# When IT Leveraging Competence Meets Uncertainty and Complexity with Social Capital in New Product Development

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**Abstract.** We examine how the aspects of IT leveraging competence [i.e., the effective uses of project and resource management systems (PRMS), organizational memory systems (OMS), and cooperative work systems (CWS)] and the social capital (SOCI) influence the performance [i.e., product effectiveness (PDT) and process efficiency (PCS)] by the coordination capability (COOR) and absorptive capacity (ACAP) under the uncertainty and complexity in the new product development (NPD). We find the IT leveraging competence positively affects COOR and ACAP, the links of SOCI-COOR, SOCI-ACAP, COOR-PCS, and ACAP-PDT are positive, neither uncertainty nor complexity has the moderating effect on the COOR-PCS link, the uncertainty negatively moderates the ACAP-PDT link, but the complexity has no moderating effect on this link. Our findings reveal why the NPD teams may have difficulty achieving high levels of performance and why these teams may vary in their ability to create the value from their COOR and ACAP.

**Keywords:** IT leveraging competence · Social capital · Project characteristics · Uncertainty · Complexity · New product development

## 1 Introduction

The new product development (NPD) is a strategic process wherein the firms integrate disparate inputs from the R&D scientists, engineers, and marketers to jointly develop and launch the new products [1]. The firms are in a position where NPD is no longer a strategic option but a necessity [2]. Under the rapidly changing technologies and customer needs, the firms must continuously introduce the new products to maintain pace with the changes [3].

Recent literature has found the influences of IT capability (a firm's ability to effectively acquire, deploy, and leverage its IT resources.), social capital (the actual and potential resources embedded in the relationships among actors, SOCI), coordination


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capability (a firm's ability to manage the dependencies among its various resources and activities, COOR), and absorptive capacity (a firm's ability to identify, assimilate, transform, and apply the valuable external knowledge, ACAP) on the NPD prospect.

Although much is known regarding the effects of IT capability, social capital, coordination, and absorptive capability on NPD performance, far less is known regarding their interactions to impact NPD performance [i.e., product effectiveness (the extent to which the new product is successful by some external criteria like quality and innovativeness, PDT) and process efficiency (the extent to which the NPD project adheres to budgets and schedules, PCS)]. Although isolated organizational capabilities are valuable, they may not be effective as single assets, particularly for complex activities such as NPD [4]. Thus, we regard IT capability and social capital as the effective organizational complements to a firm's processes for coordinating organizational activities and absorbing external knowledge. In addition, an extensive literature distinguishes between uncertainty (the newness of technologies employed in the product development effort to the development organization) and complexity (the nature, quantity, and magnitude of organizational subtasks and subtask interactions posed by the project) dimensions of NPD project characteristics that affect performance [5]. When faced with the burning debates regarding the strategic potential of IT, our study is an attempt to address this issue and therefore refine and extend comprehension of the link among IT capability, social capital, coordination capability, absorptive capacity, project characteristics, and performance in NPD.

We organize this paper as follows: the next section presents a review of theory and hypotheses. The following section shows our methodology. The final section discusses the implications, limitations and suggestions for future research, and conclusion of our work.

## 2 Theory and Hypotheses'

### 2.1 IT Leveraging Competence in NPD

In accordance with Pavlou and El Sawy [7], IT leveraging competence in NPD denotes the ability of NPD teams to effectively use IT functionalities to support IT-enabled NPD activities. The NPD teams should know what IT functionalities offer, understand when to use them, and do so effectively by utilizing their specific IT functionalities.

The IT tools that NPD teams commonly use include project and resource management systems (PRMS), organizational memory systems (OMS), and cooperative work systems (CWS) [7]. PRMS are designed for scheduling management, resource allocation, and task assignment [8]. OMS are IT tools for knowledge coding, sharing, directories, and retrieval [9]. CWS provide IT functionalities designed for real-time communication and group collaboration across time and space, such as conveyance, presentation, and convergence systems [10]. Therefore, IT leveraging competence in NPD is a three-dimensional construct that reflects how effectively these three IT tools are leveraged [11].

