Labour value and equalisation of profit rates: a multi-country study

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Abstract

This study investigates the empirical strength of the labour theory of value and its relation to profit rate equalisation. It replicates tests from previous studies, using input-output data from 18 countries spanning from year 1968 to 2000. The results are broadly consistent; labour values and production prices of industry outputs are highly correlated with its market price. The predictive power is compared to alternative value bases. Furthermore, the empirical support for profit rate equalisation, as assumed by the theory of production prices, is weak.
Keywords: Labour value, production price, profit rates.

1 Introduction

The labour theory of value (LTV) states that the market prices of commodities tend to be proportional to the labour necessary to produce them. The scientific status of the theory depends on what it can say, theoretically and empirically, about reality. The LTV can generate interesting predictions regarding price-formation, the decreasing labour content of commodities, real exchange rates, the determination of the average profit rate etc. More importantly it is potentially a powerful analytical tool for understanding how market economies regulate social labour, a special case of a general economic problem. It is essential in order to understand the mechanism of extraction of surplus labour under capitalism which, of course, was a central concern of Marx.

Labour value is an attractor to market price, or to put it in a different way, as Valle Baeza [19] argues; market price can be interpreted as a measure of labour value and random price-value deviations as signals to which the market, as a control system, regulates production.

But the time and effort spent investigating what merits the LTV may have in real capitalist economies pales in significance to that spent on the so-called "transformation problem"—the problem of reconciling the LTV with the theory of production prices (TPP) within a deterministic framework. TPP states that prices are formed to ensure equal profit rates across the economy. The problem is that if there was a common profit-wage ratio, the LTV would predict that firms with higher capital-wage ratios would earn lower rates of profit, and vice

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versa, making it systematically in error. The problem rests on the assumptions of (i) a common profit-wage ratio and (ii) an equalisation of profit rates. (i) does not necessarily follow from the LTV, but as we will see it is certainly consistent with it. (ii) is the central assumption of the TPP.

Farjoun and Machover's *Laws of Chaos* is a bold attempt to break with the deterministic framework of the transformation problem. To deal with chaotic market phenomena one must apply appropriate probabilistic concepts. If the regulation of social labour in capitalism operates in the way stated above we should understand market prices to be determined by labour values, not through a deterministic (as in classical mechanics) but stochastic process. Indeed, using arguments from statistical mechanics they formulate a powerful critique of the theoretical status of an equalisation of profit rates. The purpose of this article is to contribute to the empirical research on the labour theory of value and its relation to profit rate equalisation. Using the approach outlined in *Laws of Chaos*, it will replicate tests done for the economies of the United States, United Kingdom and Greece [3, 4, 12, 18] with data from 18 countries.

2 Theory

2.1 Value bases and the peculiarity of labour

Let us denote the market price of a commodity as P and the direct plus indirect labour time necessary to produce it, under existing standard conditions of production, as Ψ which we shall call 'labour value'. From the standpoint of *economic reproduction* it is clear that the choice of value base is not limited to labour. Ψ can be substituted for any commodity-type that enters directly or indirectly into every other commodity, for example oil or steel. The 'steel value' of a commodity is the total quantity of steel necessary to produce it. However as a concept of *economic value* any value base other than labour runs into theoretical problems; if 1 ton of steel requires 0.5 tons of steel in its production then its steel value is not unity as the concept requires. On the other hand if the steel value of one unit of steel remained exactly one there would be no net production of steel.

Social labour is special in this respect. It is a direct and indirect input to every commodity and assumes the commodity form as labour power is bought and sold but it is not produced as a commodity. There is no direct analogy between the reproduction of one ton of steel and one person hour of labour so there is no non-unity problem here. The concept of abstract labour is also applicable to all types of economies with a social division of labour throughout history, not merely when goods and services assume the commodity form. It is 'abstract' precisely because of the general human capacity to acquire skills and perform all kinds of concrete tasks.

Labour is a universal but scarce resource. During any given period of time there is a limited amount of person hours available in production which constrains the feasible consumption pattern. This imposes a practical necessity to allocate it in various branches of production in order to meet changing social demands. Thus determining demand in terms of labour becomes functionally useful in order to organize and allocate labour with some degree of efficiency. In economies governed by market exchange, a large number of producers are

integrated indirectly via purchases and sales. These economies face the same problematic of organizing and allocating social labour but have to solve it by the mechanisms of market exchange.

If we interpret the market price of a good or service as a stochastic signal, the LTV suggests that its labour value is a deterministic component underlying the noise. This implies a control mechanism in that deviations between market prices and prices proportional to labour values, caused by supply and demand discrepancies, will lead to counter-acting adjustments in output.

2.2 Distribution of price-value ratios

A more rigorous claim was made by Farjoun and Machover: Suppose we record for each transaction i during a period the ratio of market price to labour value of the commodity exchanged, $\psi_i = P_i/\Psi_i$. Each transaction differs in economic weight, i.e. there is a quantitative difference between the purchase of a cup of coffee and a jumbo jet, so each ratio is given a probability weight p_i proportional to the commodity's labour value. The period should be short enough for structural changes in the economy to be negligible but long enough for the number of recorded price-value ratios to be sufficiently large to apply probabilistic concepts. The expected characteristics of the distribution of price-value ratios are derived on very general statistical considerations.

The price P of any commodity can be decomposed into its costs of production inputs C, labour costs V and gross profits S. However, C is itself a price that can be decomposed into its input costs, labour costs and gross profits. This decomposition of production inputs can be repeated so that in the limit the price P of any commodity is made up the sum of its direct and indirect (or vertically integrated) labour costs $V^* = \sum_j V_j$ and gross profits $S^* = \sum_j S_j$, which was a fundamental insight of classical political economy.

$$P = C + V + S = S^* + V^* \tag{1}$$

If we treat $\psi = P/\Psi$ as a random variable, where each recorded ratio ψ_i during the transaction period is assigned a probability weight proportional to its labour value $p_i = \Psi_i / \sum_j \Psi_j$, we can use (1) to write the mean as

$$\begin{aligned} \mathrm{E}[\psi] &= \mathrm{E}[V^*/\Psi] + \mathrm{E}[S^*/\Psi] \\ &= \mathrm{E}[V^*/\Psi] \cdot (1 + e^*) \end{aligned} \tag{2}$$

where $\mathrm{E}[V^*/\Psi] = \sum_i V_i^* / \sum_j \Psi_j$ and $e^* = \sum_i S_i^* / \sum_i V_i^*$ in (2) are likely to be close to the average wage rate and profit-wage ratio in the economy, respectively.[1] Due to the highly integrated nature of modern economies $\psi = P/\Psi$ is made up by the sum of a large number of random variables; each of which is small relative to the whole sum and assumed to be independent. By a generalization of the Central Limit Theorem we would expect $\psi = P/\Psi$ to be approximated by a continuous normal distribution, with a mean value $\mathrm{E}[\psi]$ and standard deviation σ_ψ. This result was derived by Farjoun and Machover [8, chap. 5], reproduced here in a condensed form of course, who further estimated the standard deviation σ_ψ on the hypothesis that there is a small probability, less

[1] 'Average' meaning the aggregate ratio of wages to labour-time and profits to wages.

than 1/1000, that the market price is insufficient to pay the total labour-power required, at the average wage rate.

