Alternative Measures for Chinese Productivity Growth

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Abstract:

The paper constructs estimates of China's Total Factor Productivity (TFP) growth over the period 1970-2020 using primarily the Asian Productivity Organization (APO) data base augmented by additional data developed by Koji Nomura at Keio University. China's TFP growth will be measured using the following methods: (i) the exact index number method developed by Jorgenson (and his coworkers) and Diewert and Morrison and (ii) a nonparametric method developed by Diewert and Fox. Economy wide estimates of rates of return on assets will also be calculated. Estimates for quality adjusted labour developed by Nomura will be used as well as estimates for missing inputs such as Land. Finally, instead of using GDP as the output concept, alternative estimates of TFP growth using net output as the output concept will be provided. The alternative measure is useful in explaining Chinese real income growth.

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Key Words

Total Factor Productivity growth, terms of trade, GDP functions, land input, exact index numbers, nonparametric estimation of technology, gross versus net output, measurement of real income.

1. Introduction

A problem with most measures of national Total Factor Productivity (TFP) is that land inputs are omitted. For the most part, this is because national and international statistical offices have not been able collect and organize data on the price and quantity of land inputs into production.

Due to the efforts of the Asian Productivity Organization and the work of Koji Nomura at Keio University, data on the price and quantity of land used in production for 25 or so Asian countries has been constructed. We use these data for the People's Republic of China for the years 1970-2020. This augmented data base has national annual price and quantity estimates for four types of land: agricultural, industrial, commercial and residential. In all, there are data on 16 capital stock components. We will use this data base to construct estimates of China's TFP for these years.

Section 2 gives an introduction to user cost theory and discusses the construction of the productivity data base for China. An Appendix has more detail on the problems associated with the data construction.

Section 3 uses the data to calculate Chinese TFP following the methodology developed by Dale Jorgenson and his fellow researchers. We use Gross Domestic Product as our output concept and we initially follow Jorgenson in using ex post asset inflation rates in the user cost formula. However, land price inflation rates are very volatile and the resulting user costs were frequently negative. Thus, we smoothed the ex post asset inflation rates and used and used these smoothed asset inflation rates in the user cost formula. However, even after smoothing, there were 6 negative land user costs. However, when we aggregated over the 4 types of land, the negative user cost problem vanished.

Section 3 continues on using the data developed in section 2 to decompose real GDP into explanatory factors using the decomposition methodology developed by Diewert and Morrison (1986) and Kohli (1990).

Section 4 also uses the GDP data developed in section 2 to implement an alternative decomposition of nominal GDP growth into explanatory components. This section uses a nonparametric decomposition developed by Diewert and Fox (2018). The positive feature of this decomposition is that it decomposes TFP growth into a product of a technical progress component and an inefficiency component. We typically think of TFP growth as a measure of technical progress but when a recession occurs in a country, TFP invariably becomes negative due to the existence of fixed factors that cannot be fired. Using the Diewert and Fox methodology, technical progress never becomes negative but inefficiency can cause TFP to become negative. A simplified version of this methodology is presented in section 4 and it can be applied very easily.

Section 5 turns the analysis in a different direction. Obviously, depreciation is not "income" in the usual sense. Thus, in section 5, we turn our attention to the measurement of Net Domestic Product which is closer to a measure of income in the traditional sense. We turn away from user costs and turn towards the use of "waiting services".[1] The theory we use in this section is due to Hicks (1961) and Edwards and Bell (1961). Instead of using user costs and gross investment as our measurement concepts, we use waiting services in place of capital services and the net capital stock in place of gross capital investment. An alternative measure of TFP emerges in this section.

Section 6 uses the net data developed in section 5 and implements the Diewert Morrison Kohli decomposition of real net income growth into explanatory factors.

[1] This term is due to Rymes (1968) (1983).

Section 7 offers some concluding comments.

2. User Cost Theory and Data Construction

In this section and the following section, we use the APO Augmented Database to construct estimates of China's TFP for the years 1970-2020 using the methodology developed by Jorgenson and his coworkers.[2] A key aspect of this methodology is the construction of a *user cost of capital* to measure the services provided by the use of a capital stock asset over the course of a year.

Suppose the beginning of the year t price of a new unit of capital stock n is P_{Kn}^t and the production unit faces an annual cost of capital at the beginning of year t of r^t. Suppose further that asset n in year t has a geometric depreciation rate equal to δ_n^t. Then the net discounted (to the beginning of year t) cost of purchasing a new unit of asset n, using it during year t and then selling it at the end of year t (most likely to the same production unit) is equal to:[3]

$$\begin{aligned}(1)\ P_{Kn}^t - (1-\delta_n^t)P_{Kn}^{t+1}/(1+r^t) &= P_{Kn}^t - (1-\delta_n^t)(1+i_n^t)P_{Kn}^t/(1+r^t)\\ &= (1+r^t)^{-1}[(1+r^t) - (1-\delta_n^t)(1+i_n^t)]P_{Kn}^t\\ &= (1+r^t)^{-1}[r^t - i_n^t + \delta_n^t(1+i_n^t)]P_{Kn}^t.\end{aligned}$$

The *asset n year t inflation rate* i_n^t which appears in (1) is defined by the following equation:

$$(2)\ 1+i_n^t \equiv P_{Kn}^{t+1}/P_{Kn}^t.$$

The *user cost of capital* defined by the right hand side of (1) discounts costs (the purchase price P_{Kn}^t) and benefits (the selling price of the used asset at the end of year $(1-\delta_n^t)P_{Kn}^{t+1}$) to the beginning of year t. This is a beginning of the year perspective. If we take an end of the year perspective, then the end of year benefits are no longer discounted and the beginning of the year costs are anti-discounted to their end of the period equivalents by multiplying P_{Kn}^t by $(1+r^t)$.[4] The resulting *end of year user cost of capital* for asset n, U_n^t, is defined as follows:[5]

$$\begin{aligned}(3)\ U_n^t &\equiv (1+r^t)P_{Kn}^t - (1+i_n^t)(1-\delta_n^t)P_{Kn}^t\\ &= [r^t - i_n^t + \delta_n^t(1+i_n^t)]P_{Kn}^t.\end{aligned}$$

The user cost formula defined by (3) makes sense from the viewpoint of accounting theory: if a production unit purchases a unit of capital stock n at the beginning of year t, it has to raise capital from investors to finance the purchase so the all inclusive cost of the purchase is not only the purchase price but the implicit or explicit interest that the unit has to pay to investors to tie up their financial capital for a year. Thus, the total cost is not P_{Kn}^t but $(1+r^t)P_{Kn}^t$.

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[2] See Jorgenson (1963), Jorgenson and Griliches (1967) (1972), Christiansen and Jorgenson (1969) and Jorgenson (1989).

[3] This is the method used by Diewert (1974; 504) (1980; 472-473) to derive a user cost formula. Note that the price P_{Kn}^{t+1} is the price of a new unit of the capital stock at the end of year t.

[4] The end of year perspective is used in accounting theory where current year revenues and costs are cumulated over the year (or quarter) and regarded as taking place at the end of the accounting period; see Peasnell (1981).

[5] This user cost formula was also derived by Christensen and Jorgenson (1969) using a different method of derivation.

In many countries, land and structure assets are taxed. These property taxes need to be added to the corresponding user costs. Thus let τ_n^t be the year t property tax rate that applies to asset n. The *new end of period user cost of capital for asset n* is defined as follows:

$$(4)\ U_n^t \equiv (1+r^t+\tau_n^t)P_{Kn}^t - (1+i_n^t)(1-\delta_n^t)P_{Kn}^t$$
$$= [r^t + \tau_n^t - i_n^t + \delta_n^t(1+i_n^t)]P_{Kn}^t.$$

The Jorgenson methodology uses the *geometric model of depreciation*. This methodology relates the end of year quantity of capital for asset n in year t, Q_{Kn}^{t+1}, to the corresponding beginning of the year capital stock for asset n, Q_{Kn}^t, as follows:

$$(5)\ Q_{Kn}^{t+1} = (1-\delta_n^t)Q_{Kn}^t + Q_{In}^t$$

where Q_{In}^t is the production unit's *gross investment* in asset n in year t. Assumption (5) allows us to apply the user cost formula (4) to the aggregate capital stock for asset n (and not just to new units of the capital stock).

We apply the above methodology to the data for the People's Republic of China in the APO's Augmented data base. The data for the years 1970-2020 are explained more fully in the Data Appendix. We have data on the usual macroeconomic variables, C+G+I+X–M, which are consumption, government, gross investment, exports and (minus) imports. The year t prices and quantities for these variables is denoted by P_C^t, P_G^t, P_I^t, P_X^t and P_M^t and Q_C^t, Q_G^t, Q_I^t, Q_X^t and Q_M^t respectively. The price indexes have been normalized to equal 1 in 1970 and the quantities or volumes are measured in units of trillions of 1970 yuan. The corresponding values (in trillions of current yuan) are V_C^t, V_G^t, V_I^t, V_X^t and V_M^t where $V_C^t = P_C^t Q_C^t$ and so on. These output price and quantity indexes for China are listed in Tables A5 and A6 respectively.[6]

The APO Augmented Database has information on quality adjusted labour input for China (price, quantity and value in year t are P_L^t, Q_L^t and $V_L^t = P_L^t Q_L^t$) and on beginning of the year capital stocks for 16 assets China (price, quantity and value in year t for asset n are P_{Kn}^t, Q_{Kn}^t and $V_{Kn}^t = P_{Kn}^t Q_{Kn}^t$ for n = 1, …, 16). The 16 assets are as follows: (1) IT hardware; (2) Communications equipment; (3) Transport equipment; (4) Other machinery and equipment; (5) Dwelling structures; (6) Non-residential buildings; (7) Other structures; (8) Cultivated assets; (9) Research and development; (10) Computer software; (11) Other intangible assets; (12) Net increase in inventory stocks; (13) Agricultural land; (14) Industrial Land; (15) Commercial Land and (16) Residential Land. The price indexes have been normalized to equal 1 in 1970 and the quantities or volumes are measured in units of trillions of 1970 yuan. The APO data base also has information on the corresponding gross investments. The price and quantity indexes for investment in asset n and the value of investments in trillions of yuan are denoted by P_{In}^t, Q_{In}^t and $V_{In}^t = P_{In}^t Q_{In}^t$ respectively for n = 1, …, 12. The APO database also has estimated depreciation rates δ_n^t for the depreciable assets 1-11 (inventory assets are assumed to have zero depreciation rates) and the Q_{Kn}^t, Q_{In}^t and δ_n^t satisfy equations (5) for n = 1, …, 11 and t = 1970, …, 2020.

[6] The price and quantity indexes for gross investment in year t, P_I^t and Q_I^t, include land investment which is not included in the APO Augmented Database because the international System of National Accounts does not include land investment as part of Gross Fixed Capital Formation. As is discussed above, we think that it is appropriate to treat land investments in the same way the national accounts treat inventory investments. The price indexes in table A5 have been adjusted for indirect taxes on consumption and imports; i.e., consumption taxes have been subtracted from the final demand output prices to obtain the prices that producers receive for their outputs and added to import prices because we follow Kohli (1978) in assuming that all imports flow through the country's production sector. The importance of making these indirect tax adjustments was noted by Jorgenson and Griliches (1972).

Note that the APO Augmented Data base follows standard System of National Accounts (SNA) conventions by setting investment in land assets equal to zero for each year. We believe that this is a problem with the current SNA methodology which ignores land investments. The reason for this omission may be the assumption that at the national level, the stock of land is fixed and therefore there is no real investment in land where investment is defined as the change in the stock of land. However, as soon as we have information on alternative uses of land (as is available in the Augmented APO Database), we see that there are considerable changes in the composition of the land subaggregates. In general, agricultural land is converted to commercial and residential land and other uses[7] as population grows or as economic development proceeds. Since inventory change is accepted as part of gross investment in the SNA, it seems reasonable to also include changes in land use as part of gross investment. Thus, we define *land investment* in year t for the four types of land, Q_{In}^t for n = 13, 14, 15, 16, as follows:

$$(6)\ Q_{In}^t \equiv Q_{Kn}^{t+1} - Q_{Kn}^t ; \qquad n = 13, \ldots, 16 ; t = 1970, \ldots, 2020.$$

It turns out that the year t APO investment prices P_{In}^t are equal to the APO beginning of year t stock prices P_{Kn}^t for assets n = 1, …, 11. This is not the only choice that could be made for the beginning of the year prices for the capital stocks. The investment prices P_{In}^t for the reproducible assets are "objective" but the beginning of the year prices for the corresponding stocks could be chosen to be closer to year end prices for the investment goods rather than being an annual average of the year's investment prices. For example, we could set the beginning of the year price of asset n equal to $P_{Kn}^t \equiv (1/2)[P_{In}^t + P_{In}^{t-1}]$, an average of the year t and t−1 investment prices for the nth asset. The choice of the "right" beginning of the year price for an asset is more or less up to the national income accountant. However, in this paper, we will follow APO conventions and set the beginning of the year t asset prices equal to the corresponding year t investment price for assets 1-11. For assets 12-16, we do not have APO investment prices so we will simply set the year t investment price equal to the corresponding APO beginning of the year asset price. For asset 12, inventory stocks, the asset price does not exactly equal the corresponding inventory change price so we will take the inventory stock price and quantity data, P_{K12}^t and Q_{K12}^t as the "truth" and define Q_{I12}^t as the year t difference in inventory stocks, $Q_{K12}^{t+1} - Q_{K12}^t$. The year t price of inventory change, P_{I12}^t, will be set equal to the corresponding beginning of the year inventory stock price, P_{K12}^t. The depreciation rates for inventory stocks and the land assets are set equal to 0; i.e., we have:

$$(7)\ \delta_n^t \equiv 0 ; \qquad n = 12, \ldots, 16 ; t = 1970, \ldots, 2020.$$

To summarize the above relationships between the investment flows Q_{In}^t and the corresponding beginning of the year stocks Q_{Kn}^t and depreciation rates δ_n^t: all 16 assets satisfy equations (5) for years t = 1970, …, 2020 and n = 1, …, 16. Moreover, all of the investment prices P_{In}^t equal the corresponding beginning of the year stock prices P_{Kn}^t for n = 1, …, 16 and t = 1970, …, 2020. The asset price indexes, P_{Kn}^t, are listed in Table A1[8] and the corresponding beginning of the year quantities are listed in Table A2 of the Appendix. The depreciation rates for all assets are reported in Table A3 of the Appendix.

In order to reduce the size of our data tables, we will work with a more aggregated model where there are only 5 types of capital: (i) *Aggregate Machinery and Equipment* (an aggregate of assets 1-4), with year t price, quantity and value indexes equal to P_{KM}^t, Q_{KM}^t and $V_{KM}^t \equiv P_{KM}^t Q_{KM}^t$; (ii) *Aggregate Structures* (an aggregate of assets 5-7) with year t price and quantity indexes equal to P_{KS}^t and Q_{KS}^t; (iii) *Aggregate Other*

[7] We note that our decomposition of land use into four categories omits some addition important categories such as forest land and some forms of government land such as parks. See Eurostat (2017) for a comprehensive description of possible land use categories.

[8] The beginning of the year APO price indexes for the four land assets proved to be very volatile. Thus, these prices were smoothed and the smoothed land prices are reported in Table A1 in the Appendix. Smoothing the land prices seems appropriate since producers should value their land prices at longer run opportunity costs.

Capital (an aggregate of assets 8-11) with year t price and quantity indexes equal to P_{KO}^t and Q_{KO}^t; (iv) *Inventory Stocks* (equal to asset 12) which we label as P_{KI}^t, Q_{KI}^t and $V_{KI}^t \equiv P_{KI}^t Q_{KI}^t$ and (v) *Land Assets* (an aggregate of assets 13-16) with price and quantity indexes P_{KL}^t and Q_{KL}^t for t = 1970, …,2021. The aggregation is done using chained Törnqvist price indexes.[9] Table A4 in the Appendix lists these aggregate beginning of the year capital stocks and their corresponding aggregate price indexes. The values of these five capital stock aggregates, V_{KM}^t, V_{KS}^t, V_{KO}^t, V_{KI}^t, V_{KL}^t, along with the total value of the total capital stock V_K^t, are listed in Table 1 below along with the shares of the five subaggregate capital stocks in the total value of the capital stock, s_{KM}^t, s_{KS}^t, s_{KO}^t, s_{KI}^t, s_{KL}^t where $s_{KM}^t \equiv V_{KM}^t/V_K^t$. Note that V_K^t can be defined by summing the V_{Kn}^t or by summing the subaggregate values; i.e., we have the following equalities:

$$(8)\ V_K^t \equiv \sum_{n=1}^{16} V_{Kn}^t = V_{KM}^t + V_{KS}^t + V_{KO}^t + V_{KI}^t + V_{KL}^t ; \qquad t = 1970, \ldots, 2020.$$

Table 1: Values of Capital Stock Components and their Shares in the Total Value of the Capital Stock

Year	V_K^t	V_{KM}^t	V_{KS}^t	V_{KO}^t	V_{KI}^t	V_{KL}^t	s_{KM}^t	s_{KS}^t	s_{KO}^t	s_{KI}^t	s_{KL}^t
1970	0.4485	0.0916	0.2084	0.0119	0.0195	0.1170	0.2043	0.4647	0.0266	0.0436	0.2608
1971	0.5141	0.1058	0.2299	0.0132	0.0407	0.1244	0.2059	0.4472	0.0256	0.0792	0.2421
1972	0.5795	0.1163	0.2541	0.0150	0.0629	0.1312	0.2007	0.4385	0.0258	0.1086	0.2264
1973	0.6596	0.1294	0.2899	0.0173	0.0849	0.1382	0.1962	0.4395	0.0262	0.1286	0.2095
1974	0.7245	0.1441	0.3146	0.0179	0.1028	0.1451	0.1988	0.4343	0.0247	0.1419	0.2003
1975	0.8075	0.1510	0.3491	0.0210	0.1339	0.1525	0.1870	0.4324	0.0260	0.1658	0.1889
1976	0.9069	0.1666	0.3904	0.0243	0.1653	0.1603	0.1838	0.4305	0.0268	0.1823	0.1767
1977	1.0008	0.1755	0.4281	0.0265	0.2027	0.1679	0.1753	0.4278	0.0265	0.2026	0.1678
1978	1.0589	0.1856	0.4767	0.0279	0.1894	0.1793	0.1753	0.4502	0.0263	0.1789	0.1693
1979	1.1676	0.2020	0.5348	0.0307	0.2019	0.1982	0.1730	0.4581	0.0263	0.1729	0.1697
1980	1.3364	0.2080	0.6329	0.0321	0.2424	0.2211	0.1556	0.4736	0.0240	0.1813	0.1655
1981	1.5086	0.2114	0.7205	0.0343	0.2947	0.2477	0.1401	0.4776	0.0228	0.1953	0.1642
1982	1.6583	0.2076	0.8213	0.0363	0.3176	0.2755	0.1252	0.4953	0.0219	0.1915	0.1661
1983	1.7717	0.2066	0.9502	0.0366	0.2726	0.3057	0.1166	0.5363	0.0206	0.1538	0.1726
1984	2.0057	0.2178	1.1025	0.0405	0.3004	0.3445	0.1086	0.5497	0.0202	0.1498	0.1717
1985	2.3741	0.2477	1.3109	0.0488	0.3692	0.3975	0.1043	0.5522	0.0205	0.1555	0.1674
1986	2.8922	0.3023	1.5785	0.0578	0.4846	0.4690	0.1045	0.5458	0.0200	0.1676	0.1622
1987	3.4238	0.3558	1.8511	0.0658	0.5932	0.5578	0.1039	0.5407	0.0192	0.1733	0.1629
1988	4.2244	0.4643	2.2817	0.0816	0.7231	0.6737	0.1099	0.5401	0.0193	0.1712	0.1595
1989	5.1026	0.5860	2.6743	0.0996	0.9347	0.8080	0.1148	0.5241	0.0195	0.1832	0.1583
1990	6.0347	0.6796	3.0684	0.1156	1.2283	0.9429	0.1126	0.5085	0.0192	0.2035	0.1562
1991	7.0484	0.7555	3.5717	0.1248	1.5082	1.0882	0.1072	0.5067	0.0177	0.2140	0.1544
1992	8.6460	0.8885	4.4392	0.1448	1.8586	1.3148	0.1028	0.5134	0.0167	0.2150	0.1521
1993	11.7153	1.1824	6.3402	0.1812	2.3399	1.6716	0.1009	0.5412	0.0155	0.1997	0.1427

[9] The Törnqvist bilateral price index is defined as follows. Let $p^t \equiv [p_1^t,\ldots,p_N^t]$ and $q^t \equiv [q_1^t,\ldots,q_N^t]$ be the period t price and quantity vectors. Denote the inner product of the vectors p^t and q^t as $p^t \cdot q^t \equiv v^t$ where v^t is the period t aggregate value. Define the period t shares as $s_n^t \equiv p_n^t q_n^t / p^t \cdot q^t$ for n = 1,…,N. Denote the Törnqvist price index that links the prices of period t−1 to the prices of period t by $P_T(p^{t-1},p^t,q^{t-1},q^t)$. The logarithm of $P_T(p^{t-1},p^t,q^{t-1},q^t)$ is defined as $\sum_{n=1}^N (1/2)(s_n^{t-1} + s_n^t)\ln(p_n^t/p_n^{t-1})$. The sequence of aggregate chained price levels starting at period 1, P_T^t , t = 1,2,3,… is defined as follows: $P_T^1 \equiv 1$; $P_T^2 \equiv P_T(p^1,p^2,q^1,q^2)$; $P_T^3 \equiv P_T(p^1,p^2,q^1,q^2)P_T(p^2,p^3,q^2,q^3)$; and so on. The corresponding sequence of aggregate quantity levels Q_T^t is defined by deflating the period t value by the period t price index; i.e., $Q_T^t \equiv v^t/P_T^t$ for t = 1, 2, 3,…. All prices must be positive and the value aggregate must also be positive for each period in order to calculate chained Törnqvist price indexes. Some quantities can be negative. When we are aggregating outputs and capital stocks, we will use chained Törnqvist price indexes. However, when aggregating capital services and labour services, we will use chained Törnqvist quantity indexes because it can happen that some user costs may be negative. Törnqvist chained quantity indexes are defined in the same manner as their price counterparts but the role of prices and quantities is reversed. Thus price indexes in this case are defined by deflating values by the Törnqvist chained quantity indexes. In order to apply this second method of aggregation, we require that all quantities be positive and the value aggregates must also be positive in each period. For the relationship of the Törnqvist indexes to functional forms for unit cost functions and linearly homogeneous aggregator functions, see Diewert (1976).

1994	**14.6168**	**1.5211**	**7.6662**	**0.2124**	**3.0776**	**2.1395**	**0.1041**	**0.5245**	**0.0145**	**0.2106**	**0.1464**
1995	**17.4080**	**1.9033**	**8.8367**	**0.2545**	**3.7351**	**2.6785**	**0.1093**	**0.5076**	**0.0146**	**0.2146**	**0.1539**
1996	**20.4243**	**2.1866**	**10.3342**	**0.2937**	**4.4403**	**3.1696**	**0.1071**	**0.5060**	**0.0144**	**0.2174**	**0.1552**
1997	**23.2993**	**2.4451**	**11.7796**	**0.3198**	**5.0621**	**3.6928**	**0.1049**	**0.5056**	**0.0137**	**0.2173**	**0.1585**
1998	**26.0449**	**2.7712**	**13.0499**	**0.3442**	**5.5201**	**4.3595**	**0.1064**	**0.5011**	**0.0132**	**0.2119**	**0.1674**
1999	**28.4971**	**3.1004**	**14.3502**	**0.3703**	**5.6342**	**5.0419**	**0.1088**	**0.5036**	**0.0130**	**0.1977**	**0.1769**
2000	**31.5954**	**3.4642**	**16.0879**	**0.4225**	**5.7668**	**5.8540**	**0.1096**	**0.5092**	**0.0134**	**0.1825**	**0.1853**
2001	**35.0588**	**3.9416**	**17.8570**	**0.5036**	**6.0804**	**6.6762**	**0.1124**	**0.5093**	**0.0144**	**0.1734**	**0.1904**
2002	**38.7493**	**4.4482**	**19.7424**	**0.5449**	**6.3832**	**7.6306**	**0.1148**	**0.5095**	**0.0141**	**0.1647**	**0.1969**
2003	**43.6752**	**5.0790**	**22.5615**	**0.6726**	**6.6518**	**8.7103**	**0.1163**	**0.5166**	**0.0154**	**0.1523**	**0.1994**
2004	**50.4875**	**6.1096**	**26.8781**	**0.8223**	**7.1015**	**9.5760**	**0.1210**	**0.5324**	**0.0163**	**0.1407**	**0.1897**
2005	**56.6498**	**7.3991**	**30.2773**	**0.9821**	**8.0183**	**9.9731**	**0.1306**	**0.5345**	**0.0173**	**0.1415**	**0.1760**
2006	**62.8084**	**9.1368**	**33.7677**	**1.1733**	**8.4073**	**10.3233**	**0.1455**	**0.5376**	**0.0187**	**0.1339**	**0.1644**
2007	**71.2691**	**11.0570**	**39.1057**	**1.3518**	**8.8663**	**10.8882**	**0.1551**	**0.5487**	**0.0190**	**0.1244**	**0.1528**
2008	**86.9995**	**13.5417**	**48.8626**	**1.5683**	**10.3277**	**12.6992**	**0.1557**	**0.5616**	**0.0180**	**0.1187**	**0.1460**
2009	**98.3003**	**16.0966**	**51.5931**	**1.8998**	**12.4104**	**16.3005**	**0.1637**	**0.5249**	**0.0193**	**0.1262**	**0.1658**
2010	**116.4122**	**19.8386**	**60.7182**	**2.5811**	**12.8044**	**20.4699**	**0.1704**	**0.5216**	**0.0222**	**0.1100**	**0.1758**
2011	**141.6285**	**24.6320**	**74.1861**	**3.3948**	**14.6134**	**24.8022**	**0.1739**	**0.5238**	**0.0240**	**0.1032**	**0.1751**
2012	**163.1391**	**28.3663**	**85.1245**	**4.1021**	**17.2667**	**28.2796**	**0.1739**	**0.5218**	**0.0251**	**0.1058**	**0.1733**
2013	**182.8724**	**32.7626**	**95.2453**	**5.0523**	**18.9032**	**30.9090**	**0.1792**	**0.5208**	**0.0276**	**0.1034**	**0.1690**
2014	**204.1450**	**36.6955**	**107.4381**	**6.0751**	**20.3410**	**33.5953**	**0.1798**	**0.5263**	**0.0298**	**0.0996**	**0.1646**
2015	**222.4527**	**39.7243**	**117.0571**	**7.0901**	**21.6252**	**36.9559**	**0.1786**	**0.5262**	**0.0319**	**0.0972**	**0.1661**
2016	**243.6957**	**42.0228**	**129.7610**	**8.4529**	**21.8663**	**41.5928**	**0.1724**	**0.5325**	**0.0347**	**0.0897**	**0.1707**
2017	**279.7263**	**45.5109**	**154.8825**	**9.5788**	**22.6863**	**47.0678**	**0.1627**	**0.5537**	**0.0342**	**0.0811**	**0.1683**
2018	**321.2438**	**49.9398**	**182.2915**	**10.7748**	**24.9656**	**53.2721**	**0.1555**	**0.5675**	**0.0335**	**0.0777**	**0.1658**
2019	**367.4792**	**54.7938**	**214.0584**	**11.9926**	**27.1884**	**59.4460**	**0.1491**	**0.5825**	**0.0326**	**0.0740**	**0.1618**
2020	**416.6862**	**59.3549**	**249.0068**	**13.2883**	**29.0232**	**66.0130**	**0.1424**	**0.5976**	**0.0319**	**0.0697**	**0.1584**
2021	**467.8423**	**63.4048**	**286.6211**	**13.9958**	**30.9430**	**72.8777**	**0.1355**	**0.6126**	**0.0299**	**0.0661**	**0.1558**
Mean	**75.0160**	**11.5240**	**41.6150**	**2.1042**	**7.3535**	**12.4200**	**0.1432**	**0.5124**	**0.0220**	**0.1493**	**0.1730**

On average, the biggest share of the value of the Chinese capital stock is in Structures with an average share of 51.23%. The next highest share is Land with an average share of 17.20% followed by Inventory Stocks at 14.93%. However, in recent years, the share of inventories has fallen from a peak of 21.74% in 1996 to 6.61% in 2021. This very large drop reflects the growth of just in time delivery of inventories and more efficient management of inventories. The share of Manufactures has fallen from a high of 20.59% in 1971 to a low of 13.55% in 2021. The above Table does indicate that it is important to include land in the list of productive assets used in production.

We use Tδrnqvist price aggregation to form price and quantity indexes for the capital stock. Denote these indexes by P_K^t and Q_K^t with $V_K^t = P_K^t Q_K^t$. Use Tδrnqvist price aggregation to form price and quantity indexes, P_I^t and Q_I^t, for all 16 investments with the aggregate value of investment defined as $V_I^t = P_I^t Q_I^t$. Finally, use Tδrnqvist price aggregation to aggregate over consumption Q_C^t, government Q_G^t, comprehensive aggregate investment Q_I^t, exports Q_X^t and imports $-Q_M^t$ to form price and quantity indexes for Gross Domestic Product at producer prices, P_Y^t and Q_Y^t, with the value of gross output $V_Y^t = P_Y^t Q_Y^t$. Using these estimates for gross output and for the capital stock, we can calculate real and nominal capital output ratios for China for year t, KY^t and VKY^t, defined as follows:

$$(9)\quad KY^t \equiv Q_K^t/Q_Y^t \; ; \; VKY^t \equiv V_K^t/V_Y^t \; ; \qquad t = 1970, \ldots, 2020.$$

The price and quantity indexes for gross output and the capital stock (and the corresponding values in trillions of current yuan) are listed in Table 2 below along with the real and nominal capital output ratios defined by (9).

Table 2: Output and Labour Aggregates, Capital Stock Aggregates and Capital Output Ratios

Year	P_Y^t	P_I^t	P_L^t	P_K^t	Q_Y^t	Q_I^t	Q_L^t	Q_K^t	V_Y^t	V_I^t	V_L^t	KY^t	VKY^t
1970	**1.000**	**1.000**	**1.000**	**1.000**	**0.247**	**0.080**	**0.140**	**0.449**	**0.247**	**0.080**	**0.140**	**1.813**	**1.813**
1971	**1.025**	**1.013**	**1.014**	**1.016**	**0.262**	**0.087**	**0.148**	**0.506**	**0.269**	**0.088**	**0.150**	**1.928**	**1.911**

1972	**1.041**	**1.010**	**1.068**	**1.021**	**0.269**	**0.083**	**0.151**	**0.567**	**0.279**	**0.084**	**0.161**	**2.114**	**2.074**
1973	**1.074**	**1.049**	**1.078**	**1.059**	**0.285**	**0.094**	**0.156**	**0.623**	**0.306**	**0.099**	**0.168**	**2.186**	**2.155**
1974	**1.086**	**1.036**	**1.083**	**1.056**	**0.287**	**0.095**	**0.162**	**0.686**	**0.312**	**0.098**	**0.175**	**2.392**	**2.325**
1975	**1.112**	**1.058**	**1.098**	**1.080**	**0.303**	**0.105**	**0.167**	**0.748**	**0.337**	**0.112**	**0.184**	**2.465**	**2.395**
1976	**1.124**	**1.080**	**1.103**	**1.111**	**0.298**	**0.096**	**0.173**	**0.817**	**0.335**	**0.104**	**0.191**	**2.742**	**2.709**
1977	**1.154**	**1.110**	**1.119**	**1.153**	**0.321**	**0.109**	**0.179**	**0.868**	**0.371**	**0.121**	**0.200**	**2.702**	**2.699**
1978	**1.168**	**1.083**	**1.169**	**1.132**	**0.359**	**0.137**	**0.191**	**0.935**	**0.419**	**0.148**	**0.223**	**2.609**	**2.530**
1979	**1.213**	**1.077**	**1.269**	**1.141**	**0.378**	**0.142**	**0.196**	**1.024**	**0.459**	**0.153**	**0.249**	**2.705**	**2.544**
1980	**1.273**	**1.125**	**1.414**	**1.201**	**0.400**	**0.144**	**0.206**	**1.113**	**0.509**	**0.162**	**0.291**	**2.784**	**2.628**
1981	**1.315**	**1.166**	**1.431**	**1.256**	**0.418**	**0.146**	**0.216**	**1.201**	**0.550**	**0.171**	**0.309**	**2.871**	**2.742**
1982	**1.353**	**1.190**	**1.466**	**1.288**	**0.447**	**0.156**	**0.226**	**1.288**	**0.604**	**0.186**	**0.330**	**2.884**	**2.744**
1983	**1.382**	**1.189**	**1.508**	**1.281**	**0.484**	**0.170**	**0.234**	**1.383**	**0.669**	**0.202**	**0.352**	**2.858**	**2.649**
1984	**1.451**	**1.245**	**1.740**	**1.349**	**0.549**	**0.210**	**0.243**	**1.487**	**0.797**	**0.261**	**0.422**	**2.707**	**2.516**
1985	**1.597**	**1.342**	**2.016**	**1.462**	**0.613**	**0.274**	**0.256**	**1.624**	**0.979**	**0.368**	**0.517**	**2.647**	**2.424**
1986	**1.697**	**1.451**	**2.299**	**1.597**	**0.654**	**0.278**	**0.267**	**1.811**	**1.109**	**0.404**	**0.615**	**2.770**	**2.607**
1987	**1.811**	**1.537**	**2.510**	**1.721**	**0.723**	**0.309**	**0.278**	**1.990**	**1.309**	**0.474**	**0.698**	**2.753**	**2.615**
1988	**1.970**	**1.713**	**2.951**	**1.930**	**0.812**	**0.356**	**0.289**	**2.189**	**1.600**	**0.610**	**0.853**	**2.694**	**2.640**
1989	**2.180**	**1.863**	**3.229**	**2.112**	**0.823**	**0.343**	**0.295**	**2.416**	**1.795**	**0.640**	**0.952**	**2.935**	**2.843**
1990	**2.397**	**2.018**	**3.523**	**2.301**	**0.834**	**0.324**	**0.300**	**2.622**	**2.000**	**0.653**	**1.057**	**3.143**	**3.018**
1991	**2.598**	**2.183**	**3.849**	**2.513**	**0.906**	**0.368**	**0.308**	**2.804**	**2.353**	**0.804**	**1.185**	**3.096**	**2.996**
1992	**2.831**	**2.479**	**4.372**	**2.872**	**1.007**	**0.443**	**0.318**	**3.011**	**2.851**	**1.098**	**1.391**	**2.989**	**3.033**
1993	**3.316**	**3.075**	**5.333**	**3.570**	**1.108**	**0.516**	**0.331**	**3.281**	**3.675**	**1.586**	**1.766**	**2.961**	**3.188**
1994	**3.829**	**3.420**	**7.111**	**4.069**	**1.257**	**0.590**	**0.336**	**3.593**	**4.815**	**2.017**	**2.393**	**2.857**	**3.036**
1995	**4.426**	**3.641**	**8.405**	**4.418**	**1.386**	**0.680**	**0.345**	**3.941**	**6.133**	**2.474**	**2.897**	**2.844**	**2.839**
1996	**4.829**	**3.802**	**9.331**	**4.702**	**1.503**	**0.742**	**0.358**	**4.344**	**7.257**	**2.819**	**3.337**	**2.891**	**2.815**
1997	**4.967**	**3.878**	**10.003**	**4.894**	**1.630**	**0.771**	**0.367**	**4.761**	**8.093**	**2.991**	**3.668**	**2.922**	**2.879**
1998	**4.985**	**3.888**	**10.530**	**5.019**	**1.728**	**0.800**	**0.370**	**5.189**	**8.614**	**3.111**	**3.899**	**3.003**	**3.024**
1999	**4.964**	**3.875**	**10.882**	**5.099**	**1.854**	**0.844**	**0.381**	**5.589**	**9.203**	**3.272**	**4.144**	**3.014**	**3.097**
2000	**5.086**	**3.927**	**11.174**	**5.253**	**2.008**	**0.908**	**0.398**	**6.015**	**10.215**	**3.565**	**4.445**	**2.995**	**3.093**
2001	**5.219**	**3.983**	**11.810**	**5.422**	**2.162**	**1.052**	**0.411**	**6.466**	**11.281**	**4.192**	**4.857**	**2.991**	**3.108**
2002	**5.169**	**3.999**	**12.406**	**5.547**	**2.349**	**1.182**	**0.420**	**6.986**	**12.138**	**4.728**	**5.212**	**2.975**	**3.192**
2003	**5.272**	**4.080**	**13.814**	**5.778**	**2.563**	**1.412**	**0.435**	**7.559**	**13.514**	**5.760**	**6.010**	**2.949**	**3.232**
2004	**5.569**	**4.273**	**15.650**	**6.131**	**2.810**	**1.656**	**0.448**	**8.235**	**15.646**	**7.076**	**7.018**	**2.931**	**3.227**
2005	**5.772**	**4.317**	**17.192**	**6.271**	**3.114**	**1.841**	**0.478**	**9.034**	**17.973**	**7.947**	**8.224**	**2.902**	**3.152**
2006	**6.091**	**4.352**	**20.009**	**6.350**	**3.488**	**2.112**	**0.479**	**9.892**	**21.247**	**9.193**	**9.577**	**2.836**	**2.956**
2007	**6.407**	**4.457**	**24.315**	**6.559**	**4.018**	**2.554**	**0.470**	**10.867**	**25.745**	**11.382**	**11.422**	**2.704**	**2.768**
2008	**6.813**	**4.786**	**28.682**	**7.215**	**4.411**	**2.907**	**0.466**	**12.058**	**30.050**	**13.914**	**13.364**	**2.734**	**2.895**
2009	**6.832**	**4.726**	**31.770**	**7.373**	**4.829**	**3.481**	**0.474**	**13.333**	**32.992**	**16.453**	**15.061**	**2.761**	**2.980**
2010	**7.129**	**4.898**	**33.582**	**7.817**	**5.442**	**4.069**	**0.520**	**14.893**	**38.793**	**19.933**	**17.471**	**2.737**	**3.001**
2011	**7.679**	**5.213**	**38.799**	**8.499**	**5.935**	**4.527**	**0.538**	**16.664**	**45.572**	**23.599**	**20.876**	**2.808**	**3.108**
2012	**7.887**	**5.282**	**44.139**	**8.783**	**6.381**	**4.892**	**0.547**	**18.574**	**50.325**	**25.838**	**24.155**	**2.911**	**3.242**
2013	**8.045**	**5.290**	**49.177**	**8.901**	**6.877**	**5.388**	**0.559**	**20.545**	**55.323**	**28.506**	**27.472**	**2.988**	**3.306**
2014	**8.195**	**5.305**	**54.185**	**9.013**	**7.343**	**5.770**	**0.554**	**22.650**	**60.176**	**30.612**	**29.993**	**3.085**	**3.393**
2015	**8.407**	**5.211**	**60.260**	**8.961**	**7.704**	**5.965**	**0.538**	**24.825**	**64.765**	**31.084**	**32.440**	**3.222**	**3.435**
2016	**8.592**	**5.198**	**63.661**	**9.040**	**8.170**	**6.371**	**0.543**	**26.959**	**70.190**	**33.120**	**34.537**	**3.300**	**3.472**
2017	**8.977**	**5.457**	**68.951**	**9.588**	**8.712**	**6.825**	**0.534**	**29.174**	**78.207**	**37.245**	**36.783**	**3.349**	**3.577**
2018	**9.368**	**5.729**	**75.874**	**10.193**	**9.179**	**7.242**	**0.527**	**31.516**	**85.994**	**41.491**	**39.986**	**3.433**	**3.736**
2019	**9.842**	**6.019**	**82.767**	**10.826**	**9.535**	**7.410**	**0.517**	**33.945**	**93.845**	**44.604**	**42.806**	**3.560**	**3.916**
2020	**10.352**	**6.330**	**88.078**	**11.471**	**9.428**	**7.276**	**0.515**	**36.325**	**97.594**	**46.056**	**45.320**	**3.853**	**4.270**

The GDP deflator P_Y^t grew 10.35 fold over the sample period. The investment price index P_I^t and the labour price index P_L^t grew 6.33 fold and 88.08 fold respectively over the 5 decades. Thus, real wages increased enormously over the sample period.

The nominal and real capital output ratios started out at the fairly low level of 1.81. The real capital output ratio increased over the sample period to end up at 3.85 while the nominal capital output ratio ended up at 4.27. Thus, it took on average an investment of 4.27 yuan in 2020 to produce 1 yuan of output. The lower is the nominal capital output ratio, the more internationally competitive the economy is. For many advanced

countries, the capital output ratio[10] in 2020 is likely to be in the 6 to 8 range so the Chinese economy in 2020 is very competitive.

We are now in a position where we can calculate an approximation to the aggregate cost of capital in year t, r^t. Once we have an estimate for r^t, the Jorgensonian user costs U_n^t defined by (4) can be calculated using the Chinese data on the beginning of the year capital stocks P_{Kn}^t, on depreciation rates δ_n^t, on ex post asset inflation rats i_n^t and on specific property taxes on assets τ_n^t for n =1, …, 16.[11] Consider the following equation for the year t data which sets the value of gross output V_Y^t equal to the sum of labour earnings V_L^t plus the sum of User costs U_n^t times the corresponding beginning of the year capital stocks Q_{Kn}^t:

$$(10)\ V_Y^t = V_L^t + \Sigma_{n=1}^{16} [r^t + \tau_n^t - i_n^t + \delta_n^t(1+i_n^t)]P_{Kn}^t Q_{Kn}^t ; \qquad t = 1970, \ldots, 2020.$$

All of the variables in equation (10) for year t are known except for the cost of capital, r^t. Since the equation is linear in r^t, it can be solved for r^t for each year t. Once r^t is known, the user costs defined by (4), U_n^t for n = 1, …, 16, can be calculated for each year t.

