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On the Cause of Price Differentials between Domestic and Overseas Markets : Approach through Empirical Analyses of Markup Pricing

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This paper investigates the cause of price differentials between domestic and overseas markets through various empirical analyses of markup pricing. The results show that markup ratios (defined as price/marginal cost) are generally higher in non-manufacturing sectors than in manufacturing ones. Particularly high markup ratios are estimated for such sectors as agriculture, forestry and fisheries and financing and insurance, both of which are said to be strictly regulated. The result suggests the possibility that the existence of regulations has distorted price structures. In addition, simultaneous estimation model consisting of cost and demand functions also rejects the hypothesis of perfect competition. On the other hand, the trend line of markup ratios over the past 20 years has remained almost flat for manufacturing industry, but, in contrast, has clearly declined for non-manufacturing industry reflecting the progress of deregulation.

Key Words : Markup Pricing; Market Power ; Price Differentials

I. Introduction

According to the conventional wisdom of international economics, price differentials between domestic and overseas markets are ascribed to productivity differentials between the traded goods sectors and the non-traded goods sectors, as well as the sustained high prices of non-traded goods. But recent empirical studies show that the price level in Japan is generally higher than that in other developed countries even if this factor is taken into consideration.[1]

If price differentials between domestic and overseas markets cannot be fully explained by productivity differentials between these two sectors, then the possibility surfaces that pricing above marginal cost, or markup pricing, is extensively practiced,

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[1] On these points, see Baba (1995).

particularly in the non-traded goods sectors owing to the competition-limiting regulations and commercial practices.[2]

The purpose of this paper is to evaluate the degree of competition in Japanese industries by measuring marginal markup ratios (defined as price / marginal cost) using data available for the past 20 years and also to show changes over time and differences by sector.

Though the principal way of measuring markup ratios had been by estimating cost function,[3] Hall (1988) devised a method that utilizes the property of the so called "Solow residual" (total factor productivity).[4] However, this method is based on very definite assumptions, including constant returns to scale, and is also criticized as requiring further improvement concerning the choice of data.

Therefore, while we use the Hall type method to start out, we try to improve its shortcomings and jointly conduct a conventional analysis with a simultaneous estimation model consisting of cost and demand functions to compare the results between the two methods.

The paper is organized as follows. In Section II, markup ratios are measured by a method utilizing the property of the Solow residual, originally devised by Hall (1988), and then the levels of the ratios are compared sector by sector. Then the shortcomings of this method are clarified and attempted to improve. In Section III, a simultaneous model consisting of cost and demand functions is estimated to supplement the analyses of Section II with a view to finding out the degree of competition in Japanese industries. Finally, we observe a time series movement of markup ratios to check the validity of the conventional view that claims deregulation has promoted competition and worked to lower markup ratios. Also, the relationship with business cycle is clarified. In the Appendices, the technical details are given on the processes of deriving each model (Appendix 1, 2) and on the data used for the analysis (Appendix 3).

The major conclusions of this paper are summarized as follows.

(1) According to the measurement results of markup ratios by the Hall type testing method assuming constant returns to scale (when gross output data is used for output data), markup ratios are generally higher in non-manufacturing sectors than in manufacturing ones. Particularly high markup ratios are estimated for such sectors as

[2]For the sake of simplicity, in this paper, effects stemming from the following are discarded: (1) high factor prices (particularly wages) caused by rents due to regulations, and (2) sustaining marginal cost at a high level through suppression of productivity growth due to the existence of regulations and unique Japanese commercial practices.

[3]Breshnahan (1989) conducted an extensive survey on empirical analyses concerning markup pricing associated with market concentration.

[4] The Solow residual is defined as the residual of output growth rate minus the weighted sum of factor of production growth rates.

[5]In this paper, gross output data includes intermediate goods.

agriculture, forestry, and fisheries and financing and insurance, both of which are said to be more strictly regulated than others. This suggests the possibility that regulations have distorted price structures. On the other hand, markup ratios are below 1.0 in such manufacturing sectors as textiles and food. We may be able to infer from this evidence that these sectors have had to operate at a marginal loss due to intense competition, mainly from abroad.

(2) The results of the method that takes into consideration the existence of economies of scale show that almost the same degree of economies of scale are detected for manufacturing and non-manufacturing sectors. But, generally, non-manufacturing sectors have higher markup ratios associated with higher rates of average profit. To be specific, substantial economies of scale and high markup ratios are detected for sectors such as finance and insurance and wholesaling and retailing.

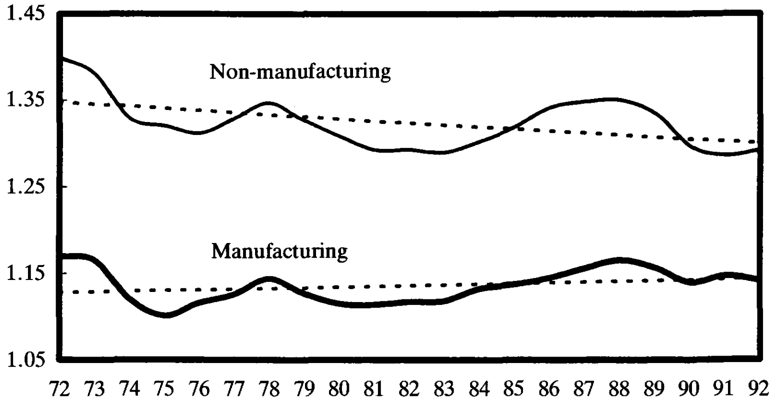
(3) The simultaneous model consisting of cost and demand functions also rejects the hypothesis of perfect competition and reveals the existence of markup pricing associated with an oligopolistic market structure. With respect to the parameter representing the degree of market power, the estimation results show that it has both a higher value and higher significance level for non-manufacturing industry than manufacturing industry.

(4) The estimated cost functions reveal slight cost-reducing effects due to technological progress for manufacturing industry, but not so for non-manufacturing industry. In other words, the price level of non-manufacturing industry is likely to be maintained at a high level due to both marginal cost being sustained at a high level because of slow technological progress and widespread markups.

(5) The trend line of markup ratios over the past 20 years has remained almost flat for manufacturing industry, but, in contrast, has clearly declined for non-manufacturing industry. However, the ratio for non-manufacturing industry is much higher than that for manufacturing industry, even in the recent period. From such evidence, we can infer that the degree of competition in non-manufacturing industry is still insufficient in comparison with manufacturing, even though it is increasing partly owing to the progress of deregulation (Figure 1).

(6) Concerning the relationship between the movement of markup ratios and business cycle, the ratios of both manufacturing and non-manufacturing industries show procyclical movements. Non-manufacturing industry, whose significance level of the parameter representing market power is higher, exhibits a stronger tendency to move with business cycle. This may suggest that a collusive price agreement is more likely to collapse in non-manufacturing industry than in manufacturing industry during a recession. This evidence presents an interesting viewpoint regarding the phenomenon of so-called "price destruction," which is currently prevailing, particularly in non-manufacturing industry.

Figure 1
Time Series Movement of Markup Ratios



Note: The dotted lines denote trend lines.

II. Test on Markup Pricing Hypothesis Utilizing the Property of the Solow Residual[6]

A. Test Under the Assumption of Constant Returns to Scale

1. Testing Method with Value Added Output Data

Hall (1988) tested whether markup pricing was practiced or not in each U.S. sector using observable data such as value added output, value added deflators, inputs of factors of production, and factor prices. He concluded that most U.S. sectors from 1950s to the beginning of the 1980s were not perfectly competitive and that markup pricing was practiced extensively. An intuitive explanation is given below for the testing method of markup pricing with value added data.

The basic concept of the testing method lies in comparing output growth with input growth for each factor, which is closely related to the method for measuring technological progress originated in Solow (1957). Solow measured the rate of technological progress as follows under the two assumptions of perfect competition and constant returns to scale.

(Rate of technological progress[7])
= (Growth rate of output)−(Weighted sum of the growth rates of factors of production)

[6]Refer to Appendix 1 for technical details on the process of deriving the model.
[7]The share of each factor of production in output is used as a weight.

Using value added output data and taking only capital stock and labor as factors of production, the rate of technological progress is nothing but the residual of the growth rate of output not explained by the increase in capital stock and labor.[8] This residual is generally called the "Solow residual" (also called "total factor productivity"). Hall (1988) tested markup pricing hypothesis by using a bias that occurred in the Solow residual when one of the two assumptions, that is, the assumption of perfect competition, does not hold in the market in reality.

Let us suppose a case where perfect competition does not hold in the market and a firm set its price at a level of marginal cost $MC_{VA,t}$ times $\mu_{VA,t}$ ($\mu_{VA,t}$ denotes markup ratio).[9] To calculate the rate of technological progress, we must first calculate the weighted sum of the growth rates of the factors of production and then subtract this from the growth rate of output. Here the relative shares of factors of production in output used for this calculation incorporate the following problem. Take, for example, the share of labor (employees' income / total factor income).[10] If perfect competition prevails in the market, it does not make any difference whether total factor income[11] forming the denominator is valued by actual price or marginal cost. But, if the market is not perfectly competitive and markup pricing is practiced, the share of labor is undervalued unless marginal cost is used for valuation instead of actual price. This is because excess profits obtained from markup pricing do not reflect the increase in output resulting from the contributions of the factors of production such as labor (this portion of profits should not be distributed as factor income), so that the rate of technological progress (the Solow residual) rises superficially.

