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Do Labor Values Explain Chinese Prices? Evidence from China's Input-Output Tables, 1990–2012

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Abstract

We use China's input-output tables from 1990 to 2012 to study the deviations between labor-value-based direct prices, prices of production, and market prices. We find that the cross-sectional deviations between direct prices and market prices averaged 17–18 percent, and the variations in relative direct prices can explain about 70 percent of the variations in relative market prices over time. Marxian and Sraffian production prices have significantly smaller deviations from market prices. When our study is applied to productive capitalist sectors, the average deviations between direct prices, Marxian prices, Sraffian prices, and market prices are reduced significantly. The results suggest that price theory based on either the Marxian or classical tradition can largely explain observed market prices in the productive capitalist sectors in China.

JEL Classification: B51, C67, O53

Keywords

price, value, profit rate, input-output table, China

1. Introduction

How to explain the relative prices of commodities has been a central question for classical political economy and modern economics. Classical political economists argue that there is one set of "natural prices" acting as centers of gravity around which the day-to-day market prices fluctuate. The labor theory of value argues that natural prices are ultimately determined by the labor time embodied in commodities. However, classical political economists realized that natural prices are unlikely to be directly proportional to labor time as long as there are differences in composition of capital among different economic sectors. Marx's attempt to solve the "transformation problem" (establishing the quantitative relationship between the labor values and the "prices of production") proved to be incomplete (Bortkiewicz 1906).

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By contrast, neoclassical economics (the mainstream economics since the 1870s) rejects natural prices or the existence of centers of gravity determined by a set of objective factors, and develops the marginalist price theory based on utility maximization. For the marginalists, equilibrium price is determined by demand and supply, with the demand function determined by the consumers' utility maximization and the supply function determined by the firms' profit maximization taking into account the marginal cost schedule. The marginal cost schedule in turn depends on resources endowment, technology, and the factor owners' utility maximization. However, neither the consumers' nor the factor owners' utility preferences can be directly observed and measured. Modern neoclassical economics has to live with faith that the observed market prices are believed to reveal the unobservable individuals' utility preferences.

Since the 1960s, interest in the labor theory of value has been revived with the publication of Sraffa's analysis of prices and his critique of marginalist theory (Sraffa 1960). Unlike marginalist price theory, both the labor theory of value and Sraffian price theory can be empirically tested. In one of the earlier studies, Shaikh (1984) found that the deviations of "direct prices" (prices directly proportional to labor values), or the Marxian prices of production, from the observed market prices were about 20–25 percent in the US economy and 17–19 percent in the Italian economy. Ochoa (1989) used US input-output tables from 1947 to 1972 and found that market prices deviated from direct prices by 12–14 percent and from Marxian prices of production by 14–17 percent. Shaikh and Ochoa argued that these findings suggest that labor values can be reasonable approximations of observed market prices, and the transformation problem may be of limited empirical importance. Since then, empirical studies using data from Germany, Greece, the United Kingdom, Japan, Korea, and Brazil have by and large confirmed Shaikh's and Ochoa's findings (Da Silva and Rosinger 1992; Cockshott, Cottrell, and Michaelson 1995; Tsoulfidis and Maniatis 2002; Tsoulfidis and Rieu 2006; Fröhlich 2013). Table 1 summarizes the empirical findings on the deviations between labor-value-based direct prices, Marxian prices of production, Sraffian prices of production, and market prices from several recent studies.

In recent years, China has overtaken the United States to become the world's largest economy measured by purchasing power parity (World Bank 2018). In this context, it would be of great interest for students of the labor theory of value and price theory in general to evaluate the empirical relationship between labor values, prices of production, and market prices in the Chinese economy.

In a recent paper, Sánchez and Montibeler (2015) used China's input-output table in 2002 to calculate direct prices and prices of production for the Chinese economy. Sánchez and Montibeler found close proximities between direct prices, prices of production, and market prices. The deviations between direct prices and market prices ranged between 14 and 15 percent, the deviations between Marxian prices of production and market prices averaged about 17 percent, and the deviations between Sraffian prices of production and market prices ranged between 18 and 19 percent. However, Sánchez and Montibeler did not take into account turnover ratios in their calculation of composition of capital, and their calculated profit rate was unrealistically large.[1]

In this study, we use China's input-output tables over a relatively long period from 1990 to 2012 to examine the deviations between the labor-value-based direct prices, the Marxian prices of production, the Sraffian prices of production, and the market prices. The labor theory of value is supposed to operate in capitalist economies with competitive labor markets and free flows of labor. The prices of production may act as centers of gravity for market prices only when there is a tendency toward equalization of the profit rate resulting from free movement of capital between

[1]In recent years, Chinese political economists have had a lively debate on whether there is a mathematical solution to the transformation problem (Bai 2005, 2006; Ding and Li 2005; Zhang 2001, 2004). However, the debate has taken place exclusively at the theoretical level, and no Chinese political economist has performed an empirical study on the relationship between labor values, productions prices, and market prices.

Table 1. Deviations Between Direct Prices, Marxian Production Prices, Sraffian Production Prices, and Market Prices (International Comparison).

	MAD	MAWD	d-distance
Direct Price and Market Price			
Canada (1997)	0.133	0.149	0.180
China (1997)	0.183	0.160	0.196
China (2002)	0.142	0.151	0.190
Greece (1997)	0.265	0.191	0.273
Japan (1990)	0.127	0.154	0.171
Korea (2000)	0.130	0.143	0.167
United Kingdom (1990)	0.222	0.186	0.285
United States (1990)	0.125	0.094	0.163
Marxian price and market price			
China (2002)	0.165	0.166	0.228
Korea (2000)	0.174	0.181	0.207
United Kingdom (1990)	0.169	0.179	0.214
United States (1990)	0.139	0.137	0.187
Sraffian Price and Market Price			
Canada (1997)	0.126	0.125	0.199
China (1997)	0.170	0.112	0.154
China (2002)	0.185	0.181	0.240
Greece (1997)	0.250	0.191	0.287
Japan (1990)	0.113	0.122	0.161
Korea (2000)	0.152	0.164	0.176
United Kingdom (1990)	0.199	0.168	0.249
United States (1990)	0.126	0.108	0.157

MAD: mean absolute deviation.
MAWD: mean absolute weighted deviation.
d-distance: a normalization-bias-free measure of deviation proposed by Steedman and Tomkins (1998).
Sources: For China (2002), results are from Sánchez and Montibeler (2015). All other data are from Mariolis and Toulfidis (2015: 75–7). For Korea (2000), the UK (1990), and the United States (1990), "Marxian price" refers to the production price calculated by assuming a uniform profit rate on fixed capital. Years in parentheses refer to years of input-output tables.

sectors. These tendencies may not operate in the non-capitalist sectors (in the sense that the purpose of production is not for profit), nor in the "non-productive" sectors (in the sense that the value-added received by these sectors derives from redistribution rather than production of surplus value, such as the wholesale and retail, finance, real estate, and government sectors). Therefore, in addition to studying the price deviations in the total economy, we also evaluate the price deviations in the productive capitalist sectors.

Section 2 of this paper discusses the cross-sectional deviations between direct prices, Marxian prices, Sraffian prices, and market prices in China's total economy. Section 3 discusses the cross-sectional price deviations in China's productive capitalist sectors. Section 4 discusses the variations in relative prices over time from 1990 to 2012. Section 5 reports the estimated "fundamental Marxian variables" (organic composition of capital, the profit/wage ratio, and the profit rate) and the Sraffian wage-profit frontier for the Chinese economy. Section 6 concludes the paper.