## 2.2 Coordination Capability

Coordination capability (COOR) signifies a firm's ability to manage the dependencies among its various resources and activities [12]. Okhuysen and Bechky suggest that coordinating mechanisms emerge through the accomplishment of three conceptually discrete but practically intertwined characteristics of interdependent organizational activity: accountability, predictability, and common understanding [13]. Accountability emerges from people's efforts to identify who is responsible for what task within the organizational output. Predictability emerges as actors anticipate the elements of an output and know when they are likely to occur within a pattern or sequence of tasks. Common understanding is accomplished when actors develop shared perspective on the goals and outputs of work.

Regarding PRMS [7], first, it provides an effective way to identify available resources and access real-time project data, thereby enabling better resources allocation. Second, its scheduling and time management functionality helps NPD managers effectively appoint NPD workers to relevant tasks and monitor the performance of NPD workers. Third, it provides real-time information on project status and enables aggregate project portfolios, thereby contributing to better synergies identification and synchronically collective activities.

Regarding OMS [7], first, it provides the functionality for the creation of knowledge directories, thereby enabling easy access to project information and best practices from prior projects. Second, its knowledge networking functionality enables communication forums and knowledge communities that help NPD teams discuss new product ideas. Third, it also helps NPD teams locate relevant expertise through visualization IT technologies.

Regarding CWS [7], first, its conveyance functionality enables data-based collaboration, content management, and sharing ideas. Second, its presentation functionality fosters NPD teams to transform their tacit ideas into graphic images. Third, its convergence functionality can clarify assumptions, elicit tacit knowledge, and construct product histories by enabling NPD teams to work together and review product designs in real time. This functionality supports NPD teams' brainstorming, converging ideas, finding solutions for new products, and reaching group consensus.

Consequently, IT leveraging competence in NPD can foster accountability, predictability, and common understanding, which underlying a team's COOR. Hence:

**H1:** IT leveraging competence is positively related to coordination capability in NPD.

## 2.3 Absorptive Capacity

Absorptive capacity (ACAP) denotes the dynamic capacity existing as two subsets of potential and realized ACAP (PACAP and RACAP) [14]. PACAP, which includes knowledge acquisition and assimilation, captures efforts expended in valuing, acquiring and assimilating new external knowledge. RACAP, which contains knowledge transformation and application, encompasses deriving new insights and consequences from the combination of existing and newly acquired knowledge and incorporating transformed knowledge into operations.

It leveraging competence is proposed to influence PASAP. **PRMS** improve the competence of NPD teams in knowing the true availability of people, skill, and resources to enable appropriate task assignment, and in analyzing and measuring work, tasks, and resources by task assignment and resource management, thus enabling knowledge acquisition and assimilation. **OMS** makes NPD teams more competent in acquiring product-related knowledge by storing, archiving, retrieving, sharing, and reusing project information and best practices. It also enhances the competence of NPD teams in articulating, interpreting, and synthesizing new and stored knowledge by facilitating easy access to stored knowledge, thus enabling knowledge assimilation [7].

IT leveraging competence in NPD is also proposed to influence RACAP. **OMS** help retrieve knowledge that was previously created and internalized for use, thus enabling knowledge exploitation [7, 15]. **CWS** can enhance the problem solving capability of NPD work units and the units' ability to generate new thinking [15], thereby enabling knowledge transformation. It can also enhance the ability of NPD work units to pursue new product initiatives and find new solutions [16], thus enabling superior knowledge exploitation. Therefore, it is hypothesized that:

**H2:** IT leveraging competence is positively related to absorptive capacity in NPD.

## 2.4 Social Capability

Social capability (SOCI) is the sum of the actual and potential resources embedded within, available through, and derived from the network of relations possessed by an individual or social unit [17]. Nahapiet and Ghoshal identified three distinct dimensions of SOCI as structural, relational, and cognitive [17].

The structural dimension of SOCI refers to the overall pattern of connection between actors [17]. The close social interactions permit people to know one another, to share vital information, to create a common understanding related to task issues or goals and to gain access to others' resources. As Sparrowe et al. theorized [18], information sharing and exchange can enhance cooperation and mutual accountability.

The relational aspect of SOCI represents the type of personal relationships people have developed with one another through a history of interactions [17]. Among SOCI's key attributes is the level of trust among actors [17]. Trusting relations facilitate collaborative behaviours and collective action in the absence of explicit mechanisms to foster and reinforce those behaviours [19].

