Chapter 11
Innovation in Information Systems and Valuation of Intangibles

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Abstract Innovations in information systems, including the adoption of new information technologies and the creation of new flows of knowledge and information beyond traditional boundaries, represent an emerging form of intangibles relevant for firms from a wide range of industries. We examine firms' incentives to invest in the production of this intangible and provide evidence on the role of this innovation in the value creation of firms' intangibles. Our research setting involves firms using internet to create a continuous stream of new knowledge about the firm's performance and share it with external stakeholders. We find that firms with more investment in other intangibles, such as R&D and advertising, are more likely to undertake this type of information systems innovation. We also find that this innovation enhances the value of firms' other intangibles, including investor trust in the firm and firms' investment in R&D and advertising. Thus, our study demonstrates that innovation in information systems creates a distinct and valuable intangible asset and complements firms' other intangibles.

Keywords Innovation • Information systems • Intangible assets • Valuation

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11.1 Introduction

It is long recognized that information systems play a fundamental and strategic role for ensuring firms' long-term competitiveness (e.g., Clemons 1986). Innovation in information systems, including the deployment of cutting-edge information technologies (e.g., hardware and software) and the creation of new flows of knowledge beyond traditional boundaries, is important in the success of information systems investment. In this study, we examine firms' incentive to undertake information systems innovation and provide evidence on the specific benefits of the innovation. We focus on the setting of firms utilizing internet to communicate internal knowledge about firms' activity and performance to external stakeholders (e.g., investors). This setting highlights how firms adopt other concurrent innovations (i.e., internet) in information systems innovation. The adoption reflects the evolving nature of innovation in information systems, a fundamental attribute of information systems innovation identified by prior research (Swanson 1994).

Internet-based sharing of firms' internal knowledge with external stakeholders features several innovations in firms' information systems. First, it substantially expands the usage of existing information goods without incurring additional information production cost. Because the value of information goods increases with the number of users (Shapiro and Varian 1999), this expansion can create new net value for firms' information systems investment. Second, the expansion also validates the robustness of a firm's information systems (e.g., the firm's internal control strength) and its ability to meet the stringent standard of external scrutiny. High quality information systems enhance firms' ability to capture new business opportunities and outperform competitors (e.g. Bharadwaj 2000). Third, unlike information systems innovations that bring only internal changes at organizations, an externalization of internal knowledge redefines the dynamics of firms' interactions with external stakeholders by creating a new channel of information sharing. Prior research suggests that firms benefit from sharing information with external stakeholders (e.g., Cachon and Fisher 2000; Ha and Tong 2008).

The setting of our study involves firms that use internet to report monthly information originally designed and compiled for internal purposes. This type of information systems innovation has not been examined in the literature that investigates the role of innovation and intangible assets in corporate value creation.[1] This innovation leads to new knowledge flows that deliver previously unavailable content (i.e., the new knowledge flow is distinct from firms' traditional information flows, such as quarterly and annual financial reports) and may generate large impact on intended information users by facilitating new transactions outside the firm.

[1] Prior studies focus on the value-relevance and risk-relevance of investment in information systems and technologies (e.g., Brynjolfsson and Hitt 1996; Brynjolfsson et al. 2002; Dewan et al. 2007). Investment in information systems, however, is different from information systems innovation in that firms' decision to invest in information systems can be driven by industry-wide adoption of information technologies rather than the strategy to differentiate from others (Porter 1985).

Existing research confirms these enhancements signify the success of firms' information systems and in turn contribute to the creation of valuable information-based intangible assets (e.g., DeLone and McLean 1992, 2003).

To shed light on firms' incentive to undertake information systems innovation, we compare our sample firms with other firms using a matched-sample research design. We predict that firms making larger investments in intangible assets, such as R&D and advertising, are more likely to be engaged in information systems innovation. Prior research shows that the output from firms' conventional information systems, such as financial accounting data, is inadequate for the purpose of valuing intangible assets, leading to undervaluation of firms' intangible investment (e.g., Chan et al. 2001; Eberhart et al. 2004). Thus, firms investing more in intangibles have stronger incentives to increase information flows by undertaking information systems innovation to create new knowledge streams with richer content and wider reach.

