Productivity Growth in China, 1981-95

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I. Introduction

It is widely agreed that the Chinese economy has grown rapidly since the reforms that were begun in 1978, however, there is much disagreement about the exact magnitude and characteristics of that growth. Was it predominantly due to accumulation of factors of production, or was it mostly due to productivity growth? What was the role of reallocation of factors across sectors? These questions are difficult to answer given the quality and quantity of data available. The answers to them, however, are important in understanding the effects of past economic policies and hence to devise future policies.

The primary purpose of this paper is to present some estimates of growth and productivity change by sectors based on currently available data. We also introduce more newly developed data here, this includes a time series of input-output tables and data from a survey of the labor force. A second aim is to discuss the various approximations and assumptions that are necessary to construct time series of data at the sectoral level for the whole economy. As with many papers in this literature we shall discuss in detail the data issues relating to proper deflators and sectoral classification. Our goal is to lay the groundwork for a systematic and clear framework for sectoral productivity analysis of China, i.e. to sketch out a comprehensive approach, and to point out the missing elements for further research to produce better estimates of growth and productivity change.

Our preferred approach to estimating productivity growth is to use gross output data rather than using only value added. To do this for the whole economy requires us to construct a time series of input-output matrices. This IO approach forces the analysis to be consistent across the whole economy, a revision of the output deflator of one sector changes the output and productivity growth of that sector but this necessarily implies that the inputs into some other sectors or final demand are also changed. For example, the service sectors are poorly measured in all countries and especially so in China. Services are also inputs into the manufacturing sector, our IO approach forces us to explicitly confront this issue. The productivity estimates for manufacturing is thus not as reliable as one might think.

If we scale these IO tables to official GDP and use official investment and labor data we find that total factor productivity growth in many sectors (at the 2-digit level) are negative. The major contributor is the agriculture sector which is large and showed high

(2%) TFP growth. We employ two sets of deflators for output and discuss how plausible adjustments to the data might change the TFP estimates.

While we are going to focus on sectoral estimates we will also discuss the aggregate economy. Our aggregate GDP is built up from the sectoral data and the method used to derive real GDP is different from most authors. We decompose aggregate TFP growth into sectoral TFP growth and reallocation effects. Our estimate for aggregate TFP growth is in the 0.3-1.1% range. Using one set of estimates, the 1.1% TFP growth is made up of 2.2% sectoral TFP growth, -1.7% reallocation of value added, 0.5% reallocation of capital, and 0.1% reallocation of labor.

There are a number of productivity studies of China at the aggregate level, or using value added for broad (1-digit) sectors. Chow (1993), using official data prior to 1980 that only included the material sectors (i.e. not including the data on service sectors that were estimated later), concluded that there was essentially no technical progress in the 1952-80 period. Since that period does not overlap with ours we shall not discuss Chow's study in detail except to note his use of official estimates of real value added.

Young (2000) discusses the problems with the official estimates of real GDP and makes estimates using alternative deflators. He estimated that for the non-agricultural sector total factor productivity growth was only 1.4% per year using his deflators compared to 3.0% using official numbers. He, however, also points out that ignoring agriculture makes this a misleading estimate, that sector is large (a quarter of GDP in this period) but with rather poor data on inputs (labor, land and capital).

Ren (1997) is focused primarily on measurements of real GDP rather than productivity measurements, but the data issues raised there are very relevant to our discussions here. Ren re-estimated GDP growth using alternative deflators and suggest that his figure of 6.0% growth rate during 1986:94 is more realistic than the official 9.8%. Young (2000) concurs and follows some of the procedures introduced by Ren (1997). Huang and Ren (2000) is a preliminary study that provides estimates of TFP growth at the 2-digit level for manufacturing value added using data from the industrial census. More than a third of their sectors show negative TFP growth in the 1985-94 period, the average for all of manufacturing was estimated to be -0.67% per annum.

Woo (1998) also discusses in some detail the poor construction of output deflators and their use in estimating real GDP. He reestimated the GDP growth using producer price indices (like Ren above), and decomposed it into factor growth, reallocation and TFP growth. Like Huang and Ren (2000) he also use value added but dividing the economy into primary, secondary and tertiary sectors. Unlike Young (2000) he did not try to obtain real value added by double deflation but merely revise the deflation of nominal value added using the produce price indices. Similarly, for labor input Woo used number of workers like Huang and Ren (2000), and unlike Young (2000) and this paper which adjust for the composition of workers. The result is that for the period 1979-93 he revised the official growth rate from 9.3% per annum to 8.0% which he decomposed to capital accumulation (4.9%), labor force growth (1.4%), reallocation effect (0.6%) and TFP growth (1.1%).

A number of other studies use detailed Census, or survey, data rather than economy wide aggregates, these include Jefferson, Rawski and Zheng (1996, 2000), Groves, Hong, McMillan and Naughton (1994) , and Woo, Hai, Jin and Fan (1994). These studies seem to agree that collective owned enterprises showed much higher TFP growth than state owned ones, but gave very different estimates of the actual performance of the state owned enterprises, ranging from positive to negative.[2] While our analysis at the 2-digit level cannot be compared to these more detailed studies we should note that our results do show both positive and negative productivity growth.

II. Sectoral and Aggregate Growth Accounting

We now summarize our methodology to account for the various factors that contribute to growth – factor accumulation, changes in composition of factors, reallocation of factors across sectors and productivity change. Each sector of the economy is described by a production function which uses primary factors and intermediate inputs to produce gross output. This output is used for final demand and intermediate demand, and GDP is the aggregate of final demand, and is also the aggregate of sectoral value added. Much of this is described in detail in our accounting of U.S. economic growth in Jorgenson, Gollop and Fraumeni (1987). (See also Jorgenson

[2] Some of these differences are discussed in Woo (1998), which also surveyed other papers.

and Stiroh 2000, and Gu and Ho 2000). Readers familiar with this may skip directly to the results in Sections IV and V.

The economy is divided into 29 sectors producing 29 different commodities. Gross output of sector j in period t is assumed to be produced with a Hicks-neutral production function using various types of capital, labor and intermediate commodities. (Land is another input in the case of agriculture, we leave it out here for notational simplicity but it is included in our calculations).

(1) $$Y_{jt} = A_{jt} f(K_{1jt}, ..K_{kjt}, L_{1jt}, ..L_{ljt}, Z_{1jt}, ..Z_{njt})$$

The index of productivity is represented by A_{jt}. We assume that the function is separable in such a way that the various types of capital, labor and intermediate inputs may be aggregated into indices K_{jt}, L_{jt}, and Z_{jt} respectively, so we may write the production function as :

(2) $$Y_{jt} = A_{jt} f(K_{jt}, L_{jt}, Z_{jt})$$

The index of capital input is aggregated from two types of assets, structures and equipment. The labor input is an aggregate of the number of workers cross classified by sex, age, and educational attainment. The material input index is aggregated over the 29 separate commodities. These intermediate goods are produced by the 29 sectors plus imports. The construction of these input aggregates is described in section III below.

We assume that (2) is described by a translog form so the index of techonology may be derived from :

(3) $$d\ln Y_{jt} = \bar{v}_{Kjt} d\ln K_{jt} + \bar{v}_{Ljt} d\ln L_{jt} + \bar{v}_{Zjt} d\ln Z_{jt} + d\ln A_{jt}$$

where $d\ln Y_{jt} = \ln Y_{jt} - \ln Y_{jt-1}$, and the $\bar{v}$'s are the two-period average share of the subscripted input in nominal gross output :

(4) $$\bar{v}_{Kjt} = \tfrac{1}{2}(v_{Kjt} + v_{Kjt-1}) \quad \text{etc.}$$

$$v_{Kjt} = \frac{P_{Kjt} K_{jt}}{P_{Yjt} Y_{jt}}$$

$$v_{Ljt} = \frac{P_{Ljt} L_{jt}}{P_{Yjt} Y_{jt}}$$

$$v_{Zjt} = \frac{P_{Zjt} Z_{jt}}{P_{Yjt} Y_{jt}}$$

The P's denote the prices, P_{Yjt} is the output price to the producer (factory gate price less taxes), P_{Kjt} is the rental price of capital, and P_{Ljt} is the price of labor input. The value of capital input is calculated such that the value of inputs equal the value of ouput:

(5) $$P_{Yjt} Y_{jt} = P_{Kjt} K_{jt} + P_{Ljt} L_{jt} + P_{Zjt} Z_{jt}$$

We shall use the output price to calculate the productivity indices. Official GDP is evaluated at purchasers' price, or industry price, P_{Ijt}. The difference between the two valuations is the net taxes on production, NT :

(6) $$P_{Ijt} Y_{jt} = P_{Yjt} Y_{jt} + NT_{jt}$$

The real value added of sector j, V_{jt}, is defined implicitly from (3) above as output less an index of intermediate inputs :

(7) $$d \ln Y_{jt} = \bar{v}_{Vjt} d \ln V_{jt} + \bar{v}_{Zjt} d \ln Z_{jt}$$

The following identity is implied:

(8) $$\bar{v}_{Vjt} d \ln V_{jt} = \bar{v}_{Kjt} d \ln K_{jt} + \bar{v}_{Ljt} d \ln L_{jt} + d \ln A_{jt}$$

where $v_{Vjt} = \frac{P_{Kjt} K_{jt} + P_{Ljt} L_{jt}}{P_{Yjt} Y_{jt}}$

is the share of value added in gross output. The price of value added is then given by the sum of values divided by the quantity index:

(9) $$P_{Vjt} V_{jt} = P_{Kjt} K_{jt} + P_{Ljt} L_{jt}$$

The above describes the accounting for each sector. We now turn to the aggregation over all the sectors to derive national output. To use an aggregate production function one must assume that there is perfect substitution among sectors, and total real value added (at factor cost) is calculated as the simple sum of sectoral value added :

(10) $$V_t = \sum_j V_{jt}$$

This aggregate output is written as a Hicks neutral function of the inputs of capital, labor and land (T) :

(11) $V_t = A_t \cdot f(K_t, L_t, T_t)$

K_t is an index representing the aggregate of the various capital asset types, where each asset type *k* is the national sum of the asset in all sectors. We use the Divisia method to derive the input aggregate :

(12) $d\ln K_t = \sum_k \bar{v}_{Kkt} d\ln K_{kt}$, k=Structures, Equipment

$$K_{kt} = \sum_j K_{jkt}$$

Similarly, L_t represents the aggregate of various types of labor :

(13) $d\ln L_t = \sum_l \bar{v}_{Llt} d\ln L_{lt}$, *l*=cross classification of sex, age, education

$$L_{lt} = \sum_j L_{jlt}$$

Due to the lack of data on land valuation and rents, in this paper we shall only make a crude estimate of land in one sector, agriculture, and make no distinction about the types of land. That is, $T_t = T_{1t} = \text{constant}$. This also means that we might be overestimating the return to capital in the mining and real estate sectors with our assumption of zero land input. This also means that the return to aggregate capital must be interpreted to include return to this ignored land input.

