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Value capture in global production networks: evidence from the Taiwanese electronics industry

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In today's global electronics industry, lead firms and suppliers of key components capture greater value than contract manufacturers. Using data from the Taiwanese Stock Exchange from 2002 to 2009, this research aims to examine if the pattern of value capture in the global electronics industry holds for Taiwan. We also test the impacts of research and development (R&D) spending on firm profitability and returns. Our results show that lead firms and component suppliers capture higher gross profits from their R&D spending, compared to contract manufacturers. However, contract manufacturers have higher return on equity. Component suppliers' return to R&D as measured by return on equity is lower than contract manufacturers. These findings suggest that component suppliers capture higher profits as lead firms do, but the cost of R&D for component suppliers is so high that their returns on investment are not as great as contract manufacturers. This also suggests that Taiwanese component suppliers are unable to create entry barriers or gain pricing power from their R&D investments.

Keywords: value capture; global production networks; Taiwan; electronics industry

1. Introduction

As value chains in the electronics industry are disintegrated across corporate and national boundaries, lead companies (brand name firms) work closely with global suppliers of components and contract manufacturers (CMs) to bring new products to market. In such a global industry, lead firms and component suppliers, particularly suppliers of key components, have been shown to capture greater value than CMs. They build up high entry barriers by deploying and integrating such resources as marketing, branding and intellectual property (Linden, Kraemer, and Dedrick 2009; Shin, Kraemer, and Dedrick 2012).

This research examines if the pattern of value capture in the global electronics industry holds for an emerging economy, Taiwan, by employing data from the Taiwanese Stock Exchange from 2002 to 2009. We choose Taiwan as our research setting for two reasons: First, Taiwanese electronics firms play a major role in global value chains of the electronics industry (Einhorn 2005). Taiwanese electronics firms are the largest producers in the global market of desktop PCs, notebooks, displays and motherboards (Dedrick and Kraemer 2005). They also manufacture many consumer electronics products, including the entire line of iPods, iPhones and iPads. Taiwanese electronics firms have developed their own regional production network, the so-called Sino-Taiwanese production network by shifting production to mainland China (Yang 2006).

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Second, Taiwanese firms have been concentrated in the low-margin assembly business. It has been the goal of many of those firms to escape this position by moving either by upstream or downstream in the value chain. In fact, it was Acer founder Stan Shih (1996) who created the 'smiling curve' concept that predicts the lower profitability of assemblers in the middle of the value chain. Taiwanese firms, such as Acer and Asustek, have tried to improve their competitive position in global value chains by spinning off their contract manufacturing business as separate companies (Wistron and Pegatron Technology, respectively) and are concentrating their own efforts on developing the brand name business. Smart phone CM HTC has developed its own line of successful brand name phones. Other assemblers, such as Quanta and Compal, have long tried to capture more value by bundling design with manufacturing services (these are referred to as original design manufacturers (ODMs)), while some, such as Quanta and Hon Hai (Foxconn), produce components as well as providing manufacturing services.

What is not known is whether Taiwanese firms are able to achieve superior performance by focusing on component or brand name markets, especially given the high cost of research & development (R&D) and brand building required by those industry segments. Existing studies (e.g. Shin, Kraemer, and Dedrick 2012) have focused on global companies, mostly located in the major markets and technology centers of the US, Europe and Japan. The purpose of this research is to analyze the profitability of Taiwanese electronics companies and compare lead firms, component suppliers and CMs. We study both overall performance and the performance relative to R&D investment.

The key questions we raise for this research are as follows: Do these lead firms capture greater value compared with component suppliers and CMs when multiple performance measures, such as gross profit, return on equity (ROE) and return on assets (ROA), are used? In what ways are they similar to or different from the general pattern in the global electronics industry? Do lead firms earn greater returns from their R&D investments than component suppliers and CMs? To answer these questions, we frame our analysis in terms of whether R&D expenditures build up entry barriers, which enable some firms (lead firms or component suppliers) to capture greater value. In the next section, we review theories related to barriers to entry and propose hypotheses. Section 3 describes our research methods and data sources. We present our results in Section 4. Discussion and conclusions are provided in Section 5.

2. Theoretical background

A company gains profits from a distinctive and unique position in an industry (Porter 1996). However, such a strategic position can attract imitation and be replicated by competitors because information about the firm's position, e.g. technological, social, economic, regulatory and market forces, is openly available for other firms in the same environment (Barney 1986; Makadok 1999). However, the information about the resources a firm owns is not readily available to other firms. If the firm implements its strategy by using these resources, and if similar resources are not owned by competing firms, then they can confer large profits (Barney 1986).

In competitive markets, dynamic capabilities can create entry barriers and lead to sustained firm profitability by enabling innovation, asset orchestration, resource combinations and reconfiguration (Teece 2007). The resources and dynamic capabilities incumbent firms possess are difficult for competitors to acquire; they are mostly intangibles, which are hard to imitate and immobile (Grant 1991; Barney 1991; Peteraf 1993).