By using this property of the Solow residual, Hall (1988) tested the existence of markup pricing in the following way. First, the rate of technological progress $\theta_{VA,t}$ is separated into an average rate $\theta_{VA,t}$ and a random error term $\varepsilon_{VA,t}$. Then an exogenous variable (an instrumental variable) that is not correlated with the random error term $\varepsilon_{VA,t}$ is introduced.

If the market is perfectly competitive, markup ratio is always equal to 1.0 (price equals marginal cost) and therefore this instrumental variable becomes uncorrelated to the Solow residual. But, if the market is not perfectly competitive and markup pricing is practiced, the share of labor is undervalued and the Solow residual rises superficially. Thus, an instrumental variable uncorrelated with the true rate of technological progress

[8]In fact, views are divided as to what extent the Solow residual actually represents real productivity growth due to technological progress. Some say that the Solow residual only reflects demand shocks. For further discussion, for example, see Yoshikawa (1992).

[9]The subscript VA to each variable denotes the use of value added output data and subscript t, time.

[10]Once the share of labor is given, the share of capital is automatically determined because of the assumption of constant returns to scale.

[11]Factor income is defined as follows: (Value added output) - (Fixed capital comsumption) - (Indirect taxes [minus subsidies]).

$\theta_{VA,t}$ but positively correlated to a variable such as change in labor input will be positively correlated to the Solow residual.

Hall (1988) conducted an analysis by regressing the Solow residual on an instrumental variable using this relationship and tested the markup pricing hypothesis by the statistical significance level of the parameter of the instrumental variable. As for its sign, it can be either positive or negative depending on the choice of instrumental variables.

So far, our argument has been based on the assumption that the markup ratio changes over time. But, only if we further assume that the markup ratio remains constant over time, we can calculate the level of an average markup ratio itself.

Hall (1988) calculated markup ratios for 26 sectors using instrumental variables such as military expenditure, crude oil price, and a dummy of the political party to which the president belonged. The results reject the perfect competition hypothesis in many sectors except for finance and insurance and real estate, when the price of crude oil is selected as an exogenous variable. The values of average markup ratios are far above 1.0 in sectors except for apparel, mineral, wholesaling, and oil and coal products. From these results, Hall (1988) concluded that the degree of competition is generally low in U.S. industries.[12]

2. *Measurement Bias Arising from the Use of Value Added Data and the Revised Model*

Concerning Hall's use of value added output data in conducting an analysis, Norrbin (1993) pointed out the existence of a measurement bias that occurred by not using gross output data including the inputs of intermediate goods.[13]

First, the output growth per unit of capital stock tends to fluctuate more widely when value added data is used instead of gross output data. It is known that the Solow residual $\theta_{VA,t}$ calculated using value added data is overestimated when it takes a positive value and is underestimated when it takes a negative value compared with the Solow residual $\theta_{G,t}$[14] estimated using gross output data (Figure 2).

Likewise, the measured average markup ratio will be biased if the growth of intermediate goods is correlated to that of output. To give an example, if the growth of intermediate goods and that of output are perfectly correlated, markup ratio estimated using value added data is biased upward if markup ratio estimated using the gross output data is above 1.0 and biased downward if the same ratio is below 1.0.

Considering these facts, Norrbin (1993) measured the markup ratios based on the production function including explicitly inputs of intermediate goods.

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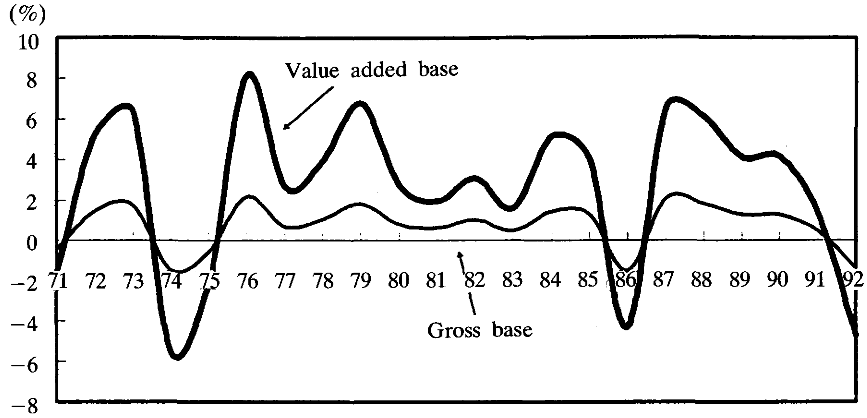
[12]Concerning Japanese sectors, Ariga *et al.* (1992) analyzed only manufacturing sectors by the same method as Hall using value added data. Their results suggest the existence of markup pricing in sectors such as metal products and chemicals.

[13]For details, see Hall (1988) and Norrbin (1993).

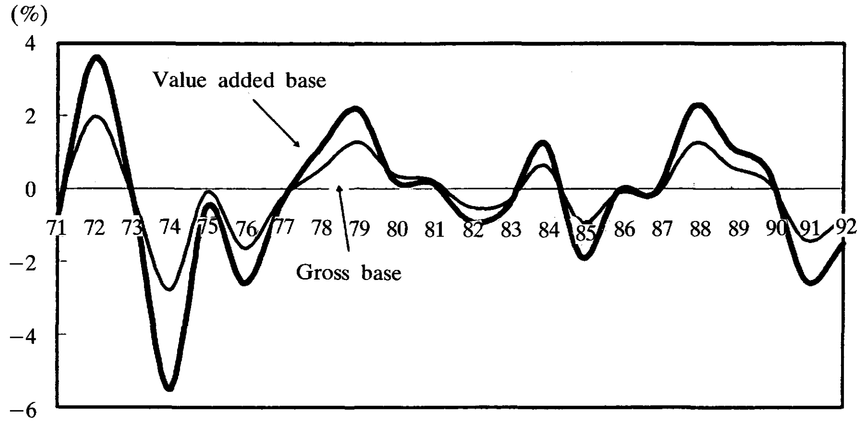
[14]The subscript G denotes the use of gross output data.

Figure 2
The Movement of Solow Residual

A. Manufacturing Industry



B. Non-manufacturing Industry



Norrbin (1993) essentially repeated the analyses of Hall (1988) with the same conditions except for the use of additional intermediate goods data. From the measurement results, he reached the conclusion that the perfect competition hypothesis cannot be rejected for every U.S. sector and that U.S. market structures as a whole are competitive enough.

3. *Measurement Results of Markup Ratios*

In this section, the markup pricing hypothesis is tested for sectors in Japan using both value added and gross output data. But the testing method by examining the correlation between the Solow residual and instrumental variable tends to show very different results depending on the choice of instrumental variables, thereby making a consistent interpretation difficult. Therefore, we show only the measurement results of average markup ratios calculated by the instrumental variable method[15] on the assumption of constant markup ratios. For the sake of comparison, measurement results by the OLS method are also shown.

The sample period is FY 1972-1992 and the industrial classification follows that of the Economic Planning Agency's national accounts (13 sectors for manufacturing industry and 9 sectors for non-manufacturing industry).[16]

Comparing the measurement results of markup ratios using gross output data with ones using value added data, we can confirm the following. That is, the estimates using value added data are either above or below the estimates using gross output data with the borderline of markup ratio at a level of 1.0, particularly in agriculture, forestry, and fisheries and manufacturing sectors. As the correlation between the growth of intermediate goods and that of output is considered to be higher in these sectors than in others, it implies that the relationship pointed out above is confirmed by the empirical results.[17] Also, the results with gross output data are better in terms of significance level of the estimates.

So let us examine the results with gross output data in more detail. First, they generally show that markup ratios are slightly higher for non-manufacturing sectors than for manufacturing ones. To be more specific, the markup ratios of finance and insurance and agriculture, forestry, and fisheries in non-manufacturing industry and of the precision machinery in manufacturing industry are especially high. On the other hand, markup ratios for textile and food in manufacturing are less than 1.0.

Now let us compare these results for each sector with respective degree of regulation, quantification of which is generally thought to be difficult because the magnitude of the regulated target cannot be confirmed statistically in value terms. But for the sake of reference, we show the estimation results on the basis of input-output tables in Table 1.

Comparison of these results points to the possibility that because of regulation the distortion of the price mechanism is greater in sectors such as finance and insurance and agriculture, forestry, and fisheries. As for precision machinery (manufacturing industry), an oligopolistic market structure is likely to be working as there is no stringent

[15]In this paper, in addition to the imported goods price for oil, coal, and natural gas and real defense expenditures, changes in both the official discount rate and outstanding credit extended by government financial institutions are used as instrumental variables.

[16]For data details, refer to Appendix 3. For some manufacturing sectors such as precision machinery, oil and coal, ceramics, and sands, stone and miscellaneous, the period covered for analysis starts from FY 1976 because of the data deficiency.

