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R & D Expenditures, Royalty Payments, and Sales Growth in Japanese Manufacturing Corporations

by

Hiroyuki Odagiri

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Institute of Socio-Economic Planning
University of Tsukuba
Sakura, Ibaraki 305, Japan

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ABSTRACT

This paper investigates the correlation among R & D expenditures per sales, patent royalty payments per sales, and the rate of sales growth, using the sample of 370 Japanese manufacturing corporations. Separating the industries into innovators -- chemical, drug, electrical equipment, and precision equipment industries that have R & D/sales ratio greater than the overall average -- and noninnovators, we found R & D contributing to growth only among the innovators. Royalty payments were estimated ineffective to growth in both. Also estimated were that slower growth stimulates internal R & D among noninnovators and royalty payments among innovators, and that R & D and royalty payments are complements.

1 INTRODUCTION

This paper empirically analyzes the relationship among R & D expenditures, patent royalty payments, and the rate of sales growth in large Japanese manufacturing corporations. Such an analysis will enable us to answer several interesting questions. For exaple, does R & D really contribute to sales growth? Which is more effective to growth making research inside of the company or acquiring licenses for patents from outside? Are R & D expenditures and royalty payments substitutes or complements? That is, does introducing outside patents reduce the necessity of making research internally or increase it by requiring internal research to utilize the patents? Is there any reverse causality such as sales growth affecting R & D expenditures or royalty payments? If so, is the effect positive or negative? Are there industrial differences on these effects? For instance, in which industries is R & D most effective to sales growth?

A rich stock of studies is available concerning the relationship between R & D and market structure (see Kamien and Schwartz, 1975). However, there are only a few on the effects of R & D on growth. Earlier supports to the contribution of research on sales growth were given by Scherer (1965a) who found a positive association between the number of patents issued during a year as a ratio to sales and the rate of sales growth after the year in his cross-section study of 365 firms, and by Mansfield (1968) who found a positive effect of successful innovations on corporate growth in the steel and petroleum industries. However, not all research yields patents or successful innovation and whether expending in research always contributes to growth has not been answered by these writers.

A more extensive study on this subject is Leonard's (1971) cross-industry study, which found the correlation coefficient between the ratio of company

R & D spending to net sales and the rate of sales growth not only positive and significant but also increasing in the length of growth period, for instance, .619 for the correlation between the R & D intensity in 1957 and the sales growth during 1958-61 and .818 for that during 1958-67. This latter fact, he argued, suggests a causality from research to growth and not the reverse of it, because the higher correlation with longer-run growth presumably resulted from the growing proportion of sales represented by new and improved products created through R & D. Branch (1974), using a distributed lag model and pooled data of cross section (across firms) and time series in each of seven industries, used the ratio of the number of patents received in a given year to sales as the measure of research intensity and found its effect on the rate of sales increase positive and significant in every industry, similarly to Scherer's results. In his another study (1973), using the data of 166 firms in eight industries, Branch also found a positive and significant (at 5% level) correlation between the ratio of the number of patents given in a year to assets averaged over 1954-68 and the rate of sales growth during 1950-64. Presuming four-year lag between reducing an innovation to practice and receiving a patent on it, these two variables are for the same period and thus the direction of causality is unclear.

Though principally aimed at inquiring into the effect of market structure on research, Rosenberg (1976) and Doi (1977) both considered the relation between research and growth by including the rate of sales growth besides market share, etc., as a variable to explain the level of R & D. Rosenberg, on the one hand, in a cross-section study over 100 U.S. companies, found the effect of sales growth during 1958-63 on the percentage of total employment allocated to professional R & D personnel in 1964 positive and significant at 1% level whereas the correlation between sales growth during 1964-69 and the same R & D variable was significant at 2% level, suggesting past growth

stimulating R & D which in turn stimulates future sales growth with the first effect a little stronger. Doi, on the other hand, made a cross-section study over 350 Japanese manufacturing companies and found a negative effect of sales growth during 1967-72 on R & D expnditures in 1972 or its ratio to sales. This negative correlation was sustained when the number of patents received during 1973-75 was alternatively used as a research variable. Doi did not investigated the correlation between R & D expenditures and the rate of growth following the research.

Thus, there seem to exist positive effects of R & D on growth and of growth on R & D in the United States but a negative effect of growth on R & D in Japan. However, the researches are too few, particularly in Japan, to claim this result final and more fact findings are desired. No study has been made on the correlation between research and post-research growth in Japan. Neither has been made a study of the relation between patent loyalty payments and growth in any country as far as the author knows. Because firms can make a choice between making research themselves and acquiring licenses for outside patents, royalty payments should be considered as an alternative means of paying for research; hence, it is more logical to include royalty payments as an alternative R & D variable. This study aims to fill these needs -- an addition of new finding and a new approach to the analysis of relation between R & D and corporate growth.