In the value chains, lead firms can capture higher profits by creating entry barriers through branding, customer loyalty and knowledge of the whole product system. They focus on product-level innovation by identifying new product markets and integrating new technologies developed by upstream suppliers, thereby obtaining more value from R&D. Component suppliers also can create entry barriers by focusing on component-level innovation and controlling key technology standards. On the other hand, assembly firms capture lower margins due to lower switching costs and lack of market power. Lead firms constantly switch (or threaten to switch) business among them, from one product to another, keeping them intensely competing with each other. Assembly firms also have little pricing power because they have few capabilities that cannot be replicated by competitors, and they may not have the financial resources to absorb the shock of losing a major customer. If they do invest in R&D, they are not in a position to capture value from innovation by locking in customers or creating barriers to entry.

Thus, we argue that in the Taiwanese electronics industry, lead firms and component suppliers have resources that may enable them to build up barriers to entry and capture greater value than CMs (or original design manufacturers). These theoretical arguments, supported by evidence from the global electronics industry, lead to the following hypotheses:

Hypothesis 1: Lead firms and component suppliers capture higher value, as measured by standard financial measures, than CMs/ODMs.

Hypothesis 2: Lead firms and component suppliers capture higher value from R&D than CMs/ODMs.

3. Research methods

To compare the performance of lead firms, component suppliers and CMs/ODMs, we employ the one-way analysis of variance (ANOVA) procedure, the nonparametric χ^2 and median tests. We also examine whether lead firms and component suppliers capture more value from R&D than CMs/ODMs by conducting two-stage least-squares (2SLS) regression analysis. We conduct two separate analyses of performance for lead firms and component suppliers, with R&D spending, a ‘lead firm’ (or ‘component supplier’) dummy variable, an interaction term of R&D spending and the lead firm (or component supplier) dummy variable and industry and year control variables. The interaction term examines if lead firms (or component suppliers) capture higher value from R&D spending, compared to CMs/ODMs.

The 2SLS is employed to account for the possibility of endogeneity that may influence the relationship between the dependent variable and independent variable. Although R&D spending may improve firm performance, the opposite may also be true; firms may spend more on R&D with increased revenue or profits. This reverse causality may result in the correlation of the independent variable with the error term, which may lead to inconsistent ordinary least-squares (OLS) estimation. We employ a set of instrument variables to address the issue of reverse causality, such as one-year lagged R&D, four-firm concentration ratio (CR4) and industry average R&D ratio. As performance measures, we employ profitability measures, including gross margin, net margin, ROA and ROE.

3.1. *The model*

Our regression model measures performance of lead firm (or component supplier) and CMs/ODMs in the Taiwanese electronics industry, while controlling for firm size, region- and year-specific effects. We employ two separate models to estimate the main effects of R&D spending and being a lead firm (or component supplier) and the interaction effect of R&D spending and being a lead firm (or component supplier), respectively.

Model for main effect:

$$\text{PERF}_{it} = \beta_0 + \beta_1\text{VCP}_{it} + \beta_2\text{R\&D}_{it} + \beta_3\text{TA}_{it} + \beta_4\text{INDUSTRY}_{it} + \beta_5\text{YEAR}_{it} + \varepsilon.$$

Model for interaction effect:

$$\text{PERF}_{it} = \beta_0 + \beta_1\text{VCP} * \text{R\&D}_{it} + \beta_2\text{TA}_{it} + \beta_3\text{INDUSTRY}_{it} + \beta_4\text{YEAR}_{it} + \varepsilon,$$

where for firm i in year t:

PERF_{it} = Gross Margin, Net Margin, ROA and ROE
VCP_{it} = A dummy for lead firm (or component supplier)
$\text{R\&D}_{it}$ = R&D ratio (R&D expense/sales)
TA_{it} = Ln(total assets)
$\text{VCP*R\&D}_{it}$ = Interaction term of lead firm (or component supplier) and R&D ratio
INDUSTRY_{it} = A dummy for industry
YEAR_{it} = A dummy for year
ε = An error term

The PERF stands for firm performance; its measure will be replaced in turn by gross margin, net margin, ROA and ROE. The value chain position (VCP) is a dummy variable representing value chain position, which will be replaced in turn by the dummy variable of lead firm and component supplier. The dummy variable of lead firm indicates whether the firm is lead firm or CM/ODM. The dummy variable of component supplier indicates whether the firm is component supplier or CM/ODM. The TA (total assets) is used as a control variable for firm size.[1] We take the log of TA in order to get a normal distribution for the value. To control for industry- and year-specific effects, dummy variables for each industry and year are included. The interaction term of lead firm (or component supplier) and R&D is included in order to examine if there is an interaction effect of R&D spending and being a lead firm (or a component supplier) for firm performance. A positive sign may suggest that lead firms (or component suppliers) capture more profits from R&D spending.

