Debt-Equity in Japanese Manufacturing Industry
1993 – 1999 — Statistical Analysis

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1. Introduction

The primary aim of this paper is to present the results of study of the tendencies, patterns and directions of company finance in Japanese manufacturing industry in years 1993–1999[1] In particular, I have measured the relationship between companies' borrowings and the: 1) Sales, 2) Earnings per Share, 3) Dividend per Share, 4) Total Assets, 5) level of Shareholders' Equity, 6) Return on Assets 7) number of Employees and 8) Research and Development Expenditures.   The secondary aim is to investigate whether there are any similarities among main Japanese manufacture industry branches with regard to above factors and compare those findings with the results of the similar study from the other periods.[2]

Since 1965–66 the corporate finance literature has been enriched in many helpful insights into capital structure dilemma.   The Modigliani-Miller Theory influenced work of many scholars that tried to put this theory into practice partly explaining actual financing behavior. Pure MM theorem was tested many times and adequately described in literature.   It was modified in time as the other theorems trying to find out on what basis a firm chooses between

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internal and external source of funding, between debt and equity, finally between domestic and international capital markets; given that a portion of the firm's capital structure will be debt, the question of optimal capital structure turns from the proportion of debt to the composition of that debt. In the literature the costs and benefits of debt versus equity financing are usually well identified. The issue of the firm's optimal borrowing level has been adequately researched in the related literature.[3] A number of correlation analyses were used to investigate the relationship between companies' borrowings and other variables that may affect companies' capital structure decisions. The variables have been considered regarding Tradeoff Theory, Pecking Order Hypothesis, Agency Theory and other established capital structure models.[4]

Data description

The materials used in this study are derived from two volumes of Japan Company Handbook: Autumn 1994 First Section and Winter 1999 First Section, published by Toyo Keizai Inc. Although there exist other reliable sources of data, such as Ministry of Finance I used Toyo Keizai Japan Company Handbook because of its completeness and accessibility.[5]

Group of thirteen main manufacturing industry branches has been chosen for this study. Each industry sample includes ten biggest companies in terms of sales. The data such — as "Sales", "Earnings per Share — (EPS)" and "Dividend per Share — (DPS)" were

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3) For example: Stiglitz, J. P 'A Re-Examination of the Modigliani-Miller Theorem' American Economic Review, vol 59, p. 784–93, 1969, Cohen, R. D. 'An Implication of Modigliani - Miller Capital Structuring Theorems on the Relation between Equity and Debt', Sheridan T. 'The Modigliani and Miller Theorem and Market Efficiency' National Bureau of Economic Research, Working paper 8641, 2001.

4) For the theory see: Majluf, N. and Myers, S., 'Corporate Financing and Investment Decisions When Firms Have Information Investors Do Not Have,' Journal of Financial Economics, 13, 1984, Jensen, M. C. and W. Meckling, 'Theory of the Firm Managerial Behavior, Agency Costs and Capital Structure,' Journal of Financial Economics, 3 October 1976, Fama and Jensen, 'Separation of Ownership and Control', Journal of Law Economics, 1983, Myers, S. C., 'Determinants of Corporate Borrowing', Journal of Financial Economics, 5, 1977, Titman, S. Wessels, R., 'The Determinants of Capital Structure', Journal of Finance, 43, 1988, Harris, M., Raviv, A., 'Theory of capital structure and technical change', Journal of Finance, 46,1991, Prasad, S., Green, C. J. and Murinde, V., 'Company Financing, Capital Structure, and Ownership: A Survey, and Implications for Developing Economies', Loughborough University, 2001, Rajan, R. and Zingales, L., 'What do we know about capital structure? Some evidence from international data,' Journal of Finance, 1995, and Brealey, R. and Myers. S. C., 'Principles of Corporate Finance. Fourth Edition. New York: McGraw-Hill, 1991,

5) Other sources did not include such data as depreciation, research and development expenditures.

extracted from the company's financial statements.   "EPS" was obtained by dividing net profit by the total number of issued shares at the close of the settlement term.   "DPS" was treated as the total of the mid-term and term-end dividends.   Ordinary dividends were most common, however, there are also special dividends, commemorative dividends and stock dividends regarded here.   "Total Assets" included all assets possessed by the company and is composed of total of current assets, fixed assets, and deferred assets.   The figure of "Total Assets" is equal to the total of liabilities and capital.   "Shareholders' Equity" was extracted from the capital part of the balance sheet, and was obtained by adding surplus to capital stock and legal reserves.   "Borrowings" showed so-called interest-bearing liabilities, namely the total of short and long-term borrowings (including commercial papers), short-term bonds, convertible bonds and warrant bonds.   "Return on Assets — ROA" was calculated as ratio of pre-tax profits to total assets.   "Employees" indicate the number of regular full-time employees of the parent firm, excluding temporary employees, outside workers, and members of the board of directors in principle.

Because of complexity of this study it was necessary to introduce certain structural and methodological limitations regarding statistical analysis.   The first one is that the sample does not include financial companies which operate on functionally different financial strategies from these of manufacturing sector.[6)]   The study includes only the biggest, international manufacturing companies.   This is due to the fact that manufacturing companies are product, innovation and technology leaders for the rest of Japanese industry.   They are also leading in marketing and advertising, and considering the process of financing decisions, may be regarded as good representatives of the whole industry.   These companies dominate corporate sector in terms of capital concentration, and output volume.   Another limitation is that all borrowings are treated as aggregate without division into long and short-term borrowings.   The division between short-term and long-term debt is obviously a significant and important feature from accounting, auditing and corporate accounting management point of view.   The focus of this study is, however, on corporate finance from economic and aggregated point of view, hence more detailed accounting analysis is not conducted here.

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6)   For example, the high debt ratios of firms from banking and finance sectors reflect the nature of their activities as well as any preferences they may have for funding sources.

2. Statistical Analysis of Debt-Equity in Japanese Manufacturing Industry 1993/1999

Coefficients of correlations have been used to measure the relationship between companies' borrowings and the: 1) Sales, 2) Earnings per Share, 3) Dividend per Share, 4) Total Assets, 5) level of Shareholders' Equity, 6) Return on Assets 7) number of Employees and 8) Research and Development Expenditures.

In table 1, coefficients of correlation for Japanese manufacturing industry are compared in six-year period (1993–1999). Companies in this sample display positive correlation between borrowing and sales with average rise of fluctuations of correlation 0.4951 in 1999 and 0.2507 in 1993. The individual industries show wide range of results of correlations regarding the change of correlation in time. The biggest changes of the values of correlations in time can be observed in machinery industry where the correlation rose from negative -0.1591 to strong positive 0.9646. Similarly, many industries have reached very high values of correlation in 1999 (above 0.8, especially for pulp and paper, steel products, oil and coal products, respectively 0.9583, 0.9401 and 0.8987). There are only two industries that reached negative values of coefficient of correlation in 1999: pharmaceuticals (-0.4787) and precision instruments (-0.0125). There are more companies in 1993, that displayed negative correlations. The strongest correlations for this period are observed in steel industry (0.9359) and oil and coal industry (0.9232). There are nine cases where t displays high values. These industries are: pulp and paper, oil and coal, rubber and steel industry in 1993, and textile and apparel, pulp and paper, oil and coal, rubber, steel and machinery in 1999.