2 DATA AND VARIABLES

Our sample consists of 370 Japanese manufacturing firms that satisfy two conditions; first, listed on the first market of Tokyo Stock Exchange through 1966 to 1980,[1] and second, without any merger that substantially changed the size of the firm (e.g., by more than a quarter) during the same period. All tha data were taken from company financial reports.

Three kinds of variables were used; GSLS is the rate of sales growth, RS is the ratio (in percentage) of R & D expenditures to sales, and PS is the ratio (in percentage) of patent royalty payments to sales. GSLS was calculated for the 12 year period that starts in 1969 and ends in 1981. RS and PS were calculated for the first four years during this 12 year period (named RSPRE and PSPRE, respectively) and for the last four years (named RSPOST and PSPOST, respectively). Thus, although there is a four-year overlap, we may say that RSPRE indicates the R & D intensity before the period for which GSLS was measured and RSPOST, after the period, and similarly for PSPRE and PSPOST. These variables were calculated as an average over the four years to eliminate the effect of yearly fluctuation. Because of this time setting, we expect that RSPRE and PSPRE may affect GSLS but RSPOST or PSPOST may not, and that GSLS may affect RSPOST and/or PSPOST but may not affect RSPRE or PSPRE. This fact will be used to estimate the causality between research and growth from statistical results.

GSLS was obtained as the slope coefficient (minus one) of the equation with time as the independent variable and the logarithm of sales as the dependent variable. This measure has an advantage over another popular measure, the ratio of sales in the ending year to that in the starting year, in that all the sales figures during the period are utilized and that the figures in the ending and starting years do not unduly influence the growth rate. Still, we report here that as a precaution all the following analyses have been also made using this alternative measure of growth rate with essentially the same results.

Several other remarks are quickly made. First, many firms had zero values for RS, PS, or both. We did not give any separate treatment to them. Since zero is the corner solution, there is a possibility of some bias here.

Second, we did not include the R & D expenditures financed by the government. Because the transfer of R & D funds from the government to businesses is almost zero in Japan,[2] this exclusion is harmless. Third, industrial classification follows that of Tokyo Stock Exchange. Admittedly there are instances in which this classification does not truly reflect the activity of a firm. Fourth and finally, because we used R & D expenditures and royalty payments as reported by companies in their financial statements, the definition on these categories may differ across firms and the figures may not accurately indicate the extent of research activity of firms. Due to the lack of any other source of data, however, we have to rely on these.

Table 1 summarizes the data. It gives the means of five variables, GSLS, RSPRE, RSPOST, PSPRE, and PSPOST, for 13 industries and for all the manufacturing. Perhaps most prominent is the exceptionally high rate of growth in the petroleum refinery industry. This reflects the steep rise in oil prices after the oil crisis of 1972-3, because the growth rate is in terms of nominal, but not real, sales volume. Also noticed is that the same industry has the lowest research intensity in terms of both R & D/sales and royalty/sales. These facts combined suggest a negative influence on the correlation coefficient between GSLS and any research variable when industries are aggregated, possibly biasing the whole result. In order to examine the extent of this bias, we redid the statistical analysis to be presented in the following section excluding from sample the seven refining companies. The result suggested little bias; that is, the results are hardly affected by the exclusion of the refining companies except that in many cases t-values were slightly decreased.

As is observed in many countries, the drug industry is most and exceptionally research intensive. It spent 4 percent of its sales revenue to R & D in 1969-72 and 6.7 percent, in 1977-80, which are more than three times the

percentage in the precision equipment industry, the second most research intensive industry. The PS's in the drug industry were much smaller than RS's, merely one seventh in 1969-72. Still, it was the largest among the 13 industries. Thus, relatively to the volume of sales, the drug industry not only spent most in making research inside the companies but also in obtaining licenses for outside patents, which are mostly from foreign companies. In terms of RS, it is followed by the precision equipment, chemical, and electrical equipment industries. These four industries are the only ones with RSPRE and RSPOST greater than the averages over all manufacturing industries, implying a skewed distribution of research intensity across industries. We will hereafter aggregate these four industries under the name of the innovators and the other nine industries, the noninnovators. This classification is similar to that of Scherer (1965b) in which 14 industries were classified to electrical, chemical, moderates, and unprogressive. Roughly speaking, the first two are here innovators and the latter two, noninnovators. We will show that there are important behavioral differences between innovators and noninnovators.