3.2. *Data sources and coding*

This research employs two data sources: the Taiwanese Stock Exchange database and the Hoovers database for the eight years from 2002 to 2009. We obtain financial data, such as sales, gross profit, ROA and ROE, from the Taiwanese Stock Exchange and other data, such as R&D expense and selling and general administration (S&GA) expense from Hoovers. The data are collected for all the firms listed in the Taiwanese Stock Exchange for the following seven electronics industries: communications and Internet (CI), computer and peripheral equipment (CPE), electronic parts/components (EPC), electronic products distribution (EPD), optoelectronic (OPT), semiconductor (SEMI) and other electronic.[2]

We employ gross margin as a measure of value capture. Value capture can be indicated by gross profit (the numerator of gross margin) since it estimates the value a company captures

Table 1. Sample statistics (2002–2009).

Variables	Lead firms			CMs/ODMs			Component suppliers		
	Mean	St. dev.	Obs.	Mean	St. dev.	Obs.	Mean	St. dev.	Obs.
Sales (millions)[a]	24,879	67,097	150	90,865	21,615	215	15,229	38,677	1220
Total assets (millions)[a]	15,726	35,774	144	45,558	10,970	211	20,104	59,118	1217
Gross margin (%)	19.71%	14.15%	150	13.36%	10.31%	215	20.15%	15.01%	1220
Net margin (%)	7.04%	18.68%	150	5.77%	6.91%	215	8.79%	32.47%	1220
ROA (%)	7.26%	12.97%	154	7.92%	7.02%	209	8.01%	10.65%	1146
ROE (%)	8.71%	28.71%	154	12.92%	13.78%	210	10.81%	17.51%	1148
Debt ratio (% of assets)	36.94%	17.44%	154	42.43%	12.73%	210	33.96%	14.83%	1149
S&GA ratio (% of sales)	12.43%	7.19%	144	6.49%	5.22%	212	9.74%	6.89%	1151
R&D ratio (% of sales)	4.32%	2.93%	143	3.46%	2.90%	210	4.69%	5.55%	1066

[a]Taiwanese dollar.

from its role in the value chain, which it can use to reward shareholders (dividends), invest in future growth (R&D), cover the cost of capital depreciation and pay its overhead expenses (marketing and administration) (Linden, Kraemer, and Dedrick 2009). Net margin, ROA and ROE are also employed to measure a company's bottom-line financial performance. The sample includes 1585 observations for the eight years from 2002 to 2009 for a total of 209 firms (20 lead firms, 28 CMs/ODMs and 161 component suppliers). The sample statistics are shown in Table 1.

4. Results

4.1. *Value capture*

As shown in Table 2, lead firms and component suppliers capture greater value in terms of gross margins, while CMs have higher ROE. Net margins are also higher for lead firms and component suppliers than for CMs/ODMs, but while the difference is statistically significant, it is very small. The reason might be that lead firms and component suppliers spend heavily on sales and marketing; our results show that lead firms and component suppliers spend more on S&GA expense. CMs might get higher ROE from debt financing; they have higher debt ratio than lead firms and component suppliers. It is notable, however, that ROE of the three types of firms are all positive. This implies that generous government policies on debt financing might affect Taiwanese electronics firms' ROE, particularly that of CMs. We do not detect any significant differences in ROA for the three types of firms.

Figures 1 and 2 depict the means of gross and net margins of lead firms, component suppliers and CMs/ODMs. The mean plot for gross margin shows the pattern of value

Table 2. ANOVA, non-parametric χ^2 (Kruskal-Wallis) and median test results (2002–2009).

		N	Mean	*F*	χ^2	Median test (χ^2)
Gross margin	Lead firms	150	19.71%	20.488^{***}	71.959^{***}	69.057^{***}
	CMs/ODMs	215	13.36%			
	Co-suppliers	1220	20.15%			
Net margin	Lead firms	150	7.04%	1.112	37.367^{***}	63.773^{***}
	CMs/ODMs	215	5.77%			
	Co-suppliers	1220	8.79%			
Return on assets	Lead firms	154	7.26%	.344	.704	1.231
	CMs/ODMs	209	7.92%			
	Cosuppliers	1146	8.01%			
Return on equity	Lead firms	154	8.71%	2.333^{*}	4.002	7.305^{**}
	CMs/ODMs	210	12.92%			
	Co-suppliers	1148	10.81%			
Debt ratio (Liabilities/Assets)	Lead firms	154	36.94%	29.714^{***}	61.743^{***}	41.215^{***}
	CMs/ODMs	210	42.43%			
	Co-suppliers	1149	33.96%			
S&GA expense/sales	Lead firms	144	12.43%	35.80^{***}	110.76^{***}	63.24^{***}
	CMs/ODMs	212	6.49%			
	Co-suppliers	1151	9.74%			
R&D expense/sales	Lead firms	143	4.32%	5.310^{***}	14.834^{***}	24.857^{***}
	CMs/ODMs	210	3.46%			
	Co-suppliers	1066	4.69%			

$^{***}p < 0.01$; $^{**}p < 9.05$; $^{*}p < 0.10$.