Regarding the relationship between borrowings and earnings per share, all correlations whose t value is higher than 2.31 (only five cases) have displayed negative values (see table 2). The only cases that show strong correlations are chemicals, pulp and paper and precision instruments (-0.7329, -07132, -0.6437) in 1993 and chemicals and precision instruments (-0.7256, -0.6758) in 1999. The biggest positive change in time is observed in oil and coal industry, and glass and ceramics (respectively 0.5751 and 0.5156). On the other hand, electrical machinery, textiles and transport equipment display negative coefficients of correlation (respectively -0.2482, -0.135 and -0.1298). 10 out of 13 industries are characterized by low correlations. In 1993 almost all correlations are negative (only rubber industry correlation is slightly positive 0.0634). Sample from 1999 displays more positive

Table 1 Coefficients of Correlation: Borrowing/Sales for Japanese Manufacturing Industry 1993/1999

INDUSTRY	r(B,Sales)1993	r(B,Sales)1999	r1999 – r1993	line of regression: Y = a + bX	
	t[7)]	t		1993	1999
textile & apparel	0.6286	**0.6795**	0.0509		Y = 153075 +
t	2.2861	**2.6196**			0.6892X
pulp & paper	**0.6527**	**0.9583**	0.3056	Y = 130431 +	Y = – 1241 +
t	**2.4367**	**9.4850**		0.8699X	1.2262X
chemicals	– 0.4167	0.0630	0.4797		
t	1.2965	0.1785			
pharmaceuticals	– 0.2509	– 0.4787	– 0.2278		
t	0.7331	1.5421			
oil&coal products	**0.9232**	**0.8987**	– 0.0245	Y = 243296 +	Y = 279366 +
t	**6.7944**	**5.4216**		2.8251X	1.8384X
rubber products	**0.7886**	**0.6499**	– 0.1387	Y = 42836 +	Y = 47939 +
t	**3.6274**	**2.4186**		3.0669X	2.3903X
glass & ceramics	– 0.3554	0.3789	0.7343		
t	1.0754	1.1580			
steel products	**0.9359**	**0.9401**	0.0042	Y = 142243 +	Y = 83797 +
t	**7.5146**	**7.8000**		1.8167X	0.9398X
metal products	0.3909	0.5734	0.1825		
t	1.2012	1.9796			
machinery	– 0.1591	**0.9646**	1.1237		Y = 55273 +
t	0.4558	**10.3455**			2.4947X
electrical machinery	0.2088	0.4875	0.2787		
t	0.6039	1.5792			
transport equipment	– 0.1303	0.3333	0.4636		
t	0.3717	0.9999			
precision instruments	0.0428	– 0.0125	– 0.0553		
t	0.1212	0.0354			
Average	0.2507	0.4951	0.2444		

Source: Calculations based on data from Japan Company Handbook: autumn 1994 first section and winter 1999 first section, Toyo Keizai Inc.

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7) Values of 't' are the results of the Student's test for each examined coefficient of correlation.   In most of cases in this study there are 8 degrees of freedom.   Assuming a probability of p = 0.05 (95% probability of making a correct statement — i.e. borrowings and one of eight examined variables are highly correlated) the critical value of the Student's test is t = 2.31 (i.e. for t > 2.31 there is more than 95% probability that two borrowings and one of eight examined variables are highly correlated.   These high values of the Student's test are indicated in the tables by the bold font.   The lines of regression for these coefficients are presented in the right part of the table.   Looking at the values in the line of regression formula Y-a + bX there is more than 95% probability that the increase in borrowings of one million yen is accompanied by the rise in examined variable (e.g. sales) of b x variable unit.

Table 2   Coefficients of Correlation: Borrowing/Earnings per Share for Japanese Manufacturing Industry 1993/1999

INDUSTRY		r(B,EPS)1993	r(B,EPS)1999	r1999 – r1993	line of regression: Y = a + bX	
		t	t		1993	1999
textile & apparel		– 0.3449	– 0.4799	– 0.1350		
	t	1.0393	1.5472			
pulp & paper		**– 0.7132**	– 0.3349	0.3783	Y = 29.74 – 0.00023X	
	t	**2.8778**	1.0053			
chemicals		**– 0.7329**	**– 0.7256**	0.0073	Y = 54.79 – 0.00021X	Y = 71.57 – 0.00017X
	t	**3.0470**	**2.9825**			
pharmaceuticals		– 0.4684	– 0.1372	0.3312		
	t	1.4995	0.3918			
oil&coal products		– 0.4588	0.1163	0.5751		
	t	1.4605	0.3098			
rubber products		0.0634	0.2733	0.2099		
	t	0.1797	0.8036			
glass & ceramics		– 0.4993	0.0163	0.5156		
	t	1.6299	0.0461			
steel products		– 0.1406	0.2663	0.4069		
	t	0.4017	0.7814			
metal products		– 0.3926	– 0.1776	0.2150		
	t	1.2074	0.5104			
machinery		– 0.1808	0.0389	0.2197		
	t	0.5199	0.1101			
electrical machinery		– 0.1571	– 0.4053	– 0.2482		
	t	0.4499	1.2540			
transport equipment		– 0.2863	– 0.4161	– 0.1298		
	t	0.8452	1.2943			
precision instruments		**– 0.6437**	**– 0.6758**	– 0.0321	Y = 24.92 – 0.00152X	Y = 53.51 – 0.00077X
	t	**2.3791**	**2.5933**			
Average		– 0.3812	– 0.2032	0.1780		

Source: Calculations based on data from Japan Company Handbook: autumn 1994 first section and winter 1999 first section, Toyo Keizai Inc.

correlations but all of them are weak.

In general, there is little correlation between the level of borrowings and earnings per share: – 0.3812 and – 0.2032, respectively for the years 1993 and 1999.

With regard to borrowings and earnings per share, Japanese manufacturing industry has been characterized by similar, weak negative coefficient of correlation of borrowings and dividend per share (see table 3) with average little change in time (0.1652).

There are only six cases of industries that are characterized by relatively strong correlations.   They are: textiles, chemicals, steel products and precision instruments in 1993

Table 3 Coefficients of Correlation: Borrowing/Dividends per Share for Japanese Manufacturing Industry 1993/1999

INDUSTRY	r(B,DPS)1993	r(B,DPS)1999	r1999 – r1993	line of regression: Y = a + bX	
				1993	1999
textile & apparel	− 0.6721	− 0.6032	0.0689	Y = 9.63 –	
t	2.5673	2.1391		4E − 05X	
pulp & paper	− 0.2231	0.2854	0.5085		
t	0.6473	0.8423			
chemicals	− 0.8904	− 0.8529	0.0375	Y = 13.24 –	Y = 16.62 –
t	5.5328	4.6207		4E − 05X	3E − 05X
pharmaceuticals	− 0.5849	− 0.3398	0.2451		
t	2.0396	1.0219			
oil&coal products	− 0.4635	− 0.2028	0.2607		
t	1.4795	0.5479			
rubber products	0.4107	0.2675	− 0.1432		
t	1.2740	0.7852			
glass & ceramics	− 0.5323	− 0.1799	0.3524		
t	1.7785	0.5173			
steel products	− 0.6466	− 0.7836	− 0.1370	Y = 8.69 –	Y = 6.24 –
t	2.3975	3.5675		1E − 05X	5E − 06X
metal products	− 0.372	− 0.1374	0.2346		
t	1.1335	0.3923			
machinery	− 0.2989	0.1887	0.4876		
t	0.8859	0.5435			
electrical machinery	− 0.0754	− 0.0983	− 0.0229		
t	0.2139	0.2794			
transport equipment	− 0.4988	− 0.3787	0.1201		
t	1.6278	1.1573			
precision instruments	− 0.6775	− 0.5427	0.1348	Y = 11.59 –	
t	2.6053	1.8275		0.0002X	
Average	− 0.4250	− 0.2598	0.1652		

Source: Calculations based on data from Japan Company Handbook: autumn 1994 first section and winter 1999 first section, Toyo Keizai Inc.

and, chemicals, steel products in 1999 (correlation values are, respectively, − 0.6721, − 0.8904, − 0.6466, − 0.6775, − 0.8529 and − 0.7839).   Except for rubber products all samples from 1993 display negative correlations.   Almost all industries in this period achieved slight or moderate positive coefficients of correlation.   The biggest positive changes are in pulp and paper and machinery (respectively, 0.5085 and 0.4876).   In contrast, only three other industries: rubber products, steel products and electrical machinery, show negative coefficients of correlation (difference between periods was, respectively, − 0.1432, − 0.1370 and − 0.0229).

