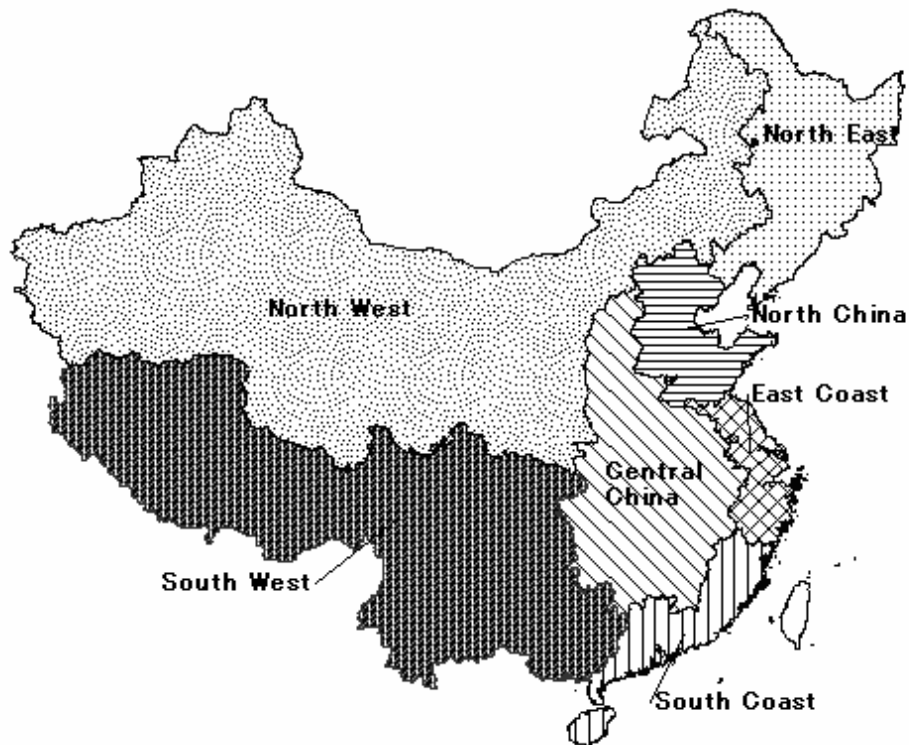
⁶ China's statistical data categories changed between 1987 and 1997. In 1987, employment in management of water conservancy is included in the Farming, Forestry, Animal Husbandry, Fishery and Water Conservancy industry (within the agriculture sector), and in 1997 it was combined instead with the Geological Prospecting and Water Conservancy industry (within the service sector). Thankfully its share is quite small, so any bias associated with this change is negligible.

⁷ *China's Statistical Yearbook 1988* reports the employment data by industries in 1987 for 29 provinces (Chongqing is included in Sichuan province at that time). *Hainan Statistical Yearbook 1988* reports data for Hainan province.

Table 1. China MRIO Region Definitions, 1987 and 1997

1987		1997	
Region (Abbreviation)	Provinces	Region (Abbreviation)	Provinces
North East (NE)	Liaoning, Jilin, Heilongjiang	Northeast (NE)	Liaoning, Jilin, Heilongjiang
<i>North China (NC)</i>	Beijing, Tianjin Hebei, Shandong <i>Inner Mongolia</i>	<i>North Municipalities</i> <i>North Coast</i> (NC)	Beijing, Tianjin Hebei, Shandong
East China (EC)	Shanghai, Jiangsu, Zhejiang	East China (EC)	Shanghai, Jiangsu, Zhejiang
South China (SC)	Guangdong, Fujian, Hainan	South Coast (SC)	Guangdong, Fujian, Hainan
Central China (CC)	Shanxi, Henan, Anhui Hubei, Hunan, Jiangxi	Central China (CC)	Shanxi, Henan, Anhui Hubei, Hunan, Jiangxi
North West (NW)	Shaanxi, Gansu, Ningxia Qinghai, Xinjiang	Northwest (NW)	Shaanxi, Gansu, Ningxia Qinghai, Xinjiang <i>Inner Mongolia</i>
South West (SW)	<i>Sichuan</i> , Guizhou, Yunnan Guangxi, Tibet	Southwest (SW)	<i>Sichuan</i> , <i>Chongqing</i> , Guizhou, Yunnan, Guangxi, Tibet

Figure 1. The Seven MRIO Regions of China 1997



Source: Hioki and Okamoto (2009)

Table 2 compares characteristics of the 1987 and 1997 MRIO tables and for the employment data we used for the two years. Note, that beyond labor data issues some other industry-based accounting issues could not be avoided. The postal and telecommunication industry are in the Service sector in 1997 table but in Trade and Transportation sector in 1987; eating and drinking establishments are included in the Service sector in 1997 table but in Trade and Transportation sector in 1987 table.

Referring to the construction of the trade coefficient matrices \mathbf{T}^A , we assigned the trade coefficient to be zero when the use of an industry's output by an industry is zero; we assigned the same value as the corresponding trade coefficient for the other year when the total use was zero in one year but positive in the other. This implied in these situations that all labor productivity will be attributed to changes in the input structure and none to changes in trade structure when all other values remain equal.