This information is sufficient to describe the entire distribution of price-value ratios. The integral $\int_a^b f(\psi)d\psi$ would give the fraction of the total product measured in labour value exchanging for a price-value ratio ψ between a and b, where $f(\psi)$ is the probability density function. If the labour theory of value holds empirically, then what is the rationale that enforces price-setting agents, obviously unaware of this 'law of value', to adapt to it? We can approach this question in a slightly different manner.

2.3 Relative prices and labour values

Following Shaikh and Antonopoulos [13], relative unit prices strongly depend on relative unit costs—which is to say relative vertically integrated labour costs. For simplicity, denote the vertically integrated profit-wage ratio S^*/V^* as β and the direct profit-wage ratio S/V as α. Then re-write (1) as $P = V^*(1+\beta)$. Now let us investigate under what conditions relative prices between two arbitrary commodities i and j are approximately equal to their relative labour values: $P_i/P_j \approx \Psi_i/\Psi_j$.

Using our notation $P_i/P_j = (V_i^*/V_j^*) \cdot [(1+\beta_i)/(1+\beta_j)]$, i.e. relative prices are made up by relative vertically integrated labour costs multiplied by relative vertically integrated profit-wage ratios. The vertically integrated profit-wage ratio β of each producer is a convex combination or weighted average of the direct profit-wage ratios α of several other producers who enter directly or indirectly in its output:

$$\beta = w_1\alpha_1 + w_2\alpha_2 + \cdots + w_n\alpha_n = \sum_{k=1}^{n} w_k\alpha_k \tag{3}$$

The weights are $w_k = V_k/\sum V_l$, i.e. the relative contribution of integrated labour costs. Again, given the level of interconnection of modern economies we would expect the sum in (3) to contain a large number of terms so that vertically integrated profit-wage ratios β across all producers will be more similar than their direct profit-wage ratios α. If β has a relatively small dispersion then $[(1+\beta_i)/(1+\beta_j)]$ can be viewed as a disturbance term so that relative prices strongly depend on relative vertically integrated labour costs V_i^*/V_j^*. Furthermore, if the distribution of wage rates is reasonably narrow then this ratio will not be far away from relative labour values Ψ_i/Ψ_j. Thus we can say that: it is the need for companies to meet the wage-bill that forces market prices to gravitate around prices proportional to labour values. We also see that the assumption of a common profit-wage ratio α is compatible with the LTV since it implies that there is no disturbance arising from differentials in vertically integrated profit-wage ratios β.

2.4 Equalisation of profit rates

The classical political economists also held the view that capital flows from low return to high return sectors. Supply drops and prices rise in less profitable ones and vice versa. Although this mechanism, which would appear to even out the profit rates, arguably exists, the question is on what time-scale does it operate?

How does it affect the distribution of profit rates and price formation? Will the distribution narrow over time and/or remain narrow in relation to other distributions, such as price-value ratios?

In theoretical models it is assumed to be a spike, i.e. all profit rates are equal so there is no variation, but no one expects to find that in reality. In the TPP equalisation affects price formation so that market prices gravitate around 'production prices' that would ensure all producers an equal profit rate. The premise is that equalisation operates in such way to make profit rates statistically independent of capital-wage ratios and similar compositions of capital (Cockshott and Cottrell [4, p. 749]). Holding a common profit-wage ratio across industry sectors, the premise contradicts the LTV which predicts profit rates to be systematically lower for sectors with high capital-wage ratios.

3 Data and method

The rest of this paper will test 1. The hypothesis that labour value is an attractor to market price. 2. Production price is a competing attractor which will make more accurate predictions, rendering labour value as a 'first approximation' or simply redundant. 3. The premise of this theory; the equalisation of profit rates.

Data was taken from Statistics Bureau of Japan, Statistics Sweden and OECD's symmetric input-output tables, in producers or basic prices, which record monetary flows across industries. The Japanese and Swedish data contain more sectors than the OECD data, which summarizes the original information at a higher level of aggregation, so the results from the former are more significant than from the latter. The Swedish tables also contain supplementary data on fixed capital stocks and labour inputs measured in 1000 persons.

3.1 Estimation of matrix of technical coefficients and labour time

The computation of labour values requires a matrix of technical coefficients that describes the technical conditions of production. The degree of accuracy of the estimated matrix will depend on the level of aggregation of national accounting data. To construct a matrix of technical coefficients using monetary data might at first seem to 'contaminate' the estimated labour values with price data but it has been shown by Cockshott and Cottrell [1, sec. 3] that this is not the case. The fact that the matrix's elements represent a yen's worth of input from sector i required to produce a yen's worth of output in sector j does not invalidate the estimation of technical coefficients.

Sectors lacking either output or labour input figures were excluded from the analysis. 'Finance', 'real estate services', 'public administration, defence and social security' were treated as unproductive expenses which form a part of the gross profits.[2] Sectors such as education and health work services may contain

[2]A deeper analysis and elaboration is not pursued here but a rational definition of productive activities could be proposed, analogous to the Sraffian basic commodities (Sraffa [15, para. 6]), that every activity that directly or indirectly enters into the wage-bundle, and thus reproduces the economy, is productive. (See [7])

a large fraction of non-marketed output but were nonetheless included despite the bias.

For simplicity all units of labour input for the Swedish data was treated as of same skill and intensity so that each unit adds equally to the labour value of a commodity. This introduces an error since we are estimating the labour time *necessary* to produce it at existing standard conditions of production. However, this error decreases as data is aggregated to industry level. For the other countries labour costs were used as a proxy for labour input as is common in the literature.

3.2 Discrete observations

For each sector a discrete observation was obtained: output price P, production inputs C, labour costs V, gross profits[3] S, labour value of output Ψ and production price of output Π. When data on depreciation of fixed capital was available it was treated as a part of C which causes some inconsistency with the computed labour values and production prices since there was insufficient information to estimate the depreciation coefficients. For the Swedish data fixed capital was taken as capital stock K.