2. Value and Price: China's Total Economy

Most of the data used in this study are from China's input-output tables. The China Input-Output Association, an affiliate of China's National Bureau of Statistics, provides input-output tables for

the following years: 1990, 1992, 1995, 1997, 2000, 2002, 2005, 2007, 2010, and 2012. The input-output tables from 1990 to 1995 each include thirty-three sectors, the input-output table in 1997 includes forty sectors, the input-output table in 2000 includes only seventeen sectors, the input-output tables from 2002 to 2007 each include forty-two sectors, the input-output table in 2010 includes forty-one sectors, and the input-output table in 2012 again includes forty-two sectors. The input-output tables provide detailed intermediate input-output coefficients between sectors, the distribution of the value added between compensation of laborers, net producer taxes (indirect taxes less subsidies), operating surplus, and depreciation of fixed capital, as well as final uses including final consumption and capital formation (China Input-Output Association 2018).

2.1. Labor Values and Direct Prices

According to Marx, the value of a commodity is the socially necessary labor time embodied in commodities (Marx 1967: 43–8). Value includes both the new value produced by the present labor time (direct labor) and the past labor time (indirect labor) embodied in the means of production used up in current production. Value of the means of production used up is transferred into the value of the final commodity. For fixed capital goods, a fraction of their value is transferred into the value of the final commodity each year in accordance with their expected lifetime (this is represented by depreciation in the conventional accounting).

Following the existing literature (Ochoa 1989; Tsoulfidis and Rieu 2006; Sánchez and Montibeler 2015; Mariolis and Tsoulfidis 2015), we solve the labor values per unit of output (in this paper, one unit of output is represented by one Yuan of gross output value) from the following system of equations:

$$\lambda = \alpha + \lambda\left(\mathrm{A} + \mathrm{D}\right)$$

and it follows that:

$$\lambda = \alpha\left(\mathrm{I} - \mathrm{A} - \mathrm{D}\right)^{-1} \tag{1}$$

where λ is the row vector of labor values embodied in each Yuan of gross output value from each economic sector, α is the row vector of direct labor input for each Yuan of gross output value from each economic sector, I is the identity matrix, A is the square matrix of intermediate input-output coefficients, and D is the square matrix of fixed capital depreciation.

In the real world, labor inputs are of various types and skills. To estimate the direct labor input, it is necessary to convert labor inputs of various types and skills into quantities of homogeneous "simple labor." Following the previous literature, we calculate quantities of simple labor by dividing the compensation of laborers for each sector by the average wage of unskilled workers, assuming that the existing wage ratios between workers of different skills and different occupations represent correctly the multiples between skilled labor and simple labor (Ochoa 1989; Tsoulfidis and Rieu 2006).[2] We use the average wage of employed persons in "urban private

[2] In the real world, various factors other than skill differences affect wage differences among different types of workers. Thus, the method of reducing skilled labor into a multiple of simple labor used in the existing literature is only an approximation.

units" as the proxy for the average wage of unskilled workers.[3] The quantities of simple labor so calculated are used as the quantities of direct labor input.

The fixed capital depreciation square matrix is constructed by multiplying the column vector of gross fixed capital formation distribution "g" (showing how each Yuan of gross fixed capital formation is spent on the purchase of fixed capital goods from various economic sectors) with the row vector of depreciation coefficients "d" (showing the depreciation of fixed capital for each Yuan of gross output value from each economic sector):

$$D = gd \tag{2}$$

The resulting square matrix D shows how depreciation of fixed capital for each Yuan of gross output value from each economic sector is replaced by various fixed capital goods produced by various economic sectors.[4]

Direct prices are prices that are directly proportional to labor values:

$$v = \delta\lambda$$

where v is the row vector of direct price coefficients, and δ can be any positive number. Following the practice of the existing literature, we set δ to be ex/λx, where e is the row unit vector representing the market price coefficients (by definition, the market price for one Yuan of gross output value is one Yuan), and x is the column vector of gross output value for each economic sector. Thus:

$$v = \left(ex / \lambda x\right)\lambda \tag{3}$$

It follows that:

$$vx = ex$$

[3]China's National Bureau of Statistics provides average wages for the employed persons in the "urban units" and the "urban private units" (National Bureau of Statistics 2018). The urban units include the government sector, state-owned enterprises, and domestic and foreign corporations, and roughly correspond to China's formal economic sector. The urban private units include domestic private enterprises owned by natural persons. The workers in the urban private units are in general less well paid and less regulated than the workers in the urban units. For the years before 2009 there are no data for the urban private units, and we use the average wage of employed persons in the "urban collective units" as the proxy for the average wage of unskilled workers. Officially, urban collective units are enterprises owned by urban communities. Since the 1990s, many of these have turned into quasi-private enterprises and the wages of workers in the urban collective units are similar to those in the urban private units.

[4]Some of the previous studies have used a depreciation square matrix directly provided by the official input-output tables (Tsoulfidis and Rieu 2006). Others have constructed a depreciation square matrix using data from sector-level fixed capital stock and fixed assets types (Ochoa 1989). However, China's National Bureau of Statistics has provided neither official estimates of depreciation square matrix nor capital stock data. Our current method to construct the depreciation square matrix implicitly assumes that depreciation in all economic sectors would be replaced by the same composition of capital goods (as China's input-output tables provide only economy-wide fixed capital formation distribution coefficients). In the future, if more detailed sector-level fixed capital formation distribution coefficients become available, a more realistic depreciation square matrix may be constructed for the Chinese economy.

The above definition of direct prices has the convenient property that the total economy gross output value measured by direct prices equals the total economy gross output value measured by market prices.

2.2. Marxian Prices of Production

The Marxian prices of production are defined as the sum of costs of production and average profits determined by a uniform profit rate on the advanced total capital (Ochoa 1989; Tsoulfidis and Rieu 2006). The advanced total capital is the sum of fixed capital stock and the advanced circulating capital.

Marxian prices of production are derived from the following system of equations:

$$m = m\left(w\beta\alpha + A + D + T\right) + \pi m\left[K + \left(w\beta\alpha + A\right)\Gamma\right] \tag{4}$$

where m is the row vector of Marxian price of production coefficients for each economic sector, w is the average wage for one unit of simple labor, β is the column vector of household consumption distribution coefficients (it tells how each Yuan of household consumption expenditures is spent on the purchase of various consumer goods and services from various economic sectors), and T is the diagonal matrix of net producer tax coefficients (showing the indirect taxes less subsidies for each Yuan of gross output value from each economic sector). Thus, $m(w\beta\alpha + A + D + T)$ represents the cost of production measured in Marxian prices for each Yuan of gross output value in each economic sector.

Note that wβ is in effect the column vector of wage goods showing how the average wage of one unit of simple labor is spent on the purchase of various consumer goods and services, π is the Marxian uniform profit rate, K is the square matrix of fixed capital stock, and Γ is the diagonal matrix of turnover time (the reciprocal of turnover ratio). Thus, $m[K + (w\beta\alpha + A)\Gamma]$ is the advanced total capital measured in Marxian prices for each Yuan of gross output value in each economic sector, and $\pi m[K + (w\beta\alpha + A)\Gamma]$ is the row vector of average profit measured in Marxian prices for each Yuan of gross output value in each economic sector.