Since I-O tables are in value terms and both MRIO tables are in nominal prices, to eliminate price effects we had to either inflate the values in the 1987 table or deflate those in the 1997 table. We opted to deflate the 1997 input-output table to make its values consistent with those in 1987. This also enabled us to preserve information from the original data, because there are 17 industries in 1997 and 9 industries in 1987 and usually aggregation after deflation is preferred. The drawback to this is that we did not use data in prices to which the reader can more readily relate, i.e., in 1997 prices.

We used RAS to deflate the 1997 MRIO table. According to Dietzenbacher and Hoen (1998), RAS is commonly used to deflate I-O tables at least in academic literature. Price indices from 1987 to 1997 were available only at national level for the 17 industries in the 1997 MRIO: we used them as deflators since regional equivalents were unavailable. Then we aggregated both the 17 industries in 1997 and 9 industries in 1987 into the 7 industries we used in the ensuing empirical analysis. The Appendix explains what deflators we used and how we applied them for each industry.

Table 2. Comparison of industries for MRIO1987 and MRIO 1997 and employment data

Industries(Abbreviation)	9 industries IRIO 1987 (Ichimura and Wang, 2003)	17 industries MRIO 1997 (SIC, 2005)	13 industries Employment in 1987 (China Statistical Yearbook, 1988)	16 industries Employment in 1997 (China Statistical Yearbook, 1998)
1. Agriculture (AGR)	1. Agriculture	1. Agriculture	1. Farming, forestry, animal husbandry and fishery, water conservancy	1. Farming, forestry, animal husbandry and fishery
2. Mining, light industry, heavy industry and supply of electricity, gas and water (MAN)	<u>2. Mining and processing</u> <u>3. Light industry</u> 4. Energy industry 5. Heavy industry and chemical industry	<u>2. Mining</u> 3. Food Products 4. Textile and wearing apparel 5. Wooden products <u>6. Paper and printing</u> 7. Chemical products 8. Non-metallic mineral products 9. Metal products 10. Machinery 11. Transport equipment 12. Electronic products 13. Other manufacturing products 14. Electricity, gas and water supply	2. Manufacturing	2. Mining 3. Manufacturing 4. Supply of electricity, gas and water
3. Construction (CON)	6. Construction	15. Construction	4. Construction	5. Construction
4. Trade and Transport (TRA)	7. Transportation, post and communication services 8. Commerce and catering services	16. Trade and transport	5. Transport, post and telecommunications 6. Commerce, catering services and wholesale and retail trade	7. Transport, storage, post and telecommunications 8. Wholesale and retail trade and catering services
5. Service (SER)	9. Non-material industries	17. Services	3. Geological prospecting 7. Real estate, public utility, resident service and consulting service 8. Health care, sports and social welfare 9. Education, culture and art, radio, film and television 10. Scientific research and polytechnical services 11. Banking and insurance 12. Government agencies, party agencies and social organizations 13. Others	6. Geological prospecting and water conservancy 9. Banking and insurance 10. Real estate trade 11. Social services 12. Health care, sports and social welfare 13. Education, culture and art, radio, film and television 14. Scientific research and polytechnical services 15. Government agencies, party agencies and social organizations 16. Others

Table 3. Summary Statistics on Labor Productivity by Sector (in 1987 RMB per employee)