The resulting ex post rates of return on Chinese assets, r^{t*} for t = 1970, …, 2020 are listed in Table 3 below. The sample average of these rates of return was 17.88% per year. This is a gigantic average rate of return on assets! However, these rates of return are quite volatile and as a result, the user costs defined by (4) turn out to be very volatile as well and, in particular, these fluctuations in r^t led to many negative user costs for assets 12-16. There was one negative user cost for inventory services, 3 for agricultural land services, 10 for industrial land services, 9 for commercial land services and 7 for residential land services. This is not very satisfactory. We would like user costs to approximate the corresponding rental prices for the various assets (but of course, these rental prices are not available to us) and rental prices are rarely negative.

The volatility in the ex post rates of return is caused by the volatility in ex post asset inflation rates i_n^t defined by equations (2) above. Equation (10) is the "right" equation to determine year to year ex post rates of return on assets but it is not the "right" equation to determine longer run rental prices for assets. In what follows, we will smooth the ex post rates of return in an attempt to find ex ante rates of return which are more suitable to insert into a user cost formula that is supposed to approximate a market rent for the use of asset. Owners of assets that rent the services of these assets to firms use the logic of user costs to form estimates of appropriate rental rates. However, the owners cannot forecast exactly what the ex post inflation rate on the asset will be. Thus, their forecasts for asset inflation rates will probably be extrapolations of past asset inflation rates. We will simply smooth actual ex post asset inflation rates to approximate these forecasts. We use the nonparametric Lowess smoothing method in Shazam (with smoothing parameter Smooth set equal to 0.3) for all 16 assets. The resulting smoothed annual asset inflation rates i_n^t are listed in Table A7 in the Appendix.

[10] Note that our capital aggregate includes the value of land. From Table A4 in the Appendix, the price of the 5 types of aggregate capital in 2020 showed that the price increases over the sample period were 2.1 fold for Machinery and Equipment, 10.5 fold for structures, 3.9 fold for Other types of capital (Cultivated assets, Research and development, Computer software and Other intangible assets), 6.7 fold for Inventories and 113.5 fold for Land assets. Thus, including Land in the capital aggregate will tend to increase the nominal capital output ratio for a country. Since quality adjusted land tends to grow more slowly than reproducible capital over time , the inclusion of land in the aggregate capital stock will tend to lead to a lower capital output ratio over time.

[11] The APO information on property taxes is not detailed. We assumed that property taxes fell on industrial land, commercial land and residential land in a proportional manner. The sample average property tax rate on the three land assets was 1.138%. Since the average rate of return on assets was so high in China, the use of these poorly estimated property tax rates will not materially affect user costs and waiting costs.

Now use the smoothed inflation rates i_n^t in equations (10) in order to determine the smoothed rates for return r^t as solutions to equations (10). The resulting smoothed balancing rates of return r^t are listed in Table 3 below. The average rate of return using the smoothed r^t turned out to be 17.96% which is slightly higher than the average ex post rate of return which was 17.88%. Use the smoothed r^t and the smoothed i_n^t in equations (4) to define new smoothed user costs, U_n^t for n = 1, …, 16. These smoothed user costs are listed in Table A8 in the Appendix. Unfortunately, 3 user costs for industrial land and 3 user costs for commercial land turned out to be negative. A negative user cost is unlikely to approximate a real world rental price for the use of a land asset. However, our method for forming expected asset inflation rates is subject to a considerable amount of error and our highly aggregated estimated cost of capital may not be close to the actual cost of financial capital in particular industries. Moreover, markets for land assets are often not very liquid and hence, the actual user cost of a land asset may well be negative. For very liquid assets, a negative user cost should induce investors to quickly bid up the price of the asset to eliminate the negative user cost. However, the transactions costs of purchasing land can often be large and the lack of sellers of land can cause negative user costs. Thus, we will leave the negative user costs in our data base.

We use the data on the smoothed user costs, U_1^t, …, U_{16}^t, along with the data on the beginning of the year asset stocks, Q_{K1}^t, …, Q_{K16}^t, to form *five capital services aggregates* for our five types of aggregate capital. Denote the prices and quantities for these aggregate capital services by P_{UM}^t, P_{US}^t, P_{UO}^t, P_{UI}^t, P_{UL}^t and Q_{UM}^t, Q_{US}^t, Q_{UO}^t, Q_{UI}^t, Q_{UL}^t. These aggregate user costs are listed in Table 3 below (with prices normalized to equal 1 in 1970) and the corresponding capital services aggregates are listed in Table 4 below.[12] The year t price and quantity of *aggregate capital services*, P_U^t and Q_U^t, were formed by aggregating P_{UM}^t, P_{US}^t, P_{UO}^t, P_{UI}^t, P_{UL}^t and Q_{UM}^t, Q_{US}^t, Q_{UO}^t, Q_{UI}^t, Q_{UL}^t.[13] Finally, the year t price and quantity of *aggregate input*, P_Z^t and Q_Z^t, were calculated by aggregating the five capital services subaggregates with aggregate labour, P_L^t and Q_L^t. These aggregate input prices are listed in Table 3 and the corresponding aggregate input quantities are listed in Table 4.[14]

Table 3: Ex Post and Smoothed Rates of Return and Aggregate Output and Input Price Indexes

Year	r^t	r^{t*}	P_Y^t	P_Z^t	P_L^t	P_U^t	P_{UM}^t	P_{US}^t	P_{UO}^t	P_{UI}^t	P_{UL}^t
1970	0.1979	0.2035	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1971	0.1955	0.1881	1.0252	1.0040	1.0138	0.9918	0.9784	0.9975	0.9790	1.0404	0.9962
1972	0.1711	0.1911	1.0405	0.9814	1.0680	0.8792	0.8793	0.8849	0.9191	0.9049	0.8561
1973	0.1779	0.1586	1.0740	1.0124	1.0775	0.9333	0.9100	0.9451	0.9975	1.0493	0.8912
1974	0.1597	0.1637	1.0863	0.9707	1.0829	0.8437	0.8653	0.8488	0.9195	0.8809	0.7718
1975	0.1635	0.1709	1.1122	0.9913	1.0983	0.8690	0.8535	0.8653	1.0192	1.0424	0.7847
1976	0.1274	0.1440	1.1241	0.9263	1.1026	0.7417	0.7677	0.7419	0.9724	0.8898	0.5420
1977	0.1489	0.1091	1.1539	0.9810	1.1185	0.8289	0.7912	0.7946	1.0909	1.2468	0.6598
1978	0.1627	0.1470	1.1676	1.0329	1.1692	0.8801	0.8422	0.8559	1.1818	1.2254	0.7360
1979	0.1613	0.1868	1.2130	1.0705	1.2687	0.8646	0.8376	0.8417	1.2385	1.1524	0.7239
1980	0.1510	0.1654	1.2726	1.1148	1.4138	0.8267	0.7962	0.8073	1.1901	1.1432	0.6426
1981	0.1555	0.1432	1.3148	1.1374	1.4306	0.8526	0.8037	0.8225	1.2117	1.2475	0.6683
1982	0.1724	0.1207	1.3529	1.1856	1.4656	0.9081	0.8444	0.8864	1.2932	1.2531	0.8005
1983	0.1967	0.1904	1.3820	1.2474	1.5075	0.9808	0.8835	1.0353	1.3169	1.0479	1.0244
1984	0.2132	0.2294	1.4507	1.4081	1.7401	1.0799	0.9329	1.1657	1.3862	1.0885	1.2122
1985	0.2274	0.2441	1.5966	1.6085	2.0161	1.2141	0.9981	1.3250	1.5201	1.2174	1.4366
1986	0.2112	0.2061	1.6966	1.6876	2.2989	1.1548	0.9662	1.2787	1.5023	1.1081	1.2701
1987	0.2330	0.2570	1.8111	1.8594	2.5099	1.2862	1.0081	1.4216	1.5768	1.2335	1.7129

[12] These capital services input subaggregates were formed using Tδrnqvist direct aggregation of input quantities; i.e., bilateral chained quantity indexes were formed first (quantities were always positive) and then the corresponding aggregate price indexes were calculated by deflating total value by the quantity index.

[13] The year t capital services aggregate price and quantity, P_U^t and Q_U^t, were calculated using Tδrnqvist direct aggregation of input quantities as were the overall input aggregates, P_Z^t and Q_Z^t.

[14] We are using two stage aggregation to form our input aggregates. We also used single stage aggregation of the original 16 capital services. The differences between the single stage and two stage aggregates were insignificant.

1988	**0.2411**	**0.2269**	**1.9697**	**2.1196**	**2.9507**	**1.4156**	**1.1058**	**1.5821**	**1.7565**	**1.2702**	**1.9777**
1989	**0.2381**	**0.2112**	**2.1802**	**2.2377**	**3.2294**	**1.4345**	**1.1326**	**1.5870**	**1.8791**	**1.3000**	**1.9885**
1990	**0.2342**	**0.2065**	**2.3966**	**2.3773**	**3.5234**	**1.4791**	**1.2046**	**1.6248**	**2.0388**	**1.3239**	**1.9607**
1991	**0.2412**	**0.2621**	**2.5978**	**2.6729**	**3.8485**	**1.7151**	**1.3541**	**1.9462**	**2.1653**	**1.4697**	**2.3062**
1992	**0.2436**	**0.3657**	**2.8309**	**3.0737**	**4.3715**	**1.9963**	**1.5343**	**2.3146**	**2.3805**	**1.6623**	**2.7363**
1993	**0.2265**	**0.2592**	**3.3162**	**3.7055**	**5.3332**	**2.3799**	**1.8082**	**2.9511**	**2.7193**	**1.7400**	**2.7158**
1994	**0.2185**	**0.2090**	**3.8292**	**4.5597**	**7.1112**	**2.7122**	**1.9603**	**3.3458**	**2.9444**	**2.1480**	**3.2132**
1995	**0.2278**	**0.2098**	**4.4258**	**5.4279**	**8.4053**	**3.2503**	**2.1543**	**3.9553**	**3.2834**	**2.7841**	**4.9603**
1996	**0.2167**	**0.1909**	**4.8290**	**5.9570**	**9.3310**	**3.5316**	**2.1925**	**4.4053**	**3.4007**	**3.0338**	**5.4644**
1997	**0.2044**	**0.1781**	**4.9665**	**6.2138**	**10.0026**	**3.6004**	**2.1327**	**4.5019**	**3.3007**	**3.2039**	**5.8781**
1998	**0.1809**	**0.1553**	**4.9852**	**6.2354**	**10.5302**	**3.4723**	**2.0536**	**4.4028**	**2.9846**	**3.0505**	**5.3510**
1999	**0.1759**	**0.1689**	**4.9635**	**6.2664**	**10.8822**	**3.4103**	**1.9463**	**4.2317**	**2.8573**	**3.1101**	**6.6090**
2000	**0.1795**	**0.1768**	**5.0863**	**6.4993**	**11.1742**	**3.5652**	**1.9182**	**4.3599**	**2.8878**	**3.2519**	**9.1781**
2001	**0.1776**	**0.1674**	**5.2187**	**6.7315**	**11.8097**	**3.6362**	**1.8868**	**4.3525**	**2.9522**	**3.3172**	**11.5323**
2002	**0.1738**	**0.1807**	**5.1685**	**6.8063**	**12.4059**	**3.5721**	**1.8141**	**4.2123**	**2.7854**	**3.1840**	**13.3442**
2003	**0.1660**	**0.1884**	**5.2719**	**7.0576**	**13.8140**	**3.5046**	**1.7302**	**4.1362**	**2.7982**	**2.9384**	**14.6591**
2004	**0.1682**	**0.1506**	**5.5690**	**7.5906**	**15.6502**	**3.6143**	**1.7154**	**4.3848**	**2.9447**	**2.9783**	**14.5792**
2005	**0.1703**	**0.1388**	**5.7724**	**7.9532**	**17.1917**	**3.6415**	**1.7182**	**4.4582**	**3.0452**	**3.1522**	**13.3036**
2006	**0.1825**	**0.1688**	**6.0912**	**8.8312**	**20.0091**	**3.8883**	**1.7830**	**4.7890**	**3.2181**	**3.4688**	**14.4938**
2007	**0.1958**	**0.2477**	**6.4072**	**10.1317**	**24.3150**	**4.2580**	**1.8452**	**5.4149**	**3.3162**	**3.8392**	**15.9049**
2008	**0.1810**	**0.1605**	**6.8132**	**11.0914**	**28.6823**	**4.3913**	**1.8058**	**5.8847**	**3.2406**	**3.7383**	**15.0575**
2009	**0.1737**	**0.1896**	**6.8316**	**11.3072**	**31.7695**	**4.1822**	**1.7184**	**5.4060**	**3.1132**	**3.9545**	**16.4880**
2010	**0.1697**	**0.2140**	**7.1288**	**11.8337**	**33.5819**	**4.3409**	**1.7181**	**5.7310**	**3.1843**	**3.9345**	**18.2957**
2011	**0.1574**	**0.1531**	**7.6790**	**12.7057**	**38.7986**	**4.3850**	**1.6636**	**5.9601**	**3.1566**	**3.9496**	**18.3950**
2012	**0.1395**	**0.1180**	**7.8868**	**13.0139**	**44.1385**	**4.0935**	**1.5654**	**5.4845**	**2.9478**	**3.8558**	**17.5903**
2013	**0.1279**	**0.1074**	**8.0450**	**13.3010**	**49.1769**	**3.8532**	**1.4797**	**5.0477**	**2.8033**	**3.6762**	**18.9047**
2014	**0.1252**	**0.0851**	**8.1946**	**13.7257**	**54.1853**	**3.7263**	**1.4391**	**4.7281**	**2.7440**	**3.5395**	**22.1671**
2015	**0.1252**	**0.0965**	**8.4065**	**14.2351**	**60.2595**	**3.6044**	**1.4078**	**4.3897**	**2.7003**	**3.4601**	**25.6135**
2016	**0.1287**	**0.1467**	**8.5915**	**14.7020**	**63.6613**	**3.6404**	**1.4146**	**4.2958**	**2.7701**	**3.4275**	**31.2884**
2017	**0.1353**	**0.1523**	**8.9773**	**15.8048**	**68.9506**	**3.8864**	**1.4500**	**4.6213**	**2.8274**	**3.5864**	**39.1030**
2018	**0.1358**	**0.1474**	**9.3684**	**16.7274**	**75.8739**	**3.9750**	**1.4586**	**4.6816**	**2.8666**	**3.7085**	**44.0751**
2019	**0.1377**	**0.1414**	**9.8420**	**17.6431**	**82.7669**	**4.0738**	**1.4713**	**4.7676**	**2.8804**	**3.9086**	**48.8818**
2020	**0.1312**	**0.1287**	**10.3520**	**17.7040**	**88.0778**	**3.8881**	**1.4461**	**4.4222**	**2.8601**	**3.6602**	**47.2236**

As was noted earlier, the average of the ex post rates of return on assets (the average of the r^{t*}) was 17.89% and the average of the smoothed rates of return (the average of the r^t) was 17.96%. There is a downward trend in the smoothed rates of return from 19.58% in 2007 to 13.12% in 2020. The GDP deflator, $P_Y{}^t$, increased 10.35 fold over the sample period while the aggregate input price index, $P_Z{}^t$, increased 17.70 fold and the quality adjusted price index for labour, $P_L{}^t$, increased an amazing 88.08 fold. The aggregate price index for capital services $P_U{}^t$ increased only 3.89 fold over the sample period. The price increases for our 5 main components of capital services increased 1.44 fold (Machinery and Equipment), 4.42 fold (Structures), 2.86 fold (Other capital services), 3.66 fold (Inventory services) and 47.22 fold (Land services).

Note that the aggregate land user cost is always positive; i.e., when we aggregate over the 4 types of land services, the 6 negative user costs are outweighed by positive user costs so that aggregate land services are always positive for China. The quantity or volume indexes that match up with the above price indexes are listed below in Table 4.

The rate of return on all assets used in production is an important statistic that measures the efficiency of an economy. Another important indicator of efficiency is the level of Total Factor Productivity (TFP) for the economy. In the following section, we use the data developed in this section to measure the Gross Output TFP for the Chinese economy.

3. Total Factor Productivity Estimates for China using Gross Output as the Measure of Output

Following Jorgenson and Griliches (1967), year t *Gross Output Total Factor Productivity* for the Chinese economy, TFP^t, is defined as the output quantity index $Q_Y{}^t$ divided by the input quantity index $Q_Z{}^t$:

(11) $TFP^t \equiv Q_Y{}^t/Q_Z{}^t$; t = 1970, …, 2020.

Year t *Total Factor Productivity Growth* (relative to year t−1), $TFP_G{}^t$, is defined as follows:

(12) $TFP_G{}^t \equiv TFP^t/TFP^{t-1}$; t = 1971, …, 2020.

Total Factor Productivity and TFP growth for China are listed in Tables 4 and 5 below respectively.

Table 4: Total Factor Productivity Levels and Input Quantity Indexes for China

Year t	TFP^t	$Q_Y{}^t$	$Q_Z{}^t$	$Q_L{}^t$	$Q_U{}^t$	$Q_{UM}{}^t$	$Q_{US}{}^t$	$Q_{UO}{}^t$	$Q_{UI}{}^t$	$Q_{UL}{}^t$
1970	1.0000	0.2474	0.2474	0.1403	0.1071	0.0312	0.0468	0.0043	0.0031	0.0216
1971	0.9794	0.2624	0.2679	0.1475	0.1205	0.0362	0.0508	0.0048	0.0062	0.0222
1972	0.9432	0.2685	0.2846	0.1507	0.1346	0.0407	0.0558	0.0054	0.0096	0.0228
1973	0.9426	0.2849	0.3023	0.1562	0.1476	0.0446	0.0612	0.0058	0.0121	0.0233
1974	0.8936	0.2869	0.3211	0.1615	0.1621	0.0488	0.0664	0.0062	0.0160	0.0239
1975	0.8913	0.3032	0.3402	0.1673	0.1766	0.0527	0.0729	0.0066	0.0187	0.0244
1976	0.8240	0.2978	0.3615	0.1732	0.1939	0.0584	0.0805	0.0072	0.0211	0.0249
1977	0.8502	0.3213	0.3780	0.1785	0.2065	0.0618	0.0872	0.0074	0.0225	0.0254
1978	0.8847	0.3585	0.4053	0.1909	0.2220	0.0648	0.0957	0.0077	0.0251	0.0259
1979	0.8825	0.3784	0.4288	0.1963	0.2428	0.0696	0.1048	0.0081	0.0297	0.0264
1980	0.8760	0.3996	0.4562	0.2057	0.2634	0.0717	0.1161	0.0086	0.0345	0.0269
1981	0.8651	0.4184	0.4837	0.2157	0.2833	0.0726	0.1291	0.0091	0.0382	0.0273
1982	0.8763	0.4467	0.5097	0.2255	0.3015	0.0710	0.1428	0.0095	0.0421	0.0279
1983	0.9026	0.4839	0.5361	0.2335	0.3229	0.0722	0.1574	0.0100	0.0455	0.0284
1984	0.9706	0.5494	0.5661	0.2425	0.3473	0.0752	0.1723	0.0108	0.0494	0.0291
1985	1.0074	0.6133	0.6088	0.2564	0.3808	0.0830	0.1895	0.0121	0.0550	0.0298
1986	0.9947	0.6539	0.6574	0.2673	0.4286	0.0980	0.2093	0.0137	0.0661	0.0306
1987	1.0267	0.7228	0.7041	0.2780	0.4753	0.1140	0.2290	0.0154	0.0753	0.0313
1988	1.0761	0.8123	0.7549	0.2890	0.5278	0.1353	0.2498	0.0173	0.0853	0.0321
1989	1.0264	0.8232	0.8021	0.2947	0.5877	0.1582	0.2735	0.0193	0.0986	0.0329
1990	0.9919	0.8344	0.8412	0.2999	0.6376	0.1678	0.2935	0.0204	0.1185	0.0335
1991	1.0289	0.9057	0.8803	0.3078	0.6811	0.1748	0.3113	0.0216	0.1364	0.0340
1992	1.0857	1.0071	0.9276	0.3183	0.7313	0.1863	0.3308	0.0234	0.1544	0.0351
1993	1.1174	1.1082	0.9918	0.3310	0.8024	0.2113	0.3590	0.0254	0.1724	0.0365
1994	1.1908	1.2574	1.0560	0.3364	0.8931	0.2553	0.3933	0.0281	0.1862	0.0383
1995	1.2264	1.3857	1.1299	0.3446	0.9957	0.3059	0.4330	0.0317	0.2014	0.0402
1996	1.2336	1.5027	1.2182	0.3576	1.1099	0.3513	0.4823	0.0355	0.2220	0.0423
1997	1.2511	1.6295	1.3024	0.3667	1.2291	0.3986	0.5341	0.0396	0.2430	0.0445
1998	1.2508	1.7279	1.3815	0.3703	1.3579	0.4598	0.5879	0.0454	0.2606	0.0471
1999	1.2625	1.8542	1.4686	0.3808	1.4835	0.5276	0.6444	0.0506	0.2687	0.0492
2000	1.2778	2.0083	1.5717	0.3978	1.6184	0.6032	0.7060	0.0574	0.2757	0.0515
2001	1.2899	2.1616	1.6758	0.4113	1.7666	0.6977	0.7728	0.0659	0.2805	0.0536
2002	1.3169	2.3485	1.7834	0.4201	1.9389	0.8129	0.8461	0.0757	0.2914	0.0561
2003	1.3387	2.5634	1.9148	0.4351	2.1412	0.9677	0.9286	0.0902	0.2976	0.0588
2004	1.3630	2.8095	2.0613	0.4484	2.3872	1.1804	1.0233	0.1051	0.3059	0.0614
2005	1.3778	3.1135	2.2598	0.4784	2.6771	1.4338	1.1324	0.1225	0.3214	0.0639
2006	1.4498	3.4882	2.4059	0.4786	3.0013	1.7531	1.2468	0.1435	0.3284	0.0671
2007	1.5813	4.0181	2.5410	0.4697	3.3637	2.1162	1.3735	0.1682	0.3386	0.0706
2008	1.6279	4.4105	2.7093	0.4659	3.7996	2.5537	1.5193	0.2005	0.3641	0.0745
2009	1.6551	4.8293	2.9178	0.4741	4.2874	3.0732	1.6649	0.2538	0.3980	0.0779
2010	1.6600	5.4417	3.2782	0.5203	4.9117	3.7458	1.8676	0.3321	0.4161	0.0813
2011	1.6546	5.9346	3.5867	0.5381	5.6320	4.5533	2.0878	0.4250	0.4506	0.0846
2012	1.6501	6.3808	3.8670	0.5472	6.3930	5.2571	2.3573	0.5343	0.4906	0.0879
2013	1.6533	6.8767	4.1594	0.5586	7.2283	6.1158	2.6300	0.6755	0.5209	0.0909
2014	1.6750	7.3433	4.3842	0.5535	8.1000	6.8819	2.9503	0.8371	0.5522	0.0938
2015	1.6933	7.7042	4.5497	0.5383	8.9684	7.5228	3.3041	1.0087	0.5877	0.0966
2016	1.7112	8.1697	4.7742	0.5425	9.7937	8.0051	3.6853	1.1893	0.6104	0.0994
2017	1.7605	8.7117	4.9483	0.5335	10.6586	8.6194	4.0735	1.3577	0.6336	0.1020
2018	1.7855	9.1791	5.1409	0.5270	11.5744	9.3536	4.4717	1.5254	0.6598	0.1046
2019	1.7926	9.5351	5.3190	0.5172	12.5285	10.1305	4.8964	1.7115	0.6714	0.1071
2020	1.7102	9.4275	5.5125	0.5145	13.4446	10.8104	5.3161	1.9107	0.6826	0.1094

From the above Table, it can be seen that TFP growth in China was largely negative for the 1970s. The initial level of TFP in 1970 was not attained until 1985. From the 1985 level of productivity equal to 1.01, the level grew to 1.79 in 2019 before falling to 1.71 in 2020 due to the adverse effects of Covid.

In Table 5 below, we list the annual productivity growth rates defined by (12) above. We also list the aggregate value of GDP, V_Y^t (which is equal to the aggregate value of input V_Z^t by construction) and the other macroeconomic input aggregates for labour and the 5 types of capital services, V_L^t, V_{UM}^t, V_{US}^t, V_{UO}^t, V_{UI}^t and V_{UL}^t.

Define the input shares in year t GDP for labour and the 5 types of capital services for t = 1970, …, 2020 as follows:

(13) $s_L^t \equiv V_L^t/V_Y^t$; $s_{UM}^t \equiv V_{UM}^t/V_Y^t$; $s_{US}^t \equiv V_{US}^t/V_Y^t$; $s_{UO}^t \equiv V_{UO}^t/V_Y^t$; $s_{UI}^t \equiv V_{UI}^t/V_Y^t$; $s_{UL}^t \equiv V_{UL}^t/V_Y^t$.

These input shares of GDP are also listed in Table 5.

Table 5: TFP Growth, Output and Input Aggregates and Input Shares of Gross Output

Year t	TFP_G^t	V_Y^t	V_L^t	V_U^t	s_L^t	s_{UM}^t	s_{US}^t	s_{UO}^t	s_{UI}^t	s_{UL}^t
1970		0.2474	0.1403	0.1071	0.5672	0.1262	0.1892	0.0176	0.0125	0.0873
1971	0.9794	0.2690	0.1495	0.1195	0.5558	0.1318	0.1886	0.0175	0.0241	0.0822
1972	0.9631	0.2793	0.1610	0.1184	0.5763	0.1281	0.1769	0.0176	0.0313	0.0698
1973	0.9994	0.3060	0.1683	0.1377	0.5499	0.1325	0.1890	0.0189	0.0417	0.0680
1974	0.9480	0.3116	0.1749	0.1367	0.5612	0.1354	0.1808	0.0182	0.0452	0.0592
1975	0.9975	0.3372	0.1837	0.1535	0.5448	0.1335	0.1870	0.0201	0.0578	0.0568
1976	0.9244	0.3348	0.1910	0.1438	0.5705	0.1340	0.1783	0.0208	0.0561	0.0403
1977	1.0318	0.3708	0.1996	0.1711	0.5384	0.1319	0.1869	0.0219	0.0758	0.0451
1978	1.0406	0.4186	0.2232	0.1954	0.5333	0.1304	0.1956	0.0217	0.0735	0.0455
1979	0.9976	0.4590	0.2491	0.2100	0.5426	0.1270	0.1922	0.0219	0.0746	0.0416
1980	0.9925	0.5086	0.2909	0.2177	0.5719	0.1122	0.1842	0.0201	0.0776	0.0339
1981	0.9876	0.5501	0.3085	0.2415	0.5609	0.1061	0.1930	0.0201	0.0867	0.0332
1982	1.0130	0.6043	0.3304	0.2738	0.5468	0.0992	0.2095	0.0203	0.0872	0.0369
1983	1.0300	0.6687	0.3520	0.3167	0.5264	0.0954	0.2436	0.0196	0.0713	0.0436
1984	1.0754	0.7971	0.4220	0.3750	0.5295	0.0880	0.2520	0.0189	0.0674	0.0442
1985	1.0379	0.9792	0.5170	0.4623	0.5279	0.0846	0.2565	0.0188	0.0684	0.0437
1986	0.9874	1.1094	0.6145	0.4949	0.5539	0.0853	0.2412	0.0185	0.0660	0.0350
1987	1.0321	1.3091	0.6978	0.6113	0.5330	0.0878	0.2487	0.0186	0.0709	0.0410
1988	1.0482	1.6000	0.8529	0.7471	0.5330	0.0935	0.2470	0.0190	0.0677	0.0397
1989	0.9537	1.7948	0.9518	0.8430	0.5303	0.0998	0.2418	0.0202	0.0714	0.0364
1990	0.9665	1.9997	1.0567	0.9430	0.5284	0.1011	0.2385	0.0208	0.0784	0.0328
1991	1.0373	2.3529	1.1847	1.1682	0.5035	0.1006	0.2575	0.0199	0.0852	0.0334
1992	1.0552	2.8511	1.3913	1.4598	0.4880	0.1003	0.2685	0.0195	0.0900	0.0337
1993	1.0291	3.6752	1.7655	1.9096	0.4804	0.1039	0.2882	0.0188	0.0816	0.0270
1994	1.0657	4.8148	2.3925	2.4224	0.4969	0.1040	0.2733	0.0172	0.0831	0.0256
1995	1.0300	6.1329	2.8967	3.2362	0.4723	0.1075	0.2793	0.0170	0.0914	0.0325
1996	1.0058	7.2566	3.3368	3.9198	0.4598	0.1061	0.2928	0.0166	0.0928	0.0318
1997	1.0142	8.0928	3.6675	4.4253	0.4532	0.1050	0.2971	0.0161	0.0962	0.0323
1998	0.9997	8.6141	3.8992	4.7150	0.4526	0.1096	0.3005	0.0157	0.0923	0.0293
1999	1.0094	9.2031	4.1439	5.0592	0.4503	0.1116	0.2963	0.0157	0.0908	0.0353
2000	1.0121	10.2148	4.4447	5.7701	0.4351	0.1133	0.3013	0.0162	0.0878	0.0463
2001	1.0095	11.2807	4.8571	6.4237	0.4306	0.1167	0.2982	0.0172	0.0825	0.0548
2002	1.0209	12.1381	5.2120	6.9261	0.4294	0.1215	0.2936	0.0174	0.0764	0.0617
2003	1.0166	13.5139	6.0100	7.5039	0.4447	0.1239	0.2842	0.0187	0.0647	0.0638
2004	1.0181	15.6462	7.0182	8.6280	0.4486	0.1294	0.2868	0.0198	0.0582	0.0572
2005	1.0109	17.9725	8.2239	9.7486	0.4576	0.1371	0.2809	0.0208	0.0564	0.0473
2006	1.0523	21.2472	9.5773	11.6698	0.4508	0.1471	0.2810	0.0217	0.0536	0.0457
2007	1.0907	25.7446	11.4219	14.3226	0.4437	0.1517	0.2889	0.0217	0.0505	0.0436
2008	1.0295	30.0495	13.3642	16.6854	0.4447	0.1535	0.2975	0.0216	0.0453	0.0374
2009	1.0167	32.9917	15.0612	17.9306	0.4565	0.1601	0.2728	0.0239	0.0477	0.0390

2010	**1.0029**	**38.7926**	**17.4713**	**21.3212**	**0.4504**	**0.1659**	**0.2759**	**0.0273**	**0.0422**	**0.0384**
2011	**0.9968**	**45.5721**	**20.8758**	**24.6962**	**0.4581**	**0.1662**	**0.2730**	**0.0294**	**0.0390**	**0.0342**
2012	**0.9973**	**50.3246**	**24.1546**	**26.1700**	**0.4800**	**0.1635**	**0.2569**	**0.0313**	**0.0376**	**0.0307**
2013	**1.0020**	**55.3234**	**27.4716**	**27.8518**	**0.4966**	**0.1636**	**0.2400**	**0.0342**	**0.0346**	**0.0311**
2014	**1.0131**	**60.1756**	**29.9926**	**30.1830**	**0.4984**	**0.1646**	**0.2318**	**0.0382**	**0.0325**	**0.0345**
2015	**1.0110**	**64.7654**	**32.4400**	**32.3254**	**0.5009**	**0.1635**	**0.2239**	**0.0421**	**0.0314**	**0.0382**
2016	**1.0106**	**70.1900**	**34.5366**	**35.6534**	**0.4920**	**0.1613**	**0.2255**	**0.0469**	**0.0298**	**0.0443**
2017	**1.0288**	**78.2070**	**36.7830**	**41.4240**	**0.4703**	**0.1598**	**0.2407**	**0.0491**	**0.0291**	**0.0510**
2018	**1.0142**	**85.9936**	**39.9857**	**46.0079**	**0.4650**	**0.1587**	**0.2434**	**0.0509**	**0.0285**	**0.0536**
2019	**1.0040**	**93.8447**	**42.8062**	**51.0386**	**0.4561**	**0.1588**	**0.2488**	**0.0525**	**0.0280**	**0.0558**
2020	**0.9540**	**97.5935**	**45.3197**	**52.2739**	**0.4644**	**0.1602**	**0.2409**	**0.0560**	**0.0256**	**0.0530**

The arithmetic average of the TFP growth rates over the years 1971-2020 was 1.13% per year which is quite good by international standards. The average share of labour and the 5 types of capital services was 0.498, 0.127 (Machinery and Equipment), 0.246 (Structures), 0.024 (Other Capital Services), 0.061 (Inventories) and 0.044 (Land). There are some big changes in these shares over time. The relatively low average share of labour is not a surprise, given the tremendous amount of investment and capital accumulation that has taken place in the Chinese economy over the past 5 decades. The share of labour in GDP has dropped from 0.567 in 1970 to 0.464 in 2020. There are other large shifts in GDP shares over the 5 decades. The average share of land is only 0.044 but it has grown during the past 5 years.

The average TFP grow rates by decade are as follows: 0.9874 or −1.26% per year during the 1970s; 1.0132 or 1.32% per year during the 1980s; 1.0259 or 2.59% per year during the 1990s; 1.0268 or 2.68% during the 2000s and 1.0086 or 0.86% per year during the 2010s.[15] Thus from 1980 on, the TFP performance of the Chinese economy has been very good by international standards. What is very interesting is that the Chinese rate of productivity growth has not declined to very low levels during he past two decades as has been the case for many OECD countries.

In the following section, we decompose real gross income growth into explanatory factors.

4. The Decomposition of Chinese Real Gross Income Growth into Explanatory Factors.

In this section, we divide the value of year t gross output V_Y^t by the year t price index for consumption P_C^t in order to obtain a measure of the year t real gross product generated by the Chinese production sector. Since nominal gross output is equal to nominal gross income V_Z^t, V_Y^t/P_C^t is equal to V_Z^t/P_C^t.

In order to simplify our notation for the various explanatory factors, we introduce some new notation for prices and quantities. Define the vectors of *real output prices* p^t and *real input prices* w^t for year t as follows for t = 1970, …, 2020:

(14) $p^t \equiv [p_1^t, \ldots, p_5^t] \equiv (1/P_C^t)[P_C^t,P_G^t,P_I^t,P_X^t,P_M^t]$; $w^t \equiv [w_1^t,..,w_6^t] \equiv (1/P_C^t)[P_L^t,P_{UM}^t,P_{US}^t,P_{UO}^t,P_{UI}^t,P_{UL}^t]$.

Thus, the real prices are equal to our existing macroeconomic prices divided by the price of consumption.

Define the vector of year t outputs y^t and the year t vector of inputs z^t as follows for all years t:

(15) $y^t \equiv [y_1^t,..,y_5^t] \equiv [Q_C^t,Q_G^t,Q_I^t,Q_X^t,-Q_M^t]$; $z^t \equiv [z_1^t,..,z_6^t] \equiv [Q_L^t,Q_{UM}^t,Q_{US}^t,Q_{UO}^t,Q_{UI}^t,Q_{UL}^t]$.

Using the above definitions, we see that *year t real income* is equal to $RI^t \equiv V_Y^t/P_C^t = p^t \cdot y^t = V_Z^t/P_C^t = w^t \cdot z^t$ for all years t. Define (one plus) *real income growth* going from year t−1 to year t, RI_G^t, as follows:

[15] We excluded the year 2020 from this average due to extraordinary Covid problems.

(16) $RI_G^t \equiv p^t \cdot y^t / p^{t-1} \cdot y^{t-1}$; $t = 1971, \ldots, 2020.$

Table 6 below lists the real gross incomes RI^t (in trillions of 1970 yuan), the real output prices p^t and the real input prices w^t.

Table 6: Gross Real Income, Real Output Prices and Real Input Prices

Year t	RI^t	p_2^t	p_3^t	p_4^t	p_5^t	w_1^t	w_2^t	w_3^t	w_4^t	w_5^t	w_6^t
1970	0.24739	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1971	0.25938	0.96190	0.97723	0.92229	0.92652	0.97762	0.94355	0.96196	0.94406	1.00325	0.96068
1972	0.26291	0.94922	0.95028	0.90337	0.88373	1.00522	0.82765	0.83293	0.86511	0.85170	0.80575
1973	0.28050	0.94253	0.96101	0.90569	0.83193	0.98758	0.83408	0.86621	0.91425	0.96179	0.81689
1974	0.27863	0.91035	0.92646	0.92989	0.82140	0.96817	0.77362	0.75884	0.82208	0.78760	0.69007
1975	0.29374	0.90515	0.92128	0.88404	0.78861	0.95661	0.74337	0.75365	0.88769	0.90797	0.68349
1976	0.28708	0.85853	0.92569	0.85614	0.77643	0.94545	0.65826	0.63613	0.83378	0.76299	0.46472
1977	0.31011	0.86244	0.92851	0.84371	0.77042	0.93546	0.66171	0.66460	0.91242	1.04280	0.55184
1978	0.34152	0.88194	0.88339	0.86793	0.76766	0.95390	0.68716	0.69831	0.96424	0.99978	0.60049
1979	0.35444	0.89293	0.83144	0.85633	0.72908	0.97962	0.64672	0.64993	0.95630	0.88982	0.55893
1980	0.37497	0.91316	0.82924	0.84219	0.72019	1.04235	0.58700	0.59520	0.87738	0.84278	0.47375
1981	0.39047	0.89191	0.82771	0.82419	0.72396	1.01547	0.57049	0.58382	0.86012	0.88554	0.47438
1982	0.41522	0.88659	0.81747	0.81980	0.71419	1.00706	0.58022	0.60905	0.88861	0.86106	0.55002
1983	0.44508	0.90061	0.79114	0.82789	0.74633	1.00334	0.58800	0.68907	0.87649	0.69747	0.68184
1984	0.50945	0.98290	0.79578	0.88242	0.84106	1.11225	0.59631	0.74505	0.88604	0.69575	0.77479
1985	0.56271	1.01329	0.77117	0.94793	0.91116	1.15855	0.57356	0.76142	0.87351	0.69958	0.82551
1986	0.60108	1.03714	0.78629	1.19140	1.12680	1.24555	0.52348	0.69282	0.81396	0.60035	0.68814
1987	0.65515	1.04966	0.76905	1.21724	1.20688	1.25612	0.50452	0.71145	0.78911	0.61732	0.85722
1988	0.69246	1.05128	0.74119	1.00872	1.42126	1.27704	0.47857	0.68471	0.76018	0.54973	0.85594
1989	0.69427	1.01720	0.72076	0.81500	1.15305	1.24921	0.43813	0.61389	0.72688	0.50287	0.76921
1990	0.72744	1.02950	0.73400	1.03671	1.22626	1.28172	0.43821	0.59107	0.74168	0.48162	0.71326
1991	0.80190	1.07179	0.74385	1.07359	1.22867	1.31161	0.46148	0.66327	0.73795	0.50090	0.78599
1992	0.93281	1.17741	0.81111	1.04765	1.19007	1.43026	0.50199	0.75729	0.77886	0.54386	0.89525
1993	1.06559	1.26565	0.89159	0.83753	1.02519	1.54632	0.52428	0.85565	0.78845	0.50450	0.78742
1994	1.19442	1.37292	0.84843	1.10332	1.35076	1.76409	0.48628	0.82999	0.73041	0.53285	0.79709
1995	1.22793	1.31481	0.72893	0.92049	1.12405	1.68290	0.43133	0.79193	0.65740	0.55742	0.99314
1996	1.30140	1.29927	0.68189	0.76879	0.90481	1.67342	0.39321	0.79005	0.60988	0.54409	0.98000
1997	1.39530	1.31461	0.66853	0.69293	0.82663	1.72457	0.36770	0.77618	0.56907	0.55239	1.01345
1998	1.48407	1.35014	0.66991	0.62874	0.74014	1.81417	0.35380	0.75853	0.51420	0.52555	0.92189
1999	1.57407	1.35642	0.66269	0.62809	0.77601	1.86126	0.33289	0.72379	0.48871	0.53194	1.13039
2000	1.69864	1.35672	0.65300	0.66053	0.81395	1.85819	0.31899	0.72502	0.48022	0.54077	1.52625
2001	1.85922	1.39911	0.65647	0.65668	0.77311	1.94641	0.31097	0.71735	0.48657	0.54673	1.90068
2002	2.10423	1.50861	0.69321	0.70783	0.80881	2.15065	0.31448	0.73023	0.48287	0.55197	2.31332
2003	2.36460	1.62601	0.71395	0.78320	0.88347	2.41711	0.30274	0.72374	0.48962	0.51415	2.56497
2004	2.69231	1.75778	0.73524	0.89229	0.97252	2.69300	0.29518	0.75451	0.50671	0.51249	2.50871
2005	3.08477	1.86853	0.74095	0.96148	0.99487	2.95076	0.29491	0.76520	0.52267	0.54105	2.28340
2006	3.43648	1.99429	0.70394	0.93387	0.94250	3.23624	0.28837	0.77457	0.52050	0.56104	2.34420
2007	4.09164	2.30769	0.70833	0.95546	0.94673	3.86444	0.29326	0.86060	0.52705	0.61018	2.52780
2008	4.60009	2.52353	0.73259	0.94436	0.94786	4.39078	0.27644	0.90085	0.49609	0.57228	2.30505
2009	5.14082	2.70048	0.73644	0.86272	0.82718	4.95037	0.26777	0.84237	0.48510	0.61619	2.56918
2010	5.75928	2.69955	0.72723	0.90952	0.87647	4.98569	0.25507	0.85084	0.47275	0.58413	2.71624
2011	6.24380	2.77180	0.71422	0.85744	0.82414	5.31576	0.22792	0.81659	0.43249	0.54113	2.52029
2012	6.78871	2.92178	0.71252	0.82683	0.78210	5.95422	0.21116	0.73985	0.39766	0.52014	2.37290
2013	7.27392	3.02022	0.69556	0.78225	0.73378	6.46578	0.19455	0.66367	0.36857	0.48334	2.48559
2014	7.60894	3.07814	0.67085	0.70963	0.67460	6.85149	0.18197	0.59785	0.34696	0.44756	2.80293
2015	7.97794	3.19524	0.64191	0.66097	0.58442	7.42289	0.17342	0.54073	0.33262	0.42622	3.15512
2016	8.24962	3.17372	0.61097	0.61605	0.54120	7.48229	0.16627	0.50490	0.32558	0.40284	3.67741
2017	8.80287	3.27148	0.61421	0.61481	0.55953	7.76099	0.16321	0.52017	0.31824	0.40368	4.40138
2018	9.41724	3.42966	0.62741	0.61456	0.56825	8.30902	0.15973	0.51269	0.31392	0.40612	4.82671
2019	9.74298	3.46525	0.62492	0.60106	0.56646	8.59287	0.15275	0.49498	0.29904	0.40579	5.07492
2020	9.77624	3.45055	0.63406	0.58685	0.52665	8.82301	0.14486	0.44299	0.28650	0.36665	4.73053

Real gross income in China grew 39.5 fold over the 50 years in our sample. This is a spectacular achievement. Real consumption growth over the sample period was lower; from Table A6 in the Appendix, it can be verified that real consumption grew 22.4 fold over the sample period. Real wages grew much

slower; an 8.8 fold increase over the sample period. The real user cost growth factors were 0.14 for Machinery and Equipment, 0.44 for Structures, 0.29 for Other Capital Services, 0.37 for Inventory and 4.7 for Land Services. Real consumption prices, p_1^t, are not listed in Table 6 because they are always equal to 1. Real Government Output prices grew 9.78 fold over the sample period and this is approximately equal to real wage growth. We note that government output prices are typically set equal to a government input price index, where government primary input consists mostly of labour.[16] The real price levels for gross investment, exports and imports in 2020 (relative to the corresponding 1970 levels) were 0.63, 0.59 and 0.53 respectively.