[17]Some measurement results with value added data take negative values, particularly when the instrumental variable method is used. This suggests that the change in the import price index of oil, coal, and natural gas does not perform the required function of an instrumental variable as it is not correlated with the rate of change in labor and capital stock inputs.

Table 1
Weight of Government Regulated Area by Industry

Industry	Value Added (100 million yen)	Value of the Regulated Area (100 million yen)	Weight of the Regulated Area (%)
Agriculture, Forestry, and Fisheries	102,189	89,044	87.1
Mining	11,454	11,454	100.0
Construction	411,309	411,309	100.0
Manufacturing	1,153,949	162,839	14.1
Wholesaling and Retailing	574,807	—	—
Finance and Insurance	219,628	219,628	100.0
Real Estate	420,435	31,630	7.5
Transportation and Communication	275,104	267,765	97.3
Electricity,Gas,and Water Supply	107,815	107,815	100.0
Service	1,016,722	565,094	55.6
Public Service	144,856	0	0.0
Others	23,300	0	0.0
Total	4,461,570	1,833,578	41.8

Notes: 1. Estimated by Section I, Domestic Research Division, Economic Planning Agency, on the basis of value added in the 1990 input-output table.
2. If there is any relevant regulation law targeted at a particular industrial sector in the input-output table, the whole sector is considered as regulated.
3. If a relevant regulation law regulates only a part of the target field, the total value added of that particular field is counted as the regulated value added.

Source: Economic Planning Agency, *Economic White Paper* for 1994.

regulation imposed on that sector. On the other hand, we can infer that the textile and food sectors suffer from intense competition brought about by cheap imports in addition to exceptionally high unit labor cost, which are forcing these sectors to operate at a marginal loss. [18]

B. Economies of Scale and Markup Pricing

In this section, basic ideas regarding the relationship between markup ratios and economies of scale are introduced along with Basu and Fernand (1994), which is not considered by Hall (1988) nor by Norrbin (1993). Then, empirical studies are conducted for Japanese industries.

[18] According to recent studies, wage rates in the textile and food sectors are almost equal to those of other sectors while their labor productivities remain extremely low. This causes unit labor costs in those sectors to be higher than in other manufacturing sectors. Also, unit labor costs are conspicuously higher than in the same sectors of other developed countries. For further discussion, see Hooper and Vrankovich (1994).

Table 2
Measurement Results of Markup Ratios under Constant Returns to Scale

Sector	Estimators with Gross Output Data		Estimators with Value Added Data	
	Instrument Variable	OLS	Instrument Varible	OLS
Manufacturing	1.337 (15.811)***	1,283 (22.562)***	2.726 (2.600)***	2.319 (3.675)***
Food	0.696 (4.176)***	0.734 (6.413)***	-1.046 (-1.167)	-0.299 (-0.624)
Textile	0.849 (3.157)***	0.791 (4.550)***	-3.136 (-1.207)	0.250 (0.359)
Pulp and Paper	1.450 (7.705)***	1.200 (13.610)***	-0.059 (-0.027)	0.997 (0.999)
Chemical	0.939 (1.810)*	1.473 (9.340)***	-3.026 (-0.995)	0.367 (0.184)
Oil and Coal	0.272 (1.401)	1.123 (-0.812)	337.264 (0.430)	0.233 (0.139)
Ceramics, Sands, and Stone	1.490 (2.643)***	0.793 (.084)***	0.547 (0.492)	0.007 (0.018)
Primary metal	1.461 (12.710)***	1.402 (16.260)***	2.212 (0.742)	0.263 (0.139)
Metal products	1.602 (12.628)***	1.506 (16.927)***	2.066 (1.858)*	1.643 (2.122)*
General machinery	1.144 (10.900)***	1.206 (19.325)***	1.163 (1.132)	1.758 (2.854)***
Electric machinery	1.455 (13.097)***	1.425 (26.977)***	3,259 (0.571)	4.605 (2.801)***
Transportation machinery	1.105 (4.720)***	0.968 (8.110)***	3.905 (1.573)	1.538 (1.646)
Precision machinery machinery	2.260 (3.560)***	1.391 (8.021)***	1.809 (0.622)	1.373 (1.411)
Miscellaneous	1.174 (10.977)***	1.166 (14.112)***	1.777 (2.341)**	1.799 (3.448)***
Non-manufacturing	1.488 (10.052)***	1.461 (15.868)***	5.655 (1.980)*	1.669 (4.643)***
Agriculture, Forestry, and Fisheries	1.955 (3.131)***	1.096 (3.003)***	6.944 (2.196)*	4.057 (1.839)*
Mining	1.530 (3.211)***	1.101 (5.724)***	-0.375 (-0.146)	0.865 (0.696)
Construction	1.323 (9.986)***	1.332 (11.716)***	3.446 (3.550)***	2.425 (4.935)***
Electricity, Gas, and Water supply	0.914 (4.916)***	0.653 (5.813)***	1.924 (1.141)	2.856 (2.290)**
Wholesaling and Retailing	1.214 (4.783)***	1.328 (6.425)***	1.446 (1.732)	0.936 (1.545)
Finance and Insurance	3.273 (2.252)**	1.589 (2.686)***	4.981 (1.144)	0.674 (0.451)
Real estate	0.450 (0.316)	1.433 (2.332)**	18.130 (3.245)***	13.419 (7.037)***
Transportation and Communication	0.951 (3.406)***	1.160 (12.718)***	0.755 (1.211)	1.256 (7.509)***
Service	1.020 (6.953)***	0.878 (8.219)***	1.064 (1.450)	0.740 (1.621)

Notes: 1. The figures in the parentheses are *t*-values. Figures with single-asterisks (*) are significant at 10% level, those with double-asterisks (**) are significant at 5% level, and those with triple-asterisks (***) are significant at 1% level.

2. As for the transportation and communication, the sample for FY1985 is eliminated as capital stock increased suddenly due to the privatization of Nihon Telegraph and Telephone Corporation in 1985.

1. Basic Ideas and Analytical Method

If all inputs are doubled and output increases more than double, it is said that economies of scale exist. In reality there are many cases where economies of scale are present owing to the existence of fixed costs.[19] Given economies of scale, how will the conclusions of the previous discussion be modified?

With economies of scale, marginal cost becomes lower than otherwise. Because of the definition of markup ratio (price / marginal cost), measurement results under the assumption of constant returns to scale overestimate marginal costs and therefore underestimate markup ratios compared with the true values measured taking the existence of economies of scale into consideration.

Based on this logic, analysis is effected as follows. First, we express output growth as the product of the weighted sum of the growth rates of the factors of production[20] and an indicator of economies of scale δ_G.[21] Thus if we assume that the degree of economies of scale remains constant throughout the sample period, δ_G can be estimated by regressing the output growth rate on the weighted sum of the growth rates of the factors of production. Also, markup ratio μ_G can be calculated from its relationship with average profit rate S_π.[22]

Basu and Fernand (1994) analyzed U.S. manufacturing sectors from 1950s to the beginning of the 1980s using gross output data. They concluded that constant returns to scale hold in U.S. manufacturing sectors and that markup ratios approximate 1.0 reflecting low average profit rates, implying that competition is close to perfect.

2. Estimation Results of Economies of Scale and Markup Ratios

Analysis in this section is an application of the method used by Basu and Fernand (1994) to Japanese industry data. Both the sectors analyzed and sample period are the same as in Section I.

The estimation results of the degree of economies of scale show that estimates with gross output data are more statistically significant and therefore more reliable than those with value added output data. A look at the estimation results with gross output data reveals about the same degree of economies of scale in both manufacturing and non-manufacturing industry. As for specific sectors, economies of scale are particularly high in precision machinery, wholesaling and retailing, and finance and insurance.

Average profit rates are overwhelmingly high (above 15%) for non-manufacturing industry, while they remain low (below 5%) for manufacturing industry. In particular,

[19] To estimate economies of scale, it is commom to use the cost or production function. But, in order to avoid multicollinearity which may arise in the process of estimating these functions, this technique is used. An estimation of economies of scale using the cost function is conducted in Section III.

[20] As for weights, cost shares are used.

[21] $\delta_G > 1$ denotes the existence of economies of scale (increasing returns to scale).

[22] The average profit rate S_π is calculated as a quotient of revenue minus cost divided by nominal output.