The fixed capital stock square matrix is constructed by multiplying the column vector of gross fixed capital formation distribution with the row vector of fixed capital stock coefficients (k, showing the fixed capital stock for each Yuan of gross output value from each economic sector):

$$K = gk \tag{5}$$

The resulting square matrix K shows how the fixed capital stock for each Yuan of gross output value in each economic sector consists of various fixed capital goods produced by various economic sectors. For detailed estimates of the fixed capital stock coefficients and the turnover ratios for each economic sector, see the Appendix.

From equation (4), it can be derived that:

$$m\left(1/\pi\right) = m\left[K + \left(w\beta\alpha + A\right)\Gamma\right]\left[I - w\beta\alpha - A - D - T\right]^{-1} \tag{6}$$

where $1/\pi$ is the Perron-Frobenius eigenvalue of $[K + (w\beta\alpha + A)\Gamma][I - w\beta\alpha - A - D - T]^{-1}$, and m is the corresponding left-hand side eigenvector multiplied by a scalar.

The scalar can be found by setting the total economy gross output value measured by the Marxian production prices to be the same as the total economy gross output value measured by market prices (Ochoa 1989; Tsoulfidis and Rieu 2006).

2.3. Sraffian Prices of Production

Following Pasinetti (1977), Shaikh (1998), Tsoulfidis and Rieu (2006), and Mariolis and Tsoulfidis (2015: 71–2), the Sraffian prices of production are defined as the sum of production costs and average profits determined by a uniform profit rate on the actually expended circulating capital.

Sraffian prices of production are derived from the following system of equations:

$$s = s\left(w\beta\alpha + A + D + T\right) + rs\left(w\beta\alpha + A\right) \tag{7}$$

where s is the row vector of Sraffian price of production coefficients for each economic sector, and r is the Sraffian uniform profit rate. From equation (7), it can be derived that:

$$s\left(1/r\right) = s\left(w\beta\alpha + A\right)\left(I - w\beta\alpha - A - D - T\right)^{-1} \tag{8}$$

where 1/r is the Perron-Frobenius eigenvalue of $(w\beta\alpha + A)(I - w\beta\alpha - A - D - T)^{-1}$, and s is the corresponding left-hand side eigenvector multiplied by a scalar. The scalar can be found by setting the total economy gross output value measured by the Sraffian production prices to be the same as the total economy gross output value measured by market prices.

2.4. Cross-Sectional Prices Deviations

Table 2 shows direct prices, Marxian prices of production, and Sraffian prices of production for forty-two sectors in the Chinese economy in 2012.

If a sector has a direct price that equals one, it means that the market price in the sector is directly proportional to labor value. If a sector has a direct price that is greater than one, it means that the market price in that sector underrepresents the labor value embodied in the commodities in that sector (the sector has to use commodities embodying comparatively more labor to exchange for commodities embodying comparatively less labor from the rest of the economy in transactions based on market prices). If a sector has a direct price that is less than one, it means that the market price in that sector overrepresents the labor value embodied in the commodities in that sector (the sector can use commodities embodying comparatively less labor in exchange for commodities embodying comparatively more labor from the rest of the economy in transactions based on market prices).

For the year 2012, there are nineteen sectors that have a direct price between 0.9 and 1.1 (that is, the absolute deviation between direct price and market price is smaller than 10 percent). There are six sectors that have a direct price greater than 1.2 (agriculture, food, and tobacco, hotels and restaurants, education, health care, and public administration) and there are seven economic sectors that have a direct price smaller than 0.8 (petroleum and natural gas, petroleum products, utilization of wastes, gas production and supply, wholesale and retail, finance, and real estate). Out of the six sectors having direct prices greater than 1.2, public administration, education, and health care are government or government-sponsored sectors governed by non-capitalist economic behaviors, and agriculture is a sector dominated by non-capitalist small family farms. Out of the seven sectors having direct prices smaller than 0.8, wholesale and retail, finance, and real estate are capitalist but non-productive sectors according to Marxian political economy. Finally,

Table 2. Direct Prices, Marxian Prices of Production, and Sraffian Prices of Production of the Chinese Economy, 2012.

Code	Sector	Direct Price	Marxian Price	Sraffian Price
01	Agriculture, forestry, and fishery	1.677	1.109	1.132
02	Coal mining and washing	0.999	0.982	0.960
03	Petroleum and natural gas	0.656	0.851	0.778
04	Metals mining	0.911	0.964	0.954
05	Non-metals mining	0.914	0.990	0.977
06	Food and tobacco	1.201	1.029	1.093
07	Textiles	1.175	1.033	1.130
08	Apparel and footwear	1.103	1.002	1.105
09	Wood and furniture	1.066	1.014	1.091
10	Paper printing and sports articles	0.994	1.004	1.043
11	Petroleum products	0.681	0.918	0.907
12	Chemical products	0.913	0.986	1.035
13	Non-metal products	0.910	1.014	1.024
14	Smelting and pressing of metals	0.821	0.942	0.964
15	Metal products	0.885	0.972	1.018
16	General purpose machinery	0.920	1.001	1.052
17	Special purpose machinery	0.928	1.001	1.046
18	Transport equipment	0.917	0.996	1.058
19	Electrical machinery	0.883	0.974	1.041
20	Computers and electronics	0.985	1.030	1.116
21	Measuring instruments	0.935	0.979	1.042
22	Other manufactures	1.011	0.996	1.058
23	Utilization of wastes	0.256	0.257	0.264
24	Machinery repair services	1.000	1.053	1.094
25	Electric power and heat supply	0.903	1.098	1.016
26	Gas production and supply	0.749	0.922	0.859
27	Water production and supply	1.109	1.303	1.052
28	Construction	0.990	0.995	1.035
29	Wholesale and retail	0.715	0.823	0.752
30	Transportation storage post	0.980	1.005	0.940
31	Hotels and restaurants	1.275	1.136	1.071
32	Information and software	0.886	0.996	0.864
33	Finance	0.757	0.716	0.682
34	Real estate	0.758	1.388	0.834
35	Rental and business services	1.011	1.047	1.010
36	Scientific research	1.019	0.941	0.967
37	Water and environment management	1.149	1.043	0.993
38	Residential services	1.155	0.988	0.985
39	Education	1.560	1.123	1.065
40	Health care	1.268	1.064	1.083
41	Culture sports entertainment	1.109	1.033	0.967
42	Public administration	1.473	1.125	1.080

according to China's input-output tables, the value-added "produced" by the sector of waste utilization includes a large "imputed element."

We use three statistical measures to evaluate the deviations between different sets of prices. Following the general practice of the existing literature, the three statistical measures are: the mean absolute deviation (MAD), the mean absolute weighted deviation (MAWD), and

"d-distance." Both MAD and MAWD are measures of absolute percentage deviation. While MAD is calculated by dividing the sum of individual sectors' absolute deviations by the number of sectors, MAWD is calculated as a weighted average with each sector's absolute deviation weighted by the sector's share in the total economy gross output value.