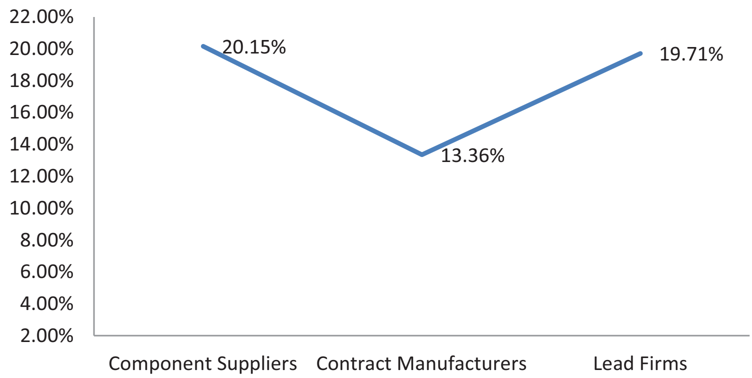

Figure 1. Mean plot for gross margin.

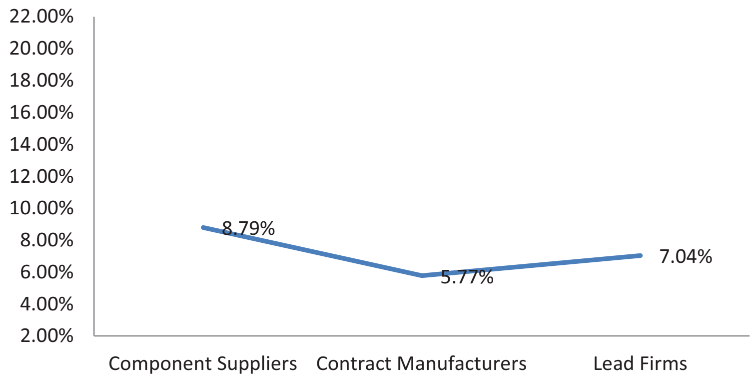

Figure 2. Mean plot for net margin.

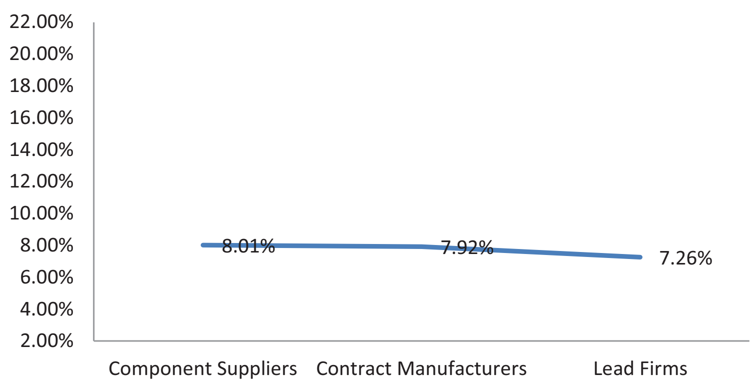

Figure 3. Mean plot for ROA.

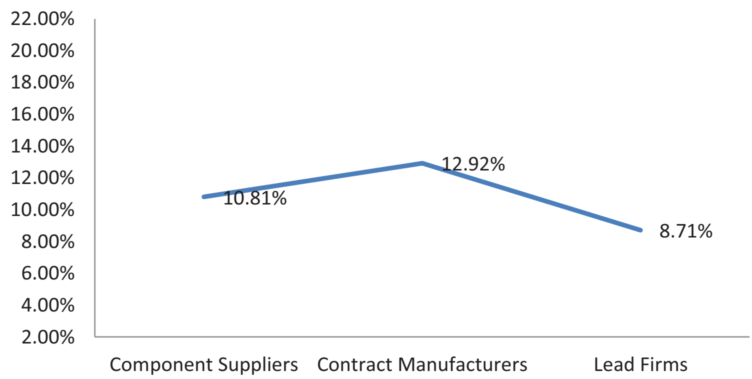

Figure 4. Mean plot for ROE.

capture for the three types of firms in the Taiwanese electronics industry. Both lead firms and component suppliers earn average gross margins of about 20%, compared to 13% for CM/ODMs. The mean plot for net margin shows a similar pattern, but the difference for the three types of firms is smaller as mentioned earlier.

Figures 3 and 4 show the mean plots for ROA and ROE. The shape of the mean plot for ROE looks the reverse compared to the mean plot for gross margin. As discussed earlier, higher levels of debt financing might mean that returns are measured against a lower equity base for CM/ODMs and thus their ROE is relatively higher.