Table 3
Estimation Results of Economies of Scale and Markup Ratios

A. Estimation Results by the Instrumental Variable Method

Sector	Estimators with Gross Output Data: Indicator of Economies of Scale	Profit Rate	Markup Ratio	Estimators with Value Added Data: Indicator of Economies of Scale	Profit Rate	Markup Ratio
Manufacturing	1.312 (14.621)***	0.045	1.373	1.774 (2.139)**	0.145	2.074
Food	0.688 (3.892)***	0.070	0.741	0.245 (0.251)	0.382	0.397
Textile	0.259 (0.582)	-0.019	0.254	-1.764 (-1.526)	-0.064	n.a.
Pulp and Paper	1.475 (8.270)***	0.027	1.516	0.691 (0.218)	0.093	0.762
Chemical	0.571 (0.704)	0.062	0.609	-3.026 (-0.995)	0.184	n.a.
Oil and Coal	0.124 (0.558)	0.046	0.130	-246.648 (-1.206)	0.061	n.a.
Ceramics, Sands, and Stone	1.230 (1.973)*	0.028	1.265	0.314 (0.533)	0.070	0.337
Primary metal	1.370 (10.146)***	0.040	1.427	-2.132 (-0.833)	0.173	n.a.
Metal products	1.576 (11.339)***	0.016	1.602	1.240 (1.187)	0.035	1.286
General machinery	1.097 (10.740)***	0.049	1.154	1.078 (1.515)	0.143	1.257
Electric machinery	1.247 (11.261)***	0.066	1.335	-0.356 (-0.222)	0.190	n.a.
Transportation machinery	1.237 (3.322)***	0.030	1.274	1.761 (1.705)	0.092	1.940
Precision machinery	2.072 (5.357)***	0.017	2.108	1.365 (0.774)	0.039	1.421
Miscellaneous	1.082 (7.821)***	0.068	1.160	0.337 (0.364)	0.179	0.410
Non-manufacturing	1.355 (9.849)***	0.158	1.610	5.951 (1.427)	0.273	8.181
Agiculture, Forestry, and Fisheries	0.593 (1.500)	0.108	0.665	0.079 (0.130)	0.179	0.096
Mining	1.440 (2.629)**	0.135	1.665	-2.033 (-0.652)	0.251	n.a.
Construction	1.027 (7.137)***	0.113	1.158	0.595 (1.002)	0.266	0.810
Electricity, Gas, and Water supply	0.998 (5.178)***	-0.024	0.975	0.353 (0.317)	-0.056	0.334
Wholesaling and Retailing	2.016 (3.579)***	0.143	2.354	2.164 (2.354)**	0.219	2.770
Finance and Insurance	2.061 (2.068)*	0.220	2.644	2.229 (0.554)	0.313	3.243
Real estate	0.550 (1.490)	0.562	1.256	1.468 (1.471)	0.641	4.086
Transportation and Communication	1.126 (1.702)	-0.034	1.089	0.902 (0.904)	-0.054	0.856
Service	0.922 (6.413)***	0.147	1.082	1.486 (2.151)**	0.284	2.077

Notes:
1. For the industries which do not meet the sign requirement, the markup ratios are not calculated.
2. The figures in the parentheses are *t*-values. Figures with single-asterisks (*) are significant at 10% level, those with double-asterisks (**) are significant at 5% level, and those with triple-asterisks (***) are significant at 1% level.
3. As for the transportation and communication, the sample for FY1985 is eliminated as capital stock increased suddenly thanks to the privatization of Nihon Telegraph and Telephone Corporation in 1985.

(B) Estimation Results by OLS

Sector	Estimators with Gross Output Data			Estimators with Value Added Data		
	Indicator of Economies of Scale	Profit Rate	Markup Ratio	Indicator of Economies of Scale	Profit Rate	Markup Ratio
Manufacturing	1.239 (20.883)***	0.045	1.297	1.493 (2.668)***	0.145	1.746
Food	0.645 (5.329)***	0.070	0.694	0.261 (0.825)	0.382	0.422
Textile	0.547 (2.801)***	-0.019	0.537	-0.636 (-0.863)	-0.064	n.a.
Pulp and Paper	1.229 (12.438)***	0.027	1.263	0.695 (0.593)	0.093	0.766
Chemical	1.328 (6.393)***	0.062	1.416	1.750 (-1.397)	0.184	n.a.
Oil and Coal	0.163 (1.544)	0.046	0.171	-104.372 (-0.778)	0.061	n.a.
Ceramics, Sands, and Stone	0.670 (4.058)***	0.028	0.689	-0.040 (-0.112)	0.070	n.a.
Primary metal	1.275 (14.300)***	0.040	1.328	-1.123 (-0.812)	0.173	n.a.
Metal products	1.461 (16.370)***	0.016	1.482	1.457 (1.874)*	0.035	1.510
General machinery	1.174 (17.603)***	0.049	1.234	1.186 (2.234)**	0.143	1.384
Electric machinery	1.284 (22.817)***	0.066	1.375	1.182 (1.267)	0.190	1.459
Transportation machinery	0.846 (6.394)***	0.030	0.872	0.620 (1.047)	0.092	0.683
Precision machinery	1.548 (9.201)***	0.017	1.575	1.831 (1.721)	0.039	1.905
Miscellaneous	1.095 (10.932)***	0.068	1.175	1.000 (1.924)*	0.179	1.218
Non-manufacturing	1.238 (11.811)***	0.158	1.471	1.125 (2.144)**	0.273	1.547
Agiculture, Forestry, and Fisheries	0.503 (1.789)	0.108	0.564	0.401 (0.781)	0.179	0.488
Mining	0.884 (4.552)***	0.135	1.022	0.411 (0.363)	0.251	0.549
Construction	1.009 (9.084)***	0.113	1.138	0.860 (2.000)*	0.266	1.171
Electricity, Gas, and Water supply	0.653 (5.813)***	-0.024	0.638	-0.793 (-1.276)	-0.056	n.a.
Wholesaling and Retailing	1.989 (6.878)***	0.143	2.321	1.756 (2.413)**	0.219	2.248
Finance and Insurance	1.316 (2.849)***	0.220	1.687	0.075 (0.044)	0.313	0.109
Real estate	0.328 (1.851)*	0.562	0.749	0.482 (2.569)**	0.641	1.343
Transportation and Communication	0.538 (1.996)*	-0.034	0.520	0.093 (0.280)	-0.054	0.088
Service	0.852 (7.545)***	0.147	0.999	1.550 (3.420)***	0.284	2.165

Notes:
1. For the industries which do not meet the sign requirement, the markup ratios are not calculated.
2. The figures in the parentheses are *t*-values. Figures with single-asterisks (*) are significant at 10% level, those with double-asterisks (**) are significant at 5% level, and those with triple-asterisks (***) are significant at 1% level.
3. As for the transportation and communication, the sample for FY1985 is eliminated as capital stock increased suddenly thanks to the privatization of Nihon Telegraph and Telephone Corporation in 1985.

they are high in such sectors as real estate and finance and insurance.

Markup ratios calculated considering the existence of economies of scale are generally higher for non-manufacturing than for manufacturing sectors. In particular, such sectors as finance and insurance and wholesaling and retailing in non-manufacturing industry and precision machinery in manufacturing industry show outstandingly high markup ratios above 2.0. On the other hand, no evidence of economies of scale is detected for agriculture, forestry, and fisheries, which shows a high markup ratio together with finance and insurance in the analysis in Section II. Rather, agriculture, forestry, and fisheries exhibits diseconomies of scale (decreasing returns to scale) and the markup ratio also remains at a low level.

From these results we can conclude that though both manufacturing and non-manufacturing sectors show slightly higher markup ratios due to economies of scale, almost similar features are observed as the results of the analysis using the Hall type model in the previous section, with the exception of agriculture, forestry, and fisheries.

However, it should be noted that a strict separation of economies of scale from the effect of technological progress is very difficult in defining an indicator of economies of scale. We must also consider the possibility that an indicator of economies of scale measured in this way may include the effects of Marshallian external economies.[23]

III. Empirical Test on the Degree of Competition in Japanese Industries: Approach through Estimation of Cost and Demand Functions[24]

The analyses in section II are based on the strong assumption that markup ratios are constant throughout the sample period. But, in reality, markup ratios are thought to be affected by factors such as the progress of deregulation and business cycle. Therefore it may be natural to assume that they fluctuate over time.

In this section, basically following the method employed by Shaffer (1993), we investigate the degree of competition (whether the markup pricing is practiced or not) in Japanese industries by estimating both cost and demand functions simultaneously. Analysis aims to supplement discussion up to the previous section and then observe the pricing behavior of Japanese industries over time by calculating variable markup ratios of the past 20 years.

A. Cost Function Used for Analysis

The cost function used in this section has labor, capital stock, and intermediate goods as factors of production and is in a dual relationship with the Cobb-Douglas

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[23]Refer to Bartelsman *et al.* (1991) for the method for detecting the external economies effect with the aid of the Solow residual.

[24]For details of the process of deriving the model, refer to Appendix 2.

production function.[25]

From this cost function, marginal cost can be derived as average cost divided by an indicator of economies of scale. If economies of scale exist, marginal cost becomes lower than average cost and, if constant returns to scale hold, marginal cost equals average cost.

The cost function is composed of factor prices of production (wages, capital rental rate, and prices of intermediate goods), output, and a parameter representing the rate of technological progress. In the estimation below, two specifications are made respectively for (1)a constant level of technology (technological level is represented by a constant term) and (2)an annual fixed rate of technological progress (technological progress is expressed by a trend term)

B. Estimation Method of the Degree of Competition and Variable Markup Ratios Over Time

When a market is perfectly competitive, a firm sets its price (marginal revenue) equal to marginal cost. But, as the degree of market power rises, market demand curve becomes closer to demand curve for the firm itself. In this case, the smaller the price elasticity of demand is, the higher the price will be above marginal cost.

