The combined effects of internal and external supply chain integration on product innovation

Citation: Wong, C.W.Y., Wong, C.Y. & Boon-itt, S. (2013). "The combined effects of internal and external supply chain integration on product innovation", International Journal of Production Economics, 146, 566-574.

Christina W.Y. Wong

Business Division, Institute of Textiles and Clothing

The Hong Kong Polytechnic University

Hung Hom, Kowloon, Hong kong

Chee Yew Wong

Leeds University Business School

University of Leeds

Leeds, LS2 9JT, UK

Sakun Boon-itt

Department of Operations Management

Thammasat Business School

Bangkok, 10200, Thailand

The combined effects of internal and external supply chain integration on product innovation

Abstract

This research examines the individual and combined effects of internal integration (II) and external integration (EI) on product innovation. Two combined effects—balanced integration and complementary integration—are examined. Based on ambidexterity theory, the combined effects of II and EI are theorised to facilitate exploration and exploitation of external and internal knowledge, and subsequently improve product innovation. Our analysis of survey data from the Thai automotive industry ascertains that EI and complementary integration are positively associated with product innovation, but II and balanced integration are not associated with product innovation. This research is the first to provide novel insights into how exploration and exploitation of external and internal knowledge can be facilitated by internal and external integration, and their complementary effects on product innovation, which was previously less understood. Our findings provide managerial insights for firms involved in supply chain integration implementation.

Keywords *Supply chain integration; Innovation; Ambidexterity; Automotive industry; Thailand.*

1. Introduction

Internal integration (II) and external integration (EI) are widely accepted as having the ability to improve operational performance outcomes, such as quality, cost, delivery and flexibility (e.g., Ragatz et al., 1997; Kim, 2009; Flynn et al., 2010; Wong et al., 2011a; Prajogo & Olhager, 2012; Dröge et al., 2012). However, their impacts on product innovation are less understood. Due to their potential in facilitating exploration and exploitation, II and EI are arguably able to facilitate product innovation within and across organisations. Moreover, II and EI may, together, improve product innovation because exploitative innovations have been shown to have a positive impact on explorative innovations (Azadegan & Wagner, 2011). Even though there is already some empirical evidence which supports these arguments (e.g., Ettlie & Reza, 1992; Tessarolo, 2007; Parker et al., 2008; Lau et al., 2010), the literature is still being confronted by a lack of theoretical explanation and empirical evidence regarding the combined effects of II and EI on product innovation.

This research tests a theoretical model which explains how II and EI individually and together affect product innovation. The individual effects of II and EI are largely explained by information processing theory and relational view theory. For the combined effects of II and EI, we refer to the ambidexterity theory from the field of organisational studies because ambidextrous firms are found to benefit from both exploitation of existing resources and exploration of new resources (March, 1991; Cao et al., 2009), and they are known to be relatively more innovative (Gibson & Birkinshaw, 2004; Jansen et al., 2006). This research offers three main contributions. The first contribution is to provide novel theoretical explanations to the individual and combined effects of II and EI on product innovation. Recent studies discover that the effects of II and EI on major operational performance outcomes are not universal. EI is distinguished as being more effective in affecting time-based performance, such as delivery and flexibility, while II is superior in affecting quality and cost, which are less dependent on time factors (Wong et al., 2011a; Schoenherr & Swink, 2012). However, it is unclear if the effects of II and EI on product innovation are indifferent, or if they follow the above logics. This research thus advances the previous studies by adding new insights into the individual and combined effects of II and EI on product innovation.

The second contribution comes from the novel approach we used to conceptualise the combined effects of II and EI on product innovation. Unlike most prior studies which tended to focus on the influence of II and EI separately (Ragatz et al., 1997; Tessarolo, 2007; Lau et al., 2010; Dröge et al., 2012), this research recognises the importance of coupling both II and EI to coordinate new product development processes within and across organisations (Hillebrand & Biemans, 2004; Koufteros et al., 2005). Based on ambidexterity theory, our theoretical model includes two possible methods in which II and EI work together to enhance product innovation. The first method is to allow II and EI to be balanced (called balanced integration), which is defined as achieving similar levels of II and EI to enable internal exploitation and external exploration processes to be linked without facing bottlenecks. The second method is to make II and EI complement each other (called complementary integration), which is defined as organisational efforts in complementing intra- and inter-organisational business processes to leverage the combined strengths of the pools of internal and external resources (Cao et al., 2009) or assets (Ragatz et al., 1997). According to our best understanding, these are novel conceptualisations in production and supply chain literature.

The third contribution rests on the operationalisation of the concepts of complementary and balanced integration. We adapted the method for measuring complementary and balance between exploration and exploitation by He and Wong (2004). Complementary integration is modelled as an interactional term (IIxEI) between II and EI. The interaction between II and EI has been examined by recent studies in operations and production literature (Dröge et al., 2004; Schoenherr & Swink, 2012) but no comparison with balanced integration has been made. Balanced integration is modelled as the difference between II and EI. The smaller the difference, the more balanced II and EI are. Such an approach to measure balance between exploitation and exploration has been used in organisational studies (He & Wong, 2004), but it is new to production and supply chain literature. In this research, these concepts are tested by survey data collected from first-tier automotive suppliers and automakers in Thailand, who are involved in combining II and EI efforts to facilitate new product innovation. This rigorous approach to operationalising balanced and complementary effects can be used to investigate the combined effects of II and EI on other performance outcomes.

2. Theoretical model and hypotheses

The effects of internal integration (II) and external integration (EI) on production innovation have been largely studied separately. Through interaction, communication, information sharing, coordination and collaboration across functional departments, II is known to have a positive effect on the performance of new product development and innovation (Gupta et al., 1986; Griffin & Hauser, 1996; Olson et al., 1995; Griffin, 1997; Troy et al., 2010). Based on the similar arguments, EI involves similar efforts between customers and suppliers, which can support joint development of new products (Ettlie & Reza, 1992; Griffin & Hauser, 1996; Handfield et al., 1999; Verona, 1999; Ragatz et al., 1997 & 2002; Monczka et al., 2000; Koufterous et al., 2005; Petersen et al., 2005; Tessarolo, 2007; Lau et al., 2010; Wong et al., 2012). Though not always clearly stated, the above studies loosely draw theoretical foundations from organisational information processing theory (Wong et al., 2011b; Schoenherr & Swink, 2012) and relational view theory (Dyer & Singh, 1998) to support their arguments. So far most empirical studies above found support for these theories, with just a few exceptions (e.g., Ragatz et al., 2002; Scannell et al., 2000). To our knowledge, no study so far compares the effects of II and EI on product innovation.