4.2. *R&D impact on value capture*

The R&D impact on value capture by the three types of firms (lead firms, component suppliers and CMs/ODMs) is analyzed by 2SLS regression. Since our data-set includes repeated observations of the same firm, we cannot assume independence of errors within firms. To address this issue, we conduct the 2SLS estimation with the errors clustered within firms. This approach includes the Huber–White adjustment to control for heteroskedasticity (Kleis et al., 2012). We use one-year lagged R&D, CR4 and industry average R&D ratio as instrument variables for R&D in order to address the issue of reverse causality between R&D and firm performance. Lagged R&D has been identified in previous research as a useful instrument (Blundell, Griffith, and van Reenen 1999; Kleis et al., 2012). Industry factors such as CR4[3] and industry average R&D ratio are related to a firm's R&D investment decision but not necessarily to the variance of firm performance. We also validate our instrument variables by using the Sagan's and Basmann's chi-square statistics. These statistics are used to test the null hypothesis that the instruments are valid and not correlated with the error term. Significant test statistics indicate that the instruments may not be valid. The statistics are reported, along with regression results, in Tables 3–6.

As shown in Tables 3 and 4, the results for main effect (model 1) show that lead firms do not perform better than CMs/ODMs, other things being equal, while R&D is strongly associated with an increase in gross profits for both lead firms and CMs/ODMs. However, the interaction term (model 2) indicates that lead firms earn higher gross profits from their R&D spending, compared to CMs/ODMs. The difference in R&D impact on bottom-line financial performance as measured by net margin, ROA and ROE is minimal. These results suggest that by leveraging their R&D activity on product-level innovation through branding, marketing and customer knowledge, lead firms capture higher gross profits from their R&D spending, compared to CMs/ODMs. However, such benefits are negated by the size of their

Table 3. 2SLS regression results for gross margin and net margin (lead firm and contract manufacturer).

	Gross margin		Net margin	
Variable	Model 1	Model 2	Model 1	Model 2
R&D ratio (R&D/Sales)	292.11*** (83.99)[1]		106.34 (102.98)	
Lead firm[2]	4.28 (2.94)		1.45 (3.13)	
Ln(Assets)	0.59 (0.69)	−1.44 (1.12)	1.64** (0.77)	0.74 (0.83)
Year 2009	−2.65 (2.09)	−1.34 (1.63)	−3.50 (1.79)*	−1.39 (1.61)
Year 2008	−1.62 (2.06)	−1.60 (1.68)	−2.71 (2.07)	−1.27 (1.86)
Year 2007	−0.32 (1.80)	−0.79 (1.57)	1.31 (2.66)	2.62 (2.31)
Year 2006	−2.82 (1.51)*	−3.09 (1.25)**	−3.70 (1.85)*	−2.17 (1.50)
Year 2005	−3.97 (1.46)***	−3.95 (1.34)***	−9.48 (3.15)***	−7.76 (2.88)***
Year 2004	−1.69 (1.06)	−2.44 (0.90)***	−4.38 (1.58)***	−3.09 (1.20)***
CI	−1.07 (3.86)	3.47 (3.49)	−1.61 (3.47)	−0.58 (2.89)
CPE	−2.09 (2.94)	0.36 (3.62)	−3.99 (2.16)*	−3.21 (2.64)
EPC	NA	NA	NA	NA
EPD	−6.45 (6.58)	2.24 (6.71)	−4.03 (7.06)	0.44 (7.36)
OPT	2.50 (5.32)	1.76 (5.68)	−2.90 (5.27)	−2.92 (5.08)
SEMI	−8.35 (5.69)	10.29 (3.25)***	−5.73 (6.23)	1.15 (2.30)
R&D ratio*lead firm		135.35* (76.26)		27.08 (91.72)
R^2	34.15%	19.15%	6.44%	5.92%
Wald χ^2	962.25***	475.91***	75.24***	44.12***
N	292[3]	325	292	325
Instrument tests[4]				
Sagan's chi-square	1.052 ($p = 0.591$)	0.108 ($p = 0.947$)	0.015 ($p = 0.993$)	0.968 ($p = 0.616$)
Basmann's chi-square	0.994 ($p = 0.608$)	0.103 ($p = 0.950$)	0.014 ($p = 0.993$)	0.923 ($p = 0.630$)

[1]The values in parentheses are clustered robust standard errors.
[2]Lead firm dummy variable: 1 for lead firm and 0 for CM.
[3]Each observation requires data for the current and previous periods; this eliminates observations for all of 2002 and some observations in other years when firms do not have consecutive years of data for lagged independent and dependent variables.
[4]Instrumental variables: one-year lagged R&D ratio, CR4 and industry average R&D ratio for Model 1 and the interaction term of one-year lagged R&D ratio and lead firm, CR4 and industry average R&D ratio for Model 2.
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table 4. 2SLS regression results for ROA and ROE (lead firm and contract manufacturer).