In this section we pay particular attention to the relationship between the price elasticity of demand function and the price, judging the degree of competition by the level of parameter λ linking the price elasticity of demand and the price. The value of λ equals 0 in the case of perfect competition and 1.0 in the case of monopoly. In order to measure parameter λ, an estimation of the price function is also needed.[26]

In the analysis in this section, we do not impose an assumption of constant returns to scale on the cost functions, taking the existence of economies of scale into consideration. In addition, time series markup ratios are observed by dividing the price by the estimated time series of marginal cost.

C. Estimation Results

The data and the sample period remain essentially the same and analysis is conducted for the broad categories of manufacturing and non-manufacturing industry. The estimation results are almost satisfactory as every parameter meets the sign requirement and most are sufficiently significant. In addition, the estimated demand, price, and cost

[25]Profit maximization problem can be replaced with cost minimization problem. By solving cost minimization problem under given production function, demand functions for each factor of production are derived and cost function formulated on that basis.

[26]Because an interactive term (price and income) is added as an explanatory variable to the demand function, the demand function is formulated so that its price elasticity changes with variation of income. Under perfect competition, the change in the slope of demand function is neutral to price and output. But, in an oligopolistic market structure, the change in the slope causes a change in marginal revenue of the firm and affects price and output.

functions show high coefficient of determination. Parameter λ representing the degree of market power, is close to 0 but is statistically significant for each industry in terms of t-value. Non-manufacturing industry shows a relatively higher value and significance than manufacturing industry. This evidence implies that competition in non-manufacturing industry is relatively low compared with manufacturing industry. This result is consistent with Section I and II, suggesting that analysis in this section is complementary with ones up to the previous section.

Additionally, parameter η detects some cost reducing effect due to technological progress in manufacturing industry, but not in non-manufacturing industry. These results suggest that in non-manufacturing industry high marginal cost because of the slow pace of technological progress, together with higher markup ratio, has contributed to the relatively high price level. On the other hand, the trend line of the markup ratio in manufacturing industry has been flat while it shows a declining trend in non-manufacturing industry over the past 20 years (Figure 3).

As for the relation with the business cycle, while markup ratios for each industry show pro-cyclical movement,[27] that for non-manufacturing industry has a higher positive correlation with real GDP growth (Table 5). How should this synchronization with business cycle be interpreted in view of industrial organization theory? Rotemberg and Saloner (1986), and subsequently Haltiwanger and Harrington (1991), present valuable viewpoints.

Rotemberg and Saloner (1986) assume the existence of a collusive price agreement in an oligopolistic market and presents a theoretical analysis on changes in markup ratio. Whether each firm follows such a price agreement or not depends on the relative magnitude between the increment of profit obtained from violating the agreement (which depends on current demand) and the loss of possible future profit that could stem from complying with the agreement (which depends on expectations of future demand). They maintain that markup ratio will move counter-cyclically as firms tend to lower markup ratios in boom periods when current demand is high and profit obtained from violating an agreement exceeds possible loss of future profit that could be occasioned by collusion. And, by the same token, firms tend to raise markup ratios during recession. But we must point out that they rely on an somewhat unrealistic assumption that expectations of future demand depend only on a stochastic demand shock and are determined independently of current demand.

Haltiwanger and Harrington (1991) rebuilt the model of Rotemberg and Saloner (1986) assuming that expectations of future demand are influenced by current demand.[28] Their analysis concludes that firms raise markup ratios in a boom when current demand is

[27]Markup ratio in manufacturing industry is confirmed to move in the same direction with business cycle by Ariga and Ohkusa (1994) and Nishimura and Inoue (1994).

[28]We can interpret that Haltiwanger and Harrington (1991) defines the period during which demand is rising as the boom period while Rotemberg and Saloner (1986) defines the peak of the demand as the boom period.

Table 4
Estimation Results of Each Function

Parameter	Manufacturing		Non-manufacturing	
	with trend	without trend	with trend	without trend
(Demand fuction)				
a_0	6415.821	15274.478	-9068.490	-13714.852
	(0.864)	(2.074)**	(-1.709)*	(-1.886)*
a_1	-15130.213	-24256.275	-27255.047	-27329.135
	(-1.833)*	(-2.693)***	(-4.568)***	(-4.390)***
a_2	0.992	1.002	1.241	1.279
	(23.891)***	(24.821)***	(32.636)***	(25.033)***
a_3	-0.038	-0.051	-0.054	-0.078
	(-1.807)*	(-2.289)**	(-2.936)***	(-2.636)***
R-SQ	0.988	0.989	0.998	0.998
(Cost function)				
Φ	——	1.298	——	0.287
	(——)	(7.587)***	(——)	(3.378)***
η	-0.008	——	0.00006	——
	(-11.207)***	(——)	(0.033)	(——)
α	0.212	0.057	0.286	0.154
	(11.294)***	(2.959)***	(4.470)***	(3.950)***
β	0.036	0.130	0.040	0.065
	(2.789)***	(5.803)***	(1.549)	(2.797)***
γ	0.801	0.835	0.756	0.731
	(39.664)***	(26.271)***	(13.761)***	(17.416)***
R-SQ	0.999	0.998	0.999	0.999
(Price function)				
λ	0.010	0.012	0.029	0.019
	(1.927)*	(2.682)***	(4.625)***	(4.489)***
R-SQ	0.996	0.997	0.989	0.995

Notes: 1. The figures in the parentheses are t-values. Figures with single-asterisks (*) are significant at 10% level, those with double-asterisks (**) are significant at 5% level, and those with triple-asterisks (***) are significant at 1% level.

2. The estimated functions are as follows;

Demand function : $Q = a_0 + a_1 P + a_2 Y + a_3 PY$

Cost function : $TC = \Phi w^{\frac{\alpha}{\rho}} r^{\frac{\beta}{\rho}} p_M^{\frac{\gamma}{\rho}} Q^{\frac{1}{\rho}}$ or $TC = e^{\eta t} w^{\frac{\alpha}{\rho}} r^{\frac{\beta}{\rho}} p_M^{\frac{\gamma}{\rho}} Q^{\frac{1}{\rho}}$

Price function : $P = \frac{-\lambda Q}{a_1 + a_3 Y} + \frac{TC}{Q} \times \frac{1}{\rho(=\alpha+\beta+\gamma)}$

Whereas $a_1 < 0$, $a_2 > 0$, $\alpha, \beta, \gamma > 0$, $\Phi > 0$, $0 < \lambda < 1$ (the signs of the other parameters cannot be pre-determined). In adition, Φ is a constant, η is a parameter that represents the rate of technological progress for the period. As for an estimation method, SUR (Seemingly Unrelated Regression) is used taking the existence of correlation among error terms of each equation into consideration.

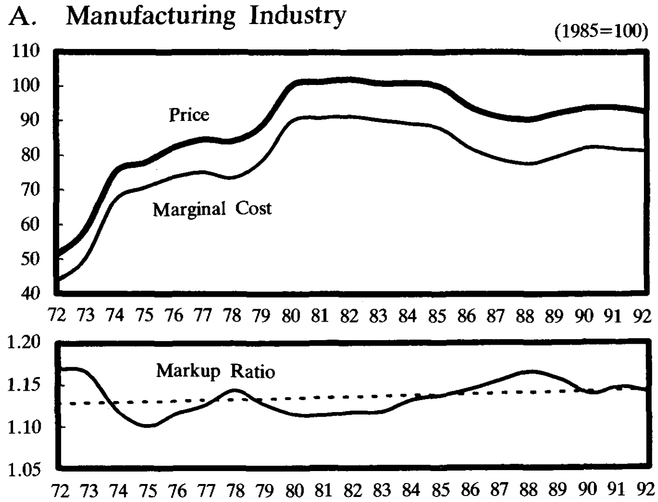
Other notations are shown below:

TC = total cost, Q = real output,
Y = real GDP (one period time lag is used for the manufacturing industry),
P = price deflator, w = wage rate,
r = capital rental rate, PM = intermediate goods deflator,
t = time.

Figure 3

Movements of Price, Marginal Cost and Markup Ratio

A. Manufacturing Industry



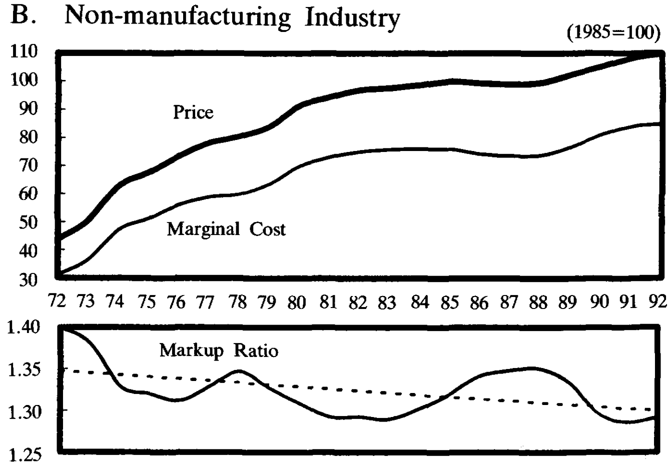
Notes: 1. Estimation result of trend line:

$$\text{(markup ratio)} = \underset{(128.261)^{***}}{1.128} + \underset{(1.114)}{0.001} \times \text{time}$$

R-SQ=0.061 D.W.=0.626

2. The figures in the parentheses are *t*-values. Figures with single-asterisks (*) are significant at 10% level, those with double-asterisks (**) are significant at 5% level, and those with triple-asterisks (***) are significant at 1% level.
3. The dotted line is the trend line.