Both MAD and MAWD are not numeraire free. Steedman and Tomkins (1998) propose "d-distance" as an alternative deviation measure: $d = [2(1 - \cos \theta)]^{1/2}$, where θ is the angle between two vectors under comparison. "d-distance" has a minimum value of 0 (when two vectors are perfectly positively correlated to each other) and a maximum value of 2 (when two vectors are perfectly negatively correlated to each other). If the two vectors under comparison are completely uncorrelated, "d" has a value of $2^{1/2}$. "d-distance" has the advantage of being numeraire free but cannot be directly interpreted as percentages of deviations.

Table 3 shows the deviations between direct prices, Marxian production prices, Sraffian production prices, and market prices for individual years between 1990 and 2012 and the average deviations for the period 1990–2012.

From 1990 to 2012, MAD between China's direct prices and market prices ranged between 10.6 percent in 2000 and 21.9 percent in 1990, and averaged 16.8 percent; MAWD ranged between 10.6 percent in 2000 and 23.3 percent in 1990, and averaged 17.5 percent; "d-distance" ranged between 0.147 in 2000 and 0.279 in 1990, and averaged 0.226.

We find that both Marxian production prices and Sraffian production prices have significantly smaller deviations from market prices than direct prices. From 1990 to 2012, MAD between China's Marxian prices of production and market prices averaged 8.6 percent, MAWD averaged 6.2 percent, and "d-distance" averaged 0.147. During the same period, MAD between China's Sraffian prices of production and market prices averaged 9 percent, MAWD averaged 7.8 percent, and "d-distance" averaged 0.145.

Both Marxian production prices and Sraffian production prices are based on assumptions of profit rate equalization across economic sectors. The finding that Marxian prices and Sraffian prices have smaller deviations from market prices than labor values suggests that the tendency toward equalization of the profit rate has been operating in the Chinese economy. It also suggests that despite various data limitations, this study is likely to have made reasonable estimates of the levels of fixed and circulating capital stock in China's various economic sectors.[5]

[5]Critics of labor theory of value have argued that the empirical findings of proximity between labor-value-based direct prices and market prices do not necessarily lend support to the labor theory of value, as there may be alternative "commodity values" that provide better approximations of the observed market prices than the direct prices. For example, Soklis (2009) found that several commodities provided better approximations of market prices than the direct prices in the Swedish economy. We have calculated the alternative commodity values for each non-labor commodity for each of China's input-output tables from 1990 to 2012. With one curious exception, we find that all non-labor commodity values have significantly larger deviations from the observed market prices than the labor-value-based direct prices. The only exception has to do with the "public administration" sector. For the years 2007 and 2010, the "alternative direct prices" using the public administration sector as the "value base" has closer proximity with market prices than labor-value-based direct prices. But for 2012, the public-administration-based alternative direct prices have much larger deviations than the labor-value-based direct prices. This curious finding may have resulted from certain assumptions that China's National Bureau of Statistics has used to estimate the "contribution" of the public administration sector to other economic sectors. Our reading of China's input-output tables for 2007 and 2010 suggests that the National Bureau of Statistics may have set the direct input from the public administration sector to each economic sector as a predetermined constant proportion of each sector's value added, making the public-administration-based alternative direct prices automatically proportional to the value-added component of the observed market prices. For years before 2007, the direct input from the public administration sector to other economic sectors was set as zero by China's input-output tables, making it impossible to calculate public-administration-based alternative direct prices.

Table 3. Deviations between direct prices, Marxian production prices, Sraffian production prices. and market prices (China, total economy, 1990–2012).

	MAD	MAWD	d-distance
Direct Price and Market Price			
1990	0.219	0.233	0.279
1992	0.196	0.233	0.236
1995	0.147	0.175	0.188
1997	0.132	0.123	0.203
2000	0.106	0.106	0.141
2002	0.133	0.127	0.205
2005	0.197	0.210	0.277
2007	0.203	0.207	0.272
2010	0.176	0.170	0.218
2012	0.169	0.168	0.239
Average (1990–2012)	0.168	0.175	0.226
Marxian Price and Market Price			
1990	0.111	0.078	0.197
1992	0.063	0.057	0.092
1995	0.082	0.068	0.104
1997	0.072	0.032	0.160
2000	0.040	0.027	0.053
2002	0.088	0.049	0.173
2005	0.116	0.084	0.202
2007	0.120	0.092	0.208
2010	0.086	0.068	0.124
2012	0.083	0.065	0.156
Average (1990–2012)	0.086	0.062	0.147
Sraffian Price and Market Price			
1990	0.099	0.090	0.173
1992	0.094	0.102	0.124
1995	0.073	0.074	0.102
1997	0.077	0.046	0.163
2000	0.049	0.037	0.065
2002	0.095	0.064	0.171
2005	0.112	0.099	0.188
2007	0.116	0.102	0.190
2010	0.088	0.083	0.119
2012	0.094	0.085	0.152
Average (1990–2012)	0.090	0.078	0.145

Previous studies on the deviations between direct prices and market prices in various countries found that MAD between direct prices and market prices ranged between 13 percent and 27 percent, MAWD ranged between 9 percent and 19 percent, and "d-distance" ranged between 0.16 and 0.29 (see Table 1). China's average deviations between direct prices and market prices over the period 1990–2012 measured by MAD, MAWD, and "d-distance" fall within the range of deviations found in previous studies.

Previous studies on the deviation between Marxian production prices and market prices in various countries found that MAD between Marxian production prices and market prices ranged between 14 percent and 17 percent, MAWD ranged between 14 percent and 18 percent, and "d-distance" ranged between 0.19 and 0.23. Previous studies on the deviation between Sraffian production prices and market prices in various countries found that MAD between Sraffian production prices and market prices ranged between 11 percent and 25 percent, MAWD ranged between 11 percent and 19 percent, and "d-distance" ranged between 0.16 and 0.29 (see Table 1).

Interestingly, China's average deviations between Marxian production prices and market prices or between Sraffian production prices and market prices over the period 1990–2012 are significantly smaller than the deviations found in previous studies. These findings suggest that the tendency toward profit equalization may have operated more effectively in China than in some other economies.[6]

3. Value and Price: Productive Capitalist Sectors

According to Marxian political economy, certain capitalist economic sectors are non-productive sectors that do not participate in the production of surplus value (Shaikh and Tonak 1996: 39–63). For example, the wholesale and retail sector facilitates the realization of surplus value but the wages, profits, and taxes paid by this sector derive from the surplus value produced in other sectors. Finance and real estate facilitate the redistribution of surplus value from industrial capitalists to financial capitalists but do not produce new surplus value themselves. Because the "value added" of the non-productive sectors does not result from production of new value but derives from surplus value that has already been produced, there is little reason to expect that the value added of these sectors should be proportional to the labor values in these sectors.[7]

In China, agriculture is still dominated by small family farms. Their revenues from agricultural production not only fall substantially below what one would expect to be the revenues from a capitalist farm but also often fail to match the wage incomes that could be earned if their labor power was employed in the urban sector. In this context, it is reasonable to assume that when the Chinese small family farms deal with capitalist enterprises in buying and selling, they are likely to suffer from unequal exchange because of their weak market power. It follows that the agricultural value added measured in market prices is likely to significantly underrepresent the labor

[6]Following the existing literature on the empirical relationship between direct prices, production prices, and market prices, this study focuses on the average deviations between these variables. However, for certain research purposes, deviations in individual sectors may be of greater interest than the average deviations. Table 2 shows that the deviations in some sectors are relatively large. Some of the large deviations can be explained by the non-productive or non-capitalist characters of individual sectors (see section 3). The unexplained portion of the observed deviations between direct prices, production prices, and market prices in various individual sectors would be an area that deserves further study by future research.

