Ownership Structure and Innovation Performance:  
The Mediating Mechanism of External Cooperation

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Abstract

Our study examines how a firm’s institutional ownership and family ownership influences its innovation performance, as measured by both the quantity and quality of the innovation outputs of the firm. Specifically, we examine the extent to which external cooperation with other firms mediate the relationship between ownership structure and firm innovation performance. We find that firms with high levels of institutional investors, especially foreign institutional investors, on average, have higher innovation performance, and the amount of external cooperation the firm engaged in mediates the relationship between institutional ownership and innovation performance. This research suggests that institutional investors play a bigger role than just monitoring managers of investee firms, as suggested by prior research.

Key words: Ownership structure; External cooperation; Innovation performance; Institutional ownership; Family ownership.
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INTRODUCTION

Innovation is important for economic development. Prior research has shown that corporate governance, and institutional structures play a major role in influencing innovation (e.g., David, Hitt, & Gimeno, 2001; Lee & O'Neill, 2003). A key focus in this stream of research is the impact of ownership structure on a firm’s innovation expenditure and activities (e.g., Munari, Oriani, & Sobrero, 2010). Owners have an interest in the innovation activities of a firm because a firm’s innovativeness has been shown to influence firm performance (Miller, 2006). Prior research, however, has established that different types of owners differ in their time horizons and incentives for investing, thus resulting in distinct preferences for corporate innovation strategies (Hoskisson et al., 2002). For example, investors with longer term horizon are more likely to invest in firms that have long-term innovation and product development strategies.

Our study focuses on two types of investors that have been identified to be critical in influencing both the strategy and operations of a firm – institutional investors and family investors. Institutional investors refer to organizations who invest large sums of money, usually on behalf of groups of individuals, or organizations. Examples include banks, insurance companies, retirement or pension funds, mutual or hedge funds, or even operating companies that are investing their profits in equities. Institutional investors control a large proportion of outstanding shares traded on all major exchanges (56%, according to Edwards & Hubbard, 2000). They are, therefore, a
very important group of shareholders that have significant influence on the governance of a firm (Hansen & Hill, 1991). Prior research has shown that ownership by institutional investors significantly influence the amount of resources and effort that a firm invests in research and development (R&D) (e.g., Choi, Il Park, & Hong, 2012). For example, David et al. (2001) show that institutional ownership increased R&D inputs over both short and long term.

Another group of investors that have been widely studied in the literature is investors of family firms, or family members who are dominant shareholders of a firm. Family firms tend to be dominated by owners who are family members, and they often possess unique characteristics in terms of their governance, structure, culture and goals (Muñoz-Bullón & Sanchez-Bueno, 2011). Family ownership and control is not uncommon in many economies, including East Asia (Chin et al., 2009). Given the unique nature of such firms, prior research has established that the ownership structure of such firms significantly influence the R&D investment of a firm. For example, Muñoz-Bullón et al. (2011) show that publicly traded family firms in Canada record lower R&D intensity compared with nonfamily firms. Munari et al. (2010) also found, based on 1000 publicly-traded firms in six European countries, that higher shareholding by families is negatively associated with R&D investment.

While prior research has established that ownership structure influences a firm’s R&D effort and investment, the focus has so far been on the inputs of R&D – the amount of effort and resources invested in R&D for a firm. Prior research has yet to examine how ownership structure
influences the innovation performance of a firm, and our study seeks to fill this gap in the literature. It is important to examine how ownership influences innovation performance because R&D expenditure represents only the inputs or the amount of effort that a firm expends on research and innovation, and is, at best, only positively correlated with a firm’s innovation performance. And it is the latter that is more directly related to firm performance. Moreover, the theoretical mechanisms through which ownership influences innovation performance is more encompassing that those through which ownership influences R&D expenditure. Hence, our research focuses on innovation performance instead of the inputs of R&D.

Moreover, while prior research has clearly established the linkage between ownership and a company’s R&D, the underlying mechanism through which this relationship occurs is unclear. Our study fills this gap by arguing that external cooperation plays a key mediating role linking ownership to innovation performance. Prior research has shown that setting up partnerships and alliances with other firms is key to allowing firms to “overcome resource constraints and offset competitive pressures, thus enhancing growth prospects” (Ang, 2008, p. 1057). We thus explicitly hypothesize and test the extent to which external cooperation is the mediating mechanism through which institutional and family ownership influences innovation performance.

THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

Institutional Ownership and Innovation Performance

There is a general consensus in the literature that the ownership structure of firms has
significant influence on a firm’s willingness to invest in R&D (Choi et al., 2012). The literature explains that this has to do with the problem of agency, which results from the separation of ownership and control. Agency theory suggests that shareholders, rather than managers, would prefer risky strategies associated with aggressive R&D investments that have the opportunity of generating high returns. This is because investors can diversify their risks by holding a portfolio of investments, while managers cannot always diversify their risk as their risk is inherently tied to a single venture. As innovation activities expose the firm to uncertain outcomes and may potentially depress a firm’s short-term performance, managers may be unwilling to invest in R&D due to their risk-aversion and tendency to prefer short-term gains (Munari et al., 2010).

According to agency theory, institutional investors help to overcome this problem by monitoring and helping to control managerial opportunism so as to ensure that R&D expenses is invested toward increasing shareholder value (Le, Walters, & Kroll, 2006). Investors can monitor management actions by taking steps to discipline or remove poor performing executives, but the cost of taking on this monitoring role is high. As major shareholders and with the oversight skills of professional investors, institutional investors have the incentive and ability to monitor executives, thus exerting more influence on a firm’s decisions than dispersed individual owners (Khan, Dharwadkar, & Brandes, 2005). Hence, only such large institutional investors can afford to intervene actively in a company’s affairs (Shleifer & Vishny, 1986).

Prior research has found substantial evidence that holdings by institutional investors
significantly influence the R&D expenditure of a firm (e.g., Hansen & Hill, 1991). Le et al. (2006) also found that external monitoring by institutional investors moderated the relationship between R&D spending and firm performance. Their findings suggest that institutional investors actively monitor and influence firm R&D spending, in a bid to protect and enhance their investment given the material impact of R&D spending on firm stock performance. In addition, Bushee (1998) found that institutional ownership mitigates managerial myopia by making managers focus more on long-term results and be less likely to cut R&D expenditure to avoid an earnings decline.

Building on this literature, we argue that institutional investors not only influence a firm’s R&D expenditure, which represents the inputs or the amount of effort that a firm expends on research and innovation, but institutional investors also influence a firm’s innovation performance. While institutional investors play a key monitoring role, encouraging managers to take risk where appropriate to invest in R&D, they can also help to bring in necessary resources for technological innovation activities (Choi et al. 2012).

Prior literature argues that external resources that a firm can access and deploy are of strategic importance to the firm (Pfeffer & Salancik, 1978). Thus, as highlighted by Choi et al. (2012), resource-rich shareholders expand the pool of resources that a firm can access for its innovation activities. Institutional shareholders, with the expertise as well as access to a pool of organizations, thus serve as knowledge brokers who are able to bring with them diverse knowledge resources about related industries and sectors. Choi et al. (2012), for example, found
that foreign investors provide advanced foreign technology and sophisticated managerial know-how to help the invested firm to gain access to the foreign market.

