2010

The Effects of R&D on Value Added: An Exploration of a Comprehensive Measures of a Firm's Financial Wealth

Jooh Lee
Rowan University

Harold Lucius
Rowan University

Patrick Coyle

2010

The Effects of R&D on Value Added: An Exploration of a Comprehensive Measures of a Firm's Financial Wealth

Jooh Lee, *Rowan University*
Harold Lucius, *Rowan University*
Patric Coyle

ISBN : 0972-5784

IJEB
www.ijeb.com

INDIAN JOURNAL OF ECONOMICS & BUSINESS

Volume 9 No. 1 March 2010

CONTENTS

SERIALS PUBLICATIONS
www.serialspublications.com
New Delhi (India)

INDIAN JOURNAL OF ECONOMICS & BUSINESS

No. 1 March 2010

CONTENTS

Indian Journal of Economics & Business, Vol. 9, No. 1, (2010) : 123-132

THE EFFECTS OF RESEARCH AND DEVELOPMENT ON VALUE ADDED: AN EXPLORATION OF A COMPREHENSIVE MEASURE OF A FIRM'S FINANCIAL WEALTH AND WELL-BEING

PATRICK T. COYLE, JOOH LEE AND HAROLD W. LUCIUS

Rowan University

Abstract

Much has been written about the effect of research and development, traditional accounting measures, and productivity as measures of wealth creation and efficiency. However, little attention has been paid to value added as a measure of performance.

The results indicate that there is a statistically significant and positive relationship between value added and R & D intensity, return on sales, productivity, and firm size. This suggests that these independent variables are positively associated with and contribute to the dependent variable value added. The significant of this research is designed to contribute to value chains and business processes in the global competitive environment.

INTRODUCTION

Value added, according to DTI, can be defined as a firm's total sales less the cost of bought-in goods and services (Pearson, 2008). It is an accounting measure that can be used by firms located in the United Kingdom to more efficiently measure wealth creation as opposed to other traditional measurements, and thus, value added is influenced by a company's work environment and aspects of its operations (Greenhalgh, 2002).

The strategic importance of value added lies in its focus on the wealth created by a firm rather than on its direct sales (Peterson, 2008). This focus facilitates questions such as how much wealth is created, whether the company is increasing the wealth that it creates year by year, and how efficiently it is creating wealth (Marsh, 2003). Value added takes into account a company's work environment and aspects of its operations such as Research and Development, Capital, Inventory, and other factors, it can be viewed as a more comprehensive measurement of the financial well-being of a firm (Greenhalgh, 2002). By exploring value added figures for top firms, we can determine if maximizing value added is the best way to improve these variables.

The primary objective of this study is to examine the fundamental research question of whether there is a relationship between Value added and key variables of

firms' wealth and well-being for firms in the United Kingdom. The key independent variables are R & D intensity, capital intensity, return on sales, inventory turnover, firm size (measured by the natural log of total assets), and productivity (measured by sales per employee), due to their high relevance as measures of wealth creation and productivity.

THEORETICAL FOUNDATION

Research and Development

Previous work by Mark Rogers indicates that a high R & D intensity is positively correlated with high value added for a firm (Rogers, 2006). Also, there is substantial evidence to suggest that the R&D for some firms in the United Kingdom is not only linearly related, but has risen faster than that of their value added due to its effect on output (Van Reenen, 1997). There also appears to be an increasing understanding that firms which put a significant amount of money into R&D should be highly valued in terms of their market capitalization and sales, thereby increasing their over-all value added (Mayhew-Smith, 2006). Harris and Robinson also document R&D as a high value added operation in a firm (Harris and Robinson, 2003).

Beyond simply justifying the relationship between value added and research and development, many studies have recognized many different aspects of the importance of R & D to create value in a wide variety of different product and labour markets (Nickell, 1999). Cooperative R & D leads to greater firm performance to a certain extent; which is also associated with high value added and growth in value added per employee is also associated with growth in R & D input and output (Belderbos, Carree, and Lokshin, 2004). There has been substantial evidence to suggest that R & D input and output are major indicators of wealth and value added; justifying the need for future research (Hoffman, Parejo, Bessant, and Perren, 1998).