On average, the innovators spent 1 to 2 percent of sales revenues in R & D and the noninnovators, .2 to .4 percent. Both spent less on royalty. In all the manufacturing, for a dollar in R & D, the companies spent only 36 cents on royalty in 1969-72. In 1977-80, this figure dropped to 19 cents suggesting that Japanese firms are relying less and less on patent licenses and more and more on internal research efforts, due perhaps to the technological catch-up of Japanese manufacturing companies and the fewer opportunities to introduce patents from foreign companies.

3 RESULTS

Table 2 gives the estimated coefficients of correlation between GSLS and the four alternative research variables. In all the manufacturing, we find the correlations with RSPRE and RSPOST positive and significant at 5 percent level, and the correlations with PSPRE and PSPOST negative but insignificant even at 10 percent level. The four innovative industries all have positive coefficients with RSPRE and RSPOST and only these plus the nonferrous metal and metal products industry have the coefficients with RSPRE greater than .2. This fact is consistent with the positive and significant correlation between GSLS and RSPRE for the innovators as a whole. Another finding about the innovators is that the correlation with RSPRE is stronger than that with RSPOST, which may suggest a stronger effect of research on growth than that of growth on research, although, individually taken, RSPOST is slightly more correlated with GSLS in the chemical and precision equipment industries. Interestingly, the correlation with PSPRE and that with PSPOST are both negative among the innovators, the former being insignificant and the latter being significant only at 10 percent level, weakly suggesting a negative effect of growth on royalty payments. We may thus speculate that in these industries a firm with slower sales growth tends to pay more to obtain patent licenses so as to recover their deteriorating position in the market. It needs be noted, however, that in the drug industry GSLS is strongly positively correlated with PSPOST, suggesting that a growing drug company tends to pay more for patent royalty, whereas strong negative correlation between GSLS and PSPOST is found in the electrical equipment industry.

Among the noninnovators, by contrast, the correlations with RSPRE and RSPOST are both negative and RSPOST is more strongly correlated with

GSLS than RSPRE. Thus the causality reverse to that for innovators, slower growth in sales stimulating research, is suggested. The correlations with PS's are negative but insignigicant, with a slightly larger absolute value for that with PSPOST. A conjecture is therefore made that a noninnovator with a lower growth rate seeks to foster growth by making more innovative efforts, with expending for research internally preferred to obtaining patent licenses from outside as the means to achieve innovation. This differs from the estimated behavior of innovators that depend on outside patents when sales growth is slow.

Looking at individual noninnovative industries, only a few coefficients are significant. In the nonferrous metal and metal products industry, GSLS is positively and significantly (though only at 10 percent level) correlated with three of the four research variables, unlike in the noninnovators as a whole. In the transportation equipment industry, GSLS is negatively and significantly correlated with RSPOST and PSPOST but not with RSPRE and PSPRE. The correlation coefficients, particularly between GSLS and PS's, are positive and rather large in the petroleum refinery industry, though not significant due at least partly to the fewness of samples.

We have observed a very important behavioral differences between the innovators and the noninnovators. To analyze further, we present in Table 3 the estimation result in which GSLS is regressed to RSPRE and PSPRE or to RSPOST and PSPOST. (Only the results for the innovators and the noninnovators are presented here to save space.) This confirms our findings above. Particularly, because among the innovators the coefficient for RSPRE is not only positive and significant but also with a larger t-value than that for RSPOST, we can estimate that the innovators' research contributes to their sales growth. For the noninnovators, on the contrary, the effect of RSPRE

on GSLS is insignificant and negative. We also observe that the partial correlation between GSLS and PSPOST for the innovators and the partial correlation between GSLS and RSPOST for the noninnovators are both negative and significant, suggesting again that under slower growth in sales the innovators tend to rely on patent licenses whereas the noninnovators tend to expend on research within the company. To confirm this hypothesis, however, requires the estimation of regression equations with RSPOST or PSPOST as the dependent variable.

Table 4 presents the estimation result of regressions with RSPOST as the dependent variable. They include RSPRE as an explanatory variable since some continuity in research activiry is expected. In fact, the coefficient for RSPRE turned out to be highly significant in every equation explaining more than sixty percent of the variation in RSPOST. The coefficient for GSLS is significantly negative at 10 percent level among the noninnovators but not significantly different from zero among the innovators. Thus, sales growth negatively affects the intensity of R & D within the firm in the case of the noninnovators but may not do in the case of innovators.