Japanese manufacturing industry in both years, 1993 and 1999, has been characterized by

Table 4　Coefficients of Correlation: Borrowing/Total assets for Japanese Manufacturing Industry 1993/1999

INDUSTRY	r(B,Assets)1993	r(B,Assets)1999	r1999 − r1993	line of regression: Y = a + bX	
	t	t		1993	1999
textile & apparel	0.5381	**0.7381**	0.2000		Y = 1999273 +
t	1.8057	**3.0942**			1.4121X
pulp & paper	**0.8331**	**0.9858**	0.1527	Y = 132204 +	Y = − 17816 +
t	**4.2601**	**16.6044**		1.7334X	1.9973X
chemicals	− 0.1016	0.0862	0.1878		
t	0.2889	0.2447			
pharmaceuticals	− 0.2164	− 0.3205	− 0.1041		
t	0.6269	0.9570			
oil&coal products	**0.9360**	**0.9595**	0.0235	Y = 130466 +	Y = 136349 +
t	**7.5210**	**9.0114**		2.6403X	1.935X
rubber products	**0.7149**	0.5973	− 0.1176	Y = 24438 +	
t	**2.8918**	2.1065		5.1303X	
glass & ceramics	− 0.1611	**0.8013**	0.9624		Y = 175638 +
t	0.4617	**3.7883**			1.8662X
steel products	**0.9811**	**0.9898**	0.0087	Y = 146979 +	Y = 117202 +
t	**14.3408**	**19.6511**		3.30624X	1.7733X
metal products	0.5407	**0.7084**	0.1677		Y = 107248 +
t	1.8180	**2.8388**			2.5131X
machinery	0.1063	**0.9811**	0.8748		Y = −107745 +
t	0.3024	**14.3408**			4.3175X
electrical machinery	0.3147	0.5634	0.2487		
t	0.9378	1.9288			
transport equipment	0.1250	0.4405	0.3155		
t	0.3563	1.3878			
precision instruments	0.0471	0.0930	0.0459		
t	0.1334	0.2642			
Average	0.3583	0.5865	0.2282		

Source: Calculations based on data from Japan Company Handbook: autumn 1994 first section and winter 1999 first section, Toyo Keizai Inc.

moderate and strong positive coefficient of correlation between level of borrowings and total assets (0.3538 and 0.5865 respectively in 1993 and 1999, see table 4). The industries in this study have not displayed significant changes in coefficients of correlation in 1993 and 1999. The only strong exceptions were observed in glass and ceramics and machinery industry (respectively, 0.9624, 0.8748). In contrast to positive change for almost all industries, pharmaceuticals and rubber products displayed, as only industries, negative change (− 0.1176 and − 0.1041).

It is important to notice that there are industries displaying very high values of coefficient

Table 5   Coefficients of Correlation: Borrowing/Shareholders equity for Japanese Manufacturing Industry 1993/1999

INDUSTRY	r(B,Shrlds)1993	r(B,Shrlds)1999	r1999 – r1993	line of regression: Y = a + bX	
	t	t		1993	1999
textile & apparel	− 0.0812	0.0855	0.1667		
t	0.2304	0.2427			
pulp & paper	0.4707	**0.8854**	0.4147		Y = − 10382 +
t	1.5090	**5.3875**			0.6217X
chemicals	**− 0.6491**	− 0.5552	0.0939	Y = 512945 −	
t	**2.4135**	1.8881		1.2882X	
pharmaceuticals	− 0.4310	− 0.3562	0.0748		
t	1.3510	1.0782			
oil&coal products	**0.7186**	**0.8671**	0.1485	Y = 61908 +	Y = 36445 +
t	**2.9227**	**4.6054**		0.4721X	0.4104X
rubber products	0.5542	0.4702	− 0.0840		
t	1.8832	1.5069			
glass & ceramics	− 0.4451	0.4955	0.9406		
t	1.4059	1.6135			
steel products	**0.8983**	**0.9436**	0.0453	Y = 124852 +	Y = 91521 +
t	**5.7826**	**8.0610**		0.6417X	0.3724X
metal products	0.2936	0.4697	0.1761		
t	0.8687	1.5048			
machinery	0.0470	**0.8729**	0.8259		Y = 52484 +
t	0.1331	**5.0603**			1.1136X
electrical machinery	− 0.1470	− 0.1974	− 0.0504		
t	0.4203	0.5695			
transport equipment	− 0.1916	0.2737	0.4653		
t	0.5522	0.8049			
precision instruments	− 0.0335	− 0.0875	− 0.0540		
t	0.0948	0.2484			
Average	0.0772	0.3206	0.2433		

Source: Calculations based on data from Japan Company Handbook: autumn 1994 first section and winter 1999 first section, Toyo Keizai Inc.

of correlation between level of borrowings and total assets (in 1999 steel products (0.9898), pulp and paper (0.9858), machinery (0.9811), in 1993 steel products (0.9811) and oil and coal products (0.9360)).   There are eleven cases of strong correlation.   The only weak negative correlations were observed in pharmaceuticals in 1999 (− 0.3205) and in pharmaceuticals, glasss and chemical industry in 1993 (respectively, − 0.2164. − 0.1611 and − 0.1016).

Although the average values of coefficient of correlation: borrowings/ shareholders equity (0.0772, 0.3206, 0.2433 for respectively 1993, 1999 and change, see table 5) may suggest that individual industries have not displayed strong correlation — that is not the case.   In both

years the values show strong dispersion, especially in 1999. In 1993 there are only three industries that display strong correlations: (steel products, oil and coal products and chemical industry (respectively 0.8983, 0.7186 and −0.6491)). In 1999 we observe more cases of strong correlations and all of them are positive: steel products (0.9436), pulp and paper (0.8854), machinery (0.8729 and oil, and coal products (0.8671). There is only one case of moderate negative correlation (chemicals (−0.5552)).

In addition, the biggest positive change of correlations in examined period have been observed in glass and ceramics and machinery (1993 and 1999 — respectively, 0.9406 and 0.8259). There are only two cases of moderate positive change of correlations (transport equipment, 0.4653 and pulp and paper, 0.4147). All remaining industries display weak positive changes of coefficients of correlation in examined period.

Almost all industries in 1993 have displayed moderate or negative correlations between the level of borrowings and return on assets (see table 6). The strongest negative correlations (in 1993) were observed in case of glass and chemicals (−0.8146), pulp and paper (−0.7134), and precision instrumenst (−0.6643). The only industries that displayed positive correlation in 1993 were: glass and ceramics (0.2675), rubber products (0.1975) and transport equipment (0.0677). On the other hand, although almost all the correlations were also negative in 1993 they were generally weaker than in 1993 (average for 1993 and 1999 respectively (−0.3121) and (−0.2619)). There were only two industries which displayed negative correlations for 1999 with t value higher that critical 2.31: precision instruments and electrical machinery with respective correlations: (−0.6946) and (−0.6699). All positive correlation in 1999 were close to zero.

In addition, there was a big dispertion in correlation changes when examinig two sets of industry samples. The strongest positive changes in correlation values were displayed by textiles (0.5525) and pulp and paper (0.4451), and the strongest negative by transport equipment (−0.6508) and electrical machinery (−0.6146).

Regarding the correlation between the level of borrowings and the number of employees there was a little positive change (0.1510) between two periods (see table 7). In average, the correlation coefficient climbed from weak 0.2933 to moderate 0.4443.

We also observe, that in period 1993−1999 almost all industries have displayed moderate or strong positive correlations. In particular, in 1993 the most extreme positive values characterized steel industry (0.9538), rubber industry (0.7491) and pulp and paper (0.7058), whereas in 1999 strong correlations were more frequent: steel products (0.9558), pulp and

Table 6   Coefficients of Correlation: Borrowing/Return on Assets for Japanese Manufacturing Industry 1993/1999

INDUSTRY		r(B,ROA)1993	r(B,ROA)1999	r1999 – r1993	line of regression: Y = a + bX	
		t	t		1993	1999
textile & apparel		– 0.5683	– 0.0158	0.5525		
	t	1.9535	0.0447			
pulp & paper		**– 0.7134**	– 0.2683	0.4451	Y = 8.13 –	
	t	**2.8795**	0.7877		6E – 05X	
chemicals		**– 0.8146**	– 0.6085	0.2061	Y = 7.44 –	
	t	**3.9723**	2.1688		4E – 05X	
pharmaceuticals		– 0.4719	– 0.3642	0.1077		
	t	1.5139	1.1061			
oil&coal products		– 0.1638	0.0782	0.2420		
	t	0.4696	0.2075			
rubber products		0.1975	0.0410	– 0.1565		
	t	0.5698	0.1161			
glass & ceramics		0.2675	0.0356	– 0.2319		
	t	0.7852	0.1008			
steel products		– 0.5906	– 0.2986	0.2920		
	t	2.0701	0.8849			
metal products		– 0.2353	– 0.1402	0.0951		
	t	0.6848	0.4005			
machinery		– 0.3120	0.0836	0.3956		
	t	0.9288	0.2373			
electrical machinery		– 0.0553	**– 0.6699**	– 0.6146		Y = 4.16 –
	t	0.1567	**2.5520**			1E – 05X
transport equipment		0.0677	– 0.5831	– 0.6508		
	t	0.1919	2.0301			
precision instruments		**– 0.6643**	**– 0.6946**	– 0.0303	Y = 4.25 –	Y = 11.85 –
	t	**2.5137**	**2.7309**		0.0003X	0.0002X
Average		– 0.3121	– 0.2619	0.0502		

Source: Calculations based on data from Japan Company Handbook: autumn 1994 first section and winter 1999 first section, Toyo Keizai Inc.

paper (0.9332), machinery (0.9265), oil and coal products (0.7909) and metal products (0.7701).   The only strong correlation in whole sample was displayed in 1993 by glass and ceramics industry (0.6898).