R & D Intensity is an important link to value added (Milkovich, Gerhart, Hannon, 1990). A recent study found that R & D intensity is an important measure of technological capacity and performance, and that a variety of factors, including value added, are influenced by it (Coombs, and Bierly, 2006). Empirical measurements of the marginal contribution of R & D intensity to value added have concluded that firms holding R & D intensity constant enjoy higher rates of growth and productivity, thus increasing their value added (Bozeman and Melkers, 1993).

It is also essential for firms to renew their portfolios R & D knowledge and intensity over time in order to maintain the market position and net output, measured by value added (Greenhalgh, and Longland, 2005). Recent studies also suggest that the comparative advantage of value added is similar to the measures of comparative performance of R & D expenditure (Frantzen, 2008). This work theoretically supports the assertion that firms with a larger intensity of research and development enjoy greater margins of value added (Kohn, and Scott, 1982).

Value added leads to high R & D and productivity (Marsh, 2003). From this, it can be theorized that firms with a high value added also have a higher R & D intensity. With respect to the research presented above, the following hypothesis is proposed:

H_1: A positive linear relationship exists between value added and Research & Development (R&D) Intensity

Capital Intensity

Another goal of the research is to identify the effects of capital intensity on value added. Capital, in the form of both assets and knowledge, is an important independent variable to measure because it is a primary contributory factor to Research and Development. It is the interplay among human, structural and customer capital that helps determine the true value of a company's overall intellectual capital (Brinker, 1998).

Capital Intensity is important because it compensates for the intangible asset known as intellectual capital. There is a strong positive relationship between value added and intellectual capital (Riahi-Belkaoui, 2003). Also, previous work suggests that there is a clear link between value added and capital intensity (Greenoway and Zhihong, 2004;) Harris and Robinson, 2003). These findings suggest that there is a substantial positive linear relationship between value added and capital intensity of a firm (Haaland, Hans, Kind, Midelfart-Knarvik, and Torstensson, 1999). With respect to the research presented above, the following hypothesis is proposed:

H_2: A positive linear relationship exists between value added and capital intensity

Financial Profitability: Return on Sales

Past findings indicate a strong and positive relationship between the use of HPWO practices in 1999 and subsequent value-added per employee in 2002, as well as a relationship between value added and operating profit margin (Thompson and Heron, 2005; Oulton, 1998; Livingstone and Tigert, 1987). Since value is created through sales and profitability, it can be theorized that value added is positively associated with return on sales (Rogers, 2006; Marsh, 2003). Return on sales and value added are highly correlated (Oulton, 1998). With respect to the research presented above, the following hypothesis is proposed:

H_3: A positive linear relationship exists between return on sales and value added

Productivity

Previous studies indicate that there are high levels of value-added per employee where HPWO practices are used (Thompson and Heron, 2005). From these findings, it can be theorized that firms with a high value added also have high sales, which leads to high sales per employee. Another study concluded that there is a positive relationship between value added and physical capital and sales; which, in turn, is positively associated with sales per employee (Haaland, Hans, Kind, Midelfart-Knarvik, and Torstensson, 1999). Other studies have investigated the relationship of value added and sales per employee; as well as their impact on firms across all industries (Brunello and Wadhwani, 1989; Nickell and Wadhwani, 1990; Holmlund and Zetterberg, 1991; Currie and McConnell, 1992; Nickell and Kong, 1992; Hartog and Teulings, 1998). All have found significant effects of value added on sales per employee or wages. With respect to the research presented above, the following hypothesis is proposed:

H_4: A positive linear relationship exists between value added and sales per employee

Inventory Turnover

Previous work indicates that inventory management and turnover may positively affect company profitability (Tawfik, 1990; Marsh, 2003). Value added is one of the driving factors in the inventory turnover ratio, but also that companies with a lower turnover ratio have a higher chance to perform better financially (Boute, Lambrecht, Lambrechts and Sterckx, 2007). This study also concluded that low inventory turnover leads to a high value added within a firm (Boute, Lambrecht, Lambrechts and Sterckx, 2007). With respect to the research presented above, the following hypothesis is proposed:

H_5: A negative relationship exists between value added and inventory turnover

Firm Size

One key determinant of industry profitability is the size of a firm (Kwoka Jr., 1979). The Schumpeter hypothesis holds that economies of scale imply greater return on innovation as a firm gets larger; and such firms, therefore, enjoy greater margins of value added (Kohn and Scott, 1982). Furthermore, in empirical tests where value added was held as the dependent variable, thus, it was found that a firm's total assets, in addition to other variables, is positively correlated to value added (Greenhalgh, 2002). Miller (1984) concluded that labor productivity increases with firm size is directly linked to value added. With respect to the research presented above, the following hypothesis is proposed:

H_6: A positive linear relationship exists between value added and firm size

RESEARCH METHODS

Sample and Data Collection

The population for this study includes data from 2,600 of the top firms in the United Kingdom across all industries. In order for the study to be feasible, the samples were selected on the basis of available data on the *WorldScope* Database. Research and Development data was also cross-referenced using the 2006 Research and Development Scoreboard. All firms needed to have all independent variable data available, in order for this study to be valid and avoid problems with missing data variables. The final sample comprised of 150 firms in the United Kingdom. Value Added figures were selected using the *2006 Value Added Scoreboard*.

Table 1 reports the total number of firms in the sample by their over-all value added score in 2006. The frequency of firms follows a standard normal distribution curve, with the most common scores falling between 201 and 2000.

Table 2 reports the total number of firms in the final sample by industry in 2006. Firms across all industries were considered.

Empirical Model and Variable Specifications

This study was designed to explore the impact of performance measures R & D intensity, capital intensity, inventory turnover, return on sales, productivity, and firm size on value added. The following empirical model captures the essence of the relationships hypothesized:

Table 1
Number of Firms in Samples by Value Added

Value Added	*No. of Firms*
Under 100	4
101 - 200	19
201 - 500	30
501 -1000	39
1001 - 2000	30
2001 - 3000	11
3001 - 4000	3
4001 and above	13
Total (N) =	150

Table 2
Number of Firms in Samples by Types of Industries

Type of Industry	*No. of firms*	*SIC Code*
Fishing and Mining	10	1000-1299
Oil and Gas, water and utilities	11	1300-1600
Food producers & processors	13	2000-2199
Chemicals	9	2830-2899
Electronic & electrical	11	3600-3699
Industrial and Machinery	25	3500-3599
Aerospace and Defense	3	3800-3812
Industrial transportation	7	4000-4999
General Retailers	12	5200-5990
Media and Broadcasting	13	7013-7019
Business services	15	7300-7399
Healthcare equipment & services	4	8000-8099
Other services	16	8700-8799
Total (N) =	150	

Value Added (lnVA)

= a0 + b1 ROS + b2 CapINT + b3 InvTURN + b4 FirmSIZE + b5 Productivity + b6 rdINTENSITY + e

Where:

lnVA (Natural Log of Value Added) is the natural log value of the firm's Value Added

ROS (Absolute Value of Return on Sales) is the firm's absolute value of their operating income/net sales ratio

CapINT (Capital Intensity) is the firm's total ratio of assets/sales

InvTURN (Inventory Turnover) is the ratio of Cost of Goods Sold/Average Inventory

FirmSIZE (Natural Log of Total Assets) is the natural log of a firm's assets

Productivity (Sales per Employee) is the ratio of the firm's total sales / number of employees

R & D INTENSITY (Research and Development Intensity) is the firm's total research and development expenditure / the firm's total number of employees

To investigate the effect of the independent variables on the natural log of a firm's Value Added, step-wise statistical (OLS) multiple regression analysis was employed, using SPSS statistical packaging software. In general, multiple regression analysis can be used to determine the strength of a relationship as well as the over-all variance, multi-collinearity, statistical significance, and otherwise identify the most important of the independent variables in relation to the dependent variable (Cryer and Miller, 1994). The use of multiple regressions was appropriate for this study because of the need to determine the linkage between the dependent variable with eacn of the independent variables. Multi-collinearity, the strength of the relationships ®, and whether or not the independent variables were statistically significant were also key factors to be aware of in this study because of the need to prove that the independent variables do indeed contribute to a firm's value added.