We also examine the economic benefits associated with information systems innovation. We predict that externalization of internal knowledge about firm activity and performance cultivates investor trust in the firm by aligning the perspectives of investors with those of management and facilitating investors' task of assessing firm performance. Prior research shows that investor trust is a valuable intangible that confers considerable advantages to firms accessing the capital market, such as lower costs of capital (e.g., Healy et al. 1999). There is, however, a dearth of research on the effect of information systems innovation on investors as an important group of stakeholders (Petter et al. 2012). Our study specifically fills this gap by providing evidence on investor response to firms' information systems innovation. We also consider the implications of information systems innovation for firms' other intangible assets. Early research of innovation finds that innovative efforts are more successful when firms invest in diverse and complementary areas of innovation (Teece 1986). Because sophisticated investors, such as analysts and institutional investors, are likely more knowledgeable about the intricacies of innovation, including the complementary nature of innovation success and the benefits of knowledge spillover in innovation, we predict that information systems innovation would increase sophisticated investors' recognition of the value of firms' other intangible assets.

Consistent with our predictions, we find that firms investing more in R&D, advertising, and other intangibles are more likely to provide new streams of information to share internal knowledge with external stakeholders. Our results indicate that firms undertaking this type of information systems innovation experience a significant increase in investor following and trust after the initiation of the innovation. We also find that this innovation effort complements firms' other innovative activities by increasing sophisticated investors' recognition of firms' intangible value. Taken together, the results of our study demonstrate that innovation in information systems not only creates a distinct and valuable intangible asset

but also complements firms' other intangibles. To our best knowledge, our study is the first to document the unique dual roles of information systems innovation in the value creation of intangible asset.[2]

The remainder of this paper proceeds as follows. We develop our research hypotheses in Sect. 11.2. In Sect. 11.3, we describe our sample and report descriptive statistics of sample firms. We report the empirical results in Sect. 11.4. Section 11.5 concludes our study.

11.2 Hypothesis Development

We predict that firms making larger investments in intangible assets have stronger incentives to undertake information systems innovation. Existing research finds that investments in intangibles, such as R&D and advertising, are *undervalued* by investors, due to the inability of firms' existing information systems, such as financial accounting, in informing investors of the value and prospects of the investment (Chan et al. 2001; Eberhart et al. 2004; Faurel 2008).[3] A logical response to the problem is for firms to innovate their information systems to create new knowledge streams beyond traditional boundaries. Innovations leading to enhanced knowledge streams, such as monthly reporting, are particularly appealing for this purpose because they can keep investors better informed. Fishman and Hagerty (1989) show that investing firms have incentives to attract investor attention with more information production and wider information dissemination when the investment is complex for investors to assess and when the intrinsic value of the investment is not adequately reflected in stock prices. Thus, we hypothesize that firms with larger investments in intangible assets are more likely to be engaged in information systems innovation to enhance knowledge flows.

H1 Firms' incentive to innovate information systems is positively associated with the amount of the firm's investment in intangible assets.

Existing research also indicates that firms moving to provide new streams of information enjoy a boost in investor trust as reflected in increases in the following by analysts and institutional investors (e.g., Healy et al. 1999). More information attracts greater analyst following because it reduces the cost of knowledge acquisition for analysts. Institutional investors also prefer investing in firms with more information because more information reduces the cost of monitoring managerial action and ensures compliance with their fiduciary duties. Innovations in

[2] For a review of prior research on the role of various intangible assets in value creation, see Lev (2001), Ashton (2005), and Lev (2008).

[3] Prior research suggests that this information deficiency exacerbates the information asymmetry problem for intangibles—investors know less about firms' innovation activities than management (Aboody and Lev 2000).

information systems, such as monthly reporting, confer these benefits to analysts and institutional investors by providing new knowledge not available from other sources. The new knowledge has considerable value to analysts and institutional investors because it facilitates the monitoring of managerial action and reduces undesirable managerial behavior. Thus, we predict increases in investor trust after the initiation of information systems innovation.

H2 Firms that are engaged in information systems innovations experience increases in investor trust.

We also consider the effect of information systems innovation on investors' recognition concerning the value of firms' investment in intangible assets. The strategic role of information systems and technologies as an enabler of other value-creating activities is well recognized by academics and practitioners. Prior research finds that firms' intangible assets perform better when they are backed by information systems innovations linked to the deployment of cutting-edge information technologies (e.g., Powell and Dent-Micallef 1997).[4] The complementary relationship between information systems innovations and other intangible assets is consistent with the finding of Teece (1986) and others (e.g., Gòmez and Vargas 2012) that investing in diverse but related innovations is crucial for the success of innovating firms. Because sophisticated investors, such as analysts and institutional investors, focus more on the importance of investment that increase firms' long-term value but may not immediately improve short-term results (Porter 1992), we predict an increase in sophisticated investors' valuation of intangible assets after firms initiate information systems innovation.