We use the new notation to define the logarithm of the *Törnqvist output price index* for year t, $P_T(p^{t-1},p^t,y^{t-1},y^t)$, and the logarithm of the *Törnqvist input quantity index* for year t, $Q_T(w^{t-1},w^t,z^{t-1},z^t)$ as follows:

(17) $\ln P_T(p^{t-1},p^t,y^{t-1},y^t) \equiv \Sigma_{n=1}^5 (1/2)[(p_n^t y_n^t/p^t\cdot y^t) + (p_n^{t-1} y_n^{t-1}/p^{t-1}\cdot y^{t-1})]\ln(p_n^t/p_n^{t-1})$; t = 1971, …, 2020;
(18) $\ln Q_T(w^{t-1},w^t,z^{t-1},z^t) \equiv \Sigma_{n=1}^6 (1/2)[(w_n^t z_n^t/w^t\cdot z^t) + (w_n^{t-1} z_n^{t-1}/w^{t-1}\cdot z^{t-1})]\ln(z_n^t/z_n^{t-1})$; t = 1971, …, 2020.

Define the year t *real output price change n contribution factor*, α_n^t, as follows:

(19) $\alpha_n^t \equiv (1/2)[(p_n^t y_n^t/p^t\cdot y^t) + (p_n^{t-1} y_n^{t-1}/p^{t-1}\cdot y^{t-1})]\ln(p_n^t/p_n^{t-1})$; n = 1, …, 5 ; t = 1971, …, 2020.

Comparing (17) and (19), it can be seen that the product over n of the year t output price growth factors α_n^t is equal to the year t Törnqvist output price index; i.e.:

(20) $P_T(p^{t-1},p^t,y^{t-1},y^t) = \Pi_{n=1}^5 \alpha_n^t$; t = 1971, …, 2020.

Define the year t *input n growth factor*, β_n^t, as follows:

(21) $\beta_n^t \equiv (1/2)[(w_n^t z_n^t/w^t\cdot z^t) + (w_n^{t-1} z_n^{t-1}/w^{t-1}\cdot z^{t-1})]\ln(z_n^t/z_n^{t-1})$; n = 1, …, 6 ; t = 1971, …, 2020.

Comparing (18) and (21), it can be seen that the product over n of the year t input growth factors β_n^t is equal to the year t Törnqvist input quantity index; i.e.:

(22) $Q_T(w^{t-1},w^t,z^{t-1},z^t) = \Pi_{n=1}^6 \beta_n^t$; t = 1971, …, 2020.

Define year *t productivity growth* TFP_G^t *using real prices as weights* as the implicit Törnqvist output quantity index, $[p^t\cdot y^t/p^{t-1}\cdot y^{t-1}]/P_T(p^{t-1},p^t,y^{t-1},y^t) = , p^t\cdot y^t/[p^{t-1}\cdot y^{t-1}P_T(p^{t-1},p^t,y^{t-1},y^t)]$, divided by the direct Törnqvist input quantity index $Q_T(w^{t-1},w^t,z^{t-1},z^t)$; i.e., we have the following definitions:

(23) $TFP_G^t \equiv p^t\cdot y^t/[p^{t-1}\cdot y^{t-1}P_T(p^{t-1},p^t,y^{t-1},y^t)Q_T(w^{t-1},w^t,z^{t-1},z^t)]$; t = 1971, …, 2020.

Using the fact that $P_T(p^{t-1},p^t,y^{t-1},y^t)$ is homogeneous of degree 1 in the components of p^t and homogeneous of degree –1 in p^{t-1} as well as the fact that $Q_T(w^{t-1},w^t,z^{t-1},z^t)$ is homogeneous of degree 0 in the components

[16] A problem with the current SNA is that only labour input and depreciation of government structures is counted as an input cost for the government sector. Typically, government sector output is measured by input cost. But there is no imputation in the SNA for the cost of capital that is associated with the use of government land and structures. Thus the existing SNA methodology greatly undervalues government sector output for most if not all countries.

of w^t and homogeneous of degree 0 in the components of w^{t-1}, it can be shown that τ^t is equal to the measure of productivity growth $TFP_G{}^t$ defined in the previous section for all t.[17]

Rearrange equations (23) to give us the following expression for year t *real income growth* over the prior year, $RI_G{}^t = p^t \cdot y^t / p^{t-1} \cdot y^{t-1}$:

$$(24)\ RI_G{}^t = \tau^t P_T(p^{t-1},p^t,y^{t-1},y^t) Q_T(w^{t-1},w^t,z^{t-1},z^t)\ ; \qquad t = 1971, \ldots, 2020$$
$$= TFP_G{}^t (\Pi_{n=1}{}^5\ \alpha_n{}^t)(\Pi_{n=1}{}^6\ \beta_n{}^t) \qquad \text{using (20) and (22).}$$

The above expression gives us a nice decomposition of year t real income growth into the following explanatory variables: TFP growth $TFP_G{}^t$, year t real output price contribution factors, $\alpha_2{}^t$-$\alpha_5{}^t$, and year t input growth factors, $\beta_1{}^t$-$\beta_6{}^t$. Table 7 below lists the ρ^t and the 12 contribution factors.

Table 7: Gross Real Income Growth, Real Output Price and Input Growth Contribution Factors

Year t	$RI_G{}^t$	$TFP_G{}^t$	$\alpha_2{}^t$	$\alpha_3{}^t$	$\alpha_4{}^t$	$\alpha_5{}^t$	$\beta_1{}^t$	$\beta_2{}^t$	$\beta_3{}^t$	$\beta_4{}^t$	$\beta_5{}^t$	$\beta_6{}^t$
1971	1.0485	0.9794	0.9959	0.9925	0.9979	1.0023	1.0282	1.0193	1.0157	1.0018	1.0129	1.0024
1972	1.0136	0.9631	0.9985	0.9913	0.9994	1.0014	1.0125	1.0152	1.0173	1.0019	1.0122	1.0019
1973	1.0669	0.9994	0.9992	1.0035	1.0001	1.0023	1.0203	1.0119	1.0169	1.0014	1.0084	1.0017
1974	0.9933	0.9480	0.9963	0.9884	1.0012	1.0007	1.0188	1.0122	1.0151	1.0012	1.0120	1.0015
1975	1.0543	0.9975	0.9994	0.9982	0.9975	1.0024	1.0197	1.0105	1.0173	1.0014	1.0081	1.0013
1976	0.9773	0.9244	0.9942	1.0015	0.9985	1.0008	1.0196	1.0138	1.0183	1.0016	1.0069	1.0009
1977	1.0802	1.0318	1.0005	1.0010	0.9994	1.0004	1.0167	1.0075	1.0147	1.0008	1.0043	1.0008
1978	1.1013	1.0406	1.0025	0.9832	1.0013	1.0002	1.0368	1.0062	1.0179	1.0007	1.0081	1.0009
1979	1.0378	0.9976	1.0015	0.9794	0.9993	1.0031	1.0151	1.0092	1.0179	1.0012	1.0126	1.0009
1980	1.0579	0.9925	1.0028	0.9991	0.9990	1.0008	1.0265	1.0035	1.0193	1.0012	1.0114	1.0006
1981	1.0413	0.9876	0.9972	0.9994	0.9985	0.9996	1.0271	1.0014	1.0203	1.0012	1.0084	1.0006
1982	1.0634	1.0130	0.9993	0.9962	0.9996	1.0011	1.0249	0.9977	1.0206	1.0007	1.0084	1.0007
1983	1.0719	1.0300	1.0019	0.9901	1.0008	0.9967	1.0190	1.0017	1.0222	1.0010	1.0063	1.0008
1984	1.1446	1.0754	1.0116	1.0018	1.0052	0.9895	1.0202	1.0037	1.0227	1.0016	1.0056	1.0010
1985	1.1045	1.0379	1.0041	0.9890	1.0066	0.9898	1.0299	1.0086	1.0245	1.0021	1.0074	1.0011
1986	1.0682	0.9874	1.0030	1.0072	1.0252	0.9673	1.0228	1.0142	1.0250	1.0022	1.0124	1.0010
1987	1.0900	1.0321	1.0015	0.9920	1.0027	0.9899	1.0216	1.0132	1.0223	1.0022	1.0090	1.0009
1988	1.0570	1.0482	1.0002	0.9864	0.9760	0.9767	1.0209	1.0157	1.0218	1.0022	1.0087	1.0010
1989	1.0026	0.9537	0.9960	0.9897	0.9739	1.0305	1.0104	1.0152	1.0224	1.0021	1.0101	1.0009
1990	1.0478	0.9665	1.0015	1.0062	1.0349	0.9912	1.0093	1.0059	1.0171	1.0012	1.0138	1.0006
1991	1.1024	1.0373	1.0052	1.0045	1.0060	0.9997	1.0136	1.0041	1.0147	1.0012	1.0116	1.0006
1992	1.1633	1.0552	1.0127	1.0320	0.9956	1.0055	1.0166	1.0064	1.0161	1.0016	1.0109	1.0010
1993	1.1423	1.0291	1.0101	1.0394	0.9619	1.0280	1.0192	1.0129	1.0230	1.0016	1.0095	1.0012
1994	1.1209	1.0657	1.0115	0.9791	1.0585	0.9424	1.0079	1.0199	1.0260	1.0018	1.0064	1.0013
1995	1.0281	1.0300	0.9941	0.9395	0.9575	1.0433	1.0117	1.0193	1.0269	1.0021	1.0069	1.0014
1996	1.0598	1.0058	0.9984	0.9739	0.9615	1.0453	1.0174	1.0149	1.0313	1.0019	1.0090	1.0016
1997	1.0722	1.0142	1.0016	0.9925	0.9782	1.0168	1.0115	1.0134	1.0306	1.0018	1.0086	1.0017
1998	1.0636	0.9997	1.0038	1.0008	0.9797	1.0191	1.0045	1.0154	1.0291	1.0022	1.0066	1.0018
1999	1.0606	1.0094	1.0007	0.9961	0.9998	0.9918	1.0127	1.0153	1.0278	1.0017	1.0028	1.0014
2000	1.0791	1.0121	1.0000	0.9948	1.0111	0.9904	1.0195	1.0152	1.0276	1.0020	1.0023	1.0019
2001	1.0945	1.0095	1.0050	1.0019	0.9986	1.0112	1.0146	1.0169	1.0275	1.0023	1.0015	1.0021
2002	1.1318	1.0209	1.0122	1.0209	1.0184	0.9898	1.0092	1.0184	1.0272	1.0024	1.0030	1.0026
2003	1.1237	1.0166	1.0119	1.0121	1.0291	0.9768	1.0154	1.0216	1.0272	1.0032	1.0015	1.0029
2004	1.1386	1.0181	1.0120	1.0130	1.0447	0.9699	1.0136	1.0255	1.0281	1.0029	1.0017	1.0026
2005	1.1458	1.0109	1.0094	1.0035	1.0288	0.9922	1.0297	1.0263	1.0292	1.0031	1.0028	1.0021
2006	1.1140	1.0523	1.0101	0.9778	0.9882	1.0188	1.0003	1.0290	1.0274	1.0034	1.0012	1.0022
2007	1.1906	1.0907	1.0226	1.0027	1.0095	0.9985	0.9916	1.0285	1.0280	1.0034	1.0016	1.0023
2008	1.1243	1.0295	1.0138	1.0154	0.9954	0.9996	0.9964	1.0291	1.0300	1.0038	1.0035	1.0022
2009	1.1175	1.0167	1.0106	1.0025	0.9702	1.0384	1.0078	1.0295	1.0264	1.0054	1.0042	1.0017
2010	1.1203	1.0029	0.9999	0.9936	1.0161	0.9848	1.0431	1.0328	1.0320	1.0069	1.0020	1.0016

[17] Diewert and Morrison (1986) and Kohli (1990) provide economic interpretations for $TFPG^t$ and the counterparts to $\alpha_n{}^t$ and $\beta_n{}^t$ that used un-normalized prices. Diewert and Lawrence (2006) extended the analysis to the case where normalized prices were used to measure the real gross income generated by the Australian production sector.

2011	**1.0841**	**0.9968**	**1.0042**	**0.9907**	**0.9817**	**1.0178**	**1.0154**	**1.0329**	**1.0311**	**1.0070**	**1.0032**	**1.0014**
2012	**1.0873**	**0.9973**	**1.0088**	**0.9988**	**0.9891**	**1.0147**	**1.0080**	**1.0240**	**1.0327**	**1.0070**	**1.0033**	**1.0012**
2013	**1.0715**	**1.0020**	**1.0056**	**0.9877**	**0.9842**	**1.0170**	**1.0101**	**1.0251**	**1.0276**	**1.0077**	**1.0022**	**1.0010**
2014	**1.0461**	**1.0131**	**1.0032**	**0.9816**	**0.9736**	**1.0217**	**0.9954**	**1.0196**	**1.0275**	**1.0078**	**1.0020**	**1.0010**
2015	**1.0485**	**1.0110**	**1.0064**	**0.9784**	**0.9822**	**1.0332**	**0.9862**	**1.0147**	**1.0261**	**1.0075**	**1.0020**	**1.0011**
2016	**1.0341**	**1.0106**	**0.9988**	**0.9768**	**0.9841**	**1.0156**	**1.0038**	**1.0101**	**1.0248**	**1.0074**	**1.0012**	**1.0012**
2017	**1.0671**	**1.0288**	**1.0053**	**1.0025**	**0.9996**	**0.9934**	**0.9919**	**1.0119**	**1.0236**	**1.0064**	**1.0011**	**1.0012**
2018	**1.0698**	**1.0142**	**1.0083**	**1.0102**	**0.9999**	**0.9968**	**0.9943**	**1.0131**	**1.0228**	**1.0058**	**1.0012**	**1.0013**
2019	**1.0346**	**1.0040**	**1.0018**	**0.9981**	**0.9954**	**1.0006**	**0.9914**	**1.0127**	**1.0226**	**1.0060**	**1.0005**	**1.0013**
2020	**1.0034**	**0.9540**	**0.9993**	**1.0069**	**0.9952**	**1.0135**	**0.9976**	**1.0104**	**1.0203**	**1.0060**	**1.0004**	**1.0012**
Mean	**1.0772**	**1.0113**	**1.0039**	**0.9965**	**0.9982**	**1.0027**	**1.0134**	**1.0151**	**1.0237**	**1.0031**	**1.0060**	**1.0014**

On average, real gross income growth generated by the Chinese economy was 7.72% per year. This is an extraordinarily high rate of growth. The sample averages of the factors that contributed to this growth are as follows in annual percentages: 1.13% (TFP change); 0.39% (government real price change); –0.35% (real investment price change); –0.18% (export price change); 0.27% (import price change); 1.34% (quality adjusted labour growth); 1.51% (manufacturing and equipment capital services growth); 2.37% (structures services growth); 0.31% (other capital services growth); 0.60% (inventory growth services) and 0.14% (land services growth). Real export prices fell over the sample period which lessened overall real gross income growth but real import prices fell even more which increased overall growth. Thus, terms of trade effects were positive for China over the sample period. Note that since population growth is turning into population decline for China, it is unlikely that quality adjusted labour will be very high in the future. This will lead to a significant slowdown in future growth for China.

Rather than look at year to year increases in real income growth, it is useful to convert the above annual rates of increase into levels. Thus, we express the *level of real income* in year t in terms of an *index of the level of Total Factor Productivity* in year t, TFP^t, of the *level of real output price* n in period t, A_n^t, and of the *level of primary input quantity* n in period t, B_n^t.[18] We use the growth factors TFP_G^t, α_n^t and β_n^t to define the corresponding levels TFP^t, A_n^t and B_n^t:

(25) $TFP^0 \equiv 1$; $TFP^t \equiv TFP^{t-1} TFP_G^t$; t = 1971, …, 2020;

(26) $A_n^0 \equiv 1$; $A_n^t \equiv A_n^{t-1}\alpha_n^t$; n = 2, 3, 4, 5 ; t = 1971, …, 2020;

(27) $B_n^0 \equiv 1$; $B_n^t \equiv B_n^{t-1}\beta_n^t$; n =1, 2, 3, 4, 5, 6 ; t = 1971, …, 2020.

Using the above definitions, we can establish the following relationships for the level of *real gross income* in year t relative to 1970, RI^t/RI^{1970} and the year t levels for technology, real output prices and input quantities:

(28) $RI^t/RI^{1970} = TFP^t A_2^t A_3^t A_4^t A_5^t B_1^t B_2^t B_3^t B_4^t B_5^t B_6^t$; t = 1970, …, 2020.

The levels decomposition for relative real gross income for China is shown in Table 8 below.

Table 8: The Levels Decomposition for Real Gross Income Growth in China

Year t	**RI^t/RI^{1970}**	**TFP^t**	**A_2^t**	**A_3^t**	**A_4^t**	**A_5^t**	**B_1^t**	**B_2^t**	**B_3^t**	**B_4^t**	**B_5^t**	**B_6^t**
1970	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
1971	**1.048**	**0.979**	**0.996**	**0.993**	**0.998**	**1.002**	**1.028**	**1.019**	**1.016**	**1.002**	**1.013**	**1.002**
1972	**1.063**	**0.943**	**0.994**	**0.984**	**0.997**	**1.004**	**1.041**	**1.035**	**1.033**	**1.004**	**1.025**	**1.004**
1973	**1.134**	**0.943**	**0.994**	**0.987**	**0.997**	**1.006**	**1.062**	**1.047**	**1.051**	**1.005**	**1.034**	**1.006**
1974	**1.126**	**0.894**	**0.990**	**0.976**	**0.999**	**1.007**	**1.082**	**1.060**	**1.067**	**1.006**	**1.046**	**1.008**
1975	**1.187**	**0.891**	**0.989**	**0.974**	**0.996**	**1.009**	**1.103**	**1.071**	**1.085**	**1.008**	**1.055**	**1.009**
1976	**1.160**	**0.824**	**0.984**	**0.976**	**0.995**	**1.010**	**1.125**	**1.086**	**1.105**	**1.009**	**1.062**	**1.010**

[18] This type of levels presentation of the data is quite instructive when presented in graphical form. It was suggested by Kohli (1990) and used extensively by him; see Kohli (1991), (2003) (2004a) (2004b) and Fox and Kohli (1998).

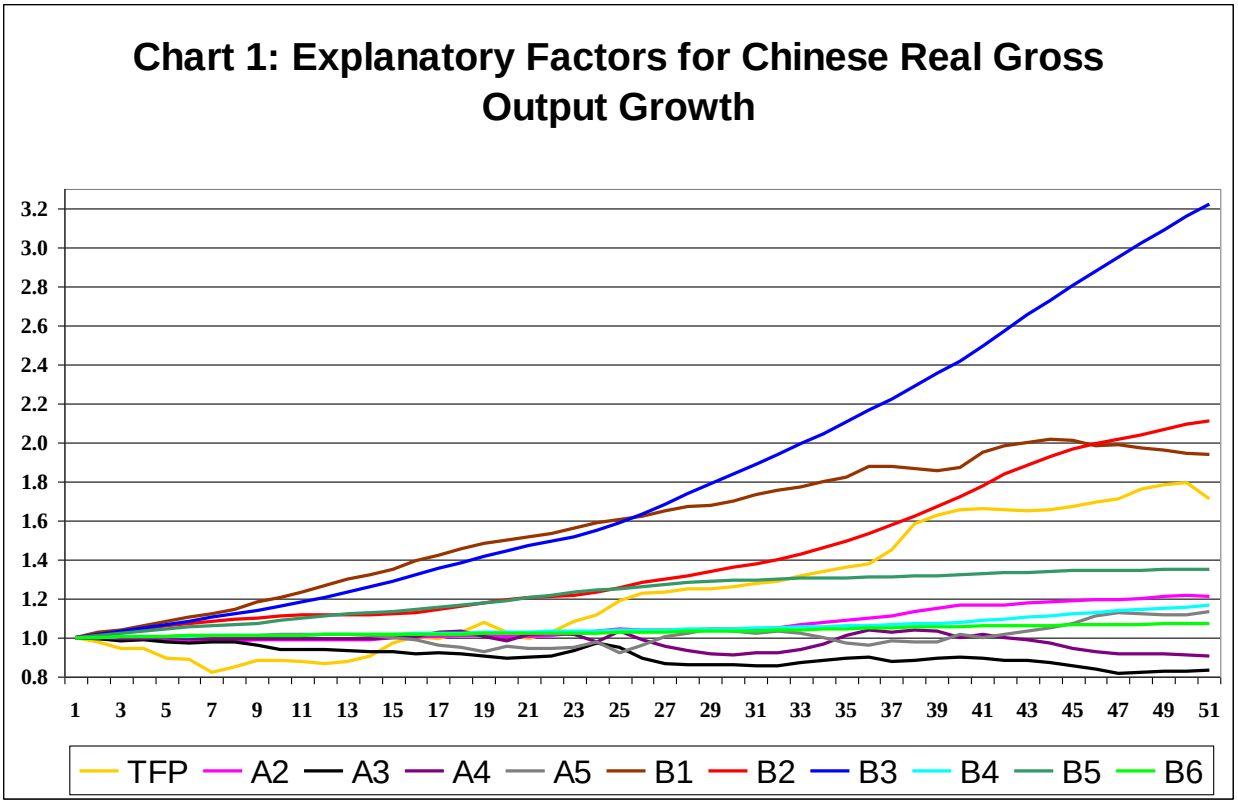
1977	**1.254**	**0.850**	**0.984**	**0.977**	**0.994**	**1.010**	**1.144**	**1.094**	**1.121**	**1.010**	**1.067**	**1.011**
1978	**1.380**	**0.885**	**0.987**	**0.960**	**0.995**	**1.011**	**1.186**	**1.101**	**1.141**	**1.011**	**1.075**	**1.011**
1979	**1.433**	**0.883**	**0.988**	**0.940**	**0.995**	**1.014**	**1.204**	**1.111**	**1.162**	**1.012**	**1.089**	**1.012**
1980	**1.516**	**0.876**	**0.991**	**0.939**	**0.994**	**1.014**	**1.236**	**1.115**	**1.184**	**1.013**	**1.101**	**1.013**
1981	**1.578**	**0.865**	**0.988**	**0.939**	**0.992**	**1.014**	**1.269**	**1.117**	**1.208**	**1.014**	**1.111**	**1.014**
1982	**1.678**	**0.876**	**0.987**	**0.935**	**0.992**	**1.015**	**1.301**	**1.114**	**1.233**	**1.015**	**1.120**	**1.014**
1983	**1.799**	**0.903**	**0.989**	**0.926**	**0.992**	**1.012**	**1.325**	**1.116**	**1.260**	**1.016**	**1.127**	**1.015**
1984	**2.059**	**0.971**	**1.001**	**0.928**	**0.998**	**1.001**	**1.352**	**1.120**	**1.289**	**1.018**	**1.133**	**1.016**
1985	**2.275**	**1.007**	**1.005**	**0.918**	**1.004**	**0.991**	**1.393**	**1.130**	**1.321**	**1.020**	**1.142**	**1.017**
1986	**2.430**	**0.995**	**1.008**	**0.924**	**1.030**	**0.959**	**1.424**	**1.146**	**1.354**	**1.022**	**1.156**	**1.018**
1987	**2.648**	**1.027**	**1.009**	**0.917**	**1.032**	**0.949**	**1.455**	**1.161**	**1.384**	**1.025**	**1.166**	**1.019**
1988	**2.799**	**1.076**	**1.009**	**0.904**	**1.008**	**0.927**	**1.485**	**1.179**	**1.414**	**1.027**	**1.176**	**1.020**
1989	**2.806**	**1.026**	**1.005**	**0.895**	**0.981**	**0.955**	**1.501**	**1.197**	**1.446**	**1.029**	**1.188**	**1.021**
1990	**2.940**	**0.992**	**1.007**	**0.901**	**1.015**	**0.947**	**1.515**	**1.204**	**1.470**	**1.030**	**1.205**	**1.022**
1991	**3.241**	**1.029**	**1.012**	**0.905**	**1.022**	**0.946**	**1.535**	**1.209**	**1.492**	**1.031**	**1.219**	**1.022**
1992	**3.771**	**1.086**	**1.025**	**0.934**	**1.017**	**0.952**	**1.561**	**1.217**	**1.516**	**1.033**	**1.232**	**1.023**
1993	**4.307**	**1.117**	**1.035**	**0.970**	**0.978**	**0.978**	**1.591**	**1.232**	**1.551**	**1.035**	**1.244**	**1.025**
1994	**4.828**	**1.191**	**1.047**	**0.950**	**1.036**	**0.922**	**1.604**	**1.257**	**1.591**	**1.037**	**1.252**	**1.026**
1995	**4.964**	**1.226**	**1.041**	**0.893**	**0.991**	**0.962**	**1.622**	**1.281**	**1.634**	**1.039**	**1.260**	**1.027**
1996	**5.261**	**1.234**	**1.039**	**0.869**	**0.953**	**1.005**	**1.651**	**1.300**	**1.685**	**1.041**	**1.272**	**1.029**
1997	**5.640**	**1.251**	**1.041**	**0.863**	**0.933**	**1.022**	**1.670**	**1.318**	**1.737**	**1.042**	**1.282**	**1.031**
1998	**5.999**	**1.251**	**1.045**	**0.863**	**0.914**	**1.042**	**1.677**	**1.338**	**1.787**	**1.045**	**1.291**	**1.032**
1999	**6.363**	**1.263**	**1.046**	**0.860**	**0.913**	**1.033**	**1.698**	**1.359**	**1.837**	**1.047**	**1.295**	**1.034**
2000	**6.866**	**1.278**	**1.046**	**0.856**	**0.924**	**1.023**	**1.731**	**1.379**	**1.888**	**1.049**	**1.297**	**1.036**
2001	**7.515**	**1.290**	**1.051**	**0.857**	**0.922**	**1.035**	**1.757**	**1.402**	**1.940**	**1.051**	**1.299**	**1.038**
2002	**8.506**	**1.317**	**1.064**	**0.875**	**0.939**	**1.024**	**1.773**	**1.428**	**1.992**	**1.054**	**1.303**	**1.041**
2003	**9.558**	**1.339**	**1.077**	**0.886**	**0.967**	**1.000**	**1.800**	**1.459**	**2.047**	**1.057**	**1.305**	**1.044**
2004	**10.883**	**1.363**	**1.090**	**0.897**	**1.010**	**0.970**	**1.825**	**1.496**	**2.104**	**1.060**	**1.307**	**1.047**
2005	**12.469**	**1.378**	**1.100**	**0.900**	**1.039**	**0.963**	**1.879**	**1.535**	**2.165**	**1.063**	**1.311**	**1.049**
2006	**13.891**	**1.450**	**1.111**	**0.880**	**1.027**	**0.981**	**1.879**	**1.580**	**2.225**	**1.067**	**1.313**	**1.051**
2007	**16.539**	**1.581**	**1.136**	**0.883**	**1.037**	**0.979**	**1.864**	**1.625**	**2.287**	**1.071**	**1.315**	**1.053**
2008	**18.595**	**1.628**	**1.152**	**0.896**	**1.032**	**0.979**	**1.857**	**1.672**	**2.356**	**1.075**	**1.319**	**1.056**
2009	**20.780**	**1.655**	**1.164**	**0.899**	**1.001**	**1.017**	**1.871**	**1.722**	**2.418**	**1.080**	**1.325**	**1.058**
2010	**23.280**	**1.660**	**1.164**	**0.893**	**1.017**	**1.001**	**1.952**	**1.778**	**2.495**	**1.088**	**1.328**	**1.059**
2011	**25.239**	**1.655**	**1.169**	**0.885**	**0.999**	**1.019**	**1.982**	**1.837**	**2.573**	**1.096**	**1.332**	**1.061**
2012	**27.441**	**1.650**	**1.179**	**0.884**	**0.988**	**1.034**	**1.998**	**1.881**	**2.657**	**1.103**	**1.336**	**1.062**
2013	**29.403**	**1.653**	**1.186**	**0.873**	**0.972**	**1.052**	**2.018**	**1.928**	**2.730**	**1.112**	**1.339**	**1.063**
2014	**30.757**	**1.675**	**1.189**	**0.857**	**0.946**	**1.074**	**2.009**	**1.965**	**2.805**	**1.120**	**1.342**	**1.064**
2015	**32.248**	**1.693**	**1.197**	**0.838**	**0.930**	**1.110**	**1.981**	**1.994**	**2.879**	**1.129**	**1.344**	**1.066**
2016	**33.347**	**1.711**	**1.196**	**0.819**	**0.915**	**1.127**	**1.989**	**2.015**	**2.950**	**1.137**	**1.346**	**1.067**
2017	**35.583**	**1.761**	**1.202**	**0.821**	**0.915**	**1.120**	**1.973**	**2.039**	**3.020**	**1.144**	**1.347**	**1.068**
2018	**38.066**	**1.786**	**1.212**	**0.829**	**0.914**	**1.116**	**1.961**	**2.065**	**3.089**	**1.151**	**1.349**	**1.070**
2019	**39.383**	**1.793**	**1.214**	**0.828**	**0.910**	**1.117**	**1.945**	**2.092**	**3.159**	**1.158**	**1.350**	**1.071**
2020	**39.518**	**1.710**	**1.213**	**0.833**	**0.906**	**1.132**	**1.940**	**2.113**	**3.223**	**1.165**	**1.350**	**1.072**

As was indicated above, real gross income grew 39.518 fold over the sample period.[19] The growth factors for 2020 that contributed to this overall growth of real income are as follows: 1.710 (TFP growth); 1.213 (Government real price growth); 0.833 (Gross Investment real price growth); 0.906 (Export real price growth)[20]; 1.132 (Import real price growth)[21] ; 1.940 (Quality Adjusted Labour Input growth); 2.113 (Machinery and Equipment services growth); 3.223 (Structure Services growth); 1.165 (Other Capital Services growth); 1.350 (Inventory Services growth); 1.072 (Land Services growth). Multiplication of all of these 2020 sample growth factors equals real gross income sample period growth of 39.518. Figure 1 below plots the 11 growth factors over the sample period.

[19] Per capita real gross income increased 23.2 fold over the sample period.

[20] This growth factor ended up less than one which indicates that real export prices fell over the sample period.

[21] The fact that this growth factor ended up greater than one indicates that real import prices fell over the sample period. If we combine the export and import growth terms, we find that China's terms of trade improved over the sample period.



The top five explanatory factors for observation 51 (2020) are B_3^{2020} (Structure Services), B_2^{2020} (Machinery and Equipment Services), B_1^{2020} (Labour), T^{2020} (Total Factor Productivity) and B_5^{2020} (Inventory Services). Note that the gold line (Total Factor Productivity) was near or below one for the first fifteen years of our sample. Note also that the contribution of Labour services (the brown line) is slowly declining over the past decade.

It can be seen that our measure of Total Factor Productivity can show declines over time. Thus, it is difficult to interpret TFP as technical progress which is an outward shift of the production possibilities set due to technical progress. It seems unlikely that technical progress can be regressive in the sense that producers forget methods of production over time and this leads to a contraction of the aggregate production possibilities set. It is likely that the declines in TFP that we see in almost all countries are due to recessions, which lead to decreases in outputs and in labour inputs. However, capital cannot be reduced in the short run, so typically, recessions lead to declines in measured TFP. In the following section, we will look at a nonparametric method for decomposing TFP into technical progress and inefficiency components.

5. A Nonparametric Decomposition of Gross Output Growth for China

The analysis in this section is based on Diewert and Fox (2018). There are two key concepts that this analysis is based on:

- An approximation to the aggregate production possibilities set for an economy can be formed by using linear multiples of past net output and primary input vectors and
- The *cost constrained value added function* can be used to form measures of efficiency, output price change, input price change, input quantity change and technology change.

We use the notation that was introduced in section 4 for the net output vector in year t, y^t, and the corresponding primary input vector x^t. Instead of letting t = 1970, …, 2020, we let t = 1, …, 51 to reduce the size of the notation. However, in this section, we will work with nominal gross output and income and nominal prices. The year t real price vectors, p^t and w^t, in the previous section are now nominal price vectors.

The basic assumption that Diewert and Fox make is that the year t technology set can be approximated by assuming it consists of past observed output and input vectors, (y^s,x^s), and linear multiples of these vectors for past periods and the current period t. Let S^t denote the resulting period t production possibilities set. Thus $S^1 \equiv \{(y,x) : y = \lambda y^1, x = \lambda x^1; \lambda \geq 0\}$, $S^2 \equiv \{(y,x) : y = \lambda_1 y^1, x = \lambda_1 x^1; \lambda_1 \geq 0, y = \lambda_2 y^2, x = \lambda_2 x^2; \lambda_2 \geq 0\}$, …, $S^t \equiv \{(y,x) : y = \lambda_s y^s, x = \lambda_s x^s; \lambda_s \geq 0, s = 1, 2, ..., t\}$. These definitions for the S^t mean that we are assuming a constant returns to scale technology for each period.[22]

The year t *cost constrained value added function* for the Chinese economy, $R^t(p,w,x)$, is defined as follows:[23]

$$(29)\ R^t(p,w,x) \equiv \max_{y,z}\{p\cdot y : (y,z)\in S^t ; w\cdot z \leq w\cdot x\}; \qquad t = 1, \ldots, 51$$
$$= \max_s \{p\cdot y^s\ w\cdot x/w\cdot x^s : s = 1,2,...,t\}$$
$$= w\cdot x\ \max_s \{p\cdot y^s/w\cdot x^s : s = 1,2,...,t\}.$$

Given nominal output prices p, nominal input prices w and the constraint that primary input costs should not exceed observed cost w·x, we assume that producers should choose the output vector y and input vector z to maximize national value added, p·y, subject to total primary input cost p·z to be equal to or less than observed input cost w·x. Due to our assumptions on the year t national production possibilities set S^t, the year t cost constrained value added function $R^t(p,w,x)$ can be calculated for a hypothetical p, w and x by solving the very simple maximization problem, $\max_s \{p\cdot y^s/w\cdot x^s : s = 1,2,...,t\}$, which involves taking the maximum of t numbers. In the definitions which follow, we will list t as going from 1970 to 2020 instead of going from 1 to 51.

The cost constrained value added function defined by (29) can be used to decompose GDP growth from year t−1 to year t, $p^t\cdot y^t/p^t\cdot y^t$, into various explanatory growth factors. The explanatory factors are as follows:

- efficiency changes;
- changes in output prices;
- changes in primary inputs;
- changes in input prices and
- technical progress.

Following the example of Balk (1998; 143), we define the *value added efficiency* of the sector for year t, e^t, as follows:

$$(30)\ e^t \equiv p^t\cdot y^t/R^t(p^t,w^t,x^t) \leq 1 ; \qquad t = 1970, \ldots, 2020.$$

where the inequality in (30) follows using definition (29).[24] Thus if $e^t = 1$, then production is allocatively efficient in year t and if $e^t < 1$, then production for the sector during period t is allocatively inefficient. Note

[22] This is a weakness of the Diewert and Fox methodology. But it is very difficult to model nonconstant returns to scale using only macroeconomic data. It is difficult to distinguish technical progress from increasing returns to scale.
[23] The cost constrained value added function and its properties are discussed in Diewert and Fox (2018) with references to the literature. It is a relabeling of Diewert's (1983; 1086) *balance of trade restricted value added function*.
[24] (y^t,x^t) is a feasible solution for the maximization problems in equations (29).

that the above definition of value added efficiency is a net revenue counterpart to Farrell's (1957; 255) cost based measure of *overall efficiency*.

Define an index of the *change in value added efficiency* ε^t for the sector over the years t−1 and t as follows:

(31) $\varepsilon^t \equiv e^t/e^{t-1} = [p^t \cdot y^t/R^t(p^t,w^t,x^t)]/[p^{t-1} \cdot y^{t-1}/R^{t-1}(p^{t-1},w^{t-1},x^{t-1})]$; t = 1970, …, 2020.

Thus if $\varepsilon^t > 1$, then value added efficiency has *improved* going from year t−1 to t whereas it has *fallen* if $\varepsilon^t < 1$.

We turn our attention to defining nonparametric measures of *output price change* going from year t−1 to t. Following the example of Konüs (1939) in his analysis of the true cost of living index, it is natural to single out two special cases of a family of output price indexes: one choice is α_L^t where we use the year t−1 technology and set the reference input prices and quantities equal to the year t−1 input prices and quantities w^{t-1} and x^{t-1} (which gives rise to a *Laspeyres type output price index*) and another choice is α_P^t where we use the year t technology and set the reference input prices and quantities equal to the year t prices and quantities w^t and x^t (which gives rise to a *Paasche type output price index*). We then define an overall measure of price change α^t by taking the geometric mean of these two indexes. These indexes are defined as follows:

(32) $\alpha_L^t \equiv R^{t-1}(p^t,w^{t-1},x^{t-1})/R^{t-1}(p^{t-1},w^{t-1},x^{t-1})$; t = 1971, …, 2020;
(33) $\alpha_P^t \equiv R^t(p^t,w^t,x^t)/R^t(p^{t-1},w^t,x^t)$; t = 1971, …, 2020;
(34) $\alpha^t \equiv [\alpha_L^t \alpha_P^t]^{1/2}$; t = 1971, …, 2020.

Two natural measures of *input price change* are the Laspeyres and Paasche input price indexes. Denote these year t indexes as cases β_L^t and β_P^t. Again it is natural to take the geometric average of these two indexes which gives rise to the Fisher ideal input price index, β^t. These indexes are defined as follows:

(35) $\beta_L^t \equiv w^{t-1} \cdot x^t/w^{t-1} \cdot x^{t-1}$; t = 1971, …, 2020;
(36) $\beta_P^t \equiv w^t \cdot x^t/w^t \cdot x^{t-1}$; t = 1971, …, 2020;
(37) $\beta^t \equiv [\beta_L^t \beta_P^t]^{1/2}$; t = 1971, …, 2020.

We now consider indexes which measures the effects on cost constrained value added of a change in input prices going from period t−1 to t. Thus we consider measures of the change in cost constrained value added of the form $R^s(p,w^t,x)/R^s(p,w^{t-1},x)$. Since $R^s(p,w,x)$ is homogeneous of degree 0 in the components of w, it can be seen that we cannot interpret $R^s(p,w^t,x)/R^s(p,w^{t-1},x)$ as an input price index. If there is only one primary input, $R^s(p,w^t,x)/R^s(p,w^{t-1},x)$ is equal to $R^s(p,1,x)/R^s(p,1,x) = 1$ and this measure of input price change will be independent of changes in the price of the single input. In the case where the number of primary inputs is greater than 1, it is best to interpret $R^s(p,w^t,x)/R^s(p,w^{t-1},x)$ as measuring the effects on cost constrained value added of a change in the relative proportions of primary inputs used in production or in the *mix* of inputs used in production that is induced by a change in relative input prices when there is more than one primary input. As usual, we will consider two special cases of this family of input mix indexes, Case 1 and a Case 2. The first case index γ_1^t will use the period t cost constrained value added function and the period t−1 reference vectors p^{t-1} and x^{t-1} while the second case index γ_2^t will use the use the period t−1 cost constrained value added function and the period t reference vectors p^t and x^t. As usual, we take the

geometric mean of these two indexes γ^t to provide a measure of the overall effects of a change in input prices.[25]

(38) $\gamma_1^t \equiv R^t(p^{t-1},w^t,x^t)/R^t(p^{t-1},w^{t-1},x^t)$; $t = 1971, \ldots, 2020;$
(39) $\gamma_2^t \equiv R^{t-1}(p^t,w^t,x^{t-1})/R^{t-1}(p^t,w^{t-1},x^{t-1})$; $t = 1971, \ldots, 2020;$
(40) $\gamma^t \equiv [\gamma_1^t\gamma_2^t]^{1/2}$; $t = 1971, \ldots, 2020.$

Finally, we use the cost constrained value added function in order to define measures of *technical progress* going from period t−1 to t. These measures hold p, w and x constant and only change the technology from the period t−1 technology to the period t technology.[26] Thus, these measures are of the form $R^t(p,w,x)/R^{t-1}(p,w,x)$. If there is positive technical progress going from period t−1 to t, then the production possibilities set S^t will be larger than the period t−1 set, S^{t-1}, and thus $R^t(p,w,x)$ will be equal to or greater than $R^{t-1}(p,w,x)$ and our measures of technical progress will be equal to or greater than 1. Our measures of technical progress cannot fall below 1.

We consider two measures of technical progress, a Laspeyres measure τ_L^t and a Paasche measure τ_P^t. However, the Laspeyres case τ_L^t will use the period t input vector x^t as the reference input vector and the period t−1 reference output price and input price vectors p^{t-1} and w^{t-1} while the Paasche case τ_P^t will use the use the period t−1 input vector x^{t-1} as the reference input and the period t reference output and input price vectors p^t and w^t.[27] As usual, we take our overall year t measure of technical change τ^t to be the geometric mean of the Laspeyres and Paasche measures of technical change.