B. Non-manufacturing Industry



Notes: 1. Estimation result of trend line:

$$\text{(markup ratio)} = \underset{(109.560)^{***}}{1.351} + \underset{(-2.437)}{0.002} \times \text{time}$$

R-SQ=0.238 D.W.=0.515

2. The figures in the parentheses are *t*-values. Figures with single-asterisks (*) are significant at 10% level, those with double-asterisks (**) are significant at 5% level, and those with triple-asterisks (***) are significant at 1% level.
3. The dotted line is the trend line.

Table 5
Markup Ratios and Business Cycle

A. Estimation by OLS (Dependent Variable: Markup Ratio)

Industry	Constant	Growth Rate of Real GDP	Time Trend	R-SQ	D.W.
Manufacturing	1.115 (117.959)***	0.529 (2.495)**	—— (——)	0.247	0.754
	1.099 (90.509)***	0.610 (3.008)***	0.001 (1.924)*	0.375	0.992
Non-manufacturing	1.285 (93.296)***	0.965 (3.126)***	—— (——)	0.340	0.778
	1.311 (76.081)***	0.833 (2.897)***	-0.002 (-2.209)**	0.480	0.854

B. Estimation by AR1[29] (Dependent Variable: Markup Ratio)

Industry	Constant	Growth Rate of Real GDP	Time Trend	R-SQ	D.W.
Manufacturing	1.127 (105.441)***	0.311 (1.977)*	—— (——)	0.566	1.493
	1.118 (62.966)***	0.347 (2.044)*	0.001 (0.551)	0.570	1.496
Non-manufacturing	1.310 (70.051)***	0.469 (2.230)**	—— (——)	0.663	1.195
	1.343 (51.367)***	0.408 (1.890)*	-0.003 (-1.666)	0.703	1.165

Note: The figures in the parentheses are *t*-values. Figures with single-asterisks (*) are significant at 10% level, those with double-asterisks (**) are significant at 5% level, and those with triple-asterisks (***) are significant at 1% level.

[29] The estimation method here is the maximum likelihood procedure. For details, refer to Beach and Makinnon (1978).

strong and expectations of further expansion of future demand prevail because the value of forgone future profit from violating the collusive agreement is higher than the profit obtained from taking advantage of current high demand. And during recession, they lower markup ratios.

The estimation results in this section may support the hypothesis of Haltiwanger and Harrington (1991). And the strong correlation between markup ratio in non-manufacturing industry with a higher value of λ (representing the degree of market power) and real GDP growth presents an important view in considering the ongoing phenomenon of "price destruction". If the fall in current real GDP growth causes firms to be very worried about future demand, then the lower real GDP growth, the higher will be the incentive for firms to violate a price agreement and lower markup ratio.

IV. Concluding Remarks

Starting with the method devised by Hall (1988), we have applied other complementary methods to investigate markup pricing in Japanese sectors. From these analyses the following facts have been found.

(1) The practice of markup pricing is significant in many sectors in Japan and the estimated level is generally higher for non-manufacturing sectors than for manufacturing ones.

(2) In non-manufacturing sectors, particularly high markup ratios are detected in such ones as agriculture, forestry, and fisheries and finance and insurance which are said to be highly regulated by the government.

(3) As for changes in markup ratios over the past 20 years, that in manufacturing industry has remained almost flat while that in non-manufacturing industry has shown a declining trend.

(4) In relation with business cycle, markup ratios of both manufacturing and non-manufacturing industry move in a pro-cyclical direction, but the correlation with real GDP growth is stronger for non-manufacturing industry.

Considering these facts with respect to deregulation, we may be able to infer that while the price structure of non-manufacturing industry has been steadily moving toward higher competition (efficiency), the degree of competition therein is still insufficient compared with manufacturing industry which has been exposed to keen competition both domestically and from overseas. This fact presents an important implication for the consideration of price differentials between domestic and overseas markets.

The pro-cyclical fluctuation of markup ratios in oligopolistic markets may be interpreted as indirectly suggestng the vulnerability of a collusive price agreement in a severe recession from the viewpoint of industrial organization theory. This point seems to present a valuable framework for considering the recent "price destruction" phenomenon.

In terms of analytical techniques, this paper still leaves room for further sophistication. For example, an assumption of perfect competition is given for the labor market in this paper. But, if a firm has monopsonistic power in the labor market, wage rates would be suppressed at a low level relative to labor productivity. This relationship may lead to an ex-post observation of the markup ratio to be above 1.0. even though firms are operating in perfectly competitive product markets. Furthermore, a more rigorous testing may be possible for the relationship with business cycle. We hope further studies will be conducted in these points.

Appendix 1: Testing Method of Markup Pricing Utilizing the Property of the Solow Residual

A. Testing Method under the Assumption of Constant Returns to Scale

1. Testing Method with Value Added Data

Hall (1988) assumes the following production function, with labor L and capital stock K, as factors of production for each sector.

$$Q_{VA,t} = \Theta_{VA,t} F(L_t, K_t) \tag{A-1}$$

where $Q_{VA,t}$ denotes value added output at period t, $\Theta_{VA,t}$ denotes a variable reflecting Hicks neutral technological progress at period t. Here, marginal cost can be defined as

$$MC_{VA,t} = \frac{w_t \Delta L_t + r_t \Delta K_t}{\Delta Q_{VA,t} - \theta_{VA,t} Q_{VA,t}} , \tag{A-2}$$

where w_t is wage rate, r_t capital rental rate, and $\theta_{VA,t}$ the rate of technological progress ($=\Delta \ln \Theta_{VA,t}$). Equation (A-2) is transformed as follows:

$$\frac{\Delta Q_{VA,t}}{Q_{VA,t}} = \frac{w_t L_t}{MC_{VA,t} \times Q_{VA,t}} \frac{\Delta L_t}{L_t} + \frac{r_t K_t}{MC_{VA,t} \times Q_{VA,t}} \frac{\Delta K_t}{K_t} + \theta_{VA,t} . \tag{A-3}$$

With an additional assumption of constant returns to scale, equation (A-3) can be further transformed as follows:

$$\frac{\Delta Q_{VA,t}}{Q_{VA,t}} - \frac{\Delta K_t}{K_t} = \frac{w_t L_t}{MC_{VA,t} \times Q_{VA,t}} \left(\frac{\Delta L_t}{L_t} - \frac{\Delta K_t}{K_t} \right) + \theta_{VA,t} .$$

That is,

$$\Delta q^k_{VA,t} - \alpha_{VA,t} \Delta l_t = \theta_{VA,t} . \tag{A-4}$$

Here, $\Delta q^k_{VA,t} = \Delta \ln\left(\frac{Q_{VA,t}}{K_t}\right)$, $\Delta l_t = \Delta \ln\left(\frac{L_t}{K_t}\right)$, $\alpha_{VA,t} = \frac{w_t L_t}{MC_{VA,t} Q_{VA,t}}$ (labor share in output) and $\theta_{VA,t}$ is called the Solow residual (total factor productivity). The Solow residual is defined as the difference of output growth and weighted sum of factors of production growth with weights of their shares in output.

To derive equation (A-4), it is assumed that price is set at a level of marginal cost $MC_{VA,t}$ under perfect competition.

At this juncture, we loosen an assumption of perfect competition and markup ratio $\mu_{VA,t} = \frac{P_{VA,t}}{MC_{VA,t}}$ is introduced ($P_{VA,t}$ is a deflator of value added output). Then, the equation (A-4) becomes

$$\Delta q^{k}_{VA,t} = \mu_t \, \alpha_{VA,t} \, \Delta l_t = \theta_{VA,t} \ . \tag{A-5}$$

Solving this equation with respect to μ_t, we obtain

$$\mu_t = \frac{\Delta q^{k}_{VA,t} - \theta_{VA,t}}{\alpha_{VA,t} \, \Delta l_t} \ .$$

Thus, if the data on the rate of technological progress is obtained, markup ratio can be calculated. But as actual rate of technological progress cannot be observed directly (it can be estimated only as an residual), the following technique is used. After separating the rate of technological progress $\theta_{VA,t}$ into an average rate of technological progress θ_{VA} and a random error terms $\varepsilon_{VA,t}$, equation (A-5) can be transformed as follows:

$$\Delta q^{k}_{VA,t} - \alpha_{VA,t} \, \Delta l_t = (\mu_{VA,t} - 1) \, \alpha_{VA,t} \, \Delta l_t + \theta_{VA} + \varepsilon_{VA,t} \ . \tag{A-6}$$

The left side of the equation (A-6) represents an estimate of the Solow residual in the case where markup ratio is introduced, and the right side becomes the sum of a constant rate of technological progress and the error term when $\mu_{VA,t}=1$.