Furthermore, while the individual impacts of II and EI on some aspects of product innovation have been previously studied, their combined effects are currently less understood. This is partly due to the existence of conflicting perspectives and the lack of theory. The first perspective considers II and EI as a single construct (Ettlie & Reza, 1992; Scannell et al., 2002) such that the roles of II and EI and their interactions are not revealed. The second perspective hypothesises II as antecedent of EI which, subsequently, positively affects product innovation; this perspective has so far received partial support from limited empirical results (Koufteros et al., 2005). The third perspective suggests that II and EI may affect each other (Flynn et al., 2010; Germain & Iyer, 2006; Stank et al., 2001). This perspective is further clarified by an empirical study which indicates that the complementarity between II and EI could have a positive impact on product development (Hillebrand & Biemans, 2004). Somehow, the lack of theoretical foundation hampers the above attempts to enhance the understanding of the combined effects of II and EI on product innovation.

Figure 1 illustrates the theoretical model of this research. The first two hypotheses (H1 & H2) explain the individual effects of II and EI on product innovation. To advance the literature, we refer to organisational information processing theory (Wong et al., 2011b; Schoenherr & Swink, 2012) and relational view theory (Dyer & Singh, 1998) to explain the impacts of EI and II on product innovation. Organisational information processing theory suggests the need to gain access to market information and improve information process capability especially to remain competitive in uncertain business environments (Lawrence & Lorsch, 1967; Thompson, 1967). Relational view theory argues that a collaborative relationship instead of an adversarial relationship in a supply chain is often a better way to gain competitive advantage through complementary assets and competences (Dyer & Singh, 1998). We further relate these two theories to the concepts of exploration and exploitation (March, 1991) such that the market intelligence and new ideas owing to integrative efforts can be explored and exploited for effective product innovation. The last two hypotheses (H3 & H4) explain the combined effects of II and EI, including balanced and complementary effects, on product innovation. They are grounded on ambidexterity theory. This model is unique because it elucidates the individual effects of II and EI as well as their combined effects on product innovation. The hypothetical relationships illustrated in the model are further explained in the next sections.

<Please insert Figure 1 here>

2.1. External integration and product innovation

In general, EI involves the strategic alignment of business processes, information sharing and joint collaboration with suppliers and customers (Dröge et al., 2004;

Koufteros et al., 2005; Flynn et al., 2010; Lai et al., 2008; Dröge et al., 2012). In the context of new product development, EI helps firms to establish mutual understanding (Petersen et al., 2005; Revilla & Villena, 2013) and gain information through network relationships (Tessarolo, 2007). Specifically, through market-directed integrative mechanisms (Ettlie & Reza, 1992), EI enables firms to acquire knowledge of customers' needs (Griffin & Hauser, 1996; Ragatz et al., 1997).Through upstream value-chain integration (Ettlie & Reza, 1992), EI shares this knowledge and product design requirements with suppliers (Clark & Fujimoto, 1991). In addition, EI supports early supplier involvement in new product development processes (Ragatz et al., 1997; Handfield et al., 1999; Koufterous et al., 2005; Cousins et al., 2011) and co-development of new products (Lau et al., 2010), which allow focal firms to explore novel product and technology knowledge from the suppliers (Verona, 1999; Ragatz et al., 2002; Petersen et al., 2005) that complement internal capabilities (Ragatz et al., 1997).

At the operational level, there is a need to integrate and transform new ideas into tangible new products (Tessarolo, 2007). This often involves inter-organisational problem-solving (Ragatz et al., 2002). EI helps coordinate tasks and problem-solving (Narasimhan & Jayaram, 1998; Flynn & Flynn, 1999; Ragatz et al., 2002), which are very important in product development. With EI, new product development processes between suppliers and customers are closely linked, and there are clear processes and procedures to communicate and coordinate key product design decisions (Tessarolo, 2007). Effective task coordination reduces waste and redundancy of efforts in managing supply chain activities (Swink et al., 2007) and makes it more effective to exchange and explore knowledge (Ragatz et al., 1997). The ability to coordinate and work jointly with suppliers has been known to improve product quality (Ettlie &

Reza, 1992; Stank et al., 1999; Scannell et al., 2000; Primo & Amundson, 2002; Rosenzweig et al., 2003), augment market success of product innovation (Koufterous et al., 2005) and reduce new product development lead time (Ragatz et al., 1997; Monczka et al., 2000; Sherman et al., 2000). Ragatz et al. (1997) suggest that the effective integration of suppliers into product innovation processes can yield benefits through reduced product development time and improved access to the application of technology. With the above arguments, we establish the following hypothesis:

Hypothesis H1: External integration is positively associated with product innovation.

2.2. Internal integration and product innovation

The same theoretical foundation is used to explain the relationship between internal integration (II) and product innovation. II is the extent to which the internal functions are working collaboratively (Morash et al., 1997). II improves the capability of firms to exploit and coordinate internal resources. II is achieved by removing functional barriers and encouraging cooperation between internal functions (Flynn et al., 2010), which are key enablers for concurrent engineering (Koufteros et al., 2005) and better coordination among functions to improve product development time, cycle time and responsiveness (Dröge et al., 2000 & 2004). Furthermore, II facilitates cross-functional teams to simultaneously generate and improve product and process designs (Rosenzweig et al., 2003). Integration of operations into the new product innovation process helps accelerate the process by eliminating steps and preventing delays and ramp-up (Turkulainen & Ketokivi, 2012). The lack of II can be detrimental, as each internal function may work at cross-purposes and fail to utilise resources and knowledge within different functions, resulting in effort redundancy and wasting resources (Pagell, 2004). II also enables sharing of knowledge across functions and manufacturing plants (Roth, 1996; Narasimhan & Kim, 2002; Caridi et al., 2012), which helps to facilitate product innovation by acquiring internal product development knowledge across business functions, such as marketing, R&D and production. Gomes et al. (2003) found a significant relationship between performance in product innovation and internal integration, through a survey of 40 British and Dutch companies from various sectors. Supporting this finding, Kahn and Mentzer (1996) indicate that the level of cross-functional integration is significantly related to new product development performance. Thus, we suggest the following hypothesis:

Hypothesis H2: Internal integration is positively associated with product innovation.