EMPIRICAL RESULTS AND STATISTICAL ANALYSIS

Table 3 reports descriptive statistics, including means, standard deviations, minimums and maximums for the regression model. The mean natural log of value added for firms in the United Kingdom is 6.6288, with a standard deviation of 1.23632. The minimum was 4.56 and the maximum was 10. 42. The mean value added is closer to the minimum, suggesting that firms have not studied ways to maximize value added. Similarly, the mean for R & D was 11.7912, with a standard deviation of 53.16809, a minimum of 0, and a maximum of 563.95. This suggests that R & D is distributed in a similar fashion. One explanation is that Research and Development output is comparatively related to the firm's value added.

Table 3
Descriptive Statistics of the Variables in the Empirical Model

Variables	*Mean*	*Std. Dev.*	*Minimum*	*Maximum*
Value Added, Independent Variable				
lnVA (Ln)	6.6288	1.23632	4.56	10.42
Performance, Dependent Variables				
ROS	12.5268	9.56258	0.71	62.75
CapINT	2.9111	25.74806	0.21	316
InvTURN	29.9292	87.24311	0.6	835.83
FirmSIZE	14.4663	1.70693	18.66	9.53
Productivity	376.8131	534.01639	45.99	4396.56
rdINTENSITY	11.7912	53.16809	0	563.95
N = 150				

Table 4 reports correlation matrix data and statistical model information that shows whether or not each variable is statistically significant. For this analysis, the value added scores were transformed to a natural logarithmic value (and also for the regressions reported in Table 5). There appears to be a statistically significant and positive relationship between Value Added and Research and Development Intensity, as well as Return on Sales, Productivity, and Firm Size. Value added and Firm Size had

a strong positive linear relationship ($p < 0.001$, $r = 0.803$). Similarly, Value added and Return on Sales were also positively correlated ($p < 0.001$, $r = 0.340$). Additionally, Value Added was positively and linearly correlated with Productivity ($p < 0.01$, $r = 0.229$) and R & D Intensity ($p < 0.01$, $r = 0.218$). This suggests that these independent variables are positively associated with, and contribute to, the dependent variable of Value Added. Further research should be done on value added with relation to all of these independent variables.

Table 4
Correlation Matrix For Variables In The Empirical Model

Variables	*1*	*2*	*3*	*4*	*5*	*6*	*7*
1. lnVA	1.0000						
2. ROS	0.340***	1.0000					
3. capINT	-0.043	0.131	1.0000				
4. InvTURN	0.046	-0.038	-0.001	1.0000			
5. FirmSIZE	0.803***	0.362***	0.258***	0.013	1.0000		
6. Productivity	0.229**	0.260***	0.0097	-0.043	0.262***	1.0000	
7. rdINTENSITY	0.218**	-0.02	-0.018	-0.020	0.184	-0.029	1.0000

Note: (1) Statistical significance in indicated as: * p <0.05; ** p < 0.01; *** p <0.001

Table 5 presents regression co-efficients and t-statistics for the regression model that was used to test the relationship between value added and the independent variables. The adjusted r^2 value is 0.715. Hence, the model is useful for exploring the relationship between value added and the independent variables. Consistent with prior correlation analysis findings, the coefficient of lnVA on rdINTENSITY is statistically significant at the 0.01% level, suggesting that it is an accurate indicator of value added. Capital intensity and firm size were statistically significant at the 0.001% level.

Table 5
Results of Multiple Regression Analysis Examining The Relationships Between Value Added and Economic Performance Measures

Independent Variables	*Dependent Variable lnVA*		*V. I. F.*
Constant	-2.201	(-4.427)	
ROS	0.010	(1.607)	1.199
CapINT	-0.013	(-5.838) ***	1.083
InvTURN	0.001	(0.925)	1.005
FirmSIZE	0.601	(16.012) ***	1.306
Productivity	-4.990E-6	(-0.046)	1.124
rdINTENSITY	0.002	(2.5068) **	1.035
F-Ratio	63.243***		
Adj. R squared	0.715		

Notes: (1) t-statistics are in parentheses.
(2) Statistical significance is indicated as: *** P<0.001; ** P<0.01; * P<0.05.
(3) V. I. F. indicates variance inflation factors to detect multi-collinearity