Here, we introduce an exogenous variable ΔZ_t that is not correlated with the random error term ε_t of the rate of technological progress but affects Δl_t and Δq_t. If the market is perfectly competitive, then $\mu_{VA,t}=1$ and the following relation holds.

$$\text{cov}(\Delta q^{k}_{VA,t} - \alpha_{VA,t} \, \Delta l_t, \, \Delta Z_t) = \text{cov}(\theta_{VA,t}, \, \Delta Z_t) = 0 \ .$$

But if the market is not perfectly competitive and markup pricing is practiced, then for an exogenous variable Δz_t that is correlated to $\alpha_{VA,t} \, \Delta l_t$, then,

$$\text{cov}(\Delta q^{k}_{VA,t} - \alpha_{VA,t} \, \Delta l_t, \, \Delta Z_t) = \text{cov}[(\mu_t - 1) \, \alpha_{VA,t} \, \Delta l_t + \theta_{VA,t}, \, \Delta Z_t]$$

takes a positive value.

If a regression analysis is conducted in the following form

$$\Delta q^{k}_{VA,t} - \alpha_{VA,t} \, \Delta l_t = b_0 + b_1 \Delta Z_t \ , \tag{A-7}$$

then this relationship can be tested by the t-value of ΔZ_t term.

The required sign condition for b_1 is positive if a selected exogenous variable ΔZ_t is positively correlated to $\alpha_{VA,t} \, \Delta l_t$, and negative if the selected exogenous variable ΔZ_t is negatively correlated to $\alpha_{VA,t} \, \Delta l_t$.

So far discussion has been made on the assumption that markup ratio is variant over time, but with an alternative assumption of constant markup ratio, average markup ratio can be expressed as follows with an exogenous variable ΔZ_t.

$$\hat{\mu}_{VA} = \frac{\mathrm{cov}(\Delta q^{k}_{VA,t}, \Delta Z_t)}{\mathrm{cov}(\alpha_{VA,t}\,\Delta l_t, \Delta Z_t)} \quad . \tag{A-8}$$

2. *Bias Arising from Using Value Added Output Data and Modified Model*

First, the relationship expressed by equation (A-5) can be rewritten as follows including intermediate goods in the equation.

$$\Delta q^{k}_{G,t} - \alpha^{k}_{G,t}\,\Delta l_t - \gamma_t\,\Delta m_t = (\mu_{G,t} - 1)\,(\alpha^{k}_{G,t}\,\Delta l_t + \gamma_t\,\Delta m_t) + \theta_{G,t} \ , \tag{A-9}$$

where,

$$\Delta m_t = \Delta \ln\left(\frac{M_t}{K_t}\right) .$$

The left side of the equation (A-9) is the Solow residual that includes intermediate goods as an additional input. The first term on the right side of the equation implies that the Solow residual is correlated with the instrumental variable if the market is not perfectly competitive and firms practice markup pricing.

The growth rate of output per unit of capital stock, corresponding to the use of value added data $\Delta q^{k}_{VA,t}$, has the following relationship with the growth rate of output per unit of capital stock corresponding to the use of gross output data $\Delta q^{k}_{G,t}$.

$$\Delta q^{k}_{VA,t} = \frac{P_{G,t}\,\Delta\left(\frac{Q_{G,t}}{K_t}\right) - p_{M,t}\,\Delta\left(\frac{M_t}{K_t}\right)}{\left(\frac{P_{G,t}\,Q_{G,t}}{K_t}\right) - \left(\frac{P_{M,t}\,M_t}{K_t}\right)} = \frac{\frac{\Delta\left(\frac{Q_{G,t}}{K_t}\right)}{\frac{Q}{K_t}} - \frac{P_{M,t}\,M_t}{P_{G,t}\,Q_{G,t}}\,\frac{\Delta\left(\frac{M_t}{K_t}\right)}{\frac{M_t}{K_t}}}{1 - \frac{P_{M,t}\,M_t}{P_{G,t}\,Q_{G,t}}} = \frac{\Delta q^{k}_{G,t} - \gamma_t\,\Delta m_t}{1 - \gamma_t} , \tag{A-10}$$

where M denotes intermediate goods (in real terms), $P_{G,t}$ deflator of gross output, $P_{M,t}$ deflator of intermediate goods and $\gamma_t = \frac{P_{M,t}M_t}{P_{G,t}Q_t}$.

It is clear from equation (A-10) that the difference between the growth rate of the output and the growth rate of intermediate goods multiplied by its cost share can be expressed as the product of the growth rate of the value added output and the share of the factors of production other than the intermediate goods (labor input and capital stock).

By substituting equation (A-9) for equation (A-10) and rearranging, we obtain

[30] The subscript $_G$ denotes the use of the gross output data including the intermediate goods.

$$\Delta q^{k}_{VA,t} - \alpha^{k}_{VA,t}\,\Delta l_t = (\mu_{G,t}-1)\left(\alpha^{k}_{VA}\,\Delta l_t + \frac{\gamma_t}{1-\gamma_t}\Delta m_t\right) + \frac{\theta_{G,t}}{1-\gamma_t}\ . \tag{A-11}$$

Hence, between the Solow residual $\theta_{VA,t}$ calculated with value added data and the Solow residual $\theta_{G,t}$ calculated with gross output data, the following relation must hold:

$$\theta_{G,t} = \theta_{VA,t}(1-\gamma_t)\ . \tag{A-12}$$

Similarly, estimated markup ratio will be biased asymptotically if the growth rate of the intermediate goods and the growth rate of gross output are correlated. Especially, if the growth rate of intermediate goods input and the growth rate of gross output are perfectly correlated, the bias can be quantified as

$$\hat{\mu}_{G,t} = \frac{\hat{\mu}_{VA}}{1-(\hat{\mu}_{VA}-1)\,\gamma_t}\ . \tag{A-13}$$

Thus $\hat{\mu}_{VA,t}$ will have an upward bias when $\hat{\mu}_{G,t}$ is above 1.0 and a downward bias when $\hat{\mu}_{G,t}$ is below 1.0. Attempting to remedy this bias, Norrbin (1993) used a production function including intermediate goods as an additional input.

$$Q_{G,t} = \Theta_{G,t}F(L_t, M_t, K_t)\ , \tag{A-14}$$

and, then with the same method as that of Hall (1988), he derived a relationship as

$$\Delta q^{k}_{G,t} - (\alpha_{G,t}\,\Delta l_t + \gamma_t\,\Delta m_t) = (\mu_{G,t}-1)\,(\alpha_{G,t}\,\Delta l_t + \gamma_t\,\Delta m_t) + \theta_G + \varepsilon_{G,t}\ . \tag{A-15}$$

He not only conducted testing of markup pricing but also estimated the markup ratio with

$$\hat{\mu}_{G,} = \frac{\mathrm{cov}\,(\Delta q^{k}_{G,t}, \Delta Z_t)}{\mathrm{cov}\,[(\alpha_{G,t}\,\Delta l_t + \gamma_t\,\Delta m_t, \Delta Z_t)]}\ , \tag{A-16}$$

where

$$\alpha_{G,t} = \frac{w_t L_t}{MC_{G,t}\,Q_{G,t}}\ .$$

B. Testing Method of Economies of Scale and Markup Pricing[31]

The production function expressed by equation (A-14) is totally differentiated as follows:

$$\Delta q_G = \left(\frac{F_L L}{Q_G}\right)\Delta l + \left(\frac{F_M M}{Q_G}\right)\Delta m + \left(\frac{F_K K}{Q_G}\right)\Delta k + \theta_G\ . \tag{A-17}$$

[31]For simplicity, subscript t will be omitted hereafter.