By serving a monitoring function as well as a knowledge broker function, institutional investors focus managers on R&D functions of a firm and bring in external resources to help the firm. This increases not only the R&D expenditure of a firm, but also the innovation performance of a firm. By leveraging their large ownership, institutional investors can affect the innovation performance of the firm through a variety of actions. First, they may undertake public announcements and shareholder proposals (David et al., 2001; Wahal, 1996). Second, they may make refinements to corporate governance of a firm such as board structure (Wu, 2004), and manager-level compensation and turnover (e.g., David, Kochhar, & Levitas, 1998). Finally, shareholders may even actively involve themselves in firms’ R&D activities in order to seek long-term gains (David et al., 2001; Hoskisson et al., 2002). Hence, we hypothesize:

Hypothesis 1: Institutional ownership has a positive relationship with innovation performance.

The Mediating Effect of External Cooperation

With increasing complexity and a more competitive market, organizations find it increasingly useful to collaborate with other firms to generate new ideas, products and services (Mention, 2011). Individual firms do not always possess all the required resources for innovation and increasingly need to rely on creating partnerships to gain access to resources that they do not have. Strategic alliances and partnerships thus play a critical role in helping organizations to access
complementary resources and knowledge from partner organizations (e.g., Eisenhardt & Schoonhoven, 1996; Hagedoorn & Duysters, 2002). Such partnerships can facilitate the exchange of knowledge, resulting in learning from partners, and such knowledge spillovers can also lead to better innovation performance for the firm (Inkpen & Dinur, 1998). Prior research has provided evidence of the benefits of cooperation with other firms on the sales of innovative products (e.g., Zeng, Xie, & Tam, 2010), sales growth (e.g., Cincera et al., 2003) and the number of patents by a firm (e.g., Miotti & Sachwald, 2003). The impact of R&D collaborations have been established for various sectors, including the US biotechnology (Arora & Gambardella, 1994), the information technology (Colombo, 1995) and the manufacturing (e.g., Becker & Dietz, 2004) industries.

As highlighted earlier, institutional investors influence the innovation performance of a firm not only by monitoring managers to prevent them from under-investing in R&D but also by bringing in external resources required by the firm. In particular, institutional investors play a knowledge broker role, bringing with them information about diverse industries. In this section, we further develop this argument by explaining how institutional investors affect the external resources available to a firm by affecting the extent of external cooperation that a firm engages in.

As institutional investors invest in multiple firms and are highly knowledgeable about the firms they are in, this puts them in an ideal position of being a knowledge broker (Burt, 1997), who have access to diverse information because they are connected to firms that are otherwise not connected to one another. They thus have the diversity of knowledge, about related, unrelated and
competitor firms, which allows them to see the potential connections between potential partners. Individuals with diverse knowledge are able to see unique combinations of existing resources and solutions (Hargadon & Sutton, 1997). Institutional investors who have diverse knowledge about the overall environment, strategy and macroeconomic conditions of various firms in different industries and sectors thus have the perspective to see plausible connections between potential partners and convey such opinions to the managers of the firms that they invest in.

Moreover, prior research has also shown that people who are not internal employees of a firm tend to support the acquisition of innovation from external sources, as such innovation is often perceived to be less risky compared to internally developed innovation endeavors (Hoskisson et al 2002). Given that institutional investors are typically not wedded to research endeavors within the firm, they are likely to encourage the acquisition of resources and knowledge from external parties that they may be knowledgeable about. We thus argue that institutional investors will encourage strategic alliances and partnerships with other firms for the investee firm to gain access to complementary resources and knowledge.

While shareholders do not directly participate in deliberations of firm strategies, there are various means by which shareholders’ views and opinions will be taken into consideration when managers deliberate on a firm’s strategies. Prior research has noted that other than formal activism – public efforts such as shareholder proposals and action taken at annual general meetings, shareholders also engage in behind-the-scenes private negotiations with firm managers that are not
publicly visible – what researchers term informal activism (Nordén & Strand, 2011). We argue that it is through such informal activism that major institutional shareholders will communicate their views and opinions to managers of invested firms. This is when the breadth and diversity of their knowledge can provide managers with valuable information, including information about potential partnerships with other related and unrelated firms. Hence, we hypothesize that firms dominated by institutional owners will benefit from the diversity of knowledge of these owners by forging more external cooperations that will facilitate their innovation performance.

Hypothesis 2: The positive relationship between institutional ownership and innovation performance is mediated by the external cooperation.

Family Ownership and Innovation Performance

Unlike the case of organizations dominated by institutional investors, agency problems are likely to be less prevalent in family firms due to several reasons (Muñoz-Bullón & Sanchez-Bueno, 2011). First, family members often hold the top management positions; hence agency problems resulting from the lack of ownership and control present less of a problem. Second, even if they do not hold key management positions, family owners usually have good access to relevant internal information about the firm, and in the case of R&D investments, about such R&D projects. Hence, they are able to effectively monitor the behavior of the managers of the company and prevent any opportunistic behavior on the part of managers that may not be in the shareholders’ interest (Fama & Jensen, 1983). As a result, family firms may not face agency
problems resulting from the tendency of managers to under-invest in R&D.

Instead, family firms tend to face agency problems of a different kind. In family firms, there may be a tendency for key managers to undertake actions that help other family members, sometimes at the expense of negatively impacting firm wealth (Gómez-Mejía, Makri, & Larraza-Kintana, 2010; Kim, Kim, & Lee, 2008). This behavior is sometimes termed “altruism”, which stems from manager-owners’ desire to help other family members and the acceptance of that amongst other family owners, but often times at the expense of minority shareholders (Chin et al., 2009). Such agency problems could potentially lead family owners and managers to invest inappropriately in R&D projects, or to under-invest in R&D projects to channel resources to help other family members. This then negatively influences the innovation performance of the firm.

A second reason that may lead family-controlled firms to under-invest in R&D projects is due to the risk aversion of such firms. Family-controlled firms are typically risk averse, as the family owners often invest a significant amount of their own wealth in the company (Munari et al 2010). Given the investment of their own wealth, family firms typically place significant emphasis on the survival of the business, so as to be able to pass control of the firm and the wealth invested to subsequent generations (Chang, Wu, & Wong, 2010; Kim et al., 2008; Muñoz-Bullón & Sanchez-Bueno, 2011). As a result of the risk aversion associated with the desire for wealth preservation, family firms are less inclined towards investing in innovation that involves too much risk (Donckels & Frohlich, 1991) and are more reluctant to back R&D investments. Instead, they
tend to favor investments that are likely to reinforce the status quo (Munari et al. 2010).

Finally, family firms are also less likely to be able to put the best resources required into
R&D investments. Due to the tendency for altruism, family firms may not always recruit and
utilize the best talent for various functions in the firm (Chang et al., 2010; Lee, Lim, & Lim,
2003). The reputation for family firms to engage in altruistic behavior and the lack of systematic
human resource practices to develop talent may also serve as a deterrent for the firm to recruit the
best talent for their R&D work (Reid & Adams, 2001). Moreover, the desire to retain control and
ownership of the firm often leads to reluctance to rely on external financing for family firms, thus
resulting in the lack of available funds to invest in large R&D projects.

Due to the above reasons – agency problems, risk averseness and the lack of resources of
family firms, we argue that firms are likely to be reluctant to invest in R&D, and may lack
appropriate resources to bring about successful innovation. As a result, the innovation
performance of the firm will be negatively impacted. Hence, we hypothesize:

Hypothesis 3: Family ownership has a negative relationship with innovation performance.