These findings suggest that there is a strong relationship between value added and these variables and that further study and evaluation should be considered in order to construct a study with a robust sample size to reinforce this. Furthermore, all variance

inflation factors were less than 1.5, indicating that multi-collinearity is not a problem in this model. Finally, the F-ratio of this model was 63.243, indicating that the over-all model was statistically significant at the 0.001% level, and thus re-enforcing the over-all reliability of the model. T statistics (as indicated in parenthesis in Table 6) show that null hypothesis can be rejected for capital intensity, total assets, and research and development intensity. It can be theorized, therefore, that these statistically significant variables can be used to predict a firm's value added score. The over-all multiple regression is also statistically significant, which means it is a valid model for predicting value added scores for a firm as well. The over-all model is listed as follows:

Value added
= -2.201 + 0.010 (lnROS) – 0.013 (CapINT)* + 0.001 (InvTURN) -+ 0.601 (FirmSIZE)*** - 4.990E-6 (Productivity) + 0.002 (rdINTENSITY)****

Note: (1) Statistical significance is indicated as: *** P<0.001; ** P<0.01; * P<0.01, therefore, these variables can be used as major determinants of value added

CONCLUSION AND IMPLICATIONS

Based on the analysis and results, we can conclude that R & D Intensity effectively contributes to a firm's value added score. Firms that spend more on Research and Development per employee have higher value added figures and create more value and wealth for the firm; thereby reinforcing value added as a potentially more reliable measure of wealth than traditional accounting measures. Capital Intensity also showed a positive linear relationship between with value added, suggesting that capital intensity has an effect on value added as hypothesized; further study should be considered. One implication of the strong correlation between value added and these key variables is the prospect of future research exploring this linkage.

We can also conclude that return on sales, sales per employee, and total assets should be examined more closely in future studies based on the information obtained from the multiple regression analysis. These variables were statistically significant with respects to over-all contribution to a high value added. Future research, examining each of these indicators of productivity and firm size as key independent variables, should be examined. Re-evaluation of the link between value added and inventory turn-over should be considered in the future as well.

The major limitation of this study was the lack of available data on Research and Development for firms in the United Kingdom. A large sample size in future research is imperative. Such research should focus on acquiring more Research and Development data and comparing that to firms with higher value added figures. This study has effectively laid the foundation for further study on value added as a measure of a firm's over-all ability to create wealth. Also, further study about how value added and research and development are related in the United Kingdom, Germany, the United States, and other nations is warranted. Firms should make an effort to study value added more closely due to the fact that investment in R & D, productivity, and firm size seem to be potential ways to increase economies of scale and wealth. Capital intensity and operating profit margin also seem to be positively associated with value added as measures of efficiency and profitability and should be studied as well.

References

Balassa, B. (1979), The Changing Pattern of Comparative Advantage in Manufactured Goods. *Review of Economics and Statistics* 61: 259-266.

Balassa, B. (1986), Comparative Advantage in Manufactured Goods: A Reappraisal. *Review of Economics and Statistics* 61: 315-319.

Belderbos, R., Carree, M., Lokshin, B. (2004), Cooperative R&D and firm performance. *Research Policy* 33: 1477–1492.

Boute R., Lambrecht M., Lambrechts O., Sterckx P. (2007), An Analysis of Inventory Turnover in the Belgian Manufacturing Industry, Wholesale and Retail and the Financial Impact on Inventory Reduction. *FETEW Research Report KBI_0725*, K.U.Leuven 1-13.

Bozeman, B., Melkers, J. (1993), *Evaluating R&D Impacts: Methods and Practice* Kluwer Academic Publishers, Boston, MA.

Brinker, B. (1998), Intellectual Capital: Tomorrow's Asset, Today's Challenge. *AICPA Financial Management Center.*

Brunello, G., Wadhwani, S. (1989), The Determinants of Wage Flexibility in Japan: Some Lessons from Acomparison with the UK using Micro Data. *Centre for Labour Economics* DP No. 362, London School of Economics.

Coombs, J., Bierly, P. (2006), Measuring Technological Capability and Performance. *R & D Management* 36 (4): 421-434.

Cryer, D., Miller, R. (1994), *Statistics for Business: Data Analysis and Modeling* Duxbury Press.

Currie, J., McConnell, S. (1992), Firm-specific Determinants of the Real Wage. *Review of Economics and Statistics* 74 (2): 297–304.

Frantzen, D. (2008), R & D and Manufacturing Production Specialization in Developed Economies. *Applied Economics,* 40 (23): 3009-3017.