F_L, F_M, and F_K denote marginal products of respective factors of production. From equation (A-17), an indicator of economies of scale δ_G can be expressed as follows:

$$\delta_G = \left(\frac{F_L L}{Q_G}\right) + \left(\frac{F_M M}{Q_G}\right) + \left(\frac{F_K K}{Q_G}\right) \quad . \tag{A-18}$$

$\delta_G > 1$ implies the existence of economies of scale. Note also that if $\delta_G = 1$, then θ_G in equation (A-17) equals the Solow residual. If a firm in a particular industry is a price-setter (it is a price-taker in the markets of factors of production), the first order condition for cost minimization is

$$P_J = \omega F_J, J = L, M, K \quad . \tag{A-19}$$

Here, ω is a Lagrangean multiplier and also means marginal cost. P_J is a factor price ($P_L \equiv w$, $P_K \equiv r$). Thus, by definition, markup ratio can be expressed as $\mu_G = \frac{P_G}{\omega}$. Therefore, equation (A-19) can be transformed as

$$\left(\frac{F_J J}{Q_G}\right) = \mu_G \left(\frac{P_J J}{P_G Q_G}\right) \equiv \mu_G S_J, \quad J = L, M, K \quad . \tag{A-20}$$

This equation implies that the elasticity of output with respect to a factor of production J can be expressed as a product of μ_G and the share of factor income S_J in the total revenue. Under perfect competition ($\mu_G = 1$), as equation (A-20) shows, the elasticity of output with respect to each factor of production equals the share of respective factor income in the total revenue. On the other hand, if perfect competition does not hold, the sum of elasticities of output, with respect to factors of production, becomes larger than the sum of shares of factor incomes in total revenue. Substituting equation (A-18) for equation (A-20) and rearranging, we have

$$\delta_G = \mu_G \left(\frac{wL + p_M M + rK}{P_G Q_G}\right) = \mu_G (1 - S_\pi) \quad . \tag{A-21}$$

Here, S_π denotes the share of profit in total revenue. The equation (A-21) implies that economies of scale and markup ratio are not independent from each other, but they are linked through profit rate. In other words, the higher economies of scale and profit rate, the higher markup ratio becomes. With these relations in mind, we can rewrite the equation (A-17) as follows with c_J as the share of factor of production J in the total cost.

$$\Delta q_G = \delta_G [c_L \Delta l + c_M \Delta m + (1 - c_L - c_M) \Delta k] + \theta_G \quad . \tag{A-22}$$

The equation (A-22) shows that the growth rate of output can be expressed as a product of the weighted sum of the growth rates of factors of production with the weights of respective cost shares and an indicator of economies of scale δ_G. Assuming a constant

[32]This will be simply called profit rate hereafter.

δ_G over the period and estimating the equation (A-22), markup ratio δ_G can be calculated from equation (A-21) in relation to profit rate S_π.

Appendix 2: Testing Method of the Degree of Competition through Estimation of the Cost Function

A. Derivation of the Cost Function

The production function of each industry is defined as follows:[33]

$$Q = \Theta L^{\alpha} K^{\beta} M^{\gamma} . \tag{A-23}$$

By duality theorem, profit maximization problem can be substituted by cost minimization problem subject to an assumed production function.[34] The following demand functions for each factor of production can be derived from cost minimization problem.

$$L^D = \Theta^{-\frac{1}{\rho}} w^{-\frac{\beta+\gamma}{\rho}} r^{\frac{\beta}{\rho}} P_M^{\frac{\gamma}{\rho}} Q^{\frac{1}{\rho}} A , \tag{A-24}$$

$$K^D = \Theta^{-\frac{1}{\rho}} w^{\frac{\alpha}{\rho}} r^{-\frac{\alpha+\gamma}{\rho}} P_M^{\frac{\gamma}{\rho}} Q^{\frac{1}{\rho}} B , \tag{A-25}$$

$$M^D = \Theta^{-\frac{1}{\rho}} w^{\frac{\alpha}{\rho}} r^{\frac{\beta}{\rho}} P_M^{-\frac{\alpha+\beta}{\rho}} Q^{\frac{1}{\rho}} C . \tag{A-26}$$

Here, $\rho = \alpha + \beta + \gamma$ and A, B, and C are constants. Thus total cost TC can be expressed as follows:[35]

$$\begin{aligned} TC &= wL^D + rK^D + p_M M^D \\ &= \Theta^{-\frac{1}{\rho}} (A+B+C) w^{\frac{\alpha}{\rho}} r^{\frac{\beta}{\rho}} p_M^{\frac{\gamma}{\rho}} Q^{\frac{1}{\rho}} . \end{aligned} \tag{A-27}$$

Thus average cost AC and marginal cost MC can be expressed as follows:

$$AC = \frac{TC}{Q} = \Theta^{-\frac{1}{\rho}} (A+B+C) w^{\frac{\alpha}{\rho}} r^{\frac{\beta}{\rho}} p_M^{\frac{\gamma}{\rho}} Q^{\frac{1}{\rho}-1} , \tag{A-28}$$

$$MC = \frac{\partial TC}{\partial Q} = \frac{1}{\rho} \Theta^{-\frac{1}{\rho}} (A+B+C) w^{\frac{\alpha}{\rho}} r^{\frac{\beta}{\rho}} p_M^{\frac{\gamma}{\rho}} Q^{\frac{1}{\rho}-1} . \tag{A-29}$$

Therefore AC and MC are related in the following manner:

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[33]In the following, the subscript $_G$ is omitted.

[34]For details, refer to Varian (1991).

[35]In the following we call total cost function simply cost function.

$$MC = AC \times \frac{1}{\rho\,(=\alpha+\beta+\gamma)} \ . \qquad \text{(A-30)}$$

This implies that MC is below AC if there exist economies of scale ($\alpha+\beta+\gamma>1$). Thus MC is overestimated and markup ratio will be underestimated compared with their real values if an analysis is conducted with an assumption of constant returns to scale while economies of scale exist in reality.

B. Testing Method of the Degree of Competition and Measurement Method of Variable Markup Ratios Over Time

Marginal revenue (MR) is defined as follows:

$$MR\,(=MC) = P + \lambda h\,(Q, Y, a) \ . \qquad \text{(A-31)}$$

Here, $h(\bullet)$ denotes the price semi-elasticity of demand, $\frac{Q}{\frac{\partial Q}{\partial P}}$. Q is an output, Y is an aggregate income and a is a vector of parameters to be estimated, respectively.

Now a new parameter λ is introduced as an indicator of the degree of market power of an industry. For $\lambda=0$, firms act as though marginal revenue coincides with demand, which describes perfectly competitive behavior (marginal cost pricing). On the other hand, for $\lambda=1$, firms choose output or prices in accordance with the industry marginal revenue curve, which describes joint monopoly or perfect collusion. In this situation price is set at a level above marginal cost by $-h(Q,\ Y,\ a)$. Intermediate values of λ correspond to various degrees of imperfect competition or collusion.

Estimation of λ requires estimating both equation (A-31) and demand function (or its reverse function). Demand function is specified as (ε is an error term)

$$Q = a_0 + a_1P + a_2Y + a_3PY + \varepsilon \ , \qquad \text{(A-32)}$$

where, PY denotes an interactive term (price and income). Owing to the inclusion of this term, the slope of demand function becomes a_1+a_3Y and changes with income variation.

From equations (A-30) and (A-32), the equation (A-31) can be transformed as

$$P = \frac{-\lambda Q}{a_1+a_3Y} + AC \times \frac{1}{\rho\,(=\alpha+\beta+\gamma)} \ . \qquad \text{(A-33)}$$

Parameter representing the degree of market power of the industry can be measured by simultaneously estimating equations both (A-32) and (A-33). In addition, in order to make a more general analysis, estimation of marginal cost is conducted to consider economies of scale by jointly estimating cost function of equation (A-27).

Furthermore, if markup ratio is defined as

$$\mu_t = \frac{P_t}{MC_t} = \frac{P_t}{AC_t \times \rho} \ . \qquad \text{(A-34)}$$

From equation (A-34), change of markup ratio over time can be observed.

Appendix 3: Data Appendix

Details of data used in this paper are as follows.[36]

Q_G : Gross output in terms of the producers' prices (in real terms).
Q_{VA} : Value added output in terms of producers' prices (in real terms).
L : Number of employees.
K : Existing capital stock by the industry (installment base, in real terms).
M : Input of intermediate goods (in real terms).
α_G : Employees' income / {nominal gross output – (indirect taxes-subsidies)}.
α_{VA} : Employees' income / {nominal value added output – (indirect taxes-subsidies)}.
γ : Intermediate goods / {nominal value added output – (indirect taxes-subsidies)}.
Y : Real GDP.
AC : (Employees' income+intermediate goods capital cost) / real gross output.
Z : For instrumental variables, in addition to the change rate of oil-coal-natural gas price index (price indexes of imported goods) and real defense expenditure in government expenditures, the official discount rate and the growth rate of the credit outstanding extended by the government financial institutions are also used.

Capital cost rK is calculated as follows, and by dividing it with real capital stock, capital rental rate r can be calculated.

$$rK = \text{fixed capital consumption} + 10 \text{ year national bond subscribers' yield} \times \text{real capital stock} \times \text{capital goods price index}^{37}$$

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[36]The data of gross output, value added output, number of employees, inputs of intermediate goods, income of employees, fixed capital comsumption, indirect taxes (minus subsidies), goverment expenditure for defense are taken from *National Accounts* (Economic Planning Agency) and Capital stock by industry from *Annual Report on Capital Stock of Private Enterprises* (Economic Planning Agency). Import price index for oil, coal, and natural gas, the official discount rate, and credit outstanding extended by goverment financial institutions from *Annual Report on Economic Statistics* (Bank of Japan).

[37]To estimate capital rental cost, a conventional method is to transform it into real terms by subtracting the growth rate of capital goods price from interest rate (for example, see Tajika *et al.* [1987]), but in this paper it is not adopted because it is loaded with a problem of the real interest rate becoming negative due to a shrp rise in the price of capital goods after oil shock. The souce of data for 10 year national bond subscriber's yield and the capital goods price (wholesale price index of capital goods) are *Annual Report in Ecomonic Statistics* (Bank of Japan).

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