In addition, there was a big dispertion in the changes of the values of correlations when examinig two sets of industry samples.   The strongest positive changes were displayed by machinery (0.8054) and the strongest negative by pharmaceuticals (– 0.4165).   There are more industries that displayed positive change in correlation.

In table 8 the correlations between borrowings and research and development expenditures

Table 7 Coefficients of Correlation: Borrowing/Employees for Japanese Manufacturing Industry 1993/1999

INDUSTRY	r(B,Empl)1993	r(B,Empl)1999	r1999 – r1993	line of regression: Y = a + bX 1993	1999
	t	T			
textile & apparel	0.4345	0.5325	0.0980		
t	1.3645	1.7794			
pulp & paper	0.6075	**0.9332**	0.3257		Y = − 283.47 +
t	2.1632	**7.3450**			0.0184X
chemicals	− 0.0583	0.1545	0.2128		
t	0.1652	0.4423			
pharmaceuticals	− 0.1445	− 0.5610	− 0.4165		
t	0.4130	1.9168			
oil&coal products	**0.7058**	**0.7909**	0.0851	Y = 908.42 +	Y = 896.72 +
t	**2.8180**	**3.4195**		0.0073X	0.003X
rubber products	**0.7491**	**0.6659**	− 0.0832	Y = 1225.12 +	Y = 1282.42 +
t	**3.1984**	**2.5246**		0.0772X	0.0451X
glass & ceramics	**− 0.6898**	− 0.1388	0.5510	Y = 7049.09 −	
t	**2.6948**	0.3964		0.0454X	
steel products	**0.9538**	**0.9558**	0.0020	Y = 3998.72 +	Y = 2432.82 +
t	**8.9793**	**9.1947**		0.0299X	0.0112X
metal products	0.5539	**0.7701**	0.2162		Y = 1988.67 +
t	1.8817	**3.4145**			0.0438X
machinery	0.1211	**0.9265**	0.8054		Y = 2659.59 +
t	0.3451	**6.9641**			0.0378X
electrical machinery	0.5301	0.2596	− 0.2705		
t	1.7682	0.7603			
transport equipment	0.0048	0.4480	0.4432		
t	0.0136	1.4173			
precision instruments	0.0455	0.0389	− 0.0066		
t	0.1288	0.1101			
Average	0.2933	0.4443	0.1510		

Source: Calculations based on data from Japan Company Handbook: autumn 1994 first section and winter 1999 first section, Toyo Keizai Inc.

are presented. There was a moderate positive change (0.2354) between two periods. On average, the correlation coefficient climbed from weak (0.1868) to moderate (0.4222). We observe that almost all industries displayed positive correlations except for (chemicals (0.4228) glass and ceramics (− 0.4138), pharmaceuticals (− 0.2175) and transport equipment (− 0.1875) – 1993, and metal products (− 0.2125), chemical (− 0.1231) and pharmaceuticals (− 0.0831) – 1999). The strongest positive correlations in 1993 were in steel products (0.9533) and rubber products (0.7246). In 1999 the strongest positive correlations were displayed by steel products (0.9468), pulp and paper (0.8454), machinery (0.8089) and glass and ceramics

Table 8   Coefficients of Correlation: Borrowing/Research and Development Expenditures for Japanese Manufacturing Industry 1993/1999

INDUSTRY	r(B,R&D)1993	r(B,R&D)1999	r1999 – r1993	line of regression: Y = a + bX	
	t	t		1993	1999
textile & apparel	0.3830	0.4329	0.0499		
t	1.1727	1.1763			
pulp & paper	0.3155	**0.8454**	0.5299		Y=−1068.33+
t	0.9404	**4.1876**			0.0177X
chemicals	− 0.4228	− 0.1231	0.2997		
t	1.3196	0.3508			
pharmaceuticals	− 0.2175	− 0.0831	0.1344		
t	0.6303	0.2359			
oil&coal products	0.3494	0.6606	0.3112		
t	0.9866	1.7599			
rubber products	**0.7246**	0.7266	0.0020	Y = 210.36 +	
t	**2.9738**	1.0575		0.217X	
glass & ceramics	− 0.4138	**0.7344**	1.1482		Y = 2420.48 +
t	1.2856	**2.4195**			0.1022X
steel products	0.9533	**0.9468**	− 0.0065	Y = 5345.71 +	Y = 2540.49 +
t	**7.7315**	**5.8840**		0.0548X	0.0274X
metal products	0.2136	− 0.2125	− 0.4261		
t	0.5356	0.2175			
machinery	0.3047	**0.8089**	0.5042		Y = 8995.78 +
t	0.7153	**3.3700**			0.1195X
electrical machinery	0.3773	0.3565	− 0.0208		
t	1.1523	1.0792			
transport equipment	− 0.1875	0.2794	0.4669		
t	0.5399	0.7699			
precision instruments	0.0490	0.1159	0.0669		
t	0.1388	0.2858			
Average	0.1868	0.4222	0.2354		

Source: Calculations based on data from Japan Company Handbook: autumn 1994 first section and winter 1999 first section, Toyo Keizai Inc.

industry (0.7344).

In addition, several individual industries show wide amplitude of values in both periods. Almost for all industries the changes in correlations are positive (with exception o metal products (− 0.4261)). The strongest positive change in correlation values was in glass and ceramics (by (1.1482) from moderate negative (− 0.4138) to strong (0.7344)). Relatively strong positive changes were displayed also by other three industries: pulp and paper, machinery and transport equipment (with change in value of coefficient correlation in period 1993–1999, respectively, (0.5299), (0.5042) and (0.4669).

From table 9, we can conclude that in 1988 the highest positive average correlations were observed for borrowings and employment (0.5448) and borrowings and sales (0.5035) whereas in 1993 for borrowing and total assets (0.5603) and borrowings and employees (0.4004).[8]

Table 9   Coefficient of Correlation and T-test results for Japanese Manufacturing Industry 1988/2003; synthetic data[9]