Labour values and production prices were estimated following Shaikh and Tonak [14, chap. 4] and Cockshott and Cottrell [1, sec. 2]. Labour value Ψ for each sector was computed by first obtaining the vector of embodied labour-output ratios $\lambda = (I - A)^{-1}l$, where I is the identity matrix, A is the matrix of input-output coefficients[4] and l is the vector of direct labour-output ratios. Labour value for sector i is then its embodied labour-output ratio λ_i multiplied by its output P_i.

Production price Π_i for each sector was computed by first obtaining the vector of production price-output ratios $p = (I - (1 + r_G)A)^{-1}w$, where w is the vector of wage-output ratios. r_G is the 'general rate of profit', which was taken as the mean of the distribution of profit rates on a flow basis, $r = S/(C+V)$. Production price for sector i is then its production price-output ratio p_i multiplied by its output P_i. These prices are consistent with the equalisation of profit rates on the flow of outlays on current inputs. In section 4.4.3 we will return to the issue of the impact of our estimated general rate of profit.

A more sophisticated study should include matrices of estimated depreciation and fixed capital stock coefficients and calculate production prices consistent with the equalisation of profit rates on a stock basis, $r^* = S/K$.

3.3 Probability distributions

In section 4.2 we will investigate distributions of the following variables:

1. ratio of market prices to labour content $\psi = P/\Psi$
2. ratio of market prices to production prices $\pi = P/\Pi$

[3] Basically gross value added plus unproductive costs less wages. Less depreciation of fixed capital if data was available. For consistency between i/o tables cast in producer and basic prices, 'net taxes on products' proportional to the productive inputs were treated as a part of C.

[4] Matrix element a_{ij} represents the input of j required to produce a unit of i.

3. gross profit rate in flow terms $r = S/(C + V)$

4. gross profit share $s = S/(S + V)$

5. composition of output $o = C/(S + V)$

What we would want is to have data on these variables at firm and commodity level. To test Farjoun and Machover's hypothesis of the distribution of price-value ratios would require data for each transaction during, say, a month. However, the available data is for industry sectors so products as polyvinyl chloride will have to merge into 'rubber and plastic products'.

The OECD data was treated as discrete distributions where each sectoral observation was given a weight w_i. For the distribution of $\psi = P/\Psi$ this was $w_i = \Psi_i / \sum \Psi_j$, for $\pi = P/\Pi$ it was $w_i = \Pi_i / \sum \Pi_j$ and for the remaining distributions the weights were $w_i = (C_i + V_i) / \sum (C_j + V_j)$. For Japan and Sweden continuous distributions were estimated following Cockshott and Cottrell [3]; each observation was treated as the mean of a normal distribution since it represents the aggregation of many firms and products.[5] The probability density function (pdf) for variable x is then defined as $f(x) = \sum w_i N_{\mu i,\sigma}(x)$ where $N_{\mu i,\sigma}(x)$ is the normal pdf with mean μ_i (the observation of sector i) and standard deviation σ (which was set to one fifth of the standard deviation of the whole convolving function).

The proability density functions can be interpreted in the following way: The integral $\int_a^b f(r)dr$ gives the fraction of the total social capital earning a profit rate $a < r < b$. And $\int_a^b f(\pi)d\pi$ gives the fraction of the total product, measured in production price, exchanging for a ratio $a < \pi < b$. An analogous interpretation can be held for the remaining pdf:s.

4 Results

4.1 Deviation between market prices, labour values and production prices

One way to quantify the relation between market prices, labour values and production prices is to measure the size of industry outputs in terms of price, labour value and production price and compute how well the measures correlate with each other.[6] Pearson's correlation coefficient ρ quantifies the linear covariation between two sets of data. Expressing the set of prices and labour values relative to that of any specific sector will of course not affect the measure.

Another measure used in the literature is the weighted average of relative deviations, MAWD, using two data sets represented as vectors x and y. MAWD $= \sum w_i |y_i - x_i| / \sum w_i x_i$. It has however the drawback that it is affected by the normalization of the data but allows a comparison with other studies. Following Shaikh [12] prices are rescaled so that the sum of prices equals the sum of labour

[5] There is no significant difference of the summary statistics between the discrete distribution and the continuous approximations.

[6] Hence it would be inappropriate to deflate industry outputs by size, as suggested in Kliman [10, sec. 4], in order to address any spurious correlation arising from aggregation. This should rather be done by using less aggregated data or comparing results to alternative predictors as in section 4.3.

Table 1: Summary of measures of deviation. N denotes number of samples. Results from previous studies: USA 1947 to 1972 from Shaikh [12]; USA 1987 and GBR 1984 from Cockshott and Cottrell [1, 4], correlations on logs of data; GRC 1970 from Tsoulfidis and Maniatis [18], adjusted ρ^2.

			LTV			TPP			
		N	$\rho(P,\Psi)$	MAWD	θ	$\rho(P,\Pi)$	MAWD	θ	$\rho(\Psi,\Pi)$
JPN	1995	85	0.986	0.131	8.88	0.984	0.098	8.71	0.992
JPN	2000	95	0.983	0.141	9.52	0.983	0.088	8.88	0.995
SWE	1995	48	0.956	0.200	14.06	0.984	0.103	7.95	0.975
SWE	2000	48	0.960	0.184	13.21	0.988	0.091	7.03	0.972
USA	1947	71	n.a.	0.105	n.a.	n.a.	0.114	n.a.	n.a.
USA	1958	71	n.a.	0.090	n.a.	n.a.	0.075	n.a.	n.a.
USA	1963	71	n.a.	0.092	n.a.	n.a.	0.076	n.a.	n.a.
USA	1967	71	n.a.	0.102	n.a.	n.a.	0.084	n.a.	n.a.
USA	1972	71	n.a.	0.071	n.a.	n.a.	0.063	n.a.	n.a.
USA	1987	47	0.971	n.a.	n.a.	0.968	n.a.	n.a.	0.936
GRC	1970	35	0.942	0.216	n.a.	0.939	0.154	n.a.	0.950
GBR	1984	101	0.955	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

values or production prices. Weights are set proportional to output size in labour value or production price.

A final measure is to treat the deviation between vectors as a geometric property; as the angle θ, in degrees, between vectors x and y.[7] The results are summarized in Tables 1 and 2 which also includes the correlation between labour values and production prices. Production prices in Shaikh [12] and Tsoulfidis and Maniatis [18] are computed on the assumption of equalisation of profit rates on a stock basis.

In terms of predicting output price the LTV and the TPP are approximately equal, both Ψ and Π are highly correlated with P. In 52 out of 55 data sets the obtained correlation coefficients were above 0.900. The exceptions for labour values were Greece 1994, Norway 1997 and Poland 1995, for production prices the two first countries and West Germany 1978. More detailed national data is required to analyse the causes of this deviation. One can see the effects of aggregation of data between the national and OECD data for Japan 1995, and of methodological differences between Cockshott and Cottrell's study [3] and the OECD data for Britain 1984.