[7]Baiman (2014) argues that the conventional measure of GDP may have overvalued economic output by including the value added from "the rentier economy." Inspired by the concept of "profit on alienation" cited by Shaikh (2016: 208–12), Baiman (2018) further argues that the modern capitalist rentier economy is exemplified by the growing ability of finance to extract profit without contributing to production. We believe the concept of rentier economy is not incompatible with the traditional Marxist argument that financial profit ultimately derives from redistribution of surplus value produced by the productive capitalist sectors. The traditional view simply means that the surplus value has to be produced first before it can be extracted by the non-productive sectors. It does not require the financial factor or other non-productive sectors be "productive" or make a productive contribution. Regardless of whether the financial sector is "productive" or not, the point here is that there is no economic reason to think that the value added of the financial sector or other non-productive sectors should be proportional to the direct and indirect labor input used in these sectors.

embodied in agricultural commodities. In addition, the government sector and government-sponsored institutions (such as public education and public health care) are non-capitalist institutions in the sense that they are not profit-oriented. Thus, the equalization of the rate of profit will not occur in those sectors.[8]

Given these considerations, we find it interesting to evaluate the price deviations for the productive capitalist sectors only by excluding the non-capitalist or non-productive sectors (agriculture, wholesale and retail, finance, real estate, education, health care, and public administration) as well as the "imputed" sector of waste utilization.

Table 4 reports the deviations between direct prices, Marxian production prices, Sraffian production prices, and market prices for China's productive capitalist sectors for individual years between 1990 and 2012 and the average deviations for the period 1990–2012.

After excluding the non-capitalist and non-productive sectors, the average deviations between direct prices and markets prices are reduced to between 8.6 and 13 percent (measured by MAWD and MAD) for the period 1990–2012. The average deviations between Marxian production prices and market prices are narrowed to only 3.3 and 6.2 percent, and the average deviations between Sraffian production prices and market prices are narrowed to only 4.2 and 6.9 percent.

4. Value and Prices: Time Series Correlations

With input-output tables over a relatively long period of time, we can also study the correlations between direct prices, Marxian prices of production, Sraffian prices of production, and market prices over time.

Ochoa (1989) studied the time series correlations between direct prices, Marxian prices of production, and market prices from 1947 to 1972 in the US economy. Ochoa found that variations in direct prices could explain about 75 percent of the variations in observed market prices over time.

Ochoa used the nominal gross output value from each economic sector measured by direct prices, production prices, and market prices respectively, divided by the "real" gross output value in constant dollars ("real" gross output value is used as a pseudo-quantity measure). Ochoa then calculated the correlation coefficients between different sets of prices for each of the individual sectors, averaged the correlation coefficients, and had the averages squared. Ochoa explained that the general measure of variations so derived was dimensionally comparable to cross-sectional R-square. Ochoa argued that while R-square could not be meaningfully calculated for cross-sectional correlations between prices, the R-square derived from the above steps was a legitimate measure of over-time variations in prices as the calculated correlations were independent of output levels.

In effect, Ochoa had calculated the absolute price levels of direct prices, production prices, and market prices for various sectors in the US economy from 1947 to 1972, using a commodity that had the worth of one constant US dollar as one unit of commodity. While Ochoa's method helps to remove the impact of changing output levels from variations of prices over time, it does not remove the impact of changes in the general price level. When there is a general tendency for the general price level to rise (as was the case in the US economy from 1947 to 1972, and in the

[8]According to some Marxist political economists, the government and other public institutions should be considered as non-productive because their expenditures are financed by redistribution of surplus value through tax revenues (Shaikh and Tonak 1996: 20–37). However, an argument can be made that, to the extent that some public spending contributes to the reproduction of labor power, such as public education and health care, such public spending may be considered productive activities. On the other hand, if education and health care were provided by private capitalists, such activities do produce commodities and therefore surplus value. Most education and health care in China are still provided by the public sector.

Table 4. Deviations Between Direct Prices, Marxian Production Prices, Sraffian Production Prices, and Market Prices (China, Productive Capitalist Sectors, 1990–2012).

	MAD	MAWD	d-distance
Direct Price and Market Price			
1990	0.190	0.107	0.201
1992	0.168	0.107	0.166
1995	0.117	0.079	0.139
1997	0.089	0.056	0.110
2000	0.098	0.066	0.109
2002	0.094	0.058	0.113
2005	0.153	0.112	0.175
2007	0.147	0.109	0.162
2010	0.129	0.088	0.144
2012	0.113	0.079	0.139
Average (1990–2012)	0.130	0.086	0.146
Marxian Price and Market Price			
1990	0.087	0.049	0.144
1992	0.051	0.025	0.078
1995	0.072	0.041	0.087
1997	0.041	0.018	0.059
2000	0.041	0.023	0.048
2002	0.063	0.028	0.089
2005	0.079	0.043	0.107
2007	0.081	0.047	0.118
2010	0.061	0.030	0.085
2012	0.046	0.023	0.072
Average (1990–2012)	0.062	0.033	0.089
Sraffian Price and Market Price			
1990	0.069	0.042	0.085
1992	0.083	0.055	0.114
1995	0.059	0.037	0.083
1997	0.050	0.026	0.079
2000	0.050	0.029	0.060
2002	0.078	0.045	0.094
2005	0.087	0.064	0.119
2007	0.085	0.061	0.102
2010	0.068	0.046	0.078
2012	0.066	0.044	0.076
Average (1990–2012)	0.069	0.042	0.085

Chinese economy from 1990 to 2012), correlations between two different sets of prices would reflect not only the changes in relative prices but also the trend for the general price level to rise that is present in both sets of prices. Thus, Ochoa's method tends to overestimate the correlations between relative direct prices, relative production prices, and relative market prices.

We use the nominal gross output value from each economic sector measured by direct prices, Marxian prices, Sraffian prices, and market prices respectively, divided by the "real" gross output value of each sector measured by constant 1990 Yuan.[9] The results are direct prices, Marxian

prices, Sraffian prices, and market prices of one unit of commodity in each economic sector for various years from 1990 to 2012, with one unit of commodity defined as the commodity that has the worth of one constant 1990 Yuan. These are "absolute" direct prices, Marxian prices, Sraffian prices, and market prices. We then convert "absolute" prices into relative prices by dividing each set of prices by the economy-wide GDP deflator. The results are relative direct prices, relative Marxian prices, relative Sraffian prices, and relative market prices. We then calculate the time-series correlations between relative direct prices, relative Marxian prices, relative Sraffian prices and relative market prices for each economic sector.

Both the number and definition of economic sectors vary among China's input-output tables of different years. We exclude the input-output table for the year 2000 from the time-series analysis as it includes only seventeen sectors. For the other years, we combine the various sectors in each year's input-output table into thirty common sectors. For each of the thirty sectors, we calculate the correlations between relative direct prices, relative Marxian prices, relative Sraffian prices, and relative market prices. We then calculate the averages of the individual sectors' correlation coefficients and have the averages squared. Table 5 shows the correlations over time between relative direct prices, relative Marxian prices, relative Sraffian prices, and relative market prices for individual sectors as well as the average R-squares for the total economy.