INDUSTRY 1988 – 2003	r(B,Sales)	r(B,EPS)	r(B,DPS)	r(B,Assets)	r(B,Shld)	r(B,ROA)	r(B/Empl)	r(B,R&D)
textile & apparel	0.5076	– 0.3371	– 0.2446	**0.6705**	0.0945	– 0.3974	0.4267	0.3387
	1.6663	1.0127	0.7135	*2.5562*	0.2685	1.2249	1.3345	1.0182
pulp & paper	**0.8532**	– 0.0525	– 0.038	**0.8847**	0.1654	– 0.549	**0.8844**	– 0.0953
	4.6267	0.1487	0.1076	*5.3679*	0.4744	1.8578	*5.3595*	0.2345
chemicals	– 0.3579	– 0.3738	**– 0.6589**	– 0.0139	– 0.3628	– 0.5311	0.3812	0.0517
	1.0841	1.1399	*2.4775*	0.0393	1.1012	1.7729	1.1663	0.1464
pharmaceuticals	0.3999	– 0.5216	– 0.5552	0.3229	0.219	**– 0.6605**	0.4751	**0.2478**
	1.2341	1.7292	1.8881	0.9650	0.6348	*2.4882*	1.5271	*0.7234*
oil&coal industry	**0.6992**	– 0.1786	– 0.3088	0.611	– 0.0463	– 0.4492	**0.748**	0.4521
	2.5876	0.4803	0.8590	2.0421	0.1226	1.3302	*2.9818*	1.2415
rubber industry	<u>**0.9674**</u>	**0.9715**	0.6895	**0.9539**	<u>**0.8499**</u>	0.2559	**0.936**	<u>**0.942**</u>
	10.8043	*11.5922*	*2.6926*	*8.9897*	*4.5619*	0.7487	*7.5210*	*7.9388*
glass & ceramics	– 0.0442	**– 0.6315**	<u>**– 0.8606**</u>	0.3682	– 0.0509	**– 0.6643**	**– 0.6361**	– 0.5731
	0.1251	*2.3036*	*4.7796*	1.1201	0.1442	*2.5137*	*2.3317*	1.9780
steel industry	**0.892**	– 0.5075	**– 0.6653**	<u>**0.9778**</u>	**0.7851**	– 0.5155	**0.8466**	**0.8997**
	5.5813	1.6659	*2.5205*	*13.1986*	*3.5853*	1.7016	*4.4991*	*5.4532*
metal industry	**0.7527**	0.4181	– 0.2265	**0.7769**	**0.6493**	– 0.2495	0.623	0.3148
	3.2337	1.3018	0.6577	*3.4900*	*2.4148*	0.7287	2.2527	0.8124
machinery	**0.7896**	– 0.6243	– 0.6119	**0.8454**	0.5046	– 0.6146	**0.7862**	**0.7915**
	3.6396	2.2604	2.1882	*4.4767*	1.6531	2.2037	*3.5984*	*3.6630*
electr. machinery	0.379	– 0.4432	– 0.3063	0.2314	– 0.0923	– 0.5972	0.5459	0.3959
	1.1584	1.3984	0.9101	0.6728	0.2622	2.1059	1.8429	1.2194
transport equipm.	0.3103	– 0.1672	0.3097	0.4787	0.1898	– 0.3189	0.4813	0.3865
	0.9232	0.4797	0.9213	1.5421	0.5468	0.9517	1.5530	1.0265
precision instr.	0.3965	0.0328	**0.771**	**0.706**	0.4433	– 0.491	0.584	**0.8782**
	1.2216	0.0928	*3.4243*	*2.8196*	1.3988	1.5941	2.0349	*5.1933*
average 1988	**0.5035**	**– 0.186**	**– 0.208**	**0.601**	**0.2576**	**– 0.445**	**0.5448**	**0.387**
for all industries	**0.5337**	**– 0.2383**	**– 0.1130**	**0.6788**	**0.3181**	**– 0.3727**	**0.6439**	**0.4578**

8) For detailed statistical analysis of years 1988 and 2003 see: Kuczynski, T., 'Statistical Analysis of Debt-equity in Japanese Manufacturing Industry 1988/2003', Journal of Economic Sciences, Hiroshima Shudo University, 2005.

9) Bold figures indicate correlations for which Student's test result was greater than 2.31, i.e. there is more than 95% prorobability that two borrowings and one of eight examined variables are highly correlated.   Underlined figures indicate the strongest correlation (positive or negative) between debt and examined variable in whole sample of industries, Italics: Student's test; t > 2.31.

textile & apparel	0.6286	– 0.3449	**– 0.6721**	0.5381	– 0.0812	– 0.5683	0.4345	0.383
	2.2861	1.0393	*2.5673*	1.8057	0.2304	1.9535	1.3645	1.1727
pulp & paper	**0.6527**	**– 0.7132**	– 0.2231	**0.8331**	0.4707	**– 0.7134**	0.6075	0.3155
	2.4367	*2.8778*	0.6473	*4.2601*	1.509	*2.8795*	2.1632	0.9404
chemicals	– 0.4167	**– 0.7329**	**– 0.8904**	– 0.1016	**– 0.6491**	**– 0.8146**	– 0.0583	– 0.4228
	1.2965	*3.047*	*5.5328*	0.2889	*2.4135*	*3.9723*	0.1652	1.3196
pharmaceuticals	– 0.2509	– 0.4684	– 0.5849	– 0.2164	– 0.4310	– 0.4719	– 0.1445	– 0.2175
	0.7331	1.4995	2.0396	0.6269	1.351	1.5139	0.413	0.6303
oil&coal products	**0.9232**	– 0.4588	– 0.4635	**0.936**	**0.7186**	– 0.1638	**0.7058**	0.3494
	6.7944	1.4605	1.4795	*7.521*	*2.9227*	0.4696	*2.818*	0.9866
rubber products	**0.7886**	0.0634	0.4107	**0.7149**	0.5542	0.1975	**0.7491**	**0.7246**
	3.6274	0.1797	1.274	*2.8918*	1.8832	0.5698	*3.1984*	*2.9738*
glass & ceramics	– 0.3554	– 0.4993	– 0.5323	– 0.1611	– 0.4451	0.2675	**– 0.6898**	– 0.4138
	1.0754	1.6299	1.7785	0.4617	1.4059	0.7852	*2.6948*	1.2856
steel products	<u>**0.9359**</u>	– 0.1406	**– 0.6466**	<u>**0.9811**</u>	**0.8983**	– 0.5906	<u>**0.9538**</u>	<u>**0.9533**</u>
	7.5146	0.4017	*2.3975*	*14.3408*	*5.7826*	2.0701	*8.9793*	*7.7315*
metal products	0.3909	– 0.3926	– 0.372	0.5407	0.2936	– 0.2353	0.5539	0.2136
	1.2012	1.2074	1.1335	1.818	0.8687	0.6848	1.8817	0.5356
machinery	– 0.1591	– 0.1808	– 0.2989	0.1063	0.0470	– 0.3120	0.1211	0.3047
	0.4558	0.5199	0.8859	0.3024	0.1331	0.9288	0.3451	0.7153
electr. machinery	0.2088	– 0.1571	– 0.0754	0.3147	– 0.1470	– 0.0553	0.5301	0.3773
	0.6039	0.4499	0.2139	0.9378	0.4203	0.1567	1.7682	1.1523
transport equipm.	– 0.1303	– 0.2863	– 0.4988	0.125	– 0.1916	0.0677	0.0048	– 0.1875
	0.3717	0.8452	1.6278	0.3563	0.5522	0.1919	0.0136	0.5399
precision instr.	0.0428	**– 0.6437**	**– 0.6775**	0.0471	– 0.0335	**– 0.6643**	0.0455	0.049
	0.1212	*2.3791*	*2.6053*	0.1334	0.0948	*2.5137*	0.1288	0.1388
average 1993	**0.2507**	**– 0.3812**	**– 0.425**	**0.3583**	**0.0772**	**– 0.3121**	**0.2933**	**0.1868**
for all industries	**0.3865**	**– 0.2289**	**– 0.2851**	**0.5603**	**0.208**	**– 0.2937**	**0.4004**	**0.2425**

textile & apparel	**0.6795**	– 0.4799	– 0.6032	**0.7381**	0.0855	– 0.0158	0.5325	0.4329
	2.6196	1.5472	2.1391	*3.0942*	0.2427	0.0447	1.7794	1.1763
pulp & paper	**0.9583**	– 0.3349	0.2854	**0.9858**	**0.8854**	– 0.2683	0.9332	0.8454
	9.485	1.0053	0.8423	*16.6044*	*5.3875*	0.7877	7.345	4.1876
chemicals	0.063	**– 0.7256**	**– 0.8529**	0.0862	– 0.5552	– 0.6085	0.1545	– 0.1231
	0.1785	*2.9825*	*4.6207*	0.2447	1.8881	2.1688	0.4423	0.3508
pharmaceuticals	– 0.4787	– 0.1372	– 0.3398	– 0.3205	– 0.3562	– 0.3642	– 0.561	– 0.0831
	1.5421	0.3918	1.0219	0.957	1.0782	1.1061	1.9168	0.2359
oil&coal products	**0.8987**	0.1163	– 0.2028	**0.9595**	**0.8671**	0.0782	**0.7909**	0.6606
	5.4216	0.3098	0.5479	*9.0114*	*4.6054*	0.2075	*3.4195*	1.7599
rubber products	**0.6499**	0.2733	0.2675	0.5973	0.4702	0.0410	**0.6659**	0.7266
	2.4186	0.8036	0.7852	2.1065	1.5069	0.1161	*2.5246*	1.0575
glass & ceramics	0.3789	0.0163	– 0.1799	**0.8013**	0.4955	0.0356	– 0.1388	**0.7344**
	1.158	0.0461	0.5173	*3.7883*	1.6135	0.1008	0.3964	*2.4195*
steel products	**0.9401**	0.2663	– 0.7836	**0.9898**	**0.9436**	– 0.2986	**0.9558**	**0.9468**
	7.8	0.7814	*3.5675*	*19.6511*	*8.061*	0.8849	*9.1947*	*5.884*