From (10) we get the aggregate real value added, and we assume that (11) may be written in the translog form. The index of aggregate production technology, A_t^a, may thus be derived from :

(14) $d\ln V_t = \bar{v}_{Kt} d\ln K_t + \bar{v}_{Lt} d\ln L_t + \bar{v}_{Tt} d\ln T_t + d\ln A_t^a$

where $v_{Kt} = \dfrac{P_{Kt}K_t}{P_{Kt}K_t + P_{Lt}L_t + P_{Tt}T_t} = \dfrac{\sum_j P_{Kjt}K_{jt}}{\sum_j (P_{Kjt}K_{jt} + P_{Ljt}L_{jt}) + P_{Tt}T_t}$.

The denominator of the value shares is simply nominal GDP at factor cost, i.e. before indirect taxes.

The relation between aggregate and sectoral TFP is done via Domar-aggregation as in Jorgenson and Stiroh (2000). From eq. (8) we have:

(15) $d\ln A_{jt} = \bar{v}_{Vjt} d\ln V_{jt} - \bar{v}_{Kjt} d\ln K_{jt} - \bar{v}_{Ljt} d\ln L_{jt}$

Multiplying by the Domar weights and summing over all sectors:

(16) $$\sum_t \frac{\bar{w}_{jt}}{\bar{v}_{Vjt}} d\ln A_{jt} = \sum_j \bar{w}_{jt} \ln V_{jt} - \sum_j \bar{w}_{jt} \frac{\bar{v}_{Kjt}}{\bar{v}_{Vjt}} d\ln K_{jt} - \sum_j \bar{w}_{jt} \frac{\bar{v}_{Ljt}}{\bar{v}_{Vjt}} d\ln L_{jt}$$

where $w_{jt} = \frac{P_{Vjt}V_{jt}}{\sum_i P_{Vit}V_{it}}$

is the value share of sector j's value added in total GDP at factor cost.

Combining eq. (14) with (16) we get the decomposition of aggregate productivity change :

(17) $$\begin{aligned} d\ln A_t^a = \; & \left(\sum_j \frac{\bar{w}_{jt}}{\bar{v}_{Vjt}} d\ln A_{jt} \right) \\ & + \left(d\ln V_t - \sum_j \bar{w}_{jt} \ln V_{jt} \right) \\ & + \left(\sum_j \bar{w}_{jt} \frac{\bar{v}_{Kjt}}{\bar{v}_{Vjt}} d\ln K_{jt} - \bar{v}_{Kt} d\ln K_t \right) \\ & + \left(\sum_j \bar{w}_{jt} \frac{\bar{v}_{Ljt}}{\bar{v}_{Vjt}} d\ln L_{jt} - \bar{v}_{Lt} d\ln L_t \right) \\ & + \left(\sum_j \bar{w}_{jt} \frac{\bar{v}_{Tjt}}{\bar{v}_{Vjt}} d\ln T_{jt} - \bar{v}_{Tt} d\ln T_t \right) \end{aligned}$$

(18) $$d\ln A_t^a = \sum_j D_{jt} d\ln A_{jt} + R_t^{VA} + R_t^K + R_t^L$$

$D_{jt} = \frac{\bar{w}_{jt}}{\bar{v}_{Vjt}} = \frac{\bar{P}_{Yjt}\bar{Y}_{jt}}{\sum_i \bar{P}_{Vit}\bar{V}_{it}}$ is the Domar weight and the first term in parentheses in (17) is the sum of Domar-weighted sectoral productivity change. The second term is the reallocation of value added across sectors and is represented by R_t^{VA}, the third and fourth terms are the reallocation of capital and labor, represented by R_t^K and R_t^L respectively. The fifth term in (17) is zero since we assume land is constant and exist in one sector only.

A positive R_t^K or R_t^L means that capital or labor are moving, on average, from low marginal product (low wage) sectors to high marginal product ones. A positive R_t^{VA}

means that, on average, smaller sectors are growing faster than larger sectors, where the size is measured by value added.

III. Constructing output and input indices for sectors

We now describe the construction of the sectoral inputs and outputs as defined in (1) and (2) above. This is based on a time series of input-output "Use" or "Activity" tables which consist of the interindustry section (dimensioned 29 commodities by 29 industries), the value added section, and the final demand section. These IO tables are constructed by the authors in cooperation with the Institute for Quantitative and Technical Economics, Chinese Academy of Social Sciences (IQTE). We start with the official tables produced by the State Statistical Bureau (SSB), and supplement it with other data. The procedures are explained in more detail in the Appendices.

Column *j* of the Use matrix gives us the value of each intermediate input, $U_{ij} = P_i^Z Z_{ij}, \quad i = 1,\ldots n = 29$, and the value of capital input ($P_{Kj} K_j$), labor input ($P_{Lj} L_j$), and net taxes (NT_j). The column sum gives us the value of gross output as described in (5) and (6) above:

$$(19) \qquad P_{Ijt} Y_{jt} = P_{Kjt} K_{jt} + P_{Ljt} L_{jt} + \sum_i P_{it}^Z Z_{ijt} + NT_{jt}$$

In Table 1, the values for gross output, capital input, land input (Agriculture), labor input, and net taxes are given for 1995. The sum of the three value added columns equals GDP for 1995.

(a) Intermediate input.

Row *i* of the Use matrix gives us the intermediate use of commodity *i* by all the industries plus the purchases of *i* by final demanders (consumption, investment, government and net exports). The row sum gives us the value of domestic use of *i*, which is the domestic output of *i*. Each commodity may be made by a few industries, and each industry may make a few commodities. The structure of commodity output is given by the input-output "Make" matrix, which is dimensioned 29 industries by 29 commodities. The prices of commodities ($P_i^Z, \quad i = 1,\ldots n$) should be derived by aggregating the price of domestic output with the price of imports (or from surveys covering both items). However, since there is little data on import prices, here we assume they behaved in the same way as domestic prices.[3] The price of domestic commodities is derived from the prices of industry output (P_{Ij}) using this Make matrix.[4]

The input-output matrices give information on the value of output. The issue of deflating them is the major concern of many papers. Here we shall use two alternative sets of prices for P_{Ijt}. In addition to the usual current Yuan input-output tables, the SSB has also made estimates of constant Yuan tables for various years -- 1981, 83, 87, 90, 92, 95 -- as reported in Hsueh and Li (1998). Using the sectoral gross output from these two sets of IO tables, and interpolating the years in between, we get our first set of deflators. We also constructed an alternative set using the "ex-factory price indices of industrial products" given in the China Statistical Yearbooks (State Statistical Bureau) (details in the Appendix). Hereafter we shall refer to this source as CSY. This second set uses the producer prices where available, mostly in manufacturing, and where they are not, we revert to the IO based ones.

Combining the current Yuan industry output data in the IO table with these deflators we derive the quantity indices of sectoral output (Y_{jt}), as well as indices of the quantity of intermediate inputs (Z_{ijt}). To do this we assume that all purchasers pay the same price for a given commodity. This is, of course, not very accurate in the period of controlled prices and favored sectors. Adjustments for this have to wait for the construction of more detailed price indices. The data used to derive the IO matrices and prices are described in Appendix A.

Given the price and quantity of input i for each sector j from the above procedure, we define the intermediate input aggregate as a Divisia index of all the components:

$$(20) \qquad d\ln Z_{jt} = \sum_i \bar{v}_{ijt}^Z d\ln Z_{ijt}, \qquad v_{ijt}^Z = \frac{P_{it}^Z Z_{ijt}}{P_{Zjt} Z_{jt}}$$

where $P_{Zjt} Z_{jt} = \sum_i P_{it}^Z Z_{ijt}$ is the total value of intermediate inputs for sector *j* and P_{Zjt} is the price index for aggregate material input into j. These are the terms that enters into eqs. (3) and (4) in the calculation of the productivity index for *j*.

[3] Young (2000) used Hong Kong trade data to estimate an import price index for China. Expanding approximations like this could provide better estimates in the future.

(b) Capital input.

The flow of capital services is derived by aggregating over two asset classes -- structures and equipment. Our method involves distinguishing between the stock of assets and the flow of services derived from them is described in detail in Jorgenson, Gollop and Fraumeni (1987). We shall merely summarize the methods here but will discuss our adaptations to the Chinese case.

The stock of capital of type k in sector j (S_{kjt}) is accumulated from the flow of investment using the perpetual inventory method :

(21) $S_{kjt} = (1-d_k)S_{kjt-1} + I_{kjt}$, k=structure, equipment

where I_{kjt} is the real investment in asset k, and d_k is the geometric depreciation rate. The real investment is given by the data on value of investment divided by the price of capital goods:

(22) $I_{kjt} = VI_{kjt} / PI_{kt}$

The total stock of capital for sector j is the aggregate of the two types:

(23) $d \ln S_{jt} = \sum_k \bar{v}^S_{kjt} d \ln S_{kjt}$ $v^S_{kjt} = \frac{PI_{kt}S_{kjt}}{\sum_a PI_{at}S_{ajt}}$

Each of the asset types generate a flow of services in period t proportional to the stock that was in place at the end of t-1 ($K_{kjt} \propto S_{kjt-1}$), at a rental cost P_{Kkjt} . The taxation of capital income has undergone many frequent changes in the 1990s and here we shall take a highly simplified view of it to express the rental cost (i.e. a simplification of the detailed formulas for the U.S. in Jorgenson, Gollop and Fraumeni 1987). We express the rental cost of one unit of the capital stock S_{kjt-1} used in period t in sector j as:

(24) $P_{Kkjt} = [r_{jt} + (1+p_{kt})d_k]PI_{kt-1}$

where r_{jt} is the nominal rate of return in sector j, and $1+p_{kt} = PI_{kt} / PI_{kt-1}$ is the rate of asset inflation.

