Does market price converge towards natural price? Input Output Analysis of Japan for 1951-2000

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Abstract

David Ricardo thought that market price fluctuates around natural prices, and that natural prices are regulated by the total labor requirements of commodities. That is, total labor required to produce that commodity (total labor requirements) determine the value of that commodity, and that relative prices are determined by its value. This paper tries to examine this discourse using data from input output tables, its supporting tables and other labor statistics of Japan.

Market prices and natural prices for outputs of 32 industries of Japan for years 1951 to 2000 were calculated. First set of Natural prices were calculated solving simultaneous equations based on input output tables as prices that achieve equal return to those engaged in production. Second and third sets of natural prices were calculated as which whose relative prices are equal to the relative value of total labor requirements by proportioning the depreciation value to each industries using capital formation table.

Findings are as follows. (i) Divergence between market prices and natural prices for all industries fluctuate. The gaps between the two prices are relatively small for 1960 and 1980, while the gap widens for years 1970, 1990 and 2000. Simple statement such as market prices converge towards natural prices does not hold with all industries, by standard deviation. (ii) When all industries other than agriculture are taken into consideration,

market prices converge towards natural prices. (iii) When narrowly defined manufacturing industries, mainly machineries only are taken into account, market prices converge towards natural prices. These movements may be explained by international competition of free entry and exit as machineries are traded goods and also by the standardized wage negotiation process of manufacturing sectors, especially of machineries. (iii)Profitable industries at profitable periods diverge from natural prices.

This is preliminary analysis. There are yet more room for improvements in data, and methodology (treatment of depreciation and traded inputs). However it may be possible to conclude that where there are competition both in commodity market and in factor market, there are tendency for the market prices of output to converge towards natural prices.

1. Introduction

There are stream of works on the determination of prices. While many economists emphasize demand and supply to determine market prices, there are some economists that think that there are some theoretical movements behind market prices.

David Ricardo in his book of “Principle of Political Economy and Taxation” analyzes as follow. Value of commodity is determined by the amount of labor bestowed to produce such a commodity. Natural prices are prices determined relative to such value, and market prices accidentally digress from such prices. However, prices are in a long run determined by natural prices.

Labor theory of value is neglected these days. Political environment, such that socialist economies are facing transition to market economy might be in the background for such theoretical movements. Negligence of labor theory of value came in the understanding that Marxian economics does not require labor theory of value, which was advocated by Morishima may be another

strong influence. In the debate between Morishima and Okishio, however, Okishio was on the labor theory of value criticizing Morishima that his statement does not hold when the input output coefficient matrix was not indecomposable. That is, when input output coefficient matrix is indecomposable, any commodity becomes necessity commodity and so commodity can be replaced to measure value. Therefore labor is not needed to be an only factor of production to measure value. Then Okishio proceed to name industry producing weapons. As there are no industry that takes weapon as intermediate inputs, economy should be understood as decomposable. If so, indecomposability of economy cannot be satisfied. Then, commodity cannot be taken as measurement of value. Therefore labor theory of value should hold. Even if the transaction table is indecomposable, you might argue that basic goods (wage goods) can be taken as measurement of value. However I do not take the view that labor can be replaced by the amount of basic goods to reproduce labor.

However, Okishio's view is minority. Leon Walrus considers demand and supply functions and relative prices are determined simultaneously in the market. Keynes' model is basically one sector model and the price level compared to wages, interest rates mattered. In such circumstances, labor theory of value is neglected.

However, are there no theoretical movements behind market prices? Are market prices always optimum? Do market prices always demonstrate first best prices without distortions? The purpose of this paper is not to measure the difference between the first best world that must prevail without externalities, no increasing return, perfect foresight, perfect competition and the reality. My question is, if there are any theoretical movements behind the market prices in the long run. In the long run, there are competition among firms, output markets, intermediate markets, and also in the factor markets. How and where do these competition lead the market prices? This is the question to be asked, and in the following I will construct natural prices and compare the market prices to natural prices.