Out of the thirty combined sectors, most sectors demonstrate strong correlations between labor values and market prices. There are twenty-one sectors that have correlations between relative direct prices and relative market prices greater than 0.9. But the sector of "hotels and restaurants" has negative correlations, and the sectors of "food and tobacco," "transportation, post, and telecommunication," and "finance and insurance" have very low correlation coefficients (about 0.3). On average, variations in relative direct prices can explain about 70 percent of the variations in relative market prices over time, variations in relative Marxian prices can explain about 80 percent of the variations in relative market prices, and variations in relative Sraffian prices can explain about 84 percent of the variation in relative market prices.

5. The Marxian Fundamental Variables and the Sraffian Wage-Profit Frontier

Using calculated direct prices, Marxian prices, and Sraffian prices, as well as observed market prices, we can calculate the Marxian fundamental variables (organic composition of capital, profit/wage ratio, and profit rate) using different sets of prices.

Figure 1 shows China's organic composition of capital measured by four different sets of prices. The organic composition of capital is defined as the ratio of the total economy's advanced total capital over the total compensation of laborers.

From 1990 to 2012, the organic composition of capital measured by direct prices fluctuated around 6; the organic composition of capital measured by Marxian prices, Sraffian prices, and market prices were similar to each other and fluctuated around 7. All four measures followed similar movements over the years. The relatively low organic composition of capital measured by direct prices suggests that direct prices of capital goods are lower than market prices or production prices of capital goods.

[9]To calculate the "real" gross output value in constant 1990 Yuan for various economic sectors, we deflate the nominal gross output value for each of the industrial sectors (including all mining, manufacturing, and utility sectors) by the producer price indexes of the individual industrial sectors; we deflate the nominal gross output value of agriculture, construction, wholesale and retail, transportation and post, hotels and restaurants, and finance by their respective GDP deflators; and we deflate the nominal gross output value of the other sectors by the GDP deflator of "the other services."

Table 5. Time Series Correlations Between Relative Direct Prices, Relative Marxian Production Prices, Relative Sraffian Production Prices, and Relative Market Prices (China, 1990–2012).

Sector	Direct and Market Price	Marxian and Market Price	Sraffian and Market Price
Agriculture, forestry, and fishery	0.787	0.944	0.941
Coal mining and washing	0.984	0.948	0.979
Petroleum and natural gas	0.983	0.970	0.969
Metals mining	0.798	0.834	0.929
Non-metals mining	0.922	0.972	0.976
Food and tobacco	0.278	0.832	0.891
Textiles	0.967	0.993	0.987
Apparel and footwear	0.932	0.982	0.980
Wood and furniture	0.991	0.998	0.998
Paper printing and sports articles	0.994	0.996	0.995
Petroleum products	0.991	0.997	0.997
Chemical products	0.981	0.991	0.990
Non-metal products	0.940	0.981	0.979
Smelting and pressing of metals	0.732	0.940	0.955
Metal products	0.815	0.974	0.974
Machinery industry	0.985	0.997	0.997
Transport equipment	0.985	0.996	0.994
Electrical machinery	0.983	0.997	0.998
Computers and electronics	0.968	0.985	0.976
Measuring instruments	0.983	0.998	0.995
Other manufactures	0.960	0.958	0.954
Electric power and heat supply	0.967	0.945	0.956
Construction	0.918	0.969	0.972
Transportation, post, and telecommunication	0.325	0.784	0.652
Wholesale and retail	0.822	0.787	0.784
Hotels and restaurants	−0.076	−0.101	0.400
Real estate and residential services	0.930	0.849	0.946
Education, health care, and science	0.977	0.990	0.998
Finance and insurance	0.349	0.358	0.343
Public administration	0.967	0.990	0.992
R-square	0.702	0.801	0.840

Figure 2 shows China's profit/wage ratio measured by four different sets of prices. The profit-wage ratio is defined as the ratio of the economy's total profit over the total compensation of laborers. Total profit is the difference between the total economy gross output value and the total cost of production (including net producer taxes). We call it the "profit/wage ratio" rather than the "rate of surplus value" because the total compensation of laborers includes wages from non-productive sectors that may be considered a part of surplus value.

From 1990 to 2012, the profit/wage ratio measured by four different prices had followed similar movements over the years. In the early 1990s, the profit/wage ratio was about 50–60 percent. In the late 1990s, as massive layoffs from state-owned enterprises led to rising unemployment and pervasive overcapacity, the profit/wage ratio fell to about 30 percent. During the boom years of 2005–7, the profit/wage ratio surged to 70–80 percent. Since then, it had fallen back to about 50–60 percent. Figure 3 shows China's Marxian profit rate measured by four different sets of

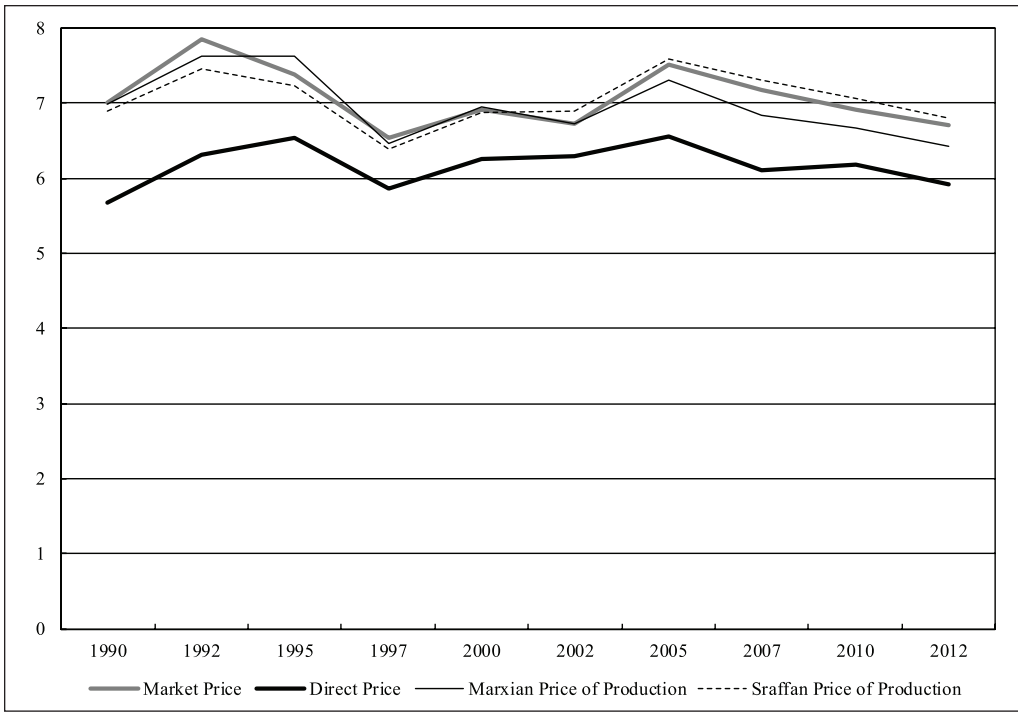

Figure 1. China's Organic Composition of Capital, 1990–2012.