The cognitive dimension of SOCI refers to those resources providing shared representations, interpretations, and systems of meaning among parties [20]. SOCI's cognitive dimension represents the fact that, as individuals interact with one another as part of a collective, they are better able to develop a common set of goals, and a shared vision for the organization [17]. When a shared goal is present in the network, project team members have similar perceptions regarding how they should interact with one another.

According to these arguments, SOCI can enable accountability, predictability, and common understanding among participants of interdependent organizational activity, which leads to the emergence of coordinating mechanisms [13]. Therefore, we propose the following hypothesis.

**H3:** Social capital is positively related to coordination capability in NPD.

As Zahra and George noted [14], social integration leads to knowledge assimilation, occurring either informally or formally. Informal mechanisms are advantageous for exchanging ideas, but formal mechanisms tend to be more systematic. Formal social integration fosters information distribution as well as interpretation collection and trend identification. Research has shown that organizational structures promote interaction, encouraging problem solving and creative action [21]. Firms that build such connectedness by social integration mechanisms tend to make their employees aware of the types of data that constitute their PACAP.

Connectedness develops trust and cooperation and fosters commonality of knowledge [22]; it encourages communication and improves the efficiency of knowledge exchange through units [23]. Thus, connectedness allows units to transform and exploit new external knowledge [14]. Moreover, connectedness reduces the likelihood of conflict regarding goals and implementation [24]. Thus, connectedness facilitates the transformation and exploitation of newly acquired knowledge and develops a unit's RACAP. Therefore,

**H4:** Social capital is positively related to absorptive capacity in NPD.

### 2.5 New Product Development Performance

New product development (NPD) intrinsically regards integrating multiple functional departments to launch a new product through idea generation, product design, manufacturing ramp-up and marketing deployment [3].

In the broader capabilities' view of resource-based theory, performance entails a firm's ability to achieve a competitive advantage that ultimately is measured by superior financial returns but that, in the shorter run, is gauged in terms of improved efficiency, market share or position, or breaking into new arenas [25]. This is similar to NPD, where performance is a combination of product effectiveness (PDT) and process efficiency (PCS) [11, 27]. PDT is the extent to which the new product is successful by some external criteria, such as quality and the level of innovativeness [26]. PCS measures the extent to which the NPD project adheres to budgets and schedules [26]. Several studies suggested that harmony between quality and cost of product is a key aspect of NPD team performance [28].

Insufficient coordination between the teams tends to cause rework on certain work products [27]. Such rework can become problematic, particularly in later development phases, and often entails delays and additional development costs. Accordingly:

**H5:** Coordination capability is positively related to process efficiency.

In accordance with Zahra and George [14], firms with well-developed PACAP tend to be more proficient at continually improving their knowledge stock by recognizing trends in their external environment and internalizing this knowledge, thereby overcoming certain of the competence traps. Zahra and George distinguish between the timing and cost dimensions of being proficient [14]. The timing dimension denotes that a developed PACAP improves the effectiveness of changes track in the industries and facilitates the deployment of production and technological competencies. The cost dimension signifies that a developed PACAP reduces the investments in changes of resource positions and operational routines. In addition, Zahra and George noted that RACAP tends to influence performance through product and process innovation [14]. RACAP's transformation capabilities foster the development of new perceptual schema or changes to existing processes through the process of bisociation. RACAP's exploitation capabilities take this a step further and convert knowledge into new products [28]. Therefore, we conclude:

**H6:** Absorptive capacity is positively related to product effectiveness.

## 2.6 Project Characteristics

An extensive literature distinguishes between uncertainty and complexity dimensions of NPD project characteristics that affect performance [5]. The project uncertainty, measured by product newness, market newness, technology newness, and process technology newness, denotes the newness of technologies employed in the product development effort to the development organization [6]. The project complexity, measured by technology interdependency, object novelty, and project difficulty, signifies the nature, quantity, and magnitude of organizational subtasks and subtask interactions posed by the project [6].