The Mediating Effect of External Cooperation

While we earlier argued that external cooperation would positively mediate the
relationship between institutional ownership and innovation performance, we argue that the
reverse would be true for family firms. Unlike institutional owners who invest widely and are
likely to serve as a knowledge broker highlighting the potential for external partnerships to the
focal firm, family owners are likely to focus their investments in a single company or limit their investment to a single industry. Their limited diversity of knowledge makes them unlikely to act in a similar knowledge broker role for the focal firm.

More importantly, prior research has found that family firms are more reluctant to engage in partnerships and strategic alliances (Gómez-Mejía et al., 2007; Gómez-Mejía et al., 2010), as external co-operations limit a family’s autonomy in subsequent decision making due to the need to consult their partners in various decisions. This flies in the face of family firms’ preference to retain total control over decision-making in order to preserve the family’s legacy (Fuentes-Lombardo & Fernández-Ortiz, 2010). Gómez-Mejía et al. (2007), for example, show that family-owned businesses are more hesitant to join a cooperative – a strategic decision associated with economic gains but also with a loss of family control.

As we previously noted, external cooperation is considered an innovation stimulus that is expected to bring benefits, such as access to complementary resources and knowledge (e.g., Hagedoorn, 1993). With the reluctance of family firms to participate in external cooperation, and their inability to serve as knowledge brokers, we argue the tendency of family firms not to engage in external cooperation will negatively influence their innovation performance. Hence:

Hypothesis 4: The negative relationship between family ownership and innovation performance is mediated by external cooperation.

The hypotheses are summarized in Figure 1, which shows the overall conceptual framework.
RESEARCH METHODS

Sample and Data Collection

To test our research model, we assembled a unique data set combining firm financial data with measures of a firm’s external cooperation coded from news articles, and measures of firm innovation performance obtained from patent databases. The research sample consists of Taiwanese publicly-traded electronics firms. Taiwan’s national R&D expenditures as a percentage of gross domestic product is ranked ninth in the world (Chin et al., 2009). Moreover, the 2011 World Economic Forum report (WEF, 2011) showed that the United States Patent and Trademark Office (USPTO) granted Taiwan the largest number of patents on a per capita basis, demonstrating the high level of innovativeness in the country. Most of the patents filed with the USPTO are generated by the Taiwanese electronics industry. Hence, Taiwanese electronics firms are among the most active in the global patenting community.

We examined the impact of ownership structure and external cooperation on firm innovation for all 344 Taiwanese publicly-traded electronics firms for the period 2001-2008. Financial data was drawn from The Taiwan Economic Journal (TEJ)\(^1\) database. Patent data was collected from the database of the USPTO for the same period. The reasons that we chose to

\(^1\) Taiwan Economic Journal (TEJ) is recognized as the most authoritative and reliable source of data in Taiwan and provides financial information on the nine major countries in emerging Asia.
examine innovative performance of the firm via patents filed with the USPTO are twofold (Chin et al., 2009). First, prior research has shown that patent filing in a firm’s non-home country, especially in the United States, is a significant indicator of the firm’s innovation ability (Grupp & Schmoch, 1999; Hall & Ziedonis, 2001), because the complicated and costly patent filing process in the US implies that only the most important innovations are patented there. Moreover, most of the Taiwanese electronic firms operate on a global basis; hence it is important for them to protect their intellectual property in key markets of export and operation, including the US.

We collected data on firms’ external partnerships according to the following process. First, we extracted external cooperation related news for the firms in our sample from five major newspapers and business magazines: Economic Daily News and Market Daily News – the two largest economic and business newspapers in Taiwan; Business Weekly and Common Wealth Magazine – the two biggest professional business magazines in Taiwan; and DigiTimes daily – the most popular professional business newspaper focusing on Taiwan’s high-tech industry. The following key words are used to search for cooperation data: cooperation, alliance, agreement, joint development, and merger and acquisition. Research assistants were recruited to help in the search and coding process, and they followed the procedures described in Appendix A to search for the news of the cooperation for firms in our sample, and to code for the type of cooperation.

Variable Measurement

Ownership Structure. To measure the concentration of ownership in a firm by
institutional\(^2\) and family investors\(^3\), we use the percentage of equity owned by institutional investors and family members. To avoid potential simultaneity problems and to facilitate causal inference, we used the institutional ownership (INS) and family ownership (FAM) in year \(t-1\) to predict the innovation performance of a firm in year \(t\) (Muñoz-Bullón & Sanchez-Bueno, 2011).

**External Cooperation (COOP).** Many prior studies use a dummy variable to proxy for whether a firm engages in external cooperation with other firms (e.g., Hagedoorn & Schakenraad, 1994; Sakakibara, 2002). Such a measure, however, cannot represent the frequency and intensity of external cooperation that each firm engages in. Therefore, we measure the total number of new external cooperations announced per year to reflect the intensity of cooperation activities undertaken by the focal firm. Following prior research (Park, Chen, & Gallagher, 2002; Stuart, 2000), we use the number of cooperations formed by a firm in each year during the period 2001-2008, divided by the average number of cooperations in the same sub-industry\(^4\) so as to measure the intensity of external cooperation relative to the sub-industry’s average.

**Dependent variables.** As highlighted earlier, prior research tends to use the amount of R&D expenditure of a firm to proxy the innovativeness of a firm. The amount of R&D

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\(^2\) Institutional Investors as defined by TEJ to include government agencies, domestic financial institutions, domestic trust funds, domestic corporations, foreign financial institutions, foreign corporations, and foreign trust funds.

\(^3\) The TEJ database uses the following definition to code for family firms: (1) both the board chairman and the CEO are family members; or (2) family members occupy over 50% of the board seats while affiliated companies and outside directors occupy less than 33% of the board seats; or (3) family members occupy over 33% of the board seats and at least three family members are board directors, supervisors, or managers; or (4) controlling ownership exceeds the critical control level. For family firms, family ownership is calculated as the sum of equity holdings by family owners. For non-family firms, family ownership is calculated as the sum of equity holdings by family firms and their controlling members.

\(^4\) Taiwan’s electronics industries include following sub-industries: semiconductor, optoelectronics, telecommunications, computer component, computer and peripheral equipment.
expenditure, however, represents the inputs or the amount of investment in R&D, rather than the output. As we focus on innovation performance, we thus chose to use the patenting performance of firms, rather than the amount of R&D expenditure, as the patenting performance shows in concrete terms the innovation outputs of the electronic firms. Furthermore, we differentiate between two different aspects of innovation performance: innovation quantity and quality.

We use the number of patents granted in the United States as a measure of each firm’s innovation output quantity (INN QUAN). Prior research has commonly used patent counts to provide indications of a firm’s technological capability (Chin et al., 2009; Francis & Smith, 1995). To alleviate industry effects, we divide the number of patents granted for each company by the average number of patents granted to firms in the same industry.

As a measure of innovation, the number of patents granted to a firm represents only one aspect of a firm’s innovation performance – the quantity of innovations generated; but as highlighted by Chin et al 2009 (page 153), “not all patents are created equal”. Some innovations are more impactful than others. Prior research has used the forward citations of patents to indicate the value and usefulness of an invention (e.g., Nerkar & Paruchuri, 2005). The number of times a patent has been cited by other patents provides a measure of its technological significance and impact; hence, it further establishes the technological competence and innovation performance of a firm (Jaffe, Trajtenberg, & Fogarty, 2000). Therefore, we use the number of patent citations divided by the average number of patents citations received by firms in the same industry, as an
indicator of a firm’s innovation output quality (INN_QUAL) relative to the industry average.