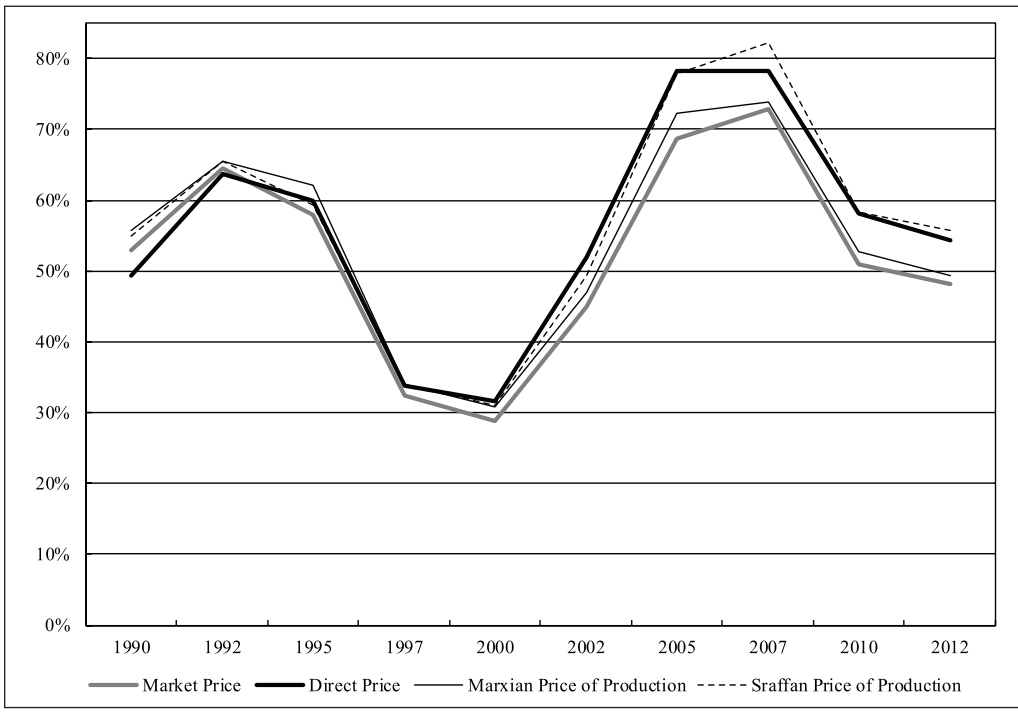

Figure 2. China's Profit/Wage Ratio, 1990–2012.

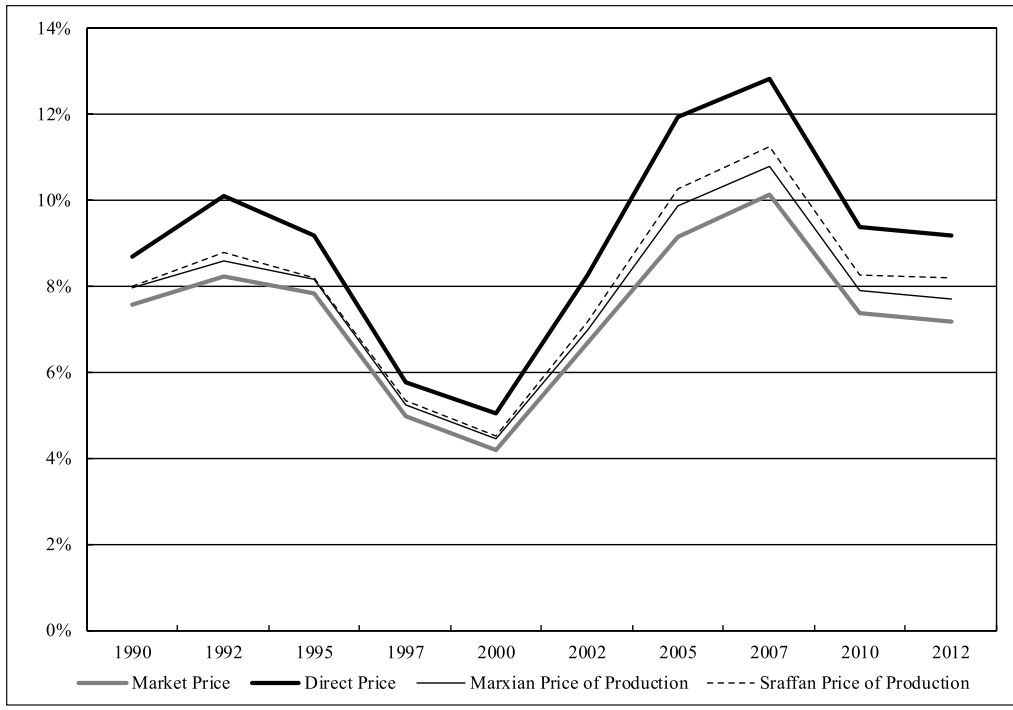

Figure 3. China's Marxian Profit Rate, 1990–2012.

prices. The profit rate is defined as the ratio of the economy's total profit over the advanced total capital.

The profit rate measured by direct prices has stayed consistently above the profit rate measured by the other prices, reflecting the smaller advanced total capital measured by the direct prices.[10]

Figure 4 shows the Sraffian wage-profit frontier for the Chinese economy in 1990, 1995, 2000, 2005, 2010, and 2012.

The wage-profit frontier shows all possible combinations of the real wage and Sraffian profit rate given the input-output structure of an economy. It describes an economy's underlying "technique." To calculate the wage-profit frontiers, all commodities are measured by their Sraffian prices.

Similar to the findings in previous studies, we find that China's wage-profit frontiers are nearly completely linear. A key Sraffian critique of the neoclassical concept of capital has to do

[10]Sánchez and Montibeler (2015) report their "vertically integrated" composition of capital (similar to the organic composition of capital defined in this paper) measured in four different sets of prices in 2002 to be in the range of 1.98–2.26 (compared with our estimate of the organic composition of capital ranging from 6.29 to 6.90 in 2002), their rate of surplus value to be in the range of 96–102 percent (compared with our estimate of the profit/wage ratio ranging from 45 to 52 percent in 2002), and their profit rate to be in the range of 51–59 percent (compared with our estimate of the profit rate ranging from 7–8.3 percent in 2002). Their capital stock is defined as the advanced total capital, although their circulating capital is not adjusted for turnover time. This should make their capital stock larger, composition of capital larger (not smaller), and profit rate smaller (not larger). The underlying reason for the large differences between their findings and ours remains a puzzle to us.