2.3. The combined effects of internal and external integration

The combined effects of II and EI on product innovation can be understood by first referring to the concepts of exploration and exploitation. While March (1991) first introduced the concepts of exploration and exploitation that are inherently conflicting in competing for scarce organisational resources, other scholars call for the importance of achieving a balance between the two in order to improve performance (e.g., Tushman & O'Reilly, 1996; Ghemawat & Costa, 1993). In addition to managing trade-offs between the two, recent studies argue that both exploitation and exploration are inter-independent and firms can perform both at a high level concurrently (e.g., Lavie & Rosenkopf, 2006; Jansen et al., 2006; Greve, 2007). This school of thought reasons that exploration and exploitation can be complementary where they interact and synergise to improve performance.

The organisational literature evokes successful firms have the ability to explore and exploit organisational resources and knowledge simultaneously. Such firms are ambidextrous, meaning they have the capability to align and efficiently manage changing market demands, ranging from customer needs to new market opportunities (Duncan, 1972; Tushman & O'Reilly, 1996; Gibson & Birkinshaw, 2004; Raisch & Birkinshaw, 2008). Ambidexterity theory is relevant to the study of SCI because ambidexterity is "likely to require both internal and external knowledge process as well as integration across organisational boundaries" (Raisch et al., 2009: 689). In order to innovate and adapt to the changing business environment, firms address the need to exploit their internal resources through II, while accessing novel knowledge and information from the external environment (e.g., suppliers and customers) via EI.

While the concepts of exploration and exploitation from ambidexterity theory and the concepts of II and EI from SCI literature are different, they are related and can be used together to understand how II and EI affect product innovation. II helps internal functions to exploit internal resources and knowledge more effectively, while EI helps firms to explore external resources and knowledge. The external resources and knowledge explored via the facilitation of EI can be transformed into innovative products via II only when II and EI are working together effectively, especially when dealing with the tensions between exploration and exploitation (March, 1991; Benner & Tushman, 2003). Even though there is some evidence suggesting that external exploration is more essential than internal exploration (Rosenkopf & Nerkar, 2001), we argue that both II and EI are required for product innovation.

In terms of how II and EI should work together, some may argue for the need to maintain a relatively balanced implementation of II and EI (called balanced integration). On the other hand, it is argued that complementary implementation of II and EI (called complementary integration) for exploiting and exploring resources helps to achieve product innovation effectively. According to organisational the ambidexterity literature, these two different perspectives of ambidexterity are distinct in conceptualisation, and they rely on different interrelated mechanisms for contributing to performance (Cao et al., 2009). While balanced integration is concerned with investing matching resources in II and EI for operations efficiency across organisational and cross-functional boundaries, complementary integration relates to the combined resources of II and EI, where they form a larger pool of complementary resources to be leveraged.

A balance between internal and external exploitation and exploration processes is argued to be sustainable due to its ability to avoid the risk of obsolescence. Such risk is induced by the focus on exploiting existing resources and markets, but failing to obtain reasonable returns from the expensive search of new information and opportunities (Cao et al., 2009). Consequently, firms with unbalanced II and EI are confined to exploit existing resources to satisfy their existing and mature market, neglecting new opportunities and market needs by not utilising new information and knowledge obtained through EI.

From the perspective of absorption capacity, excessive dominance of internal or external knowledge processes will be ineffective (Cohen & Levinthal, 1990; Zahra & George, 2002). By focusing only on II, firms may not be able to identify new opportunities and create new knowledge and resources to strengthen their competencies in developing new products. Similarly, firms focusing solely on EI may fail to recognise and fully utilise the resources residing within the firms to successfully produce product innovation for capturing new market opportunities. With a high level of EI, firms are able to explore external resources and knowledge, but if II is relatively lower, then such resources and knowledge cannot be effectively transformed into product innovation. Similarly, relatively lower EI will not allow access to external resources and knowledge. Thus, a balance between II and EI (balanced integration) becomes crucial to reap the benefits of being able to identify new opportunities while using internal resources to develop new products for emerging markets (Zhu & Chen, 2012). We therefore hypothesise the following:

Hypothesis H3*:* A balanced internal and external integration is positively associated with product innovation.

Alternately, product innovation may be enhanced by the complementary implementation of II and EI. The concept of complementary effect has been proven valid by several studies (Carr & Kaynak, 2007; Braunscheidel & Suresh, 2009; Zhao et al., 2011). We argue that EI and II do interact with each other and complement each other's abilities in enhancing product innovation. Such a complementary effect is supported by ambidexterity theory, which suggests that the exploitation and exploration processes can be complementary; these complementary effects can lead to better results that cannot be achieved separately (Gupta et al., 2006). This can be explained as follows. Complementary resources may reside internally or externally. While complementary integration between internal resources refers to synergy between internal processes and capabilities, complementary integration between resources beyond organisational boundaries is concerned with integrating external resources that are unavailable internally. Exploitative and explorative innovations have been found to be associated with each other (Azadegan & Wagner, 2010). Thus, EI and II are arguably supportive of one another and can leverage on each other's effects on product innovation.