(41) $\tau_L^t \equiv R^t(p^{t-1},w^{t-1},x^t)/R^{t-1}(p^{t-1},w^{t-1},x^t)$; $t = 1971, \ldots, 2020;$
(42) $\tau_P^t \equiv R^t(p^t,w^t,x^{t-1})/R^{t-1}(p^t,w^t,x^{t-1})$; $t = 1971, \ldots, 2020;$
(43) $\tau^t \equiv [\tau_L^t\tau_P^t]^{1/2}$; $t = 1971, \ldots, 2020.$

Finally, we define I_G^t to be year t *nominal gross income growth* instead of real income growth since our explanatory price factors are nominal prices in this section instead of real prices. Thus define I_G^t as follows:

(44) $I_G^t \equiv p^t \cdot y^t/p^{t-1} \cdot y^{t-1}$; $t = 1971, \ldots, 2020.$

Diewert and Fox (2018) show that the following *exact decomposition of nominal income growth into explanatory growth factors* holds:

(45) $I_G^t = \varepsilon^t \alpha^t \beta^t \gamma^t \tau^t$; $t = 1971, \ldots, 2020.$

Table 9 below lists I_G^t and the growth components on the right hand side of (45).

[25] These choices of the reference vectors will make our decomposition of value added growth an exact one. Usually, these input mix growth factors are close to one for all periods.

[26] These measures of technical progress measures were defined by Diewert and Morrison (1986; 662) using the value added function. A special case of the family was defined earlier by Diewert (1983; 1063). Balk (1998; 99) also used this definition and Balk (1998; 58), following the example of Salter (1960), also used the joint cost function to define a similar family of technical progress indexes.

[27] In our case where the reference technology is subject to constant returns to scale, τ_L^t turns out to be independent of x^t and τ_P^t turns out to be independent of x^{t-1}. These "mixed" indexes of technical progress are then true Laspeyres and Paasche type indexes.

A new measure of *Total Factor Productivity growth* for the economy going from period t−1 to t can be defined (following Jorgenson and Griliches (1967)) as an index of output growth divided by an index of input growth. An appropriate index of output growth is the value added ratio divided by the value added price index α^t. An appropriate index of input growth is β^t. Thus define the new *year t TFP growth rate*, $TFP_G{}^{t*}$, for the Chinese economy as follows:

$$(46)\ TFP_G{}^{t*} \equiv \{[p^t \cdot y^t / p^{t-1} \cdot y^{t-1}]/\alpha^t\}/\beta^t = \varepsilon^t \gamma^t \tau^t ; \qquad t = 1971, \ldots, 2020.$$

where the last equality in (46) follows from (45). Thus in general, the nonparametric period t TFP growth, $TFP_G{}^{t*}$, is equal to the product of period t value added efficiency change ε^t, a period t input mix index γ^t (which typically will be small in magnitude) and a period t measure of technical progress τ^t. $TFP_G{}^{t*}$ and our old index number measure of TFP growth, $TFP_G{}^t$, are listed in Table 9 below.

Table 9: A Nonparametric Decomposition of Nominal GDP Growth and TFP Growth Estimates

Year t	$I_G{}^t$	ε^t	α^t	β^t	γ^t	τ^t	e^t	$TFP_G{}^{t*}$	$TFP_G{}^t$
1971	1.0872	0.9793	1.0257	1.0824	1.0000	1.0000	0.9793	0.9793	0.9794
1972	1.0385	0.9674	1.0151	1.0624	0.9954	1.0000	0.9474	0.9629	0.9631
1973	1.0956	0.9958	1.0316	1.0620	1.0042	1.0000	0.9434	1.0000	0.9994
1974	1.0183	0.9551	1.0111	1.0621	0.9928	1.0000	0.9010	0.9482	0.9480
1975	1.0821	0.9918	1.0240	1.0596	1.0056	1.0000	0.8936	0.9973	0.9975
1976	0.9928	0.9329	1.0120	1.0625	0.9898	1.0000	0.8336	0.9233	0.9244
1977	1.1074	1.0145	1.0264	1.0456	1.0171	1.0000	0.8457	1.0318	1.0318
1978	1.1290	1.0430	1.0126	1.0722	0.9970	1.0000	0.8820	1.0399	1.0406
1979	1.0966	1.0098	1.0404	1.0581	0.9865	1.0000	0.8907	0.9962	0.9976
1980	1.1080	1.0085	1.0487	1.0640	0.9846	1.0000	0.8983	0.9929	0.9925
1981	1.0816	0.9807	1.0350	1.0601	1.0051	1.0000	0.8809	0.9857	0.9876
1982	1.0985	1.0137	1.0290	1.0538	0.9994	1.0000	0.8930	1.0130	1.0130
1983	1.1066	1.0366	1.0237	1.0518	0.9915	1.0000	0.9257	1.0278	1.0300
1984	1.1919	1.0803	1.0499	1.0559	0.9928	1.0024	1.0000	1.0751	1.0754
1985	1.2286	1.0000	1.1007	1.0755	1.0000	1.0378	1.0000	1.0378	1.0379
1986	1.1329	0.9922	1.0592	1.0798	0.9983	1.0000	0.9922	0.9906	0.9874
1987	1.1800	1.0078	1.0658	1.0710	0.9997	1.0260	1.0000	1.0338	1.0321
1988	1.2222	1.0000	1.0873	1.0722	1.0000	1.0484	1.0000	1.0484	1.0482
1989	1.1218	0.9550	1.1063	1.0626	0.9992	1.0000	0.9550	0.9542	0.9537
1990	1.1141	0.9724	1.0941	1.0487	0.9985	1.0000	0.9286	0.9710	0.9665
1991	1.1767	1.0371	1.0823	1.0465	1.0017	1.0000	0.9630	1.0388	1.0373
1992	1.2117	1.0384	1.0904	1.0537	1.0002	1.0153	1.0000	1.0546	1.0552
1993	1.2890	1.0000	1.1715	1.0692	1.0000	1.0291	1.0000	1.0291	1.0291
1994	1.3101	1.0000	1.1539	1.0647	1.0000	1.0664	1.0000	1.0664	1.0657
1995	1.2738	1.0000	1.1558	1.0700	1.0000	1.0300	1.0000	1.0300	1.0299
1996	1.1832	1.0000	1.0911	1.0781	1.0000	1.0058	1.0000	1.0058	1.0058
1997	1.1152	1.0000	1.0284	1.0691	1.0000	1.0143	1.0000	1.0143	1.0142
1998	1.0644	1.0000	1.0038	1.0607	0.9993	1.0004	1.0000	0.9997	0.9997
1999	1.0684	1.0000	0.9957	1.0631	1.0000	1.0094	1.0000	1.0094	1.0094
2000	1.1099	1.0000	1.0248	1.0702	1.0000	1.0121	1.0000	1.0121	1.0121
2001	1.1044	1.0000	1.0260	1.0663	1.0000	1.0095	1.0000	1.0095	1.0095
2002	1.0760	1.0000	0.9904	1.0642	1.0000	1.0209	1.0000	1.0209	1.0209
2003	1.1133	1.0000	1.0200	1.0737	1.0000	1.0166	1.0000	1.0166	1.0166
2004	1.1578	1.0000	1.0563	1.0765	1.0000	1.0182	1.0000	1.0182	1.0181
2005	1.1487	1.0000	1.0365	1.0963	1.0000	1.0109	1.0000	1.0109	1.0109
2006	1.1822	1.0000	1.0552	1.0647	1.0000	1.0523	1.0000	1.0523	1.0523
2007	1.2117	1.0000	1.0519	1.0562	1.0000	1.0906	1.0000	1.0906	1.0907
2008	1.1672	1.0000	1.0634	1.0662	1.0000	1.0295	1.0000	1.0295	1.0295
2009	1.0979	1.0000	1.0027	1.0770	1.0000	1.0167	1.0000	1.0167	1.0167
2010	1.1758	1.0000	1.0435	1.1235	1.0000	1.0029	1.0000	1.0029	1.0029
2011	1.1748	0.9991	1.0768	1.0942	0.9980	1.0000	0.9991	0.9971	0.9968
2012	1.1043	1.0008	1.0266	1.0781	0.9969	1.0000	1.0000	0.9977	0.9973
2013	1.0993	1.0000	1.0201	1.0756	0.9998	1.0021	1.0000	1.0019	1.0020
2014	1.0877	1.0000	1.0186	1.0541	1.0000	1.0131	1.0000	1.0131	1.0131
2015	1.0763	1.0000	1.0258	1.0378	1.0000	1.0110	1.0000	1.0110	1.0110

2016	**1.0838**	**1.0000**	**1.0220**	**1.0493**	**1.0000**	**1.0106**	**1.0000**	**1.0106**	**1.0106**
2017	**1.1142**	**1.0000**	**1.0449**	**1.0365**	**1.0000**	**1.0288**	**1.0000**	**1.0288**	**1.0288**
2018	**1.0996**	**1.0000**	**1.0436**	**1.0389**	**1.0000**	**1.0142**	**1.0000**	**1.0142**	**1.0142**
2019	**1.0913**	**1.0000**	**1.0506**	**1.0347**	**1.0000**	**1.0040**	**1.0000**	**1.0040**	**1.0040**
2020	**1.0399**	**0.9549**	**1.0519**	**1.0364**	**0.9990**	**1.0000**	**0.9549**	**0.9539**	**0.9540**
Mean	**1.1288**	**0.9993**	**1.0485**	**1.0642**	**0.9990**	**1.0130**	**0.9701**	**1.0114**	**1.0113**

Our nonparametric estimate of average TFP growth rates is 1.14% per year whereas our index number estimate of average TFP growth rates was 1.13%. There is very little difference between the two sets of estimates which helps to establish the credibility of both sets of estimates.

On average, nominal GDP grew at 12.88% per year. Output price inflation averaged 4.85% per year so real GDP grew at a very rapid rate over the sample period. There was a great deal of inefficiency in the early years of our sample. Our measure of efficiency, e^t, was below 1 for the years 1971-1983, 1986, 1989-1991 and 2011. The inefficiency in the early years of our sample reflect the problems that China faced in going from a command economy to a market economy in the 1970s and early 1980s. The inefficiencies in later years correspond to recessions.

Aggregate input growth averaged 6.42% per year which is remarkable.[28] The input mix growth factor, γ^t, was on average equal to 0.9990 which indicates a very small negative contribution to GDP growth over the sample period. The average rate of technical progress τ^t was 1.30% per year which is quite good. Note that when efficiency e^t is below 1, τ^t is equal to 1, which indicates no technical progress. Conversely, when technical progress is greater than 1, then efficiency e^t is equal to 1.

We again follow the example of Kohli (1990) and obtain a levels decomposition for the observed level of nominal Gross Domestic Product in year t, $p^t \cdot y^t$, relative to its observed value in year 1 of our sample, $p^1 \cdot y^1$. Define the cumulated explanatory variables as follows:

(47) $E^1 \equiv 1$; $A^1 \equiv 1$; $B^1 \equiv 1$; $C^1 \equiv 1$; $T^1 \equiv 1$.

For t = 2,3,...,51, define the above variables recursively as follows:

(48) $E^t \equiv \varepsilon^t E^{t-1}$; $A^t \equiv \alpha^t A^{t-1}$; $B^t \equiv \beta^t B^{t-1}$; $C^t \equiv \gamma^t C^{t-1}$; $T^t \equiv \tau^t T^{t-1}$; t = 1971, …, 2020.

Using the above definitions, it can be seen that we have the following *levels decomposition* for the level of period t observed nominal GDP or nominal gross income I^t to its level in 1970:

(49) $I^t/I^{1970} \equiv p^t \cdot y^t / p^{1970} \cdot y^{1970} = A^t B^t C^t E^t T^t$; t = 1970, …, 2020.

Define the period t level of Total Factor Productivity, TFP^t, as follows:

(50) $TFP^{1*} \equiv 1$; for t = 2,...,T, define $TFP^{t*} \equiv (TFP_G{}^{t*})(TFP^{t-1*})$; t = 1971, …, 2020

where $TFP_G{}^t$ is defined by (46). Using (47)-(50), it can be seen that we have the following *levels decomposition for TFP* using the cumulated explanatory factors defined by (47) and (48):

(51) $TFP^{t*} = [p^t \cdot y^t / p^1 \cdot y^1]/[A^t B^t] = C^t E^t T^t$; t = 1970, …, 2020.

[28] As the population of China starts to decline more noticeably, we can expect input growth to slow down in the future.

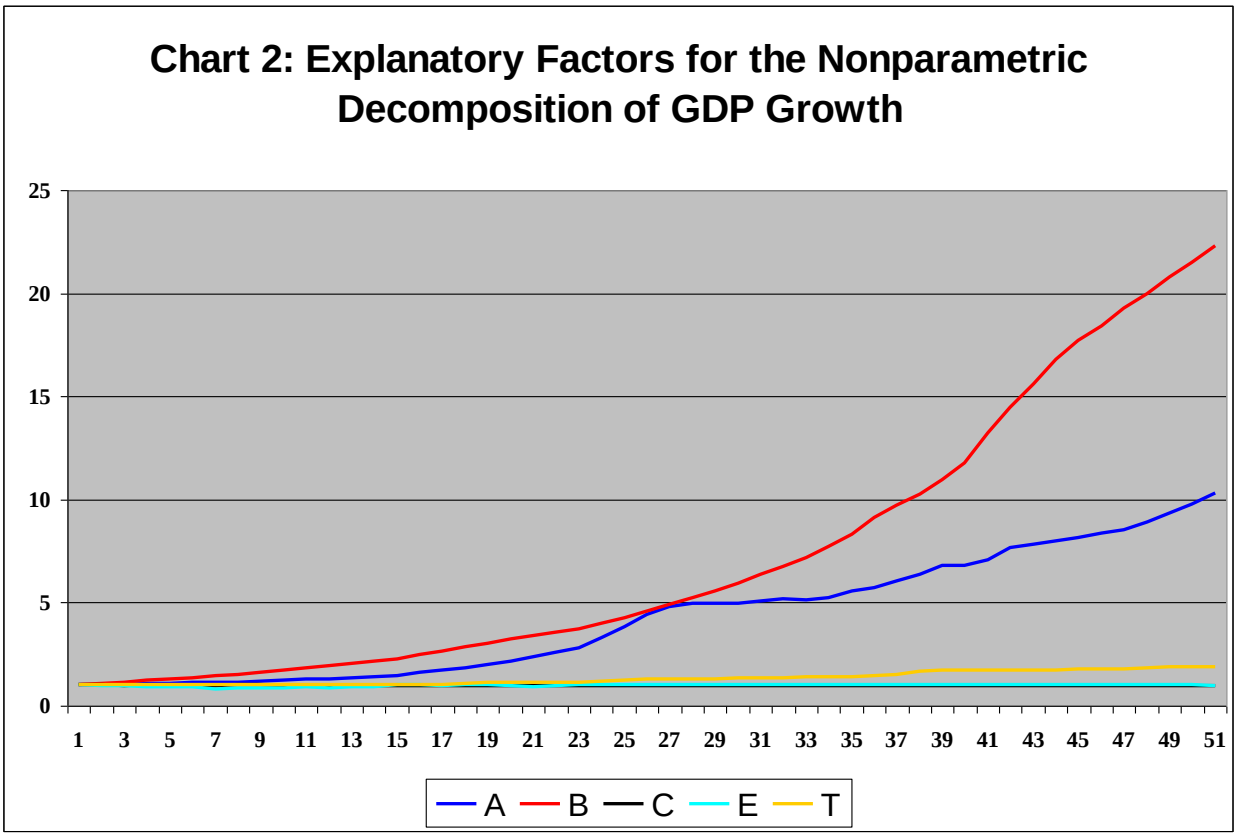
The components of the decomposition of GDP relative to its 1970 level into explanatory factors which is given by (49) are listed in Table 10 below along with our nonparametric estimates of Total Factor Productivity levels relative to 1970, TFP^{t*}.

Table 10: Decomposition of Nominal GDP Growth Relative to the 1970 Level

Year t	I^t/I^{1970}	A^t	B^t	C^t	E^t	T^t	TFP^{t*}
1970	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1971	1.0872	1.0257	1.0824	1.0000	0.9793	1.0000	0.9793
1972	1.1291	1.0412	1.1500	0.9954	0.9474	1.0000	0.9430
1973	1.2371	1.0741	1.2214	0.9996	0.9434	1.0000	0.9430
1974	1.2597	1.0861	1.2972	0.9923	0.9010	1.0000	0.8941
1975	1.3632	1.1121	1.3746	0.9979	0.8936	1.0000	0.8917
1976	1.3534	1.1254	1.4605	0.9877	0.8336	1.0000	0.8234
1977	1.4987	1.1552	1.5271	1.0046	0.8457	1.0000	0.8496
1978	1.6920	1.1697	1.6374	1.0016	0.8820	1.0000	0.8834
1979	1.8556	1.2170	1.7326	0.9880	0.8907	1.0000	0.8801
1980	2.0559	1.2763	1.8434	0.9728	0.8983	1.0000	0.8738
1981	2.2236	1.3210	1.9542	0.9778	0.8809	1.0000	0.8614
1982	2.4426	1.3593	2.0593	0.9772	0.8930	1.0000	0.8726
1983	2.7031	1.3915	2.1660	0.9688	0.9257	1.0000	0.8968
1984	3.2218	1.4610	2.2871	0.9618	1.0000	1.0024	0.9642
1985	3.9583	1.6081	2.4598	0.9618	1.0000	1.0403	1.0006
1986	4.4845	1.7033	2.6562	0.9602	0.9922	1.0403	0.9912
1987	5.2917	1.8154	2.8448	0.9600	1.0000	1.0674	1.0246
1988	6.4676	1.9740	3.0500	0.9600	1.0000	1.1190	1.0742
1989	7.2550	2.1839	3.2409	0.9592	0.9550	1.1190	1.0251
1990	8.0831	2.3895	3.3988	0.9578	0.9286	1.1190	0.9953
1991	9.5110	2.5862	3.5568	0.9595	0.9630	1.1190	1.0340
1992	11.5248	2.8200	3.7480	0.9597	1.0000	1.1362	1.0904
1993	14.8558	3.3037	4.0075	0.9597	1.0000	1.1692	1.1221
1994	19.4625	3.8120	4.2668	0.9597	1.0000	1.2469	1.1966
1995	24.7904	4.4058	4.5655	0.9597	1.0000	1.2842	1.2325
1996	29.3326	4.8072	4.9223	0.9597	1.0000	1.2917	1.2396
1997	32.7128	4.9438	5.2626	0.9597	1.0000	1.3102	1.2574
1998	34.8200	4.9623	5.5822	0.9590	1.0000	1.3107	1.2570
1999	37.2007	4.9408	5.9344	0.9590	1.0000	1.3230	1.2688
2000	41.2903	5.0631	6.3508	0.9590	1.0000	1.3390	1.2841
2001	45.5990	5.1949	6.7715	0.9590	1.0000	1.3516	1.2963
2002	49.0646	5.1449	7.2062	0.9590	1.0000	1.3799	1.3234
2003	54.6261	5.2478	7.7375	0.9590	1.0000	1.4028	1.3453
2004	63.2449	5.5434	8.3294	0.9590	1.0000	1.4282	1.3697
2005	72.6484	5.7458	9.1317	0.9590	1.0000	1.4437	1.3846
2006	85.8853	6.0633	9.7223	0.9590	1.0000	1.5192	1.4570
2007	104.0647	6.3780	10.2683	0.9590	1.0000	1.6569	1.5890
2008	121.4662	6.7822	10.9485	0.9590	1.0000	1.7057	1.6358
2009	133.3593	6.8007	11.7910	0.9590	1.0000	1.7341	1.6631
2010	156.8073	7.0965	13.2474	0.9590	1.0000	1.7392	1.6680
2011	184.2115	7.6416	14.4947	0.9571	0.9991	1.7392	1.6631
2012	203.4221	7.8452	15.6272	0.9541	1.0000	1.7392	1.6593
2013	223.6284	8.0030	16.8088	0.9539	1.0000	1.7428	1.6624
2014	243.2416	8.1519	17.7173	0.9539	1.0000	1.7656	1.6842
2015	261.7946	8.3620	18.3865	0.9539	1.0000	1.7851	1.7028
2016	283.7220	8.5461	19.2936	0.9539	1.0000	1.8040	1.7207
2017	316.1283	8.9298	19.9974	0.9539	1.0000	1.8559	1.7703
2018	347.6032	9.3189	20.7756	0.9539	1.0000	1.8823	1.7954
2019	379.3393	9.7900	21.4957	0.9539	1.0000	1.8898	1.8026
2020	394.4928	10.2985	22.2776	0.9529	0.9549	1.8898	1.7195

Recall that I^t/I^{1970} is nominal GDP in year t relative to 1970 nominal GDP. From the above Table, it can be seen that Chinese nominal GDP grew an amazing 394.5 fold over the 50 year sample period. Output prices grew 10.3 fold over the sample period, input labour and capital services grew 22.3 fold, the input mix

overall growth factor was 0.95 which means the input mix factor subtracted from GDP growth, the overall efficiency growth factor was also 0.95 which means that inefficiency also subtracted a bit from GDP growth and finally, the technical progress growth factor in 2020 was 1.89 which was an overall positive contribution to nominal GDP growth. The explanatory variables that appear on the right hand side of equations (49) are plotted on Chart 2 below.



It can be seen that input growth (the top red line) explains most of nominal GDP growth over the sample period followed by output price growth (the blue line) followed by technical progress (the gold line). The remaining two growth factors, input mix changes induced by changes in input prices and inefficiency are so close to 1 that they are difficult to distinguish in the above Chart. However, when one looks at Table 10 and the efficiency change E^t column, it can be seen that inefficiency was fairly significant during the early sample period.

It can be seen that the decompositions presented in this section and the previous section have their advantages and disadvantages. The index number decomposition can measure the contributions of individual output prices and input quantities but cannot measure inefficiency. The nonparametric decomposition can measure inefficiency but can only provide the aggregate contributions of output price change and input quantity change. Both decompositions give the same measures of TFP growth to a high degree of approximation.[29]

[29] It is straightforward to adapt the decomposition of real GDP growth in the previous section to provide a decomposition of nominal GDP. Similarly, it is possible to convert the decomposition of nominal GDP growth presented in this section to provide a decomposition of real GDP growth.

The above decompositions of real and nominal GDP are fine for many purposes but they do not accurately reflect the growth of real and nominal income for the Chinese economy. The gross income measure includes depreciation (which is not income) and excludes possible long term real capital gains on assets (which are part of income). Thus, in the following section, we will look at an alternative income concept which adjusts gross income into a more realistic measure of actual income.

6. Decomposing Net Income into Explanatory Factors

In this section, we attempt to define a more realistic income concept that does not count depreciation as income but does allow longer term capital gains on assets to become a component of income generated by the production sector. The model we use is a generalization of the Austrian model of production that dates back to Böhm-Bawerk (1891).[30] This Neo-Austrian model of production is based on a well established model of production that is used both by economists and thoughtful accountants as the following two quotations will show:

"We must look at the production process during a period of time, with a beginning and an end. It starts, at the commencement of the Period, with an Initial Capital Stock; to this there is applied a Flow Input of labour, and from it there emerges a Flow Output called Consumption; then there is a Closing Stock of Capital left over at the end. If Inputs are the things that are put in, the Outputs are the things that are got out, and the production of the Period is considered in isolation, then the Initial Capital Stock is an Input. A Stock Input to the Flow Input of labour; and further (what is less well recognized in the tradition, but is equally clear when we are strict with translation), the Closing Capital Stock is an Output, a Stock Output to match the Flow Output of Consumption Goods. Both input and output have stock and flow components; capital appears both as input and as output." John R. Hicks (1961; 23).

"The business firm can be viewed as a receptacle into which factors of production, or inputs, flow and out of which outputs flow...The total of the inputs with which the firm can work within the time period specified includes those inherited from the previous period and those acquired during the current period. The total of the outputs of the business firm in the same period includes the amounts of outputs currently sold and the amounts of inputs which are bequeathed to the firm in its succeeding period of activity." Edgar O. Edwards and Philip W. Bell (1961; 71-72).

Hicks, Edwards and Bell obviously had the same model of production in mind: in each accounting period, the business unit combines the capital stocks and goods in process that it has inherited from the previous period with "flow" inputs purchased in the current period (such as labour, materials, services and additional durable inputs) to produce current period "flow" outputs as well as end of the period depreciated capital stock components which are regarded as outputs from the perspective of the current period (but will be regarded as inputs from the perspective of the next period). Their model can be viewed as an Austrian model of production in honour of the Austrian economist Böhm-Bawerk (1891) who viewed production as an activity which used raw materials and labour to further process partly finished goods into finally demanded goods.

In what follows, we use the notation that was used in section 2 above. In the new measurement framework, gross investment disappears from the list of outputs produced by the production sector.[31] It is replaced by the end of the period value of the capital stock less the beginning of the

[30] Further contributions to this model were made by Hicks (1946; 230) (1973; 27-35) and Diewert (1977; 108-111) (1980; 472-474).

[31] See Diewert and Fox (2022) for a more detailed explanation and justification for the use of equations (52).

period value of the capital stock. This difference corresponds to net investment. On the income side of the accounts, the value of capital services using user costs is replaced by the value of *waiting services* which is essentially the value of direct and implicit interest payments for the use of capital plus specific property taxes (if applicable). The counterpart to equations (10) in section 2 is now the following equations, which determine a new balancing rate of return on assets for each year t, r^{t**}:

$$(52)\ P_C^t Q_C^t + P_G^t Q_G^t + P_X^t Q_X^t - P_M^t Q_M^t + \Sigma_{n=1}^{16} P_{Kn}^{t+1} Q_{Kn}^{t+1} - \Sigma_{n=1}^{16} P_{Kn}^t Q_{Kn}^t = P_L^t Q_L^t + \Sigma_{n=1}^{16} P_{Kn}^t (r^{t**}+\tau_n^t) Q_{Kn}^t ; \quad t = 1970, \ldots, 2020.$$

We use ex ante or expected prices to value the end of year capital stocks. Recall that i_n^t is the year t smoothed asset n inflation rate for n = 1, …, 16. We assume that the expected year end price for asset n in year t is $(1+i_n^t)$ times the beginning of year t price of asset n:

$$(53)\ P_{Kn}^{t+1} \equiv (1+i_n^t) P_{Kn}^t ; \quad n = 1, \ldots, 16 ; t = 1970, \ldots, 2020.$$

Substitute definitions (53) into equations (52) and solve the resulting equations for the *new balancing rates of return on assets* for year t, r^{t**}, for t = 1970, …, 2020. These new rates of return are listed on Table 11 below. These new rates of return on assets will differ somewhat from our smoothed balancing rates of return r^{t*} because we are valuing gross investment at end of year prices instead of beginning of the year prices.

In this new model of production, year t user costs U_n^t are replaced by year t *waiting costs*,[32] P_{Wn}^t, defined as follows:

$$(54)\ P_{Wn}^t \equiv (r^{t**} + \tau_n^t) P_{Kn}^t ; \quad n = 1, \ldots, 16 ; t = 1970, \ldots, 2020.$$

Since the year t rates of return r^{t**} are positive for China, the waiting costs, P_W^t, are also positive. Thus, for the Chinese data, we do not encounter the negative user cost problem that we encountered earlier.

We use the data on the waiting costs, P_{W1}^t, …, P_{W16}^t, along with the data on the beginning of the year asset stocks, Q_{K1}^t, …, Q_{K16}^t, to form *five waiting services aggregates* for our five types of aggregate capital. Denote the prices and quantities for these aggregate capital services by P_{WM}^t, P_{WS}^t, P_{WO}^t, P_{WI}^t, P_{WL}^t and Q_{WM}^t, Q_{WS}^t, Q_{WO}^t, Q_{WI}^t, Q_{WL}^t. These aggregate waiting costs are listed in Table 11 below (with prices normalized to equal 1 in 1970) and the corresponding capital services aggregates are listed in Table 12 below along with the corresponding values.[33] Finally, the year t price and quantity of *aggregate input*, P_Z^{t*} and Q_Z^{t*}, were calculated by aggregating the five capital services subaggregates with aggregate labour, P_L^t and Q_L^t.[34] These aggregate input prices and quantities are listed in Table 14.

Table 11: Balancing Rates of Return and Price Indexes for Labour and Waiting Services

Year t	r^{t**}	r^{t*}	P_L^t	P_{WM}^t	P_{WS}^t	P_{WO}^t	P_{WI}^t	P_{WL}^t
1970	0.2003	0.1979	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

[32] Rymes (1968) (1983) appears to have introduced this terminology. He was a strong advocate for replacing user costs by waiting costs.

[33] These capital services input subaggregates were formed using Tδrnqvist direct aggregation of input quantities; i.e., bilateral chained quantity indexes were formed first (quantities were always positive) and then the corresponding aggregate price indexes were calculated by deflating total value by the quantity index.

[34] The year t aggregate price and quantity, P_Z^{t*} and Q_Z^{t*}, were calculated using Tδrnqvist direct aggregation of input quantities. The year t total value of net income is $V_Z^{t*} \equiv P_Z^{t*} Q_Z^{t*}$.

1971	**0.1980**	**0.1955**	**1.0138**	**0.9836**	**1.0035**	**0.9823**	**1.0207**	**1.0224**
1972	**0.1730**	**0.1711**	**1.0680**	**0.8409**	**0.8824**	**0.8762**	**0.8896**	**0.9216**
1973	**0.1802**	**0.1780**	**1.0775**	**0.8904**	**0.9564**	**0.9749**	**0.9923**	**0.9859**
1974	**0.1616**	**0.1597**	**1.0829**	**0.8129**	**0.8582**	**0.8515**	**0.8195**	**0.9103**
1975	**0.1655**	**0.1635**	**1.0983**	**0.8077**	**0.8878**	**0.9504**	**0.9341**	**0.9588**
1976	**0.1292**	**0.1275**	**1.1026**	**0.6290**	**0.7018**	**0.7940**	**0.7983**	**0.7784**
1977	**0.1510**	**0.1489**	**1.1185**	**0.7319**	**0.8295**	**0.9780**	**1.0711**	**0.9320**
1978	**0.1651**	**0.1627**	**1.1692**	**0.8083**	**0.9196**	**1.0878**	**0.9825**	**1.0611**
1979	**0.1638**	**0.1613**	**1.2687**	**0.8140**	**0.9339**	**1.1238**	**0.8773**	**1.1295**
1980	**0.1542**	**0.1510**	**1.4138**	**0.7665**	**0.9395**	**1.0441**	**0.8537**	**1.1642**
1981	**0.1594**	**0.1555**	**1.4306**	**0.7966**	**0.9945**	**1.0902**	**0.9692**	**1.3177**
1982	**0.1772**	**0.1724**	**1.4656**	**0.8904**	**1.1389**	**1.2383**	**1.0554**	**1.5826**
1983	**0.2027**	**0.1967**	**1.5075**	**0.9978**	**1.3680**	**1.3560**	**0.9567**	**1.9463**
1984	**0.2209**	**0.2132**	**1.7401**	**1.1034**	**1.5802**	**1.5087**	**1.0599**	**2.3127**
1985	**0.2374**	**0.2274**	**2.0161**	**1.2277**	**1.8363**	**1.7474**	**1.2561**	**2.7574**
1986	**0.2215**	**0.2112**	**2.2989**	**1.1961**	**1.8689**	**1.7221**	**1.2806**	**2.9133**
1987	**0.2451**	**0.2330**	**2.5099**	**1.3428**	**2.2166**	**1.9386**	**1.5226**	**3.7032**
1988	**0.2555**	**0.2412**	**2.9507**	**1.5431**	**2.6109**	**2.2513**	**1.7070**	**4.4722**
1989	**0.2513**	**0.2381**	**3.2294**	**1.6415**	**2.7498**	**2.4534**	**1.8782**	**5.0812**
1990	**0.2460**	**0.2342**	**3.5234**	**1.7565**	**2.8777**	**2.6540**	**2.0111**	**5.7233**
1991	**0.2538**	**0.2412**	**3.8485**	**1.9350**	**3.2578**	**2.8143**	**2.2129**	**6.7089**
1992	**0.2568**	**0.2436**	**4.3715**	**2.1619**	**3.8544**	**3.0785**	**2.4375**	**7.9094**
1993	**0.2391**	**0.2265**	**5.3332**	**2.3671**	**4.7242**	**3.3260**	**2.5580**	**8.9996**
1994	**0.2297**	**0.2185**	**7.1112**	**2.4406**	**5.0092**	**3.4169**	**2.9922**	**10.5951**
1995	**0.2374**	**0.2278**	**8.4053**	**2.6526**	**5.4236**	**3.7882**	**3.4710**	**13.1340**
1996	**0.2238**	**0.2167**	**9.3310**	**2.5131**	**5.3692**	**3.7139**	**3.5292**	**14.1088**
1997	**0.2089**	**0.2044**	**10.0026**	**2.3199**	**5.1585**	**3.4082**	**3.4305**	**14.7812**
1998	**0.1836**	**0.1810**	**10.5302**	**2.0127**	**4.5632**	**2.8275**	**3.0664**	**14.7618**
1999	**0.1780**	**0.1759**	**10.8822**	**1.8972**	**4.4370**	**2.6599**	**2.9423**	**16.0597**
2000	**0.1813**	**0.1795**	**11.1742**	**1.8926**	**4.6242**	**2.7333**	**2.9892**	**18.3116**
2001	**0.1796**	**0.1776**	**11.8098**	**1.8642**	**4.6439**	**2.8181**	**3.0690**	**19.9759**
2002	**0.1760**	**0.1738**	**12.4059**	**1.7972**	**4.5968**	**2.6095**	**3.0402**	**21.2631**
2003	**0.1687**	**0.1660**	**13.8140**	**1.6874**	**4.5852**	**2.6044**	**2.9725**	**22.9189**
2004	**0.1716**	**0.1682**	**15.6502**	**1.7233**	**5.0411**	**2.7996**	**3.1401**	**24.2473**
2005	**0.1738**	**0.1703**	**17.1917**	**1.7566**	**5.1988**	**2.9350**	**3.4189**	**24.8435**
2006	**0.1865**	**0.1825**	**20.0091**	**1.9130**	**5.6496**	**3.2514**	**3.7655**	**27.6665**
2007	**0.2004**	**0.1958**	**24.3151**	**2.0606**	**6.3787**	**3.4748**	**4.1367**	**30.5237**
2008	**0.1855**	**0.1811**	**28.6823**	**1.9301**	**6.6698**	**3.1671**	**4.1489**	**32.4076**
2009	**0.1779**	**0.1737**	**31.7695**	**1.8245**	**6.1610**	**2.9450**	**4.3726**	**38.8543**
2010	**0.1735**	**0.1697**	**33.5820**	**1.7952**	**6.3059**	**3.0217**	**4.2102**	**46.2015**
2011	**0.1609**	**0.1574**	**38.7986**	**1.6977**	**6.3888**	**2.9218**	**4.1134**	**51.0452**
2012	**0.1424**	**0.1395**	**44.1385**	**1.4986**	**5.7470**	**2.5524**	**3.9504**	**51.6809**
2013	**0.1308**	**0.1279**	**49.1769**	**1.3672**	**5.2925**	**2.3610**	**3.7409**	**51.4504**
2014	**0.1286**	**0.1252**	**54.1853**	**1.3393**	**5.2359**	**2.3325**	**3.7363**	**54.2039**
2015	**0.1291**	**0.1252**	**60.2595**	**1.3305**	**5.1122**	**2.3417**	**3.7452**	**57.2801**
2016	**0.1329**	**0.1287**	**63.6613**	**1.3602**	**5.2301**	**2.5082**	**3.7532**	**63.1779**
2017	**0.1400**	**0.1353**	**68.9506**	**1.4412**	**5.9502**	**2.6792**	**3.9520**	**71.8681**
2018	**0.1411**	**0.1358**	**75.8739**	**1.4687**	**6.4294**	**2.7458**	**4.2096**	**78.5780**
2019	**0.1434**	**0.1377**	**82.7669**	**1.5117**	**7.0088**	**2.8049**	**4.5795**	**85.5863**
2020	**0.1372**	**0.1312**	**88.0778**	**1.4667**	**7.1821**	**2.6927**	**4.5995**	**87.0180**
Mean	**0.1849**	**0.1795**	**18.6510**	**1.5021**	**3.7330**	**2.2737**	**2.5533**	**21.7420**

The average of the new balancing rates of return r^{t**} is 18.49%, which is somewhat higher than our previous average rate of return for the gross output model which was 17.95%. There is an 88.1 fold increase in quality adjusted wage rates over the sample period and an 87.0 fold increase in the price of waiting services for land. For Table 12 below, the units of measurement for the quantity indexes are in trillions of 1970 yuan and in trillions of current yuan for the values.