2. Labor Value and on Calculation of Total Labor Requirements.

I wish to explain about the method of calculation of labor value or total labor requirements. Total labor requirements may be considered as labor bestowed to produce the commodity. Let me denote the total labor requirements of each industry by t_j and its vector by row vector $\boldsymbol{t}$. When a_{ij} is the ij factor of input output coefficient matrix $\mathbf{A}$ and l_j is the direct labor coefficient of

industry *j* , total labor requirement is obtained by direct labor coefficient vector ***l*** post multiplied by Leontief Inverse.

$$t = l(I - A)^{-1}$$

This can be explained in two ways. Leontief thought that in order to produce one unit of commodity of each sector it is necessary to produce one unit times Leontief inverse. Therefore, the labor required to produce one net product are net product times Leontief inverse times labor coefficients.

The same equation can be interpreted as equation solving simultaneous equation of n unknowns of total labor requirements.
When total labor requirements of sector j is denoted by t_j , row vector of total labor requirements ***t*** can be solved as sum of total labor contained in intermediate inputs plus direct labor requirements.

$$t = tA + l$$

$$t = l(I - A)^{-1}$$

Above solution needs further improvements when applied to real calculation. One problem is depreciation of capital, and another is calculation of imported inputs.

Depreciation.

Capital is always the most problematic issue in input output analysis as input output tables are flow tables. If capital formation table is available, depreciation allowance of each sector can be proportioned to each industry supplying capital goods. That is, the depreciation allowance of sector *j* denoted by Z_j are allocated (proportioned) to each industry of origin as

$$d_{ij} = \frac{K_{ij}}{\sum_i K_{ij}} \frac{Z_j}{X_j}$$

Where K_{ij} is the *i* component of *j* industry's capital formation obtained from the capital formation table. X_j is the total output of *j* industry. Therefore d_{ij} denotes the *i* depreciation coefficient of industry *j*.

Then the equations to obtain total labor requirements are modified as

$$t = t(A + D) + l$$

$$t = l(I - A - D)^{-1}$$

where ***D*** denotes depreciation coefficients matrix.

Import and Export

Treatment of imported commodity may have several ways. One way is to treat all imports as competitive and treat imported commodity exactly as domestically produced products. However results of this treatment did not give good results for Japan. Let us call this treatment as ultra fair trade model. As Japan highly depends on imports of energy, prices of energy related imports were to be over-valued by this replacements.

The (labor) value of imported inputs are unknown. In order to determine the unknown value, a method to replace the imported value by the labor value contended in the same monetary value of exports to purchase the imported inputs is developed in Japanese tradition ( ). This does not necessarily assume balance in the current account of balance of payments, however any purchase are eventually paid (it might be paid by capital return or transfer but as input output analysis does not assume intertemporal equilibrium and so time is not included in the analysis, concept that requires different time horizon are neglected.) Let us assume that in order to purchase imported inputs, tradables (exportables) are produced. Labor value of imported inputs are replaced by the labor value of average export times the monetary value of imported inputs. By denoting average export components by vector ***e'***, and row vector of imported inputs by ***m***, the labor value of unit inport which is denoted by t^m must equal ***te'*** (multiplication of each average export contents by its total labor requirements).

Then the equations of total labor value are modified as,

$$t = t(A^d + D) + t^m m + l$$
$$t^m = te'$$

By inserting the second equation the first equation gives,

$$t = t(A^d + D) + te'm + l$$

This can be solved as

$$t = l(I - A^d - D - e'm)^{-1}$$

Export component vector are calculated as $e_j = \frac{e_j}{\sum_j e_j}$ and therefore $\sum_j e_j = 1$

Domestically produced input output coefficients are calculated as the proportion of total output to domestic products using the proportion from the final demands. That is, taking the proportion of total imports to total output as μ, $a_{ij}^d = \frac{1}{1+\mu} a_{ij} = \frac{1}{1+M_i / X_i} a_{ij}$

Therefore, import coefficients can also be calculated as

$$a_{ij}^m = \frac{\mu}{1+\mu} a_{ij} = \frac{M_i / X_i}{1+M_i / X_i} a_{ij}$$

Then,

$m_j = \sum_i a_{ij}^m$

Import coefficient vector is a row vector of import these m_j s.

3. Natural prices

Natural prices are obtained basically in two methods. This is because precise capital depreciation matrix was not obtainable.