	ROA		ROE	
Variable	Model 1	Model 2	Model 1	Model 2
R&D ratio (R&D/sales)	58.37 (57.35)[1]		68.76 (90.01)	
Lead firm[2]	0.24 (2.56)		−0.60 (4.43)	
Ln(Assets)	1.70* (0.88)	1.35* (0.82)	3.70** (1.56)	3.22** (1.43)
Year 2009	−6.10 (1.70)***	−3.72 (1.49)**	−9.78 (2.77)***	−5.68 (2.40)**
Year 2008	−5.95 (1.76)***	−3.76 (1.43)***	−9.94 (2.99)***	−5.88 (2.35)**
Year 2007	−2.17 (1.71)	−0.04 (1.41)	−3.83 (2.92)	0.10 (2.47)
Year 2006	−4.19 (1.78)**	−2.15 (1.48)	−6.38 (2.86)**	−2.65 (2.49)
Year 2005	−6.74 (2.18)***	−4.79 (1.82)***	−10.14 (3.94)***	−6.59 (3.38)*
Year 2004	−5.07 (1.61)***	−3.04 (1.20)**	−9.46 (3.50)***	−5.75 (2.76)**
CI	0.08 (2.40)	0.58 (2.40)	0.83 (4.29)	1.24 (4.32)
CPE	−2.39 (1.98)	−2.08 (2.06)	−4.88 (3.57)	−4.66 (3.53)
EPC	NA	NA	NA	NA
EPD	−11.25 (3.80)***	−9.44 (4.46)**	−14.46 (5.93)**	−12.03 (6.83)*
OPT	−0.73 (3.69)	−1.11 (3.51)	−2.56 (6.31)	−3.22 (6.03)
SEMI	6.04 (3.29)*	8.36 (1.99)***	10.91 (5.24)**	12.95 (3.51)***
R&D ratio*lead firm		18.66 (59.09)		8.04 (93.04)
R^2	11.16%	10.57%	13.26%	12.98%
Wald χ^2	360.17***	377.09***	267.87***	303.54***
N	290[3]	320	291	321
Instrument tests[4]				
Sagan's chi-square	5.887* ($p = 0.053$)	2.624 ($p = 0.269$)	7.099** ($p = 0.029$)	3.499 ($p = 0.174$)
Basmann's chi-square	5.657* ($p = 0.059$)	2.514 ($p = 0.285$)	6.851** ($p = 0.033$)	3.361 ($p = 0.186$)

[1] The values in parentheses are clustered robust standard errors.
[2] Lead firm dummy variable: 1 for lead firm and 0 for CM.
[3] Each observation requires data for the current and previous periods; this eliminates observations for all of 2002 and some observations in other years when firms do not have consecutive years of data for lagged independent and dependent variables.
[4] Instrumental variables: one-year lagged R&D ratio, CR4 and industry average R&D ratio for Model 1 and the interaction term of one-year lagged R&D ratio and lead firm, CR4 and industry average R&D ratio for Model 2.
$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.10$.

Table 5. 2SLS regression results for gross margin and net margin (component supplier and contract manufacturer).

	Gross margin		Net margin	
Variable	Model 1	Model 2	Model 1	Model 2
R&D ratio (R&D/sales)	130.64*** (29.74)[1]		−65.43 (45.42)	
CO[2]	4.00 (2.52)		7.81 (7.49)	
Ln(Assets)	−1.76*** (0.54)	−2.03*** (0.52)	0.76 (1.45)	0.40 (1.18)
Year 2009	−5.26 (1.23)***	−5.12 (1.17)***	−1.12 (3.11)	−0.65 (3.18)
Year 2008	−4.44 (1.16)***	−4.43 (1.08)***	−6.02 (2.17)***	−5.48 (2.15)**
Year 2007	−0.38 (1.07)	−0.53 (1.00)	3.72 (2.10)*	4.42 (2.27)*
Year 2006	0.25 (1.07)	0.08 (1.03)	5.32 (3.41)	5.98 (3.62)*
Year 2005	−1.79 (0.90)**	−1.90 (0.87)**	1.67 (2.54)	2.28 (2.76)
Year 2004	0.90 (0.80)	0.68 (0.77)	0.22 (1.23)	1.01 (1.35)
CI	−4.23 (3.20)	−0.74 (3.12)	0.79 (5.35)	−4.18 (3.69)
CPE	−2.36 (3.18)	−1.22 (3.09)	5.60 (8.08)	6.19 (8.45)
EPC	−2.12 (3.49)	−1.16 (2.96)	−0.81 (5.14)	3.06 (3.76)
EPD	−18.45 (3.47)***	−17.61 (3.19)***	−33.11 (5.05)***	−30.11 (5.57)***
OPT	−3.50 (3.63)	−2.18 (3.13)	−7.27 (5.95)	−3.86 (4.59)
SEMI	1.16 (3.89)	3.12 (3.57)	2.76 (5.51)	5.83 (4.57)
R&D ratio*CO		119.79*** (27.77)		−52.96 (41.85)
R^2	32.16%	29.45%	4.46%	3.78%
Wald χ^2	282.13***	260.14***	2227.68***	2035.31***
N	1067[3]	1100	1067	1100
Instrument tests[4]				
Sagan's chi-square	0.741 ($p = 0.690$)	0.526 ($p = 0.769$)	0.142 ($p = 0.931$)	0.030 ($p = 0.985$)
Basmann's chi-square	0.729 ($p = 0.694$)	0.518 ($p = 0.772$)	0.140 ($p = 0.932$)	0.029 ($p = 0.986$)