Table 12: Quantity Indexes and Current Yuan Values for Labour and Waiting Services

Year	Q_L^t	Q_{WM}^t	Q_{WS}^t	Q_{WO}^t	Q_{WI}^t	Q_{WL}^t	V_L^t	V_{WM}^t	V_{WS}^t	V_{WO}^t	V_{WI}^t	V_{WL}^t
1970	**0.1403**	**0.0184**	**0.0417**	**0.0024**	**0.0039**	**0.0239**	**0.1403**	**0.0184**	**0.0417**	**0.0024**	**0.0039**	**0.0239**
1971	**0.1475**	**0.0213**	**0.0453**	**0.0027**	**0.0079**	**0.0246**	**0.1495**	**0.0209**	**0.0455**	**0.0026**	**0.0081**	**0.0252**

1972	**0.1507**	**0.0239**	**0.0498**	**0.0030**	**0.0122**	**0.0252**	**0.1610**	**0.0201**	**0.0440**	**0.0026**	**0.0109**	**0.0233**
1973	**0.1562**	**0.0262**	**0.0546**	**0.0032**	**0.0154**	**0.0259**	**0.1683**	**0.0233**	**0.0522**	**0.0031**	**0.0153**	**0.0255**
1974	**0.1615**	**0.0286**	**0.0593**	**0.0034**	**0.0203**	**0.0265**	**0.1749**	**0.0233**	**0.0509**	**0.0029**	**0.0166**	**0.0241**
1975	**0.1673**	**0.0309**	**0.0651**	**0.0037**	**0.0237**	**0.0271**	**0.1837**	**0.0250**	**0.0578**	**0.0035**	**0.0222**	**0.0260**
1976	**0.1732**	**0.0342**	**0.0719**	**0.0040**	**0.0268**	**0.0277**	**0.1910**	**0.0215**	**0.0504**	**0.0031**	**0.0214**	**0.0215**
1977	**0.1785**	**0.0362**	**0.0779**	**0.0041**	**0.0286**	**0.0282**	**0.1996**	**0.0265**	**0.0646**	**0.0040**	**0.0306**	**0.0262**
1978	**0.1909**	**0.0379**	**0.0856**	**0.0042**	**0.0318**	**0.0288**	**0.2232**	**0.0306**	**0.0787**	**0.0046**	**0.0313**	**0.0306**
1979	**0.1963**	**0.0407**	**0.0938**	**0.0045**	**0.0377**	**0.0297**	**0.2491**	**0.0331**	**0.0876**	**0.0050**	**0.0331**	**0.0335**
1980	**0.2057**	**0.0418**	**0.1038**	**0.0047**	**0.0438**	**0.0303**	**0.2909**	**0.0321**	**0.0976**	**0.0049**	**0.0374**	**0.0353**
1981	**0.2157**	**0.0423**	**0.1155**	**0.0050**	**0.0485**	**0.0310**	**0.3085**	**0.0337**	**0.1149**	**0.0055**	**0.0470**	**0.0408**
1982	**0.2255**	**0.0413**	**0.1278**	**0.0052**	**0.0533**	**0.0318**	**0.3304**	**0.0368**	**0.1456**	**0.0064**	**0.0563**	**0.0503**
1983	**0.2335**	**0.0420**	**0.1408**	**0.0055**	**0.0577**	**0.0327**	**0.3520**	**0.0419**	**0.1926**	**0.0074**	**0.0552**	**0.0636**
1984	**0.2425**	**0.0436**	**0.1541**	**0.0059**	**0.0626**	**0.0337**	**0.4220**	**0.0481**	**0.2435**	**0.0090**	**0.0664**	**0.0780**
1985	**0.2564**	**0.0479**	**0.1695**	**0.0066**	**0.0698**	**0.0350**	**0.5170**	**0.0588**	**0.3112**	**0.0116**	**0.0877**	**0.0966**
1986	**0.2673**	**0.0560**	**0.1871**	**0.0074**	**0.0838**	**0.0366**	**0.6145**	**0.0670**	**0.3496**	**0.0128**	**0.1073**	**0.1065**
1987	**0.2780**	**0.0649**	**0.2047**	**0.0083**	**0.0955**	**0.0378**	**0.6978**	**0.0872**	**0.4537**	**0.0161**	**0.1454**	**0.1398**
1988	**0.2890**	**0.0769**	**0.2233**	**0.0093**	**0.1082**	**0.0393**	**0.8529**	**0.1186**	**0.5829**	**0.0208**	**0.1847**	**0.1759**
1989	**0.2947**	**0.0897**	**0.2444**	**0.0102**	**0.1251**	**0.0409**	**0.9518**	**0.1472**	**0.6720**	**0.0250**	**0.2349**	**0.2076**
1990	**0.2999**	**0.0952**	**0.2623**	**0.0107**	**0.1502**	**0.0414**	**1.0567**	**0.1672**	**0.7548**	**0.0284**	**0.3021**	**0.2372**
1991	**0.3078**	**0.0991**	**0.2783**	**0.0113**	**0.1730**	**0.0421**	**1.1847**	**0.1917**	**0.9065**	**0.0317**	**0.3828**	**0.2822**
1992	**0.3183**	**0.1055**	**0.2957**	**0.0121**	**0.1958**	**0.0436**	**1.3913**	**0.2281**	**1.1399**	**0.0372**	**0.4772**	**0.3450**
1993	**0.3310**	**0.1194**	**0.3209**	**0.0130**	**0.2187**	**0.0455**	**1.7655**	**0.2827**	**1.5159**	**0.0433**	**0.5594**	**0.4096**
1994	**0.3364**	**0.1431**	**0.3515**	**0.0143**	**0.2362**	**0.0476**	**2.3925**	**0.3493**	**1.7606**	**0.0488**	**0.7068**	**0.5041**
1995	**0.3446**	**0.1704**	**0.3868**	**0.0160**	**0.2555**	**0.0496**	**2.8967**	**0.4519**	**2.0980**	**0.0604**	**0.8868**	**0.6510**
1996	**0.3576**	**0.1947**	**0.4308**	**0.0177**	**0.2816**	**0.0515**	**3.3368**	**0.4894**	**2.3129**	**0.0657**	**0.9938**	**0.7271**
1997	**0.3667**	**0.2202**	**0.4770**	**0.0196**	**0.3082**	**0.0535**	**3.6675**	**0.5107**	**2.4606**	**0.0668**	**1.0574**	**0.7914**
1998	**0.3703**	**0.2528**	**0.5251**	**0.0223**	**0.3305**	**0.0557**	**3.8992**	**0.5088**	**2.3960**	**0.0632**	**1.0135**	**0.8225**
1999	**0.3808**	**0.2908**	**0.5756**	**0.0248**	**0.3408**	**0.0575**	**4.1439**	**0.5518**	**2.5538**	**0.0659**	**1.0027**	**0.9229**
2000	**0.3978**	**0.3318**	**0.6307**	**0.0280**	**0.3497**	**0.0595**	**4.4447**	**0.6280**	**2.9163**	**0.0766**	**1.0453**	**1.0893**
2001	**0.4113**	**0.3796**	**0.6904**	**0.0321**	**0.3557**	**0.0615**	**4.8571**	**0.7077**	**3.2063**	**0.0904**	**1.0918**	**1.2293**
2002	**0.4201**	**0.4357**	**0.7560**	**0.0368**	**0.3696**	**0.0638**	**5.2120**	**0.7830**	**3.4751**	**0.0959**	**1.1236**	**1.3574**
2003	**0.4351**	**0.5076**	**0.8298**	**0.0436**	**0.3774**	**0.0663**	**6.0100**	**0.8566**	**3.8049**	**0.1134**	**1.1218**	**1.5200**
2004	**0.4484**	**0.6082**	**0.9146**	**0.0504**	**0.3880**	**0.0687**	**7.0182**	**1.0481**	**4.6108**	**0.1411**	**1.2182**	**1.6657**
2005	**0.4784**	**0.7321**	**1.0123**	**0.0582**	**0.4077**	**0.0709**	**8.2239**	**1.2861**	**5.2627**	**0.1707**	**1.3937**	**1.7616**
2006	**0.4786**	**0.8909**	**1.1149**	**0.0673**	**0.4165**	**0.0736**	**9.5773**	**1.7043**	**6.2989**	**0.2189**	**1.5683**	**2.0352**
2007	**0.4697**	**1.0752**	**1.2285**	**0.0780**	**0.4295**	**0.0766**	**11.4219**	**2.2156**	**7.8360**	**0.2709**	**1.7766**	**2.3368**
2008	**0.4659**	**1.3016**	**1.3591**	**0.0919**	**0.4618**	**0.0799**	**13.3642**	**2.5121**	**9.0646**	**0.2909**	**1.9159**	**2.5909**
2009	**0.4741**	**1.5692**	**1.4894**	**0.1147**	**0.5048**	**0.0830**	**15.0612**	**2.8630**	**9.1764**	**0.3379**	**2.2073**	**3.2256**
2010	**0.5203**	**1.9176**	**1.6708**	**0.1482**	**0.5277**	**0.0862**	**17.4713**	**3.4424**	**10.5358**	**0.4479**	**2.2218**	**3.9826**
2011	**0.5381**	**2.3339**	**1.8678**	**0.1869**	**0.5714**	**0.0894**	**20.8758**	**3.9621**	**11.9328**	**0.5461**	**2.3506**	**4.5659**
2012	**0.5472**	**2.6949**	**2.1088**	**0.2288**	**0.6223**	**0.0927**	**24.1546**	**4.0385**	**12.1190**	**0.5840**	**2.4582**	**4.7908**
2013	**0.5586**	**3.1332**	**2.3529**	**0.2798**	**0.6607**	**0.0958**	**27.4716**	**4.2836**	**12.4529**	**0.6606**	**2.4715**	**4.9289**
2014	**0.5535**	**3.5245**	**2.6396**	**0.3350**	**0.7003**	**0.0988**	**29.9926**	**4.7204**	**13.8206**	**0.7815**	**2.6166**	**5.3575**
2015	**0.5383**	**3.8544**	**2.9559**	**0.3909**	**0.7454**	**0.1020**	**32.4400**	**5.1282**	**15.1113**	**0.9153**	**2.7917**	**5.8443**
2016	**0.5425**	**4.1050**	**3.2966**	**0.4478**	**0.7741**	**0.1055**	**34.5366**	**5.5837**	**17.2418**	**1.1232**	**2.9055**	**6.6666**
2017	**0.5335**	**4.4205**	**3.6439**	**0.5005**	**0.8036**	**0.1088**	**36.7830**	**6.3711**	**21.6820**	**1.3409**	**3.1759**	**7.8192**
2018	**0.5270**	**4.7976**	**4.0004**	**0.5537**	**0.8368**	**0.1123**	**39.9857**	**7.0462**	**25.7201**	**1.5202**	**3.5225**	**8.8231**
2019	**0.5172**	**5.1988**	**4.3805**	**0.6132**	**0.8515**	**0.1159**	**42.8062**	**7.8590**	**30.7020**	**1.7201**	**3.8996**	**9.9182**
2020	**0.5145**	**5.5526**	**4.7570**	**0.6771**	**0.8658**	**0.1197**	**45.3197**	**8.1438**	**34.1650**	**1.8232**	**3.9821**	**10.4145**

We need to form a new net investment aggregate. The year t value of this investment aggregate is V_I^{t*} which is defined as follows:

(55) $V_I^{t*} \equiv \Sigma_{n=1}^{16} (1+i_n^t) P_{Kn}^t Q_{Kn}^{t+1} - \Sigma_{n-=1}^{16} P_{Kn}^t Q_{Kn}^t$; t = 1970, …, 2020.

The year t price index for this net investment aggregate is P_I^{t*} which is calculated as the direct Törnqvist price index of the 32 components of this aggregate. The Q_{Kn}^{t+1} enter the index number formula with plus signs and the Q_{Kn}^t enter the index formula with minus signs. The new year t net investment aggregate quantity Q_I^{t*} is defined as V_I^{t*}/P_I^{t*}. Once the P_I^{t*} and Q_I^{t*} have been defined, a new year t net output aggregate V_Y^{t*} can be defined as follows:

(56) $V_Y^{t^*} \equiv P_C^t Q_C^t + P_G^t Q_G^t + P_I^{t^*} Q_I^{t^*} + P_X^t Q_X^t - P_M^t Q_M^t$; t = 1970, …, 2020.

The year t price index for this net output aggregate is $P_Y^{t^*}$ which is calculated as the direct Törnqvist price index of the 5 components of this aggregate. The quantities enter the index number formula with plus signs except for imports, Q_M^t, which enters the index formula with a minus sign. The new year t net output aggregate quantity $Q_Y^{t^*}$ is defined as $V_Y^{t^*}/P_Y^{t^*}$. The new net investment aggregates and the new measures of net output (and net income) are compared with our old gross investment and gross output measures in Table 13 below.

Table 13: Gross Output, Net Output and Investment Aggregates for China 1970-2020.

Year	$P_Y^{t^*}$	P_Y^t	$Q_Y^{t^*}$	Q_Y^t	$V_Y^{t^*}$	V_Y^t	$P_I^{t^*}$	P_I^t	$Q_I^{t^*}$	Q_I^t	$V_I^{t^*}$	V_I^t
1970	1.0000	1.0000	0.2306	0.2474	0.2306	0.2474	1.0000	1.0000	0.0630	0.0798	0.0630	0.0798
1971	1.0316	1.0252	0.2440	0.2624	0.2518	0.2690	1.0335	1.0134	0.0685	0.0868	0.0708	0.0880
1972	1.0535	1.0405	0.2485	0.2685	0.2618	0.2793	1.0485	1.0096	0.0634	0.0833	0.0665	0.0841
1973	1.0922	1.0740	0.2635	0.2849	0.2878	0.3060	1.1088	1.0485	0.0728	0.0944	0.0807	0.0989
1974	1.1087	1.0863	0.2640	0.2869	0.2927	0.3116	1.1044	1.0362	0.0717	0.0947	0.0792	0.0981
1975	1.1437	1.1122	0.2782	0.3032	0.3181	0.3372	1.1571	1.0577	0.0799	0.1054	0.0924	0.1115
1976	1.1621	1.1241	0.2659	0.2978	0.3090	0.3348	1.2071	1.0796	0.0647	0.0962	0.0781	0.1039
1977	1.2012	1.1539	0.2927	0.3213	0.3516	0.3708	1.2745	1.1101	0.0802	0.1093	0.1022	0.1214
1978	1.2189	1.1676	0.3274	0.3585	0.3990	0.4186	1.2465	1.0827	0.1031	0.1368	0.1285	0.1481
1979	1.2780	1.2130	0.3454	0.3784	0.4414	0.4590	1.2687	1.0768	0.1067	0.1422	0.1354	0.1531
1980	1.3648	1.2726	0.3650	0.3996	0.4981	0.5086	1.4035	1.1248	0.1079	0.1439	0.1514	0.1619
1981	1.4427	1.3148	0.3815	0.4184	0.5504	0.5501	1.5681	1.1661	0.1089	0.1463	0.1708	0.1705
1982	1.5274	1.3529	0.4098	0.4467	0.6259	0.6043	1.7492	1.1897	0.1184	0.1559	0.2070	0.1855
1983	1.6058	1.3820	0.4438	0.4839	0.7127	0.6687	1.9091	1.1887	0.1289	0.1700	0.2460	0.2020
1984	1.7264	1.4507	0.5022	0.5494	0.8669	0.7971	2.1367	1.2450	0.1549	0.2097	0.3309	0.2610
1985	1.9393	1.5966	0.5583	0.6133	1.0828	0.9792	2.4319	1.3420	0.1940	0.2744	0.4718	0.3682
1986	2.1232	1.6966	0.5924	0.6539	1.2578	1.1094	2.8039	1.4513	0.1969	0.2782	0.5521	0.4038
1987	2.3518	1.8111	0.6548	0.7228	1.5401	1.3091	3.2318	1.5367	0.2182	0.3086	0.7052	0.4742
1988	2.6533	1.9697	0.7296	0.8123	1.9359	1.6000	3.8597	1.7126	0.2450	0.3560	0.9455	0.6096
1989	3.0010	2.1802	0.7460	0.8232	2.2386	1.7948	4.4186	1.8633	0.2452	0.3433	1.0835	0.6397
1990	3.3310	2.3966	0.7644	0.8344	2.5464	1.9997	4.9156	2.0177	0.2440	0.3236	1.1996	0.6529
1991	3.6191	2.5978	0.8233	0.9057	2.9796	2.3529	5.3483	2.1826	0.2674	0.3682	1.4304	0.8037
1992	3.9413	2.8309	0.9182	1.0071	3.6188	2.8511	5.9612	2.4791	0.3130	0.4431	1.8660	1.0984
1993	4.5740	3.3162	1.0005	1.1082	4.5765	3.6752	7.1057	3.0750	0.3500	0.5156	2.4869	1.5856
1994	5.1510	3.8292	1.1186	1.2574	5.7621	4.8148	7.6337	3.4201	0.3883	0.5896	2.9639	2.0167
1995	5.7248	4.4258	1.2306	1.3857	7.0448	6.1329	7.6950	3.6406	0.4400	0.6795	3.3859	2.4740
1996	6.0057	4.8290	1.3197	1.5027	7.9255	7.2566	7.4545	3.8022	0.4679	0.7415	3.4883	2.8194
1997	5.9566	4.9665	1.4361	1.6295	8.5544	8.0928	6.9857	3.8775	0.4943	0.7714	3.4528	2.9913
1998	5.8298	4.9852	1.4928	1.7279	8.7031	8.6141	6.5615	3.8884	0.4877	0.8001	3.2001	3.1112
1999	5.7441	4.9635	1.6088	1.8542	9.2410	9.2031	6.3523	3.8745	0.5210	0.8444	3.3095	3.2715
2000	5.8782	5.0863	1.7353	2.0083	10.2002	10.2148	6.4133	3.9268	0.5537	0.9080	3.5508	3.5654
2001	6.0495	5.2187	1.8485	2.1616	11.1826	11.2807	6.5599	3.9831	0.6240	1.0523	4.0934	4.1915
2002	6.0583	5.1685	1.9885	2.3485	12.0471	12.1381	6.7853	3.9987	0.6833	1.1823	4.6365	4.7276
2003	6.2841	5.2719	2.1366	2.5634	13.4266	13.5139	7.2181	4.0803	0.7859	1.4117	5.6730	5.7602
2004	6.7599	5.5690	2.3228	2.8095	15.7021	15.6462	7.8782	4.2728	0.9053	1.6562	7.1324	7.0764
2005	7.1322	5.7724	2.5376	3.1135	18.0987	17.9725	8.2819	4.3169	0.9748	1.8409	8.0733	7.9470
2006	7.6135	6.0912	2.8112	3.4882	21.4028	21.2472	8.5773	4.3523	1.0899	2.1122	9.3485	9.1928
2007	8.0634	6.4072	3.2068	4.0181	25.8579	25.7446	8.9237	4.4568	1.2882	2.5539	11.4956	11.3823
2008	8.6283	6.8132	3.4466	4.4105	29.7386	30.0495	9.7167	4.7856	1.3999	2.9074	13.6027	13.9137
2009	8.7136	6.8316	3.7724	4.8293	32.8714	32.9917	9.7386	4.7262	1.6771	3.4813	16.3331	16.4534
2010	9.1034	7.1288	4.1854	5.4417	38.1019	38.7926	10.1159	4.8983	1.9022	4.0693	19.2421	19.9327
2011	9.8035	7.6790	4.5120	5.9346	44.2332	45.5721	10.7536	5.2129	2.0700	4.5270	22.2601	23.5990
2012	10.0664	7.8868	4.7827	6.3808	48.1451	50.3246	10.8795	5.2819	2.1746	4.8919	23.6588	25.8383
2013	10.2744	8.0450	5.0873	6.8767	52.2690	55.3234	10.8888	5.2903	2.3374	5.3883	25.4512	28.5057
2014	10.6397	8.1946	5.3845	7.3433	57.2892	60.1756	11.2783	5.3054	2.4583	5.7700	27.7260	30.6123
2015	11.0889	8.4065	5.6120	7.7042	62.2308	64.7654	11.4078	5.2111	2.5026	5.9651	28.5498	31.0844
2016	11.5101	8.5915	5.9129	8.1697	68.0574	70.1900	11.7501	5.1983	2.6372	6.3713	30.9875	33.1200
2017	12.2779	8.9773	6.2855	8.7117	77.1721	78.2070	12.9008	5.4568	2.8068	6.8254	36.2098	37.2447
2018	13.1274	9.3684	6.5982	9.1791	86.6178	85.9936	14.2509	5.7292	2.9553	7.2421	42.1152	41.4910

2019	**14.1803**	**9.8420**	**6.8338**	**9.5351**	**96.9050**	**93.8447**	**15.8491**	**6.0192**	**3.0074**	**7.4102**	**47.6639**	**44.6036**
2020	**15.3741**	**10.3520**	**6.7547**	**9.4275**	**103.8482**	**97.5935**	**17.7132**	**6.3297**	**2.9532**	**7.2762**	**52.3109**	**46.0563**

It can be seen that switching from a gross output measure to a net output measure makes a big difference. Net investment value is 52.3 trillion yuan in 2020 while gross investment value is only 46.1 trillion yuan. Our net investment aggregate adds capital gains (or losses) on all assets that accrue over the course of each year whereas the gross investment model does not include these gains. The price of net investment ends up much higher at 14.25 whereas the price of gross investment ends up at 5.73. Conversely, the quantity or volume of net investment ends up much lower at 2.96 while the quantity or volume of gross investment ends up much higher at 7.24.

What is important for measuring the real income generated by the production sector is the fact that net nominal income V_Y^{2020*} ends up at 103.85 and gross nominal income V_Y^{2020} ends up at 97.59 trillion yuan. Both of these measures can be converted into measures of real income generated by the production sector by dividing them by the price of consumption in 2020. Thus ,the net measure of real income ends up 6.4% higher than the corresponding gross measure. This is not a huge difference but it is not negligible either.

The shares of labour and the five types of waiting services in net income in year t are defined as follows:[35]

(57) $s_L^{t*} \equiv V_L^t/V_Z^{t*}$; $s_{WM}^t \equiv V_{WM}^t/V_Z^{t*}$; $s_{WS}^t \equiv V_{WS}^t/V_Z^{t*}$; $s_{WO}^t \equiv V_{WO}^t/V_Z^{t*}$; $s_{WI}^t \equiv V_{WI}^t/V_Z^{t*}$;
$s_{WL}^t \equiv V_{WL}^t/V_Z^{t*}$; t = 1970, …, 2020.

These income shares of total net income are listed in Table 14 below.

Having defined new measures of year t net output and input, Q_Y^{t*} and Q_Z^{t*}, a new measure of (Net Output) *Total Factor Productivity* for year t, TFP^{t*}, can be defined by dividing Q_Y^{t*} by Q_Z^{t*}:

(58) $TFP^{t*} \equiv Q_Y^{t*}/Q_Z^{t*}$; t = 1970, …, 2020.

A new measure of *Net Output TFP growth* is defined as follows:

(59) $TFP_G^t \equiv TFP^{t*}/TFP^{t-1*}$; t = 1971, …, 2020.

These TFP measures are listed in Table 14 below.

Table 14: Net TFP Levels and Growth, Input Aggregates and Input Shares

Year	TFP^{t*}	TFP^t	TFP_G^{t*}	P_Z^{t*}	Q_Z^{t*}	V_Z^{t*}	s_L^{t*}	s_{WM}^t	s_{WS}^t	s_{WO}^t	s_{WI}^t	s_{WL}^t
1970	**1.0000**	**1.0000**		**1.0000**	**0.2306**	**0.2306**	**0.6084**	**0.0796**	**0.1810**	**0.0104**	**0.0170**	**0.1036**
1971	**0.9787**	**0.9794**	**0.9787**	**1.0096**	**0.2494**	**0.2518**	**0.5937**	**0.0832**	**0.1807**	**0.0104**	**0.0320**	**0.0999**
1972	**0.9398**	**0.9432**	**0.9603**	**0.9901**	**0.2644**	**0.2618**	**0.6149**	**0.0769**	**0.1679**	**0.0099**	**0.0416**	**0.0889**
1973	**0.9398**	**0.9426**	**1.0000**	**1.0265**	**0.2804**	**0.2878**	**0.5848**	**0.0810**	**0.1815**	**0.0108**	**0.0531**	**0.0887**
1974	**0.8874**	**0.8936**	**0.9443**	**0.9839**	**0.2975**	**0.2927**	**0.5976**	**0.0796**	**0.1738**	**0.0099**	**0.0568**	**0.0825**
1975	**0.8842**	**0.8913**	**0.9964**	**1.0113**	**0.3146**	**0.3181**	**0.5776**	**0.0785**	**0.1816**	**0.0109**	**0.0696**	**0.0817**
1976	**0.7991**	**0.8240**	**0.9038**	**0.9287**	**0.3327**	**0.3090**	**0.6181**	**0.0697**	**0.1633**	**0.0102**	**0.0691**	**0.0697**
1977	**0.8430**	**0.8502**	**1.0549**	**1.0127**	**0.3472**	**0.3516**	**0.5677**	**0.0753**	**0.1839**	**0.0114**	**0.0871**	**0.0746**
1978	**0.8787**	**0.8847**	**1.0424**	**1.0711**	**0.3725**	**0.3990**	**0.5595**	**0.0768**	**0.1972**	**0.0115**	**0.0784**	**0.0766**
1979	**0.8775**	**0.8825**	**0.9986**	**1.1215**	**0.3936**	**0.4414**	**0.5643**	**0.0750**	**0.1985**	**0.0114**	**0.0749**	**0.0759**
1980	**0.8713**	**0.8760**	**0.9929**	**1.1891**	**0.4189**	**0.4981**	**0.5840**	**0.0644**	**0.1959**	**0.0099**	**0.0750**	**0.0708**
1981	**0.8581**	**0.8651**	**0.9848**	**1.2379**	**0.4446**	**0.5504**	**0.5606**	**0.0612**	**0.2087**	**0.0099**	**0.0854**	**0.0742**
1982	**0.8716**	**0.8763**	**1.0157**	**1.3312**	**0.4701**	**0.6259**	**0.5280**	**0.0588**	**0.2326**	**0.0103**	**0.0900**	**0.0804**
1983	**0.8957**	**0.9026**	**1.0277**	**1.4383**	**0.4955**	**0.7127**	**0.4939**	**0.0587**	**0.2702**	**0.0104**	**0.0775**	**0.0892**

[35] Note that $V_Y^{t*} = V_Z^{t*}$ for all t.

1984	**0.9586**	**0.9706**	**1.0702**	**1.6550**	**0.5238**	**0.8669**	**0.4868**	**0.0555**	**0.2809**	**0.0103**	**0.0765**	**0.0899**
1985	**0.9917**	**1.0074**	**1.0345**	**1.9232**	**0.5630**	**1.0828**	**0.4774**	**0.0543**	**0.2874**	**0.0107**	**0.0810**	**0.0892**
1986	**0.9746**	**0.9947**	**0.9828**	**2.0692**	**0.6078**	**1.2578**	**0.4886**	**0.0532**	**0.2780**	**0.0102**	**0.0853**	**0.0847**
1987	**1.0064**	**1.0267**	**1.0326**	**2.3668**	**0.6507**	**1.5401**	**0.4531**	**0.0566**	**0.2946**	**0.0105**	**0.0944**	**0.0908**
1988	**1.0456**	**1.0761**	**1.0390**	**2.7743**	**0.6978**	**1.9359**	**0.4406**	**0.0613**	**0.3011**	**0.0108**	**0.0954**	**0.0909**
1989	**1.0023**	**1.0264**	**0.9586**	**3.0078**	**0.7443**	**2.2386**	**0.4252**	**0.0658**	**0.3002**	**0.0112**	**0.1049**	**0.0927**
1990	**0.9725**	**0.9919**	**0.9703**	**3.2393**	**0.7861**	**2.5464**	**0.4150**	**0.0656**	**0.2964**	**0.0112**	**0.1187**	**0.0931**
1991	**0.9959**	**1.0289**	**1.0241**	**3.6044**	**0.8267**	**2.9796**	**0.3976**	**0.0644**	**0.3042**	**0.0106**	**0.1285**	**0.0947**
1992	**1.0500**	**1.0857**	**1.0543**	**4.1383**	**0.8745**	**3.6188**	**0.3845**	**0.0630**	**0.3150**	**0.0103**	**0.1319**	**0.0953**
1993	**1.0690**	**1.1174**	**1.0181**	**4.8895**	**0.9360**	**4.5765**	**0.3858**	**0.0618**	**0.3312**	**0.0095**	**0.1222**	**0.0895**
1994	**1.1247**	**1.1908**	**1.0522**	**5.7935**	**0.9946**	**5.7621**	**0.4152**	**0.0606**	**0.3056**	**0.0085**	**0.1227**	**0.0875**
1995	**1.1605**	**1.2264**	**1.0318**	**6.6435**	**1.0604**	**7.0448**	**0.4112**	**0.0641**	**0.2978**	**0.0086**	**0.1259**	**0.0924**
1996	**1.1578**	**1.2336**	**0.9977**	**6.9536**	**1.1398**	**7.9255**	**0.4210**	**0.0617**	**0.2918**	**0.0083**	**0.1254**	**0.0917**
1997	**1.1828**	**1.2511**	**1.0216**	**7.0455**	**1.2142**	**8.5544**	**0.4287**	**0.0597**	**0.2876**	**0.0078**	**0.1236**	**0.0925**
1998	**1.1665**	**1.2508**	**0.9862**	**6.8007**	**1.2797**	**8.7031**	**0.4480**	**0.0585**	**0.2753**	**0.0073**	**0.1165**	**0.0945**
1999	**1.1918**	**1.2625**	**1.0217**	**6.8458**	**1.3499**	**9.2410**	**0.4484**	**0.0597**	**0.2764**	**0.0071**	**0.1085**	**0.0999**
2000	**1.2105**	**1.2778**	**1.0156**	**7.1153**	**1.4336**	**10.2002**	**0.4357**	**0.0616**	**0.2859**	**0.0075**	**0.1025**	**0.1068**
2001	**1.2201**	**1.2899**	**1.0079**	**7.3808**	**1.5151**	**11.1826**	**0.4343**	**0.0633**	**0.2867**	**0.0081**	**0.0976**	**0.1099**
2002	**1.2448**	**1.3169**	**1.0203**	**7.5412**	**1.5975**	**12.0471**	**0.4326**	**0.0650**	**0.2885**	**0.0080**	**0.0933**	**0.1127**
2003	**1.2603**	**1.3387**	**1.0125**	**7.9200**	**1.6953**	**13.4266**	**0.4476**	**0.0638**	**0.2834**	**0.0084**	**0.0836**	**0.1132**
2004	**1.2894**	**1.3630**	**1.0231**	**8.7160**	**1.8015**	**15.7021**	**0.4470**	**0.0667**	**0.2936**	**0.0090**	**0.0776**	**0.1061**
2005	**1.3004**	**1.3778**	**1.0086**	**9.2749**	**1.9514**	**18.0987**	**0.4544**	**0.0711**	**0.2908**	**0.0094**	**0.0770**	**0.0973**
2006	**1.3705**	**1.4498**	**1.0539**	**10.4344**	**2.0512**	**21.4028**	**0.4475**	**0.0796**	**0.2943**	**0.0102**	**0.0733**	**0.0951**
2007	**1.4968**	**1.5813**	**1.0921**	**12.0689**	**2.1425**	**25.8579**	**0.4417**	**0.0857**	**0.3030**	**0.0105**	**0.0687**	**0.0904**
2008	**1.5246**	**1.6279**	**1.0186**	**13.1549**	**2.2606**	**29.7386**	**0.4494**	**0.0845**	**0.3048**	**0.0098**	**0.0644**	**0.0871**
2009	**1.5681**	**1.6551**	**1.0285**	**13.6634**	**2.4058**	**32.8714**	**0.4582**	**0.0871**	**0.2792**	**0.0103**	**0.0672**	**0.0981**
2010	**1.5714**	**1.6600**	**1.0022**	**14.3055**	**2.6634**	**38.1019**	**0.4585**	**0.0903**	**0.2765**	**0.0118**	**0.0583**	**0.1045**
2011	**1.5719**	**1.6546**	**1.0003**	**15.4101**	**2.8704**	**44.2332**	**0.4719**	**0.0896**	**0.2698**	**0.0123**	**0.0531**	**0.1032**
2012	**1.5647**	**1.6501**	**0.9954**	**15.7505**	**3.0567**	**48.1451**	**0.5017**	**0.0839**	**0.2517**	**0.0121**	**0.0511**	**0.0995**
2013	**1.5697**	**1.6533**	**1.0032**	**16.1275**	**3.2410**	**52.2690**	**0.5256**	**0.0820**	**0.2382**	**0.0126**	**0.0473**	**0.0943**
2014	**1.5955**	**1.6750**	**1.0165**	**16.9761**	**3.3747**	**57.2892**	**0.5235**	**0.0824**	**0.2412**	**0.0136**	**0.0457**	**0.0935**
2015	**1.6167**	**1.6933**	**1.0132**	**17.9272**	**3.4713**	**62.2308**	**0.5213**	**0.0824**	**0.2428**	**0.0147**	**0.0449**	**0.0939**
2016	**1.6313**	**1.7112**	**1.0090**	**18.7765**	**3.6246**	**68.0574**	**0.5075**	**0.0820**	**0.2533**	**0.0165**	**0.0427**	**0.0980**
2017	**1.6810**	**1.7605**	**1.0305**	**20.6395**	**3.7390**	**77.1721**	**0.4766**	**0.0826**	**0.2810**	**0.0174**	**0.0412**	**0.1013**
2018	**1.7047**	**1.7855**	**1.0141**	**22.3784**	**3.8706**	**86.6178**	**0.4616**	**0.0813**	**0.2969**	**0.0176**	**0.0407**	**0.1019**
2019	**1.7106**	**1.7926**	**1.0035**	**24.2569**	**3.9950**	**96.9050**	**0.4417**	**0.0811**	**0.3168**	**0.0178**	**0.0402**	**0.1023**
2020	**1.6322**	**1.7102**	**0.9542**	**25.0936**	**4.1384**	**103.8482**	**0.4364**	**0.0784**	**0.3290**	**0.0176**	**0.0383**	**0.1003**
Mean	**1.1943**	**1.2427**	**1.0104**	**7.6473**	**1.4914**	**19.6240**	**0.4854**	**0.0712**	**0.2617**	**0.0109**	**0.0780**	**0.0929**

Net Output TFP^{t^*} finished at 1.6322 which is somewhat lower than the final value for Gross Output TFP^t which was 1.7102. On average, Net Output TFP was 1.04% per year whereas the average growth rate for Gross Output TFP was 1.13% per year. The labour share of net income, $s_L{}^{t^*}$, was quite variable. It started at 60.84% in 1970, decreased to 38.54% in 1993, increased to 52.56 in 2013 and then declined to 43.64% in 2020. Thus over the entire sample period, the income share of capital increased enormously which is perhaps not surprising given the very large rates of gross investment for the Chinese economy. The income share of Manufactures was roughly constant around 7% and the Land share was also roughly constant around 9%. However, the income share of structures increased from 18.10% in 1970 to 32.90%, which is a very large increase. The share of inventories started at 1.70%, increased to 13.19% in 1992 and then decreased steadily to end up at 7.80% in 2020. The average share of Other Capital was 1.09% and it was roughly constant as well.

The average annual rates of Net Output TFP growth over the 5 decades were as follows: −1.28% (1970s), 1.16% (1980s), 2.23% (1990s), 2.68% (2000s), 0.95% (2010s).[36]

The index number decomposition of GDP that was undertaken in section 4 above can be repeated using the new data for the Net Income model that was explained in this section. The counterparts to Tables 6, 7 and 8 in section 4 are Tables 15, 16 and 17 and they are listed below using the net income approach.

[36] We excluded 2020 from this average.

Table 15: Net Real Income, Real Net Output Prices and Real Net Input Prices

Year t	RI^{t^*}	p_2^t	$p_3^{t^*}$	p_4^t	p_5^t	w_1^t	$w_2^{t^*}$	$w_3^{t^*}$	$w_4^{t^*}$	$w_5^{t^*}$	$w_6^{t^*}$
1970	0.23060	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.0000
1971	0.24280	0.96190	0.99670	0.92230	0.92650	0.97760	0.94850	0.96770	0.94720	0.98430	0.9859
1972	0.24640	0.94920	0.98690	0.90340	0.88370	1.00520	0.79150	0.83050	0.82470	0.83730	0.8674
1973	0.26380	0.94250	1.01630	0.90570	0.83190	0.98760	0.81610	0.87660	0.89360	0.90950	0.9037
1974	0.26170	0.91030	0.98740	0.92990	0.82140	0.96820	0.72680	0.76730	0.76130	0.73270	0.8138
1975	0.27710	0.90510	1.00790	0.88400	0.78860	0.95660	0.70350	0.77320	0.82780	0.81360	0.8351
1976	0.26500	0.85850	1.03510	0.85610	0.77640	0.94540	0.53930	0.60170	0.68080	0.68450	0.6675
1977	0.29410	0.86240	1.06600	0.84370	0.77040	0.93550	0.61220	0.69380	0.81800	0.89590	0.7795
1978	0.32560	0.88190	1.01700	0.86790	0.76770	0.95390	0.65940	0.75030	0.88750	0.80160	0.8657
1979	0.34080	0.89290	0.97960	0.85630	0.72910	0.97960	0.62850	0.72110	0.86770	0.67740	0.8721
1980	0.36720	0.91320	1.03470	0.84220	0.72020	1.04230	0.56510	0.69260	0.76980	0.62940	0.8583
1981	0.39070	0.89190	1.11310	0.82420	0.72400	1.01550	0.56550	0.70590	0.77390	0.68790	0.9354
1982	0.43000	0.88660	1.20190	0.81980	0.71420	1.00710	0.61180	0.78260	0.85090	0.72520	1.0874
1983	0.47440	0.90060	1.27060	0.82790	0.74630	1.00330	0.66410	0.91050	0.90250	0.63670	1.2954
1984	0.55410	0.98290	1.36570	0.88240	0.84110	1.11220	0.70530	1.01000	0.96430	0.67750	1.4782
1985	0.62220	1.01330	1.39740	0.94790	0.91120	1.15860	0.70550	1.05520	1.00410	0.72180	1.5845
1986	0.68150	1.03710	1.51910	1.19140	1.12680	1.24550	0.64810	1.01260	0.93310	0.69380	1.5784
1987	0.77070	1.04970	1.61740	1.21720	1.20690	1.25610	0.67200	1.10930	0.97020	0.76200	1.8533
1988	0.83780	1.05130	1.67040	1.00870	1.42130	1.27700	0.66780	1.13000	0.97430	0.73870	1.9355
1989	0.86590	1.01720	1.70920	0.81500	1.15310	1.24920	0.63500	1.06370	0.94900	0.72650	1.9655
1990	0.92630	1.02950	1.78820	1.03670	1.22630	1.28170	0.63900	1.04680	0.96550	0.73160	2.0820
1991	1.01550	1.07180	1.82280	1.07360	1.22870	1.31160	0.65950	1.11030	0.95910	0.75420	2.2864
1992	1.18400	1.17740	1.95040	1.04760	1.19010	1.43030	0.70730	1.26110	1.00720	0.79750	2.5877
1993	1.32690	1.26570	2.06020	0.83750	1.02520	1.54630	0.68630	1.36980	0.96430	0.74170	2.6094
1994	1.42940	1.37290	1.89370	1.10330	1.35080	1.76410	0.60540	1.24260	0.84760	0.74230	2.6283
1995	1.41050	1.31480	1.54070	0.92050	1.12400	1.68290	0.53110	1.08590	0.75850	0.69500	2.6297
1996	1.42140	1.29930	1.33690	0.76880	0.90480	1.67340	0.45070	0.96290	0.66600	0.63290	2.5303
1997	1.47490	1.31460	1.20440	0.69290	0.82660	1.72460	0.40000	0.88940	0.58760	0.59150	2.5485
1998	1.49940	1.35010	1.13040	0.62870	0.74010	1.81420	0.34670	0.78620	0.48710	0.52830	2.5432
1999	1.58060	1.35640	1.08650	0.62810	0.77600	1.86130	0.32450	0.75890	0.45500	0.50320	2.7468
2000	1.69620	1.35670	1.06650	0.66050	0.81400	1.85820	0.31470	0.76900	0.45450	0.49710	3.0451
2001	1.84310	1.39910	1.08120	0.65670	0.77310	1.94640	0.30720	0.76540	0.46450	0.50580	3.2923
2002	2.08840	1.50860	1.17630	0.70780	0.80880	2.15060	0.31160	0.79690	0.45240	0.52700	3.6861
2003	2.34930	1.62600	1.26300	0.78320	0.88350	2.41710	0.29520	0.80230	0.45570	0.52010	4.0102
2004	2.70190	1.75780	1.35560	0.89230	0.97250	2.69300	0.29650	0.86740	0.48170	0.54030	4.1723
2005	3.10640	1.86850	1.42150	0.96150	0.99490	2.95080	0.30150	0.89230	0.50380	0.58680	4.2641
2006	3.46170	1.99430	1.38730	0.93390	0.94250	3.23620	0.30940	0.91380	0.52590	0.60900	4.4747
2007	4.10960	2.30770	1.41830	0.95550	0.94670	3.86440	0.32750	1.01380	0.55230	0.65750	4.8512
2008	4.55250	2.52350	1.48750	0.94440	0.94790	4.39080	0.29550	1.02100	0.48480	0.63510	4.9611
2009	5.12210	2.70050	1.51750	0.86270	0.82720	4.95040	0.28430	0.96000	0.45890	0.68130	6.0543
2010	5.65670	2.69950	1.50180	0.90950	0.87650	4.98570	0.26650	0.93620	0.44860	0.62510	6.8592
2011	6.06040	2.77180	1.47330	0.85740	0.82410	5.31580	0.23260	0.87530	0.40030	0.56360	6.9937
2012	6.49470	2.92180	1.46760	0.82680	0.78210	5.95420	0.20220	0.77530	0.34430	0.53290	6.9717
2013	6.87230	3.02020	1.43170	0.78220	0.73380	6.46580	0.17980	0.69590	0.31040	0.49180	6.7647
2014	7.24400	3.07810	1.42610	0.70960	0.67460	6.85150	0.16930	0.66210	0.29490	0.47240	6.8539
2015	7.66570	3.19520	1.40520	0.66100	0.58440	7.42290	0.16390	0.62970	0.28850	0.46130	7.0559
2016	7.99900	3.17370	1.38100	0.61600	0.54120	7.48230	0.15990	0.61470	0.29480	0.44110	7.4255
2017	8.68640	3.27150	1.45210	0.61480	0.55950	7.76100	0.16220	0.66970	0.30160	0.44480	8.0894
2018	9.48560	3.42970	1.56060	0.61460	0.56830	8.30900	0.16080	0.70410	0.30070	0.46100	8.6052
2019	10.06070	3.46530	1.64550	0.60110	0.56650	8.59290	0.15690	0.72770	0.29120	0.47540	8.8856
2020	10.40280	3.45060	1.77440	0.58680	0.52660	8.82300	0.14690	0.71950	0.26970	0.46070	8.7169

There are some substantial differences between the Net Output real waiting costs listed in Table 15 compared to their user cost counterparts in Table 6. For example, the land real waiting cost $w_6^{t^*}$ is equal to 8.7169 for t = 2020 but the corresponding land real user cost w_6^{2020} was only equal to 4.7305.