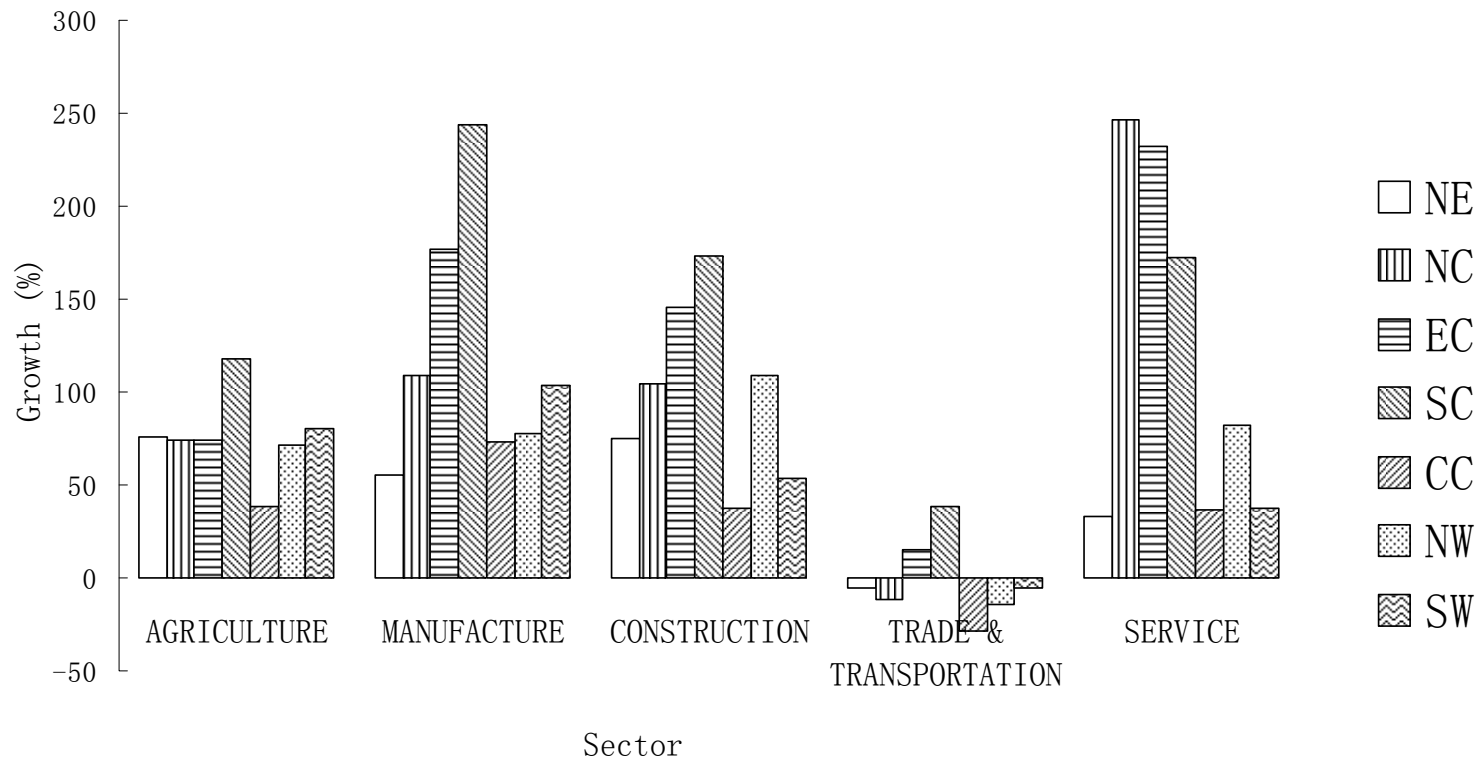
Sector	1987									1997								
	Mean	Standard Deviation	Dispersion coefficient	Max.	Region	Share ¹	Min.	Region	Share	Mean	Standard Deviation	Dispersion coefficient	Max.	Region	Share	Min.	Region	Share
AGR	1,116	310	27.78	1,647	NE	8.36	644	SW	16.25	2,006	688	34.30	2,895	NE	5.65	1,160	SW	26
MAN	4,926	523	10.62	5,768	NE	16.08	4,327	CC	19.47	1,0731	3,089	28.79	15,235	SC	10.25	7,488	CC	24.27
CON	2,819	444	15.75	3,806	NE	13.64	2,422	CC	21	5,673	1,651	29.11	7559	SC	11.04	3,320	CC	26.63
TRA	3,288	529	16.09	4,270	EC	17.98	2,627	CC	20.84	3,285	1,069	32.54	4935	EC	12.89	1,866	CC	27.76
SER	2,933	413	14.08	3,846	NE	12.68	2,535	SW	13.09	6,461	2,807	43.45	10,114	NC	13.91	3,492	SW	19.43

Note: 1. Share means the employment share of the sector with the max. or min. labor productivity in its corresponding (max. or min.) region.

Table 4. Labor Productivity Levels (in 1987 RM per Employee) and Annualized Growth Rate (%) by Region

Region	1987	1997	Annualized Growth Rate
NE	3,492.13	5,000.01	3.65
NC	2,489.05	5,473.01	8.20
EC	3,023.54	7,425.38	9.40
SC	2,239.29	6,688.80	11.56
CC	1,771.94	2,702.89	4.31
NW	1,887.71	3,263.19	5.63
SW	1,332.61	2,455.71	6.30
China	2,142.89	4,174.60	6.90

Figure 2. China's Labor Productivity Growth by Region and Sector, 1987-1997



4. EMPIRICAL ANALYSIS

4.1 Descriptive statistics

Labor productivity is value added per unit of labor input. We divided the value added by the corresponding employment in 1987 and 1997, respectively. The employment data we used measures the total persons employed within each region's sectors during the corresponding year.

Tables 3 and 4 show general information on labor productivity for both sectors and regions. Table 3 focuses on sectors, and Table 4 on regions. Figure 2 shows sectoral growth rates for each region. Table 3 shows that labor productivity levels were quite different across sectors and that big differences existed among regions, even for the same industry.

Of the sectors we examine, Manufacturing had the highest labor productivity in both 1987 and 1997. It is followed by Trade and Transportation, Service, Construction, and Agriculture in 1987. While in 1997, labor productivity in Service, Construction, Trade and Transportation rank second, third, and fourth, respectively. This shows the basic transition in China's economic development during the period toward Services.