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metal products	0.5734	− 0.1776	− 0.1374	**0.7084**	0.4697	− 0.1402	**0.7701**	− 0.2125
	1.9796	0.5104	0.3923	*2.8388*	1.5048	0.4005	3.4145	0.2175
machinery	**0.9646**	0.0389	0.1887	**0.9811**	**0.8729**	0.0836	**0.9265**	**0.8089**
	10.3455	0.1101	0.5435	*14.3408*	*5.0603*	0.2373	*6.9641*	*3.37*
electr. machinery	0.4875	− 0.4053	− 0.0983	0.5634	− 0.1974	**− 0.6699**	0.2596	0.3565
	1.5792	1.254	0.2794	1.9288	0.5695	*2.552*	0.7603	1.0792
transport equipm.	0.3333	− 0.4161	− 0.3787	0.4405	0.2737	− 0.5831	0.448	0.2794
	0.9999	1.2943	1.1573	1.3878	0.8049	2.0301	1.4173	0.7699
precision instr.	− 0.0125	**− 0.6758**	− 0.5427	0.093	− 0.0875	**− 0.6946**	0.0389	0.1159
	0.0354	*2.5933*	1.8275	0.2642	0.2484	*2.7309*	0.1101	0.2858
average 1999	**0.4951**	**− 0.2032**	**− 0.2598**	**0.5865**	**0.3206**	**− 0.2619**	**0.4443**	**0.4222**
for all industries	**0.6222**	**− 0.2145**	**− 0.1837**	**0.7401**	**0.402**	**− 0.1807**	**0.6057**	**0.5082**

textile & apparel	**0.9014**	− 0.5507	− 0.5606	**0.929**	0.4347	**− 0.6662**	0.4154	**0.8654**
	5.8883	1.8661	1.9148	*7.1001*	1.3653	*2.5266*	1.2916	*4.8849*
pulp & paper	**0.9729**	− 0.1718	− 0.0853	**0.9895**	**0.9307**	− 0.1211	0.4481	**0.8745**
	11.9008	0.4933	0.2421	*19.3640*	*7.1967*	0.3451	1.4177	*5.0996*
chemicals	0.3018	− 0.5381	**− 0.6601**	0.2798	− 0.2994	− 0.4031	0.0027	0.1616
	0.8954	1.8057	*2.4855*	0.8243	0.8875	1.2458	0.0076	0.4632
pharmaceuticals	− 0.2746	− 0.5559	**− 0.6917**	− 0.3732	− 0.4193	− 0.5174	0.2015	− 0.3327
	0.8077	1.8915	*2.7090*	1.1378	1.3063	1.7101	0.5819	− 0.9979
oli&coal industry	**0.8396**	− 0.0142	− 0.3457	**0.9173**	**0.7942**	− 0.4495	0.4836	**0.9745**
	4.0894	0.0376	0.9747	*6.0948*	*3.4580*	1.3313	1.4618	*9.7111*
rubber industry	**0.9535**	**0.7803**	**0.7908**	**0.9612**	**0.919**	0.3968	**0.9854**	**0.9776**
	8.9481	*3.5289*	*3.6543*	*9.8556*	*6.5930*	1.2227	*16.3703*	*12.2890*
glass & ceramics	**0.8912**	0.0823	− 0.4075	**0.9135**	0.5826	0.133	0.138	0.3721
	5.5570	0.2336	1.2621	*6.3508*	2.0275	0.3796	0.3941	1.1339
steel industry	**0.9714**	0.2877	− 0.4019	**0.9894**	**0.9026**	0.2548	0.4735	**0.9483**
	11.5710	0.8497	1.2414	*19.2709*	*5.9304*	0.7453	1.5205	*8.4512*
metal industry	0.4786	− 0.4143	0.0751	0.4439	0.2961	− 0.5055	− 0.149	0.2513
	1.5417	1.2875	0.2130	1.4012	0.8768	1.6571	0.4262	0.7343
machinery	**0.9623**	− 0.0607	− 0.0968	**0.9527**	**0.8151**	− 0.0539	**0.9067**	**0.9081**
	10.0070	0.1720	0.2751	*8.8665*	*3.9796*	0.1527	*6.0803*	*6.1337*
electr. machinery	**0.6394**	− 0.6065	**− 0.6355**	0.6076	− 0.1702	− 0.604	0.1624	0.2764
	2.3521	2.1576	*2.3280*	2.1638	0.4885	2.1435	0.4655	0.8135
transport equipm.	**0.8884**	0.354	**0.8105**	**0.9947**	**0.9743**	0.3629	**0.9892**	**0.9577**
	5.4736	1.0706	*3.9138*	*27.3628*	*12.2339*	1.1015	*19.0888*	*9.4131*
precision instr.	**0.7623**	− 0.3658	− 0.3998	**0.7789**	0.1005	− 0.4411	0.411	**0.6955**
	3.3313	1.1117	1.2337	*3.5128*	0.2857	1.3902	1.2752	*2.7378*
average 2003	**0.7145**	**− 0.136**	**− 0.201**	**0.7219**	**0.4508**	**− 0.201**	**0.4207**	**0.61**
for all industries	**0.8657**	**0.1291**	**0.0005**	**0.9290**	**0.7838**	**− 0.0202**	**0.7414**	**0.7496**

Sources: data from 1988 and 2003 from: Kuczynski, T., 'Statistical Analysis of Debt-equity in Japanese Manufacturing Industry 1988/2003', Journal of Economic Sciences, Hiroshima Shudo University, 2005.   Calculations for other periods based on data from Japan Company Handbook: autumn 1994 first section and winter 1999 first section, Toyo Keizai Inc.

In 1999 the strongest positive correlations existed between borrowings and total assets (0.7401), borrowing and sales (0.6222) and borrowings and employees (0.6057).   Finally, in 2003 the strongest positive correlations were observed between borrowings and assets (0.7216) and, borrowings and sales (0.7146).   In contrast, the average, negative correlations in 1988 and 1993 were observed between borrowings and return on assets (respectively $-0.455, -0.2937$), borrowings and dividend per share ($-0.208, -0.2851$) and borrowings and earnings per share ($-0.186, -0.2289$).   In 1999 and 2003 the average, negative correlations were observed, similarly, between borrowings and earnings per share (respectively $-0.2145, -0.201$), borrowings and dividend per share ($-0.1837, -0.201$) and borrowings and return on assets (in 1999 -0.1807).   Out of all 416 coefficients of correlation (where sample consisted of 10 companies, i.e. 8 degrees of freedom) there are 139 cases where Student's test result t is greater than 2.31 (i.e. 95% of probability that examined variable is strongly correlated with borrowings) out of which 36 were displayed by industries in 1988, 27 in 1993, 33 in 1999 and 43 cases in 2003.   There were 113 strong positive and 26 strong negative correlations.   In 1988 there were 30 strong positive and 6 strong negative coefficients of correlation wheras in 1993 there were only 15 strong positive and 12 strong negative correlations.   In years 1999 and 2003 there were more strong positive correlations (respectively 28 and 40) than strong negative (5 and 3).

Companies' borrowings, in 1999, displayed higher values of coefficient of correlations with all examined factors compared with 1993.   All positive correlations were stronger in 1999, and in case of negative correlations (borrowings and return on assets, borrowings and dividend per share and borrowings and earnings per share) companies in 1993 displayed lower values and therefore stronger correlations (although all three average correlations are similarly weak for companies from two periods).   The differences in average correlations for companies from 1993 and 1999 were significant especially in research and development expenditures, sales and employees, respectively, 0.2657, 0.2357, 0.2053).   There were small differences between two periods regarding negative correlations between borrowings and three variables: ROA, EPS and DPS (respectively, 0.1130, 0.1014, 0.0144).   Two remaining variables: Assets and shareholders' equity displayed similar change in time (0.1798) and (0.1940).   Looking at the changes of all average correlations it is interesting to note that in time positive correlations became stronger and negative weaker.