Following Grote [31], the greater the uncertainty and complexity, the greater the information quantity that must be processed during project execution in order to achieve high levels of performance. Hence, NPD teams face more difficulties and spend more time when developing products with a higher level of novelty [30]. As Sheremata noted [21], uncertain projects increase the coordination need that results in higher costs. NPD cycle times and costs increase with product newness due to greater uncertainty and complexity [32]. Besides, higher project uncertainty and complexity imply high variability in and unpredictability of exact means to accomplish the project, in turn resulting in poorer project outcomes. Thus, a higher level of uncertainty and complexity is expected to have a negative effect on the quality of project outcome [29]. Accordingly, we have the following hypotheses:

**H7:** The level of project uncertainty negatively moderates the relationship between coordination capability and process efficiency.

**H8:** The level of project uncertainty negatively moderates the relationship between absorptive capacity and product effectiveness.

**H9:** The level of project complexity negatively moderates the relationship between coordination capability and process efficiency.

**H10:** The level of project complexity negatively moderates the relationship between absorptive capacity and product effectiveness.

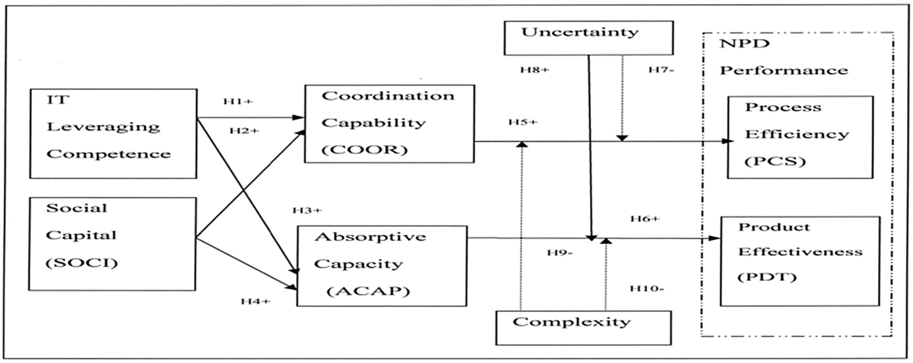


**Fig. 1.** Research framework

### 2.7 Research Framework

As shown in Fig. 1, the model proposes that there are two key areas for which the process of establishing NPD performance can be understood i.e., PDT, and PCS. Within these two key areas, constructs such as IT leveraging competence, SOCI, COOR, ACAP, and project characteristics, emerge. What is said above is a description of these constructs and a discussion on their interrelationships.

## 3 Methodology

### 3.1 Data Collection Procedure

In this survey, all of the items were measured with 7-point Likert scale (1 = strongly disagree, 7 = strongly agree). The measurements used in this study were primarily derived from the previous studies appears as in Appendix A, available if needed.

After pre-test, two rounds of survey were conducted by distributing the survey instrument in the form of questionnaire to the production managers of 770 electrical manufacturing firms in Taiwan from Jan 1 to March 31, 2012. These firms were listed in the directories of the 2012 top 2000 firms in Chinese Credit (Taiwan's leading credit company). The exclusion of 3 invalid questionnaires resulted in a total of 121 complete and effective responses for data analysis. The total response rate is 16 %. Each respondent was asked to provide their opinions about project A and B because we hope to obtain the responses from projects with different performance and thereby we got two samples from single questionnaire, consequently, there are 242 samples in this study. To examine the possibility of nonresponsive bias, a Chi-square test was conducted to compare early and late respondents on the research variables. Responses from the first mailing were 65 questionnaires. The late respondents were 56 questionnaires after a follow-up mailing. The results revealed no significant differences ($p > .05$) between the early and late respondents suggesting that non-response bias is not a problem in this study [33]. Appendix B **shows the non-response analysis results**, available if needed.

### 3.2 Analysis of Measurement Model

Our main data analyzing tool is the partial least squares (PLS), a component-based technique for structural equation modeling, because this study includes both formative and reflective constructs. The formative and reflective indicators require different approaches and criteria for validating reliability, convergent validity, and discriminant validity [34].