Table 16: Net Real Income Growth and Real Output Price and Input Growth Contribution Factors

Year	$RI_G^{t^*}$	$TFP_G^{t^*}$	$\alpha_2^{t^*}$	$\alpha_3^{t^*}$	$\alpha_4^{t^*}$	$\alpha_5^{t^*}$	$\beta_1^{t^*}$	$\beta_2^{t^*}$	$\beta_3^{t^*}$	$\beta_4^{t^*}$	$\beta_5^{t^*}$	$\beta_6^{t^*}$

1971	**1.0527**	**0.9787**	**0.9956**	**0.9991**	**0.9977**	**1.0025**	**1.0303**	**1.0122**	**1.0151**	**1.0011**	**1.0174**	**1.0030**
1972	**1.0149**	**0.9604**	**0.9984**	**0.9974**	**0.9994**	**1.0015**	**1.0134**	**1.0094**	**1.0165**	**1.0011**	**1.0162**	**1.0024**
1973	**1.0705**	**1.0000**	**0.9992**	**1.0079**	**1.0001**	**1.0025**	**1.0216**	**1.0072**	**1.0162**	**1.0008**	**1.0110**	**1.0022**
1974	**0.9920**	**0.9444**	**0.9961**	**0.9921**	**1.0013**	**1.0007**	**1.0200**	**1.0072**	**1.0146**	**1.0006**	**1.0152**	**1.0019**
1975	**1.0589**	**0.9965**	**0.9993**	**1.0058**	**0.9973**	**1.0025**	**1.0210**	**1.0061**	**1.0168**	**1.0008**	**1.0100**	**1.0016**
1976	**0.9562**	**0.9039**	**0.9938**	**1.0073**	**0.9984**	**1.0009**	**1.0210**	**1.0076**	**1.0173**	**1.0008**	**1.0084**	**1.0014**
1977	**1.1100**	**1.0551**	**1.0005**	**1.0080**	**0.9993**	**1.0004**	**1.0179**	**1.0040**	**1.0141**	**1.0004**	**1.0052**	**1.0011**
1978	**1.1069**	**1.0426**	**1.0026**	**0.9857**	**1.0013**	**1.0002**	**1.0387**	**1.0035**	**1.0180**	**1.0004**	**1.0089**	**1.0015**
1979	**1.0468**	**0.9989**	**1.0015**	**0.9883**	**0.9993**	**1.0032**	**1.0157**	**1.0053**	**1.0183**	**1.0006**	**1.0130**	**1.0019**
1980	**1.0775**	**0.9932**	**1.0029**	**1.0169**	**0.9990**	**1.0009**	**1.0273**	**1.0020**	**1.0203**	**1.0006**	**1.0113**	**1.0013**
1981	**1.0639**	**0.9852**	**0.9971**	**1.0227**	**0.9985**	**0.9996**	**1.0274**	**1.0007**	**1.0218**	**1.0006**	**1.0082**	**1.0012**
1982	**1.1008**	**1.0162**	**0.9993**	**1.0249**	**0.9996**	**1.0010**	**1.0244**	**0.9986**	**1.0226**	**1.0004**	**1.0084**	**1.0015**
1983	**1.1031**	**1.0283**	**1.0018**	**1.0190**	**1.0007**	**0.9969**	**1.0181**	**1.0009**	**1.0246**	**1.0005**	**1.0067**	**1.0018**
1984	**1.1681**	**1.0709**	**1.0107**	**1.0266**	**1.0048**	**0.9903**	**1.0188**	**1.0022**	**1.0253**	**1.0009**	**1.0062**	**1.0021**
1985	**1.1229**	**1.0353**	**1.0038**	**1.0094**	**1.0061**	**0.9907**	**1.0272**	**1.0052**	**1.0274**	**1.0012**	**1.0086**	**1.0026**
1986	**1.0952**	**0.9837**	**1.0027**	**1.0372**	**1.0224**	**0.9708**	**1.0203**	**1.0084**	**1.0283**	**1.0012**	**1.0154**	**1.0028**
1987	**1.1310**	**1.0334**	**1.0013**	**1.0285**	**1.0023**	**0.9912**	**1.0187**	**1.0082**	**1.0261**	**1.0012**	**1.0118**	**1.0020**
1988	**1.0871**	**1.0400**	**1.0002**	**1.0154**	**0.9798**	**0.9805**	**1.0175**	**1.0100**	**1.0262**	**1.0011**	**1.0119**	**1.0027**
1989	**1.0335**	**0.9595**	**0.9967**	**1.0112**	**0.9787**	**1.0248**	**1.0085**	**1.0099**	**1.0275**	**1.0011**	**1.0146**	**1.0025**
1990	**1.0697**	**0.9707**	**1.0012**	**1.0218**	**1.0275**	**0.9930**	**1.0073**	**1.0039**	**1.0213**	**1.0006**	**1.0207**	**1.0009**
1991	**1.0963**	**1.0246**	**1.0041**	**1.0092**	**1.0048**	**0.9998**	**1.0107**	**1.0026**	**1.0179**	**1.0005**	**1.0176**	**1.0009**
1992	**1.1659**	**1.0554**	**1.0100**	**1.0343**	**0.9965**	**1.0043**	**1.0131**	**1.0040**	**1.0190**	**1.0007**	**1.0163**	**1.0023**
1993	**1.1207**	**1.0194**	**1.0080**	**1.0294**	**0.9696**	**1.0222**	**1.0153**	**1.0077**	**1.0267**	**1.0007**	**1.0142**	**1.0026**
1994	**1.0772**	**1.0536**	**1.0094**	**0.9564**	**1.0479**	**0.9524**	**1.0065**	**1.0111**	**1.0294**	**1.0008**	**1.0095**	**1.0025**
1995	**0.9868**	**1.0331**	**0.9949**	**0.9025**	**0.9636**	**1.0367**	**1.0100**	**1.0109**	**1.0293**	**1.0009**	**1.0098**	**1.0024**
1996	**1.0077**	**0.9988**	**0.9986**	**0.9368**	**0.9656**	**1.0403**	**1.0155**	**1.0085**	**1.0322**	**1.0009**	**1.0123**	**1.0025**
1997	**1.0376**	**1.0227**	**1.0015**	**0.9569**	**0.9797**	**1.0156**	**1.0107**	**1.0075**	**1.0300**	**1.0008**	**1.0113**	**1.0024**
1998	**1.0166**	**0.9873**	**1.0037**	**0.9758**	**0.9804**	**1.0185**	**1.0043**	**1.0082**	**1.0274**	**1.0010**	**1.0084**	**1.0026**
1999	**1.0541**	**1.0226**	**1.0007**	**0.9857**	**0.9998**	**0.9919**	**1.0126**	**1.0083**	**1.0257**	**1.0007**	**1.0035**	**1.0021**
2000	**1.0732**	**1.0167**	**1.0000**	**0.9935**	**1.0111**	**0.9904**	**1.0195**	**1.0080**	**1.0260**	**1.0009**	**1.0027**	**1.0026**
2001	**1.0866**	**1.0089**	**1.0051**	**1.0049**	**0.9986**	**1.0113**	**1.0146**	**1.0084**	**1.0263**	**1.0011**	**1.0017**	**1.0028**
2002	**1.1331**	**1.0211**	**1.0123**	**1.0322**	**1.0186**	**0.9897**	**1.0093**	**1.0089**	**1.0264**	**1.0011**	**1.0037**	**1.0032**
2003	**1.1249**	**1.0133**	**1.0120**	**1.0291**	**1.0293**	**0.9766**	**1.0155**	**1.0099**	**1.0270**	**1.0014**	**1.0019**	**1.0035**
2004	**1.1501**	**1.0238**	**1.0121**	**1.0315**	**1.0448**	**0.9699**	**1.0136**	**1.0119**	**1.0285**	**1.0013**	**1.0022**	**1.0031**
2005	**1.1497**	**1.0093**	**1.0093**	**1.0216**	**1.0286**	**0.9923**	**1.0295**	**1.0129**	**1.0301**	**1.0013**	**1.0038**	**1.0026**
2006	**1.1143**	**1.0548**	**1.0100**	**0.9893**	**0.9883**	**1.0186**	**1.0003**	**1.0149**	**1.0287**	**1.0014**	**1.0016**	**1.0027**
2007	**1.1872**	**1.0931**	**1.0225**	**1.0098**	**1.0095**	**0.9985**	**0.9917**	**1.0157**	**1.0294**	**1.0015**	**1.0022**	**1.0028**
2008	**1.1078**	**1.0196**	**1.0139**	**1.0217**	**0.9953**	**0.9996**	**0.9964**	**1.0164**	**1.0312**	**1.0017**	**1.0048**	**1.0029**
2009	**1.1251**	**1.0294**	**1.0106**	**1.0096**	**0.9700**	**1.0386**	**1.0079**	**1.0162**	**1.0271**	**1.0022**	**1.0059**	**1.0026**
2010	**1.1044**	**1.0032**	**0.9999**	**0.9948**	**1.0162**	**0.9846**	**1.0435**	**1.0179**	**1.0324**	**1.0028**	**1.0028**	**1.0028**
2011	**1.0714**	**1.0015**	**1.0043**	**0.9904**	**0.9813**	**1.0182**	**1.0158**	**1.0178**	**1.0309**	**1.0028**	**1.0044**	**1.0027**
2012	**1.0717**	**0.9966**	**1.0091**	**0.9981**	**0.9887**	**1.0153**	**1.0083**	**1.0126**	**1.0321**	**1.0025**	**1.0044**	**1.0024**
2013	**1.0581**	**1.0043**	**1.0059**	**0.9879**	**0.9834**	**1.0179**	**1.0106**	**1.0126**	**1.0272**	**1.0025**	**1.0029**	**1.0021**
2014	**1.0541**	**1.0174**	**1.0034**	**0.9981**	**0.9722**	**1.0228**	**0.9952**	**1.0097**	**1.0279**	**1.0024**	**1.0027**	**1.0020**
2015	**1.0582**	**1.0141**	**1.0067**	**0.9931**	**0.9814**	**1.0348**	**0.9856**	**1.0074**	**1.0278**	**1.0022**	**1.0028**	**1.0021**
2016	**1.0435**	**1.0099**	**0.9988**	**0.9921**	**0.9836**	**1.0162**	**1.0040**	**1.0052**	**1.0274**	**1.0021**	**1.0017**	**1.0024**
2017	**1.0859**	**1.0313**	**1.0054**	**1.0235**	**0.9996**	**0.9932**	**0.9918**	**1.0061**	**1.0271**	**1.0019**	**1.0016**	**1.0023**
2018	**1.0920**	**1.0148**	**1.0083**	**1.0350**	**0.9999**	**0.9968**	**0.9943**	**1.0067**	**1.0273**	**1.0018**	**1.0017**	**1.0025**
2019	**1.0606**	**1.0042**	**1.0018**	**1.0262**	**0.9955**	**1.0006**	**0.9915**	**1.0065**	**1.0282**	**1.0018**	**1.0007**	**1.0025**
2020	**1.0340**	**0.9548**	**0.9993**	**1.0383**	**0.9954**	**1.0129**	**0.9977**	**1.0053**	**1.0270**	**1.0018**	**1.0007**	**1.0026**
Mean	**1.0802**	**1.0111**	**1.0037**	**1.0047**	**0.9983**	**1.0027**	**1.0130**	**1.0082**	**1.0250**	**1.0012**	**1.0078**	**1.0023**

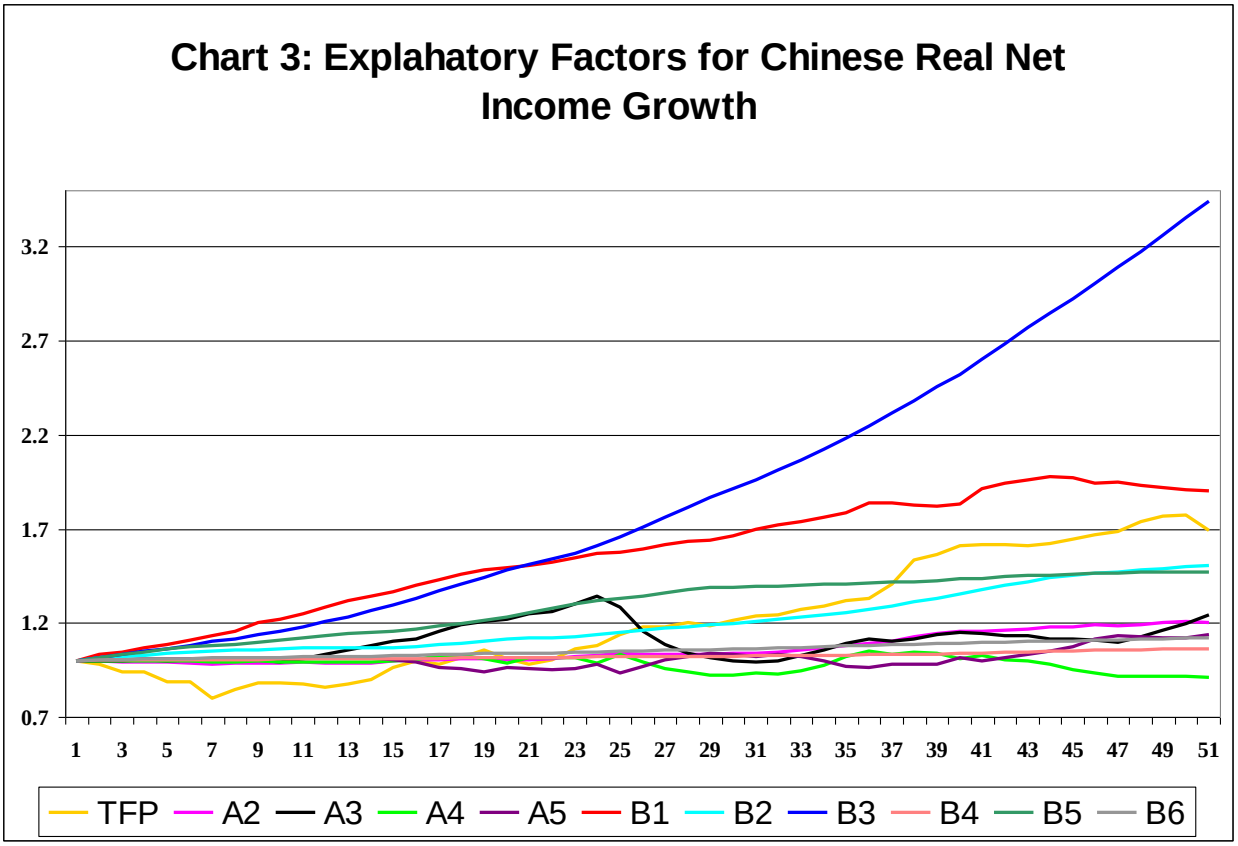
The sample average Net Real Income growth was 8.02% per year which is somewhat greater than the corresponding average Gross Real Income growth which was 7.72% per year. The biggest changes in the contribution factors going from the gross output model to the net output model took place in investment prices (the average contribution factor changed from –0.35% to +0.47% per year) and in manufacturing input services (the average contribution factor changed from 1.51% to 0.82% per year). The contribution of land services almost doubled from 0.14% to 0.23% per year). Thus moving from the gross output measurement framework to the net output framework did lead to some substantial changes.

Table 17 below is the net output counterpart to Table 8 in section 4. It cumulates the contribution factors listed in Table into levels.

Table 17: The Levels Decomposition for Real Net Income Growth in China

Year	RI^{t*}/RI^{1970*}	TFP^{t*}	A_2^{t*}	A_3^{t*}	A_4^{t*}	A_5^{t*}	B_1^{t*}	B_2^{t*}	B_3^{t*}	B_4^{t*}	B_5^{t*}	B_6^{t*}
1970	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1971	1.0527	0.9787	0.9956	0.9991	0.9977	1.0025	1.0303	1.0122	1.0151	1.0011	1.0174	1.0030
1972	1.0684	0.9399	0.9940	0.9964	0.9971	1.0040	1.0440	1.0216	1.0318	1.0022	1.0339	1.0054
1973	1.1437	0.9399	0.9932	1.0043	0.9972	1.0065	1.0666	1.0290	1.0486	1.0030	1.0452	1.0075
1974	1.1346	0.8876	0.9893	0.9964	0.9985	1.0072	1.0879	1.0364	1.0639	1.0036	1.0611	1.0095
1975	1.2015	0.8845	0.9887	1.0021	0.9958	1.0097	1.1107	1.0427	1.0817	1.0044	1.0717	1.0111
1976	1.1489	0.7995	0.9825	1.0094	0.9942	1.0106	1.1340	1.0506	1.1005	1.0052	1.0807	1.0125
1977	1.2752	0.8436	0.9830	1.0175	0.9935	1.0110	1.1543	1.0548	1.1160	1.0056	1.0862	1.0137
1978	1.4116	0.8796	0.9856	1.0029	0.9949	1.0112	1.1990	1.0586	1.1361	1.0060	1.0960	1.0152
1979	1.4777	0.8786	0.9871	0.9912	0.9941	1.0145	1.2179	1.0642	1.1569	1.0066	1.1102	1.0171
1980	1.5923	0.8727	0.9900	1.0079	0.9932	1.0154	1.2511	1.0663	1.1803	1.0072	1.1228	1.0184
1981	1.6940	0.8597	0.9871	1.0307	0.9917	1.0149	1.2853	1.0671	1.2060	1.0078	1.1320	1.0197
1982	1.8647	0.8737	0.9864	1.0564	0.9912	1.0160	1.3167	1.0656	1.2332	1.0082	1.1415	1.0212
1983	2.0569	0.8984	0.9882	1.0765	0.9920	1.0128	1.3405	1.0665	1.2636	1.0087	1.1491	1.0231
1984	2.4027	0.9621	0.9988	1.1051	0.9968	1.0030	1.3657	1.0688	1.2955	1.0096	1.1563	1.0252
1985	2.6979	0.9961	1.0026	1.1155	1.0028	0.9937	1.4028	1.0744	1.3310	1.0107	1.1662	1.0279
1986	2.9548	0.9798	1.0053	1.1570	1.0253	0.9646	1.4313	1.0834	1.3686	1.0119	1.1841	1.0308
1987	3.3419	1.0125	1.0066	1.1899	1.0277	0.9561	1.4581	1.0923	1.4043	1.0131	1.1981	1.0329
1988	3.6329	1.0530	1.0068	1.2083	1.0070	0.9375	1.4836	1.1032	1.4412	1.0143	1.2124	1.0357
1989	3.7547	1.0104	1.0035	1.2218	0.9855	0.9607	1.4962	1.1141	1.4809	1.0153	1.2301	1.0384
1990	4.0165	0.9807	1.0047	1.2485	1.0127	0.9539	1.5071	1.1184	1.5124	1.0159	1.2556	1.0393
1991	4.4031	1.0049	1.0089	1.2599	1.0175	0.9537	1.5232	1.1214	1.5395	1.0164	1.2776	1.0403
1992	5.1337	1.0606	1.0190	1.3030	1.0139	0.9578	1.5432	1.1259	1.5688	1.0172	1.2984	1.0427
1993	5.7535	1.0812	1.0271	1.3414	0.9831	0.9791	1.5668	1.1346	1.6107	1.0180	1.3168	1.0454
1994	6.1978	1.1392	1.0368	1.2829	1.0302	0.9325	1.5769	1.1472	1.6581	1.0188	1.3293	1.0481
1995	6.1159	1.1768	1.0315	1.1578	0.9927	0.9668	1.5927	1.1598	1.7068	1.0198	1.3423	1.0506
1996	6.1630	1.1755	1.0301	1.0846	0.9585	1.0058	1.6174	1.1696	1.7618	1.0206	1.3588	1.0532
1997	6.3950	1.2021	1.0316	1.0379	0.9391	1.0214	1.6346	1.1783	1.8146	1.0215	1.3742	1.0558
1998	6.5013	1.1869	1.0354	1.0128	0.9207	1.0403	1.6417	1.1880	1.8643	1.0225	1.3858	1.0586
1999	6.8533	1.2137	1.0361	0.9983	0.9205	1.0318	1.6624	1.1979	1.9121	1.0233	1.3905	1.0608
2000	7.3547	1.2340	1.0361	0.9918	0.9307	1.0220	1.6948	1.2075	1.9619	1.0242	1.3943	1.0635
2001	7.9914	1.2449	1.0414	0.9967	0.9295	1.0335	1.7196	1.2177	2.0134	1.0253	1.3967	1.0664
2002	9.0554	1.2712	1.0542	1.0287	0.9467	1.0229	1.7355	1.2285	2.0666	1.0264	1.4018	1.0699
2003	10.1866	1.2881	1.0669	1.0587	0.9745	0.9990	1.7624	1.2406	2.1224	1.0278	1.4044	1.0737
2004	11.7155	1.3187	1.0798	1.0920	1.0181	0.9689	1.7865	1.2553	2.1829	1.0291	1.4075	1.0770
2005	13.4694	1.3310	1.0898	1.1156	1.0473	0.9614	1.8392	1.2715	2.2485	1.0305	1.4129	1.0798
2006	15.0096	1.4038	1.1007	1.1037	1.0350	0.9793	1.8397	1.2904	2.3130	1.0320	1.4152	1.0827
2007	17.8193	1.5345	1.1255	1.1145	1.0448	0.9779	1.8245	1.3106	2.3809	1.0335	1.4183	1.0857
2008	19.7394	1.5646	1.1411	1.1387	1.0400	0.9775	1.8178	1.3321	2.4552	1.0352	1.4252	1.0889
2009	22.2091	1.6106	1.1532	1.1496	1.0088	1.0153	1.8322	1.3537	2.5217	1.0376	1.4335	1.0917
2010	24.5274	1.6158	1.1532	1.1436	1.0252	0.9997	1.9119	1.3779	2.6035	1.0405	1.4375	1.0948
2011	26.2775	1.6181	1.1581	1.1326	1.0060	1.0179	1.9421	1.4025	2.6840	1.0434	1.4439	1.0977
2012	28.1608	1.6126	1.1687	1.1305	0.9946	1.0334	1.9582	1.4201	2.7703	1.0460	1.4504	1.1004
2013	29.7982	1.6195	1.1756	1.1168	0.9781	1.0519	1.9790	1.4380	2.8457	1.0486	1.4546	1.1027
2014	31.4096	1.6477	1.1796	1.1147	0.9509	1.0760	1.9695	1.4520	2.9252	1.0511	1.4586	1.1049
2015	33.2383	1.6710	1.1875	1.1070	0.9333	1.1134	1.9411	1.4627	3.0064	1.0534	1.4627	1.1072
2016	34.6833	1.6876	1.1861	1.0982	0.9179	1.1314	1.9488	1.4703	3.0889	1.0556	1.4651	1.1098
2017	37.6639	1.7404	1.1925	1.1240	0.9175	1.1237	1.9327	1.4793	3.1727	1.0576	1.4674	1.1124
2018	41.1292	1.7662	1.2024	1.1634	0.9174	1.1202	1.9217	1.4892	3.2594	1.0595	1.4699	1.1151
2019	43.6228	1.7735	1.2046	1.1939	0.9133	1.1209	1.9055	1.4990	3.3515	1.0614	1.4709	1.1179
2020	45.1061	1.6934	1.2037	1.2396	0.9091	1.1353	1.9012	1.5069	3.4419	1.0632	1.4719	1.1208

Chart 3 below plots the 12 explanatory factors that explain real net income growth for China.



It can be seen that the main factors which explain real net income growth are (i) Structure Waiting Services (the blue line), (ii) Labour Services (the red line), (iii) Total Factor Productivity Growth (the gold line) and (iv) Manufacturing and Equipment Waiting Services (the bright blue line) and (v) Inventory Waiting Services (the green line). The growth in real net investment prices (the black line) was significant in the first half of the sample period. Real export prices (the bright green line) fell below 1 for most of the last half of the sample period, indicating declining real export prices and a drag on real income growth.

As was mentioned earlier, Chinese per capita real gross income grew 23.2 fold over our 50 year sample period. It turns out that per capita real net income grew 26.5 fold over the same period, which is a significant difference from the gross rate of growth.

7. Conclusion

A big problem with many macroeconomic models is that they ignore land. Some possible reasons for this omission are:

- The current System of National Accounts does not assign much of a role to changes in land use in the flow accounts and while Land appears in the Balance Sheet accounts of many countries, the data are sparse and typically do not break down land into alternative categories.
- It is difficult to decompose market prices for properties into their land and structure components. This hinders the production of land price and quantity indexes.
- Transactions in commercial and industrial land are sparse, making the construction of indexes difficult.

- The aggregate land stock is constant and hence does not play much of a role as a contributor to economic growth. As we have seen using the Chinese data, land usage changes significantly over time. In general, agricultural land is converted into other land uses.

The work of the Asian Productivity Organization (and augmented by the work of Koji Nomura) has led to the development of a useful data base on national stocks of 4 types of land for about 25 Asian countries. We utilized this data base for China to develop alternative measures of Total Factor Productivity Growth. Our work indicates that land is an important factor of production and neglecting land inputs into production can lead to substantial measurement errors. We also argued that changes in land use by type of land should be recorded as part of investment. This would put land stocks on the same footing as inventory stocks. Changes in inventory stocks are routinely regarded as current output. We argue that changes in land stocks should also be recorded as part of current output and we implemented this approach using our Chinese data.

The current international System of National Accounts focuses on the measurement of Gross National Product and the corresponding measure of Gross National Income. But these gross measures include depreciation which is not "income" and they exclude longer term capital gains (and losses) on assets which households typically regard as "income". Thus, our recommendation is that the next revision of the international SNA develop income accounts which would supplement the usual gross output accounts.

Here are some important measurement problems which require more research:

- How exactly should expected asset inflation rates be estimated?
- What is the "right" cost of capital to use in user costs and in waiting costs?
- Why does the current SNA not impute a rate of return for the user cost of capital applied to government assets? Only depreciation is regarded as a cost of using a government asset and so there is no opportunity cost assigned to the use of land in the government sector in the SNA.
- How fine can we make the land classification? There is forest land, park land, and land that is tied up in roads. Commercial land includes a wide variety of different uses of land. And of course, land should be disaggregated by geographical location.
- How do we deal with negative user costs?

Appendix: Data on Outputs and Inputs for China

The Asian Productivity Organization (APO) has cooperated with many Asian countries to produce annual estimates for the Total Factor Productivity (TFP) of these countries. The APO data has been augmented by additional data on labour and capital input developed by Koji Nomura and his colleagues at Keio University. In this paper, we will use his Augmented APO Productivity Database for 2022 dated September 19, 2022. This database has current yuan and constant yuan estimates for the main economic aggregates for the People's Republic of China as well as detailed investment data for 12 types of capital for the years 1970-2020. APO implied price indexes are formed by dividing the current yuan series by the corresponding constant yuan series. The database also has current and constant yuan estimates for the 12 corresponding beginning of the year capital stocks as well as current and constant yuan estimates for 4 types of land. The Augmented Database also has detailed information on hourly wage rates and annual hours worked for many types of labour classified by age, sex, education and type of worker (employee or self-employed). We will not make use of the detailed labour information: we will simply use the resulting aggregate price and quantity of labour for year t, P_L^t and Q_L^t, which are listed in the Augmented APO Database.

The APO price indexes for the output aggregates for year t are defined as P_C^t (private consumption), P_G^t (government consumption), P_I^t (the price of aggregate gross fixed capital formation), P_X^t (exports of goods and services), and P_M^t (imports of goods and services). The corresponding quantity or volume indexes are defined as Q_C^t, Q_G^t, Q_I^t, Q_X^t and Q_M^t. The 12 components of the APO Gross Fixed Capital Formation or Investment series are as follows: (1) IT hardware; (2) Communications equipment; (3) Transport equipment; (4) Other machinery and equipment; (5) Dwelling structures; (6) Non-residential buildings; (7) Other structures; (8) Cultivated assets; (9) Research and development; (10) Computer software; (11) Other intangible assets and (12) Net increase in inventory stocks. Denote the year t price index for investment good n by P_{In}^t and the corresponding quantity or volume index by Q_{In}^t for n = 1, …, 12 and t = 1970, 1971, …, 2020.

The corresponding beginning of the year t capital stocks for the above 12 investment assets are also available in the Augmented APO Database. Denote the asset n and year t stock price index by P_{Kn}^t and the corresponding quantity index by Q_{Kn}^t for n = 1, …, 12 and t = 1970, 1971, …, 2020. The Augmented APO Database also has current and constant yuan series for four types of land used by the Chinese production sector: (13) Agricultural land; (14) Industrial Land; (15) Commercial Land and (16) Residential Land. Denote the beginning of the year t price index for these land assets by P_{Kn}^t and the corresponding quantity index by Q_{Kn}^t for n = 13, 14, 15, 16 and t = 1970, …, 2020.

Assets 12-16 are non-depreciable assets so we set the period t depreciation rate for asset n, δ_n^t, equal to 0 for n = 12, …,16 and t = 1970, …, 2020. Since the APO uses the geometric model for depreciation for assets 1-11, the depreciation rates should satisfy the following equations:

(A1) $Q_{Kn}^{t+1} = (1-\delta_n^t)Q_{Kn}^t + Q_{In}^t$; n = 1, …, 11; t = 1970, …, 2019.

Since we can obtain estimates for the Q_{Kn}^t and Q_{In}^t for the years t and assets n listed at the end of equations (A1), we can solve equations (A1) for the depreciation rates δ_n^t for the years 1970-2019 for assets 1-11. The resulting estimates for the depreciation rates were quite reasonable and are fairly smooth except that the depreciation rates for asset 1 showed unusual volatility for 4 observations so we smoothed the rates δ_1^t using the Lowess nonparametric smoothing method in Shazam.[37]

Equations (A1) enabled us to determine depreciation rates for assets 1-11 for the years 1970-2019. The depreciation rates for inventory stocks, δ_{12}^t, were assumed to be equal to 0 as indicated earlier. We assumed that the depreciation rates for 2020 for assets 1-11 were the same as the corresponding rates for 2019 and then we used equations (A1) for t = 2020 to determine the beginning of year 2021 capital stocks, QK_n^{2021}, for n = 1, ,,,, 12. Then nonzero depreciation rates are listed below in Table A3.

Our measurement methodology requires estimates for the price and quantity of each capital stock for beginning of 2021. The APO Augmented database does not have this information. The previous paragraph explained how estimates for the beginning of year 2021 capital stocks were obtained for the first 12 assets. For the four land assets, we extrapolated the rate of change in the land stocks going from 2019 to 2020 to obtain estimated beginning of 2021 land stocks, Q_{Kn}^{2021}, for n = 13, 14, 15, 16. Estimates for the beginning of year 2021 capital stock prices, P_{Kn}^{2021} for n = 1, …, 16, were formed by extrapolating the rate of change in the APO price indexes going from 2019 to 2020.

[37] The smoothing parameter was chosen to be 0.15. Equations (A1) for n = 1 were used recursively to generate new estimates for the QK_1^t; i.e., we assumed that beginning of 1970 capital stock QK_1^{1970} was the "correct" estimate along with the investments in asset 1 (the QI_1^t were also assumed to be correct) and the new smoothed depreciation rates δ_1^t were also correct.

Land prices turn out to be very volatile. Rather than use short run fluctuations in land prices in order to value the opportunity costs of holding land, we chose to smooth the land prices to capture longer run trends in the value of land assets used in production. Again, we used the Lowess nonparametric smoothing method to smooth the land prices P_{K13}^t, P_{K14}^t, P_{K15}^t and P_{K16}^t using the Smooth parameter set equal to 0.15.[38] The smoothed land price indexes are listed in Table A1 below along with the APO beginning of the year prices for assets 1-12.

Table A1: Beginning of Year Asset Price Indexes

Year t	P_{K1}^t	P_{K2}^t	P_{K3}^t	P_{K4}^t	P_{K5}^t	P_{K6}^t	P_{K7}^t	P_{K8}^t
1970	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1971	0.96017	0.94266	0.99321	0.99576	1.01166	1.00944	1.04320	0.92345
1972	0.87368	0.89450	0.98999	0.97202	1.02174	0.99748	1.04260	0.89513
1973	0.75302	0.81961	0.96485	0.99405	1.07324	1.01120	1.05310	0.95397
1974	0.75604	0.72982	0.89117	1.02404	1.05790	1.03392	1.11430	0.86310
1975	0.69820	0.70654	0.95597	0.98146	1.06006	1.05451	1.15853	0.97414
1976	0.76291	0.68841	0.95974	0.97777	1.07572	1.06158	1.16688	1.02635
1977	0.75291	0.66010	0.93340	0.97724	1.08910	1.06902	1.18138	1.09128
1978	0.66165	0.63373	0.93710	0.98838	1.09770	1.08245	1.22382	1.04324
1979	0.58612	0.63206	0.93632	1.00598	1.13009	1.09899	1.23910	1.08629
1980	0.45167	0.59537	0.89100	1.01508	1.20691	1.16876	1.33345	1.01809
1981	0.38178	0.57766	0.89726	1.02028	1.22353	1.20671	1.39067	0.97901
1982	0.33769	0.56241	0.90174	1.02622	1.26053	1.23934	1.43558	0.99942
1983	0.29620	0.53196	0.87000	1.00871	1.32579	1.29928	1.50642	0.93400
1984	0.27678	0.52665	0.87737	1.02495	1.40502	1.37835	1.59521	0.94263
1985	0.27572	0.53200	0.90222	1.06268	1.52339	1.49043	1.71511	1.04963
1986	0.27213	0.53225	0.94243	1.11086	1.66738	1.61874	1.86716	1.07403
1987	0.25132	0.52007	0.94452	1.13154	1.80058	1.72108	1.98937	1.07067
1988	0.24675	0.54803	1.03382	1.25171	2.03727	1.94287	2.24558	1.17752
1989	0.25934	0.57882	1.09214	1.36203	2.18902	2.07743	2.39397	1.32552
1990	0.27458	0.61780	1.17233	1.49607	2.33878	2.22175	2.56068	1.43661
1991	0.27875	0.63784	1.22569	1.60653	2.56544	2.43922	2.80986	1.35146
1992	0.29276	0.69399	1.35885	1.77375	3.00828	2.84634	3.27849	1.42186
1993	0.30623	0.80978	1.59409	2.08943	4.00131	3.71524	4.28210	1.49631
1994	0.31808	0.86017	1.69388	2.24988	4.43901	4.07688	4.71764	1.58898
1995	0.30153	0.89132	1.77852	2.36963	4.63111	4.28809	4.94846	1.72464
1996	0.26668	0.83933	1.80090	2.38412	4.86585	4.50392	5.19315	1.85844
1997	0.24534	0.78285	1.78811	2.36215	5.02529	4.61938	5.34089	1.80277
1998	0.23622	0.74014	1.76651	2.33606	5.05961	4.64069	5.38069	1.61063
1999	0.22456	0.67728	1.72109	2.27723	5.09388	4.64527	5.38422	1.53093
2000	0.21130	0.63465	1.67402	2.23945	5.20071	4.75543	5.52063	1.57541
2001	0.17983	0.60403	1.67889	2.23082	5.27526	4.81894	5.59665	1.72444
2002	0.16171	0.56347	1.67249	2.19701	5.32349	4.87533	5.64489	1.52264
2003	0.13759	0.52197	1.64980	2.16631	5.52892	5.08037	5.88860	1.68681
2004	0.12230	0.50445	1.67156	2.18630	5.95369	5.49747	6.38415	1.87163
2005	0.10932	0.48944	1.69493	2.21305	6.01464	5.61284	6.53149	1.99748
2006	0.10346	0.47493	1.72494	2.26015	6.08069	5.67987	6.62840	2.08616
2007	0.09898	0.45246	1.73919	2.27706	6.40428	5.95923	6.96310	2.03221
2008	0.08978	0.43776	1.76947	2.31879	7.16673	6.71661	7.94711	1.83014
2009	0.07761	0.41268	1.77308	2.29194	6.91905	6.46965	7.64360	1.83716
2010	0.07404	0.38853	1.81041	2.31446	7.23419	6.78939	8.04161	2.06858
2011	0.07105	0.36697	1.85710	2.36934	7.81844	7.53719	8.75600	2.20131
2012	0.06736	0.34010	1.85489	2.37254	7.91017	7.66271	8.92969	2.14500
2013	0.06558	0.33570	1.86686	2.34545	7.96217	7.68292	8.92816	2.36374
2014	0.06628	0.33825	1.86317	2.33069	8.04086	7.68777	8.98439	2.50831
2015	0.06771	0.34048	1.84749	2.30163	7.82602	7.46918	8.74934	2.77310
2016	0.06385	0.33072	1.83029	2.29430	7.78411	7.42714	8.68870	3.38088
2017	0.06468	0.33015	1.83858	2.30896	8.41736	8.00885	9.38467	3.52838
2018	0.06530	0.32266	1.85394	2.34071	9.02119	8.57839	10.07137	3.63033

[38] The lower is the Smooth number, the less severe is the smoothing. Thus, we did a minimal amount of smoothing of the land prices at this stage.

2019	**0.06475**	**0.32288**	**1.87350**	**2.37456**	**9.63605**	**9.20413**	**10.82256**	**3.63662**
2020	**0.06452**	**0.32470**	**1.90849**	**2.40492**	**10.38758**	**9.81767**	**11.59028**	**3.31221**
2021	**0.06430**	**0.32653**	**1.94414**	**2.43567**	**11.19773**	**10.47210**	**12.41246**	**3.01674**

Year t	P_{K9}^t	P_{K10}^t	P_{K11}^t	P_{K12}^t	P_{K13}^t	P_{K14}^t	P_{K15}^t	P_{K16}^t
1970	**1.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**
1971	**1.06525**	**0.94910**	**1.07794**	**1.03280**	**1.02973**	**1.11423**	**1.11423**	**1.02973**
1972	**1.13383**	**0.89934**	**1.15285**	**1.03001**	**1.05388**	**1.23509**	**1.23509**	**1.05388**
1973	**1.21527**	**0.83761**	**1.21851**	**1.10305**	**1.07782**	**1.35675**	**1.35674**	**1.07782**
1974	**1.24691**	**0.68219**	**1.24937**	**1.01547**	**1.10064**	**1.49235**	**1.49234**	**1.10064**
1975	**1.32949**	**0.65512**	**1.35461**	**1.13055**	**1.12735**	**1.62697**	**1.62697**	**1.12735**
1976	**1.43730**	**0.64539**	**1.51290**	**1.23720**	**1.15458**	**1.80492**	**1.80491**	**1.15458**
1977	**1.50796**	**0.62489**	**1.61279**	**1.42079**	**1.17843**	**2.04417**	**2.04417**	**1.17843**
1978	**1.59284**	**0.60575**	**1.70975**	**1.19195**	**1.21854**	**2.36146**	**2.36145**	**1.21854**
1979	**1.65950**	**0.61930**	**1.74424**	**1.07279**	**1.29584**	**2.74174**	**2.74174**	**1.29584**
1980	**1.68563**	**0.59204**	**1.75969**	**1.10921**	**1.40565**	**3.15836**	**3.15835**	**1.40565**
1981	**1.74248**	**0.59756**	**1.86166**	**1.21767**	**1.53073**	**3.62280**	**3.62280**	**1.53073**
1982	**1.78089**	**0.60937**	**1.89057**	**1.19261**	**1.63973**	**4.23184**	**4.23184**	**1.63973**
1983	**1.72414**	**0.58830**	**1.86388**	**0.94543**	**1.73568**	**5.09105**	**5.09104**	**1.73568**
1984	**1.77003**	**0.59135**	**1.90827**	**0.96109**	**1.84996**	**6.22144**	**6.22143**	**1.84996**
1985	**1.88053**	**0.60644**	**1.97779**	**1.05965**	**2.00569**	**7.56281**	**7.56279**	**2.00569**
1986	**2.02087**	**0.62652**	**2.09503**	**1.15800**	**2.21335**	**9.20769**	**9.20767**	**2.21335**
1987	**2.07756**	**0.64384**	**2.16402**	**1.24423**	**2.50029**	**11.17683**	**11.17681**	**2.50029**
1988	**2.33364**	**0.71169**	**2.40419**	**1.33827**	**2.85210**	**13.45890**	**13.45888**	**2.85210**
1989	**2.56730**	**0.73967**	**2.72217**	**1.49708**	**3.24138**	**16.07815**	**16.07813**	**3.24138**
1990	**2.88915**	**0.77307**	**2.96654**	**1.63751**	**3.64206**	**19.37708**	**19.37705**	**3.64206**
1991	**3.14457**	**0.81583**	**3.17070**	**1.74645**	**3.99896**	**24.17647**	**23.36653**	**3.99896**
1992	**3.47366**	**0.84801**	**3.55143**	**1.90133**	**4.39099**	**31.26175**	**29.85216**	**4.39099**
1993	**4.28016**	**1.00622**	**4.30242**	**2.14293**	**5.02690**	**40.90647**	**39.45066**	**5.02690**
1994	**4.59629**	**1.08001**	**4.67631**	**2.60963**	**6.12961**	**52.34583**	**48.24970**	**6.12961**
1995	**4.88736**	**1.15333**	**4.96187**	**2.92821**	**7.67440**	**63.62200**	**54.86572**	**7.67440**
1996	**4.95985**	**1.15067**	**5.02135**	**3.15844**	**9.35975**	**72.07302**	**56.72688**	**9.35975**
1997	**4.96384**	**1.10894**	**4.97949**	**3.28945**	**10.76867**	**74.10548**	**57.41623**	**11.45596**
1998	**4.90974**	**1.08171**	**4.96546**	**3.34527**	**11.72828**	**69.84276**	**60.41501**	**14.14995**
1999	**4.85551**	**1.05425**	**4.91361**	**3.31145**	**12.31970**	**62.83323**	**65.74308**	**16.75453**
2000	**4.84912**	**1.02912**	**4.87821**	**3.30290**	**12.82040**	**56.11962**	**74.47946**	**19.26425**
2001	**4.87296**	**1.01309**	**4.92365**	**3.42349**	**13.42595**	**52.16606**	**85.62375**	**21.03942**
2002	**4.86152**	**0.98604**	**4.93458**	**3.45932**	**14.20625**	**49.82861**	**98.54631**	**22.74534**
2003	**4.89726**	**0.94810**	**4.94044**	**3.53031**	**15.42102**	**47.60797**	**109.46948**	**25.00406**
2004	**5.02607**	**0.94517**	**5.05158**	**3.66636**	**17.12266**	**46.09583**	**110.99135**	**27.58057**
2005	**5.11769**	**0.93741**	**5.12321**	**3.93965**	**19.02567**	**45.53876**	**99.72303**	**30.13845**
2006	**5.27575**	**0.94069**	**5.21146**	**4.04328**	**21.39806**	**49.15381**	**86.94128**	**32.31580**
2007	**5.32953**	**0.93160**	**5.24922**	**4.13492**	**24.44382**	**59.05091**	**79.03976**	**34.10073**
2008	**5.47724**	**0.93159**	**5.31651**	**4.47951**	**28.05203**	**70.02353**	**86.73232**	**38.21599**
2009	**5.22456**	**0.89659**	**5.28883**	**4.92410**	**32.12796**	**79.53409**	**111.01598**	**46.94495**
2010	**5.40661**	**0.89214**	**5.39720**	**4.85983**	**36.77402**	**83.98145**	**136.76967**	**56.94257**
2011	**5.64106**	**0.89990**	**5.62915**	**5.12206**	**42.10403**	**85.30541**	**160.98898**	**66.80909**
2012	**5.63316**	**0.87608**	**5.60461**	**5.55771**	**48.30903**	**87.95542**	**177.29725**	**73.34728**
2013	**5.54001**	**0.84217**	**5.50983**	**5.73076**	**54.62908**	**91.61045**	**186.56962**	**77.30978**
2014	**5.51887**	**0.81508**	**5.47769**	**5.81758**	**60.11880**	**95.30045**	**194.79163**	**81.69470**
2015	**5.39844**	**0.78317**	**5.37360**	**5.81078**	**64.75446**	**99.08095**	**203.67814**	**88.58893**
2016	**5.38136**	**0.77825**	**5.41512**	**5.65754**	**68.91544**	**102.30528**	**218.55994**	**98.29595**
2017	**5.47439**	**0.77167**	**5.46306**	**5.65447**	**72.99758**	**103.92881**	**243.14280**	**107.55426**
2018	**5.62421**	**0.76927**	**5.55795**	**5.97583**	**77.66456**	**105.24744**	**276.07632**	**114.90064**
2019	**5.69757**	**0.76531**	**5.62474**	**6.39522**	**84.21718**	**110.32219**	**314.48632**	**117.30514**
2020	**5.72810**	**0.78759**	**5.74278**	**6.71445**	**91.00683**	**115.92094**	**353.18629**	**119.27282**
2021	**5.75881**	**0.81052**	**5.86330**	**7.04961**	**98.02298**	**122.10621**	**391.91348**	**120.97916**

It can be seen that land prices increased very rapidly during the past three decades. The price of commercial land increased 392 fold over the five decades. On the other extreme, the prices of IT hardware and Communications equipment, assets 1 and 2, fell dramatically over the sample period.

The corresponding constant yuan beginning of the year capital stocks, Q_{Kn}^t are listed in Table A2 below. The units of measurement are in 10 billions of 1970 yuan. Values for these capital stocks (in units of 10 billion current year yuan) can be obtained as $V_{Kn}^t = P_{Kn}^t Q_{Kn}^t$.