The results are broadly consistent with the results from previous studies summarized in Table 1. It is also notable that Ψ and Π are in terms of correlation close to each other and in several cases closer than either is to P.

4.2 Empirical distributions

The mean values of the distributions are summarized in Tables 3 and 5. For the Swedish data $\psi = P/\Psi$ was measured in units of the average wage rate (the ratio of aggregate wages to labour). When using labour costs as a proxy this rate equals 1 by definition. It is notable that the mean values $\mathrm{E}[\psi]$ across countries

[7] The angle θ is defined by the dot product between the vectors: $x \cdot y = |x||y| \cos\theta$. Note that the unit is degrees. Cockshott [5], however, suggests that the appropriate measures are for vectors in a 'commodity amplitude space'.

Table 2: Summary of measures of deviation. OECD data.

			LTV			TPP			
		N	$\rho(P,\Psi)$	MAWD	θ	$\rho(P,\Pi)$	MAWD	θ	$\rho(\Psi,\Pi)$
AUS	1968	30	0.968	0.108	10.72	0.966	0.134	10.95	0.991
AUS	1974	30	0.982	0.081	8.32	0.976	0.118	9.47	0.994
AUS	1986	30	0.955	0.196	14.09	0.970	0.155	10.64	0.979
AUS	1989	30	0.948	0.218	15.68	0.971	0.161	10.47	0.983
CAN	1971	31	0.977	0.132	9.27	0.974	0.124	9.59	0.988
CAN	1976	31	0.966	0.154	11.46	0.966	0.117	10.99	0.987
CAN	1981	31	0.950	0.179	13.48	0.957	0.131	12.03	0.984
CAN	1986	31	0.974	0.136	9.86	0.963	0.128	11.11	0.972
CAN	1990	31	0.978	0.139	9.52	0.967	0.126	10.84	0.978
CAN	1997	32	0.967	0.130	10.08	0.957	0.136	10.91	0.954
DEU	1978	29	0.942	0.160	11.72	0.882	0.226	16.80	0.951
DEU	1986	29	0.961	0.118	9.53	0.945	0.156	11.12	0.976
DEU	1988	29	0.965	0.113	9.09	0.950	0.153	10.73	0.979
DEU	1990	29	0.968	0.110	8.85	0.952	0.156	10.71	0.981
DEU	1995	33	0.965	0.102	9.89	0.949	0.143	11.83	0.989
DNK	1972	28	0.976	0.109	9.82	0.977	0.120	9.64	0.980
DNK	1977	28	0.974	0.118	10.11	0.982	0.116	8.59	0.976
DNK	1980	28	0.978	0.115	9.17	0.987	0.091	7.06	0.974
DNK	1985	28	0.967	0.134	10.77	0.976	0.133	9.29	0.978
DNK	1990	28	0.974	0.123	9.55	0.976	0.135	9.30	0.981
DNK	1997	36	0.957	0.159	13.03	0.964	0.142	11.62	0.991
FRA	1980	31	0.958	0.120	11.12	0.953	0.182	12.11	0.961
FRA	1985	31	0.959	0.127	10.96	0.952	0.173	12.10	0.952
FRA	1990	31	0.972	0.108	9.34	0.960	0.167	11.47	0.957
FRA	1995	37	0.976	0.078	8.31	0.977	0.122	8.26	0.981
GBR	1968	31	0.990	0.076	5.20	0.980	0.093	7.31	0.985
GBR	1979	31	0.980	0.078	7.49	0.977	0.099	7.92	0.987
GBR	1984	31	0.941	0.128	12.93	0.947	0.127	12.24	0.981
GBR	1990	31	0.952	0.183	13.17	0.953	0.146	13.24	0.985
GBR	1998	37	0.977	0.121	8.88	0.977	0.133	8.91	0.996
JPN	1970	32	0.956	0.145	11.72	0.954	0.167	11.95	0.968
JPN	1975	32	0.960	0.125	11.30	0.967	0.123	10.13	0.982
JPN	1980	32	0.967	0.138	10.50	0.974	0.111	8.91	0.987
JPN	1985	32	0.966	0.152	10.78	0.978	0.100	8.13	0.982
JPN	1990	32	0.984	0.116	8.18	0.986	0.071	6.84	0.983
JPN	1995	37	0.986	0.113	7.80	0.977	0.123	8.99	0.982
JPN	1996	37	0.986	0.115	7.95	0.977	0.125	8.93	0.982
JPN	1997	37	0.985	0.114	8.04	0.975	0.124	9.07	0.980
NLD	1995	35	0.965	0.138	11.34	0.975	0.115	9.36	0.985
NLD	1996	35	0.964	0.139	11.56	0.973	0.115	9.78	0.985
NLD	1997	35	0.966	0.139	11.18	0.975	0.115	9.35	0.985
NLD	1998	35	0.970	0.130	10.50	0.977	0.120	9.03	0.986
CHN	1997	35	0.965	0.212	13.32	0.991	0.105	6.36	0.986
CZE	1995	37	0.986	0.075	6.55	0.984	0.099	7.09	0.987
ESP	1995	36	0.948	0.188	13.18	0.948	0.188	13.21	0.974
GRC	1994	33	0.837	0.384	25.60	0.891	0.318	20.99	0.914
HUN	1998	33	0.982	0.081	7.18	0.977	0.127	8.08	0.969
ITA	1992	35	0.907	0.238	16.74	0.904	0.232	16.99	0.973
KOR	1995	36	0.933	0.171	13.76	0.940	0.174	13.06	0.955
NOR	1997	37	0.863	0.244	23.73	0.872	0.222	22.89	0.983
POL	1995	33	0.888	0.305	20.46	0.913	0.233	18.18	0.969

and time are quite close to each other. This follows from the yet unexplained fact that the aggregate ratio of gross profits to wages, estimated as e_0 in the tables[8], is quite stable and tends to be in the same order of magnitude across industrialized countries.

Under the conditions outlined in section 2.2, Farjoun and Machover predict $\mathrm{E}[\psi] \approx 1 + e_0$. In our data this tends to be an underestimate in most cases, on the other hand it is given for one year under which an economy surely undergoes structural change. They suggest further that $\Pr(\psi < 1)$, i.e. the probability that the market price is insufficient to pay the total labour-power required, at the average wage rate, is low. A guesstimate is that $\psi = 1$ is three standard deviations from the mean on a normal distribution. Figure 1 illustrates this prediction. Sectors with very low price-value ratios are typically health care and education services and similar non-marketed outputs. The outliers in the high ratio region are tobacco and mainly a category of products presumably exhibiting high rent effects such as crude petroleum, natural gas and petroleum refinery products. Figure 1 shows that the predicted normal distribution is a good approximation of the core of capitalist sectors.