[1]The values in parentheses are clustered robust standard errors.
[2]Component supplier dummy variable: 1 for component supplier and 0 for CM.
[3]Each observation requires data for the current and previous periods; this eliminates observations for all of 2002 and some observations in other years when firms do not have consecutive years of data for lagged independent and dependent variables.
[4]Instrumental variables: one-year lagged R&D ratio, CR4 and industry average R&D ratio for Model 1 and the interaction term of one-year lagged R&D ratio and component supplier, CR4 and industry average R&D ratio for Model 2.
***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

Table 6. 2SLS regression results for ROA and ROE (component supplier and contract manufacturer).

	ROA		ROE	
Variable	Model 1	Model 2	Model 1	Model 2
R&D ratio (R&D/sales)	−9.69 (16.71)[1]		−32.33 (22.92)	
CO[2]	−0.85 (1.59)		−3.04 (2.56)	
Ln(Assets)	−0.17 (0.41)	−0.11 (0.39)	0.02 (0.62)	0.18 (0.60)
Year 2009	−4.04 (0.94)***	−3.56 (0.92)***	−6.06 (1.56)***	−5.28 (1.50)***
Year 2008	−5.74 (− 91)***	−5.20 (0.87)***	−8.56 (1.52)***	−7.63 (1.42)***
Year 2007	−0.04 (0.79)	0.46 (0.75)	0.26 (1.36)	1.10 (1.27)
Year 2006	−0.51 (0.86)	−0.05 (0.84)	−0.70 (1.55)	0.06 (1.51)
Year 2005	−1.75 (0.74)**	−1.30 (0.72)*	−1.95 (1.29)	−1.19 (1.23)
Year 2004	−0.90 (.71)	−0.40 (.65)	−0.48 (1.62)	0.32 (1.44)
CI	−2.33 (2.75)	−2.55 (2.64)	−2.14 (4.54)	−2.51 (4.43)
CPE	0.09 (2.54)	−0.20 (2.32)	1.10 (3.62)	0.21 (3.38)
EPC	0.13 (2.70)	−0.20 (2.26)	1.57 (3.82)	0.33 (3.28)
EPD	−9.37 (2.88)***	−9.29 (2.54)***	−2.01 (3.93)	−2.41 (3.53)
OPT	−1.41 (2.88)	−1.69 (2.53)	−2.03 (4.10)	−3.13 (3.73)
SEMI	2.23 (3.16)	2.12 (2.84)	3.08 (4.36)	2.18 (3.95)
R&D ratio*CO		−14.13 (15.83)		−39.96* (21.84)
R^2	6.12%	6.10%	6.35%	6.16%
Wald χ^2	372.06***	360.99***	122.80***	119.11***
N	1045[3]	1075	1047	1077
Instrument tests[4]				
Sagan's chi-square	1.338 ($p = 0.512$)	0.592 ($p = 0.744$)	1.030 ($p = 0.597$)	0.280 ($p = 0.869$)
Basmann's chi-square	1.316 ($p = 0.518$)	0.583 ($p = 0.747$)	1.013 ($p = 0.603$)	0.276 ($p = 0.871$)

[1] The values in parentheses are clustered robust standard errors.
[2] Component supplier dummy variable: 1 for component supplier and 0 for CM.
[3] Each observation requires data for the current and previous periods; this eliminates observations for all of 2002 and some observations in other years when firms do not have consecutive years of data for lagged independent and dependent variables.
[4] Instrumental variables: one-year lagged R&D ratio, CR4 and industry average R&D ratio for Model 1 and the interaction term of one-year lagged R&D ratio and component supplier, CR4 and industry average R&D ratio for Model 2.
***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

R&D spending and marketing, so lead firms' return to R&D is not significantly different from CMs/ODMs.

Similarly, component suppliers do not perform better than CMs/ODMs, other things being equal (Tables 5 and 6), while R&D is strongly associated with an increase in gross profits for both component suppliers and CMs/ODMs. However, the interaction term (model 2) indicates that component suppliers earn higher gross profits from their R&D spending, compared to CMs/ODMs. The difference in R&D impact on bottom-line financial performance as measured by net margin and ROA is minimal. However, the impact of R&D on ROE is negative and such negative impact is greater for component suppliers than for CMs/ODMs. These results suggest that component suppliers capture higher gross profits from their R&D spending, compared to CMs/ODMs, by focusing on component-level innovation. However, component suppliers' returns to R&D as measured by ROE are lower than CMs/ODMs due to the size of their R&D spending.