H3 Firms that are engaged in information systems innovation experience increases in sophisticated investors' recognition concerning the value of intangible assets.

11.3 Sample and Data

We seek to examine firms that innovate information systems to create new flows of knowledge and information beyond traditional boundaries. Our research setting involves firms using internet to share monthly information with external

[4] A high quality internal information reporting system, such as timely and reliable monthly reporting procedure, is particularly valuable for capturing total innovation value because it can directly facilitate the assessment of externalities and knowledge spillover in innovation, which are the key to value creation in innovation (IMA 2005).

stakeholders. Our sample includes 52 firms that innovate their information systems by providing monthly reporting on their websites during the period of 1998–2007 ("innovating firms" hereafter). We identified these firms by searching relevant information on firms' websites during the sample period. To ensure data availability, we require sample firms to be covered in COMPUSTAT. To obtain insights into factors associated with firms' innovation in information systems, we match each innovating firm with a non-innovating firm by three-digit SIC industry membership and firm size measured by sales and total assets. We perform this matching procedure in the year when the sample firm started the innovation and obtain an industry-, size-, and year-matched sample of 52 firms ("non-innovating firms" hereafter).

Table 11.1 reports descriptive statistics of our sample firms. It shows that besides similar size, the innovating firms and non-innovating firms have similar financial leverage and sales growth. The innovating firms, however, have larger amounts of capital expenditure, spend more on R&D, advertising, and acquired intangibles, and have more employees relative to sales than the non-innovating firms. Table 11.1 also provides statistics on analysts following, institutional holding, and managerial ownership for the sample firms. Information on analyst following is from I/B/E/S. Data on institutional ownership is obtained from 13f filings, and the statistics on managerial stock ownership are based on COMPUSTAT Execucomp. Compared to the non-innovating firms, the innovating firms are covered by more analysts (e.g., 9.346 vs. 5.885 for the mean) and have more institutional investors (e.g., 195 vs. 144 for the mean). The level of managerial stock ownership, however, is similar for both samples.

11.4 Empirical Results

11.4.1 The Incentive of Information Systems Innovation

We examine firms' incentive to innovate information systems by estimating the following logistic regression for the year of the innovation initiation:

$$INNOVATE_{it} = \alpha_0 + \alpha_1 R\&DE_{it} + \alpha_2 ADVT_{it} + \alpha_3 INTG_{it} + \alpha_4 CAPE_{it} + \alpha_5 NEMP_{it} + \alpha_6 AFLW_{it} + \alpha_7 PIH_{it} + \alpha_8 PMH_{it} + \alpha_9 FIN_{it} + \alpha_{10} ROA_{it} + \alpha_{11} M/B_{it} + \alpha_{12} BVOLT_{it} + \varepsilon_{it}, \quad (11.1)$$

where i and t are firm and year subscripts, respectively. *INNOVATE* is a binary variable that takes the value of one for innovating firms and zero otherwise. *R&DE* is the firm's R&D expenditure. *ADVT* is advertising expense. *INTG* is the firm's reported intangible assets other than goodwill. *NEMP* is the number of employees (our proxy for investment in human capital). *CAPE* is capital expenditure.[5] *R&DE*,

[5] We include capital expenditure as a control in this test because increases in investment in intangibles may require firms to invest in new capital projects as well.