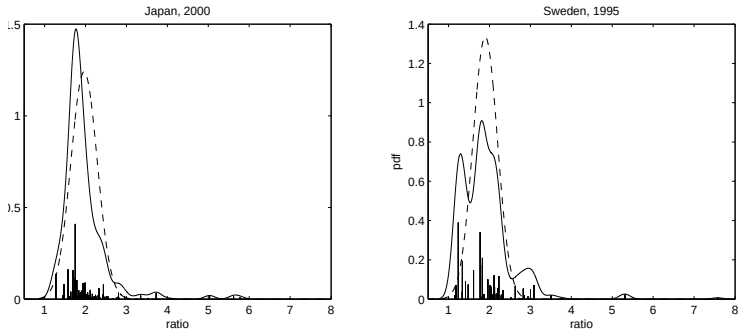

Figure 1: Empirical distributions of price-value ratios. Dashed line represents normal distribution with standard deviation $\sigma_\psi = (\mathrm{E}[\psi] - 1)/3$.

The coefficient of variation (c.v.) measures the dispersion of a random variable as the standard deviation divided by the mean. The results are summarized in Tables 4 and 6. The distributions of $\psi = P/\Psi$ and $\pi = P/\Pi$ remain fairly narrow and narrower than of the other variables. Note that the Japanese and Swedish data excludes two and one oil related sectors respectively while the OECD data makes no such adjustments. The dispersion of the composition of output, $o = C/(S + V)$, tends to be of a certain order, a fact that is typically ignored in theoretical models which can make them quite unrealistic. The tables also show that the distribution of profit rates $r = S/(C + V)$ is wide and shows no consistent tendency to narrow over time. The limited data from Sweden of the distribution of profit rates on a stock basis $r^* = S/K$ does not contradict this conclusion. This is illustrated in Figure 2.

[8]Lacking depreciation coefficients, depreciation was included in gross profits for estimates of e_0.

Table 3: Mean values of empirical distributions. Oil industry excluded. GBR 1984 from Cockshott and Cottrell [3].

		N	ψ	π	r	s	o	e_0
JPN	1995	83	1.973	1.644	0.206	0.357	1.553	0.816
JPN	2000	93	1.946	1.640	0.195	0.345	1.622	0.800
SWE	1995	47	1.884	1.538	0.188	0.338	1.484	0.708
SWE	2000	47	1.807	1.500	0.156	0.299	1.681	0.636
GBR	1984	96	n.a.	n.a.	0.211	0.315	0.846	n.a.

Table 4: Coefficients of variation of empirical distributions. Oil industry excluded. GBR 1984 from Cockshott and Cottrell [3]. GRC 1970 from Tsoulfidis and Maniatis [18], does not exclude oil industry.

		N	ψ	π	r	s	o
JPN	1995	83	0.303	0.276	0.889	0.454	0.735
JPN	2000	93	0.295	0.275	0.900	0.491	0.820
SWE	1995	47	0.321	0.238	0.911	0.432	0.627
SWE	2000	47	0.276	0.194	0.828	0.450	0.725
GRC	1970	35	0.291	0.211	1.262	n.a.	1.417
GBR	1984	96	0.104	0.114	0.608	0.423	0.752

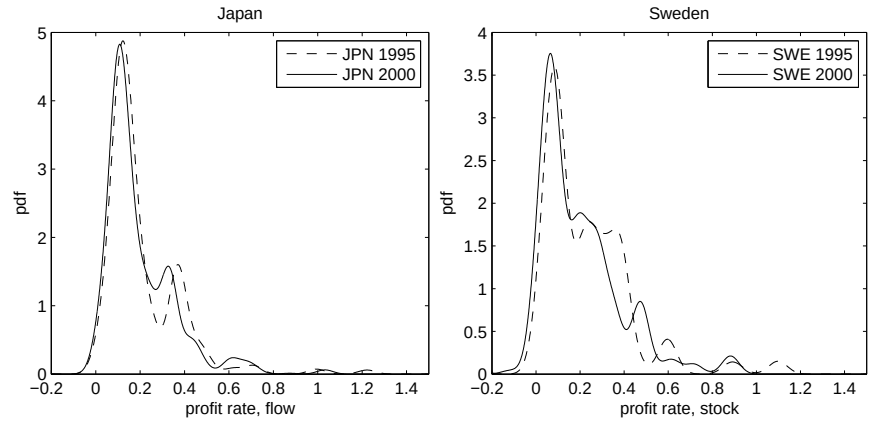

Figure 2: The distribution of profit rates. Coefficient of variation: Japan 0.919 and 0.907; Sweden 0.912 and 0.951, for years 1995 and 2000 respectively.

4.3 Alternative value bases: the empirical evidence

In this section we will address the significance of the empirical results by comparison to alternative value bases. In section 2.1 it was argued that any value base produced as a good would be problematic to use on theoretical grounds. Value bases, such as energy, fuel, chemicals, and products of agriculture, can nonetheless be empirically tested as predictors of market prices.[9] The alterna-

[9]The direct and indirect input of 'Electrical energy, gas, steam and hot water' (energy), 'Coke, refined petroleum products, nuclear fuels' (fuel), 'Chemicals, chemical products and

Table 5: Mean values of empirical distributions. OECD data.