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[4] The details of relation between industries and commodities, and between domestic and imports, are given in Garbaccio, Ho and Jorgenson (1999).

The total value of capital services is given by the capital row of the Use matrix, as expressed in eq. (19) above. The values for 1995 are given in Table 1 in the column marked "Capital Input". The rate of return is calculated such that the sum of the services over all asset types is equal to this sectoral value:

(25) $$P_{Kjt} K_{jt} = \sum_k P_{Kkjt} K_{kjt} = \sum_k P_{Kkjt} S_{kjt-1}$$

With this we can now give the expression for the quantity of capital services in eqs. (2) and (3) as the aggregate of all assets :

(26) $$d \ln K_{jt} = \sum_k \bar{v}^K_{kjt} d \ln K_{kjt} = \sum_k \bar{v}^K_{kjt} d \ln S_{kjt-1} \ ,$$

$$v^K_{kjt} = \frac{P_{Kkjt} K_{kjt}}{\sum_a P_{Kajt} K_{ajt}}$$

That is, the weight for each asset type is the rental cost which depend on the common rate of return and an asset specific rate of depreciation. This makes our capital input index different from those that use a simple linear sum of asset types.

The data sources for capital input and construction of the above elements are described in the Appendix. These are also constructed in cooperation with IQTE. Appendix Table A1 gives the time series for our estimates of the national capital input.

(c) Labor input.

The labor input used in this study is constructed by combining the value estimates from the above IO matrices and data from a labor force surveys conducted by our study partner, the IQTE. The methodology follows very closely the one in Jorgenson, Gollop and Fraumeni (1987) and Ho and Jorgenson (1999). We divide the work force by sex, age and educational attainment and aggregate them consistently, $L_{jt} = f(L_{1jt}, ..L_{ljt}, ..L_{70jt})$. The two sexes, seven age groups and five educational classes give us a total of 70 labor categories for each sector. The groups are:

Educational Attainment
1. University
2. Other Tertiary or Diploma
3. Senior High School
4. Junior High School
5. Primary School or less

Age groups
1. 0-19 years old
2. 20-24
3. 25-29
4. 30-39
5. 40-49
6. 50-55
7. 56+

We begin by assuming that effective labor services for each category of labor in sector j is proportional to the hours worked by all workers in that category :

(27) $L_{ljt} = q_l^L H_{ljt}$, l=1,2,...70

The proportionality constant is represented by q to denote "quality". This is assumed to be constant over time. The total annual number of hours worked is ideally the product of the number of workers, the average hours per week, and the average weeks per year:

(28) $H_{ljt} = N_{ljt} h_{ljt} w_{ljt}$

We, however, do not have data on hours and weeks by category of worker and therefore have to assume[5] :

(28') $H_{ljt} = N_{ljt} * \text{constant}$

The number of workers for 1995 is given in the last column of Table 1. As with the capital input in (26), we define the growth of total real labor input as a weighted average of the growth rates of all the categories:

(29) $d \ln L_{jt} = \sum_l \bar{v}_{ljt}^L d \ln L_{ljt} = \sum_l \bar{v}_{ljt}^L d \ln N_{ljt}$,

$$v_{ljt}^L = \frac{P_{Lljt} L_{ljt}}{\sum_{a=1}^{70} P_{Lajt} L_{ajt}}$$

The second equality in (29) is given by (27) and (28'). The value shares are the compensation shares, where P_{Lljt} is the annual cost of a category l worker. The relative costs of the different types of workers are estimated from compensation surveys as

[5] Jefferson, Rawski, Wang and Zheng (2000) adjust for the shortening of the work week during this period. Such an adjustment here would raise the estimate of productivity growth of all sectors. However, unless there is sectoral data on hours, there would be no effect on our relative rankings across sectors.

described in the Appendix. The actual value of P_{Lljt} is scaled such that the sum over all categories of workers is equal to the total value of labor compensation in *j* as given by the Input-Output table (eq. 19) (Table 1, column marked "Labor input") :

(30) $$P_{Ljt}L_{jt} = \sum_{l} P_{Lljt}L_{ljt}$$

This labor input index, L_{jt}, is the one that enters into eqs. (3) and (4) for the sectoral productivity calculation, and P_{Ljt} is the price index of this labor input. We may now define an index of "quality of sectoral labor input", or index of compositional change, as the ratio of labor input to a simple linear sum of hours :

(31) $$q^L_{jt} = \frac{L_{jt}}{H_{jt}}, \qquad H_{jt} = \sum_{l} H_{ljt}$$

A rising q^L_{jt} means that the work force is getting a bigger share of higher paid categories (e.g. relatively more highly educated workers). Since the wages for the different categories for much of this period are not very different, compared, say, to those of the post War U.S. (Ho and Jorgenson 1999), a given change in the quality index for China may come from sources quite different from the U.S. change.

We should perhaps remind the reader here how this relates to the economy aggregate labor input as given in (13) above. National labor input, L_t, is the Divisia aggregate over all 70 categories of labor input, $L_{lt} = \sum_{j} L_{ljt}$, where each category is the simple sum over the 29 industries. That is, L_{lt}, is not a Divisia aggregate of the workers in the different industries. The labor reallocation effect is given by the fourth term of eq. (17). We may also define an index of compositional change (which excludes sectoral changes) for the aggregate labor input in a way similar to (31) :

(32) $$q^L_t = \frac{L_t}{H_t}, \qquad H_t = \sum_{l} H_{lt} = \sum_{l}\sum_{j} H_{ljt}$$

The construction of the labor indices is described in Appendix C. Appendix Table A2 gives the times series for the national labor input.

IV. Sectoral Productivity Change

We begin by giving summary statistics of our data to provide some comparisons to other estimates. A snapshot view for one year, 1995, is given in Table 1. The largest sector by value added or gross output is Agriculture, the smallest is Other Manufacturing. The sector with the largest stock of reproducible capital is the Utilities, household services and real estate sector, while the sector with the highest employment outside of agriculture is Commerce (Wholesale, retail and restaurants). The sum of capital, land, labor input and net taxes is GDP, which was 5850 bil. *yuan* in 1995.

Table 2 gives the growth rates of output and inputs averaged over 1981-95. As mentioned in the previous section we have two sets of deflators for output – one based on SSB's real IO estimates, and one based on the producer (factory gate) prices. Let us label them "IO" and "PPI". The first two columns gives the annual growth rate of each sector's output for each set of real output estimates.

Output growth has been rapid in all sectors of the economy using either deflator. However, the growth rates are generally higher using the IO deflators than using the PPI. These average growth rates mask substantial variation and differences for any given year. How reasonable are these estimates? In our previous paper, Garbaccio, Ho and Jorgenson (1999a) we have discussed the problems of deverticalization, i.e. enterprises breaking up their vertical production process into different companies. This raises the measured nominal gross output for some sectors even though there is no change in total value added or final demand. We will leave the task of adjusting for this for future work and accept the nominal values as correct. Our judgements about the estimates of real growth rates are thus judgements of the deflators, but one should keep this issue in mind.

One way to have a sense of real output would be to examine the data on output of specific commodities, as in Rawski (2000). This is of course difficult for industries with many heterogenous products. For Building Materials, the growth rates estimated in Table 2 are 17.7%(IO) and 12.6%(PPI), and if we turn to the tons of cement produced, (CSY1997 Table 12-20) the growth rate is 12.6%. For Primary Metals they are 11.8%(IO) and 9.1%(PPI) compared to the growth rate of tons of steel, 6.5%. For Electric Power, Steam and Hot Water they are 7.3%(IO) and 9.7%(PPI) compared to the growth rate of kilowatt-hours, 8.4%.

Another angle to gauge the plausibility of the estimates is to calculate real GDP using the final demand section of the IO tables. Our time series of IO matrices include the current Yuan value of consumption, investment and net exports by the 29 commodities. The sum of this is scaled to the official nominal GDP in CSY1999. If one maintains the assumption that all buyers of a particular commodity group pays the same price, then one can deflate these final demand categories with the above output deflators. Again, because we do not have good import deflators we are forced to assume that they are the same as domestic prices. We aggregated over the 29 commodities using the Divisia method and the results are given in the row marked "GDP" in the first two columns of Table 2. The IO based deflators give us a real GDP growth over 1981:95 of 11.7% per annum, while the PPI data give 9.7%. This is to be compared to the official 10.5% growth rate (calculated from CSY1999). Since there seem to be some consensus that the official growth data prior to 1998 is somewhat overestimated while data after 1998 is very exaggerated (e.g. Rawski 2000) both indices seem plausible for the whole period, with the PPI being preferred. The performance of the two deflators for different subperiods are different and will be examined in future exercises.

We should emphasize that these are not our preferred deflators for GDP, the exercise was just to show that the results if we used average sectoral output deflators and applied them to final demand by commodities. Furthermore, the time series data for final demand by commodities do not exist for China (nor for the U.S.), these are the estimates from our exercise in interpolating IO tables.

The growth of sectoral capital and labor input are reported in the next two columns of Table 2. Recall that our factor inputs are aggregate indices of the components, as given in eqs. (26) and (29). The change in quality of the inputs are given in the last two columns, recall that capital quality is the ratio of input to stock, and labor quality is the ratio of input to number of workers.

The growth in capital quality are half negative but small in all cases, so the growth in stock is similar to the growth in capital input. The growth rates for capital are very high, in many cases higher than the growth rate of output. This may seem to be an overestimate, and could be due to poor guesses of the initial sectoral capital stock or due to poor deflators of investment. This is especially so for the Electronic and telecommunication equipment sector where there was a large jump in investment in 1986.