Table A2: Beginning of Year Capital Stocks in Constant 10 Billion 1970 Yuan

Year t	Q_{K1}^t	Q_{K2}^t	Q_{K3}^t	Q_{K4}^t	Q_{K5}^t	Q_{K6}^t	Q_{K7}^t	Q_{K8}^t
1970	0.01364	0.03394	1.02309	8.09366	16.05711	2.21140	2.57276	0.60644
1971	0.01480	0.03747	1.18826	9.39303	17.31123	2.46157	2.86471	0.64928
1972	0.01658	0.04227	1.34647	10.54001	18.76212	2.83973	3.26475	0.71253
1973	0.01911	0.04775	1.48715	11.52183	20.15474	3.34044	3.77684	0.76624
1974	0.02463	0.05728	1.66838	12.55597	21.41517	3.85998	4.32249	0.80898
1975	0.03015	0.07067	1.89012	13.46832	22.84526	4.59881	5.04610	0.86808
1976	0.04071	0.09081	2.15268	14.83498	24.57971	5.43266	5.85371	0.92536
1977	0.04622	0.10647	2.32888	15.62166	25.85010	6.30600	6.70314	0.94051
1978	0.05153	0.12260	2.50630	16.29166	27.45042	7.41166	7.77631	0.95446
1979	0.06799	0.15160	2.78674	17.35409	29.54385	8.40567	8.76354	1.01401
1980	0.08103	0.16970	2.95230	17.76273	31.92330	9.72639	10.04275	1.05552
1981	0.10240	0.18706	3.09077	17.85908	34.24863	11.49986	11.69918	1.10407
1982	0.11707	0.19413	3.07480	17.38423	36.36113	13.54304	13.59130	1.13143
1983	0.16158	0.22768	3.20822	17.54645	38.35234	15.79780	15.69915	1.21187
1984	0.21252	0.28045	3.48130	18.06527	40.64956	17.96069	17.79369	1.32951
1985	0.35583	0.40677	4.07350	19.55757	43.02600	20.59459	20.31749	1.52168
1986	0.75664	0.62779	5.58778	21.98583	45.98548	23.47873	23.12157	1.80200
1987	0.93295	0.80506	6.91708	25.09434	48.89929	26.36402	25.98417	2.14295
1988	1.27180	1.11817	8.34213	29.46445	52.20543	29.25657	28.93409	2.55112
1989	1.69963	1.42211	9.86639	34.18239	56.00410	32.54550	32.25802	3.01285
1990	1.78712	1.48669	10.43993	36.29984	59.47467	35.07237	35.07514	3.17816
1991	1.95955	1.53289	10.91552	37.75225	62.29808	37.38250	37.78280	3.40188
1992	2.24338	1.67330	11.79886	40.02663	65.31585	39.99642	40.74736	3.81496
1993	2.51058	2.16792	13.61162	44.99678	68.75584	44.44371	45.25547	4.29506
1994	3.46574	3.19104	19.25183	51.40503	73.02642	49.91758	50.65033	5.12997
1995	4.62451	4.80670	25.31152	58.92464	78.57369	55.93646	56.56850	6.13564
1996	5.59015	7.04416	28.80283	66.85240	85.85548	63.24916	63.69713	7.11999
1997	7.48373	9.25822	32.10841	75.36105	92.98152	71.21671	71.47151	8.04693
1998	9.34168	13.16957	35.97222	86.30732	100.42852	79.36353	79.64807	9.40328
1999	9.35242	14.71446	37.26505	102.68511	108.76338	87.66057	87.99581	10.30339
2000	11.59904	18.53502	39.79905	118.59362	118.60417	96.17519	96.83886	11.61490
2001	17.26692	28.97097	43.42193	134.77117	129.10478	105.48943	106.54498	12.98881
2002	29.18897	44.28504	50.25708	150.70156	140.35733	115.87521	117.29471	14.47274
2003	73.18719	60.31084	60.46213	169.22897	152.70004	127.77664	129.52595	16.76394
2004	145.77775	76.69145	74.75445	196.44572	165.21749	142.52223	144.20739	18.43968
2005	223.98363	92.68498	92.74781	231.74099	179.42902	159.64141	161.14078	19.66716
2006	321.73146	108.43987	116.12512	278.11494	193.02951	178.25967	179.61046	20.65001
2007	405.56649	124.05403	144.05728	333.27554	208.54910	198.59522	199.83719	21.50308
2008	460.40425	140.75978	179.30833	402.76883	227.48257	221.46941	222.52460	22.55539
2009	536.93575	158.54000	224.00907	482.28495	246.09023	244.47708	245.29223	27.45197
2010	597.97929	181.06682	285.11117	584.61651	269.14570	278.75047	277.58353	35.34934
2011	694.32756	206.69550	361.28398	703.60407	294.23556	315.76848	312.71550	43.77949
2012	774.26623	234.40582	431.42286	802.72951	329.37366	358.36657	353.98596	49.22646
2013	892.90757	268.34084	521.35546	918.51093	361.65954	402.81107	397.63721	53.67363
2014	1000.67612	299.17673	598.59941	1024.04471	397.15982	456.51103	449.75182	55.38213
2015	1065.87791	321.04731	662.93583	1114.94381	432.19119	518.08221	509.03606	55.45330
2016	1088.41399	333.89540	711.26341	1185.78092	464.89137	586.83814	575.32236	53.87618
2017	1165.66100	354.41505	771.39754	1273.47677	496.12901	657.11608	644.60545	50.38672
2018	1254.62193	380.15966	842.81929	1378.57823	526.91755	729.14919	716.96293	46.32415
2019	1316.67305	404.07531	919.36662	1491.32354	559.79494	805.57984	794.35683	43.17479
2020	1346.22556	418.15944	987.05590	1592.17995	592.50862	880.01139	871.96226	40.60925
2021	1339.64982	420.34326	1042.59493	1679.26680	622.76433	948.90454	946.75286	39.00435

Year t	Q_{K9}^t	Q_{K10}^t	Q_{K11}^t	Q_{K12}^t	Q_{K13}^t	Q_{K14}^t	Q_{K15}^t	Q_{K16}^t
1970	0.56965	0.00778	0.01029	1.95448	2.48381	0.06175	0.44812	8.70339
1971	0.65540	0.00850	0.01170	3.94448	2.51455	0.07366	0.47361	8.97825
1972	0.73633	0.00975	0.01280	6.11032	2.54566	0.07883	0.49370	9.23118

1973	**0.80079**	**0.01157**	**0.01299**	**7.69268**	**2.57657**	**0.08229**	**0.51124**	**9.49489**
1974	**0.85672**	**0.01390**	**0.01300**	**10.12346**	**2.61412**	**0.08645**	**0.53492**	**9.72773**
1975	**0.92441**	**0.01782**	**0.01272**	**11.84091**	**2.65859**	**0.08695**	**0.54661**	**9.95580**
1976	**1.00561**	**0.02196**	**0.01277**	**13.36022**	**2.68944**	**0.09484**	**0.56357**	**10.16311**
1977	**1.05548**	**0.02682**	**0.01203**	**14.26887**	**2.72893**	**0.09311**	**0.56922**	**10.36947**
1978	**1.10099**	**0.03274**	**0.01125**	**15.88918**	**2.76840**	**0.10073**	**0.60319**	**10.58104**
1979	**1.15850**	**0.04031**	**0.01151**	**18.81584**	**2.80836**	**0.11067**	**0.68749**	**10.79515**
1980	**1.23805**	**0.04921**	**0.01152**	**21.84939**	**2.83893**	**0.11620**	**0.72533**	**11.00095**
1981	**1.31606**	**0.06300**	**0.01130**	**24.20138**	**2.86945**	**0.12456**	**0.75468**	**11.22833**
1982	**1.36743**	**0.07811**	**0.01013**	**26.63397**	**2.90493**	**0.12579**	**0.80997**	**11.47875**
1983	**1.42165**	**0.09501**	**0.01011**	**28.82971**	**2.96922**	**0.13001**	**0.87009**	**11.71094**
1984	**1.53195**	**0.11782**	**0.01057**	**31.25511**	**3.03895**	**0.13724**	**0.94376**	**11.94564**
1985	**1.68144**	**0.15305**	**0.01187**	**34.84283**	**3.11667**	**0.14878**	**1.04583**	**12.19720**
1986	**1.82378**	**0.20396**	**0.01483**	**41.84856**	**3.19572**	**0.16391**	**1.16430**	**12.46756**
1987	**1.95618**	**0.27946**	**0.01842**	**47.67730**	**3.23663**	**0.17294**	**1.24045**	**12.75464**
1988	**2.06977**	**0.37656**	**0.02292**	**54.03104**	**3.27217**	**0.18585**	**1.36311**	**13.03892**
1989	**2.15182**	**0.49996**	**0.02716**	**62.43580**	**3.30979**	**0.20179**	**1.47042**	**13.32216**
1990	**2.22077**	**0.64540**	**0.02792**	**75.00777**	**3.35070**	**0.20763**	**1.47165**	**13.60423**
1991	**2.26612**	**0.82324**	**0.02786**	**86.35730**	**3.39224**	**0.21173**	**1.48258**	**13.87616**
1992	**2.32707**	**1.02652**	**0.02891**	**97.75355**	**3.43027**	**0.22895**	**1.58069**	**14.13739**
1993	**2.40839**	**1.24092**	**0.03213**	**109.19038**	**3.44987**	**0.25596**	**1.69700**	**14.40176**
1994	**2.47059**	**1.43942**	**0.03831**	**117.93280**	**3.47604**	**0.28477**	**1.82017**	**14.66819**
1995	**2.56765**	**1.81499**	**0.04603**	**127.55463**	**3.50689**	**0.31497**	**1.93751**	**14.93170**
1996	**2.67801**	**2.24869**	**0.05302**	**140.58574**	**3.50690**	**0.34006**	**2.06910**	**15.19824**
1997	**2.83728**	**2.78413**	**0.06025**	**153.88876**	**3.50715**	**0.36432**	**2.21794**	**15.46495**
1998	**3.10445**	**3.41598**	**0.06729**	**165.01244**	**3.50710**	**0.38786**	**2.40392**	**15.72440**
1999	**3.39703**	**4.16310**	**0.07630**	**170.14360**	**3.50706**	**0.40703**	**2.55154**	**15.97553**
2000	**3.81967**	**4.87411**	**0.08483**	**174.59699**	**3.50704**	**0.43065**	**2.73575**	**16.22258**
2001	**4.46158**	**5.68392**	**0.09442**	**177.60896**	**3.50701**	**0.43967**	**2.93539**	**16.45772**
2002	**5.21044**	**6.69467**	**0.10569**	**184.52050**	**3.51097**	**0.46336**	**3.15038**	**16.69089**
2003	**6.20049**	**8.45351**	**0.12125**	**188.42021**	**3.51494**	**0.48138**	**3.38701**	**16.92272**
2004	**7.37248**	**10.39366**	**0.16632**	**193.69439**	**3.51889**	**0.51616**	**3.60698**	**17.15747**
2005	**8.89841**	**12.88204**	**0.25479**	**203.52782**	**3.52282**	**0.55244**	**3.81859**	**17.39744**
2006	**10.79415**	**16.02973**	**0.42696**	**207.93152**	**3.52677**	**0.58247**	**4.12219**	**17.63357**
2007	**13.03780**	**19.47784**	**0.73307**	**214.42565**	**3.53072**	**0.62601**	**4.50492**	**17.87308**
2008	**15.83967**	**24.11195**	**1.19116**	**230.55335**	**3.53467**	**0.68478**	**4.96330**	**18.11641**
2009	**19.28226**	**33.43813**	**1.66910**	**252.03315**	**3.59155**	**0.72185**	**5.36189**	**18.36176**
2010	**24.05751**	**47.86684**	**2.26389**	**263.47380**	**3.64843**	**0.77475**	**5.76139**	**18.61129**
2011	**29.43484**	**67.38774**	**2.91757**	**285.30304**	**3.70530**	**0.82332**	**6.16721**	**18.87649**
2012	**35.65712**	**96.95593**	**3.35656**	**310.68073**	**3.76218**	**0.87433**	**6.56261**	**19.16601**
2013	**43.02883**	**139.84830**	**4.03006**	**329.85488**	**3.81906**	**0.92246**	**6.94231**	**19.43531**
2014	**51.46905**	**194.44233**	**4.75692**	**349.64772**	**3.83986**	**0.96694**	**7.31746**	**19.72160**
2015	**59.61602**	**260.46596**	**5.47388**	**372.15719**	**3.86092**	**1.01923**	**7.72959**	**19.98266**
2016	**68.30543**	**337.31285**	**6.10322**	**386.49851**	**3.86047**	**1.06009**	**8.19880**	**20.27403**
2017	**77.60267**	**411.87448**	**6.85300**	**401.20926**	**3.85988**	**1.09876**	**8.63775**	**20.55348**
2018	**87.51114**	**487.77145**	**7.53783**	**417.77665**	**3.85959**	**1.13528**	**9.11843**	**20.80574**
2019	**97.79046**	**575.52076**	**7.93566**	**425.13611**	**3.85957**	**1.17525**	**9.60383**	**21.05306**
2020	**107.85519**	**672.07217**	**8.22031**	**432.25008**	**3.85957**	**1.20538**	**10.11749**	**21.27032**
2021	**116.74162**	**691.20801**	**8.42258**	**438.93147**	**3.85957**	**1.23538**	**10.61749**	**21.47032**

It can be seen that there are very large growth rates in the capital stocks for many of the assets.

Table A3 lists the depreciation rates δ_n^t for the reproducible assets, n = 1,…,11. Assets 12-16 have 0 depreciation rates.

Table A3: Annual Geometric Depreciation Rates for Reproducible Assets

Year t	δ_1^t	δ_2^t	δ_3^t	δ_4^t	δ_5^t	δ_6^t	δ_7^t	δ_8^t	δ_9^t	δ_{10}^t	δ_{11}^t
1970	**0.35923**	**0.29509**	**0.15961**	**0.13420**	**0.03692**	**0.05552**	**0.01760**	**0.18170**	**0.18957**	**0.41331**	**0.33381**
1971	**0.36776**	**0.29847**	**0.15752**	**0.13181**	**0.03692**	**0.05552**	**0.01760**	**0.18405**	**0.18719**	**0.42423**	**0.32706**
1972	**0.37611**	**0.29869**	**0.15540**	**0.13002**	**0.03692**	**0.05552**	**0.01760**	**0.18211**	**0.18402**	**0.43208**	**0.31459**
1973	**0.38434**	**0.30856**	**0.15669**	**0.12980**	**0.03692**	**0.05552**	**0.01760**	**0.18039**	**0.18246**	**0.43498**	**0.31247**
1974	**0.39036**	**0.31331**	**0.15750**	**0.12874**	**0.03692**	**0.05552**	**0.01760**	**0.18191**	**0.18326**	**0.45103**	**0.30894**

1975	**0.38856**	**0.32049**	**0.15794**	**0.13053**	**0.03692**	**0.05552**	**0.01760**	**0.18129**	**0.18404**	**0.44101**	**0.31299**
1976	**0.38539**	**0.31631**	**0.16467**	**0.13834**	**0.04710**	**0.06570**	**0.02778**	**0.18801**	**0.18067**	**0.43902**	**0.30328**
1977	**0.38324**	**0.30179**	**0.15331**	**0.12689**	**0.03692**	**0.05552**	**0.01760**	**0.17680**	**0.18010**	**0.43895**	**0.30221**
1978	**0.38239**	**0.31373**	**0.15595**	**0.12828**	**0.03692**	**0.05552**	**0.01760**	**0.18097**	**0.18091**	**0.44088**	**0.31601**
1979	**0.38465**	**0.29726**	**0.15207**	**0.12569**	**0.03692**	**0.05552**	**0.01760**	**0.17909**	**0.18235**	**0.43889**	**0.31239**
1980	**0.38571**	**0.29505**	**0.15132**	**0.12473**	**0.03708**	**0.05568**	**0.01776**	**0.17970**	**0.18186**	**0.45061**	**0.30940**
1981	**0.39040**	**0.28839**	**0.14972**	**0.12497**	**0.03917**	**0.05777**	**0.01985**	**0.18012**	**0.17974**	**0.44265**	**0.29620**
1982	**0.40125**	**0.30477**	**0.15089**	**0.12481**	**0.03692**	**0.05552**	**0.01760**	**0.18174**	**0.17980**	**0.43800**	**0.31200**
1983	**0.42751**	**0.31305**	**0.15397**	**0.12607**	**0.03692**	**0.05552**	**0.01760**	**0.18402**	**0.18314**	**0.44268**	**0.31947**
1984	**0.45013**	**0.34376**	**0.16025**	**0.12936**	**0.03692**	**0.05552**	**0.01760**	**0.18818**	**0.18490**	**0.45433**	**0.33157**
1985	**0.45157**	**0.35763**	**0.17593**	**0.13272**	**0.03766**	**0.05626**	**0.01834**	**0.19247**	**0.18376**	**0.46099**	**0.35114**
1986	**0.43967**	**0.32358**	**0.16848**	**0.13620**	**0.03992**	**0.05852**	**0.02060**	**0.19537**	**0.18270**	**0.46840**	**0.35023**
1987	**0.41072**	**0.33524**	**0.16302**	**0.13516**	**0.03703**	**0.05563**	**0.01771**	**0.19233**	**0.18142**	**0.46392**	**0.35040**
1988	**0.38814**	**0.32068**	**0.16307**	**0.13604**	**0.03868**	**0.05728**	**0.01936**	**0.19329**	**0.17980**	**0.46001**	**0.34121**
1989	**0.37782**	**0.28955**	**0.15449**	**0.13056**	**0.03926**	**0.05786**	**0.01994**	**0.18286**	**0.17913**	**0.45274**	**0.31671**
1990	**0.37012**	**0.28715**	**0.15319**	**0.12884**	**0.03892**	**0.05752**	**0.01960**	**0.18385**	**0.17810**	**0.44970**	**0.31199**
1991	**0.37270**	**0.30032**	**0.16020**	**0.13444**	**0.04301**	**0.06161**	**0.02369**	**0.19278**	**0.17867**	**0.44404**	**0.31821**
1992	**0.38443**	**0.32314**	**0.16010**	**0.13299**	**0.03791**	**0.05651**	**0.01859**	**0.18762**	**0.17938**	**0.43651**	**0.32968**
1993	**0.39311**	**0.35104**	**0.18230**	**0.13705**	**0.04066**	**0.05926**	**0.02134**	**0.19663**	**0.17858**	**0.42685**	**0.34236**
1994	**0.39932**	**0.35740**	**0.17639**	**0.13872**	**0.04200**	**0.06061**	**0.02269**	**0.19823**	**0.17976**	**0.44680**	**0.34382**
1995	**0.40068**	**0.34936**	**0.16117**	**0.13584**	**0.03999**	**0.05859**	**0.02067**	**0.19291**	**0.18009**	**0.44246**	**0.33602**
1996	**0.39367**	**0.33327**	**0.16429**	**0.14017**	**0.04449**	**0.06309**	**0.02517**	**0.19516**	**0.18154**	**0.44230**	**0.33360**
1997	**0.38696**	**0.34194**	**0.15856**	**0.13522**	**0.03877**	**0.05737**	**0.01945**	**0.19230**	**0.18460**	**0.44009**	**0.33057**
1998	**0.38692**	**0.30709**	**0.15986**	**0.14543**	**0.04578**	**0.06438**	**0.02646**	**0.19354**	**0.18461**	**0.43846**	**0.33324**
1999	**0.39932**	**0.31973**	**0.15531**	**0.13642**	**0.03934**	**0.05794**	**0.02002**	**0.18930**	**0.18727**	**0.42899**	**0.32978**
2000	**0.43660**	**0.35973**	**0.15457**	**0.13286**	**0.03707**	**0.05567**	**0.01775**	**0.18604**	**0.19111**	**0.42807**	**0.32997**
2001	**0.48497**	**0.35571**	**0.16024**	**0.13249**	**0.03778**	**0.05639**	**0.01846**	**0.18647**	**0.19110**	**0.43038**	**0.33097**
2002	**0.50919**	**0.33230**	**0.16360**	**0.13278**	**0.03778**	**0.05638**	**0.01846**	**0.19032**	**0.19305**	**0.44716**	**0.33531**
2003	**0.50331**	**0.32157**	**0.16789**	**0.13694**	**0.03948**	**0.05808**	**0.02016**	**0.18706**	**0.19296**	**0.44059**	**0.37036**
2004	**0.46757**	**0.31046**	**0.16609**	**0.13601**	**0.03750**	**0.05611**	**0.01819**	**0.18198**	**0.19455**	**0.44255**	**0.39538**
2005	**0.42462**	**0.30587**	**0.16771**	**0.13805**	**0.03823**	**0.05683**	**0.01891**	**0.18131**	**0.19508**	**0.44353**	**0.41783**
2006	**0.39756**	**0.30175**	**0.16641**	**0.13750**	**0.03781**	**0.05642**	**0.01849**	**0.18010**	**0.19462**	**0.43775**	**0.42426**
2007	**0.38225**	**0.30015**	**0.16644**	**0.13786**	**0.03756**	**0.05616**	**0.01824**	**0.18049**	**0.19524**	**0.44226**	**0.40989**
2008	**0.37359**	**0.30457**	**0.17205**	**0.14239**	**0.04247**	**0.06107**	**0.02315**	**0.20059**	**0.19546**	**0.47168**	**0.37497**
2009	**0.37098**	**0.30067**	**0.16803**	**0.13761**	**0.03711**	**0.05571**	**0.01779**	**0.20095**	**0.19813**	**0.48052**	**0.36796**
2010	**0.36936**	**0.30140**	**0.16837**	**0.13782**	**0.03781**	**0.05641**	**0.01849**	**0.19740**	**0.19600**	**0.47584**	**0.35741**
2011	**0.36887**	**0.29981**	**0.16247**	**0.13343**	**0.03734**	**0.05594**	**0.01802**	**0.18687**	**0.19494**	**0.48196**	**0.33582**
2012	**0.36727**	**0.30148**	**0.16368**	**0.13378**	**0.03748**	**0.05608**	**0.01816**	**0.18404**	**0.19452**	**0.48267**	**0.34365**
2013	**0.36357**	**0.29763**	**0.15956**	**0.13229**	**0.03779**	**0.05639**	**0.01847**	**0.17924**	**0.19359**	**0.47239**	**0.34048**
2014	**0.35917**	**0.29136**	**0.15618**	**0.13029**	**0.03744**	**0.05604**	**0.01812**	**0.17617**	**0.19025**	**0.46235**	**0.33586**
2015	**0.35619**	**0.28647**	**0.15339**	**0.12849**	**0.03722**	**0.05582**	**0.01790**	**0.17333**	**0.18915**	**0.45355**	**0.33027**
2016	**0.35521**	**0.29003**	**0.15477**	**0.12965**	**0.03770**	**0.05630**	**0.01838**	**0.17066**	**0.18830**	**0.43892**	**0.33150**
2017	**0.35432**	**0.29100**	**0.15480**	**0.12963**	**0.03718**	**0.05578**	**0.01786**	**0.16870**	**0.18756**	**0.43165**	**0.32793**
2018	**0.35325**	**0.28958**	**0.15461**	**0.12953**	**0.03712**	**0.05573**	**0.01781**	**0.16976**	**0.18666**	**0.43079**	**0.32056**
2019	**0.35191**	**0.28571**	**0.15341**	**0.12871**	**0.03718**	**0.05579**	**0.01787**	**0.17057**	**0.18537**	**0.42839**	**0.31792**
2020	**0.35191**	**0.28571**	**0.15341**	**0.12871**	**0.03718**	**0.05579**	**0.01787**	**0.17057**	**0.18537**	**0.42839**	**0.31792**
Mean	**0.39439**	**0.31213**	**0.16041**	**0.13288**	**0.03851**	**0.05711**	**0.01919**	**0.18493**	**0.18620**	**0.44581**	**0.33623**

In the main text, we worked with a more aggregated model where there are only 5 types of capital: (i) *Aggregate Machinery and Equipment* (an aggregate of assets 1-4), with year t price, quantity and value indexes equal to P_{KM}^t, Q_{KM}^t and $V_{KM}^t \equiv P_{KM}^t Q_{KM}^t$; (ii) *Aggregate Structures* (an aggregate of assets 5-7) with year t price and quantity indexes equal to P_{KS}^t and Q_{KS}^t; (iii) *Aggregate Other Capital* (an aggregate of assets 8-11) with year t price and quantity indexes equal to P_{KO}^t and Q_{KO}^t; (iv) *Inventory Stocks* (equal to asset 12) which we label as P_{KI}^t, Q_{KI}^t and $V_{KI}^t \equiv P_{KI}^t Q_{KI}^t$ and (v) *Land Assets* (an aggregate of assets 13-16) with price and quantity indexes P_{KL}^t and Q_{KL}^t for t = 1970, …,2021. The aggregation is done using chained Törnqvist price indexes. Table A4 below lists these aggregate beginning of the year capital stocks and their corresponding aggregate prices. The units of measurement for the quantity indexes are now in units of trillions of 1970 yuan.

Table A4: Prices and Quantities for Five Beginning of the Year Aggregate Capital Stocks

Year t	$\mathbf{P_{KM}^t}$	$\mathbf{P_{KS}^t}$	$\mathbf{P_{KO}^t}$	$\mathbf{P_{KI}^t}$	$\mathbf{P_{KL}^t}$	$\mathbf{Q_{KM}^t}$	$\mathbf{Q_{KS}^t}$	$\mathbf{Q_{KO}^t}$	$\mathbf{Q_{KI}^t}$	$\mathbf{Q_{KL}^t}$

1970	**1.00000**	**1.00000**	**1.00000**	**1.00000**	**1.00000**	**0.09164**	**0.20841**	**0.01194**	**0.01954**	**0.11697**
1971	**0.99523**	**1.01537**	**0.99385**	**1.03280**	**1.03350**	**0.10634**	**0.22639**	**0.01327**	**0.03944**	**0.12041**
1972	**0.97362**	**1.02161**	**1.01447**	**1.03001**	**1.06208**	**0.11945**	**0.24869**	**0.01475**	**0.06110**	**0.12352**
1973	**0.98976**	**1.06311**	**1.08369**	**1.10305**	**1.09057**	**0.13076**	**0.27265**	**0.01596**	**0.07693**	**0.12669**
1974	**1.00731**	**1.06348**	**1.05519**	**1.01547**	**1.11873**	**0.14301**	**0.29585**	**0.01698**	**0.10123**	**0.12971**
1975	**0.97761**	**1.07449**	**1.15021**	**1.13055**	**1.15059**	**0.15442**	**0.32493**	**0.01829**	**0.11841**	**0.13255**
1976	**0.97491**	**1.08772**	**1.23052**	**1.23720**	**1.18508**	**0.17094**	**0.35890**	**0.01974**	**0.13360**	**0.13525**
1977	**0.97092**	**1.10035**	**1.29726**	**1.42079**	**1.21934**	**0.18071**	**0.38909**	**0.02046**	**0.14269**	**0.13769**
1978	**0.98060**	**1.11574**	**1.31964**	**1.19195**	**1.27301**	**0.18930**	**0.42727**	**0.02113**	**0.15889**	**0.14084**
1979	**0.99535**	**1.14210**	**1.37420**	**1.07279**	**1.36589**	**0.20297**	**0.46829**	**0.02233**	**0.18816**	**0.14508**
1980	**0.99603**	**1.22075**	**1.35666**	**1.10921**	**1.49194**	**0.20882**	**0.51843**	**0.02367**	**0.21849**	**0.14821**
1981	**1.00089**	**1.24951**	**1.36973**	**1.21767**	**1.63524**	**0.21123**	**0.57664**	**0.02506**	**0.24201**	**0.15145**
1982	**1.00619**	**1.28709**	**1.39932**	**1.19261**	**1.77246**	**0.20634**	**0.63811**	**0.02596**	**0.26634**	**0.15541**
1983	**0.98611**	**1.35204**	**1.34004**	**0.94543**	**1.91381**	**0.20950**	**0.70281**	**0.02730**	**0.28830**	**0.15974**
1984	**1.00057**	**1.43289**	**1.36797**	**0.96109**	**2.09091**	**0.21765**	**0.76946**	**0.02964**	**0.31255**	**0.16474**
1985	**1.03582**	**1.54922**	**1.47414**	**1.05965**	**2.32238**	**0.23916**	**0.84615**	**0.03307**	**0.34843**	**0.17116**
1986	**1.08186**	**1.69009**	**1.55727**	**1.15800**	**2.62503**	**0.27942**	**0.93399**	**0.03712**	**0.41849**	**0.17866**
1987	**1.09756**	**1.81148**	**1.58422**	**1.24423**	**3.02392**	**0.32419**	**1.02189**	**0.04152**	**0.47677**	**0.18446**
1988	**1.21004**	**2.04708**	**1.76510**	**1.33827**	**3.50519**	**0.38372**	**1.11462**	**0.04621**	**0.54031**	**0.19220**
1989	**1.30866**	**2.19193**	**1.95557**	**1.49708**	**4.04793**	**0.44776**	**1.22007**	**0.05094**	**0.62436**	**0.19960**
1990	**1.43049**	**2.34325**	**2.16110**	**1.63751**	**4.65764**	**0.47505**	**1.30945**	**0.05351**	**0.75008**	**0.20244**
1991	**1.52737**	**2.57119**	**2.22124**	**1.74645**	**5.29530**	**0.49466**	**1.38912**	**0.05620**	**0.86357**	**0.20550**
1992	**1.68666**	**3.00678**	**2.40157**	**1.90133**	**6.17132**	**0.52677**	**1.47640**	**0.06030**	**0.97754**	**0.21306**
1993	**1.98344**	**3.95798**	**2.78663**	**2.14293**	**7.51941**	**0.59614**	**1.60188**	**0.06503**	**1.09190**	**0.22230**
1994	**2.12912**	**4.36898**	**2.98031**	**2.60963**	**9.20944**	**0.71444**	**1.75470**	**0.07127**	**1.17933**	**0.23231**
1995	**2.23842**	**4.57578**	**3.19616**	**2.92821**	**11.06720**	**0.85027**	**1.93119**	**0.07963**	**1.27555**	**0.24202**
1996	**2.24978**	**4.80546**	**3.32405**	**3.15844**	**12.59804**	**0.97191**	**2.15050**	**0.08835**	**1.40586**	**0.25159**
1997	**2.22517**	**4.94671**	**3.26842**	**3.28945**	**14.12874**	**1.09884**	**2.38129**	**0.09784**	**1.53889**	**0.26137**
1998	**2.19640**	**4.97842**	**3.08498**	**3.34527**	**16.02924**	**1.26169**	**2.62130**	**0.11156**	**1.65012**	**0.27197**
1999	**2.13589**	**4.99394**	**2.99406**	**3.31145**	**17.97489**	**1.45157**	**2.87353**	**0.12369**	**1.70144**	**0.28050**
2000	**2.09187**	**5.10977**	**3.02047**	**3.30290**	**20.16185**	**1.65605**	**3.14846**	**0.13988**	**1.74597**	**0.29035**
2001	**2.08029**	**5.18063**	**3.14394**	**3.42349**	**22.22750**	**1.89471**	**3.44688**	**0.16019**	**1.77609**	**0.30036**
2002	**2.04584**	**5.23087**	**2.96957**	**3.45932**	**24.49215**	**2.17426**	**3.77420**	**0.18350**	**1.84521**	**0.31155**
2003	**2.00549**	**5.44600**	**3.09348**	**3.53031**	**26.91286**	**2.53256**	**4.14276**	**0.21741**	**1.88420**	**0.32365**
2004	**2.01382**	**5.88627**	**3.26915**	**3.66636**	**28.56569**	**3.03384**	**4.56623**	**0.25154**	**1.93694**	**0.33523**
2005	**2.02596**	**5.99110**	**3.38254**	**3.93965**	**28.82290**	**3.65213**	**5.05372**	**0.29033**	**2.03528**	**0.34601**
2006	**2.05584**	**6.06668**	**3.49187**	**4.04328**	**28.76127**	**4.44429**	**5.56610**	**0.33601**	**2.07932**	**0.35893**
2007	**2.06151**	**6.37630**	**3.47418**	**4.13492**	**29.15402**	**5.36357**	**6.13297**	**0.38909**	**2.14426**	**0.37347**
2008	**2.08560**	**7.20168**	**3.42010**	**4.47951**	**32.57056**	**6.49294**	**6.78488**	**0.45856**	**2.30553**	**0.38990**
2009	**2.05626**	**6.93844**	**3.31714**	**4.92410**	**40.26715**	**7.82809**	**7.43583**	**0.57273**	**2.52033**	**0.40481**
2010	**2.07389**	**7.27930**	**3.48865**	**4.85983**	**48.70779**	**9.56590**	**8.34121**	**0.73987**	**2.63474**	**0.42026**
2011	**2.11566**	**7.95600**	**3.63909**	**5.12206**	**56.88352**	**11.64272**	**9.32455**	**0.93287**	**2.85303**	**0.43602**
2012	**2.10999**	**8.08576**	**3.59181**	**5.55771**	**62.59609**	**13.44381**	**10.52770**	**1.14206**	**3.10681**	**0.45178**
2013	**2.09608**	**8.10829**	**3.61783**	**5.73076**	**66.21764**	**15.63045**	**11.74666**	**1.39650**	**3.29855**	**0.46678**
2014	**2.08703**	**8.15304**	**3.63276**	**5.81758**	**69.78175**	**17.58261**	**13.17766**	**1.67231**	**3.49648**	**0.48143**
2015	**2.06595**	**7.93232**	**3.63431**	**5.81078**	**74.38837**	**19.22814**	**14.75699**	**1.95089**	**3.72157**	**0.49680**
2016	**2.05204**	**7.88433**	**3.78209**	**5.65754**	**80.98605**	**20.47851**	**16.45808**	**2.23497**	**3.86499**	**0.51358**
2017	**2.06376**	**8.51384**	**3.83430**	**5.65447**	**88.91484**	**22.05245**	**18.19186**	**2.49819**	**4.01209**	**0.52936**
2018	**2.08659**	**9.12758**	**3.89861**	**5.97583**	**97.54046**	**23.93370**	**19.97149**	**2.76375**	**4.17777**	**0.54615**
2019	**2.11272**	**9.78813**	**3.91746**	**6.39522**	**105.49048**	**25.93512**	**21.86918**	**3.06133**	**4.25136**	**0.56352**
2020	**2.14279**	**10.48511**	**3.93072**	**6.71445**	**113.45564**	**27.69986**	**23.74861**	**3.38064**	**4.32250**	**0.58184**
2021	**2.17336**	**11.23139**	**3.95463**	**7.04961**	**121.45317**	**29.17363**	**25.51965**	**3.53909**	**4.38931**	**0.60005**

The aggregate price of land grew 121 fold over the sample period while the price of Machinery and Equipment capital grew only 2.17 fold. The price of structures grew 11.2 fold.

We turn our attention to the components of output and investment in particular.

The investment quantity indexes Q_{In}^t, the capital stock quantity indexes Q_{Kn}^t and the non zero depreciation rates δ_n^t are all consistent with equations (A1) above for assets n = 1, …, 11. For the zero depreciation assets, we define the corresponding investments by differencing the beginning and end of year capital stocks listed above in Table A2. Thus define the investments for the non-depreciable assets 12-16 as follows:

(A2) $Q_{In}^t \equiv Q_{Kn}^{t+1} - Q_{Kn}^t$; n = 12, …, 16; t = 1970, …, 2020.

Differencing the stock of inventories to obtain an estimate for investment in inventories is acceptable from the viewpoint of the international System of National Accounts (SNA). The same logic should apply to land stocks; i.e., estimates for investment in the different types of land can be obtained by differencing the stocks as we have done in definitions (A2) above. However, the current SNA does not follow the inventories example and ignores changes in land use in the definition of aggregate investment. It may be that the logic behind this decision is that land as a whole does not change from year to year and hence there is no investment in land by definition. But it can be seen that when we decompose land use into different components, agricultural land is frequently converted into more valuable types of land and hence investment in land should be included in aggregate investment. Thus, the definition of aggregate investment used in this paper will differ from the APO estimate for aggregate investment because we have included land investment in our aggregate investment.

The APO data base sets the beginning of the year price of an asset $P_K K_n^t$ equal to the price of the corresponding investment P_{In}^t for n = 1, …, 11. We will follow the APO convention and set the price of investment equal to the corresponding beginning of the year price of the asset. Thus, we have:

(A3) $P_{In}^t \equiv P_{Kn}^t$; n = 12, …, 16; t = 1970, …, 2020.

We can now construct a new investment aggregate that includes land investment. Use chained Törnqvist Theil price indexes to construct the new aggregate investment price PI^t and the corresponding implicit quantity index QI^t by aggregating over all 16 types of investment that are defined above for the years t = 1970-2020. Define the corresponding year t value of aggregate investment as $V_I^t \equiv P_I^t Q_I^t$. Define a reproducible capital investment aggregate that aggregates investments over the first 12 types of investment (call this aggregate $V_{IR}^t = P_{IR}^t Q_{IR}^t$) and a land investment aggregate that aggregates over the 4 types of land (call this aggregate $V_{IL}^t = P_{IL}^t Q_{IL}^t$) using chained Törnqvist Theil price indexes. The aggregate investment price indexes P_I^t, P_{IR}^t and P_{IL}^t are listed in Table A5 below and the corresponding quantity indexes and the values V_I^t, V_{IR}^t and V_{IL}^t are listed in Table A6 below.

Table A5 also lists the APO price indexes for P_C^t (private consumption),[39] P_G^t (government consumption), P_X^t (exports of goods and services), and P_M^t (imports of goods and services). The corresponding quantity or volume indexes are defined as Q_C^t, Q_G^t, Q_X^t and Q_M^t and are listed in Table A6 below. The Q_M^t are listed with a negative sign since they are a cost to producers whereas the other outputs are a source of revenue.

Table A5: Output Price Indexes for the Main Aggregates for China

Year t	P_Y^t	P_C^t	P_G^t	P_I^t	P_X^t	P_M^t	P_{IR}^t	P_{IL}^t
1970	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1971	1.02518	1.03698	0.99747	1.01337	0.95639	0.96078	1.01237	1.03776
1972	1.04051	1.06245	1.00850	1.00962	0.95979	0.93892	1.00729	1.06910
1973	1.07402	1.09103	1.02833	1.04849	0.98814	0.90766	1.04640	1.10091
1974	1.08629	1.11850	1.01822	1.03624	1.04008	0.91873	1.03280	1.13142
1975	1.11216	1.14809	1.03919	1.05771	1.01496	0.90539	1.05390	1.16570
1976	1.12415	1.16625	1.00126	1.07958	0.99847	0.90551	1.07540	1.20128
1977	1.15386	1.19562	1.03114	1.11014	1.00875	0.92113	1.10565	1.24199
1978	1.16756	1.22567	1.08096	1.08275	1.06379	0.94090	1.07480	1.33072

[39] The APO consumption price has been adjusted downward by the amount of indirect taxes paid on outputs and the APO imports price has been adjusted upward by indirect taxes on imports. The required tax information is also available in the APO Augmented Database. Thus, we adjust the APO final demand prices to obtain prices that producers actually pay for inputs and obtain revenues for the outputs that they produce. Jorgenson and Griliches (1973) noted the importance of making these tax adjustments when constructing productivity estimates for the economy.

1979	1.21300	1.29513	1.15646	1.07682	1.10905	0.94425	1.06545	1.45917
1980	1.27264	1.35641	1.23861	1.12478	1.14236	0.97687	1.11115	1.60809
1981	1.31476	1.40880	1.25651	1.16608	1.16111	1.01991	1.14937	1.77712
1982	1.35292	1.45535	1.29030	1.18970	1.19309	1.03940	1.16892	1.96036
1983	1.38200	1.50247	1.35314	1.18866	1.24389	1.12134	1.16210	2.18366
1984	1.45066	1.56452	1.53777	1.24501	1.38057	1.31585	1.21197	2.48791
1985	1.59660	1.74021	1.76335	1.34201	1.64961	1.58561	1.30173	2.87708
1986	1.69657	1.84569	1.91425	1.45125	2.19895	2.07973	1.40308	3.35290
1987	1.81109	1.99817	2.09740	1.53669	2.43226	2.41155	1.47849	3.95084
1988	1.96966	2.31061	2.42909	1.71261	2.33075	3.28398	1.64317	4.66808
1989	2.18023	2.58518	2.62963	1.86329	2.10692	2.98085	1.78393	5.40438
1990	2.39658	2.74894	2.83003	2.01773	2.84985	3.37091	1.92991	6.13688
1991	2.59779	2.93419	3.14482	2.18261	3.15011	3.60515	2.08238	7.04693
1992	2.83092	3.05646	3.59870	2.47914	3.20210	3.63741	2.35555	8.66188
1993	3.31621	3.44895	4.36517	3.07504	2.88859	3.53582	2.91695	11.09008
1994	3.82917	4.03112	5.53442	3.42011	4.44761	5.44507	3.22834	13.65762
1995	4.42576	4.99452	6.56686	3.64065	4.59739	5.61407	3.42133	15.99332
1996	4.82905	5.57599	7.24474	3.80219	4.28678	5.04519	3.56736	17.29387
1997	4.96653	5.80005	7.62483	3.87753	4.01904	4.79451	3.63224	18.20047
1998	4.98518	5.80440	7.83676	3.88842	3.64947	4.29606	3.62924	19.62629
1999	4.96347	5.84666	7.93051	3.87450	3.67226	4.53706	3.59909	21.43279
2000	5.08635	6.01351	8.15863	3.92681	3.97211	4.89473	3.62611	24.04999
2001	5.21869	6.06745	8.48901	3.98311	3.98439	4.69082	3.65448	27.12578
2002	5.16851	5.76843	8.70233	3.99872	4.08307	4.66556	3.64116	30.61641
2003	5.27189	5.71510	9.29283	4.08029	4.47609	5.04912	3.69767	33.73317
2004	5.56897	5.81142	10.21523	4.27279	5.18548	5.65170	3.87580	34.69596
2005	5.77237	5.82620	10.88646	4.31693	5.60179	5.79632	3.93024	32.53891
2006	6.09124	6.18283	12.33035	4.35231	5.77393	5.82733	3.98212	29.73399
2007	6.40721	6.29200	14.51997	4.45684	6.01178	5.95681	4.09218	28.23642
2008	6.81319	6.53238	16.48468	4.78556	6.16889	6.19177	4.38854	31.28168
2009	6.83165	6.41761	17.33066	4.72620	5.53661	5.30852	4.29512	39.30093
2010	7.12878	6.73566	18.18326	4.89834	6.12620	5.90362	4.42369	47.72570
2011	7.67900	7.29877	20.23072	5.21294	6.25829	6.01519	4.69061	55.67907
2012	7.88684	7.41298	21.65908	5.28187	6.12927	5.79773	4.73782	61.16015
2013	8.04501	7.60572	22.97099	5.29026	5.94955	5.58095	4.73655	64.44785
2014	8.19459	7.90853	24.34355	5.30540	5.61212	5.33508	4.74272	67.49127
2015	8.40646	8.11806	25.93913	5.21106	5.36577	4.74437	4.64562	71.08682
2016	8.59149	8.50827	27.00282	5.19831	5.24149	4.60466	4.61930	76.72723
2017	8.97725	8.88425	29.06470	5.45677	5.46209	4.97102	4.83870	84.85712
2018	9.36841	9.13150	31.31800	5.72915	5.61188	5.18899	5.06660	95.03978
2019	9.84203	9.63204	33.37742	6.01924	5.78947	5.45614	5.30879	106.28319
2020	10.35200	9.98273	34.44594	6.32970	5.85836	5.25737	5.56939	117.74754

The corresponding aggregate quantity indexes are measured in units equal to 1 trillion 1970 yuan. The product of the price and corresponding quantity indexes listed in Tables A4 and A5 are equal to current yuan values in trillions of current yuan. Thus $V_Y^t = P_Y^t Q_Y^t$ is year t Chinese (Augmented) Gross Domestic Product in trillions of yuan.[40] Table A5 also includes the year t current yuan value of reproducible (or "regular") gross investment V_{IR}^t and the year t net investment in land V_{IL}^t in trillions of yuan. It can be seen that net land investment for China is in general not large.