**Formative constructs:** We modeled the indicators of IT leveraging competence (2nd-order) and absorptive capacity (2nd-order) as formative measures since these indicators are not expected to have covariation within the same latent construct and they are causes of, rather than caused by, their latent construct [34]. Diamantopoulos and Winklhofer (2001) propose that the formative items should correlate with a "global item that summarizes the essence of the construct" [35]. PLS item weights, which indicate the impact of individual formative items [36], can be multiplied by the item values and summed, as noted by Bagozzi and Fornell [42]. In effect, our results in a modified multitrait, multimethod (MTMM) matrix of item-to-construct and item-to-item correlations similar to that analyzed by Bagozzi and Fornell as well as Loch et al. [37]. The resulting matrix, showing item-to-construct correlations as grayed out cells, appears as in Appendix C, available if needed.

Loch et al. suggest that the convergent validity is demonstrated if the items of the same construct correlate significantly with their corresponding composite construct value (item-to-construct correlation) [37]. This condition has been met in our study, as all items correlated significantly ($p < 0.01$) with their respective construct composite value. The results, therefore, indicate an acceptable level of convergent validity.

The discriminant validity can be established if the item-to-construct correlations are higher with each other than with other construct measures and their composite value [37]. This condition is also met in our study. In a sense, very high reliability can be undesirable for the formative constructs because the excessive multicollinearity among the formative indicators can destabilize the model [34]. To ensure that the multicollinearity is not a significant issue, we assessed the VIF (variance inflator factor) statistic. If the VIF statistic is greater than 3.3, the conflicting item should be removed as long as the overall content validity of the construct measures is not compromised [38]. For our formative measures, we find the VIF values of both IT leveraging competence and absorptive capacity to be 1.000 and 1.591. In summary, the results suggest that all indicators have VIF statistics lower than 3.3.

**Reflective constructs:** The convergent validity is demonstrated if (1) the item loadings are in excess of 0.70 on their respective factors and (2) the average variance extracted (AVE) for each construct is above 0.50 [39]. These conditions have been met in our study. Gefen and Straub also contend that the discriminant validity is demonstrated if (1) the square root of each construct's AVE is greater than the inter construct correlations, and (2) the item loadings on their respective constructs are greater than their loadings on other constructs [39], available in Appendix D, available if needed. These conditions have also been met, thereby demonstrating that the independent construct indicators discriminate well. The composite reliability scores equal to or greater than 0.70 are regarded as acceptable [39]. So the composite reliability scores of these

**Table 1.** Structure model

**Structure model**

| Baseline model<br>Process E R2=0.348<br>Product E R2=0.291 | | | Model with interaction<br>Process E<br>R2=0.428 *f*2=0.086 | | Model with interaction<br>Product E<br>R2=0.308 *f*2=0.024 | | Model with interaction<br>Process E<br>R2=0.391 *f*2=0.070 | | Model with interaction<br>Product E<br>R2=0.297 *f*2=0.008 | | Support |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Parameter | t-statistic | Parameter | t-statistic | Parameter | t-statistic | Parameter | t-statistic | Parameter | t-statistic | |
| H1 | 0.49 | 7.084 | 0.522 | 8.173 | 0.522 | 7.791 | 0.522 | 8.295 | 0.522 | 7.484 | YES |
| H2 | 0.461 | 7.876 | 0.438 | 7.386 | 0.438 | 7.949 | 0.438 | 7.935 | 0.438 | 7.957 | YES |
| H3 | 0.273 | 3.510 | 0.311 | 4.319 | 0.311 | 4.243 | 0.311 | 4.427 | 0.311 | 4.223 | YES |
| H4 | 0.328 | 5.102 | 0.353 | 6.301 | 0.353 | 6.791 | 0.353 | 6.782 | 0.353 | 6.847 | YES |
| H5 | 0.599 | 12.927 | 0.389 | 4.864 | 0.608 | 12.711 | 0.539 | 8.692 | 0.608 | 12.489 | YES |
| H6 | 0.539 | 10.488 | 0.498 | 7.287 | 0.339 | 4.335 | 0.498 | 7.039 | 0.396 | 6.324 | YES |
| H7 | | | 0.002 | 0.038 | | | | | | | NO |
| H8 | | | | | -0.169 | 2.287 | | | | | YES |
| H9 | | | | | | | -0.006 | 0.084 | | | NO |
| H10 | | | | | | | | | -0.003 | 0.024 | NO |

reflective variables are acceptable, available in Appendix E, available if needed. Our validation results suggest that all reflective measures demonstrated satisfactory reliability and construct validity and all formative measures demonstrated satisfactory construct validity and no significant multicollinearity. Therefore, all of the measures were valid and reliable.