In addition, it is important to notice that the values of average coefficient correlation from all thirteen industries (ten companies each) are different from the values of coefficient of correlation 'for all industries' (where sample consists of hundred and thirty companies) (see

appendix).

As for individual industries, the highest values of correlations in 1993 were observed in steel industry (moderate positive correlation 0.6042 (see table 10)) and rubber industry (0.5700), whereas in 1999 in machinery (0.7068), pulp and paper (0.6805), steel industry (0.6503) and oil and coal industry (0.6197). In contrast, the strongest negative correlations were in chemicals (– 0.4901) and glass and ceramics (– 0.4427) in 1993 and in pharmaceuticals (– 0.3291) and chemicals (– 0.3135) in 1999. In addition, there were only three industries in 1999 that displayed negative correlations in average.

Looking at the average of coefficients for industries the biggest positive changes in average coefficient of correlation were observed in glass and ceramic industry where the average correlation rose by 0.7084 (from – 0.4427 in 1993 to 0.3254 in 1999) and in machinery (change by 0.7084 from – 0.0016 to 0.7068). In contrast, negative change was observed in case of rubber industry (– 0.0548) and electrical machinery (– 0.0170).[10]

Table 10   Changes of correlations for individual Japanese Manufacturing Industry in period 1988 – 2003

INDUSTRY	1993	1999	change
textile & apparel	0.1006	0.1839	0.0833
pulp & paper	0.3017	0.6805	0.3788
chemicals	– 0.4901	– 0.3135	0.1766
pharmaceuticals	– 0.3431	– 0.3291	0.0140
oil&coal industry	0.4287	0.6197	0.1910
rubber industry	0.5700	0.5151	**– 0.0548**
glass & ceramics	– 0.4427	0.3254	0.7681
steel industry	0.6042	0.6503	0.0461
metal industry	0.1902	0.3080	0.1178
machinery	– 0.0016	0.7068	0.7084
electrical machinery	0.1131	0.0961	**– 0.0170**
transport equipment	– 0.1695	0.1567	0.3263
precision instruments	– 0.1505	– 0.1448	0.0057

Source: Calculations based on data from Japan Company Handbook:
autumn 1994 first section and winter 1999 first section, Toyo Keizai Inc.

10) For results of similar study in different periods see: Kuczynski, T., 'Statistical Analysis of Debt-equity in Japanese Manufacturing Industry 1988/2003', Journal of Economic Sciences, Hiroshima Shudo University, 2005.

3.   Conclusion

The results of this study show that, compared with 1993 the companies' borrowings, in 1999, were more correlated with all examined variables, where correlations were positive, and less correlated where negative, (the differences were significant especially in research and development expenditures and employees).   Companies in 1993 displayed stronger negative correlations between borrowings and: return on assets, earnings per share and dividend per share, comparing companies from 1999 (with regard to relationship between borrowings and earnings per share there was almost no difference between two periods).   Comparing the results from this study with the results from previous study[*] we note that the companies displayed stronger correlations in years 1988 and 2003 than in 1993 and 1999.   Moreover, in 1988 and 2003 there were relatively more strong positive correlations than strong negative, comparing with relative big amount of strong negative coefficients, especially in 1999.

In 1993 the highest, positive correlations were observed for borrowing and total assets and borrowings and employees.   In 1999 the strongest correlations existed between borrowings and total assets, borrowing and sales and borrowings and employees.   In contrast, the average, negative correlations in both 1993 and 1999 were observed between borrowings and return on assets, borrowings and dividend per share and borrowings and earnings per share.

As for individual industries, the highest values of correlations in 1993 were observed in steel industry and rubber industry whereas in 1999 in machinery, pulp and paper, steel industry and oil and coal industry.   In contrast, the strongest negative correlations were in chemicals and glass and ceramics in 1993 and in pharmaceuticals and chemicals in 1999.   In addition, there were only three industries in 1999 that displayed in average negative correlations.   The biggest positive changes in average coefficient of correlation were observed in glass and ceramic industry and in machinery.   In contrast, negative changes were observed in case of rubber industry (– 0.0548) and electrical machinery (– 0.0170).

In 1993 steel products displayed the strongest correlations between borrowings and six (out of eight) examined variables.   The highest values for the two remaining correlations (between borrowings and earnings per share and, dividend per share; strong negative correlations) were displayed by chemical industry.   Also in 1999 steel industry was a

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[*]   Kuczynski, T., 'Statistical Analysis of Debt-equity in Japanese Manufacturing Industry 1988/ 2003', Journal of Economic Sciences, Hiroshima Shudo University, 2005.

particular case as it displayed most of highest values of correlations (five out of eight).   The highest average from all eight correlations and highest value for correlation between borrowings and sales were displayed by machinery industry.   Two remaining strongest correlations were displayed by chemical industry.

Appendix   Japanese multinational corporations in this project

name of the company 1993	Sales	Borro wings	name of the company 1999	Sales	Borro wings	rank
textile & apparel						
Toray Industries	529199	145,334	Toray Industries	533320	297,094	1
Kanebo	418911	251,089	Teijin	281137	146,096	2
Teijin	310872	127,635	Toyobo	296831	219,144	3
Toyobo	300241	99,067	Kuraray	267675	99,221	4
Kuraray	262478	25,337	Kanebo	248080	314,420	5
Unitika	247275	216,185	Mitsubishi Rayon	232385	107,757	6
Mitsubishi Rayon	225597	98,114	Unitika	193601	200,761	7
Renown	203989	45,275	Onward Kashiyama	169167	0	8
Gunze	175866	18,220	Nisshinbo Industries	162662	35,791	9
Onward Kashiyama	171488	0	World	154378	42,903	10
pulp & paper						
Nippon Paper Industries	626781	276,665	Oji Paper	844322	656,149	1
New Oji Paper	486861	240,556	Nippon Paper Industries	561310	390,156	2
Honshu Paper	369106	195,373	Daio Paper	300375	265,835	3
Daishowa Paper Mfg.	275090	433,286	Daishowa Paper Mfg.	270438	352,489	4
Daio Paper	263110	203,029	Rengo	219909	106,485	5
Rengo	228070	28,636	Mitsubishi Paper Mills	173466	157,777	6
Mitsubishi Paper Mills	172266	93,560	Hokuetsu Paper Mills	107527	105,492	7
Hokuetsu Paper Mills	94238	43,672	Chuetsu Pulp Industry	94091	92,731	8
Chuetsu Pulp Industry	86235	54,912	Japan Paperboard Industries	75968	69,845	9
Tomoku	69629	1,898	Tomoku	73629	32,194	10
chemicals						
Asahi Chemical Industry	936669	143,056	Asahi Chemical Industry	959624	297,854	1
Fuji Photo Film	810000	0	Mitsubishi Chemical	868529	518,417	2
Mitsubishi Kasei	696517	188,033	Fuji Photo Film	807706	0	3
Sekisui Chemical	687396	109,207	Kao	661519	75,699	4
Kao	639598	500	Mitsui Chemicals	615973	461,494	5
Sumitomo Chemicals	530000	215,383	Sekisui Chemical	595550	76,738	6
Dainippon Ink & Chemicals	464543	175,363	Sumitomo Chemical	562971	407,630	7
Showa Denko	440000	312,957	Dainippon Ink and Chemicals	428081	337,853	8
Shiseido	391085	0	Shin-Etsu Chemical	381069	98,253	9
Ube Industries	368876	354,090	Showa Denko	360000	330,021	10
pharmaceuticals						
Takeda Chemical Industries	561610	0	Takeda Chemical Industries	642186	0	1
Sankyo	395689	12,087	Sankyo	463538	38,860	2
Yamanouchi Pharmaceutical	259753	784	Yamanouchi Pharmaceutical	264141	61,276	3
Fujisawa Pharmaceutical	234854	34,547	Daiichi Pharmaceutical	237971	35,963	4
Shionogi	230176	5,756	Eisai	230289	36,552	5
Eisai	224360	0	Taisho Pharmaceutical	229571	0	6
Daiichi Pharmaceutical	207469	6,497	Shionogi	216747	30,855	7
Taisho Pharmaceutical	200282	0	Fujisawa Pharmaceutical Ind.	201652	48,119	8
Tanabe Seiyaku	182840	15,570	Tanabe Seiyaku	181103	44,175	9
Chugai Pharmaceutical	160000	15,520	Yoshitomi Pharmaceutical Ind	175950	37,301	10
oli&coal products						
Nippon Oil	1806377	575,986	Nippon Mitsubishi Oil	1756330	797,840	1