We use the dispersion coefficient (standard deviation divided by the mean) to enable comparisons in the productivity across regions. Using it, we find that Agriculture's productivity varied most across the seven regions in both 1987 and 1997. This is unsurprising since a basic criterion for regional definitions used in the MRIOs was the geography of Agriculture, which relies on natural endowments. All five sectors have increased in this measure for productivity from 1987 to 1997. This indicates that China's experienced increasing productivity disparity among regions even within these major sectors.

During the study period, China's economy experienced some rapid growth as the fully centrally planned economy transformed into more of a market economy. The path of labor productivity's part in this transformation differed significantly across regions. In 1987 among the seven regions, Northeast China consistently was among the most productive regions for almost every one of the five sectors. By 1997, however, South and North China had made sufficient progress to surpass Northeast China in one or two of

them. East China had the highest labor productivity for Trade and Transportation sector in both years. This general spatial pattern of high productivity undoubtedly reflects China's focus on economic development along its eastern seaboard. As we know, some preferential policies had been implemented for the Coast by then. We also should note that the high dispersion of labor productivity levels within the same sector among regions is likely due to the very different mix of industries below the sector level used in our analysis, rather than to a high variation in labor productivity levels of uniform products. Given the high level of aggregation in the MRIO tables, we often had to remind ourselves of this fact, particularly when analyzing results for the Manufacturing and Service sectors. Both are aggregates of a large number of heterogeneous industries. Also in the course of the analysis we recalled the sage advice of Dietzenbacher et al. (2000) that sectors with the highest productivity levels ought not to be automatically interpreted as being the technologically most advanced. This is because labor productivity levels are also affected by capital-labor ratios that partly depend upon relative factor prices. Thus, we often found that the employment share of the sector with the lowest labor productivity level among the five sectors was greater than the one with highest labor productivity. This implies that labor productivity can increase with regional specialization, which causes the demand for labor to decrease.

Table 4 presents summary statistics for the seven regions in China from 1987 to 1997. Central China, Southwest China, and Northwest China, which start out with low initial labor productivity endowments, have relatively low productivity growth during the ten following years. On the contrary, the other three regions including North China, East China, and South China develop with surprising speed. The Northeast, as we can observe from Table 3, maintains a relatively low growth rate throughout the period, despite a higher initial labor productivity endowment.

From Figure 2 we can see that almost all sectors in every region experienced positive labor productivity growth rates during the study period. An exception is Trade and Transportation. Labor productivity for that sector even decreased across five of the regions during the study period. The reason for this may be manifold. First, it can probably be attributed to inaccuracies in China's statistical system. Hioki and Okamoto (2009) point out some problems about China's statistical information system for the

transportation industry, in particular they focus upon the consistency between transportation statistics and other national economic statistics. Second, the Trade and Transport sector itself in general does not appear to produce high amounts of value added per unit of production compared with the other four sectors. Also, since data on total hours worked by sector were not available, the employment data we use represents the total number of workers engaged in the industry including temporary employees. Thus, the issue could be more fundamental. That is, it may well be that, as elsewhere in the world, the sector experienced a rapid increase in its use of part-time and seasonal employees. This would, of course, lead to some bias in our analysis—bias that we cannot account for due to data limitations in China.

For North China, the Service sector is of vital importance. Its share increased from 13.7 percent in 1987 to 26.3 percent and was the region's second largest sector in 1997. Particularly it experienced an increase in its labor productivity growth of more than 100 percent during the period of study, although several other sectors also have such strong performance. All sectors in East China performed above average, and the region especially excelled in Services, Manufacturing, and Construction. South China owes most of its aggregate productivity increase to Manufacturing, but Construction and Service also contributed. In Central China things appear to be far less sanguine with almost all its sectors lagging behind those in other regions. The growth in the Northwest can largely be attributed to Construction as its labor productivity ranks top among all sectors in this region. This can probably be attributed to the national government's West Development Strategy. The Southwest performed best in Manufacturing, and sectors in Northeast did not show much change.

To this point, we attempted to relate a general understanding about temporal and spatial variations in China's labor productivity from 1987 to 1997. Both labor productivity and its growth rate differ across regions and industries. But we have not yet ascertained what contributed to the total change. The following decomposition analysis is our attempt to make this determination.

4.2 Decomposition results

The results of the application of decomposition for Equations (1) and (2) are reported in Table 5 and 6. Table 5 displays the perspective of regions by aggregating sectors, and Table 6 focuses on sectors by aggregating regions.

Based on the MRIO data, labor productivity in China increased by 94.8 percent during the 1987-1997 period—an annualized average growth rate of 6.9 percent. The increase was mainly caused by a decrease in labor used per unit of gross output. It alone accounts for an increase in productivity of 100.7 percent (the geometric average of the two decompositions). This effect was partly offset by a shrinking of value added's share of total output—a reduction of about 18 percent.