The change in labor input is as expected, with a small change in agriculture and larger growth in manufacturing and construction. The quality change in labor is modest, less than half a percent per year in most cases. (This does not mean that the economy wide labor quality is so slow, the reallocation effect is examined in the next section.) The output and input estimates for "Instruments" and "Other Manufacturing" do not seem sensible, this is probably due to the changing classification over time of these sectors.

We now turn to changes in total factor productivity as defined in eqn. (3). All five terms in eq. (3), averaged over the sample period, are reported in Table 3 for the IO set and in Table 4 for the PPI set. The columns for intermediate, capital and labor contributions are the growth rates multiplied by the value shares exactly as written in the equation. The growth rates of TFP are quite varied across sectors with a few implausible estimates. Oil & gas mining, Electricity, and Finance & Insurance show large falls in productivity over the 15 year period for both sets of output estimates. For the IO deflated output, Transportation Equipment, Other Manufacturing, and Public Administration showed very high TFP growth. Of the 16 manufacturing sectors 4 have negative productivity change. And of the 7 service sectors 4 have a small negative change, and 3 have large positive change.

The PPI based estimates have lower output growth for many sectors, but because of the input-output framework, that means there is also lower intermediate input growth for all sectors. Table 5 reports the two TFP estimates side by side. By and large, the TFP estimates here are lower, 14 of the 29 sectors have negative growth, many implausibly high ones. Most of the negative growth sectors are in manufacturing where we have the producer prices. The two sets of deflators for services are similar, and since the PPI set generated lower output growth, and hence lower intermediate input growth, the TFP growth for some services are higher in the second set of estimates.

Turning back to the contribution of intermediate inputs, capital and labor in Tables 3 and 4, one can see that the slow growth of the Chinese labor force applies to all sectors, with the biggest contribution in Commerce and Construction. Capital contribution is highest in the Finance & Insurance, Electricity, Electronic &

telecommunication equipment, and Transportation sectors. For intermediate inputs, the smallest contributions are in the service sectors most notably Utilities, household services & real estate.

The largest sector in economy, agriculture, shows good productivity growth in both sets of data, some two and a third percent per year. Land input growth was set at zero lacking any better estimate but this would have only a small effect on the TFP numbers given that any growth is likely to be small. Improvements to land in the form of construction is taken into account in the capital stock estimates. The contribution of TFP growth to output growth in Agriculture (i.e. 2.4% out of 7.3%) is only second to that of the Public Administration sector in Table 3 with the IO measure, and is the highest contributor in Table 4 with the PPI measure.

The public sector is poorly measured with an implausibly high TFP growth rate of 5.2% using the IO constant yuan tables. In Table 4 with the PPI data set, the Public Administration output is deflated by a weighted average of the wage index of government staff and GDP deflator, this lowers the output growth rate by a quarter and the TFP growth rate is cut in half.

Among manufacturing, the "high tech" sector, Electronic and telecommunications equipment (#20), shows the highest growth rate of output. Our estimates, however, also showed a very unusual jump in the capital stock in 1986 without a corresponding jump in output. This could be due to a number of reasons, an important one being the assumption of common asset price deflators across all sectors, and the lack of an explicit producer price index for this sector.

The manufacturing sector that has been emphasized by the government is the Transportation equipment sector (#18) which makes motor vehicles. This has a growth rate second only to the Electronic equipment sector, but unlike it, has a high positive estimated TFP growth. This may reflect the transfer of foreign technology and management pratices into the car making enterprises. Apparel is a major export sector in the post-reform China and but here the two sets of estimates diverge quite a bit, the IO based estimates give a TFP growth rate of 2.6% per annum while the PPI based one give –0.3%, reflecting the difference in estimated output growth.

The biggest sector in terms of value added, after Agriculture, is Commerce. For this sector we had to rely on the deflators for sectoral GDP given in the CSY. This leads to a growth rate of less than 8%, less than overall official GDP growth. This, however, has one of the highest growth rates of employment, giving a –1.0% TFP growth rate. While one may be skeptical about the deflator for this difficult to measure sector, this may reflect the entrance of many small retail shops and restaurants in the 1990s, radically changing the structure of this industry.

The Oil & gas mining sector has a large negative estimated TFP growth. As we noted, we do not have estimates of land input for the mining sectors and this may well play a role in producing such an implausible estimate. Another point to note is the large effect of the economic reforms during this period on prices of this sector. This produces very unusual changes in the rates of return to capital.

V. Aggregate Productivity Change and Sectoral Contributions

As we have reviewed in the Introduction there are several estimates of Chinese aggregate productivity performance. Here we use our sectoral accounts to build up aggregate GDP as described in Section II above. The typical approach would take the an estimate of real GDP, capital and labor inputs and apply something like eq. (14), assuming that an aggregate production function exists, i.e. assuming perfect substitution among sectors.

Here we also apply eq. (14) but use our estimate of aggregate real value added, not the official estimate of real GDP. Our nominal GDP is scaled to the official one as explained in the Appendices, and GDP at factor cost is obtained by subtracting estimated net taxes on production. Our real GDP is given by the sum of the sectoral real value added (eq. 10) and the sectoral value added is given by subtracting the intermediate input index from the output index (eqs. 3,8). The intermediate input index depends on the prices of commodities and thus we calculate two alternative estimates of real aggregate growth using the IO deflators and PPI deflators.

Table 6 reports the growth rate of this GDP based on the IO deflators in the first line. Compared to the official growth rate of 10.5% our measure grew at 8.8% per annum. The contributions of capital, labor and TFP growth, i.e. the components of eq. 14, are given in lines 4 through 6. The contributions of the primary factors are the growth rates multiplied by the value shares. We note again that land contributes zero by assumption, and left out of the table. In this case with the IO deflators, of the 8.8% GDP growth, capital contributed 6.1%, labor 1.6% and aggregate TFP growth 1.1%. TFP growth was slower in the 1980s compared to the 1990s.

If we turn to Table 7 which is identical to Table 6 except that output and intermediate inputs are calculated using the PPIs, then GDP growth is 8.0% per annum and TFP growth is a smaller 0.3%. This is, however, the average of the negative shock of 1989, and the rapid growth after 1990. In both sets of output definitions the contribution of capital accumulation is the dominant factor, contributing 6.1%. If one believes the capital growth to be too high (due to low deflators say) then correcting for it will raise the estimated TFP growth.

The decomposition of factor growth into quantity and quality change is given in lines 7-10 of Tables 6 and 7. There is virtually no change in the quality, or composition, of capital. (The details of the time series of aggregate capital input are given in Appendix Table A1.) Of the 1.6% annual growth in labor input, 0.5% of it is due to changes in the composition of the total work force. While the individual sectors' labor quality indices are changing a little more slowly, the shift of workers out of agriculture into the rest of the economy parallels the rise in average educational attainment. Thus the rise in aggregate quality is higher than the sectoral quality indices given in Table 2. (See Appendix Table A2 for further details.)

We next turn to the decomposition of this aggregate TFP growth to the components given in eq. 18. That breaks up aggregate TFP growth into the Domar weighted sum of sectoral TFP growth, reallocation of value added, capital and labor. These are given in the last four lines of Tables 6 and 7. In the IO case, of the 1.1% TFP growth, 2.2% is due to the sectoral TFP growth, -1.7% to reallocation of value added, 0.5% to reallocation of capital input, and 0.1% to reallocation of labor. That is, individual sectors of the economy performed well, but the sectors that expanded relatively more included the poor performers. The movement of labor out of low wage agriculture into higher wage sectors contributed a small number to aggregate TFP growth, while the movement of capital contributed more. For the PPI case the 0.3% aggregate TFP growth is made up of 0.6% sectoral TFP, -0.9% reallocation of value added, and the same 0.5%, 0.1% for the reallocation of capital and labor.

To give a complete picture of the sectoral TFP contributions to aggregate TFP (the first term on the right hand side of eq. (18), $\sum_j D_j d\ln A_{jt}$), we list each sector's contribution in Tables 8 and 9. The first column gives the Domar weight, D_j, which is the value of gross output of j divided by GDP at factor cost. The third column gives $D_j d\ln A_{jt}$, while the last column is the sector share of summed sectoral TFP growth, $D_j d\ln A_{jt} / \sum_j D_j d\ln A_{jt}$. We can see that of the 2.16% summed growth, agriculture is the biggest contributor by far with 1.12%, followed by Electronic Equipment with 0.32%. The dampers are Paper with -0.29% and Building Materials with -0.26%.

The picture is slightly different in Table 9 with the PPI deflated estimates. Of the 0.58% growth in the sum of weighted TFP, Agriculture contributed 1.16%, and Transportation equipment 0.30%, while Commerce contributed -0.23% and Metal Products -0.37%.

Comparison with other studies

There are few published studies at the level of detail here that we can directly compare our results to. Jefferson, Rawski, Li and Zheng (2000) used the Industrial Census data to estimate productivity in the Industrial sector (mining, manufacturing and electricity). Aggregating over all ownership forms they report a TFP growth rate of 2.8% for 1980-96 and a rapid 4.7% for the 1984-88 period. If we add up the Domar-weighted TFP growth for our corresponding industrial sectors we get 0.56% per annum, 1981-95, for the IO based estimates. That is, of the 2.16% aggregate weighted productivity, agriculture contributed 1.12% and industry contributed 0.56%. For the PPI based estimates the industrial sectors contributed a -0.86% of the total 0.58% TFP growth. These differences are probably due in part to use of different output and input deflators. As Jefferson, et.al. emphasized, the intermediate input deflators that they use show a higher rate of inflation than the output price deflators. In our input-output framework, these prices diverge only to the extent that tax and subsidy rates change over time. They may also diverge if intermediate buyers and final demanders face very different inflation rates, however, we do not have deflators for final demand to sort this out.