Table 11.1 Mean (median) value of key financial characteristics of sample firms

Variable	Innovating firms	Non-innovating firms	*p*-value for mean (median) difference
Total assets (*TAST*)	7,286	8,586	$p = 0.456$
	(1,899)	(1,899)	($p = 0.442$)
Sales revenue (*SALES*)	3,246	3,421	$p = 0.434$
	(1,490)	(1,582)	($p = 0.478$)
Financial leverage (*LEVG*)	0.282	0.287	$p = 0.452$
	(0.275)	(0.272)	($p = 0.516$)
Sales growth rate ($\Delta SALES$)	0.186	0.171	$p = 0.423$
	(0.098)	(0.094)	($p = 0.551$)
Return on assets (*ROA*)	0.0529	0.0174	$p = 0.074$*
	(0.0556)	(0.0433)	($p = 0.062$)*
Market-to-book ratio (*MTB*)	2.776	1.933	$p = 0.072$*
	(2.427)	(1.876)	($p = 0.010$)***
Capital expenditure (*CAPE*)	0.066	0.039	$p = 0.037$**
	(0.047)	(0.027)	($p = 0.052$)*
R&D expenditure (*R&DE*)	0.025	0.012	$p = 0.082$***
	(0.006)	(0.000)	($p = 0.025$)**
Advertising expenditure (*ADVT*)	0.006	0.002	$p = 0.043$**
	(0.0002)	(0.000)	($p = 0.001$)***
Acquired intangible assets (*INTG*)	0.070	0.036	$p = 0.063$***
	(0.002)	(0.000)	($p = 0.047$)**
Number of employees relative to sales (*NEMP*)	0.013	0.008	$p = 0.081$***
	(0.007)	(0.003)	($p = 0.079$)***
Number of analysts following (*NAFL*)	9.346	5.885	$p = 0.004$***
	(8.000)	(4.000)	($p = 0.002$)***
Number of institutional investors (*NIH*)	195	144	$p = 0.024$**
	(179)	(105)	($p = 0.018$)**
Percentage of institutional ownership (*PIH*)	0.584	0.521	$p = 0.074$*
	(0.624)	(0.547)	($p = 0.066$)*
Managerial ownership (*PMH*)	0.012	0.021	$p = 0.200$
	(0.0000)	(0.0000)	($p = 0.286$)
Financing activity (*FIN*)	0.308	0.250	$p = 0.259$
	(0.000)	(0.000)	($p = 0.259$)

Variable definitions are as follows. *TAST* is the amount of the firm's total assets. *SALES* is the firm's sales revenue. *LEVG* is the firm's financial leverage, defined as the ratio of the sum of long-term debt and current liabilities to total assets. $\Delta SALES$ is the percentage rate of sales change from the prior year to the current year. *ROA* is the return on assets, defined as the ratio of the firm's income before extraordinary items to average total assets. *MTB* is the ratio of the firm's market value to book value measured at the fiscal year-end. *CAPE* is the firm's capital expenditure deflated by sales. *R&DE* is the firm's R&D expenditure deflated by sales. *ADVT* is the firm's advertising expense deflated by sales. *INTG* is the firm's recorded intangible assets other than goodwill (deflated by total assets). *NEMP* is the number of employees deflated by sales. *NAFL* is the number of analysts issuing earnings forecasts for the firm. *NIH* is the number of institutional investors holding the firm's share. *PIH* is the percentage of shares held by institutional investors. *PMH* is the percentage of shares held by management. *FIN* is a dummy variable that takes the value of 1 for firms issuing equity or debt during the period of year t to year $t + 1$ and 0 otherwise *, **, and *** indicate one-tailed statistical significance at the 0.1, 0.05, and 0.01 level, respectively

ADVT, *NEMP*, and *CAPE* (*INTG*) are deflated by the firm's sales (total assets). The control variables of Eq. (11.1) include *AFLW*, *PIH*, *PMH*, *FIN*, *ROA*, *M*/*B*, and *BVOLT*. *AFLW* is the measure of analyst following defined as the logarithm of the number of analysts issuing earnings forecasts for the firm. *PIH* is the percentage of shares held by institutional investors. *PMH* is the percentage of shares held by management. *FIN* is a dummy variable that takes the value of 1 for firms issuing equity or debt during the period of year t to year t+1. *ROA* is the firm's return on assets. *M*/*B* is the firm's market-to-book ratio at fiscal year-end. *BVOLT* is the measure for the firm's business volatility, defined as the absolute change in the firm's decile rank of book value from year $t-1$ to year t (Lev and Zarowin 1999) Prior research suggests that firms' incentive to increase information flow is associated with these control variables (Lang and Lundholm 1993).

We report the results of the logistic regression of Eq. (11.1) in Table 11.2. The model is statistically significant in explaining firms' decision of information systems innovation. Consistent with prior evidence, the coefficients on analyst following (*AFLW*), institutional ownership (*PIH*), financing activity (*FIN*), and business volatility (*BVOLT*) are significantly positive. The coefficients on R&D expenditure (*R&DE*), advertising expense (*ADVT*), intangible assets (*INTG*), capital expenditure (*CAPE*), and the number of employees (*NEMP*) are all positive and statistically significant at the 0.05 level or higher. These results are consistent with our predictions on the positive relation between firms' investment in intangibles and the incentive of information systems innovation (H1).