For product innovation, collaboration between partner firms in a supply chain requires an effective complementary implementation of II and EI. II is the interface connecting external and internal parties (Flynn et al., 2010). II enables firms to effectively utilise existing knowledge and resources across intra-organisational business functions and have deeper understanding of their capabilities. Without II, EI efforts would hit a disintegrative wall at the interface between the two firms (Germain & Iyer, 2006). Using a case-research design, Hillebrand and Biemans (2004) developed a conceptual framework which shows the positive effects of complementary integration between II and EI on product development. Complementary integration between II and EI allows companies to access and reconfigure internal capabilities for novel product development (Cao et al., 2009). When II and EI complement each other, a firm is able to acquire and process information shared by external parties (via EI) as well as coordinate with external parties more effectively (via EI). According to ambidexterity theory, this means that the interaction between EI and II facilitates the firm to internalise external knowledge and better respond to customer demands by effectively exploiting internal resources and assimilating external knowledge for product innovation. According to Lorenzoni and Lipparini (1999), the ability of organisations to access and utilise knowledge that is located within and outside the organisation leads to competitive advantage, including product innovation. Thus, we suggest the following hypothesis:

> **Hypothesis H4**: A complementary internal and external integration is positively associated with product innovation.

3. Research methods

3.1. Sample and data collection

The Thai automotive industry was the sample frame of this research since Thailand is one of the largest motor vehicle manufacturing bases in the world in terms of gross output and export value and it currently ranks 13th globally (The Economist

Intelligence Unit, 2010). We identified a total of 799 first-tier automotive suppliers and automakers in Thailand from two sources: (1) the Directory of the Society of Automotive Engineering of Thailand and (2) the Thailand Automotive Industry Directory. An address validation exercise was conducted and a final mailing list of 724 firms was concluded. We obtained 116 responses from the first wave of mailing, and subsequently 35 additional responses from the second wave of mailing. Finally, we achieved a total of 151 returned responses at a response rate of 20.8 %.

Mail survey was used to collect data for this research. A five-point Likert scale (1=”very low” and 5=”very high”) was used for all measures in the questionnaire. After we pre-tested the questionnaire (see section 3.3), we sent the survey to presidents, general managers, plant managers, production managers, logistics/supply chain managers or purchasing managers who have knowledge of supply chain management practices. These respondents were asked to rate their firms on II, EI and PI. Among the respondents, 12% are from automakers and the rest are different part first-tier suppliers. We study both echelons because our focus is to examine the combine effects of II and EI. Therefore, the integration between first-tier suppliers and automakers is the right level of analysis. The unit of analysis of this research was also limited to the plant level because most empirical research in operations management occurs at the corporation or individual level of analysis (Flynn et al., 2010). The demographic characteristics of the respondents included in this research were position, plant ownership, number of employees, and type of products produced (see Table 1).

<Please Insert Table 1 about here>

3.2. Non-response bias and common method variance

We first tested non-response bias by using the extrapolation method suggested by Armstrong and Overton (1977). A comparison between early (n=116) and late responses (n=31) showed no statistical differences across the four key characteristics (e.g., number of employees, respondent's position, and number of years in business) at $p < 0.05$, which indicates that non-response bias does not seem to be a problem. We further tested non-response bias by conducting a t-test to check for any significant differences across the four key characteristics between respondents and non-responding firms who initially declined to participate, but later returned the questionnaires. The t-test results show no significant differences ($p < 0.05$). Thus, the sample appears to be free of non-response bias issues.

Since the research design was cross-sectional and data regarding the firms was collected from key informants, common method variance might be a threat of this research. We took three steps to avoid and detect the problem of common method variance. First, we divided the survey questions into different sections in the questionnaire based on their dependency (i.e., product innovation) or independency (i.e., II and EI) in the model (Podsakoff et al., 2003). Second, we conducted the Harman's one-factor test (Podsakoff & Organ, 1986), which is widely adopted by other supply chain management researchers (e.g., Nyaga et al., 2010), to ensure no single factor accounted for the majority of covariance between the independent and dependent variables. Our factor analysis indicated that independent and dependent variables load on different factors with the first factor accounting for less than 40% of total variance, suggesting that common method variance is not an issue in this research. Third, we checked common method variance following the suggestion by

Lindell and Whitney (2001). We used the years of employment of the respondents as the marker variable. As shown in Table 2, the years of employment is not significantly related to the three variables in this research, providing further evidence that common method variance was not a concern.

<Please Insert Table 2 here>

3.3. Measurement validity and reliability

As depicted in Appendix A, all measures of our key constructs are adapted from the existing literature. We adopted measurement items from the following literature to measure II (Stank et al., 2001; Narasimhan & Kim, 2002; Flynn et al., 2010), EI (Narasimhan & Kim, 2002; Flynn et al., 2010; Vijayasarathy, 2010; Dröge et al., 2012) and product innovation (Rondeau et al., 2000; Koufteros et al., 2005) to improve reliability and validity of the measures.

Since the scales adapted from the literature are in English, we applied a back-translation process to ensure conceptual equivalence (Cai et al., 2010). Three academics from the field of supply chain and operations management reviewed the initial measurement scales and provided feedback. Next, we invited four expert judges who have related industry experience to validate the scales using the Q-Sort method. The Q-Sort method requires experts in the area to sort the scales into groups, in which each group corresponds to a construct upon agreement (Moore & Benbasat, 1991). The Q-Sort results suggested acceptable content validity because the scale achieved a placement score greater than 70% (Moore & Benbasat, 1991). The revised questionnaire was pilot-tested with a small-scale survey to ensure that the indicators were understandable and relevant to practices in Thailand's automotive industry. We used feedback from the pilot test to improve the wording in some of the questions.

The reliability and validity measures for our constructs and their measurement items and scales appear in Appendix A.

The internal consistency of our measurement items were also measured using Cronbach's coefficient alpha, α (Cronbach, 1951). Since the values of Cronbach's alpha ranged from 0.79 to 0.89 for all variables and were well above the critical values (above 0.7), we thus conclude that our theoretical constructs exhibited acceptable psychometric properties. We used confirmatory factor analysis (CFA) to measure unidimensionality (Li et al., 2005). The CFA results for II, EI and product innovation measures showed that all of the measurement models had acceptable fit indices, such as comparative fix index (CFI), incremental fit index (IFI), and the Tucker Lewis index (TLI). All fit indices were well above the recommended value of 0.90, proving the unidimensionality of the constructs (Bentler & Bonett, 1980).