Woo (1998) divided the economy into primary, industrial, construction and tertiary sectors, revised the official GDP and estimated TFP under various assumptions of the labor share. For the period 1979-93 under the central assumption, he revised the official GDP growth rate from 9.1% to 8.0%, and estimated an aggregate TFP growth of 1.75%. This is decomposed to 0.6% net TFP growth (strictly speaking, net and capital reallocation) and 1.1% labor reallocation effect. The magnitude of our adjustment to official GDP is the same for a slightly different sample period, and our aggregate TFP growth is 1.1%(IO) and 0.3%(PPI) compared to his 1.75%. Our estimation of the labor reallocation effect over the 29 sectors is however much smaller, possibly due to the inclusion of a quality element in labor input and the treatment of land.

Alwyn Young (2000) recalculated GDP growth in the 1978-98 period using alternative expenditure deflators and gave 6.1% compared to the official 7.8%. Using a labor measure that includes compositional change like ours here, he estimated that TFP growth in the non-agriculture sector to be some 1.4% per annum. Ours is quite a bit lower for a shorter sample but in the same range of uncertainty, our overall GDP TFP growth is 1.1% and agriculture's is 2.2%. Our lower estimate is probably due to our higher rate of capital input growth.

VI. Conclusion

We have laid out a methodology to account for Chinese economic growth, both at the sectoral level and the aggregate level. Our input-output approach covers the whole economy, both the well and poorly measured sectors. This forces one to employ a consistent set of accounts, where estimates of the output and productivity performance of one sector have immediate effects on the estimates of other sectors.

"Well-measured" is a relative term, we discussed the various uncertainties about the data, and the assumptions that one needs to make in such an exercise. As a contribution to improving the data for productivity studies we introduced a new data set for labor input which takes into account the age and educational attainment of workers. In addition we generated a time series of IO tables that we have endeavored to make consistent over time.

Our results at this stage are suggestive. The agriculture sector showed good productivity gains, as did many manufacturing sectors. However, many other manufacturing industries showed negative productivity growth. The reallocation of capital and labor to the high marginal product sectors helped raise aggregate TFP growth and could continue to do so.

Definitive statements of Chinese productivity in this period will take quite a bit more data improvement and time, if ever. Overall, the results point to a need to improve the estimates for deflators (output and investment) and estimates of initial sectoral capital. The reliability of the gross output data has been commented on by many others. We believe they are also afflicted by the deverticalization problem discussed above and devising methods to adjust for it would be an important improvement.

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Table 1. Sectoral characteristics of the economy in 1995

	Sector	Output bil. Yuan	Capital Input bil. Yuan	Labor input bil. Yuan	Net Taxes bil. Yuan	Capital Stock bil. Yuan	Employment million
1	Agriculture	2034.5	158.95	601.41	33.19	1142.2	356.49
	(Land input)		406.8				
2	Coal mining	170.2	26.97	46.58	7.32	437.6	8.42
3	Oil & Gas mining	167.1	62.32	12.52	17.14	403.2	1.78
4	Metal ore mining	80.1	12.11	14.26	2.01	113.5	1.62
5	Non-metallic ore	145.1	25.58	25.90	10.72	304.8	1.72
6	Food processing	1056.7	126.90	45.91	179.97	453.5	8.01
7	Textiles	800.5	62.40	70.93	26.74	504.1	12.44
8	Apparel	563.6	79.23	34.89	16.88	144.7	5.97
9	Lumber, Furniture	179.5	25.32	17.99	9.17	76.5	2.21
10	Paper	458.1	54.20	37.96	25.22	210.4	5.25
11	Electric power, Steam	280.1	82.94	19.36	31.67	916.3	2.79
12	Petrol refining	276.9	36.91	15.89	18.06	176.0	1.07
13	Chemicals	1129.1	144.04	80.36	59.47	1218.3	12.44
14	Building materials	661.8	95.42	76.96	43.99	430.9	11.29
15	Primary metals	763.9	88.55	66.46	41.32	514.0	6.60
16	Metal products	402.2	48.06	30.84	16.49	164.0	4.27
17	Machinery	849.2	82.64	101.24	35.78	683.2	11.62
18	Transportn. equip	392.6	38.42	33.10	18.64	388.2	6.22
19	Electric machinery	416.6	55.86	28.45	15.92	205.6	5.23
20	Electronic equip.	315.0	57.59	15.01	9.75	287.0	3.18
21	Instruments	43.6	4.77	6.01	1.86	49.2	1.43
22	Other manufacturing	40.1	5.06	3.26	1.79	191.6	5.28
23	Construction	1340.6	139.34	204.75	37.92	137.5	35.87
24	Transp & comm	527.2	132.75	146.85	20.35	407.1	20.97
25	Commerce	1100.4	399.27	160.09	29.30	1018.0	46.34
26	Utilities, Household svcs, Real estate	430.7	147.83	82.56	21.38	5423.8	7.59
27	Educ, health, etc.	447.2	50.54	173.10	7.23	1008.1	22.69
28	Finance & insurance	245.9	70.72	51.63	28.84	117.2	3.85
29	Public admin	340.2	28.30	132.06	0.24	596.4	11.25
	Total	15659	2750	2336	768	17723	624

Table 2. Sectoral output and inputs (growth rates % per annum)

	Sector	Output (IO) 1981:95	Output (PPI) 1981:95	Capital input 1981:95	Labor input 1981:95	Capital quality 1981:95	Labor quality 1981:95
1	Agriculture	7.3	6.4	10.6	1.6	0.59	0.42
2	Coal mining	8.9	6.7	11.0	2.9	0.46	0.19
3	Oil & Gas mining	4.4	4.5	8.8	9.0	0.94	0.69
4	Metal ore mining	12.0	12.3	10.5	3.5	0.50	0.12
5	Non-metallic ore	13.3	13.9	16.7	6.8	-0.04	0.52
6	Food processing	11.6	9.5	15.6	5.9	-0.02	0.77
7	Textiles	11.1	7.7	13.3	3.7	0.24	0.34
8	Apparel	19.4	14.1	19.8	4.9	-0.64	-0.28
9	Lumber, Furniture	17.1	13.8	17.0	1.7	-0.88	0.38
10	Paper	16.3	12.0	17.8	5.2	-0.33	0.55
11	Electric power, Steam	7.3	9.7	15.6	6.0	0.52	0.28
12	Petrol refining	11.0	10.0	13.5	12.7	0.27	0.60
13	Chemicals	15.7	11.3	17.0	4.8	-0.34	-0.11
14	Building materials	17.7	12.6	16.0	4.9	-0.34	0.63
15	Primary metals	11.8	9.1	13.2	4.5	0.21	0.20
16	Metal products	18.8	15.5	21.0	3.0	-0.59	0.45
17	Machinery	16.4	12.6	26.5	1.4	0.02	0.34
18	Transportn. equip	21.0	15.4	8.0	4.6	-0.24	0.25
19	Electric machinery	20.7	21.0	36.0	5.0	-0.99	0.24
20	Electronic equip.	23.8	23.9	47.6	5.7	-1.21	0.10
21	Instruments	16.7	17.2	39.6	0.5	-0.13	0.85
22	Other manufacturing	16.0	8.9	5.8	1.7	0.23	-0.35
23	Construction	12.5	11.6	10.0	9.7	-0.10	0.52
24	Transp & comm	10.5	11.7	9.8	6.8	0.40	0.22
25	Commerce	7.6	6.7	12.7	8.3	0.45	0.07
26	Utilities, Household svcs, Real estate	16.8	15.7	17.7	5.8	-0.12	-0.71
27	Educ, health, etc.	12.3	11.1	11.5	2.9	0.28	0.48
28	Finance & insurance	10.4	10.6	17.0	7.3	-0.38	0.26
29	Public admin	14.4	11.0	9.4	5.2	0.18	0.23
	GDP	11.7	9.7				
	GDP(official)	10.5					

Notes: Output(IO) is that derived from constant Yuan IO tables,
Output(PPI) is that derived from producer price indices.
Capital and labor input are as defined in eq. (26) and (29).

Table 3. Contributions to growth in sectoral output (IO) 1981-95 (% per annum)

	Sector	Output (IO)	Interme-diate	Capital	Labor	TFP
1	Agriculture	7.30	3.58	0.82	0.53	2.37
2	Coal mining	8.94	5.47	1.90	0.81	0.76
3	Oil and gas mining	4.40	4.22	3.82	0.30	-3.94
4	Metal ore mining	11.96	9.23	2.43	0.43	-0.14
5	Non-metallic ore	13.30	8.72	5.28	1.24	-1.94
6	Food processing	11.60	9.48	2.18	0.31	-0.37
7	Textiles	11.13	8.84	1.79	0.28	0.22
8	Apparel	19.40	13.62	2.71	0.46	2.61
9	Lumber, Furniture	17.12	12.13	2.73	0.18	2.08
10	Paper	16.28	10.60	2.30	0.40	2.97
11	Electric power, Steam	7.35	7.53	5.45	0.33	-5.97
12	Petrol refining	11.02	7.98	2.30	0.34	0.40
13	Chemicals	15.67	11.67	3.15	0.31	0.54
14	Building materials	17.72	11.60	3.24	0.79	2.09
15	Primary metals	11.84	9.90	2.44	0.24	-0.74
16	Metal products	18.85	12.61	2.94	0.29	3.01
17	Machinery	16.44	11.08	5.79	0.20	-0.63
18	Transportn. equip	21.03	14.77	1.12	0.35	4.79
19	Electric machinery	20.70	14.28	5.41	0.36	0.64
20	Electronic Equip.	23.82	16.71	7.53	0.36	-0.78
21	Instruments	16.66	9.38	4.94	0.24	2.09
22	Other manufacturing	15.97	10.25	0.83	0.16	4.73
23	Construction	12.47	10.44	0.62	1.43	-0.02
24	Transp & comm	10.48	5.93	3.67	1.28	-0.40
25	Commerce	7.57	5.24	1.81	1.50	-0.97
26	Utilities, Household svcs, Real estate	16.82	6.76	5.73	1.04	3.29
27	Educ, health, etc.	12.27	7.05	1.58	0.85	2.78
28	Finance & insurance	10.36	5.97	11.36	0.60	-7.57
29	Public admin	14.37	6.56	0.80	1.80	5.21

Note: The contribution of capital, labor and intermediate is their growth rates multiplied by their value shares.