**Control variables.** As highlighted earlier, the level of R&D investments (RD) is a proxy for the level of innovative effort. Hence, we use the ratio of R&D expenditures to total sales to proxy the extent of R&D investment by a firm (e.g., Hall & Bagchi-Sen, 2002; Sakakibara, 2002). Firm size can influence the amount of resources available to the firm and the benefits from economies of scale. As per prior studies (Chin et al., 2009; Francis & Smith, 1995), we measure firm size (SIZE) as the natural logarithm of the firm’s annual sales. We also include firm free cash flow (FCF) in the model (Claessens et al., 2002; Harford, Mansi, & Maxwell, 2008), which proxies a firm’s availability of slack resources (Harford et al., 2008). Capital structure reflects the operation risk of a firm and is deemed as an important decisive factor of performance. Therefore, we use the ratio of total liabilities to total assets to proxy capital structure (DEBT).

**Empirical Models**

We test the hypotheses using the following functional form:

$$Y_{it} = \alpha + X_{it} \beta + u_i + \epsilon_{it}$$

(1)

where Y represents the dependent variable, i denotes the firm, and t denotes the year. X is the vector of variables including key independent variables and control variables. $u_i$ represents the firm level stochasticity, $\epsilon_{it}$ represents stochasticity across firm and time and $\beta$ represents estimated parameters. We performed two sets of random effects generalized least squares (GLS) regression estimations predicting innovation quantity and quality respectively. We used random effects instead of fixed effects to estimate our model because various control variables employed in the
model are invariant across the firm. Further, Hausman tests suggest that random effects estimators are consistent and efficient.

Hypotheses 1 and 3 present hypotheses regarding the relationship between ownership and innovation performance. We first tested H1 and H3 by using equations (2) and (3).\(^5\)

\[
\text{INN\_QUAN}_{it} = \alpha + INS_{it}\beta_1 + FAM_{it}\beta_2 + X_{it}\beta + u_i + \epsilon_{it} \tag{2}
\]

\[
\text{INN\_QUAL}_{it} = \alpha + INS_{it}\beta_1 + FAM_{it}\beta_2 + X_{it}\beta + u_i + \epsilon_{it} \tag{3}
\]

Then, in order to investigate the mediating effect of external cooperation on the relationship between ownership and innovation performance (H2 and H4), we adopted the approach recommended by Baron and Kenny (1986). We establish that INS and FAM are associated with the mediating variable (COOP), by testing equation (4).

\[
\text{COOP}_{it} = \alpha + INS_{it}\beta_1 + FAM_{it}\beta_2 + X_{it}\beta + u_i + \epsilon_{it} \tag{4}
\]

Finally, to show that the variable (COOP) mediates the relationship between the independent variables (INS and FAM) and the dependent variables (INN\_QUAN and INN\_QUAL), we test equations (5) and (6).

\[
\text{INN\_QUAN}_{it} = \alpha + INS_{it}\beta_1 + FAM_{it}\beta_2 + \text{COOP}_{it} + X_{it}\beta + u_i + \epsilon_{it} \tag{5}
\]

\[
\text{INN\_QUAL}_{it} = \alpha + INS_{it}\beta_1 + FAM_{it}\beta_2 + \text{COOP}_{it} + X_{it}\beta + u_i + \epsilon_{it} \tag{6}
\]

**Self-Selection of Institutional Investors**

Endogeneity may be an issue in our analysis as innovation performance may be associated with the percentage holdings of institutional investors. This association may represent

\(^5\) For equations (2) to (6), \(X_{it}\beta\) represents the control variables described in the prior section – RD, SIZE, FCF and DEBT and their associated beta coefficients.
an attraction of institutional investors to firms that exhibit better innovation performance. While
the lagging of the ownership variables will alleviate this concern to some extent, it will not
completely eliminate the bias if the innovation performance and ownership variables are both
persistent over time (Cornett et al., 2007). Accordingly, we control for possible endogeneity in
our hypotheses test by using instrumental variables estimation via two-stage least squares (2SLS).
Details of the instrumental variables estimation are provided in Appendix B. We tested the
hypotheses with both GLS and 2SLS as recommended by (Larcker & Rusticus, 2007), and found
that they provide similar results. In this paper, however, we report the 2SLS results.

RESEARCH RESULTS

Table 1 presents descriptive statistics and correlations for the variables used. On average,
institutional investors and family owners hold an average of 10.87 percent and 27.29 percent of
firms’ common stock respectively in Taiwanese public electronics firms. All of the values of
correlation coefficients between independent variables are well under 0.6. The highest VIF value
is 1.95, indicating that there is no serious multicollinearity (Judge et al., 1988).

Insert Table 1 About Here

The estimations of Equation (2) and (3) presented in the first and second columns of
Table 2 provide the tests of H1 and H3. The coefficient of INS is positive and significant in
predicting both innovation quantity (β=0.2591, p < 0.01) and innovation quality (β=0.2273, p <
0.05), providing support for H1. The coefficient on FAM is, however, insignificant in influencing
both innovation quantity ($\beta=0.0022, p > 0.10$) and innovation quality ($\beta=-0.0081, p > 0.10$). This indicates that family ownership has no association with innovation performance, thus H3 is not supported. Taken together, these results suggest that firms with higher ownership of institutional investors, on average, have higher innovation performance.

Insert Table 2 About Here

Models 3 to 5 in Table 2 test the mediation hypotheses – H2 and H4. The results indicate that companies with high institutional ownership have more external cooperation ($\beta=0.086, p < 0.001$), while companies with high family ownership have a negative although insignificant association with external cooperation ($\beta=-0.0249, p > 0.10$). When controlling for external cooperation, the effect of institutional ownership on innovation performance becomes smaller and insignificant for both innovation quantity ($\beta=0.1509, p>0.10$) and innovation quality ($\beta=0.1412, p>0.10$). The results are consistent with the H2 that external cooperation completely mediates the institutional ownership–innovation performance relationship. However, H4 is unsupported, as the tests show that external cooperation does not mediate the family ownership – innovation performance relationship.

Additional Analyses on Foreign vs. Domestic Institutional Ownership

Prior research often differentiates between foreign and domestic institutional investors, showing that foreign investors may encourage the technological innovation activities of focal firms by transferring advanced technological resources and helping them boost their R&D efforts.
Foreign investors also push local partners to invest more in technology development by using their ownership shares as leverage (Chang, Chung, & Mahmood, 2006). Choi et al. (2012), for example, found that foreign ownership has a significant effect on firm technological innovation performance. Srholec (2009) indicates that foreign ownership facilitates cooperation with non-affiliated partners, especially with those located abroad. Thus, we further separated the institutional ownership into foreign institutional ownership and domestic institutional ownership, to examine if the significant findings found about institutional investors applied to both domestic and foreign institutional investors. In this section, we describe the additional tests conducted.

Applying a similar treatment of instrumental variable analysis described in Appendix B, we catered for the potential endogeneity of FORINS and DOMINS on innovation performance. The results of the 2SLS analysis are presented in Table 3. Models 1 and 2 of Table 3 present the association between ownership and innovation performance. The results show that firms with a higher percentage of foreign institutional ownership enhances both innovation quantity ($\beta=0.3806$, $p < 0.05$) and innovation quantity ($\beta=0.5320$, $p < 0.01$). However, neither domestic institutional ownership ($\beta=-0.1296$, $p>0.10$ for INN_QUAN; $\beta=-0.4125$, $p>0.10$ for INN_QUAL) nor family ownership ($\beta=0.0486$, $p>0.10$ for INN_QUAN; $\beta=0.0900$, $p>0.10$ for INN_QUAL) are significantly associated with innovation performance.