Table 5 similarly presents the regression result with PSPOST as the dependent variable. Again, its earlier rate, PSPRE, is highly significant. The coefficient for GSLS is significantly negative among the innovators but insignificant among the noninnovators, giving a sharp contrast to the result concerning RSPOST. That is, sales growth negatively affects the intensity of royalty payments in the case of the innovators but may not do in the case of the noninnovators.

Table 5 also presents the result when RSPOST is added as an explanatory variable. It is found that, with or without GSLS as another explanatory variable, the effect of RSPOST on PSPOST is positive in both of the two industrial categories but significant only among the noninnovators. It is

therefore estimated that internal research and patent introduction are complements than substitutes; that is, a firm with a larger expenditure on internal R & D tends to pay more for royalty payments. This may be because a research intensive firm tends to utilize both of the two means to achieve innovation or because introducing a patent from outside requires internal research efforts to comprehend the new technology implied in the patent and apply it to meet the company's own needs, experiences, and equipments. In case of the noninnovators, we may conjecture that a decrease in the rate of sales growth increases internal research effort which in turn increases or accompanies royalty payments. This indirect negative effect of GSLS on PSPOST is consistent with the negative (though insignificant) correlation coefficient between the two variable.

4. SUMMARY AND CONCLUDING REMARKS

This paper analyzed the correlation among R & D expenditures (per sales revenue) RS, patent royalty payments (per sales revenue) PS, and the rate of sales growth GSLS, using the sample of 370 Japanese manufacturing corporations. Two variables were defined for RS (PS) depending on the period -- RSPRE (PSPRE) which measures research intensity around the beginning of the period in which the rate of growth is measured and RSPOST (PSPOST) which measures it around the end of the period. It was found convenient to separate the entire sample into two categories, innovators and noninnovators, depending on whether the research intensity is above or below average, respectively. We found important differences between the two in our results.

The major findings are as follows: (i) Both RSPRE and RSPOST are positively correlated with GSLS with a stronger correlation between RSPRE and GSLS [for the innovators only]. (ii) PSPOST is negatively correlated

(rather weakly) with GSLS [innovators]. (iii) RSPOST is negatively correlated with GSLS [noninnovators]. (iv) The correlation between PSPRE and GSLS is negative but insignificant [both innovators and noninnovators]. (v) RSPOST positively affects PSPOST [significantly for noninnovators; insignificantly for innovators].

Combined with the a priori reasoning that timewise while RSPRE or PSPRE (or both) can affect GSLS, RSPOST or PSPOST cannot, we conclude that the positive effect of research on growth was confirmed only among the innovators, namely, those firms in the chemical, drug, electrical equipment, and precision equipment industries, and that the effect on growth of paying for patent licenses is dubious. It is also estimated that, faced with slow growth, the innovators tend to rely on patent licenses whereas the noninnovators tend to expend on internal research which may be reinforced by the introduction of outside patents.

This result raises an interesting question on the rationality of corporations. If R & D expenditures are effective to growth but royalty payments are not, why do innovators tend to rely on the latter than the former when sales growth is slow? Also, if the noninnovators' R & D expenditures do not contribute to their sales growth, why do they tend to pay more on R & D when sales growth is slow? Here may be a cumulative effect: A badly performing (in terms of sales growth) innovator (noninnovators) tend to rely on patent licenses (internal research) which actually are hardly effective to sales growth and thus may well hurt its performance further through the increased cost. Or it may be that the relative effectiveness of the two means of innovation changed between 1970 and 1980 and the corporate managers accurately foresaw it. This study cannot answer which.

Another interesting question is whether the result mainly owes to

differences across industries or to differences across firms. One way to answer this is to analyze the cross-industry data. We calculated the correlation coefficient between RSPRE and GSLS using the mean values for the 13 industries in Table 1, and found it -.0209 and insignificant even at 10 percent level. Also in a multiple regression using these industrial data with GSLS as the dependent variable, we found the coefficients for RSPRE positive and for PSPRE negative with the t-values .194 and .351, respectively, which needless to say are insignificant. Therefore, we infer that the results presented in this paper mostly owe to the differences across firms, suggesting the importance of utilizing company data in the analysis of research activity.

N O T E S

1. Since 1961, Tokyo Stock Echange has been separated into two markets. The first market is more prestigious with stricter listing requirements and lists all the big well-known Japanese corporations.

2. Among the R & D performed by businesses only 2 percent is financed by the national and local governments. See Japan, Office of the Prime Minister, Report on the Survey of Research and Development.