Table 4. Contributions to growth in sectoral output (PPI) 1981-95 (% per annum)

Sector	Output (PPI)	Interme-diate	Capital	Labor	TFP
1 Agriculture	6.39	2.84	0.82	0.53	2.20
2 Coal mining	6.68	4.37	1.90	0.81	-0.41
3 Oil and gas mining	4.50	3.54	3.82	0.30	-3.16
4 Metal ore mining	12.26	8.29	2.43	0.43	1.11
5 Non-metallic ore	13.89	7.78	5.28	1.24	-0.40
6 Food processing	9.50	8.31	2.18	0.31	-1.30
7 Textiles	7.74	6.75	1.79	0.28	-1.08
8 Apparel	14.14	11.27	2.71	0.46	-0.29
9 Lumber, Furniture	13.76	10.37	2.73	0.18	0.48
10 Paper	12.01	8.50	2.30	0.40	0.80
11 Electric power, Steam	9.71	6.87	5.45	0.33	-2.94
12 Petrol refining	10.05	7.46	2.30	0.34	-0.04
13 Chemicals	11.31	9.65	3.15	0.31	-1.79
14 Building materials	12.62	10.13	3.24	0.79	-1.54
15 Primary metals	9.06	8.50	2.44	0.24	-2.11
16 Metal products	15.51	10.63	2.94	0.29	1.64
17 Machinery	12.64	9.21	5.79	0.20	-2.56
18 Transportn. equip	15.41	12.06	1.12	0.35	1.88
19 Electric machinery	21.01	12.52	5.41	0.36	2.72
20 Electronic Equip.	23.95	15.89	7.53	0.36	0.18
21 Instruments	17.24	8.23	4.94	0.24	3.83
22 Other manufacturing	8.92	7.70	0.83	0.16	0.23
23 Construction	11.60	8.26	0.62	1.43	1.29
24 Transp & comm	11.74	5.05	3.67	1.28	1.74
25 Commerce	6.75	4.39	1.81	1.50	-0.95
26 Utilities, Household svcs, Real estate	15.75	5.95	5.73	1.04	3.03
27 Educ, health, etc.	11.14	5.88	1.58	0.85	2.83
28 Finance & insurance	10.59	5.50	11.36	0.60	-6.87
29 Public admin	10.98	5.78	0.80	1.80	2.61

Note: The contribution of capital, labor and intermediate is their growth rates multiplied by their value shares.

Table 5. Sectoral total factor productivity growth (% per annum)

	Sector	TFP (IO)		TFP (PPI)	
		1981:95	1989:95	1981:95	1989:95
1	Agriculture	2.37	1.67	2.20	3.33
2	Coal mining	0.76	3.63	-0.41	-2.13
3	Oil and gas mining	-3.94	-4.44	-3.16	-8.53
4	Metal ore mining	-0.14	4.44	1.11	5.88
5	Non-metallic ore	-1.94	6.86	-0.40	9.91
6	Food processing	-0.37	4.14	-1.30	0.18
7	Textiles	0.22	3.32	-1.08	-0.14
8	Apparel	2.61	5.51	-0.29	1.02
9	Lumber, Furniture	2.08	6.45	0.48	5.21
10	Paper	2.97	3.86	0.80	1.14
11	Electric power, Steam	-5.97	-8.72	-2.94	-3.52
12	Petrol refining	0.40	-1.28	-0.04	-0.54
13	Chemicals	0.54	3.57	-1.79	0.61
14	Building materials	2.09	7.58	-1.54	1.41
15	Primary metals	-0.74	1.52	-2.11	-1.99
16	Metal products	3.01	3.99	1.64	3.93
17	Machinery	-0.63	4.29	-2.56	3.03
18	Transportn. equip	4.79	4.76	1.88	0.48
19	Electric machinery	0.64	4.19	2.72	7.91
20	Electronic Equip.	-0.78	5.33	0.18	5.87
21	Instruments	2.09	1.89	3.83	5.96
22	Other manufacturing	4.73	1.30	0.23	-2.72
23	Construction	-0.02	1.19	1.29	0.80
24	Transp & comm	-0.40	-3.19	1.74	-0.35
25	Commerce	-0.97	-2.46	-0.95	1.11
26	Utilities, Household svcs, Real estate	3.29	-0.95	3.03	-0.18
27	Educ, health, etc.	2.78	-1.04	2.83	0.13
28	Finance & insurance	-7.57	-7.90	-6.87	-7.20
29	Public admin	5.21	2.13	2.61	-0.18

Table 6. Growth in Aggregate Output (IO) and its Sources

	1981-95	1981-89	1989-95
Value added	8.79	9.02	8.48
Capital input	13.22	14.55	11.44
Labor input	3.72	3.90	3.48
Contribution to aggregate growth (eq. 14)			
Capital	6.06	6.55	5.41
Labor	1.65	1.73	1.55
Aggr. TFP	1.07	0.74	1.52
Contribution of factor components			
Capital quality	-0.02	-0.02	-0.02
Capital stock	6.08	6.57	5.42
Labor quality	0.52	0.42	0.66
Labor hours	1.13	1.31	0.89
Contribution to aggr. TFP (eq. 18)			
Weighted sectoral TFP	2.16	0.16	4.82
Reallocation of value added	-1.70	-0.68	-3.07
Reallocation of capital	0.48	1.02	-0.22
Reallocation of labor	0.13	0.24	-0.01

Table 7. Growth in Aggregate Output (PPI) and its Sources

	1981-95	1981-89	1989-95
Value added	8.00	7.87	8.19
Capital input	13.22	14.55	11.44
Labor input	3.72	3.90	3.48
Contribution to aggregate growth (eq. 14)			
Capital	6.06	6.55	5.41
Labor	1.65	1.73	1.55
Aggr. TFP	0.29	-0.41	1.23
Contribution of factor components			
Capital quality	-0.02	-0.02	-0.02
Capital stock	6.08	6.57	5.42
Labor quality	0.52	0.42	0.66
Labor hours	1.13	1.31	0.89
Contribution to aggr. TFP (eq. 18)			
Weighted sectoral TFP	0.58	-1.26	3.04
Reallocation of value added	-0.91	-0.41	-1.58
Reallocation of capital	0.48	1.02	-0.22
Reallocation of labor	0.13	0.24	-0.01

Table 8. Domar-weight decomposition of productivity growth (IO deflated), 1981-95

	Sector	Domar weight	TFP growth	Weighted TFP growth	Share of agg TFP growth
1	Agriculture	0.470	2.372	1.123	0.520
2	Coal mining	0.010	-0.136	-0.005	-0.002
3	Oil and gas mining	0.165	0.219	0.006	0.003
4	Metal ore mining	0.067	2.969	0.198	0.092
5	Non-metallic ore	0.171	0.542	0.134	0.062
6	Food processing	0.049	3.006	0.161	0.074
7	Textiles	0.055	0.641	0.053	0.024
8	Apparel	0.014	4.728	0.066	0.030
9	Lumber, Furniture	0.226	-0.972	-0.178	-0.083
10	Paper	0.041	-7.570	-0.287	-0.133
11	Electric power, Steam	0.034	0.762	0.028	0.013
12	Petrol refining	0.024	-1.938	-0.037	-0.017
13	Chemicals	0.057	2.612	0.182	0.084
14	Building materials	0.039	-5.970	-0.256	-0.118
15	Primary metals	0.086	2.091	0.240	0.111
16	Metal products	0.142	-0.634	-0.086	-0.040
17	Machinery	0.039	-0.783	0.009	0.004
18	Transportn. equip	0.228	-0.020	0.021	0.010
19	Electric machinery	0.057	3.293	0.144	0.067
20	Electronic Equip.	0.060	5.215	0.320	0.148
21	Instruments	0.028	-3.943	-0.112	-0.052
22	Other manufacturing	0.153	-0.370	-0.038	-0.018
23	Construction	0.021	2.076	0.049	0.023
24	Transp & comm	0.038	0.403	0.017	0.008
25	Commerce	0.113	-0.740	-0.044	-0.020
26	Utilities, Household svcs, Real estate	0.046	4.791	0.214	0.099
27	Educ, health, etc.	0.009	2.091	0.018	0.008
28	Finance & insurance	0.089	-0.396	-0.058	-0.027
29	Public admin	0.100	2.784	0.281	0.130
	Aggregate weighted TFP growth			2.161	1.000

Note: The "weighted TFP growth" is the first term on the right of eq. (18): $D_{jt} d \ln A_{jt}$, where the weights are gross output divided by GDP.

Table 9. Domar-weight decomposition of productivity growth (PPI deflated), 1981-95

	Sector	Domar weight	TFP growth	Weighted TFP growth	Share of agg TFP growth
1	Agriculture	0.470	2.201	1.155	1.977
2	Coal mining	0.010	1.110	0.007	0.013
3	Oil and gas mining	0.165	-1.076	-0.194	-0.333
4	Metal ore mining	0.067	0.796	0.050	0.085
5	Non-metallic ore	0.171	-1.793	-0.272	-0.466
6	Food processing	0.049	1.644	0.100	0.171
7	Textiles	0.055	2.719	0.177	0.303
8	Apparel	0.014	0.226	0.002	0.003
9	Lumber, Furniture	0.226	-0.952	-0.204	-0.349
10	Paper	0.041	-6.873	-0.259	-0.443
11	Electric power, Steam	0.034	-0.407	-0.015	-0.026
12	Petrol refining	0.024	-0.405	0.002	0.004
13	Chemicals	0.057	-0.295	0.012	0.020
14	Building materials	0.039	-2.944	-0.132	-0.225
15	Primary metals	0.086	-1.544	-0.098	-0.168
16	Metal products	0.142	-2.557	-0.368	-0.630
17	Machinery	0.039	0.178	0.049	0.085
18	Transportn. equip	0.228	1.286	0.302	0.518
19	Electric machinery	0.057	3.032	0.123	0.211
20	Electronic Equip.	0.060	2.605	0.149	0.254
21	Instruments	0.028	-3.157	-0.105	-0.181
22	Other manufacturing	0.153	-1.297	-0.185	-0.317
23	Construction	0.021	0.483	0.010	0.017
24	Transp & comm	0.038	-0.037	0.015	0.027
25	Commerce	0.113	-2.113	-0.234	-0.400
26	Utilities, Household svcs, Real estate	0.046	1.882	0.050	0.086
27	Educ, health, etc.	0.009	3.830	0.035	0.059
28	Finance & insurance	0.089	1.743	0.133	0.228
29	Public admin	0.100	2.827	0.279	0.477
	Aggregate weighted TFP growth			0.584	1.000

Note: The "weighted TFP growth" is the first term on the right of eq. (18): $D_{jt} d \ln A_{jt}$, where the weights are gross output divided by GDP.