First set of natural prices were obtained as prices that will achieve equal return to all labor participated in production. That is, natural prices row vector ***p*** are calculated as prices that achieve

$$p = pA + d + y^* l$$

Where y* is average income per labor participated in production (scalar). As depreciation matrix is not obtained, depreciation of each industry are added to price equation as vector ***d***. Solution of the above equation is obtained by solving n simultaneous equations

$$p = (y^* l + d)(I - A)^{-1}$$

However, as I mentioned earlier, this treatment of import and export did not give good result for mineral and oil related industries. Therefore, the

calculation was based on the equations that converts the imported value by the total labor requirements embodied in the same monetary value of exports

$$p = pA^d + pe'm + d + y^* l$$

Therefore the solution was obtained as

$$p = (y^* l + d)(I - A^d - e'm)^{-1}$$

This solution is called as solution obtained from program. N simultaneous equations (32 simultaneous equations) were solved. Row vector of the sum of average labor remunerations plus depreciation cost taken as fixed cost is post multiplied by the import/export modified Leontief Inverse Matrix.
The transaction table was integrated into 32 sectors for 1951 to 1980, while 32 sector transaction tables were available for 1990 and 2000. Data on labor coefficients were obtained from various tables, both population census, labor statistics, and supplementary tables of input output tables ().

Second and third sets of solution were obtained as follows. As total labor requirements of industries data compiled by Izumi-Lee was available, using these data, relative prices that equal to the relative amount of total labor requirements were calculated.
By using data on total labor requirements, natural prices must fulfill the following

$$\frac{t_i}{t_j} = \frac{p_i}{p_j}$$

That is, relative prices must equal to relative value of total labor requirements to produce such commodities. Therefore, by calculating average income y*, prices must be obtained as
$p_i = y^* t_i$ for all i.

Here, average income per labor engaged in production are sum of all value added (sum of final demands) divided by sum of direct labor force. This set of prices is called as second set of natural prices, prices obtained by equal income. This did not give good result as prices obtained from program. (This is basically because of the data on total labor requirements of year 1970)

Therefore, calculation was modified to give another set of prices as

$$p_i = \lambda t_i$$

where

$$\lambda = \frac{\sum_i X_i}{\sum_i t_i}$$

$$X = (I - A^d - D - e'm)^{-1} F$$

$$t = l(I - A^d - D - e'm)^{-1}$$

D is a depreciation matrix. ***e'm*** represent that imported inputs are replaced by labor embodied in same value of exports.

That is ramda is obtained as sum of total output (sum of control total) divided by all sector's total labor requirements(sum of both direct and indirect labor requirements). This value of ramda is very close to average income per labor in production for year 1980, 1990 and 2000, but varies from that in 1970 considerably. There must be enquiry why that difference occurs for year 1970. However due to this reason, instead of income per labor engaged, total output per total labor was used as ramda. This calculation will be called as natural price obtained by ramda. (this is third set of prices)

Careful reader might think the prices that equalizes the income of all labor participated in production might differ from prices which are relatively equal to total labor requirements. The two sets of prices are identical. That can be proved as follow.
By denoting the value of commodity as total labor requirements by t,
$$t = l(I - A^d - D - e'm)^{-1}$$
The natural prices of commodities must fulfill the following
$$\frac{p_j}{p_i} = \frac{t_j}{t_i}$$

Assuming

$p_i = \lambda t_i$ holds for any i, then,

$$p = \lambda t = \lambda l(I - A^d - D - e^{'}m)^{-1}$$

Rewriting gives,

$$p(I - A^d - D - e'm) = \lambda l$$

That is,

$$p = p(A^d - D - e'm) + \lambda l$$

Therefore, return for all labor is equal. (Value added per labor are all equal in all sectors.) That is, natural price are prices that give equal return to all labor in production.

The following might be repetition of what I wrote earlier, however, I wish to clarify the idea of measuring the gap between the market price and the natural prices. Natural price of time 1 is different from natural price of time 2. Market prices are normalized to 1 for all sector for all periods. The ratio between 1 and natural prices, or the difference between 1 and natural prices measure the difference between the market price and natural prices of each period.

When there are discrepancy between demand and supply, the gap will be adjusted either by prices, or by quantities. Price adjustments are called as Walrasian adjustment and quantity adjustment are called Marshallian adjustments. The purpose of this paper is not to show the speed of market price adjustments between equilibrium market price and the distorted real prices. The differences that are measured are the difference between natural prices and the real market prices. Real market prices are subject to different degree of monopoly/oligopoly, increasing returns, different degree of market shares, different degree of factor market distortions, and other institutional constraints.