Moreover, we assessed the convergent and discriminant validity of the scales using the method suggested by Fornell and Larcker (1981). The validity measurements showed that the standardised coefficients for all items were more than twice their standard errors. Furthermore, the standardised coefficients for all variables were large (≥ 0.5) and significant (all t-values are larger than 2). Therefore, all items were significantly related to their underlying theoretical constructs. The composite reliability of the constructs exceeded the recommended threshold value of 0.60 (Bagozzi & Yi, 1988), providing further evidence of convergent validity. In this research, we evaluated discriminant validity using CFA. For each of the dependent and independent variables, we conducted discriminant validity checks. The results confirmed discriminant validity among the constructs because all three Chi-square differences between the fixed and free solutions in Chi-square were statistically significant at a level of $p \leq 0.01$. In addition, the square-root of AVE of all constructs were greater than the correlation between any pair of constructs, suggesting that the measurement items share common variance with their hypothesised constructs more than with other constructs, providing evidence of discriminant validity.

4. Results

We tested the hypotheses using structural equation modelling. Table 3 summarises the results of the structural models. The overall fit of the model was sufficient with $\chi2$ = 369.31; d.f. = 94; CFI = 0.90; IFI = 0.91; RMSEA = 0.08, where CFI and IFI were well above the recommended threshold of 0.90 and RMSEA was the same as the recommended threshold of 0.08. II was found to have no significant relationship with product innovation ($p > 0.05$) which fails to provide support for H1. On the other hand, EI was found to have a positive and significant relationship with product innovation ($p < 0.01$), providing support for H2.

<Please Insert Table 3 here>

Following He and Wong (2004), balance integration was operationalised as the absolute difference between EI and II (the average of the respective items).The absolute difference between EI and II was calculated, and it was reversed by subtracting the difference score from 5 to facilitate interpretation, where a higher value of balanced integration indicates a better balance of II and EI. The results indicate that balanced integration has an insignificant relationship with product innovation ($p > 0.05$), failing to support H3.

As defined in organisational ambidexterity literature, complementary integration is manifested as the interaction of II and EI, where they complement and leverage one another to improve performance. We followed prior studies (He & Wong 2004; Cao et al., 2009) and used the interactive term of EI and II to operationalise complementary integration. EI and II were mean-centred before obtaining their product to mitigate the potential of multicollinearity. The results suggest that complementary integration is positively related to product innovation ($p < 0.01$), lending support for H4.

5. Discussion and implications

This research provides some novel insights. Specifically, the findings reveal that the effects of EI and II on product innovation are not the same. EI, but not II, is positively associated with product innovation. This new evidence supports the argument for the need to differentiate the effects of II and EI (Wong et al., 2011a). The findings mean II alone is unable to directly improve product innovation, and EI is more effective especially in exploration of external knowledge to create innovative products (Tessarolo, 2007). We explain these interesting findings as follows. II has a tendency to focus on internal resources. Such a focus may adversely affect the ability to explore and acquire new information and identify new business for new product innovation. This finding mirrors the argument of Hillebrand and Biemans (2004), which suggests that even though II is a part of an organisational learning cycle, it is not sufficient to facilitate shared information for achieving product innovation.

As expected, EI is found to have a positive and significant effect on product innovation. This is mainly due to EI's ability to enable information and knowledge sharing and efficient coordination (Swink et al., 2007), facilitate cross-organisational new product innovation (Parker et al., 2008; Lau et al., 2010), and speed up innovation processes (Tessarolo, 2007). EI also helps leveraging capabilities and resources which are usually owned by other firms, such as suppliers and customers

(Aloini & Martini, 2013). This is probably what happened to our samples. While staff from purchasing and manufacturing needed to work with suppliers to ensure that the suppliers understand the design of the new parts and possess capabilities to produce according to the requirements, such would largely need EI; II alone is inadequate. Furthermore, due to the limited R&D capability of most Thai automotive firms, innovation originating solely from within a firm is rare.

Our findings on the combined effects of II and EI are novel and specifically interesting. Following our theorisation, the impact of complementary integration on the ability of firms to produce new products is ascertained. This is in line with the ambidexterity theorisation that II and EI complement one another in enabling organisational processes. While new product development decisions within a firm rely on information obtained from suppliers and customers, such information is only transformed into useful insights for product innovation internally when there is an effective interaction between II and EI.

Essentially, the above finding indicates the need for a firm's capacity to generate, acquire as well as integrate both internal and external sources of knowledge (Rosenkopf & Nerkar, 2001) by allowing II and EI to complement each other. When II and EI interact, knowledge or assets residing within suppliers and customers can be incorporated into the dynamics of innovation endeavours. This means, to ensure the effective development of innovations, firms are suggested to improve their firm's internal capacity to absorb external knowledge (Tracey, 2004; Xia & Roper, 2008) via complementary integration between II and EI. In line with prior studies (Swink et al., 1996; Verona, 1999), managers are recommended to examine how EI and II efforts interact with each other and ensure their complementarities.

As suggested by a plant manager in a post-hoc interview, the Thai automotive supply chain relies on information integration to manage business processes across a supply chain and coordinate new products and product features development, which requires interaction between II and EI. Such interface enables internal functions to acquire the latest market information and respond to market needs through coordinating production across a supply chain. The finding points to the importance of information exchange between suppliers and internal development teams for encouraging interaction and synergies to design innovative products (McDermott & Handfield, 2000). Thus, firms putting an emphasis on one integration activity also need to consider the development of other integration activities (Sherman et al., 2000).