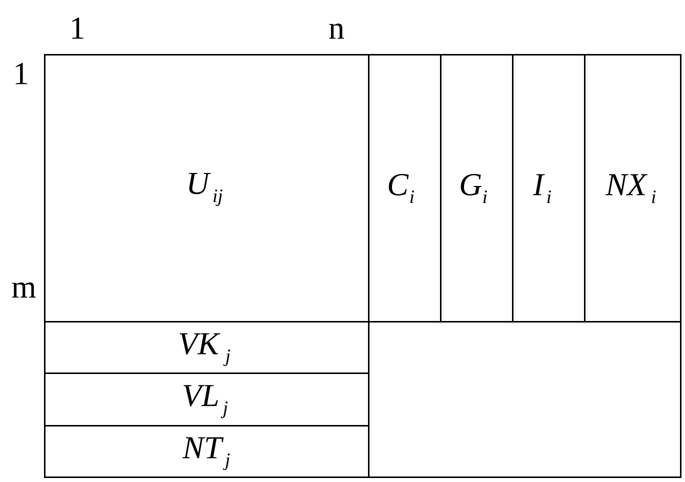
Appendices for "Sectoral Productivity Growth in China, 1981-95"

The Institute of Quantitative and Technical Economics, Chinese Academy of Social Sciences (IQTE) was our partner in producing the current version of the data set. An earlier data set for 1981-87 was generated in Li, Jorgenson, Zheng, Kuroda (1993) (hereafter LJZK). Appendices A, B and C here are in part a summary of the following reports produced by our IQTE collaborators (in Chinese): "Description of Input Output Table Data" by Gong Feihong; "Construction of Capital Data" by Guo Jinlong; and "Labor Data" by Chen Ping and Zhang Guochu.

Appendix A. Input Output data and deflators.

We describe here the construction of a time series of input output matrices 1981-95 based on the official benchmark tables produced by the State Statistical Bureau (SSB). The first official benchmark was for 1987 based on the System of National Accounts (SNA) but it ignored parts of the service sectors that were estimated in later official revisions of GDP. It also provided little information on production taxes by sector. An IO matrix for 1990 was also extrapolated from this benchmark by the SSB. The next benchmark IO table for 1992 (SSB 1996) was also based on the SNA and incorporated more complete data for services and taxes. Based on this benchmark the SSB then extrapolated a table for 1995.

These tables consist of two sets – the Use tables and the Make tables. The Use table consist of three sections, as illustrated below : (i) interindustry flows of intermediate inputs, dimensioned m commodities by n industries, (ii) value added matrix giving capital income, labor income and taxes on production for each of the n sectors, (iii) final demand matrix giving Consumption, Government, Investment, Net exports for each of the m commodities. The sum of column j gives the value of gross output (to purchasers) of industry j, the sum of row i gives the total demand for domestic commodities.



The Make matrix is dimensioned n industries by m commodities, the M_{ji} element is the value of type i commodity produced by industry j. The sum of the *j*th row of the Make matrix is equal to the gross output of j (the column sum of Use), and the sum of the *i*th column of Make equals the domestic output of commodity i (the row sum of Use).

The 1987 and 1992 benchmark tables both have Use tables for 33 industries and 33 commodities. (A more detailed table is also published but only for a "commodity by commodity" Activity matrix.) We aggregated the 33 sector table to m=n=29, as listed in Table 1.

The SSB has also went back to produce IO tables for 1981 and 1983 albeit with a smaller number of sectors. These tables were based on the Material Product System (MPS) and adjusted to the SNA in our previous study in LJZK. There IQTE produced a time series of IO matrices for 1981-87 based on these adjusted SSB tables.

The first task here was to revise the 1987 and 1990 tables to the new SNA based format that included a more complete accounting of the service sectors. This involved raising the value added for the tertiary sectors by the amount given in revised GDP accounts (China Statistical Yearbook 1997 Table 2-9, hereafter CSY97). The official IO tables are not exactly equal to GDP given different treatment of tariffs and certain imputations. We make simple adjustments so that they match, as in the Social Accounting Matrix described in Garbaccio, Ho and Jorgenson (1999b). The matrices are then rebalanced so that commodity supply is equal to commodity demand for each item. We then made a similar revision to the series for 1981-87 used in LJZK.

The SSB also produced a set of IO tables for those years – 1981,83,87,90,92,95 – that are based on "comparable prices" (Hsueh and Li 1998). From these sets of current and constant Yuan tables a set of deflators is generated for these years. For the years in between, the "Ex-factory prices of industrial products" from the China Statistical Yearbooks (CSY) are used for the manufacturing and mining sectors. For the service sectors the consumer price indices and sectoral GDP deflators were used. We refer to this set of deflators as the "IO" set.

The next task was to interpolate to get IO tables for 1988,89,91,93,94. This was first done for the constant Yuan tables using data on real commodity output. Using the sectoral growth rates for 87-88, 88-89, etc., the constant Yuan output is estimated from the benchmark years. For manufacturing and mining sectors, the tables for Industrial output in the CSY are used. For Agriculture, Construction, Transportation Post & Communication, and Commerce, the data from the table "Principal Aggregate Indicators on National Economic and Social Development" in the *China Statistical Yearbook* are used (CSY93 p. 51; CSY94 p. 20; CSY96 p. 24). Finally, for Public Utilities, Culture Education Health & Research, Finance & Insurance, and Public Administration the Tertiary sector value added is used (*The Gross Domestic Product of China, 1952-1995*, SSB 1998). These are crude approximations and reflect the state of accounting for services in China and elsewhere.

Multiplying this constant Yuan output with the price deflators we obtain the current *yuan* sectoral gross output for the non-benchmark years. Using the benchmark Make matrices this industry output is translated to commodity output for each of the 29 items. I.e. we assume that the pattern in 1992 holds for 93 and 94 too. The GDP tables in CSY99 give the value of consumption, government, investment and net exports for each year and thus provide control totals for the final demand section of the Use table. The total value added (capital, labor and net taxes) is also scaled to equal this nominal GDP. With this gross output, commodity output and GDP values, the Use tables for 1988,89,91,93,94 are obtained by RASing an initial guess matrix based on the adjacent benchmark matrices. (The RAS procedure for biproportional fitting of matrices to row and column totals is explained in Jorgenson, Gollop and Fraumeni 1987, p. 72).

The final task is to make adjustments to the classification of value added. In the official IO tables the capital input for Agriculture is essentially the depreciation of reproducible capital, the rental value of land is not included there as in the US accounting conventions. The payments classified under labor are, from a market point of view, payments to farmers as workers and payments of land rents. We estimate a rental value for the land based on production function estimates of agriculture in the literature. This is then subtracted from the labor compensation and thus our total value of labor input is much smaller than the total in the official tables. (Such an adjustment for land in the Real Estate sector should ideally be made but lacking any data whatsoever to construct a national estimate we have to defer this for future work. There are some prices on land for some cities, but what one need are land rental values for the whole country.)

A second adjustment to value added is for self employed workers who make up 7.5% of the total work force in 1995. In the official IO tables all income of self employed individuals – labor and profits – are included in the labor compensation row. In the capital stock calculations (described in Appendix B) we estimated the stock of "Individual owned" capital, which is mostly housing. Excluding the housing element we estimated a return to the self employed capital and subtract it from labor compensation and add to capital input. This is a very small adjustment for most years, not necessarily because it is actually small, but because the data on investment by the self employed is very poor.

Given that some of the sectoral output estimates of the constant *yuan* tables seem implausible as discussed in the main text, we constructed an alternate set of output deflators. This is centered on the producer price indices for the mining and manufacturing sectors, or "ex-factory prices of industrial products" as they are labelled in the CSY97 (Table 8-12). We refer to this set as the "PPI" set. For the Coal Mining sector we use the index for Coal Industry, for Oil & Gas Mining use Petroleum Industry, for Food processing use Food Industry, for Textiles use Textile Industry, for Apparel use Tailoring Industry, for Paper use Paper Industry, for Electric Power, Steam & Hot Water use Power Industry, for Chemicals use Chemical Industry, for Building Materials use Building Materials Industry, for Primary Metals use Metallurgical Industry, for Metal products and Machinery use Machine Building Industry, and finally, for Transportation Equipment and Other Manufacturing use the General Index. For Wood & Furniture we turn to the

Consumer Price Indices (CSY Table 8-3) and use the one for Furniture for the published period after 1987, prior to that we use the overall Retail index. For the mining and manufacturing sectors where there are no explicit PPI's we retain the constant yuan IO estimates – Metal mining, Nonmetal mining, Petroleum Refining, Electrical Machinery, Electronic Equipment, and Instruments.

For Agriculture we use the overall agriculture products price index (CSY97 Table 8-10). For Transportation & Communication and Commerce we use the deflator for sectoral GDP, and for Finance & Insurance use the overall GDP deflator (CSY Table 2-9). These are poor proxies but services are notoriously difficult to estimate in every economy. For Construction we use the price index for fixed investment (construction) after 1992, and the deflator for sectoral GDP prior to 1992. For Utilities, household service & real estate we use a weighted average of the CPI for rent and overall retail price index. For Education, Health, etc. we use a weighted average of the CPI for medical services representing Health (CSY Table 8-8), and the GDP deflator representing Tuition. For Public Administration we use the average wage of government agencies (CSY97 Table 4-24).

Appendix B. Capital data.