5. Discussion and conclusions

As expected, our results show that lead firms have higher gross margins than CMs/ODMs (Figure 1). However, they have low net margins, probably due to R&D, sales and marketing costs. In contrast, component suppliers capture higher profits (net margins), even accounting for R&D costs (Figure 2). However, their returns on investment are not as great as CMs (Figure 4). This suggests that Taiwanese component suppliers are unable to gain pricing power from their R&D investments, perhaps because some firms focus on commodity components such as memory chips and displays rather than more proprietary components such as microprocessors or application specific integrated circuits, and some firms focus on component manufacturing services. Assemblers (CMs/ODMs) have thin margins, but earn reasonable returns due to scale and efficient use of resources.

Our results imply that the economic performance of firms depends not only on the returns from their strategies, but also on the cost of implementing those strategies (Barney 1986; Peteraf 1993). According to Peteraf (1993), without imperfections in strategic factor markets, where the resources necessary to implement strategies are acquired, firms can only hope for normal returns. Rumelt (1987) also argues that unless there is a difference between the *ex post* value of a venture and the *ex ante* cost of acquiring the necessary resources, the entrepreneurial rents are zero.

The R&D impact on value capture in terms of ROE shows a mixed picture. Among the three types of firms, Taiwanese CMs/ODMs have competitive advantage in terms of ROE over component suppliers in the industry. Differences may be due to different financial structure, e.g. degree of debt leverage across sectors.

This research makes several contributions to knowledge about global production networks. First, it uses previous theoretical work on who captures the value in global value chains and produces empirical results consistent with these theories (Barney 1986; Peteraf 1993; Teece 2007), thereby providing indirect support. Second, whereas previous empirical research focused on global electronics firms ranked by the Electronics Business 300 (Shin, Kraemer, and Dedrick 2012), this research focuses on electronics firms in a single country, Taiwan. Like the earlier research, it shows that business practices and industry segment characteristics, such as R&D activity coupled with branding, marketing and positioning close to the consumer markets, can have a profound impact on the economic performance of the three types of firms. Third, despite this similarity, there are several differences. The practice of high leverage affects significantly Taiwanese electronics companies' ROE, particularly that of CMs. Compared to the previous research, showing that all three types of firms in the global electronics industry have negative ROE, Taiwanese firms' ROE is positive and high. The Taiwan government's policy on debt financing helps these electronics firms gain high ROE. This research also employs a different methodology (2SLS) to analyze the interaction of R&D with value chain position as an indicator of R&D performance, which was not done in previous research.

Our findings suggest that lead firms need to create barriers to entry to sustain higher gross margins. This can be done by continuing product-level innovation, improving customer knowledge and improving their sales and marketing activities. Component suppliers may be at risk if margins come under pressure. Thus, they also need to create entry barriers probably through improving their innovation activities, changing their focus from commodity components to high-value components, or developing more intellectual property that can be used as a competitive weapon. Assemblers might vertically integrate or diversify to increase margins, but face entry barriers in either case. For example, Foxconn diversified its product lines, including PCs and mobile phones. HTC has made a transition from CM to brand name business. However, such moves are not easy to make for most other firms and are risky. HTC's recent decline in revenues (Garside and Arthur 2012) shows the difficulty in sustaining a brand name business (similar to the struggles of former mobile leaders Nokia and Research in Motion).

This research also raises an important issue for policy-makers. If the goal is to promote high margin businesses, countries must invest heavily in R&D and/or marketing, employing high-paid scientists, engineers and marketing people. However, if the goal is to increase total employment, then the labor-intensive middle of the value chain has the greatest potential for job creation. Thus, for policy-makers, the issue is a matter of country goals – high paying jobs and high margin companies or large numbers of low paying jobs. This is especially important for an economy such as Taiwan that can no longer compete based on low wages at home, but has not yet caught up the developed world in R&D, marketing and branding. It is the cooperation between mainland China and Taiwan that enables Taiwan to be price-competitive, while also developing capabilities for R&D, product development, marketing and developing own-brand companies.

Notes

1. The number of employee could not be employed for a measure of firm size because the data was available only for a few firms in the sample; its use reduces the number of observations significantly for the analysis.
2. The sample does not include firms in the information service industry.
3. Four-firm concentration ratio (CR4) is a measure of market concentration. It measures the total market share of the four largest firms in an industry. Firms in concentrated industries tend to invest more in R&D because concentration reduces market uncertainty and provides cash flow for R&D (Roucan-Kane, Ubilava, and Xu 2007). On the other hand, reduced competition due to industry concentration can lead to reduced R&D (Schimmelpfennig, Pray, and Brennan 2004). In either case, concentration is not necessarily related to the variance of firm performance.

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