The decrease of labor input per unit of gross output indicates the adoption of labor-saving processes, which resulted in the substitution of capital for labor or reductions in disguised unemployment. Much of the change was undoubtedly induced via market pressures as China engaged more fully in the world marketplace as suggested by Tybout (1992), among others. China's reform started in 1978 and in 1992 China's government proposed its current socialist market economy. During the transition, in July 1986, the government issued a regulation that state-owned enterprise could hire via contracts. This meant that such enterprises not only could hire but also fire personnel. In 1995, the labor contract system was implemented comprehensively. But it was not until 1998 that the government definitely proposed that employment would be open to the full force of the market economy and not through government intervention. Our study period from 1987 to 1997 strictly covers the period of employment transition toward to a market-oriented system. Therefore, the large labor saving effect is not especially odd for the coastal regions, where the reformation first took place.

Table 5 Labor Productivity Decomposition Results by Region

Region	Total ¹	Factor 1 ²		Factor 2			Factor 3			Factor 4			Factor 5			
NE	1.432	0.755	0.782	0.769	1.927	1.877	1.902	1.027	0.994	1.010	0.952	0.975	0.963	1.005	1.007	1.006
NC	2.199	0.825	0.811	0.818	2.410	2.224	2.315	1.021	1.071	1.046	1.028	1.028	1.028	1.054	1.108	1.081
EC	2.456	0.787	0.797	0.792	2.809	2.459	2.628	1.071	1.156	1.112	0.974	0.955	0.964	1.065	1.135	1.100
SC	2.987	0.823	0.857	0.840	2.935	2.572	2.747	1.057	1.091	1.074	1.036	1.059	1.048	1.129	1.172	1.150
CC	1.525	0.847	0.850	0.848	1.597	1.559	1.578	1.066	1.064	1.065	1.028	1.020	1.024	1.029	1.061	1.044
NW	1.729	0.870	0.872	0.871	1.903	1.873	1.888	1.006	1.011	1.009	0.974	0.980	0.977	1.065	1.070	1.067
SW	1.843	0.843	0.856	0.849	1.919	1.905	1.911	1.091	1.081	1.086	0.972	0.975	0.973	1.075	1.073	1.074
China	1.948	0.818	0.827	0.823	2.090	1.928	2.007	1.066	1.086	1.076	0.998	0.997	0.998	1.071	1.128	1.099

Note: 1. Ratio of labor productivity in 1997 to that in 1987;

2. First columns of each factor refer to results of Equation (1) and second columns refer to results of Equation (2) and third columns refer to Fisher indexes, which is the geometric average of the first two indexes.

Table 6 Labor Productivity Decomposition Results by Sector

Industry	Total ¹	Factor 1 ² (value added per unit of gross output)			Factor 2 (labor input per unit of gross output)			Factor 3 (input structure)			Factor 4 (interregional trade among intermediate inputs)			Factor 5 (final demand)		
AGR	1.668	0.867	0.864	0.866	1.929	1.912	1.920	0.998	1.000	0.999	1.001	1.000	1.000	0.999	1.010	1.004
MAN	2.142	0.790	0.791	0.790	2.786	2.645	2.715	0.982	0.981	0.981	0.995	0.998	0.996	0.997	1.047	1.021
CON	1.892	0.942	0.947	0.945	2.010	1.905	1.957	0.998	1.000	0.999	1.000	1.000	1.000	1.001	1.049	1.025
TRA	0.950	0.832	0.832	0.832	1.125	1.092	1.108	1.005	1.001	1.003	0.996	0.994	0.995	1.013	1.052	1.032
SER	2.072	0.795	0.803	0.799	2.587	2.299	2.439	0.996	1.055	1.025	1.000	0.997	0.998	1.012	1.068	1.039

Note: 1. Ratio of labor productivity in 1997 to that in 1987;

2. First columns of each factor refer to results of Equation (1) and second columns refer to results of Equation (2) and third columns refer to Fisher indexes, which is the geometric average of the first two indexes.

Although not directly detectable from the results in Table 5, we should note that the length of the work week was substantially reduced in 1994 and again in 1995. Prior to March 1, 1994, the work week was mandated as 48-hours long; from that date on, it was reduced to 44 hours. The official work week was reduced further by 4 hours to 40 hours starting on May 1, 1995. This means that if one is really interested in measures of labor productivity growth and labor input per unit of gross output that are based on a labor-hours rather than a job basis, the numbers in Table 5 and Table 6 are clear underestimates. Unfortunately, the figures do not distinguish part-time labor and full-time labor, and thus it may also lead to underestimates according to China's existing statistical system.

We should note that value added per unit of gross output was, in many cases, also caused by the same labor-saving effect as well as being laid open to the ravages of pressures from increasing exposure to world markets. In particular, the latter undoubtedly induced tax and profit shares in China to decrease by about 5 percent between 1987 and 1997. Changes in input structure (factor 3) and in final demand (factor 5) have a net positive effect on the growth of labor productivity. While changes in interregional trade (factor 4) seem to have yielded no contribution to the labor productivity at national level, change in final demand provided a greater impetus for labor productivity growth than did change in intermediate input structure—i.e., change in technology and in the mix of industries within each sector.