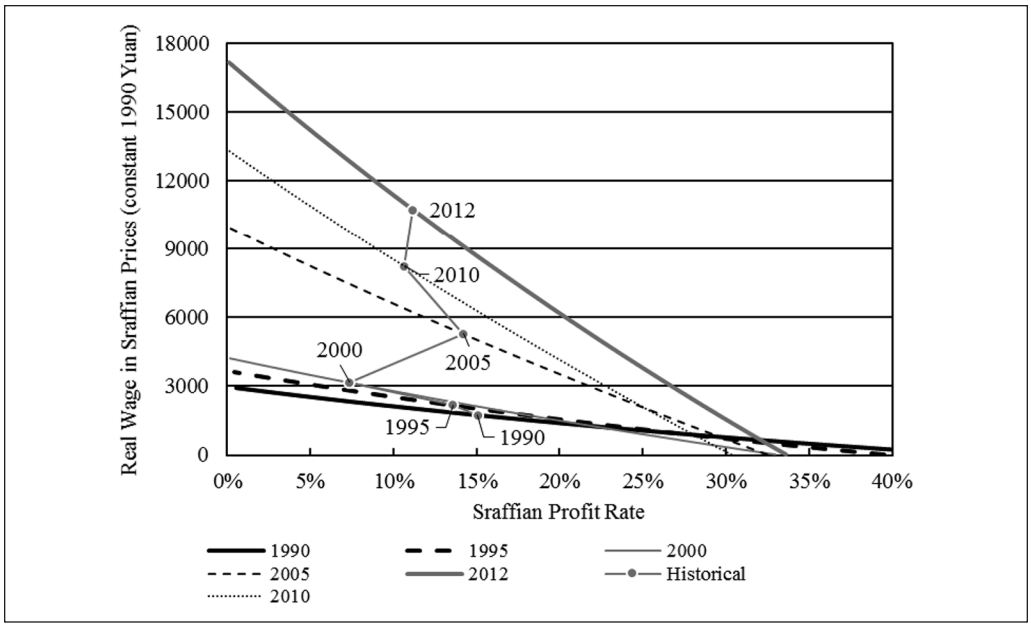

Figure 4. China's Sraffian Wage-Profit Frontier, 1990–2012.

with the argument that with curving wage-profit frontiers, changing levels of profit rate may lead to "re-switching of techniques," making the neoclassical definition of capital inconsistent. However, empirical studies have found that wage-profit frontiers in the real world are more likely to be near linear than curved, making the re-switching problem more theoretical than being empirically relevant.

6. Conclusion

In this paper, we use China's input-output tables from 1990 to 2012 to study deviations between labor-value-based direct prices, Marxian prices of production, Sraffian prices of production, and market prices. We find that the cross-sectional deviations between direct prices and market prices averaged 17–18 percent, and variations in the relative direct prices can explain about 70 percent of the observed variations in relative market prices over time. The average deviations between direct prices and market prices in the Chinese economy fall within the range of the deviations in various countries found in previous studies. Several authors have argued that such deviations suggest that labor values provide reasonable approximations of observed market prices in capitalist economies (Shaikh 1984; Ochoa 1989; Tsoulfidis and Rieu 2006).

We find that both Marxian production prices and Sraffian production prices have significantly smaller deviations from observed market prices in the Chinese economy than in various countries found in previous studies. Our findings suggest that the tendency toward equalization of the profit rate may have operated more effectively in China than in some other countries. We also find that variations in relative Marxian and Sraffian prices can explain about 80–84 percent of the observed variations in relative market prices over time.

When our study is applied to the productive capitalist sectors, the deviations between direct prices, Marxian production prices, Sraffian production prices, and market prices are reduced significantly. Measured by MAWD, the average deviations are reduced to about 9 percent between direct prices and market prices, 3 percent between Marxian prices and market prices,

and 4 percent between Sraffian prices and market prices. Such small deviations suggest that price theory based on either the Marxian or the classical tradition can largely explain observed market prices in the productive capitalist sectors in the Chinese economy.

Appendix

Estimating China's Fixed Capital Stock

There is no official measurement of China's capital stock. Nevertheless, China's total economy fixed capital stock can be constructed using the perpetual inventory method.

$$K_n = K_0 + \sum_{t=1}^{n} (NI_t)$$

where K_n is the real capital stock in year n, K_0 is the real capital stock in the initial year, and NI_t is the real net investment in year t ($t = 1, 2, 3,... n$). This formula says that real capital stock in any year is the sum of the initial real capital stock and the cumulative real net investment between the initial year and the current year.

The *China Statistical Yearbook 1985* (National Bureau of Statistics 1985: 374) provides net value of fixed assets of state-owned enterprises in the industrial sector, which stood at 10.08 billion Yuan in 1952. In 1952, state-owned industrial enterprises accounted for 41.6 percent of China's industrial gross output value (National Bureau of Statistics 1985: 306). Assuming that the non-state industrial enterprises had the same capital-output ratio as the state industrial enterprises, the industrial sector's net stock of fixed assets in 1952 is estimated to be 24.25 billion Yuan.

In 1952, China's industrial GDP was 17.6 percent of China's total GDP. Assuming that other economic sectors had the same capital-output ratio as the industrial sector, China's total net stock of fixed assets in 1952 is calculated to be 137.78 billion Yuan.

The *China Statistical Yearbook 1993* provides "accumulation" of fixed assets from 1952 to 1992 (National Bureau of Statistics 1993: table 2-28). "Accumulation" is the term used for net investment in the net material product accounting system. We use the "accumulation" of fixed assets as the proxy for net investment in fixed assets. After 1993, China's National Bureau of Statistics no longer publishes the series of "accumulation" based on the net material product accounting.

For the years 1993 to 2012, we calculate the net investment in fixed assets as the difference between China's gross fixed capital formation and depreciation of fixed capital. The gross fixed capital formation from 1952 to 2012 is from the China Data Center (All China Data Center 2018). China's National Bureau of Statistics provides depreciation of fixed capital by province from 1993 to 2012. Depreciation of fixed capital of provinces is summed up to derive China's total depreciation of fixed capital.

The net investment calculated above is in current prices. This is deflated into real net investment in constant 1952 prices by using a fixed investment price index. The National Bureau of Statistics provides a fixed investment price index from 1990 to 2012. For 1953–89, we use the national fixed investment price index calculated by Zhang, Wu, and Zhang (2004) and reported by Jin (2012: table 1). For 1952–3, we use the Shanghai fixed investment price index reported by Zhang and Zhang (2003) as the proxy for the national fixed investment price index.

Using the above data, China's real net stock of fixed assets from 1952 to 2012 can be calculated. The real capital stock from 1990 to 2012 is then reinflated by having it multiplied by the fixed investment price index. The results are China's net stock of fixed assets in current prices from 1990 to 2012.

The total fixed capital stock is then allocated to various economic sectors by assuming that all sectors have the same ratio of depreciation to fixed capital stock. This allows us to construct the fixed capital coefficients vector.

Estimating the Circulating Capital's Turnover Ratios

For year 2012, we used data from the *China Statistical Yearbook 2013* to estimate the turnover ratios of circulating capital in China's various economic sectors.

The *China Statistical Yearbook 2013* reports the turnover ratios for forty-one industrial sectors in 2012 (National Bureau of Statistics 2013: table 14-2). These sectors are more detailed than the twenty-seven industrial sectors reported by the Input-Output Table 2012 (sector 2 through sector 27). We merged the more detailed forty-one sectors into twenty-seven sectors that match the Input-Output Table 2012.

For construction, wholesale and retail, and hotels and restaurants (sectors 28, 29, and 31), we calculated the turnover ratio as the ratio of total circulating cost (total operating cost less depreciation) over circulating assets (National Bureau of Statistics 2013: tables 15-2, 17-2, 17-4, 18-2, and 18-4).

For transportation, storage, and post (sector 30), we assume that its turnover ratio is the same as the industrial sector's average.

For agriculture (sector 1), we assume that its turnover ratio is 2, based on the observation that most Chinese agricultural products yield two crops a year. For the other sectors (sector 32 through 42), we calculate their turnover ratios based on the following assumption: their wage expenses are assumed to have a turnover ratio of 12 (based on the common Chinese practice of monthly wage payment) and their non-wage circulating expenses are assumed to have a turnover ratio of 2.

Turnover ratios in other years are estimated in a similar manner using data from the *China Statistical Yearbook* in earlier years.

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