Greenhalgh, C., Longland, M. (2002), Running to Stand Still? - Intellectual Property and Value Added in Innovating Firms. *The Future of Manufacturing in the UK* 134: 1-32.

Greenoway, D., Zhihong, Y. (2004), Firm-level Interactions between Exporting and Productivity: Industry-specific Evidence. *Review of World Economics*, 140(3): 376-392.

Haaland, J., Hans J., Kind H., Midelfart-Knarvik, K., Torstensson, J. (1999), What Determines the Economic Geography of Europe? *CEPR Discussion Paper no. 2072* 1-34.

Harris, R., Robinson, C. (2003), Foreign Ownership and Productivity in the United Kingdom Estimates for U.K. Manufacturing Using the ARD. *Review of Industrial Organization* 22: 207–223.

Hartog, J., Teulings, C. N. (1998), On Labour Market Institutions and Wage Structure: Claims, Hopes and Dreams. *University of Amsterdam* mimeo.

Hewitt, P. (2005), *2005 Value Added Scoreboard* Retrieved October 10, 2008 from *http://213.219.8.102/value_added/home.asp?p=home*

Hoffman, K., Parejo, M., Bessant, J. and Perren, L. (1998), Small firms, R&D, Technology and Innovation in the UK: a Literature Review. *Technovation*, 18(1), (1998), 39–55.

Holmlund, B., Zetterberg, J. (1991), Insider Effects in Wage Determination: Evidence from Five Countries. *European Economic Review* 35 (5), 1009–1034.

Kohn, M., Scott, J. (1982), Scale Economies in Research and Development: The Schumpeterian Hypothesis. *The Journal of Industrial Economics* 30 (3): 239-250.

Kwoka, Jr. J. (1979), The Effect of Market Share Distribution on Industry Performance. *The Review of Economics and Statistics* 61 (1): 101-111.

Livingstone, J., Tigert, D. (1987), Strategy Implementation: Competition Among Supermarkets. *Planning Review* 15(6): 14-24.

Marsh, P. (2003), Valuing Value Added: Business Performance: Investors have a Hard Time Assessing How Well Companies turn the Skills of their Employees into Goods and Services. A New Scoreboard System May Help. *Financial Times* 14: 13-15.

Milkovich, G., Gerhart, B., Hannon, J. (1990), The Effects of Research and Development Intensity on Managerial Compensation in Large Organizations. *Center for Advanced Human Resource Studies Working Paper Series* Cornell University.

Miller, E. (1984), Extent of Economies of Scale: An Update. *Southern Economic Journal* 51 (2): 582-588.

Nickell, S. (1990), Product Markets and Labour Markets. *Labour Economics* 6, 1-20.

Nickell, S. J., Wadhwani, S. (1990), Insider Forces and Wage Determination. *Economic Journal* 100, 496–509.

Nickell, S., Kong, P. (1992), An Investigation into the Power of Insiders in Wage Determination. *European Economic Review* 36, 1573–1599.

Oulton, N. (1998), Labour Productivity and Foreign Ownership in the UK. *NIESR* Discussion Paper No. 143.

Patrizio, P., Fabiano, S. (2003), Firm Size Distribution and Growth. *Scandinavian Journal of Economics* 105(2): 255–274.

Pearson, I. (2008), The 2008 Value Added Scoreboard: The top 800 UK and 750 European Companies by Value Added, Commentary and Analysis. *The Department for Business Enterprise and Regulatory Forum* BERR Publishing.

Riahi-Belkaoui, A. (2003), Intellectual Capital and Firm Performance of US Multinational Firms: A Study of the Resource-based and Stakeholder Views. *Journal of Intellectual Capital* 4 (2): 215-26.

Rogers, M. (2006), Estimating the Impact of R&D on Productivity using the BERD-ARD Data. *Oxford Intellectual Property Research Centre and Harris Manchester College.*

Tawfik, M. (1990), Inventory Performance in Egyptian Industry: Analysis and Insights *Industrial Management + Data Systems* 90 (3): 1-7.

Thompson, M., Herron, P. (2005), Management Capability and High Performance Work Organization. *International Journal of Human Resource Management* 16 (6): 1029-1048.

Van Reenen, J. (1997), Why has Britain had Slower R & D Growth? *Research Policy* 26: 493-507.