		N	ψ	π	r	s	o	e_0
AUS	1968	30	1.995	1.352	0.330	0.447	1.331	0.951
AUS	1974	30	1.707	1.261	0.272	0.358	1.292	0.683
AUS	1986	30	2.177	1.400	0.438	0.502	0.909	1.049
AUS	1989	30	2.408	1.560	0.489	0.552	0.885	1.238
CAN	1971	31	2.083	1.642	0.322	0.416	1.190	0.812
CAN	1976	31	2.115	1.652	0.329	0.495	1.051	0.829
CAN	1981	31	2.243	1.708	0.328	0.437	1.795	0.901
CAN	1986	31	2.240	1.670	0.364	0.465	1.248	0.953
CAN	1990	31	2.190	1.655	0.362	0.451	1.352	0.913
CAN	1997	32	1.899	1.353	0.317	0.439	1.365	0.791
DEU	1978	29	1.827	1.339	0.217	0.346	1.769	0.633
DEU	1986	29	1.847	1.402	0.222	0.375	1.461	0.629
DEU	1988	29	1.847	1.402	0.234	0.378	1.364	0.646
DEU	1990	29	1.887	1.413	0.252	0.393	1.298	0.697
DEU	1995	33	1.757	1.348	0.284	0.360	1.107	0.674
DNK	1972	28	1.861	1.266	0.327	0.405	1.410	0.850
DNK	1977	28	1.844	1.265	0.291	0.419	1.510	0.794
DNK	1980	28	1.759	1.188	0.260	0.419	1.575	0.733
DNK	1985	28	2.076	1.430	0.308	0.455	1.658	0.908
DNK	1990	28	1.997	1.399	0.347	0.449	1.153	0.905
DNK	1997	36	1.833	1.476	0.253	0.362	1.286	0.613
FRA	1980	31	1.945	1.231	0.356	0.473	1.188	0.959
FRA	1985	31	2.061	1.282	0.399	0.493	1.086	1.057
FRA	1990	31	2.297	1.388	0.512	0.552	0.856	1.299
FRA	1995	37	1.741	1.234	0.274	0.410	1.263	0.711
GBR	1968	31	1.619	1.212	0.233	0.382	1.360	0.616
GBR	1979	31	1.688	1.264	0.222	0.387	1.558	0.649
GBR	1984	31	1.974	1.353	0.314	0.450	1.451	0.896
GBR	1990	31	2.091	1.328	0.413	0.481	0.969	1.125
GBR	1998	37	1.743	1.294	0.265	0.398	1.122	0.702
JPN	1970	32	2.760	1.931	0.272	0.524	2.093	1.174
JPN	1975	32	2.285	1.772	0.223	0.439	2.079	0.787
JPN	1980	32	2.347	1.824	0.214	0.451	2.097	0.788
JPN	1985	32	2.282	1.754	0.235	0.465	1.741	0.797
JPN	1990	32	2.189	1.642	0.262	0.469	1.545	0.824
JPN	1995	37	1.811	1.358	0.302	0.410	1.078	0.717
JPN	1996	37	1.832	1.367	0.313	0.417	1.034	0.734
JPN	1997	37	1.810	1.355	0.305	0.410	1.041	0.713
NLD	1995	35	1.936	1.402	0.285	0.429	1.449	0.798
NLD	1996	35	1.929	1.399	0.276	0.429	1.527	0.787
NLD	1997	35	1.923	1.391	0.273	0.432	1.574	0.786
NLD	1998	35	1.887	1.366	0.271	0.428	1.438	0.769
CHN	1997	35	1.992	1.305	0.217	0.488	1.939	0.873
CZE	1995	37	2.212	1.313	0.230	0.505	2.150	1.052
ESP	1995	36	2.025	1.326	0.334	0.454	1.393	0.958
GRC	1994	33	3.153	1.381	0.670	0.619	1.235	2.152
HUN	1998	33	2.225	1.482	0.271	0.504	1.830	0.990
ITA	1992	35	2.315	1.451	0.407	0.495	1.195	1.217
KOR	1995	36	2.519	1.448	0.340	0.558	1.648	1.293
NOR	1997	37	2.037	1.400	0.324	0.377	1.463	0.899
POL	1995	33	2.531	1.461	0.327	0.512	2.013	1.318

Table 6: Coefficients of variation of empirical distributions. OECD data.

		N	ψ	π	r	s	o
AUS	1968	30	0.235	0.229	0.811	0.307	0.691
AUS	1974	30	0.222	0.233	0.900	0.398	0.902
AUS	1986	30	0.255	0.222	0.600	0.324	0.746
AUS	1989	30	0.285	0.209	0.537	0.289	0.685
CAN	1971	31	0.218	0.227	0.795	0.284	0.796
CAN	1976	31	0.279	0.271	0.998	0.810	0.764
CAN	1981	31	0.308	0.287	1.027	0.306	1.402
CAN	1986	31	0.242	0.262	0.862	0.263	0.834
CAN	1990	31	0.241	0.261	0.794	0.256	1.294
CAN	1997	32	0.222	0.223	0.783	0.301	1.225
DEU	1978	29	0.235	0.273	0.800	0.630	1.107
DEU	1986	29	0.196	0.201	0.631	0.441	0.764
DEU	1988	29	0.189	0.200	0.612	0.475	0.697
DEU	1990	29	0.188	0.201	0.612	0.490	0.617
DEU	1995	33	0.293	0.316	0.937	0.411	0.776
DNK	1972	28	0.232	0.208	0.774	0.411	0.932
DNK	1977	28	0.220	0.174	0.700	0.372	0.982
DNK	1980	28	0.191	0.146	0.627	0.394	0.855
DNK	1985	28	0.279	0.219	0.774	0.331	1.234
DNK	1990	28	0.277	0.260	0.779	0.303	0.793
DNK	1997	36	0.317	0.292	0.904	0.432	1.401
FRA	1980	31	0.236	0.238	0.647	0.369	0.683
FRA	1985	31	0.232	0.238	0.622	0.332	0.625
FRA	1990	31	0.217	0.227	0.511	0.202	0.584
FRA	1995	37	0.190	0.185	0.608	0.323	0.693
GBR	1968	31	0.106	0.123	0.572	0.303	0.714
GBR	1979	31	0.190	0.185	0.789	0.416	0.657
GBR	1984	31	0.343	0.305	1.098	0.359	1.078
GBR	1990	31	0.251	0.245	0.711	0.529	0.477
GBR	1998	37	0.193	0.178	0.591	0.348	0.505
JPN	1970	32	0.260	0.261	0.780	0.281	0.591
JPN	1975	32	0.259	0.233	0.805	0.386	0.724
JPN	1980	32	0.248	0.212	0.670	0.377	0.648
JPN	1985	32	0.234	0.192	0.506	0.343	0.609
JPN	1990	32	0.201	0.173	0.431	0.261	0.628
JPN	1995	37	0.240	0.226	0.766	0.349	0.717
JPN	1996	37	0.237	0.221	0.739	0.344	0.705
JPN	1997	37	0.242	0.225	0.754	0.349	0.715
NLD	1995	35	0.336	0.285	0.967	0.409	0.814
NLD	1996	35	0.362	0.312	1.046	0.373	0.859
NLD	1997	35	0.345	0.294	1.025	0.357	0.895
NLD	1998	35	0.311	0.265	0.912	0.364	0.677
CHN	1997	35	0.203	0.125	0.580	0.399	0.465
CZE	1995	37	0.143	0.147	0.556	0.298	0.504
ESP	1995	36	0.252	0.245	0.833	0.359	0.689
GRC	1994	33	0.528	0.432	0.860	0.309	0.916
HUN	1998	33	0.157	0.155	0.528	0.277	0.690
ITA	1992	35	0.332	0.341	0.849	0.364	0.580
KOR	1995	36	0.292	0.284	0.810	0.286	0.557
NOR	1997	37	0.537	0.520	1.942	0.505	0.788
POL	1995	33	0.362	0.311	1.068	0.406	0.738

tive values of industry outputs were calculated the same way as labour values (see section 3.2) but the direct labour inputs were substituted by the alternative direct inputs. From a theoretical point of view it is worth noting that e.g. to produce 1 unit of fuel requires total 0.069 units of fuel. The results are summarized in Table 7. The alternatives clearly fall short in the presence of labour which indicates that its empirical strength is not a statistical artefact.