11.4.2 Information Systems Innovation and Investor Trust

We next turn to examine the effect of firms' information systems innovation on investor trust. Prior research finds that investor trust is a valuable intangible asset that confers future benefits to firms, such as better access to capital market and lower costs of capital. We use two benchmarks to assess the effect of information systems innovation on the level of investor trust. First, we examine the change in the proxies for investor trust for innovating firms after the initiation of the innovation. This test of time-series changes uses the innovating firms as their own controls. Second, we compare the time-series changes for the innovating firms with those for the matched non-innovating firms. This test of cross-sectional differences controls for the effect of contemporaneous and common factors that affect both the innovating firms and non-innovating firms. The use of both cross-sectional and time-series benchmarks enhances the robustness of our conclusion. We report the results of these tests in Table 11.3. The first (middle) three columns of Table 11.3 give the mean statistics for the year before the innovation, year $t-1$, the year after the innovation, year $t+1$, and the time-series from year $t-1$ to year $t+1$ for the innovating firms (non-innovating firms). The last three columns, titled "Innovating firms vs. non-innovating firms," report the statistical differences between

Table 11.2 Results from the logistic regression of information systems innovation

Variable	Predicted sign	Coefficient	*p*-value
Intercept	+/−	4.211	0.001
R&DE	+	4.945**	0.003
ADVT	+	3.732**	0.003
INTG	+	3.723**	0.006
CAPE	+	5.894*	0.017
NEMP	+	4.011*	0.033
BVOLT	+	1.147**	0.005
ROA	+	1.738	0.131
AFLW	+	0.858**	0.003
PIH	+	2.375	0.072
PMH	+	−0.558	0.143
M/B	+	0.034	0.362
FIN	+	1.424*	0.021
N		104	
Model χ^2		47.29	
(*p*-value)		(0.0005)	
Pseudo R^2		31.34 %	

Variable definitions are as follows. *R&DE* is the firm's R&D expenditure deflated by sales. *ADVT* is the firm's advertising expense deflated by sales. *INTG* is the firm's recorded intangible assets other than goodwill (deflated by total assets). *CAPE* is the firm's capital expenditure deflated by sales. *NEMP* is the number of employees deflated by sales. *BVOLT* is the measure for the firm's business volatility, defined as the absolute change in the firm's decile rank of book value from year $t-1$ to year t. *ROA* is the return on assets, defined as the ratio of the firm's income before extraordinary items to average total assets. *AFLW* is the logarithm of the number of analysts issuing earnings forecasts for the firm. *PIH* is the percentage of shares held by institutional investors. *PMH* is the percentage of shares held by management. *MTB* is the ratio of the firm's market value to book value measured at the fiscal year-end. *FIN* is a dummy variable that takes the value of 1 for firms issuing equity or debt during the period of year t to year $t+1$ and 0 otherwise. The logistic regression is based on 104 observations (52 innovating firms and 52 matched non-innovating firms). The dependent variable of the logistic regression, *INNOVATE*, is an indicator variable that takes the value of 1 for firms undertaking information systems innovation ("innovating firms") and 0 otherwise

*, **, and *** indicate one-tailed statistical significance at the 0.05, 0.01, and 0.001 level, respectively

innovating firms and non-innovating firms in year $t-1$, year $t+1$, and for the changes from year $t-1$ to year $t+1$, respectively.

The first row of Table 11.3 provides statistics on the extent of analysts following (*NAFL*), measured as the number of financial analysts who provide earnings forecasts for the firm. Consistent with our prediction in H2, we find a significant increase in the number of analysts following the innovating firms from year $t-1$

Table 11.3 Mean value of key variables reflecting investor trust before and after initiation of information systems innovation

	Innovating firms			Non-innovating firms			Innovating firms vs. non-innovating firms		
Variable	Year $t-1$	Year $t+1$	Change (t-stat.)	Year $t-1$	Year $t+1$	Change (t-stat.)	Year $t-1$ (t-stat.)	Year $t+1$ (t-stat.)	Change (t-stat.)
NAFL	8.308	9.865	1.557** (2.63)	5.615	6.112	0.497 (0.58)	2.693** (2.57)	3.753*** (3.45)	1.060** (2.49)
PIH	0.571	0.653	0.082*** (3.21)	0.514	0.535	0.021 (0.41)	0.057** (2.52)	0.118*** (3.14)	0.061** (2.43)
NIH	182.2	220.1	37.9** (2.82)	142.3	145.6	3.300 (0.24)	39.9 (3.58)	74.5*** (4.56)	34.6** (2.75)