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TABLE 1 DATA

Industry	Mean Values of					Number of Observations
	GSLS	RSPRE	RSPOST	PSPRE	PSPOST	
Food	5.493	.231	.382	.0426	.0308	30
Textiles	3.477	.395	.424	.0258	.0396	35
Paper	5.493	.185	.268	.0253	.0131	14
Chemical	6.072	.886	1.126	.192	.103	54
Drugs	5.867	3.976	6.573	.580	.529	15
Petroleum Refinery	10.371	.0339	.0343	.00114	.000293	7
Rubber, Glass and Cement	5.648	.209	.302	.127	.0872	29
Iron and Steel	5.533	.0850	.115	.0630	.0242	27
Nonferrous Metal and Metal Products	4.693	.325	.531	.0488	.0197	29
Machinery	4.553	.371	.551	.401	.260	43
Electrical Equipment	5.440	.575	.870	.538	.384	42
Transportation Equipment	6.124	.157	.328	.0719	.156	33
Precision Equipment	6.692	1.160	1.885	.420	.524	12
All Manufacturing	5.427	.562	.839	.204	.158	370
Innovators	5.892	1.183	1.777	.380	.292	123
Noninnovators	5.195	.253	.373	.117	.0914	247

TABLE 2 CORRELATION COEFFICIENTS BETWEEN GSLS AND FOUR ALTERNATIVE RESEARCH VARIABLES

Industry	Variables			
	RSPRE	RSPOST	PSPRE	PSPOST
Food	.055	-.077	.109	.118
Textiles	-.029	-.055	.023	.364**
Paper	.152	.150	.125	.110
Chemical	.362*	.380*	.235**	.100
drugs	.233	.187	-.053	.634*
Petroleum Refinery	.141	.271	.363	.446
Rubber, Glass and Cement	.000	.020	.150	.050
Iron and Steel	.080	-.001	-.013	-.172
Nonferrous Metal and Metal Products	.327**	.256	.321**	.338**
Machinery	-.182	-.202	-.177	-.147
Electrical Equipment	.202	.117	-.148	-.379*
Transportation Equipment	-.007	-.377*	.062	-.292**
Precision Equipment	.403	.426	-.083	.144
All Manufacturing	.125*	.102*	-.019	-.065
Innovators	.222*	.173**	-.069	-.177**
Noninnovators	-.110**	-.153*	-.074	-.075

Notes: * (**) indicates significance at 5 (10) percent level.

TABLE 3. MULTIPLE REGRESSION RESULTS
(WITH GSLS AS THE DEPENDENT VARIABLE)

Industry	Coefficients for				Adjusted R^2
	RSPRE	RSPOST	PSPRE	PSPOST	
Innovators	.256†		-.263		.044
	(2.653)		(1.172)		
Innovators		.153*		-.548*	.059
		(2.358)		(2.395)	
Noninnovators	-.475		-.392		.008
	(1.611)		(.978)		
Noninnovators		-.521*		-.345	.017
		(2.184)		(.574)	

Notes:

In parentheses are t-values.

† (*) indicates significance at 1 (5) percent level.

TABLE 4 THE DETERMINANTS OF RSPOST

Industry	Coefficients for		Adjusted R^2
	RSPRE	GSLS	
Innovators	1.272†		.734
	(18.382)		
Innovators	1.278†	-.0248	.732
	(17.944)	(.374)	
Noninnovators	1.009†		.633
	(20.608)		
Noninnovators	.999†	-.0181**	.635
	(20.375)	(1.701)	

Notes:

In parentheses are t-values.

† (**) indicates significance at 1 (10) percent level.

TABLE 5 THE DETERMINANTS OF PSPOST

Industry	Coefficients for			Adjusted R^2
	PSPRE	GSLS	RSPOST	
Innovators	.642†			.428
	(9.608)			
Innovators	.633†	-.0515**		.441
	(9.560)	(1.949)		
Innovators	.631†		.0195	.428
	(9.317)		(.991)	
Innovators	.617†	-.0585*	.0275	.445
	(9.197)	(2.184)	(1.397)	
Noninnovators	.449†			.430
	(13.660)			
Noninnovators	.448†	-.00284		.428
	(13.562)	(.539)		
Noninnovators	.431†		.0536†	.445
	(13.020)		(2.788)	
Noninnovators	.431†	-.00081	.0532†	.443
	(12.973)	(.154)	(2.733)	

Notes:

In parentheses are t-values.

† indicates significance at 1 percent level; *, at 5 percent level; and **, at 10 percent level.

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