The construction of time series for capital input consist of two major steps. The first is to estimate the stocks of capital for each asset type. The second is to estimate the quantity and price of capital input.

Investment data by sectors are scarce and do not exist for the period before the 1980s, are not complete even in the period of our analysis. The construction of our capital stock in the first step are therefore made with many guesstimates and assumptions. We shall endeavor to describe them and suggest alternative measures. An important effort to construct capital data for China is Huang and Ren (2000) which carefully describes their work on the manufacturing sectors. Here the IQTE had to make estimates for all sectors of the economy, many of which have sparser data than manufacturing.

The first task is to collect the value of investment for 1981 on. The primary source of information is the *China Statistical Yearbook on Investment in Fixed Assets (1950-1995)* and subsequent annual issues. This provide the value of investment in fixed assets by the various ownership classes for each sector. These include the state-owned, urban collective-owned, rural collective-owned, individual, and "other forms of ownership". The sectoral data for the state-owned sector is complete but those for the other classes require some extrapolation.

For the urban collective-owned class, sectoral investment are not given after 1984, and IQTE extrapolated the 1985-95 period using the pattern of shares that existed in 1980s. For the rural collective-owned class, investment is given for Industry (i.e. mining, manufacturing and electricity) as a whole. This was allocated to the various sectors using rural collective output data. The Individual class has data only for Construction of buildings and equipment for agriculture. These are allocated accordingly to Agriculture and Real Estate sectors. The "other forms of ownership" class is predominantly foreign owned. Sectoral data is not given for the whole class but for foreign owned investment in 1997. This foreign owned investment data is used to allocate investment for this class for the 1990s. There is no such category of ownership in the earlier years.

The total value of investment summing across these ownership classes do not match exactly the number for given in the GDP accounts, "Structure of Gross Domestic Product by Expenditure Approach" (CSY 1999 Table 3-12). The above sectoral estimates are scaled such that the total equals this GDP value for fixed investment for all years.

The second task is to collect estimates of depreciation rates. In our earlier study, LJZK, we used unpublished depreciation rates for 1981-87 from the State Statistical Burean. These rates are also used for the subsequent years. The SSB estimates have been criticized as being too low for equipment and we shall use alternative estimates for sensitivity analyses.

The third task is to estimate the initial stock of capital for each sector, i.e. K(j,1980). Investment since 1953 is cumulated using the perpetual inventory method. The total national investment for that period is given in the *Yearbook on Investment* (op cit). The total investment for 1953-79 is allocated to the various sectors using the earliest year for which the sectoral data for the state sector are given – 1980. This is a very crude measure and is a serious potential source of error in TFP estimates for the early years of our analysis. The sectoral capital stock for 1953 is assumed to be equal to the estimated sectoral investment in 1953.

The fourth task is to divide fixed investment into Construction and Equipment investment. This data is given for 1990 and 1991 in the *China Investment in Fixed Assets Statistics 1990-1991*. These shares are used to allocate total fixed investment for the other years.

The final piece of data for the construction of the capital stock series are the investment deflators. The SSB has published deflators for construction and equipment since 1992 (Table titled "Price Indices of Investment in Fixed Assets", e.g. CSY99 T8-14). For the prior years, the index for equipment is the ex-factory price index for the Machinery sector. For construction, the price index of Building Materials is first related to the price index of construction for 1992-99. Using this regression estimate, and the price index of Building Materials for 1981-92, the construction price index is estimated.

With the above pieces in hand – value of investment by asset for each sector, initial capital stock, asset deflators and depreciation rates – one can calculate the stocks of capital (*S*). The value of investment is deflated and then cumulated with the perpetual inventory method (eq. 21) :

$$S_{kjt} = (1-d_k)S_{kjt-1} + I_{kjt} \qquad j=1,.....29; \quad k=\text{construction, equipment}$$

The capital stock for each sector (S_{jt}) is then the aggregate of construction and equipment as given in eq. (23). The price of the aggregate stock is the value of the construction and equipment divided by this aggregate stock index:

$$PI_{jt} = \frac{\sum_k PI_{kjt} S_{kjt}}{S_{jt}}$$

The second major step is to calculate capital input based on equations (24-26), where the service flow of each type of asset is proportional to the stock. The rate of return and the rental prices for these capital services for each type of asset is related as in (24). The rate of return in each sector is calculated such that the value of services summed over both asset types equal the value of capital input estimated in the IO tables described in Appendix A:

(25') $$\sum_k P_{Kkjt} S_{kjt-1} = VK_{jt} \qquad j=1,2...29$$

This gives us the rate of return and the rental prices of construction and equipment. With this we apply eq. (26) to obtain the index of capital input (K_{jt}) for each sector. The aggregate rental price for sector j (P_{Kjt}) is the value of capital input divided by K_{jt}.

Finally, we construct the national capital aggregate using eq. (12). Table A1 reports the price and quantity of national capital input, and in the last three columns we give the price, quantity and value of the stock of fixed capital.

Table A1. Aggregate capital input in China.

	Capital Input				Capital Stock		
	Price	Quantity	Value	Quality	Price	Quantity	Value
		bil yuan95	bil. yuan			bil yuan95	bil. yuan
1981	0.060	2786	167.9	1.006	0.262	2807	736
1982	0.057	3233	185.7	1.005	0.271	3278	889
1983	0.055	3771	207.7	1.004	0.282	3803	1071
1984	0.057	4371	247.9	1.003	0.293	4434	1298
1985	0.061	5094	311.8	1.002	0.332	5140	1707
1986	0.062	5904	365.5	1.002	0.368	5910	2173
1987	0.067	6790	456.1	1.002	0.393	6789	2665
1988	0.077	7800	604.3	1.002	0.441	7765	3427
1989	0.073	8922	652.9	1.002	0.529	8506	4498
1990	0.074	9767	726.6	1.002	0.545	9222	5023
1991	0.082	10586	866.4	1.001	0.581	10125	5881
1992	0.098	11614	1138.9	1.001	0.668	11451	7648
1993	0.114	13130	1496.1	1.000	0.864	13361	11547
1994	0.123	15317	1886.0	1.000	0.953	15459	14732
1995	0.132	17723	2343.0	1.000	1.000	17723	17723

Appendix C. Labor Data.

As with the capital data this is built upon our earlier work reported in LJZK. In that study, sectoral labor data cross classified by sex, age, educational attainment and occupation were compiled for 1981-87. The employment matrix was derived from population data at the SSB while the annual compensation matrix was estimated from a labor force survey.

For this study we drop the occupation classification and used the education and age categories given in section III(c). The IQTE used the SSB's 1% population sample survey in 1990 and 1995, and the sectoral employment data in the *Labor Statistical Yearbook*, to obtain an employment matrix (L_{ljt}) for the 29 sectors for 1990 and 1995. These two matrices are then used to interpolate for the other years during 1988-95 using the national sectoral data (CSY97 Table 4-5) as control totals. The total employment estimates underwent a large upward revision after the 1990 Census. However, this adjustment was not made for sectoral employment, we therefore chose to keep the old definitions which are still published. This gives us the wrong level of labor input but does not give any obvious bias to the growth rate of sectoral labor.

As discussed in the text, we would ideally like to have an estimate of hours worked. There is, however, no such information in the above sectoral datasets, and we assume that the annual hours worked per worker is unchanged in this 1981-95 period.

For labor compensation the IQTE participated in surveys done in 1991, 1992, 1994 and 1997 with sample sizes of up to 54,000 people. Since this is a relatively small sample for the matrix (P_{Lljt}) with 29 sectors*2 sexes*5 educational classes*7age groups, national wage data from the National Industrial Censuses (1985, 1995) were also used. The Labor Statistical Yearbook also gives a time series of wages classified by age and educational attainment. These supplementary information is used to fill in cells of the compensation matrix that have too small a sample size. After the matrices for 1992, 94, 97 are estimated they are used to interpolate for the remaining years in our study period.

The agriculture sector farmers are not part of the wage survey for obvious reasons. Their relative wage structure (i.e. relative to sex-age-education) is assumed to be equal to workers in the survey and the actual labor compensation, excluding their rental income as people with rights to the land, is estimated in the final stage together with the other sectors.

In the final step, the compensation matrix for each year is scaled such that the total labor compensation for each sector is equal to the value of labor input estimated in the IO tables (eq. 30). The value for all sectors is given for 1995 in Table 1 in the column marked "Labor Input".

After the construction of the sectoral labor inputs we use eq. (13) to derive the national indices. The price and quantity for national labor input (L_t) is given the first two columns of Table A2. The number of workers as a sum of the sectoral data is given in the column marked "Employment" (as noted, this is not the national total given in the CSY after the 1990 revisions). The quality, or composition index, of aggregate labor (eq. 32) is the ratio of input to employment and is given in the column marked "Quality". The last column gives the average annual compensation per worker (reminder, this includes our rough estimate of the large agriculture sector labor earnings).

Table A2. Aggregate labor input in China.

	Labor Input					Average
	Price	Quantity	Value	Quality	Employment	Compensation
		bil Yuan95	bil. Yuan		million	Yuan/year
1981	0.118	1387.0	164.2	0.847	437.2	375.6
1982	0.124	1448.3	180.2	0.854	453.0	397.8
1983	0.133	1524.1	202.3	0.876	464.4	435.6
1984	0.155	1618.2	250.5	0.897	482.0	519.7
1985	0.193	1674.0	323.8	0.896	498.7	649.3
1986	0.218	1721.7	375.0	0.897	512.8	731.3
1987	0.249	1764.0	439.9	0.892	527.8	833.4
1988	0.301	1846.9	556.4	0.908	543.3	1024.0
1989	0.352	1895.6	667.5	0.915	553.3	1206.5
1990	0.357	1958.9	698.9	0.922	567.4	1231.8
1991	0.405	2044.3	828.7	0.935	583.6	1420.0
1992	0.480	2119.1	1017.5	0.952	594.3	1712.0
1993	0.587	2170.7	1275.2	0.963	602.2	2117.5
1994	0.833	2263.8	1886.8	0.983	614.7	3069.4
1995	1.000	2336.3	2336.3	1.000	623.9	3744.8