Variable definitions are as follows. *NAFL* is the number of analysts following the firm. *PIH* is the firm's percentage of shares held by institutional investors. *NIH* is the number of institutional investors holding the firm's shares. Year $t-1$ ($t+1$) is the year before (after) the initiation of information systems innovation

*, **, and *** indicate one-tailed statistical significance at the 0.05, 0.01, and 0.001 level, respectively

to year $t+1$ (8.308 vs. 9.865). The non-innovating firms, however, experience no significant increase in the number of analyst following from year $t-1$ to year $t+1$ (5.615 vs. 6.112). Consistent with these patterns of intertemporal changes, we find that the innovating firms experience a significantly larger increase in analyst following over time than the non-innovating firms (1.557 vs. 0.497).[6] A comparison between the innovating firms and non-innovating firms with respect to changes in investor trust over time, reported under the last column titled "Innovating firms vs. non-innovating firms" (Change), shows that the innovating firms experienced significantly greater increases in analyst following over time than the non-innovating firms. This evidence is consistent the prediction of H2 and indicates the effect of information systems innovation on improving firms' visibility and credibility with analysts.

The second and third rows of Table 11.3 report statistics on the percentage of institutional holding (*PIH*) and the number of institutional investors (*NIH*), respectively. We find that the innovating firms have statistically significant increases in institutional ownership after the initiation of information systems innovation. From year $t-1$ to year $t+1$, the mean percentage of institutional holding increases from 57.1 to 65.3 %. The change is statistically significant at the 0.001 level. The mean number of institutional investors increases from 182.2 to 220.1, with the change statistically significant at the 0.001 level. Table 11.3 also shows that the innovating firms have significantly larger increases in the percentage of institutional holding and the number of institutional investors over time than the non-innovating firms.

[6] In un-tabulated tests, we find that the increases in analyst following for the innovating firms continue in future years. For year $t+2$, the mean number of analysts following the innovating firms further increases to 11.077, whereas the mean number of analysts following the non-innovating firms is 6.365 in year $t+2$ vs. 6.112 in year $t+1$.

These results are consistent with the prediction of H2 and indicate that innovations in information systems attract more institutional investors. Thus, our tests reported in Table 11.3 indicate that information systems innovation is associated with increases in investor trust. Given the prominence of investors among all stakeholders, an increase in investor trust may likely have a spillover effect on other stakeholders, such as suppliers and customers.

11.4.3 Information Systems Innovation and Valuation of Intangibles

We now turn to examine whether the innovation in information systems also leads to changes in investors' recognition of the value of firms' investment in intangibles. We focus on analysts and institutional investors as representative types of investors and examine the relation between the recognition of analysts and institutional investors and changes in firms' investment in intangible assets, including R&D, advertising, human capital, and others. Our measure of analysts' recognition is their forecasts of firms' long-term earnings growth (*AFLTG*), a direct indicator of analysts' assessment of long-term firm performance. Our regression for the examination of analysts' recognition is as follows:

$$AFLTG_{it} = \gamma_0 + \gamma_1 \Delta R\&DE_{it} + \gamma_2 \Delta ADVT_{it} + \gamma_3 \Delta INTG_{it} + \gamma_4 \Delta CAPE_{it} + \gamma_5 \Delta NEMP_{it} + \gamma_6 SIZE_{it} + \gamma_7 AGE_{it} + \gamma_8 M/B_{it} + \gamma_9 \Delta EARN_{it} + \varphi_{it}, \tag{11.2}$$

where i and t are firm and year subscripts, respectively. *AFLTG* is the median analyst forecast of the firm's long-term earnings growth rate. $\Delta R\&DE$ is the yearly change in R&D expenditure. $\Delta ADVT$ is the yearly change in advertising expense. $\Delta INTG$ is the change in intangible assets. $\Delta CAPE$ is the change in capital expenditure. $\Delta NEMP$ is the change in the number of employees. $\Delta R\&DE$, $\Delta ADVT$, $\Delta CAPE$, and $\Delta NEMP$ are deflated by the firm's sales. $\Delta INTG$ is deflated by total assets. *SIZE* is the logarithm of total assets. *AGE* is the firm's age as a publicly traded firm. *M/B* is the market-to-book ratio. $\Delta EARN$ is the change in earnings relative to the prior year. *SIZE*, *AGE*, *M/B*, and $\Delta EARN$ are control variables for analyst forecast of long-term earnings growth. Analysts' expectations of earnings growth over long run are likely greater for smaller firms, younger firms, firms with higher investor expectations of growth as reflected in higher market-to-book ratios, and firms recently reporting better news of earnings change.