According to Model 3 in Table 3, companies with higher foreign institutional ownership have more external cooperation ($\beta=0.0831$, $p<0.001$), while companies with higher domestic
institutional ownership and family ownership have no association with external cooperation.

When controlling for external cooperation (Models 4 and 5 of Table 3), the effect of foreign institutional ownership on innovation performance becomes smaller ($\beta=0.3423$, $p < 0.05$ for INN_QUAN; $\beta=0.4952$, $p<0.05$ for INN_QUAL). Taken together, the above results suggest that it is ownership by foreign institutional investors that matters in influencing a firm’s innovation performance, and external cooperation partially mediates the foreign institutional ownership–innovation performance relationship.

**DISCUSSION**

Our study examines how institutional ownership and family ownership influences innovation performance of a firm, as measured by both the quantity and quality of the innovation outputs of the firm. Specifically, we examine the extent to which external cooperation with other firms mediate the relationship between ownership structure and firm innovation performance.

Our results show that a higher percentage of ownership by institutional investors significantly improved both the quantity and quality of the innovation outputs of a firm. This provides support for our arguments for H1 that institutional investors improve the innovation performance of a firm. We further examined whether the influence that institutional investors have on innovation performance is mediated via the mechanism of increasing the amount of external cooperation that the firm engaged in, based on the theoretical argument that institutional investors may be able to act as knowledge brokers to provide the diversity of knowledge to recognize
potential collaborations with other organizations (H3). Our results provide support for this hypothesis, showing that institutional investment does significantly increase the amount of external cooperation of a firm, which in turn, increases both the quantity and quality of innovation performance of a firm. This shows that institutional investors indeed act as a knowledge broker to increase the external cooperations of a firm, and such external cooperations bring various synergistic and spillover effects to increase the overall innovation performance of a firm.

Overall, our results show that institutional investors play a significant role in influencing the innovation performance of a firm. We conducted additional tests to examine if the significant findings found about institutional investors applied to both domestic and foreign institutional investors. The additional tests showed that foreign institutional investors were a much more significant driving force for improving the amount of external cooperation and innovation performance of a firm, compared to domestic institutional investors. This shows that it is the foreign institutional investors that, in particular, have a focus on innovation and thus play a more significant monitoring role as well as knowledge brokering role in highlighting potential collaborations and thus increasing the innovation performance of the firm in the process.

We also examined the influence of family ownership on innovation performance and the associated mediating effects of external cooperation. Our results, however, showed that the amount of ownership by family members did not seem to influence either innovation performance or the extent of external cooperation. This may be because family ownership of large electronic
firms is prevalent in Taiwan and the families have, over the years, done a good job of making sure 
that the family owned firms are, nevertheless, run in a professional manner (Tsao & Lien, 2013). 
As a result, the agency problems, risk averseness and the lack of resources that may explain a 
negative relationship between family ownership and innovation performance is less prevalent in 
the Taiwanese electronics industry.

**Qualitative Study**

Overall, the theoretical arguments and explanations for our findings draw upon the 
underlying premise that major and significant institutional shareholders can influence a firm’s 
external cooperations through a knowledge brokering role. While prior research acknowledges 
that shareholders influence managerial strategies and actions through informal activism (Nordén 
& Strand, 2011), the dominant view in the literature is that shareholders generally serves only a 
monitoring role. To make a more concrete contribution to the literature and to solidify our 
arguments, we further investigated our findings, by conducting a qualitative study. We 
interviewed institutional investors and investee firms to determine whether and in what ways the 
former may have some form of influence over a firm’s strategies and actions.

**Method and Participants.** We conducted one-on-one interviews with institutional 
investors. In addition, to triangulate the interview findings, we also interviewed investee 
companies from the high tech industry. In total, we conducted 10 interviews with 2 foreign 
institutional investors, 3 domestic institutional investors, and the senior management of 5 investee
firms. All interviews were conducted in Chinese by a member of the research team.

Semi-structured interviews, which lasted thirty to forty minutes each, were conducted. All interviews were transcribed, generating 82 pages of transcribed text with 44,924 Chinese words.

Key Findings. Our interviews revealed several key findings about institutional investors and how they influence the actions and strategies of the firms that they invested in:

1) Investors’ Attitude towards Investee Firm. Our findings reveal that if an institutional investor invested heavily in a firm, he/she will take a long term view of the relationship with the firm, focusing on helping the firm to succeed, rather than identifying the opportune moment to sell the stocks. As highlighted by one institutional investor:

“We are concerned about our relationship with the company. We will not be opportunistic and, with a narrow focus on our own interests, interact with the company only to collect private information, such that we know when is the best time to sell our stocks – this is not something that we do or believe in.”

Instead, institutional investors with major shareholdings are interested in learning more about the firm’s situation and strategy, and would do what they can to provide opinions and advice that they hope can help the firm. This is also acknowledged by investee firms, as highlighted by the following quote from an investee firm:

“There are two types of institutional investors. The first type of investors treats any investment as an arms-length transaction – focusing only on the financial performance of the firm, and normally doesn’t know much about the company’s technology. The second type of investors typically has considerable shareholdings with the firm. They would want to be actively
engaged with the firm and hope to influence firm strategy. If they invest more, they will even be able to appoint board members. Syoung is a case. They wish to regularly meet with us, to understand the company’s situation and long term plans, and through these meetings, provide suggestions relating to innovation and strategy.”

2) **Investors’ Interactions with the Firms.** While the current literature provides the impression that interactions between investors and firm managers are very much restricted to annual general meetings, our findings reveal that there are many informal avenues through which investors can interact with firm managers, and in that process, convey their views and opinions to the managers. A large part of the informal interactions between major institutional investors and firm managers take place through regular visits and even plant tours that the investors make to the company, which are a routine part of many institutional investors’ investment process. Institutional investors use the visits to gain a more thorough understanding of the firm’s operating conditions, industry trends, and the firm’s strategies and future plans to supplement their financial analysis of the firm. Such meetings can be significant for the investee firm, especially for meetings with institutional investors with large shareholdings, as noted by one institutional investor,

“Through our meetings with them, we try to understand the company fundamentals, and their growth prospects. The meeting may be even more significant to the company if we are a large shareholder, and their senior management and CEO may attend our meetings in such cases.”

3) **Breadth of Knowledge of Institutional Investors.** A key finding of our qualitative interviews is the confirmation that institutional investors do play a knowledge broker role as they share
their opinions and knowledge with the managers of the firms they invest in. Both institutional investors and managers of investee firms highlighted in the interviews that the key value that institutional investors provide when they share their views, is the knowledge that they have of other firms – either competitor firms, or firms upstream or downstream of the supply chain, or even firms in other industries. Institutional investors acknowledged that they had limited direct influence on the strategies of firms they invested in, but they try to help the firms by sharing knowledge and information that they gain from analyzing, visiting and meeting the management of a variety of companies that they have either invested in or have wanted to invest in. The information shared ranged from best practices of competitor firms that might benefit the focal investee firm, potential firms that the focal firm could consider partnering with, and industry trends. As noted by an institutional investor:

"Because of the breadth of our exposure – we visit and analyze competitor firms as well as firms upstream and downstream of their supply chain. So investee firms are usually interested in our opinions and views. Although they might know their own company operations well, we have a better birds’ eye view of the industry and potential partners. Firm managers are usually focused on operations and sales, but what we focus on is future growth and strategy. Hence, we often bring a different perspective to them. For example, we might think that a company is developing on the right path, but the company might be less optimistic of their short term growth and performance. That’s because we focus on the future direction of the firm and whether it is in line with industry trends and changes. They may have a more myopic view than us. We will then provide some suggestions – about whether to expand, whether to partner other firms. But of course such comments are only suggestions – we cannot directly influence
In some situations, active shareholders who have a close relationship with the managers of invested firms may even directly broker connections for the investee firm, to facilitate partnerships for the latter. Institutional investors and investee firms we spoke with highlighted at least three such examples. An institutional investor explained:

“What we can do to help the companies we invest in is to introduce potential partners that we may know to be a good match to the needs of the firm. For example, in the case of GD Company, we do not have any contacts who are in their target market segment, but what we do have is another investee firm – a LED manufacturer – whom they can establish a cross-industry relationship with. So we introduced them to each other and they started a collaboration. In the case of another investee firm – a touch material manufacturer, after we invested in the firm, we introduced distributors to them to help them compete in China.”