Table 7: Measures of deviation from market prices, 48 samples. Sweden, 1995.

	ρ	θ	C.V.
Agriculture	0.192	73.29	2.085
Chemical	0.471	46.58	0.815
Fuel	0.541	40.81	0.833
Energy	0.722	31.83	0.540
Labour	0.956	14.06	0.343

Kliman [10] argues that this is not a significant result since it follows from the close correlation between prices and costs. Indeed this was shown in section 2.3. But the objection has it backwards, for what are costs if not prices? Surely, a labour theory of value cannot fall short to something as tautological as a cost theory of value.

4.4 Some theoretical considerations

4.4.1 Equalisation of profit rates

There is no evidence that the dispersion of profit rates is small or that it tends to decrease over time. As pointed out in section 2.4, however, the TPP rests on the idea that the equalisation renders profit rates statistically independent of capital-wage ratios, and similar compositions of capital.[10] Tables 8 and 9 show that this is not the case. In most data sets there is a significant negative correlation between profit rates in flow terms $r = S/(C + V)$ and compositions of output $o = C/(S+V)$, and also between profit rates in stock terms $r^* = S/K$ and capital-wage ratios $o^* = K/V$.

Cockshott and Cottrell [3] also find a positive correlation between composition of output and profit shares. This mechanism would indeed push profit rates closer to each other as a fraction of firms with high compositions would be 'compensated' with higher profit shares. It appears to be more of a British, rather than universal, feature of capitalism as there is no consistent tendency in the data and few correlations are statistically significant.

4.4.2 The assumptions of the transformation problem

We can also address the two extreme assumptions of the transformation problem: (i) a common profit-wage ratio, the 'ideal case' for labour values. (ii)

man-made fibres' (chemical) and 'Products of agriculture, hunting and related services' (agriculture).

[10] Such as $o = C/(S + V)$ to be consistent with the methodology in Cockshott and Cottrell [3].

Table 8: Correlations between variables. Correlations in panel (b) weighted by K. Figures with * indicate $p > 0.05$. GBR 1984 and USA 1987 from Cockshott and Cottrell [3, 4].

(a)		N	$\rho(r, o)$	$\rho(r, 1/o)$	$\rho(o, s)$
JPN	1995	85	-0.333	0.533	0.147*
JPN	2000	95	-0.332	0.550	0.156*
SWE	1995	48	-0.304	0.735	-0.078*
SWE	2000	48	-0.361	0.645	-0.117*
GBR	1984	96	-0.288	n.a.	0.369
(b)		N	$\rho(r^*, o^*)$	$\rho(r^*, 1/o^*)$	$\rho(o^*, s^*)$
SWE	1995	48	-0.478	0.758	0.538
SWE	2000	48	-0.520	0.758	0.438
USA	1987	47	-0.454	0.780	n.a.

equalised profit rates, the 'ideal case' for production prices. If the profit rate $r^* = S/K$ is re-written as $r^* = s^*/o^*$, where $s^* = S/V$ and $o^* = K/V$, it is clear that the assumptions predict two different sets of profit rates:

1. $r_1 = e_0/o^*$, where e_0 is the average profit-wage ratio.
2. $r_2 = \mathrm{E}[r^*]$, which is the mean profit rate.[11]

Both sets are compared to the empirical profit rates in Figure 3. Empirical data does not fall neatly onto either of these predicted profit rates, but it is clear that assumption (i) is better in accounts with reality than (ii). This is further implied by the positive linear correlation between profit rates and the inverse capital-wage ratio in Table 8.

4.4.3 Production prices and the general rate of profit

Production prices Π were computed from $p = (I-(1+r_G)A)^{-1}w$, where r_G is the general rate of profit towards which profit rates are thought to gravitate. If $r_G = 0$ production prices are proportional to labour values, when abstracting from wage-rate differentials across industries. How will an increase in this parameter affect the deviation of production prices to market prices? To answer this r_G was set to 501 equally spaced values in the interval [0,0.50], resulting in 501 different sets of production prices. For each set the correlation coefficient $\rho(P, \Pi)$ was calculated. The result is shown in Figure 4 where $\rho(P, \Pi)$ is plotted against r_G.

Increasing r_G, which pushes production prices further apart from labour values, does lead to a slight improvement in predictive power for Sweden but marginally for Japan and negatively for Germany, acting only as a disturbance on the matrix of technical coefficients. It is notable that when it is set to 0.50, roughly two times greater than the empirical estimate, correlation coefficients are still above 0.9. This could help explain the puzzling fact that despite the anomalies for the TPP its predictive power is approximately equal to the LTV.

[11] Since the distribution of r^* is weighted by K, $\mathrm{E}[r^*]$ is equivalent to the theoretical 'general rate of profit' on a stock basis.

Table 9: Correlations between variables. OECD data. * indicates $p > 0.05$.

		N	$\rho(r, o)$	$\rho(r, 1/o)$	$\rho(o, s)$
AUS	1968	30	-0.456	0.716	0.159*
AUS	1974	30	-0.366	0.454	0.076*
AUS	1986	30	-0.550	0.598	0.153*
AUS	1989	30	-0.566	0.557	0.322*
CAN	1971	31	-0.473	0.786	-0.142*
CAN	1976	31	0.123	0.670	-0.922*
CAN	1981	31	-0.325	0.718	0.020*
CAN	1986	31	-0.473	0.854	-0.062*
CAN	1990	31	-0.390	0.773	-0.116*
CAN	1997	32	-0.346	0.633	0.034*
DEU	1978	29	-0.359*	0.427	-0.368
DEU	1986	29	-0.377	0.308*	-0.116*
DEU	1988	29	-0.462	0.344*	-0.195*
DEU	1990	29	-0.475	0.376	-0.188*
DEU	1995	33	-0.369	0.486	-0.112*
DNK	1972	28	-0.483	0.678	-0.112*
DNK	1977	28	-0.408	0.640	0.188*
DNK	1980	28	-0.376	0.559	0.358*
DNK	1985	28	-0.284*	0.623	0.251*
DNK	1990	28	-0.327*	0.820	0.013*
DNK	1997	36	-0.213*	0.556	-0.070*
FRA	1980	31	-0.529	0.642	-0.007*
FRA	1985	31	-0.650	0.698	-0.188*
FRA	1990	31	-0.697	0.646	-0.216*
FRA	1995	37	-0.565	0.362	-0.160*
GBR	1968	31	-0.405	0.442	0.437
GBR	1979	31	-0.348*	0.577	0.392
GBR	1984	31	-0.244*	0.651	0.383
GBR	1990	31	-0.460	0.560	-0.023*
GBR	1998	37	-0.476	0.490	-0.125*
JPN	1970	32	-0.522	0.428	0.113*
JPN	1975	32	-0.353	0.421	0.358
JPN	1980	32	-0.419	0.549	0.420
JPN	1985	32	-0.393	0.368	0.416
JPN	1990	32	-0.476	0.369	0.252*
JPN	1995	37	-0.443	0.419	-0.012*
JPN	1996	37	-0.431	0.441	0.041*
JPN	1997	37	-0.425	0.411	0.031*
NLD	1995	35	-0.374	0.450	-0.407
NLD	1996	35	-0.354	0.471	-0.105*
NLD	1997	35	-0.341	0.458	-0.014*
NLD	1998	35	-0.438	0.406	-0.043*
CHN	1997	35	-0.522	0.538	0.298*
CZE	1995	37	-0.628	0.638	-0.214*
ESP	1995	36	-0.574	0.381	-0.034*
GRC	1994	33	-0.555	0.253*	-0.155*
HUN	1998	33	-0.539	0.553	0.230*
ITA	1992	35	-0.659	0.261*	-0.539
KOR	1995	36	-0.553	0.390	0.180*
NOR	1997	37	-0.315*	0.694	0.138*
POL	1995	33	-0.415	0.380	0.156*