We report the regression estimates of Eq. (11.2) in Table 11.4, Panel A. To provide more robust evidence, we estimate Eq. (11.2) for both the innovating firms and non-innovating firms in the year before the innovation initiation (year $t-1$) and the year after the innovation initiation (year $t+1$), respectively. The results for the innovating firms indicate that in year $t-1$, analyst forecast of long-term earnings

Table 11.4 Relation between information systems innovation and sophisticated investors' recognition for the value of firms' intangible assets

	Innovating firms		Non-innovating firms	
Variable	Year $t-1$	Year $t+1$	Year $t-1$	Year $t+1$
Panel A. Analyst forecast of long-term earnings growth (AFLTG)				
Intercept	−0.104	−0.037	0.041	0.021
	(−0.59)	(−0.57)	(0.52)	(0.27)
ΔR&DE	−4.842	10.219**	−2.124	−3.778
	(−1.27)	(2.72)	(−0.42)	(−0.75)
ΔADVT	3.702	4.315*	2.781	2.029
	(1.45)	(1.71)	(0.83)	(0.61)
ΔINTG	−0.052	−0.359	−0.803*	−0.847*
	(−0.15)	(−1.02)	(−1.73)	(−1.85)
ΔCAPE	0.376	0.709*	0.072	0.087
	(1.14)	(2.19)	(1.23)	(1.51)
ΔEMP	3.366	16.630*	−10.451*	−6.089
	(0.80)	(2.02)	(−2.08)	(−1.23)
SIZE	−0.026**	−0.024**	−0.010	−0.009
	(−2.85)	(−2.62)	(−1.04)	(−0.89)
AGE	−0.006**	−0.002*	−0.003*	−0.003*
	(−2.80)	(−2.20)	(−2.14)	(−2.03)
MTB	0.001	0.006	−0.001	−0.003
	(0.15)	(1.25)	(−0.12)	(−0.35)
ΔEARN	−0.009	0.007	0.081*	0.108**
	(−0.26)	(0.19)	(2.05)	(2.81)
N	52	52	52	52
F-stat.	2.72	2.96	1.77	1.83
Adj. R^2	23.3 %	27.8 %	12.0 %	12.7 %
Panel B. Change of institutional ownership (ΔPIH)				
Intercept	0.001	0.004	0.002	0.002
	(1.24)	(1.87)	(2.75)	(0.10)
ΔR&DE	−0.015	0.118***	−0.041	−0.371***
	(−0.71)	(3.27)	(−0.57)	(−4.43)
ΔADVT	−0.025	0.051**	−0.074*	0.151
	(−1.28)	(2.87)	(−1.69)	(1.46)
ΔINTG	−0.002	0.001	−0.002	−0.004
	(−0.89)	(0.59)	(−0.12)	(−0.42)
ΔCAPE	−0.001	0.010***	0.001	−0.009
	(−0.52)	(4.55)	(0.70)	(−0.69)
ΔEMP	0.014	0.059*	−0.171**	−0.096
	(0.29)	(1.86)	(−2.55)	(−0.41)
ΔNAFL	0.001**	0.001	0.001	0.001
	(2.89)	(0.82)	(0.90)	(0.34)
ΔEARN	0.005***	0.002*	0.008**	0.017***
	(5.87)	(1.68)	(2.76)	(4.56)
SIZE	−0.001	−0.001	0.002	0.001
	(−1.44)	(−1.58)	(0.67)	(0.55)

(continued)

Table 11.4 (continued)

	Innovating firms		Non-innovating firms	
Variable	Year $t-1$	Year $t+1$	Year $t-1$	Year $t+1$
MTB	0.001*	−0.000	−0.001	−0.001*
	(2.11)	(−0.36)	(−1.52)	(−1.86)
N	52	52	52	52
F-stat.	2.89	3.32	2.10	2.94
Adj. R^2	25.45 %	31.01 %	21.06 %	26.88 %