### 3.3 Assessment of Structural Model

The structural model aims to examine the relationship among a set of dependent and independent constructs. In this section, we tested the amount of variance explained and the significance of the relationships. Additionally, a bootstrap re-sampling approach is suggested in order to estimate the precision of the PLS estimates [41]. Following this suggestion, a bootstrap analysis with 500 bootstrap samples [42] and the original 242 cases were performed to examine the significance of the path coefficients. The result of our structural model analysis is presented in Table 1.

Following Henseler and Fassott [40], we have used the product-indicator technique to test the moderating relationship included in our research model (H7, 8, 9, 10). As in regression analysis, the predictor and the moderator variables are multiplied to obtain the interaction term. Chin et al. recommend the standardization of the product indicators [41]. In our study, the coefficient of Task uncertainty × ACAP → Production E (–0.169) is statistically significant. The R-square for this interaction model is compared to the R-square for the baseline model, which excludes the interaction term [42]. The difference in R-square assesses the overall effect size $f^2$ for the interaction effect. The effect size $f^2$ can be calculated as $f^2 = (R^2 \text{ included} - R^2 \text{excluded})/1 - R^2 \text{ included}$. Values of 0.02, 0.15 and 0.35 indicate that the interaction term has a low, medium, or large effect on the criterion variable. In our case, the H8 of interaction term achieves a $f^2$ value of 0.024. Therefore, hypothesis 8 is supported.

## 4 Discussion

### 4.1 Implications

We did not find the uncertainty to negatively moderate the relationship between coordination capability and process efficiency. In addition, we failed to demonstrate the moderating effects of complexity on the link between coordination capability and process efficiency, as well as the link between absorptive capability and product effectiveness. Although managers are often tempted to undertake simple NPD projects, this study shows that projects with a higher level of uncertainty and/or complexity do not necessarily lead to poor performance. Managers should resist the temptation to fall back on me-too products. Managers should be encouraged to undertake breakthrough projects even if such projects increase the level of uncertainty and/or complexity. The competitive advantage is gained often by doing difficult tasks better than the competition.

In addition, investing in the creation of SOCI inside the NPD team eventually creates performance. NPD performance depends on the employees' complementary capabilities and the ability to manage the social interactions to achieve common goals. To effectively leverage investments in human resources, it may be imperative for NPD teams to invest in the development of SOCI to provide the necessary conduits for their participants to network and share their expertise. NPD teams that neglect the social side of individual skills and inputs and do not create synergies between their human and SOCI are unlikely to realize the potential of their members to realize superior performance. Thus, a team's efforts at hiring, training, work design, and other human resource management activities may need to focus on not only strengthening their members' specific technological skills/ expertise but also developing their abilities to network, collaborate, and share information and knowledge.

### 4.2 Limitations and Suggestions for Future Research

First, our survey research was conducted at the production managers of 770 electrical manufacturing firms in Taiwan. Such a focus helped to account for corporate-, industry-, country-, and cultural-specific differences that might have otherwise masked significant effects. Empirical studies in a wider variety of organizations within different industries and countries are necessary to further generalize the findings.

Second, our construct measures were perceptual, based on key informants. We relied on perceptual measures because strategic capabilities are difficult to capture with self-reported survey responses. The measures of IT leveraging competence, SOCI, COOR, ACAP, uncertainty, and complexity in NPD may not be perfectly captured with primary data. Future research could use objective third-party assessments for these capabilities.

Third, it is possible, however, to measure IT leveraging competence beyond NPD or other specific processes. In this study, the IT leveraging competence construct is based on IT functionalities specifically used for NPD. Future research could develop a generalizable measure of IT leveraging competence that is not dependent on context-specific tools.

### 4.3 Conclusions

Our study provides an empirically grounded framework simultaneously linking various aspects of IT leveraging competence, SOCI, COOR, ACAP, uncertainty, and complexity to performance in NPD. This framework shows how NPD project teams need to combine their IT leveraging competence and SOCI to improve COOR and

ACAP under uncertainty and complexity for superior performance. This framework also provides a structure for future research, probing through more specific questions regarding the capabilities-performance link.

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