Conversely, balanced integration implementation is found to have no significant impact on product innovation. This contradictory finding can be explained as follows. The balanced implementation of II and EI is unable to facilitate product innovation because it does not always enable firms to connect different pools of resources together to create novel product discoveries. While prior literature suggests that a balance between exploration and exploitation is required to minimise the risk associated by these two approaches (Cao et al., 2009), balanced integration does not operate in such a manner. Instead, according to Lin et al. (2013), successful combined effects of II and EI on product innovation depend on the enabling mechanism and routine for exploitation and exploration practices that facilitate learning and transfer of internal and external knowledge, where such mechanisms and routines enable II and EI to complement each other. Thus, managerial efforts to achieve a balanced II and EI are unnecessary. To compete in product innovation, managers must take account of the complement between II and EI to capture the knowledge and innovation created by the suppliers into their new products.

This research provides some theoretical implications. First, the above findings concerning the combined effects of II and EI on product innovation represent a crucial step forward because prior literature has so far largely focused on the individual effects of II and/or EI (Parker et al., 2008; Lau et al., 2010) and has failed to clarify how II and EI work together. The existing production and supply chain literature has so far suggested the potential interaction effects between II and EI (Flynn et al., 2010; Koufteros et al., 2005) but lacks theories to explain such a claim. This research advances the literature by providing the crucial theoretical foundation for conceptualising and operationalising two ways in which II and EI work together. This research adds to the literature by demonstrating that complementary integration between II and EI is crucial for product innovation, which is an important performance dimension often ignored by production and supply chain literature (Kärkkäinen & Elfvengren, 2002).

More significantly, this research introduces a new perspective for explaining how product innovation can be achieved by facilitating cross-functioning (II) and cross-firm (EI) exploration and exploitation of knowledge and resources. More specifically, this research provides the much needed theoretical foundation to explain how II and EI work together to enhance product innovation. Such a theoretical advancement could not be understood by studies which examine the performance impact of each supply chain integration (SCI) dimension independently, the impact of SCI as a whole (e.g., Scannell et al., 2000) or the clusters of firms based on certain SCI dimensions (Frohlich & Westbrook, 2001; Thun, 2010). This research advances SCI theory by demonstrating that, while having no direct effect on product innovation, II can affect product innovation when it is able to complement the efforts of EI, but not when it is at the same level as EI.

Finally, this research brings a new theory from the organisational literature to production and supply chain literature which is ambidexterity theory. Ambidexterity theory helps us to distinguish two ways in which II and EI work together. In line with the ambidexterity theory, this research demonstrates that while II and EI may be implemented by different individuals or initiatives, it is important to ensure they are leveraging each other in order to achieve product innovation. This novel theoretical perspective, which looks into the complementary effects of II and EI, opens up a whole new arena for future research in SCI. The interrelations between internal and external knowledge processes can be regarded as a new type of dynamic capability (Eisenhardt & Martin, 2000). We call this new theory the ambidexterity theory of SCI. This novel theoretical perspective clarifies the complex and inconclusive relationships between II and EI described by the existing literature (Hillebrand & Biemans, 2003; Zhao et al., 2011). This new theoretical foundation could also possibly explain existing findings which indicate that firms with “uniform” or balanced SCI dimensions and those with customer-leaning SCI tend to outperform other firms (Flynn et al., 2010; Frohlich & Westbrook, 2001; Thun, 2008).

6. Conclusion and future research

This research develops and tests an ambidexterity theory of supply chain integration (SCI). The research clarifies how internal integration (II) and external integration (EI) independently and collectively enhance product innovation. While EI independently has a positive link to product innovation, our findings suggest that the complementary integration of II and EI (not the balance between them) enhances the ability of II and

EI in improving product innovation. The theoretical and practical implications are significant. Researchers and managers should no longer treat II and EI as independent but should use a holistic approach to manage supply chain integration in product innovation. Researchers and managers should take into account how II and EI can complement each other to allow focal firms to capture external knowledge and information into new product development. Managers should be aware that external integrative efforts might not be effective when II is incapable of complementing the process of integrating new knowledge from external sources into its internal processes and resources.

This research has several limitations and, thus, provides the foundation for future research. First, this research conceptualises EI to incorporate both supplier and customer integration and ignores their differences. Future research should further investigate the performance impacts of supplier integration and customer integration, instead of an aggregated measure of external integration, to provide insights into internal, supplier, and customer integration which could be implemented together to effectively achieve product innovation. Second, though common method variance does not seem to be a problem here, future studies may consider using objective measures of product innovation, such as patent count (Modi & Mabert, 2010), to avoid socially desirable responses. Third, we conducted this research in a single industry, the automotive industry. Single industry studies have disadvantages: confounding problems may be induced by industry differences, and the generalisability of the findings may be reduced. We suggest replicating our research approach in other industries to improve generalisability of findings while further exploring other contingent factors, such as supply chain structure and industrial contexts. Future research, also, may use this research's findings to investigate the complementary integration of different dimensions of SCI and/or in other settings or performances, especially using longitudinal research to provide insights into the dynamics of supply chain relationships or integration (Terpend et al., 2008).

References

Aloini, D., Martini, A., 2013. Exploring the exploratory search for innovation: A structural equation modelling test for practices and performance. International Journal of Technology Management, 61(1), 23-46.

Armstrong, J.S., Overton, T.S., 1977. Estimating nonresponse bias in mail surveys. Journal of Marketing Research, 14, 396-402.

Azadegan, A., Wagner, S.M., 2011. Industrial upgrading, exploitative innovations and explorative innovations. International Journal of Production Economics, 130, 54-65.

Bagozzi, R.P., Yi, Y., 1988. On the evaluation of structural equation modes. Journal of Academy of Marketing Science, 16(1), 74-94.

Benner, M.J., Tushman, M.L., 2003. Exploitation, exploration, and process management: The productivity dilemma revisited. Academy of Management Review, 28, 238-256.

Bentler, P.M., Bonett, D.G. 1980. Significance tests and goodness-of-fit tests in the analysis of covariance structures. Psychological Bulletin, 88, 588-606.

Braunscheidel, M.J., Suresh N.C., 2009. The organizational antecedents of a firm's supply chain agility for risk mitigation and response. Journal of Operations Management, 27(2), 119-140.

Cai, S., Jun, M., Yang, Z., 2010. Implementing supply chain information integration in China: The role of institutional forces and trust. Journal of Operations Management, 28(3), 257-268.