Variable definitions are as follows. *AFLTG* is the median analysts' forecast of the firm's long-term earnings growth rate. *ΔPIH* is the change in the percentage of firms' shares held by institutional investors. *ΔR&DE* is the change in the firm's R&D expenditure deflated by sales. *ΔADVT* is the change in the firm's advertising expense deflated by sales. *ΔINTG* is the change in the firm's recorded intangible assets other than goodwill (deflated by total assets). *ΔCAPE* is the change in the firm's capital expenditure deflated by sales. *ΔEMP* is the change in the number of employees deflated by sales. *ΔEARN* is the change in the firm's income before extraordinary items deflated by average total assets. *ΔNAFL* is the change in the number of analysts issuing earnings forecasts for the firm. *SIZE* is the logarithm of the firm's total assets. *AGE* is the number of years for which the firm is a publicly traded firm. *MTB* is the ratio of the firm's market value to book value measured at the fiscal year-end

*, **, and *** indicate one-tailed statistical significance at the 0.05, 0.01, and 0.001 level, respectively

growth is not significantly associated with increases in firm's investment in R&D, advertising, human capital, other intangibles, and capital expenditure. In year $t+1$, however, we find significantly positive coefficients on *ΔR&DE*, *ΔADVT*, *ΔCAPE*, and *ΔNEMP*. Thus, our evidence indicates an increase in analysts' recognition concerning the effect of investment in intangibles on firms' long-term performance. The results from estimating Eq. (11.2) for the non-innovating firms, however, show no consistent relation between analysts' forecast of long-term earnings growth and firms' investment in intangibles.

We examine the relation between changes in the percentage of institutional holding (*ΔPIH*) and changes in firms' intangible investment with the following regression:

$$\Delta PIH_{it} = \delta_0 + \delta_1 \Delta R\&DE_{it} + \delta_2 \Delta ADVT_{it} + \delta_3 \Delta INTG_{it} + \delta_4 \Delta CAPE_{it} + \delta_5 \Delta NEMP_{it} + \delta_6 \Delta NAFL_{it} + \delta_7 \Delta EARN_{it} + \delta_8 SIZE_{it} + \delta_9 M/B_{it} + \xi_{it}, \tag{11.3}$$

where i and t are firm and year subscripts, respectively. *ΔPIH* is the yearly change of the percentage of institutional holding. All other regression variables have the same definitions as in Eq. (11.2), except for *ΔNAFL*, which is the change in the number of analysts following the firm. We include *ΔNAFL* as a control variable because prior research suggests a positive association between analysts' and institutions' decision to follow a firm (e.g., O'Brien and Bhushan 1990). Table 11.4, Panel B, presents the regression estimates of Eq. (11.3). For the innovating firms in year $t-1$, the year before the innovation initiation, none of the coefficients on the changes of intangible investment. In year $t+1$, however, the coefficients on

ΔR&DE, *ΔADVT*, *ΔCAPE*, and *ΔNEMP* for the innovating firms are positive and statistically significant at the 0.05 level or better. These results indicate that after the initiation of the innovation, institutional investors recognize the value-enhancing effect of the innovating firm's investment in intangibles. This, however, is not the case for the non-innovating firms as none of the coefficients on the investment variables is positive for these firms.[7]

11.5 Summary and Conclusions

This study examines firms' information systems innovation that generates new flows of knowledge and information beyond traditional boundaries. We focus on firms that use internet to share knowledge created for internal purposes with external stakeholders. Our evidence shows that firms with greater investment in intangible assets (e.g., R&D, advertising, and human capital) have stronger incentives to undertake this type of innovation in information systems. The innovation complements firms' existing intangible assets by enhancing external stakeholders' trust in the firm and improving sophisticated investors' valuation of firms' investment in R&D, advertising, and human capital. Taken together, our study demonstrates that information systems innovation not only creates a distinct and valuable intangible asset but also enhances the value of firms' other intangibles.

The ongoing evolution in information technologies and business practices provide firms with new opportunities to innovate their information systems. For example, the XBRL-based reporting approach has significantly increased the scope and depth of information sharing between firms and their stakeholders (e.g., Wagenhofer 2007), whereas new forms of communication, such as social media, can further enhance the speed and reach of new information production and dissemination. The adoption of these emerging technologies in information systems innovation can lead to new and improved forms of information-based intangible assets. Future research can increase our knowledge about information systems innovation by examining newer forms of innovation in information systems and their impact on a broader range of intangible assets (e.g., customer loyalty, employee productivity, and technological creativity).

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[7] We also examined changes in the number of institutional investors (*ΔNIH*) as an alternative measure and obtained similar results.

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