The findings summarized for each of the seven regions are quite similar to those for the China as a whole. Decreased labor input per unit of gross output contributes the most to labor productivity growth followed by changes in final demand. Input structure tends to rank third and fourth as a key factor. Reduction in the ratios of value added per unit of gross output markedly dampened the labor productivity increases.

Our result differ quite a bit from those of Dietzenbacher et al. (2000) in that they found the effects from both changes in intermediate structure and trade and changes in final demand had no perceptible effect on growth of labor productivity for any of the Euro-6 countries they analyzed. While our findings for change in interregional trade were similar, those for final demand were not. Indeed, change in final demand nearly consistently contributed substantially to labor productivity growth in each of the seven regions and five industries in the MRIO tables we used to analyze China's economy.

Thus, in our case both the change in the structure of final demand and of intermediate input appear to have fostered growth in labor productivity in China from 1987 to 1997.

We also found that value-added's share of gross output reduced its contribution to labor productivity growth by about 18 percent for each of China's regions. Dietzenbacher et al. (2000) found a less dramatic 10 percent reduction in this factor's contribution to labor productivity growth. The difference is undoubtedly due to the establishment of market economy and world's openness to rapidly increase trade with China. While the Euro-6 also benefited from a greater openness in trade during the study period employed by Dietzenbacher et al. (2000), those countries already were among the world leaders in adopting technological innovations and engaged heavily in international trade prior to the study period. Hence, the economic pressures of freer trade were not nearly so heavily felt in Europe between 1975 and 1985 as they were in China between 1987 and 1997.

When we look at the factors by region, it can be inferred that the high labor productivity growth in North China, East China, and South China derives largely from large decreases in the use of labor per unit of gross output. Except in Northeast and Northwest, changes in input structure improved their respective labor productivity positively, particularly in East China, where the effect was over 11 percent. Interregional trade had a clear positive effect on North China, South China, and Central China—about 2.8, 4.8, and 2.4 percent. But it had negative effects on Northeast, East China, Northwest, and Southwest and—about 3, 4, 3, and 3 percent, respectively.

We made several cursory investigations in attempts to explain why the interregional trade effects were positive for some regions while negative for others. Unfortunately, each approach only supported a subset of the regions. In one approach we examined each region's in-and out-flows with imports calculated from perspectives of both using and producing industries. Analyses of these data revealed that Manufacturing was by far the dominant trading sector for all regions in both periods. We also compare the change in labor productivity of in- and outflows (calculated for using industries using a weighted average) for the sectors by region. We hypothesized that those regions' sectors with higher labor productivities for their outflows than their inflows should yield positive effects on labor productivity and, of course, that opposite results should yield negative productivity effects. It proved to be the case for five of the seven regions: East

China and Central China were anomalies. We also calculate each sector's outflow share by region with the hypothesis that interregional trade effects would be positive when the outflow's share in high-productivity sectors increases between 1987 and 1997. Again, for all but East China the hypothesis appeared to ring true. Thus despite a modicum of success our search for explanations of the results obtained, it is clear that some further research is required to ascertain more precisely what factors contributed to the interregional trade effects we obtained.

Factor 5, change in final demand, has a major effect on all the regions but the Northeast. We found that, from 1987 to 1997, the Northeast's final demand share in Trade and Transportation increased from 1.6 percent to 7.4 percent. As we mentioned above, labor productivity of this sector decreased during the period. Thus, it may be a major reason that the effect of final demand is less important in Northeast.

From Table 6, observe that labor productivity increased by an astounding 114 percent from 1987 to 1997 in Manufacturing and 107 percent in the Service sector! At the same time, as stated earlier, productivity in Trade and Transportation declined. Most sectors in China experienced larger rises in labor productivity and drops in value-added per unit of gross output from 1987 to 1997 than did their counterparts in the Euro-6 between 1975 and 1985. Again, labor productivity improvements for each of the sectors derive mainly from declines in labor input per unit of gross output. Skyrocketing labor productivity in the Manufacturing and Service sectors are largely caused by this. The second most important factor across the sectors is the change in value added per unit of output. It is negative, however, and hence dampened productivity growth.

As has been the story throughout this paper, changes in the structure of inputs and final demand had smaller effects compared with the first two factors. Their magnitudes are, nonetheless, significantly larger than the corresponding factors for the Euro-6 countries during the 1975-1985 period, as estimated by Dietzenbacher et al. (2000). The effects of input structure are negligible for almost all the sectors except Service, and final demand factor made up about 2.1, 2.5, 3.2 and 3.9 percent for all the sectors but Agriculture. Changes in the pattern of interregional trade almost had no effect on the productivity of the sectors; there may be some explanations for this. Construction and Service sectors do not generally produce a traded good or service. Dietzenbacher et al.

(2000) also give some reasons for this in their paper. Compared to other sectors, change in the structure of final demand for the Service sector contributed most to overall sectoral productivity growth, and at 2.9 percent its change in input structure also yielded relatively large effects compared to other sectors.