4. EMPIRICAL RESULT

Natural prices obtained through program show better results than natural prices obtained from data on total labor requirements. The data on total labor requirements (in real terms) seems to be over-valued for 1970 and did not give good results. The empirical results will follow on results on program.

The natural prices obtained from program are not identically relative to total labor requirements except for 1951. The data on 1951 has no data on depreciation allowances and ***d*** vector is identical to zero, programmed

natural prices are identically (relatively) equal to total labor requirements. For other years, 1960 to 2000, prices are quasi-identical to relative values of total labor requirements.

From calculating standard deviation of natural prices minus 1(market prices of each period), all industries show 0.36 (1951), 0.32(1960), 0.40(1970), 0.34(1980), 0.42(1990) and 0.44(2000). If agriculture is deleted, the standard deviation becomes 0.28(1951), 0.24(1960), 0.31(1970), 0.22(1980), 0.23(1990) and 0.20(2000). Therefore there are tendency for the natural prices to converge towards market prices (other than 1970) for all industries other than agriculture.

From the graph, the movements of prices are clearer. There is one point to note to see this graph. The data on labor participated in production for industries for sector 26 (education) for 1951, and data for 28 (other public service) requires revision. There is no output data on other public service sector for 1951 and this results in zero natural price for sector 28 for 1951. Labor engaged in religious activities are included in 1951 to education, requires revision. Direct labor input data for sector 28 for 1970 requires revision. Reclassification of services sectors are induced in 1985, and therefore direct labor data requires another check for services sector especially for personal services, business services, and other public services. There are activity such as machinery maintenance or repair which was included in the machinery sector before the reclassification, which are included in business service after the reclassification. This change cannot be treated. (Number of labor associated this activity before 1985 cannot be counted) Such limitation should be kept in mind.

From the overall movements for 1951 to 2000, there are quite a clear trend that market prices are converging towards natural prices. The gap between market prices and natural prices are decreasing over time.

The only exception is agriculture for all the period. The noticed movement against this trend are, communication (1990-2000), transport machinery (1970s), iron and steel, and general machinery (1980s). These may be explained as the period that these industries are highly profiatable but free entry to these industries were yet limited or difficult.

The market prices of oil and coal and electricity stay high compared to natural prices. These are industries where market forces do not work as these are highly protected, or oligopoly, or regional monopoly except coal.

Even for highly profitable industries as finance and insurance and real estate, market prices are very slowly moving (lowering) towards natural prices.

Manufactures can be classified to two groups. Market prices of light manufactures rise toward natural prices. Market prices of heavy manufacturing industries lower towards natural prices. The movements of industries 8 to 15 (metal related machinery industries) are very clear. Probably this is one of the most clear finding of this study.

Food processing, textile and commerce require increasing of efficiency or increase of market prices.

More efficiency is required, or even exit from the market might be required in light industries which face low international output prices. Also commerce, recent construction (2000), and personal services needs more efficiency. Elderly care also requires revision.

More free entry are required in oil plus coal, mining, water, electricity plus energy supply, finance plus insurance and real estate. Output prices of these industries should become lower.

Detailed observation by industrial groups.

From agriculture to oil and coal products

Agriculture Agricultural market prices are diverging from natural prices. The gap between the market prices and natural prices are increasing over time. Calculation of direct number of labor engaged in production might require revision. As agriculture is seasonal work, the number might require seasonal adjustment (multiplying by 0.69). As taking side jobs were common in agricultural sector , this fact might require revision. Production of home consumption might require revision of output data. (income or output data might need to be re-estimated to include these home production). The former revisions, will revise agricultural natural price to decrease. At the same time, they increase the natural prices of all the other products, and this will reduce the gap between the natural price and market prices of all other sectors.

Oil and coal products. Market prices of this industry remain low. The protected nature of this industry, oligopoly is apparent over time. However if we take ultra-fair trade model, this sector's natural price becomes very high (about 3 times). That is, oil and coal products highly depend on imported intermediate inputs, and therefore if competitive assumption is taken, we have to pay very high natural prices.

Mining and Chemical Market prices of mining and chemical also remain low compared to natural prices.

Food processing, textiles and pulp and pulp products Food processing, textiles and pulp plus pulp products converge toward natural prices. Market prices are rising toward natural prices.