On the part of the investee firms, they also highlighted that the strong reputation and wide networks of a good institutional investor brought significant value to a firm:

“Our institutional investors have good reputation, good connections and lots of experience investing in an industry. So they are very familiar with the key players of the industry, as well as the upstream and downstream companies. Through this experience and network, they can match-make us to potential partners for collaboration.”

Our interviewees also point out that the access that institutional investors have to various databases is also an asset investee firms tap on to help them to locate potential partners – for example, during the search for a company manufacturing a new type of material that was required for new product development.
4) **Managers’ Attitudes toward Major Shareholders.** Our interviews reveal that managers were mindful about major shareholders’ views and their potential reactions to any major news, strategy or undertaking of the firm. Even though shareholders had limited formal influence on the firm’s decision making process, managers placed significant weight on the suggestions and views of shareholders that were obtained through the informal interactions they shared, especially if the shareholders had major shareholdings in the firm. Institutional investors also shared that managers would even contact them if they realize they are selling the shares of their firm, to obtain shareholders’ views about why they disagreed with certain decisions of the firm.

Overall, our qualitative study reveals that major shareholders of a firm have significant opportunities for informal interactions with investee firms, and they do share their opinions and views, often characterized by breadth of knowledge about the overall industry and other companies, with investee firms. This confirms the knowledge broker role that major institutional investors play when they communicate with managers of investee firms.

**Research and Practical Implications**

This paper contributes to research in several ways. First, this study extends prior research by recognizing that different ownership constituents have distinct influences on corporate innovation performance. We show that institutional ownership significantly and positively influence a corporation’s innovation performance, while family ownership did not significantly influence a corporation’s innovation performance. We also contribute to the literature examining
how ownership structure influences R&D within a firm by focusing on the innovation performance of a firm – measuring both the quantity and quality of innovation outputs of a firm, rather than the R&D effort and investment, as typically examined in the literature. Prior research has yet to examine how ownership structure influences the innovation performance of a firm, and our study seeks to fill this gap in the literature. It is important to examine how ownership influences the innovation performance of a firm, as it is the latter that impacts firm performance. We found that our results were consistent in terms of explaining both the quantity and quality of the innovation output of the firm. This shows that both are important aspects of innovation performance to examine.

Our study also contributes to the literature by examining the underlying mechanism through which institutional ownership influences its innovation performance. Prior research has yet to directly discuss and test the underlying theoretical mechanism through which the effect manifests. We thus fill this gap by testing the theoretical mechanism through which institutional investors influence innovation performance.

In particular, we introduced a new argument highlighting that institutional investors can play a knowledge broker role by highlighting potential external cooperations, that have significant influence on a firm’s innovation performance. Our study explicitly tests for and found support for external cooperations as a theoretical mechanism mediating institutional ownership and firm innovation performance. As we are the first to propose that institutional investors can
play a knowledge broker role in the literature, we further validated this potential explanation for
our results by conducting an interview study of institutional investors and managers of investee
firms. The qualitative findings provided corroborating evidence that institutional investors indeed
share their opinions and views, characterized by breadth of knowledge of other firms and
industries, with the managers of invested firms. In addition, our results further show that foreign
institutional investors, in particular, are most likely to take on such a knowledge broker role and
influence innovation performance of a firm by encouraging external cooperation.

Based on these findings, we provide a significant contribution to the literature by
highlighting the broader role that institutional investors play, in reality. This shows that our
traditional conceptualizations of institutional investors may be too limited, especially if we
confine ourselves to only using an agency perspective to understand the relationship between
investors and the firm.

Limitations

There are some limitations to this study that highlight the need for further research. First,
different owners can have different objectives (Bushee, 1998). As a result, some empirical studies
have explored the differences in the interests of distinct types of institutional owners, such as
professional investment funds, pension funds, banks, and insurance companies (Tihanyi, Johnson
et al. 2003). While we examined institutional ownership and family ownership on innovation
performance and further explored foreign vs domestic institutional ownership, we did not
differentiate between distinct types of institutional ownership, other than foreign and domestic institutional owners. Future research might thus further explore the extent to which our findings were applicable across different types of institutional investors.

Second, while we contribute to the literature by examining the innovation output quality and quantity in terms of the patents produced by a firm, patents do not necessarily and always translate into actual innovations and products. Future research may thus benefit from other measures of innovation performance, such as new product sales and time to market.

**CONCLUSIONS**

In this study, we find support for the proposition that firms with high levels of institutional ownership are significantly associated with higher innovation performance (both innovation quantity and quality). Moreover, the analysis provides support for the argument that the relationship between institutional ownership and innovation performance is mediated by external cooperation. Further analysis shows that it is likely the foreign institutional investors, in particular, that are most interested in driving the innovation performance of a firm. This research suggests that institutional investors play a bigger role than just monitoring managers of investee firms, as suggested by prior research, as we find evidence that they also play a knowledge broker role through their informal interactions with firm managers.


Colombo M. 1995. Firm size and cooperation: The determinants of cooperative agreements in information technology industries


Figure 1: Overall Conceptual Framework
### Table 1: Correlation Matrix

<table>
<thead>
<tr>
<th></th>
<th>MEAN</th>
<th>SD</th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
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<td></td>
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<td></td>
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</tr>
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<tr>
<td>4. INS</td>
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<td>0.2744</td>
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<td>-0.0762</td>
<td>-0.0705</td>
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<td>6. RD</td>
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<td>0.036</td>
<td>-0.1389</td>
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</tr>
<tr>
<td>7. SIZE</td>
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<td>0.5972</td>
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<td>8. FCF</td>
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<td>0.425</td>
<td>0.0026</td>
<td>0.0023</td>
<td>0.0284</td>
<td>0.0233</td>
<td>-0.0258</td>
<td>0.0151</td>
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<tr>
<td>9. DEBT</td>
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<td>-0.0068</td>
<td>-0.3332</td>
<td>0.2239</td>
<td>0.0572</td>
</tr>
</tbody>
</table>

Notes:

- Number of observations = 1,957.
- INN_QUAN: The number of patents granted for each company divided by the average number of patents granted in the same industry; INN_QUAL: The number of patent citations divided by the average number of patents citations in the same industry; COOP: The number of cooperations formed by a firm in each year during the period 2001-2008, divided by the average number of cooperations in the same sub-industry; INS: The percentage of equity owned by institutional investors in year t-1; FAM: The percentage of equity owned by family members in year t-1; RD: The ratio of R&D expenditures to total sales; SIZE: The natural logarithm of the firm’s annual sales; FCF: Free cash flow; DEBT: The ratio of total liabilities to total assets.
- Bold values indicate statistical significance at the 0.01 level.
Table 2. Testing the Influence of Ownership Structure (INS, FAM) on Innovation Performance