Cao, Q., Gedajlovic, E., Zhang, H., 2009. Unpacking organizational ambidexterity: Dimensions, contingencies, and synergistic effects. Organization Science, 20(4), 781-796.

Caridi, M., Pero, M., Sianesi, A., 2012. Linking product modularity and innovativeness to supply chain management in Italian furniture industry. International Journal of Production Economics, 136(1), 207-217.

Carr, A.S., Kaynak, H., 2007. Communication methods, information sharing, supplier development and performance. International Journal of Operations & Production Management, 27(4), 346-370.

Clark, K., Fujimoto, T., 1991. Product development performance. Boston, MA: Harvard Business School Press.

Cousins, P.D., Lawson, B., Peterson, K.J., Handfield, R., 2011. Breakthrough scanning, supplier knowledge exchange, and new product development performance. Journal of Product Innovation Management, 28, 930-942.

Cohen, W., Levinthal D., 1990. Absorptive capacity: A new perspective on learning and innovation. Administrative Science Quarterly, 35(1), 128-152.

Cronbach, L.J., 1951. Coefficient alpha and internal structure of tests. Psychometrika, 16, 297-334.

Dröge, C., Vickery, S.K., Jacobs, M.A., 2012. Does supply chain integration mediate the relationships between product/process strategy and service performance? An empirical study. International Journal of Production Economics, 137, 250-262.

Dröge, C., Jayaram J., Vickery, S.K., 2004. The effects of internal versus external integration practices on time-based performance and overall firm performance. Journal of Operations Management, 22(6), 557-573.

Dröge, C., Jayaram J., Vickery, S.K., 2000. The ability to minimize the timing of new product development and introduction: An examination of antecedent factors in the North American automotive supply industry. Journal of Production Innovation Management, 17, 24-40.

Duncan, R.B.,1972. Characteristics of organizational environments and perceived environmental uncertainty. Administrative Science Quarterly, 17(3), 313-327.

Dyer, J.H., Singh, H. (1998). The relational view: cooperative strategy and sources of Interorganizational competitive advantage. Academy of Management Review, 23(4), 660-679.

Eisenhardt, K.M., Martin, J.A., 2000. Dynamic capabilities: What are they? Strategic Management Journal, 21(10-11), 1105-1121.

Ettlie, J.E., Reza, E., 1992. Organizational integration and process innovation. Academy of Management Journal, 34, 795-827.

Flynn, B.B., Huo, B., Zhao, X., 2010. The impact of supply chain integration on performance: A contingency and configuration approach. Journal of Operations Management, 28, 58-71.

Flynn, B., Flynn, J., 1999. Information-processing alternatives for coping with manufacturing environment complexity. Decisions Sciences, 17(3), 249-269.

Fornell, C., Larcker, D.F., 1981. Evaluating structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 18(1), 39-50.

Frohlich, M.T., Westbrook, R., 2001. Arcs of integration: An international study of supply chain strategies. Journal of Operations Management, 19, 185-200.

Germain, R., Iyer, K.N.S., 2006. The interaction of internal and downstream integration and its association with performance. Journal of Business Logistics, 27(2), 29-52.

Ghemawat, P., Costa, J., 1993. The organizational tension between static and dynamic efficiency. Strategic Management Journal, 14(Winter), 59-73.

Gibson, G.B., Birkinshaw, J., 2004. The antecedents, consequences, and mediating role organizational ambidexterity. Academy of Management Journal, 47(2), 209-226.

Gomes, J.F.S., de Weerd-Nederhof, P.C., Pearson, A.W., Cunha, M.P., 2003. Is more always better? An exploration of the differential effects of functional integration on performance in new product development," Technovation, 23, 185-91.

Greve, H.R., 2007. Exploration and exploitation in product innovation. Industrial and Corporate Change, 16(5), 945-975.

Griffin, A., 1997. PDMA research on new product development practices. Journal of Production Innovation Management, 14(6), 429-458.

Griffin, A., Hauser, J.R., 1996. Integrating R&D and marketing: A review of the literature. Journal of Product Innovation Management, 13(3), 191-215.

Gupta, A.K., Raj, S.P., Wilemon, D.A., 1986. A model for studying R&D-Marketing interface in the product innovation process. Journal of Marketing, 50(2), 7-17.

Gupta, A.K., Smith, K.G., Shalley, C.E., 2006. The interplay between exploration and exploitation. Academy of Management Journal, 49, 693-708.

Handfield, R.B., Ragatz, G.L., Petersen, K.J., Monczka, R.M., 1999. Involving suppliers in new product development. California Management Review, 42(1), 59-82.

He, Z., Wong, P., 2004. Exploration vs. exploitation: An empirical test of the ambidexterity hypothesis. Organization Science, 15(4), 481-494.

Hillebrand, B., Biemans, W.G., 2004. Links between internal and external cooperation in product development: An exploratory study. Journal of Product Innovation Management, 21, 110-122.

Jansen, J., Bosch, F. van den, Volberda, H., 2006. Exploratory innovation, exploitative innovation, and performance: Effects of organizational antecedents and environmental moderators. Management Sciences, 52, 1661-1674.

Kärkkäinen, H., Elfvengren, K., 2002. Role of careful customer need assessment in product innovation management-empirical analysis. International Journal of Production Economics, 80, 85-103.

Khan, K.B., Mentzer, J.T., 1996. Logistics and interdepartmental integration. Journal of Physical Distribution and Logistics Management, 26(1), 6-14.

Kim, S.W., 2009. An investigation on the direct and indirect effect of supply chain integration on firm performance. International Journal of Production Economics, 119, 328-346.

Koufteros, X., Vonderembse, M., Jayaram, J., 2005. Internal and external integration for product development: The contingency effects of uncertainty, equicovality, and platform strategy. Decision Science, 36(1), 97-133.

Lai, K.H., Wong, C.W.Y., Cheng, T.C.E., 2008. A coordination-theoretic investigation of the impact of electronic integration on logistics performance. Information & Management, 45(1), 10-20.