Table A6: Output Quantity Indexes and Current Yuan Values for Gross Output

Year t	Q_Y^t	Q_C^t	Q_G^t	Q_I^t	Q_X^t	Q_M^t	Q_{IR}^t	Q_{IL}^t	V_Y^t	V_{IR}^t	V_{IL}^t
1970	0.24739	0.14385	0.02529	0.07979	0.00636	-0.00790	0.07636	0.00343	0.24739	0.07636	0.00343
1971	0.26237	0.14632	0.02967	0.08681	0.00761	-0.00791	0.08373	0.00309	0.26897	0.08476	0.00321
1972	0.26846	0.15480	0.03075	0.08325	0.00921	-0.00962	0.08011	0.00315	0.27933	0.08069	0.00336
1973	0.28495	0.16127	0.03100	0.09435	0.01297	-0.01492	0.09139	0.00299	0.30604	0.09563	0.00329
1974	0.28688	0.16294	0.03365	0.09470	0.01543	-0.02073	0.09194	0.00281	0.31164	0.09495	0.00318
1975	0.30323	0.16740	0.03454	0.10543	0.01600	-0.02054	0.10288	0.00265	0.33724	0.10843	0.00309

[40] The GDP estimate is "augmented" because it includes land investments which are not included in "regular" estimates of GDP.

1976	**0.29783**	**0.16670**	**0.03805**	**0.09621**	**0.01510**	**-0.01839**	**0.09388**	**0.00242**	**0.33481**	**0.10096**	**0.00291**
1977	**0.32133**	**0.17567**	**0.03976**	**0.10932**	**0.01548**	**-0.01872**	**0.10632**	**0.00307**	**0.37077**	**0.11756**	**0.00381**
1978	**0.35852**	**0.18521**	**0.04394**	**0.13679**	**0.01833**	**-0.02499**	**0.13285**	**0.00400**	**0.41859**	**0.14278**	**0.00532**
1979	**0.37844**	**0.19616**	**0.04886**	**0.14217**	**0.02234**	**-0.03112**	**0.13970**	**0.00291**	**0.45905**	**0.14884**	**0.00425**
1980	**0.39965**	**0.21264**	**0.05094**	**0.14394**	**0.02759**	**-0.03720**	**0.14138**	**0.00299**	**0.50861**	**0.15709**	**0.00482**
1981	**0.41840**	**0.22583**	**0.05181**	**0.14626**	**0.03648**	**-0.04515**	**0.14279**	**0.00361**	**0.55009**	**0.16412**	**0.00642**
1982	**0.44665**	**0.23599**	**0.05503**	**0.15590**	**0.04080**	**-0.04264**	**0.15218**	**0.00387**	**0.60428**	**0.17789**	**0.00758**
1983	**0.48388**	**0.25491**	**0.06208**	**0.16997**	**0.04115**	**-0.04593**	**0.16576**	**0.00431**	**0.66872**	**0.19263**	**0.00940**
1984	**0.54944**	**0.27899**	**0.07134**	**0.20967**	**0.04985**	**-0.06003**	**0.20453**	**0.00529**	**0.79705**	**0.24788**	**0.01316**
1985	**0.61333**	**0.30969**	**0.07333**	**0.27440**	**0.05848**	**-0.09694**	**0.26975**	**0.00595**	**0.97924**	**0.35114**	**0.01711**
1986	**0.65391**	**0.32649**	**0.07507**	**0.27824**	**0.06011**	**-0.08312**	**0.27703**	**0.00450**	**1.10941**	**0.38870**	**0.01510**
1987	**0.72283**	**0.34456**	**0.07609**	**0.30859**	**0.07062**	**-0.07670**	**0.30508**	**0.00586**	**1.30911**	**0.45106**	**0.02315**
1988	**0.81233**	**0.35978**	**0.07809**	**0.35596**	**0.08744**	**-0.07138**	**0.35534**	**0.00551**	**1.60001**	**0.58388**	**0.02574**
1989	**0.82322**	**0.37336**	**0.08617**	**0.34333**	**0.10260**	**-0.08483**	**0.35209**	**0.00215**	**1.79482**	**0.62811**	**0.01161**
1990	**0.83439**	**0.38341**	**0.09106**	**0.32357**	**0.11554**	**-0.08726**	**0.33087**	**0.00233**	**1.99968**	**0.63855**	**0.01433**
1991	**0.90574**	**0.40833**	**0.09797**	**0.36822**	**0.13446**	**-0.10555**	**0.36719**	**0.00554**	**2.35293**	**0.76463**	**0.03905**
1992	**1.00713**	**0.44291**	**0.10912**	**0.44305**	**0.16361**	**-0.14230**	**0.44268**	**0.00642**	**2.85111**	**1.04275**	**0.05563**
1993	**1.10824**	**0.48453**	**0.11729**	**0.51565**	**0.20773**	**-0.19618**	**0.51785**	**0.00677**	**3.67517**	**1.51054**	**0.07509**
1994	**1.25741**	**0.51515**	**0.12384**	**0.58965**	**0.26979**	**-0.21373**	**0.59665**	**0.00662**	**4.81483**	**1.92620**	**0.09046**
1995	**1.38573**	**0.55500**	**0.12431**	**0.67955**	**0.30785**	**-0.23951**	**0.69136**	**0.00679**	**6.13291**	**2.36538**	**0.10862**
1996	**1.50270**	**0.60504**	**0.13083**	**0.74151**	**0.34746**	**-0.27229**	**0.75475**	**0.00734**	**7.25660**	**2.69247**	**0.12690**
1997	**1.62947**	**0.63486**	**0.14378**	**0.77144**	**0.43979**	**-0.30128**	**0.78115**	**0.00846**	**8.09283**	**2.83731**	**0.15395**
1998	**1.72795**	**0.67157**	**0.16248**	**0.80011**	**0.47891**	**-0.32963**	**0.81920**	**0.00704**	**8.61413**	**2.97306**	**0.13810**
1999	**1.85416**	**0.72726**	**0.18689**	**0.84437**	**0.51448**	**-0.37290**	**0.85971**	**0.00827**	**9.20307**	**3.09418**	**0.17733**
2000	**2.00828**	**0.79779**	**0.20697**	**0.90798**	**0.60460**	**-0.45728**	**0.92838**	**0.00828**	**10.21480**	**3.36639**	**0.19905**
2001	**2.16160**	**0.84405**	**0.21435**	**1.05231**	**0.64588**	**-0.51697**	**1.07961**	**0.00907**	**11.28074**	**3.94543**	**0.24603**
2002	**2.34847**	**0.90413**	**0.22478**	**1.18227**	**0.76844**	**-0.62127**	**1.21722**	**0.00965**	**12.13809**	**4.43210**	**0.29546**
2003	**2.56340**	**0.95274**	**0.22646**	**1.41172**	**0.93248**	**-0.78621**	**1.47216**	**0.00939**	**13.51393**	**5.44358**	**0.31667**
2004	**2.80952**	**1.01240**	**0.23171**	**1.65617**	**1.09326**	**-0.94659**	**1.74364**	**0.00918**	**15.64616**	**6.75800**	**0.31845**
2005	**3.11354**	**1.08806**	**0.25462**	**1.84090**	**1.27394**	**-1.07345**	**1.92321**	**0.01194**	**17.97248**	**7.55866**	**0.38836**
2006	**3.48815**	**1.17273**	**0.26376**	**2.11217**	**1.52534**	**-1.24515**	**2.19994**	**0.01454**	**21.24716**	**8.76044**	**0.43239**
2007	**4.01807**	**1.30525**	**0.27208**	**2.55390**	**1.77351**	**-1.42071**	**2.66394**	**0.01703**	**25.74457**	**10.90134**	**0.48095**
2008	**4.41050**	**1.41842**	**0.28053**	**2.90742**	**1.86092**	**-1.49136**	**3.06076**	**0.01539**	**30.04954**	**13.43227**	**0.48139**
2009	**4.82925**	**1.56465**	**0.29668**	**3.48133**	**1.70704**	**-1.52507**	**3.68615**	**0.01580**	**32.99175**	**15.83244**	**0.62099**
2010	**5.44168**	**1.71406**	**0.33061**	**4.06928**	**2.00533**	**-1.86023**	**4.33235**	**0.01609**	**38.79256**	**19.16496**	**0.76777**
2011	**5.93464**	**1.86668**	**0.36755**	**4.52701**	**2.25084**	**-2.19003**	**4.83979**	**0.01612**	**45.57209**	**22.70156**	**0.89743**
2012	**6.38083**	**1.99855**	**0.39179**	**4.89189**	**2.40148**	**-2.33439**	**5.25510**	**0.01538**	**50.32459**	**24.89775**	**0.94053**
2013	**6.87674**	**2.13090**	**0.41002**	**5.38833**	**2.62328**	**-2.58293**	**5.81274**	**0.01510**	**55.32344**	**27.53230**	**0.97335**
2014	**7.34333**	**2.31486**	**0.41815**	**5.77003**	**2.86100**	**-2.80774**	**6.22717**	**0.01598**	**60.17556**	**29.53374**	**1.07858**
2015	**7.70424**	**2.52902**	**0.43069**	**5.96508**	**2.86642**	**-2.82483**	**6.42118**	**0.01764**	**64.76539**	**29.83039**	**1.25398**
2016	**8.16971**	**2.75249**	**0.45232**	**6.37131**	**2.89961**	**-2.98851**	**6.89429**	**0.01659**	**70.18997**	**31.84682**	**1.27321**
2017	**8.71168**	**2.95145**	**0.46733**	**6.82540**	**3.13014**	**-3.20640**	**7.39183**	**0.01742**	**78.20697**	**35.76686**	**1.47779**
2018	**9.17910**	**3.16277**	**0.48538**	**7.24208**	**3.25507**	**-3.43929**	**7.86024**	**0.01753**	**85.99355**	**39.82467**	**1.66630**
2019	**9.53510**	**3.30624**	**0.49568**	**7.41018**	**3.26957**	**-3.31336**	**8.04329**	**0.01791**	**93.84472**	**42.70015**	**1.90349**
2020	**9.42750**	**3.22153**	**0.49298**	**7.27622**	**3.34163**	**-3.26777**	**7.90339**	**0.01732**	**97.59355**	**44.01701**	**2.03925**

We turn our attention to the construction of annual rates of return on assets used in production and on measuring capital services. The smoothed asset inflation rates, i_n^t, are listed in Table A7 below.

Table A7: Smoothed Asset Inflation Rates for Assets 1-16

Year t	i_1^t	i_2^t	i_3^t	i_4^t	i_5^t	i_5^t	i_7^t	i_8^t
1970	**-0.03910**	**-0.07114**	**-0.01140**	**-0.00477**	**0.00927**	**0.00174**	**0.02246**	**-0.01207**
1971	**-0.04365**	**-0.06641**	**-0.01056**	**-0.00356**	**0.01065**	**0.00450**	**0.02360**	**-0.00661**
1972	**-0.04942**	**-0.06172**	**-0.00986**	**-0.00234**	**0.01227**	**0.00732**	**0.02481**	**-0.00216**
1973	**-0.05643**	**-0.05722**	**-0.00939**	**-0.00103**	**0.01413**	**0.01024**	**0.02612**	**0.00144**
1974	**-0.06427**	**-0.05303**	**-0.00914**	**0.00034**	**0.01613**	**0.01331**	**0.02761**	**0.00436**
1975	**-0.07228**	**-0.04904**	**-0.00887**	**0.00163**	**0.01815**	**0.01653**	**0.02931**	**0.00700**
1976	**-0.07920**	**-0.04492**	**-0.00829**	**0.00269**	**0.02003**	**0.01982**	**0.03121**	**0.00960**
1977	**-0.08523**	**-0.03965**	**-0.00702**	**0.00313**	**0.02188**	**0.02297**	**0.03330**	**0.00994**
1978	**-0.09458**	**-0.03546**	**-0.00667**	**0.00337**	**0.02615**	**0.02676**	**0.03559**	**0.00467**
1979	**-0.10236**	**-0.03169**	**-0.00641**	**0.00535**	**0.03246**	**0.03196**	**0.03894**	**0.00112**
1980	**-0.10615**	**-0.02855**	**-0.00532**	**0.00877**	**0.04000**	**0.03882**	**0.04435**	**-0.00104**
1981	**-0.10482**	**-0.02510**	**-0.00173**	**0.01241**	**0.04807**	**0.04648**	**0.05087**	**0.00014**

1982	**-0.09580**	**-0.02011**	**0.00439**	**0.01734**	**0.05659**	**0.05442**	**0.05763**	**0.00591**
1983	**-0.07953**	**-0.01309**	**0.01211**	**0.02428**	**0.06443**	**0.06160**	**0.06365**	**0.01608**
1984	**-0.05883**	**-0.00389**	**0.02109**	**0.03323**	**0.07100**	**0.06758**	**0.06864**	**0.02810**
1985	**-0.03731**	**0.00673**	**0.03039**	**0.04344**	**0.07750**	**0.07347**	**0.07362**	**0.03852**
1986	**-0.01839**	**0.01835**	**0.04036**	**0.05467**	**0.08660**	**0.08198**	**0.08158**	**0.04527**
1987	**-0.00294**	**0.03160**	**0.05212**	**0.06698**	**0.09975**	**0.09442**	**0.09394**	**0.04904**
1988	**0.00867**	**0.04470**	**0.06352**	**0.07841**	**0.11325**	**0.10709**	**0.10685**	**0.05148**
1989	**0.01490**	**0.05457**	**0.07156**	**0.08623**	**0.12224**	**0.11571**	**0.11570**	**0.05320**
1990	**0.01522**	**0.05856**	**0.07487**	**0.08873**	**0.12475**	**0.11855**	**0.11862**	**0.05458**
1991	**0.01064**	**0.05557**	**0.07324**	**0.08543**	**0.12168**	**0.11609**	**0.11618**	**0.05293**
1992	**0.00237**	**0.04631**	**0.06735**	**0.07702**	**0.11492**	**0.10973**	**0.10997**	**0.04481**
1993	**-0.00873**	**0.03246**	**0.05814**	**0.06504**	**0.10592**	**0.10072**	**0.10121**	**0.03251**
1994	**-0.02137**	**0.01633**	**0.04693**	**0.05146**	**0.09426**	**0.08911**	**0.08985**	**0.02266**
1995	**-0.03566**	**-0.00105**	**0.03421**	**0.03700**	**0.07832**	**0.07367**	**0.07451**	**0.01780**
1996	**-0.05147**	**-0.01951**	**0.02059**	**0.02206**	**0.05891**	**0.05535**	**0.05613**	**0.01367**
1997	**-0.06767**	**-0.03750**	**0.00762**	**0.00799**	**0.04060**	**0.03844**	**0.03910**	**0.00919**
1998	**-0.08112**	**-0.05098**	**-0.00164**	**-0.00234**	**0.02890**	**0.02803**	**0.02862**	**0.00705**
1999	**-0.08970**	**-0.05736**	**-0.00575**	**-0.00714**	**0.02482**	**0.02488**	**0.02554**	**0.00884**
2000	**-0.09341**	**-0.05792**	**-0.00608**	**-0.00759**	**0.02416**	**0.02501**	**0.02582**	**0.01463**
2001	**-0.09474**	**-0.05517**	**-0.00394**	**-0.00537**	**0.02547**	**0.02710**	**0.02809**	**0.02194**
2002	**-0.09618**	**-0.05165**	**-0.00054**	**-0.00211**	**0.02916**	**0.03150**	**0.03285**	**0.02640**
2003	**-0.09774**	**-0.04871**	**0.00300**	**0.00092**	**0.03304**	**0.03583**	**0.03765**	**0.02723**
2004	**-0.09688**	**-0.04668**	**0.00634**	**0.00355**	**0.03625**	**0.03945**	**0.04160**	**0.02722**
2005	**-0.09230**	**-0.04581**	**0.00919**	**0.00592**	**0.03889**	**0.04286**	**0.04481**	**0.02813**
2006	**-0.08477**	**-0.04575**	**0.01118**	**0.00780**	**0.04022**	**0.04507**	**0.04651**	**0.02912**
2007	**-0.07592**	**-0.04539**	**0.01224**	**0.00857**	**0.03970**	**0.04498**	**0.04581**	**0.02919**
2008	**-0.06633**	**-0.04404**	**0.01204**	**0.00777**	**0.03741**	**0.04242**	**0.04281**	**0.02793**
2009	**-0.05718**	**-0.04159**	**0.01054**	**0.00561**	**0.03340**	**0.03769**	**0.03781**	**0.03139**
2010	**-0.04907**	**-0.03820**	**0.00845**	**0.00317**	**0.02872**	**0.03229**	**0.03212**	**0.04302**
2011	**-0.04085**	**-0.03411**	**0.00648**	**0.00142**	**0.02493**	**0.02795**	**0.02742**	**0.05823**
2012	**-0.03152**	**-0.02963**	**0.00491**	**0.00073**	**0.02347**	**0.02587**	**0.02511**	**0.07054**
2013	**-0.02204**	**-0.02444**	**0.00381**	**0.00085**	**0.02523**	**0.02675**	**0.02615**	**0.07490**
2014	**-0.01692**	**-0.01942**	**0.00466**	**0.00245**	**0.03249**	**0.03280**	**0.03293**	**0.06120**
2015	**-0.01243**	**-0.01428**	**0.00572**	**0.00392**	**0.03924**	**0.03805**	**0.03894**	**0.04556**
2016	**-0.00825**	**-0.00930**	**0.00682**	**0.00543**	**0.04612**	**0.04344**	**0.04508**	**0.03015**
2017	**-0.00435**	**-0.00458**	**0.00807**	**0.00713**	**0.05360**	**0.04950**	**0.05186**	**0.01411**
2018	**-0.00073**	**-0.00014**	**0.00953**	**0.00904**	**0.06173**	**0.05629**	**0.05934**	**-0.00311**
2019	**0.00260**	**0.00408**	**0.01123**	**0.01113**	**0.07040**	**0.06368**	**0.06740**	**-0.02182**
2020	**0.00565**	**0.00814**	**0.01316**	**0.01336**	**0.07950**	**0.07152**	**0.07589**	**-0.04217**

Year t	i_9^t	i_{10}^t	i_{11}^t	i_{12}^t	i_{13}^t	i_{14}^t	i_{15}^t	i_{16}^t
1970	**0.06932**	**-0.08528**	**0.07624**	**0.03997**	**0.01394**	**0.09312**	**0.09312**	**0.01394**
1971	**0.06624**	**-0.07758**	**0.07330**	**0.03644**	**0.01800**	**0.09897**	**0.09897**	**0.01800**
1972	**0.06298**	**-0.06961**	**0.07003**	**0.03233**	**0.02238**	**0.10509**	**0.10509**	**0.02238**
1973	**0.05949**	**-0.06165**	**0.06636**	**0.02771**	**0.02703**	**0.11138**	**0.11138**	**0.02703**
1974	**0.05574**	**-0.05402**	**0.06229**	**0.02273**	**0.03189**	**0.11770**	**0.11770**	**0.03189**
1975	**0.05179**	**-0.04669**	**0.05804**	**0.01788**	**0.03686**	**0.12395**	**0.12395**	**0.03686**
1976	**0.04782**	**-0.03919**	**0.05409**	**0.01386**	**0.04181**	**0.13018**	**0.13018**	**0.04181**
1977	**0.04390**	**-0.02921**	**0.05081**	**0.01030**	**0.04722**	**0.13747**	**0.13747**	**0.04722**
1978	**0.03826**	**-0.01940**	**0.04477**	**0.00039**	**0.05311**	**0.14806**	**0.14806**	**0.05311**
1979	**0.03373**	**-0.01125**	**0.03806**	**-0.00836**	**0.05905**	**0.15973**	**0.15973**	**0.05905**
1980	**0.03088**	**-0.00559**	**0.03206**	**-0.01180**	**0.06571**	**0.17099**	**0.17099**	**0.06571**
1981	**0.03031**	**0.00011**	**0.02900**	**-0.00629**	**0.07334**	**0.18066**	**0.18066**	**0.07334**
1982	**0.03307**	**0.00748**	**0.03070**	**0.00647**	**0.08143**	**0.18851**	**0.18851**	**0.08143**
1983	**0.03898**	**0.01530**	**0.03678**	**0.02161**	**0.08909**	**0.19500**	**0.19500**	**0.08909**
1984	**0.04786**	**0.02287**	**0.04536**	**0.03430**	**0.09580**	**0.20085**	**0.20059**	**0.09580**
1985	**0.05853**	**0.03010**	**0.05453**	**0.04600**	**0.10153**	**0.20689**	**0.20547**	**0.10153**
1986	**0.07048**	**0.03716**	**0.06488**	**0.06011**	**0.10678**	**0.21382**	**0.21063**	**0.10678**
1987	**0.08413**	**0.04637**	**0.07767**	**0.07643**	**0.11279**	**0.22175**	**0.21674**	**0.11279**
1988	**0.09643**	**0.05660**	**0.09018**	**0.09126**	**0.12102**	**0.22981**	**0.22209**	**0.12102**
1989	**0.10398**	**0.06453**	**0.09887**	**0.10093**	**0.13179**	**0.23596**	**0.22346**	**0.13179**
1990	**0.10560**	**0.06766**	**0.10148**	**0.10651**	**0.14339**	**0.23725**	**0.21779**	**0.14385**
1991	**0.10132**	**0.06507**	**0.09740**	**0.10831**	**0.15278**	**0.23063**	**0.20474**	**0.15602**
1992	**0.09186**	**0.05791**	**0.08799**	**0.10549**	**0.15757**	**0.21421**	**0.18723**	**0.16792**

1993	**0.07882**	**0.04862**	**0.07539**	**0.09829**	**0.15735**	**0.18764**	**0.16870**	**0.17906**
1994	**0.06424**	**0.03861**	**0.06170**	**0.08853**	**0.15307**	**0.15220**	**0.15098**	**0.18823**
1995	**0.04886**	**0.02716**	**0.04756**	**0.07764**	**0.14564**	**0.11084**	**0.13442**	**0.19314**
1996	**0.03319**	**0.01377**	**0.03259**	**0.06502**	**0.13509**	**0.06756**	**0.11917**	**0.19173**
1997	**0.01871**	**-0.00051**	**0.01825**	**0.05062**	**0.12144**	**0.02665**	**0.10596**	**0.18361**
1998	**0.00844**	**-0.01252**	**0.00799**	**0.03694**	**0.10613**	**-0.00780**	**0.09535**	**0.17025**
1999	**0.00433**	**-0.01905**	**0.00354**	**0.02760**	**0.09227**	**-0.03203**	**0.08564**	**0.15405**
2000	**0.00439**	**-0.02067**	**0.00312**	**0.02397**	**0.08357**	**-0.04213**	**0.07384**	**0.13707**
2001	**0.00672**	**-0.01912**	**0.00476**	**0.02455**	**0.08216**	**-0.03568**	**0.05938**	**0.12063**
2002	**0.00955**	**-0.01666**	**0.00686**	**0.02849**	**0.08750**	**-0.01521**	**0.04623**	**0.10749**
2003	**0.01121**	**-0.01496**	**0.00848**	**0.03454**	**0.09718**	**0.01212**	**0.03989**	**0.10193**
2004	**0.01224**	**-0.01363**	**0.00993**	**0.03995**	**0.10843**	**0.03818**	**0.04151**	**0.10518**
2005	**0.01343**	**-0.01209**	**0.01151**	**0.04393**	**0.11909**	**0.05801**	**0.04841**	**0.11388**
2006	**0.01430**	**-0.01081**	**0.01257**	**0.04706**	**0.12793**	**0.07134**	**0.05765**	**0.12256**
2007	**0.01385**	**-0.01068**	**0.01237**	**0.04914**	**0.13408**	**0.07994**	**0.06843**	**0.12715**
2008	**0.01170**	**-0.01229**	**0.01069**	**0.04926**	**0.13677**	**0.08417**	**0.08172**	**0.12768**
2009	**0.00821**	**-0.01532**	**0.00798**	**0.04685**	**0.13568**	**0.08267**	**0.09687**	**0.12663**
2010	**0.00487**	**-0.01809**	**0.00556**	**0.04186**	**0.13096**	**0.07439**	**0.10982**	**0.12524**
2011	**0.00299**	**-0.01960**	**0.00409**	**0.03563**	**0.12324**	**0.06082**	**0.11580**	**0.12201**
2012	**0.00283**	**-0.01979**	**0.00347**	**0.02995**	**0.11389**	**0.04670**	**0.11305**	**0.11425**
2013	**0.00346**	**-0.01895**	**0.00322**	**0.02655**	**0.10446**	**0.03715**	**0.10450**	**0.10106**
2014	**0.00460**	**-0.01470**	**0.00485**	**0.02908**	**0.09744**	**0.03640**	**0.10448**	**0.08781**
2015	**0.00519**	**-0.00978**	**0.00657**	**0.03120**	**0.09100**	**0.03670**	**0.10415**	**0.07479**
2016	**0.00585**	**-0.00462**	**0.00846**	**0.03302**	**0.08441**	**0.03714**	**0.10440**	**0.06251**
2017	**0.00679**	**0.00081**	**0.01062**	**0.03512**	**0.07790**	**0.03770**	**0.10581**	**0.05080**
2018	**0.00800**	**0.00655**	**0.01306**	**0.03781**	**0.07167**	**0.03841**	**0.10843**	**0.03937**
2019	**0.00941**	**0.01259**	**0.01573**	**0.04117**	**0.06587**	**0.03939**	**0.11208**	**0.02797**
2020	**0.01090**	**0.01897**	**0.01861**	**0.04513**	**0.06057**	**0.04067**	**0.11649**	**0.01649**

The above smoothed asset inflation rates replace the actual asset inflation rates in equations (10) and the resulting equations are solved for r^t which is now a smoothed version of the ex post rates of return. These smoothed r^t are used as an approximation to the Chinese cost of capital for year t. The resulting user costs U^t for assets 1-16 defined by equations (4) in the main text (but using the smoothed asset inflation rates i_n^t and the smoothed rates of return r^t) are listed in Table 8 below.

Table A8: Annual Smoothed User Costs for Chinese Assets used in Production

Year t	**U_1^t**	**U_2^t**	**U_3^t**	**U_4^t**	**U_5^t**	**U_6^t**	**U_7^t**	**U_8^t**
1970	**0.58217**	**0.54313**	**0.36708**	**0.33622**	**0.22588**	**0.25177**	**0.19343**	**0.38946**
1971	**0.56734**	**0.50958**	**0.35947**	**0.32902**	**0.22477**	**0.24912**	**0.19813**	**0.35548**
1972	**0.50500**	**0.45892**	**0.33145**	**0.29463**	**0.20043**	**0.21912**	**0.17129**	**0.31773**
1973	**0.44957**	**0.43117**	**0.33051**	**0.30681**	**0.21600**	**0.22630**	**0.17891**	**0.34072**
1974	**0.44551**	**0.37181**	**0.28957**	**0.29510**	**0.19160**	**0.20955**	**0.16737**	**0.29179**
1975	**0.41631**	**0.36550**	**0.31443**	**0.28719**	**0.19393**	**0.21449**	**0.17644**	**0.33029**
1976	**0.42839**	**0.32664**	**0.28700**	**0.25762**	**0.16724**	**0.18539**	**0.14573**	**0.31577**
1977	**0.44021**	**0.31575**	**0.28761**	**0.26683**	**0.17940**	**0.19532**	**0.15803**	**0.34648**
1978	**0.39934**	**0.31738**	**0.30392**	**0.28474**	**0.19153**	**0.20890**	**0.17792**	**0.35459**
1979	**0.35691**	**0.30391**	**0.29849**	**0.28400**	**0.18867**	**0.20510**	**0.17426**	**0.36875**
1980	**0.27185**	**0.27752**	**0.27335**	**0.27205**	**0.18046**	**0.19866**	**0.16689**	**0.33752**
1981	**0.23282**	**0.26674**	**0.27519**	**0.27509**	**0.18169**	**0.20452**	**0.17453**	**0.32848**
1982	**0.21309**	**0.27623**	**0.28817**	**0.28943**	**0.19516**	**0.21877**	**0.19149**	**0.34910**
1983	**0.19836**	**0.27593**	**0.29613**	**0.30413**	**0.22740**	**0.25206**	**0.22857**	**0.34329**
1984	**0.19254**	**0.29464**	**0.31208**	**0.32141**	**0.25529**	**0.28236**	**0.26054**	**0.35681**
1985	**0.19286**	**0.30896**	**0.34133**	**0.34270**	**0.29023**	**0.31948**	**0.29758**	**0.40810**
1986	**0.17993**	**0.27804**	**0.32621**	**0.33348**	**0.28012**	**0.31171**	**0.28367**	**0.39756**
1987	**0.16221**	**0.28459**	**0.33284**	**0.35103**	**0.31323**	**0.34328**	**0.31516**	**0.41298**
1988	**0.15397**	**0.29125**	**0.36292**	**0.38733**	**0.34828**	**0.38366**	**0.34969**	**0.46266**
1989	**0.15732**	**0.28296**	**0.36265**	**0.39997**	**0.34999**	**0.38829**	**0.34619**	**0.50033**
1990	**0.16330**	**0.29630**	**0.37982**	**0.42747**	**0.35834**	**0.39987**	**0.35208**	**0.53657**
1991	**0.16927**	**0.32061**	**0.41663**	**0.48471**	**0.43043**	**0.47294**	**0.42564**	**0.52879**
1992	**0.18342**	**0.37153**	**0.47165**	**0.54947**	**0.51413**	**0.55943**	**0.50565**	**0.56132**
1993	**0.19137**	**0.45063**	**0.57591**	**0.64238**	**0.66250**	**0.70973**	**0.63723**	**0.59408**
1994	**0.20061**	**0.48636**	**0.60346**	**0.70402**	**0.75562**	**0.79666**	**0.72365**	**0.63334**

1995	**0.19595**	**0.51504**	**0.64074**	**0.78592**	**0.89193**	**0.93062**	**0.86840**	**0.70079**
1996	**0.17110**	**0.47254**	**0.65515**	**0.80565**	**0.99705**	**1.02665**	**0.97197**	**0.74498**
1997	**0.15527**	**0.44705**	**0.63761**	**0.78599**	**1.02605**	**1.04199**	**0.99097**	**0.70186**
1998	**0.14589**	**0.38736**	**0.60447**	**0.76711**	**1.00763**	**1.01682**	**0.96607**	**0.59400**
1999	**0.14128**	**0.36212**	**0.57842**	**0.72532**	**0.97504**	**0.97744**	**0.92020**	**0.54815**
2000	**0.14129**	**0.36573**	**0.56777**	**0.71415**	**1.00507**	**1.00582**	**0.94867**	**0.55705**
2001	**0.12792**	**0.34359**	**0.57269**	**0.70208**	**1.00678**	**1.00419**	**0.94281**	**0.59697**
2002	**0.11808**	**0.30462**	**0.56512**	**0.67765**	**0.97718**	**0.97747**	**0.90348**	**0.52194**
2003	**0.09877**	**0.27174**	**0.54672**	**0.65451**	**0.96055**	**0.96692**	**0.87893**	**0.55818**
2004	**0.08407**	**0.25771**	**0.55001**	**0.65847**	**1.01719**	**1.02864**	**0.92942**	**0.61381**
2005	**0.07084**	**0.24862**	**0.55992**	**0.67108**	**1.02922**	**1.04792**	**0.94861**	**0.65631**
2006	**0.06530**	**0.24518**	**0.58585**	**0.70814**	**1.10463**	**1.11569**	**1.02999**	**0.70672**
2007	**0.06185**	**0.23875**	**0.61221**	**0.74287**	**1.24962**	**1.24834**	**1.17700**	**0.71603**
2008	**0.05352**	**0.22599**	**0.60716**	**0.73452**	**1.34513**	**1.35869**	**1.29040**	**0.65758**
2009	**0.04506**	**0.20776**	**0.59033**	**0.70236**	**1.23590**	**1.25378**	**1.17964**	**0.64216**
2010	**0.04220**	**0.19341**	**0.59935**	**0.70544**	**1.30138**	**1.32843**	**1.25999**	**0.68797**
2011	**0.03923**	**0.17655**	**0.58395**	**0.68615**	**1.33491**	**1.40912**	**1.30024**	**0.65363**
2012	**0.03548**	**0.15702**	**0.55478**	**0.64691**	**1.22139**	**1.31167**	**1.18786**	**0.57055**
2013	**0.03315**	**0.14860**	**0.53058**	**0.60843**	**1.12563**	**1.22164**	**1.07727**	**0.58059**
2014	**0.03282**	**0.14555**	**0.51685**	**0.59041**	**1.05593**	**1.15499**	**0.99680**	**0.62939**
2015	**0.03314**	**0.14364**	**0.50580**	**0.57612**	**0.97566**	**1.08395**	**0.91770**	**0.72349**
2016	**0.03124**	**0.14066**	**0.50826**	**0.58186**	**0.94971**	**1.06948**	**0.89338**	**0.92754**
2017	**0.03185**	**0.14181**	**0.52080**	**0.59734**	**1.01722**	**1.15584**	**0.95916**	**1.03119**
2018	**0.03197**	**0.13729**	**0.52348**	**0.60267**	**1.02389**	**1.18713**	**0.96014**	**1.11867**
2019	**0.03159**	**0.13576**	**0.52754**	**0.60955**	**1.03184**	**1.22727**	**0.96699**	**1.18683**
2020	**0.03094**	**0.13349**	**0.52193**	**0.59710**	**0.95411**	**1.17294**	**0.86401**	**1.11544**

Year t	U_9^t	U_{10}^t	U_{11}^t	U_{12}^t	U_{13}^t	U_{14}^t	U_{15}^t	U_{16}^t
1970	**0.33128**	**0.66123**	**0.48091**	**0.15792**	**0.18394**	**0.10993**	**0.10994**	**0.18911**
1971	**0.35032**	**0.63059**	**0.51013**	**0.16430**	**0.18279**	**0.11352**	**0.11352**	**0.18828**
1972	**0.34434**	**0.57799**	**0.50456**	**0.14290**	**0.15670**	**0.08825**	**0.08825**	**0.16247**
1973	**0.37888**	**0.54257**	**0.54199**	**0.16571**	**0.16266**	**0.09816**	**0.09816**	**0.16889**
1974	**0.37091**	**0.43688**	**0.53177**	**0.13912**	**0.14070**	**0.07147**	**0.07147**	**0.14716**
1975	**0.40587**	**0.41312**	**0.59144**	**0.16462**	**0.14277**	**0.07418**	**0.07418**	**0.14959**
1976	**0.38655**	**0.37978**	**0.59463**	**0.14053**	**0.09887**	**0.00642**	**0.00642**	**0.10613**
1977	**0.44181**	**0.37757**	**0.67034**	**0.19690**	**0.11980**	**0.03665**	**0.03665**	**0.12749**
1978	**0.49746**	**0.37222**	**0.76620**	**0.19352**	**0.13360**	**0.05022**	**0.05022**	**0.14162**
1979	**0.52450**	**0.37560**	**0.78055**	**0.18200**	**0.13248**	**0.02212**	**0.02212**	**0.14091**
1980	**0.51842**	**0.35797**	**0.77114**	**0.18053**	**0.11983**	**-0.04230**	**-0.04230**	**0.12917**
1981	**0.54085**	**0.35740**	**0.80293**	**0.19701**	**0.12578**	**-0.06728**	**-0.06728**	**0.13584**
1982	**0.57893**	**0.36940**	**0.87587**	**0.19790**	**0.14918**	**-0.04053**	**-0.04053**	**0.15989**
1983	**0.59992**	**0.37111**	**0.91534**	**0.16549**	**0.18670**	**0.04130**	**0.04130**	**0.19792**
1984	**0.63553**	**0.38734**	**0.98163**	**0.17190**	**0.21710**	**0.11678**	**0.11841**	**0.22906**
1985	**0.68344**	**0.40765**	**1.07432**	**0.19226**	**0.25252**	**0.20501**	**0.21576**	**0.26569**
1986	**0.67966**	**0.41342**	**1.08794**	**0.17499**	**0.23117**	**0.03703**	**0.06637**	**0.24582**
1987	**0.71789**	**0.43269**	**1.15329**	**0.19480**	**0.30054**	**0.19805**	**0.25401**	**0.31673**
1988	**0.79775**	**0.47725**	**1.25726**	**0.20059**	**0.34260**	**0.24130**	**0.34524**	**0.36141**
1989	**0.85192**	**0.48484**	**1.32630**	**0.20530**	**0.34448**	**0.13897**	**0.33999**	**0.36567**
1990	**0.94042**	**0.49991**	**1.41314**	**0.20908**	**0.33071**	**0.06439**	**0.44146**	**0.35227**
1991	**1.05868**	**0.52954**	**1.56321**	**0.23211**	**0.35365**	**0.40970**	**1.00104**	**0.36612**
1992	**1.20732**	**0.54904**	**1.82638**	**0.26251**	**0.37757**	**1.11619**	**1.87131**	**0.36003**
1993	**1.45677**	**0.62939**	**2.23425**	**0.27478**	**0.34773**	**1.86333**	**2.54451**	**0.27215**
1994	**1.58842**	**0.69549**	**2.44034**	**0.33921**	**0.40117**	**3.81638**	**3.57659**	**0.22606**
1995	**1.79769**	**0.75556**	**2.64090**	**0.43967**	**0.63047**	**7.83902**	**5.46601**	**0.31394**
1996	**1.84056**	**0.74947**	**2.65428**	**0.47911**	**0.76394**	**11.19810**	**5.88604**	**0.29205**
1997	**1.85542**	**0.71506**	**2.60321**	**0.50596**	**0.89374**	**13.62214**	**6.00088**	**0.30771**
1998	**1.76099**	**0.67763**	**2.52674**	**0.48174**	**0.87751**	**13.57339**	**5.50963**	**0.23055**
1999	**1.74637**	**0.64919**	**2.47312**	**0.49115**	**1.03052**	**13.41478**	**6.30012**	**0.45939**
2000	**1.77969**	**0.63738**	**2.47488**	**0.51355**	**1.22929**	**12.72734**	**8.25399**	**0.91670**
2001	**1.77000**	**0.62694**	**2.48819**	**0.52387**	**1.28092**	**11.38124**	**10.54197**	**1.30159**
2002	**1.74618**	**0.62141**	**2.48991**	**0.50282**	**1.22649**	**9.51936**	**12.77181**	**1.55439**
2003	**1.71358**	**0.58304**	**2.62343**	**0.46404**	**1.06112**	**7.62284**	**14.48827**	**1.75801**
2004	**1.77383**	**0.58448**	**2.81682**	**0.47034**	**1.02416**	**6.11341**	**14.35014**	**1.80994**
2005	**1.81452**	**0.58171**	**2.97873**	**0.49781**	**0.97411**	**5.25041**	**12.45533**	**1.79097**
2006	**1.92908**	**0.58922**	**3.12464**	**0.54781**	**1.16867**	**6.02877**	**11.85338**	**2.30838**
2007	**2.02451**	**0.59994**	**3.14092**	**0.60630**	**1.50802**	**7.75291**	**11.28704**	**2.86722**

2008	**2.01066**	**0.61413**	**2.92057**	**0.59037**	**1.24217**	**8.18940**	**10.35592**	**2.80660**
2009	**1.90815**	**0.59368**	**2.83795**	**0.62450**	**1.22085**	**8.95203**	**10.91904**	**3.22003**
2010	**1.95611**	**0.58438**	**2.82568**	**0.62134**	**1.42527**	**9.89591**	**11.27144**	**3.81476**
2011	**1.97398**	**0.58450**	**2.76109**	**0.62373**	**1.43848**	**10.35486**	**10.69069**	**4.02128**
2012	**1.86885**	**0.55406**	**2.69521**	**0.60891**	**1.23796**	**10.70476**	**9.81531**	**3.97290**
2013	**1.76540**	**0.51393**	**2.56880**	**0.58055**	**1.27844**	**11.13099**	**10.10446**	**4.45276**
2014	**1.72017**	**0.48531**	**2.50768**	**0.55897**	**1.66642**	**11.61416**	**10.47815**	**5.75656**
2015	**1.67446**	**0.45747**	**2.42407**	**0.54643**	**2.21675**	**11.85941**	**10.64032**	**7.22879**
2016	**1.68029**	**0.44377**	**2.46140**	**0.54128**	**3.05186**	**12.36196**	**11.71003**	**9.38345**
2017	**1.73714**	**0.43713**	**2.49154**	**0.56637**	**4.18907**	**13.03134**	**13.92534**	**12.07645**
2018	**1.77700**	**0.43300**	**2.48720**	**0.58565**	**4.98171**	**12.98651**	**14.73433**	**14.06814**
2019	**1.79698**	**0.42771**	**2.50231**	**0.61725**	**6.04780**	**13.57684**	**15.84048**	**15.77540**
2020	**1.76259**	**0.43220**	**2.50639**	**0.57803**	**6.42938**	**13.01314**	**12.86868**	**16.27296**

All of the smoothed user costs are positive except for 3 negative user costs for industrial land and 3 negative user costs for commercial land in the years 1980, 1981 and 1982.

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