<table>
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<td>COOP</td>
<td>INN_QUAN</td>
<td>INN_QUAL</td>
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<td>(0.004)</td>
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<td>(0.024)</td>
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<td>(0.005)</td>
<td>(0.003)</td>
<td>(0.005)</td>
<td>(0.005)</td>
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<td>(0.047)</td>
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Notes:
- Please refer to Table 1 for the definitions of variables.
- Standardized beta coefficients; Standard errors in parentheses
- * p < 0.10, ** p < 0.05, *** p < 0.01
Table 3: Testing the Influence of Domestic and Foreign Ownership Structure (DOMINS, FORINS) on Innovation Performance

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<td>(0.139)</td>
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<td>0.0831***</td>
<td>0.3423**</td>
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<td>0.2889***</td>
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<td>(0.009)</td>
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</table>

| N     | 1952    | 1952    | 1952    | 1952    | 1952    |
| chi2  | 378.0   | 284.1   | 196.2   | 514.9   | 336.7   |

Notes:
- DOMINS: The percentage of equity owned by domestic institutional investors in year t-1; FORINS: The percentage of equity owned by foreign institutional investors in year t-1; Please refer to Table 1 for the definitions of other variables.
- Standardized beta coefficients; Standard errors in parentheses
- * p < 0.10, ** p < 0.05, *** p < 0.01
Appendix A. Detailed Description of Data Collection Process for Firms’ External Cooperation Using News Articles

Research assistants observed the following procedures to search for relevant news articles and coded the type of cooperation for the firm. First, for each article retrieved based on the search terms, each assistant read and decided whether the news article referred to collaboration between a company in our sample and other companies. Each assistant was responsible for searching for collaboration news for a subset of the sample companies. We used the following rules to code for the external cooperation that each firm in our sample engaged in. (1) If the news article described cooperation between one sample firm and other firms, then we will code the news as one instance of cooperation between the focal sample firm with other firms. If the news article described cooperation between two (or more) sample firms, we will code the news as one instance of cooperation for each of the sample firms. (2) If the content of the cooperation news is duplicated in multiple news articles, we will ignore the duplications and code as one instance of cooperation involving the focal firm. (3) If there was any ambiguity in the news article regarding whether there was indeed tight cooperation and the form of the cooperation, we excluded the news article in the coding process. For example, if a news article had reported that “…the two companies will strengthen cooperation to increase global opportunities for the frequency conversion air-conditioner compressor module”, the article did not address the substantive content of cooperation, so the news was not included in the data.

Having identified the relevant set of articles that met the above criteria, a different set of
research assistants coded for the following information about the external cooperation for each focal firm in our sample: news date, cooperation type (see Table A1 for details), partners that the focal firm cooperated with, news text that summarized the content of cooperation, and sources of news. One research assistant was put in charge of integrating and checking all the collected data. Finally, a third set of research assistants checked and recoded all the news articles to ensure the validity of the coding. The first author supervised the coding process to ensure the reliability of the data collected. Table A1 lists the example of news content for each type of cooperation.

Table A1. Example of News Content for Each Type of Cooperation

<table>
<thead>
<tr>
<th>Cooperation Type</th>
<th>Example News Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperation</td>
<td>After a thorough evaluation, Sharp selects Microsoft Taiwan and OpenPath Software Corp. as cooperation partners. They will build dealership oriented B2B commerce systems, as well as the Customer Consulting Centers with a total investment of NT $ 250million.</td>
</tr>
<tr>
<td>Alliance</td>
<td>To achieve the objective of advancing the home appliance industry, the Technology Department of the Ministry of Economic Affairs and ITRI jointly formed a “Smart Home Appliance Industrial R&amp;D Alliance”. Teco, Sampo, Tatung, Kolin, Taiwan Hitachi, Panasonic Taiwan home appliance manufacturers will join the alliance and develop the communication specifications of intelligent home appliances to achieve the interoperability of products and enhance market competitiveness.</td>
</tr>
<tr>
<td>Agreement</td>
<td>Sampo Technology Corp. has entered into an agreement to license Genesis Microchip Inc.’s U.S. Patent No. 5739867.</td>
</tr>
<tr>
<td>Joint development</td>
<td>To advance the technology of lighting industry, eleven optical semiconductor manufacturers formed a “Next Generation Lighting R&amp;D Alliance”. Through the establishment of the R&amp;D alliance, the members will integrate the industry R&amp;D capabilities and resources to jointly develop the next generation of white LED lighting to enhance the autonomy of the domestic LED industry and international competitiveness.</td>
</tr>
<tr>
<td>Merger and acquisition</td>
<td>Domestic well-known electronics company, UMC Group, recently announced a merger involving four printed circuit board (PCB) company, and will form a</td>
</tr>
</tbody>
</table>
strategic alliance with Hon Hai Group to enter the mainland communications industry.
Appendix B. Details of Instrumental Variable Estimation

To run the 2SLS, we need to identify instrumental variables (IVs) that sufficiently explain INS, but is uncorrelated with the error term in our estimations. We identified an initial set of potential IVs based on the findings of Bushee (2001) and Dikolli, Kulp, & Sedatole (2009), studies that model the determinants of transient versus long-term ownership. Our objective is to select from their set of determinants those variables for which no theory exists to support a relation with the innovation performance—that is, variables that are exogenous to our innovation performance model. Based on the findings of Bushee (2001) and Dikolli et al. (2009), we include the following variables as instruments. We first include the Taiwan Corporate Credit Risk Index (TCRI), a corporate credit rating system, which was developed by TEJ. The main risk assessment factors affecting the rating include profitability, security, activity and scale. Second, we include the time listed on the Taiwan Stock Exchange (TIME) to proxy for the quality of investment in the firm. Because institutional investors may have different preferences for firm risk, we include the firm’s market-model beta (BETA). Last, we include lagged book value per share (lnBVPS) to proxy for institutional investor preferences for firms that have established value in their financial statements.\(^6\)

While theoretical justification exists to support that these IVs influence the level of

\(^6\) We exclude some of the potential instrumental variables mentioned by Bushee (2001) and Dikolli et al. (2009) because of following reasons: (1) the variables are associated with innovation performance, such as the ratio of debt to asset; (2) the variables are not applicable to our context, such as SP500 listed firms, regulated firms, and high tech firms; (3) the variable are not valid in our instrumental variables test, such as dividend yield.
institutional ownership, no prior research has theoretically linked any of the following variables
to a firm’s innovation performance.

Using these IVs, we ran 2SLS with the first-stage model estimated as follows:

\[
INS_{it} = \beta_0 + \beta_1 TCRI_{it} + \beta_2 TIME_{it} + \beta_3 BETA_{it} + \beta_4 SALESGROW_{it} + \beta_5 \ln BVPS_{it} \\
+ \text{<exogenous variables>} + u_i + \epsilon_{it}
\]

where exogenous includes all exogenous variables in Equation (1), as recommended
(Kennedy, 1997). The first-stage regression is estimated with GLS using random effects. To the
extent the IVs explain INS and are uncorrelated with the residuals from the structural model (2)
and (3), they are suitable as IVs. We test this presumption with an over-identifying restrictions
test described below. The results of the estimation of Equation (7) are presented in Table B1.