Metal and Machinery (Industry 8 to 15)

The market prices of these industries are clearly converging towards natural prices. The movements of these industries are so clearly "harmonious". That is, the movements are clearly "together". The output prices are clearly "lowering" towards natural prices. The general price increase of these era (general GDP deflator is greater than these price increase, and the real growth of these industries (manufacturing) was greater than real GDP growth throughout the period with very few exceptions. The growth of these industries were transmitted to other industries in the development process of Japan.

The only exception of such price movements are, that is, market prices are increasing more than the natural prices are transportation machinery of 1970s and iron, steel and general machinery of 1980s. These periods can be noticed as periods that these industries were the leading industry of each period.

Service Related Industries

Movements of eight industries in this group are somewhat complex. General tendency is that market prices are converging towards natural prices.

Commerce indicates a little exceptional movement, especially for years 1980 to 2000. Market prices remained low compared to natural prices, either reflecting the inefficiency of this industry, or the keen competition of this industry faced to the international competition after mid 1980s which lowered the output price.

Communication is another exception that market prices are digressing from the natural prices, especially from the 1980s. Market prices are higher than natural prices and the gap in increasing from 1980s. This is realizing high profit in this industry throughout the period.

Market prices of construction fluctuate around the natural prices. Market price starts from the point that per income of construction labor are higher than the economy's average. Construction achieves high income per labor in the 1990s, but it turned down in the 2000s after the burst of the bubble economy.

Prices of water and waste is decided in local congress. There are considerable lowering of market price of water and waste against natural

prices in the 1970s. This reflects that the price adjustment delayed or was sluggish to the inflation of the 1970s. The GDP deflator increase was 13.4% in 1973 and 19.8% in 1974. And yet, water which is supplied by regional monopoly, and waste are achieving market prices that yields high per labor income compared to the whole economy.

Transportation as service industry shows clear well fitted convergence of market price and natural prices.

Electricity, gas and energy supply remain high market price as these are regional monopoly prices.

Finance and insurance also remain high market prices, but there are slow tendency to converge towards natural prices. Market prices move towards natural prices especially in 1980s and 1990s. 1990s deregulation (big bang) might have worked, but there are slight digression in 2000 data.

Real estate also remain high market prices, but the trend is that the market prices are converging towards natural prices. The gap is big, but there are slow trend to converge.

Service

The first note that must be taken is, that revision of data is necessary for these industrial groups. The reclassification of service industry in 1985 in input output analysis, and the difference of the integration of industries of labor statistics should be noted. The other public sector of 1951 and 1970, education of 1951 should be neglected.

Education and public sector may require a little lower output prices, lower income per labor after 1980s.

Medical service includes elderly care recently. For this reason, the high income nature of this industry was obscured after 1980s.

Business service shows good convergence of market prices and natural prices.

Personal services requires higher market prices. It is likely that the labor of this sector are lowly paid.

Reclassification of labor data are essential for these industries.

5. CONCUSION

This was a first and preliminary trial to construct natural prices and to analyze the movements between actual market prices.

Exceptions exist such as the movements of agricultural sector, or profitable sector such as communication of 1990s and 2000s, leading sectors of 1970s (transport machinery) and 1980s (iron, steel and general machinery), however, I think it is approved to state that there are tendency for the market prices to converge towards natural prices. This tendency was clearly apparent for metal and machinery related industries.

Above statements reveals that the economy is moving towards perfect competition, and that the economy is shifting towards realizing free entry and free exit. In the machinery industry where increasing return may work, free entry and free exit are limited. Besides, life time employment was apparent in Japan until recent, which could have created wage differential among industries. However, uniform negotiation process such as IMF-JC lead wage negotiation created very equal income structure for the manufacturing sectors. Manufactured goods as traded goods facing international competition made output market to operate as perfect competitive markets. Such limited market forces that existed achieved equality among industries especially among manufacturing sectors. Equality among industries does not necessarily result in equality among person to person income (and moreover asset) distribution. The fact that personal income distribution after the burst of the bubble economy is worsening (especially for the aged); equality among industries did not necessarily guaranteed the person to person income equality.

Data Source

Input Output Tables:

Government of Japan, Keizai Sangyou Chosakai, Interindustry tables for Showa 26-60 (46 sector tables)
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