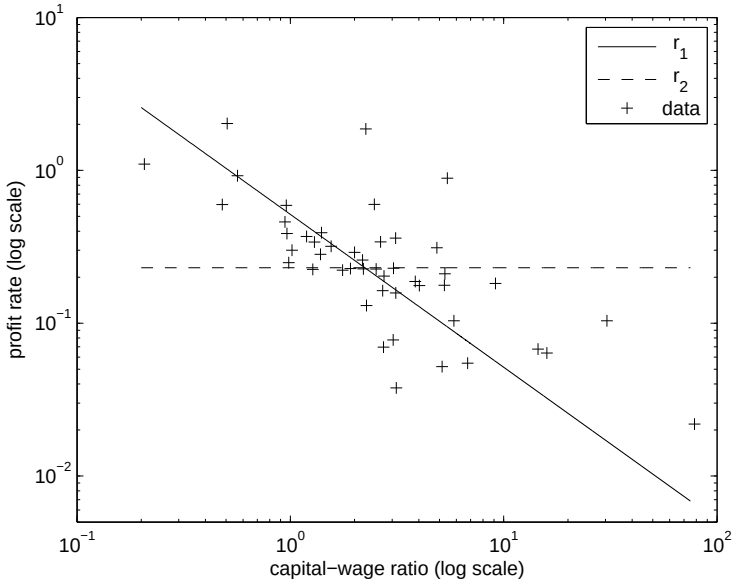

Figure 3: Profit rates versus capital-wage ratios, in log-log scale, 47 samples (negative data excluded). Sweden 1995.

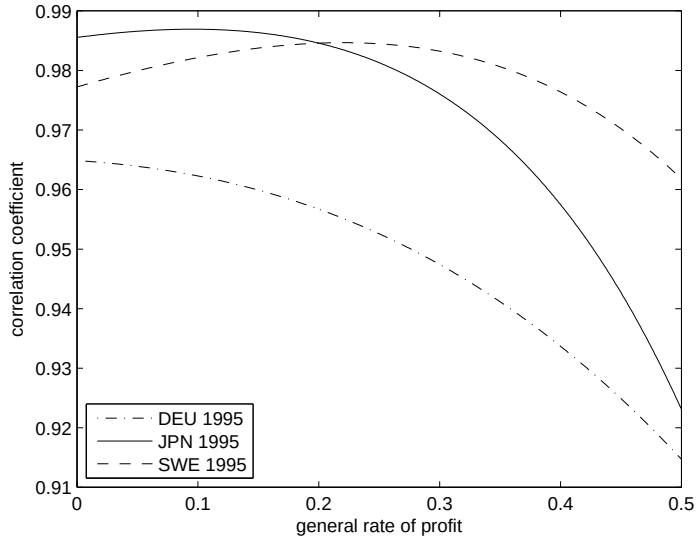

Figure 4: Correlation coefficent $\rho(P, \Pi)$ versus general rate of profit r_G. Note that r_G was set to 0.284 (Germany), 0.212 (Japan) and 0.186 (Sweden) respectively, for 1995.

5 Conclusion

We have found that market prices and labour value of industry outputs are highly correlated for a fairly broad sample of economies covering different sizes, levels of development and institutional structures. The results are in line with similar studies done for the US, Britain, Greece, Italy, former Yugoslavia and Mexico. (See Tsoulfidis and Maniatis [18].) The distribution of price-value ratios remains narrow in relation to the distribution of profit rates and alternative value bases and is broadly consistent with the prediction Farjoun and Machover made some twenty years ago. The results for the alternatives indicate that the empirical strength of labour is not a statistical artefact.

Production price is not found to be a superior predictor of market price and indeed deviates little from labour values. The equalisation of profit rates does not appear to operate in the way assumed by the theory of production prices: The distributions of profit rates were wide and showed no consistent sign of narrowing over time. Whatever forces pushing profit rates closer, they are always checked by counter-forces so profit rates should instead be thought to conform to some statistical distribution when the economy is in a stable condition. The profitability mechanism that pushes firms to move from low to high return industry sectors is likely to operate on a longer time-scale than the more immediate constraints imposed by the need to pay the wage-bill and by technical conditions represented by the production matrix. Reducing the scale of production in one sector while building up capital stocks in another is by its nature a relatively slow process. These constraints explain why the simple labour theory of value is better in accounts with empirical data than the theory of production prices.

Further research must explain why the disturbance between labour values and market prices, arising from variations in the vertically integrated profit-wage ratio, is relatively low. For each firm this ratio is the weighted average of the direct profit-wage ratios of all producers that enter directly and indirectly in its output. Part of the explanation lies in the level of interconnection in modern economies but the question that remains is what restricts the dispersion of direct profit-wage ratios?

The results suggest that labour value is an attractor to market price. This could be interpreted as a practical way for market economies, capitalist or socialist, to regulate social labour, a special case of a general economic problem. Market prices are then a measure of labour value and, according to measurement theory, they will be subject to (1) random errors caused by supply-demand discrepancies which are necessary for the market to regulate social labour, (2) systematic errors caused by profit rate equalising mechanisms and rent effects. From this perspective the preoccupation with the "transformation problem" appears to be a mistake, drawing time and effort away from useful theoretical and empirical research aimed at uncovering the processes of economies governed by market exchange.

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