Comparing Table 5 to Table 6, we can make further inferences. The first two factors tend to yield the largest effects, while effects from the last three factors tend to be smaller. The lack of effect from changes in input structure is readily explained by the generally slow pace of technology change within a ten-year timeframe. Work by Carter (1970), Blair and Wyckoff (1989), and Shishido et al. (2000) suggests that ten years is insufficiently long to change average industry structure much even in innovative industries.⁸ That the factors have more effect upon regions than upon sectors implies that different intrasectoral structures exist across the regions and, thus, that subsector mix issues generate some substantial share of the regional disparity in labor productivity.

Along the way we have compared our results for China with those by Dietzenbacher et al. (2000) for the Euro-6 countries. Doing so gives us some measure for comparison and enlightens us about the relative magnitude of labor productivity growth as well as provides some background for identifying further causes of interregional disparities in productivity growth. In summary we have found that all factors tended to provide greater impetus for labor productivity growth in China between 1987 and 1997 than they did in Euro-6 countries from 1975 to 1985. We believe that Chinese economic reform and transformation from planned economy to market economy is the main force. Meanwhile, there are also other reasons, like the different ways the tables were built.

Dietzenbacher et al. (2000) note that the input-output tables they used were constructed using exchange rates among the countries rather than purchasing power parity (PPP) conversions. Since our analysis focuses on regions of a single country, PPP versus exchange-rate conversion is a non-issue. For similar reasons, transaction costs of trade among regions of a single country are naturally smaller than they are for trade among different countries. That is, outside of transportation costs, the flow of commodities and services should be relatively frictionless for China, which is not the

⁸ See Chapter 7 and the initial sections of Chapter 13 and 14 of Miller and Blair (2009) for additional details.

case for the Euro-6. Thus, China's economic reformation, which started in 1978, had better ability to induce sweeping technology change during the second decade following that reform than did the formation of the European Union. Most studies of technology change have been undertaken in relatively stable economies or in economies in decades when trade and information exchange were slower on the uptake.

5. CONCLUSIONS

Few papers have studied the factors contributing to changes in labor productivity with multiregional input-output tables. This is particularly the case for China. In this paper we use two multiregional input-output tables and disaggregated employment data to examine change in labor productivity growth for seven regions and five sectors of the Chinese economy between 1987 and 1997. We decompose the potential causes of change in labor productivity into five partial effects. We find that the increase of labor productivity for regions and sectors in China mainly comes from the decreasing labor input per unit of gross output and from changes in value added's share of gross output. Aggregate production mix, interregional trade, and final demand also have important but smaller effect on most of regions and their sectors in China.

We found that the factor effects were larger by region than by industry. This suggests that regions' subsector industry mixes also play a major role in causing interregional disparities in labor productivity. The paper also shows that all the factors displayed larger effects in China from 1987 to 1997 than did Euro-6 countries from 1975 to 1985.

Like other decomposition methods, this approach deals only with proximate causality, and thus we give our understanding based on the knowledge of institutions, history, policy, and so on. Due to relatively poor economic statistical reporting, especially for the early years, we can only present a rather aggregate decomposition of China's labor productivity among regions and sectors. There may be some bias in our analysis, due to employment data limitation, which forced us to use job-years instead of hours worked. Accordingly, some associated in-depth and more-detailed insight is not really possible. Nonetheless, our analysis presents a fresh perspective on an issue of national and possibly even international interest. We therefore hope our work induces others to

make further investigations into China's interregional disparities in labor productivity when higher quality data are readily available.

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APPENDIX

Table of Data Used to Produce Price Indices

No.	Sector	Price index calculation	Remark
1	Agriculture	Product of year-by-year agriculture product producer price index	Data from the website of Ministry of Agriculture of the People's Republic of China http://www.agri.gov.cn/sjzl/baipsh/WB2007.htm#26
2	Mining	Product of year-by-year mining index	Index from "ex-factory price indices of industrial products" in 2006 China urban life and price yearbook
3	Food products	Product of year-by-year food index	Index from "ex-factory price indices of industrial products by sector" in 2006 China urban life and price yearbook
4	Textile and wearing apparel	Weighted average of price index from 3 constituent industries, which are textile goods, wearing apparel, leather, furs and related products	Index from "ex-factory price indices of industrial products by industry." Weight is share of workers in different industries in base year and the data come from China statistical yearbook for different years
5	Wooden products	Product of year-by-year wooden index	Index from "ex-factory price indices of industrial products by sector" 2006 China urban life and price yearbook
6	Paper and printing	Products of year-by-year price index of paper industry	Index from "ex-factory price indices of industrial products by industry." There is no printing index from China's database and it is probably a common sense that the index of printing is similar with that of paper industry, we just use the price index of paper industry as that of the sector.
7	Chemical products	Weighted average of the following 6 industries: petroleum refining and coking, chemical raw material and products, medical and pharmaceutical products, chemical fibers, rubber products and plastic products	Index from "ex-factory price indices of industrial products by industry."
8	Non-metallic mineral products	Product of year-by-year index	Index from "ex-factory price indices of industrial products by sector"
9	Metal products	Weighted average of 3 industries: ferrous metal processing, nonferrous metal processing and metal products	Index from "ex-factory price indices of industrial products by industry."
10	Machinery	Products of year-by-year price index of special machinery industry	The machinery sector include both the general and special machinery industries, yet China only publish the price index for special machinery, we then use it as a price index for the whole sector for we believe they are almost approximate based on our practical experience.
11	Transportation equipment	Product of year-by-year index	Index from "ex-factory price indices of industrial products by industry"