<table>
<thead>
<tr>
<th>Table B1: Instrumental Variables Prediction of Institutional Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model (1)</td>
</tr>
<tr>
<td><strong>EQUATION (2) AND (3)</strong></td>
</tr>
<tr>
<td>TCRI</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>TIME</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>BETA</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>SALESGROW</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>LNBVPS</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>FAM</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>COOP</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>RD</td>
</tr>
</tbody>
</table>
To assess the degree of endogeneity present for equation (2) and (3), we conduct a Wu-Hausman specification test and find that, in fact, endogeneity is present between innovation performance and INS (F= 4.97, p=0.03 for INN_QUAN and F= 3.27, p=0.07 for INN_QUAL).

For equation (5) and (6), endogeneity was not found to be present for INS on innovation performance (F=2.45, p=0.1175 for INN_QUAN and F= 1.64, p=0.2003 for INN_QUAL).

However, for the sake of consistency, we provide the 2SLS for all the results, given the GLS results are similar.

We next assess the relevance and exogeneity of our chosen IVs for our equations. First, the adjusted-R2 of the full INS model (including all exogenous variables) is 45.99 percent (47.30 percent). The partially adjusted-R2 for the model including only the IVs is more relevant to
determining the efficacy of our IV estimation. The INS model has a partial adjusted-R2 of 8.76 percent with only the IVs as predictors. Moreover, a joint test of the instruments is highly significant in the model (F = 37.29, p < 0.0001). Taken together, the chosen variables appear to be relevant instruments for estimating INS.

We also conduct a Sargan over-identifying restrictions test to ensure that the chosen IVs are sufficiently exogenous to the dependent variables used in the second stage. This test fails to reject the null of exogenous instruments ($\chi^2 = 1.71$, p = 0.79 for INN_QNAN and $\chi^2 = 8.15$, p = 0.08 for INN_QNAL) and supports our claim that the IVs are sufficiently exogenous in the second stage. In sum, our first-stage IV estimation suggests that 2SLS is an improvement over GLS in the estimation of Equations (2), (3), (5) and (6).

**Estimating Instrumental Variables for Domestic and Foreign Institutional Ownership**

Like the original variable – Institutional Ownership, domestic institutional ownership (DOMINS) and foreign institutional ownership (FORINS) can both be endogeneous with a firm’s innovation performance. We thus use the instrumental variables (IVs) and 2SLS methodology to help control for endogeneity in tests. We used the same IVs as institutional ownership to estimate both DOMINS and FORINS, showing the results in Table B2. To assess the degree of endogeneity, we conduct a Wu-Hausman specification test and find that, in fact, endogeneity is indicated between innovation performance and DOMINS/FORINS (F = 2.86, p = 0.06 for INN_QUAN and F = 3.43, p = 0.03 for INN_QUAL). For mediating models (including COOP),
DOMINS and FORINS are exogenous for INN_QUAN model (F=1.83, p=0.16), while DOMINS and FORINS are endogenous for INN_QUAL model (F=3.20, p=0.04). To provide consistent path analysis, we still apply 2SLS methodology.

Table B2: Instrumental Variables Prediction of Domestic and Foreign Institutional Ownership

<table>
<thead>
<tr>
<th></th>
<th>DOMINS</th>
<th>FORINS</th>
<th>DOMINS</th>
<th>FORINS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TCRI</strong></td>
<td>-0.0740** (0.126)</td>
<td>-0.2351*** (0.211)</td>
<td>-0.0651*** (0.124)</td>
<td>-0.2313*** (0.211)</td>
</tr>
<tr>
<td><strong>TIME</strong></td>
<td>-0.0634** (0.031)</td>
<td>-0.0175 (0.052)</td>
<td>-0.0599** (0.031)</td>
<td>-0.0160 (0.052)</td>
</tr>
<tr>
<td><strong>BETA</strong></td>
<td>-0.1275*** (0.376)</td>
<td>-0.1312*** (0.631)</td>
<td>-0.1089*** (0.374)</td>
<td>-0.1234*** (0.633)</td>
</tr>
<tr>
<td><strong>SALES GROW</strong></td>
<td>-0.0657*** (0.003)</td>
<td>-0.0616*** (0.005)</td>
<td>-0.0609*** (0.003)</td>
<td>-0.0596*** (0.005)</td>
</tr>
<tr>
<td><strong>LNBVPS</strong></td>
<td>-0.0590** (0.362)</td>
<td>-0.0429* (0.607)</td>
<td>-0.0562* (0.357)</td>
<td>-0.0418* (0.605)</td>
</tr>
<tr>
<td><strong>FAM</strong></td>
<td>0.0231 (0.008)</td>
<td>-0.2526*** (0.014)</td>
<td>0.0308 (0.008)</td>
<td>-0.2493*** (0.014)</td>
</tr>
<tr>
<td><strong>COOP</strong></td>
<td>0.1693*** (0.068)</td>
<td>0.0713*** (0.115)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>RD</strong></td>
<td>-0.0446* (0.029)</td>
<td>0.0487** (0.048)</td>
<td>-0.0461** (0.028)</td>
<td>0.0481** (0.048)</td>
</tr>
<tr>
<td><strong>SIZE</strong></td>
<td>0.4145*** (0.144)</td>
<td>0.4661*** (0.242)</td>
<td>0.3229*** (0.153)</td>
<td>0.4275*** (0.260)</td>
</tr>
<tr>
<td><strong>FCF</strong></td>
<td>0.0437** (0.300)</td>
<td>0.0160 (0.504)</td>
<td>0.0366* (0.297)</td>
<td>0.0131 (0.503)</td>
</tr>
<tr>
<td><strong>DEBT</strong></td>
<td>-0.1764*** (0.010)</td>
<td>-0.0374 (0.018)</td>
<td>-0.1608*** (0.010)</td>
<td>-0.0308 (0.018)</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>1952</td>
<td>1952</td>
<td>1952</td>
<td>1952</td>
</tr>
<tr>
<td>adj. $R^2$</td>
<td>0.155</td>
<td>0.386</td>
<td>0.176</td>
<td>0.390</td>
</tr>
<tr>
<td>Adj. Partial $R^2$</td>
<td>0.009</td>
<td>0.0222</td>
<td>0.008</td>
<td>0.0233</td>
</tr>
<tr>
<td>$F$</td>
<td>36.88</td>
<td>123.72</td>
<td>38.85</td>
<td>114.17</td>
</tr>
</tbody>
</table>

Notes:
- TRCI: Taiwan Corporate Credit Risk Index; TIME: The time listed on the Taiwan Stock Exchange; BETA: The firm’s market-model beta; LNBVPS: Lagged book value per share; DOMINS: The percentage of
equity owned by domestic institutional investors in year t-1; FORINS: The percentage of equity owned by foreign institutional investors in year t-1; Please refer to Table 1 for the definitions of other variables.

- Standardized beta coefficients; Standard errors in parentheses
- * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

We also conduct a Sargan over-identifying restrictions test to ensure that the chosen IVs are sufficiently exogenous to the dependent variables used in the second stage. This test fails to reject the null of exogenous instruments ($\chi^2=0.63$, $p=0.89$ for INN_QUAN and $\chi^2=2.75$, $p=0.43$ for INN_QUAL). We also obtain similar results for the mediating models ($\chi^2=0.39$, $p=0.94$ for INN_QUAN and $\chi^2=2.40$, $p=0.49$ for INN_QUAL). In sum, the results support that the IVs are sufficiently exogenous in the second stage.

References