Cosmo Oil	1438401	449,270	Cosmo Oil	1323647	598,550	2
Japan Energy	1364723	445,536	Showa Shell Sekiyu	1300000	202,307	3
Showa Shell Sekiyu	1350000	260,570	Japan Energy	1225654	603,689	4
Mitsubishi Oil	1049845	121,454	General Sekiyu	490000	20,120	5
General Sekiyu	492608	63,393	Tonen	464000	69,495	6
Tonen	450000	50,777	Koa Oil	191967	63,664	7
Koa Oil	205486	93037	Fuji Kosan	77160	6267	8
Fuji Kosan	88854	5,597	Nichireki	29179	820	9
Nichireki Chemical Industry	24612	835	10			

rubber products

Bridgestone	600000	97,500	Bridgestone	730000	118,789	1
Yokohama Rubber	250000	90,948	Yokohama Rubber	240209	115,159	2
Sumitomo Rubber Industries	235000	108,725	Sumitomo Rubber Industries	215000	147,738	3
Toyo Tire&Rubber	187430	59,765	Toyo Tire&Rubber	183426	94,225	4
Achilles	110749	3,800	Tokai Rubber Industries	127527	20,900	5
Okamoto Industries	72480	1,486	Ohtsu Tire&Rubber	97526	43,503	6
Mitsuboshi Belt	67808	10,390	Achilles	93797	14,900	7
Kinugawa Rubber Industrial	60252	20,474	Okamoto Industries	69363	9,270	8
Bando Chemical Industries	54953	3,016	Mitsubishi Belting	59292	8,986	9
Secaicho	22700	5,937	Bando Chemical Industries	50287	6,801	10

glass & ceramics

Asahi Glass	950000	373	Asahi Glass	727073	241,203	1
Toto	420867	0	Toto	351223	50,593	2
Inax	270000	0	Taiheiyo Cement	308965	430,910	3
Onoda Cement	215966	136,894	Inax	239000	0	4
Nippon Sheet Glass	214619	31,298	Ngk Insulators	235630	70,911	5
Ngk Insulators	214390	1,410	Nippon Electric Glass	216698	178,713	6
Nippon Electric Glass	204181	101,358	Nippon Sheet Glass	185090	92,291	7
Nihon Cement	198879	95,355	Ngk Spark Plug	168072	77,030	8
Sumitomo Cement	135293	60,292	Sumitomo Osaka Cement	163248	174,350	9
Ngk Spark Plug	115261	484	Nichias	103077	56,857	10

steel products

Nippon Steel	2158779	811,588	Nippon Steel	1918538	1,464,531	1
Nkk	1203948	776,235	Nkk	1013636	1,094,090	2
Kobe Steel	1068158	546,968	Sumitomo Metal Industries	945710	1,263,986	3
Sumitomo Metal Industries	1042632	597,880	Kobe Steel	938455	985,712	4
Kawasaki Steel	1005316	499,776	Kawasaki Steel	836240	919,646	5
Nisshin Steel	373846	121,514	Nisshin Steel	322223	189,284	6
Hitachi Metals	278598	19,280	Hitachi Metals	284618	125,881	7
Daido Steel	240928	71,166	Mory Industries	24154	12,088	8
Aichi Steel Works	155000	0	Kurimoto	141322	22,022	9
Tokyo Steel Mfg.	152696	0	Tokyo Steel Mfg.	124361	0	10

metal products

Toyo Seikan	529366	17,600	Tostem	509473	172,778	1
Tostem	494744	18,089	Toyo Seikan	468045	17,400	2
Sankyo Aluminium Industry	274000	38,096	Sankyo Aluminium Industry	201174	82,978	3
Sanwa Shutter	195332	4,600	Nhk Spring	152281	60,579	4
Nhk Spring	140466	38,672	Sanwa Shutter	150784	67,480	5
Rinnai	123709	500	Noritz	125000	4,364	6

Noritz	114000	0	Rinnai	119455	0	7
Bunka Shutter	101172	2,508	Bunka Shutter	94304	3,984	8
Kawada Industries	92873	4,373	Kawada Industries	79702	43,489	9
Hokkai Can	79000	1,485	Hokkai Can	73000	36,387	10

machinery

Kubota	744121	19,848	Mitsubishi Heavy Industries	2479148	956,933	1
Komatsu	501556	86,716	Kubota	743019	232,759	2
Chiyoda	356400	34,031	Ricoh	720502	120,120	3
Nsk	325157	98,030	Komatsu	475700	114,943	4
Daikin Industries	296449	110,891	Ebara	442672	160,912	5
Sumitomo Heavy Industries	287980	108,228	Hitachi Zosen	394825	194,297	6
Ebara	265480	42,061	Sumitomo Heavy Industries	344252	191,960	7
Ntn	244173	17,976	Nsk	328501	199,760	8
Koyo Seiko	244000	53,517	Daikin Industries	320030	117,590	9
Zexel	238501	28,805	Koyo Seiko	262993	99,350	10

electrical machinery

Matsushita Electric Industrial	4349586	0	Matsushita Electric Industrial	4597561	323,188	1
Hitachi	3739534	216,906	Hitachi	3781118	728,514	2
Toshiba	3256247	373,813	Nec	3686444	1,586,449	3
Nec	2899361	350,885	Toshiba	3407611	883,828	4
Mitsubishi Electric	2394085	211,293	Fujitsu	3191146	1,388,922	5
Fujitsu	2172984	469,524	Mitsubishi Electric	2770756	973,984	6
Sony	1698333	195,114	Sony	2432690	736,830	7
Sharp	1170221	130,205	Denso	1329003	143,664	8
Sanyo Electric	1020000	66,463	Sharp	1306157	314,834	9
Matsushita Electric Works	980000	0	Sanyo Electric	1076584	333,594	10

transport equipment

Toyota Motor	8100000	0	Toyota Motor	7525555	514,150	1
Nissan Motor	3583482	553,780	Nissan Motor	3319659	1,437,966	2
Honda Motor	2505258	111,522	Honda Motor	2962170	103,917	3
Mitsubishi Motors	2455928	329,553	Mitsubishi Motors	2333971	550,631	4
Mitsubishi Heavy Industries	2434908	554,024	Mazda Motor	1454017	423,356	5
Mazda Motor	1768684	238,624	Suzuki Motor	1189622	98,219	6
Nippondenso	1270000	700	Kawasaki Heavy Industries	1006977	359,849	7
Isuzu Motors	1140000	298,470	Isuzu Motors	934865	361,460	8
Suzuki Motor	1008659	52,472	Fuji Heavy Industries	928277	190,531	9
Kawasaki Heavy Industries	955578	226,153	Ishikawajima-Harima Heavy Ind.	846527	255,059	10

precision instruments

Canon	1080000	25,328	Canon	1500000	76,463	1
Ricoh	596820	7,000	Minolta	292383	62,235	2
Citizen Watch	233700	1,282	Olympus Optical	257391	106,400	3
Nikon	201049	31,894	Nikon	252495	166,629	4
Minolta	184255	32,648	Citizen Watch	194773	910	5
Olympus Optical	176915	1,300	Shimadzu	156392	78,267	6
Shimadzu	162921	898	Dainippon Screen Mfg.	133626	117,188	7
Dainippon Screen Mfg.	121719	47,107	Seiko	118056	192,277	8
Hoya	104651	4,000	Hoya	117903	0	9
Sankyo Seiki Mfg.	91623	19,961	Asahi Optical	88396	32,120	10

Source: Calculations based on data from Japan Company Handbook: autumn 1994 first section and winter 1999 first section Toyo Keizai Inc.