Table of Price index (Cont)

No.	Sector	Price index calculation	Remark
12	Electronic products	Weighted average of the electric equipment & machinery and electric & telecommunication equipments	Workers data comes from 2 different sources; from 1990 to 1996 it is from China statistical yearbook and from 1987 to 1989 from China industry economy yearbook because no detailed data is published in China statistical yearbook in early years. We should notice that these two kinds of data are not quite consistent even for the same year and same industry, we believe different statistical definition have been used. But this will not lead to mistake in our analysis because we use percentage as a weight.
13	Other manufacturing products	Weighted average of instrument, meters, culture & office machinery industry and other manufacturing products industry	Index from “ex-factory price indices of industrial products by industry”
14	Electricity, gas and water supply	Weighted average of electricity and water industry	Index from “ex-factory price indices of industrial products by industry”. The employment data for gas is only available from 1993 to 1996 because the data before is included in the industry of coking industry. The worker percentage for gas industry of the whole sector from 1993 to 1996 is 7.2, 7.3, 7.0, and 6.6 percent, respectively, which shows a weighted average of price index from electricity industry and water industry is feasible. Though we don't have the data for years from 1986 to 1992, we can infer the percentage will be no more than that for the latest four years because the volume of gas supply in 1986-1992 mostly is less or equal to that in 1993-1996. Given that the technology for producing gas almost does not change, it is easy to prove the worker percentage will be less or equal to 7 percent.
15	Construction	Product of year-by-year index of construction material industry	Index from “ex-factory price indices of industrial products by sector”
16	Trade and transport	Weighted average of trade and transport industry	Data is from China Statistical yearbook.
17	Services	a) Index for 1991-1997, weighted average of all the industries b) Index for 1988-1990, we infer it with the price index of the whole tertiary sector, the trade industry and transport industry c) Product of the year-by-year index	a) Industries including geological prospecting and water conservancy, banking and insurance, real estate trade, social services, health care, sports and social welfare, education, culture and art, radio, film and television, scientific research and polytechnic services, government agencies, party agencies and social organizations and others. b) China Statistical yearbook does not present GDP data for detailed industries from 1986 to 1989, thus the method used in step a can not be adopted here.

The data we used to calculate the price index come from *the website of Ministry of Agriculture of the People's Republic of China*, *China Statistical Yearbook*, the *China Urban Life and Price Yearbook*, and the *China Industry Economy Yearbook*. We were unable to find a proper price index for tertiary industries (both for the aggregate Service sector and its finer component industries) in the *China Urban Life and Price Yearbook* or other data bases for China. Nonetheless, we needed to calculate them using existing data. Thus we created an implicit GDP price deflator using data in the *China Statistical Yearbook*. We calculated it by taking the ratio of nominal GDP to real GDP for both 1987 and 1997, and dividing the 1997 result by the 1987 value.

For industries of the Manufacturing sector in the 1997 MRIO table, we selected the most appropriate price index from “ex-factory price indices of industrial products”, “ex-factory price indices of industrial products by sector” or “ex-factory price indices of industrial products by industry” in the *China Urban Life and Price Yearbook*. (For the “ex-factory price indices of industrial products by sector,” see the definition of the industry in the appendix to the *1988 China Industry Economy Yearbook*.) Naturally, if an index was perfectly consistent with an industry in the 1997 MRIO table, we used it directly; Otherwise, we generated a price index based on weighting of several finer industries’ indices. As weights we used GDP share of tertiary industries. Due the greater detail in the manufacturing industries and the lack of equivalently detailed GDP data, we used worker shares. We used base-year shares as weights.

Industrial reporting in China changed during the ten years that we study. For example, the foraging industry was a distinct industry before 1993: It was merged subsequently into the food-processing industry. Similarly, the coke-making industry was a distinct industry before 1990 and was subsequently merged into the petroleum-refining and coke-making industry. The industrial arts industry was included within the “other manufacturing” industry prior to 1990 and was reported separately afterward. All of these anomalies were accounted for in as much as data permitted.

In several cases, we were forced to use a combination of data on manufacturing workers for both 1987 and 1988 from the *China Statistical Yearbook* as weights. We note that the *1989 China Statistical Yearbook* reports 1988 industry data on workers only for

establishments that were collectively owned. In 1988 about 98.8 percent of all Chinese manufacturing workers were employed by such organizations. Similarly, the *1988 China Statistical Yearbook* reports workers counts by industry only for establishments collectively owned above the county level. In 1987 these organizations comprised more than 88.4 percent of all Chinese manufacturing workers. Despite this, our use of shares as weights should minimize any inherent bias, except in those industries especially sensitive to type of ownership.