Lau, A.K.W., Tang E., Yam, C.M., 2010. Effects of supplier and customer integration on product innovation and performance: Empirical evidence in Hong Kong manufacturers. Journal of Product Innovation Management, 27, 761-777.

Lawrence, P., Lorsch, J., 1967. Organization and environment: managing differentiation and integration. Irwin, Illinois.

Lavie, D., Rosenkopf, L., 2006. Balancing exploration and exploitation in alliance formation. Academy of Management Journal, 49, 797-818.

Li, S., Rao, S., Ragu-Nathan, T.S., Ragu-Nathan, B., 2005. Development and validation of a measurement studying supply chain management practices. Journal of Operations Management, 23(6), 618-641.

Lin, H.E., McDonough, E.F., Lin, S.J., Lin C.Y.Y., 2013. Managing the exploitation/exploration paradox: The role of a learning capability and innovation ambidexterity. Journal of Product Innovation Management, 30(2), 262-278.

Lindell, M.K., Whitney, D.J., 2001. Accounting for common method varience in cross-sectional research designs. Journal of Applied Psychology, 86(1), 114-121.

Lorenzoni, G., Lipparini, A., 1999. The leveraging of interfirm relationships as a distinctive organizational capability: A longitudinal study. Strategic Management Journal, 20, 317-338.

March, J.G., 1991. Exploration and exploitation in organizational learning. Organization Science, 2, 71-87.

McDermott, C., Handfield, R., 2000. Concurrent development and strategic outsourcing: Do the rules change in breakthrough innovation? The Journal of High Technology Management Research, 11(1), 35-57.

Modi, S.B., Mabert, V.A., 2010. Exploring the relationship between efficient supply chain management and firm innovation: An archival search and analysis. Journal of Supply Chain Management, 46(4), 81-94.

Monczka, R.M., Handfield, R.B., Scannell, T.V., Ragatz, G.L., Frayer, D.L., 2000. New product development strategies for supplier integration. ASQ Quality Press.

Morash, E.A., Dröge, C. Vickery, S., 1997. Boundary-spanning interfaces between logistics, production, marketing and new product development. International Journal of Physical Distribution & Logistics Management, 27(5/6), 350-369.

Moore, G.C., Benbasat I., 1991. Development of an instrument to measure the perceptions of adopting an information technology innovation. Information Systems Research, 2(3), 173-191.

Narasimhan, R., Kim, S.W., 2002. Effect of supply chain integration on the relationship between diversification and performance: Evidence from Japanese and Korean firms. Journal of Operations Management, 20, 303-323.

Narasimhan, R., Jayaram, J., 1998. Causal linkage in supply chain management: An exploratory study of North American manufacturing firms. Decision Science, 29(3), 579-605.

Nyaga, G.N., Whipple, J.M., Lynch, D.F., 2010. Examining supply chain relationships: Do buyer and supplier perspectives on collaborative relationships differ? Journal of Operations Management, 28(2), 101-114.

Olson, E., Walker, O., Ruekert, R., 1995. Organizing for effective new product development: The moderating role of product innovativeness. Journal of Marketing, 59(1), 48-62.

Pagell, M., 2004. Understanding the factors that enable and inhibit the integration of operations, purchasing and logistics. Journal of Operations Management, 22, 459-487.

Parker, D.B., Zsidisin G.A., Ragatz G.L., 2008. Timing and extent of supplier integration in new product development: A contingency approach. Journal of Supply Chain Management, 44(1), 71-83.

Petersen, K.J., Handfield, R.B., Ragatz, G.L., 2005. Supplier integration into new product development: Coordinating product, process, and supply chain design. Journal of Operations Management, 23(3/4), 371-388.

Podsakoff, P.M., MacKenzie, S.B., Lee, J.Y., Podsakoff, N.P., 2003. Common method biases in behavioral research: A critical review of the literature and recommended remedies. Journal of Applied Psychology, 88(5), 879-903.

Podsakoff, P.M., Organ, D.M., 1986. Self-reports in organizational research: Problems and prospects. Journal of Management, 12(4), 531-544.

Prajogo, D., Olhager, J., 2012. Supply chain integration and performance: The effects of long-term relationships, information technology and sharing logistis integration. International Journal of Production Economics, 135, 514-522.

Primo, M., Amundson, S., 2002. An exploratory study of the effects of supplier relationships on new product development outcomes. Journal of Operations Management, 20(1), 33-52.

Ragatz, G.L., Handfield, R.B., Peterson, K.J., 2002. Benefits associated with supplier integration into new product development under conditions of technology uncertainty. Journal of Business Research, 55, 389-400.

Ragatz, G.L., Handfield, R.B., Scannell, T.V., 1997. Success factors for integrating suppliers into new product development. Journal of Product Innovation Management, 14(3), 190-202.

Raisch, S., Birkinshaw, J., Probst, G., Tushman, M.L., 2009. Organizational ambidexterity: Balancing exploitation and exploration for sustained performance. Organizational Science, 20(4), 685-695.

Raisch, S., Birkinshaw, J., 2008. Organizational ambidexterity: Antecedents, outcomes and moderators. Journal of Management, 34, 375-409.

Revilla, E., Villena, V.H., 2013. Knowledge integration taxonomy in buyer-supplier relationships: Trade-offs between efficiency and innovation. International Journal of Production Economics, 140(2), 854-864.

Rondeau, P.J., Vonderembsa, M.A., Ragu-Nathan, T.S., 2000. Exploring work system practices for time-based manufacturers: Their impact on competitive capabilities. Journal of Operations Management, 18, 509-529.

Rosenkopf, L., Nerkar, A., 2001. Beyond local search: Boundary-spanning, exploration, and impact in the optical disk industry. Strategy Management Journal, 22(4), 287-306.

Rosenzweig, E.D., Roth, A.V., Dean, J.W., 2003. The influence of an integration strategy on competitive capabilities and business performance: An exploratory study of consumer products manufacturers. Journal of Operations Management, 21, 437-456.

Roth, A.V., 1996. Achieving strategic agility through economies of knowledge. Strategy & Leadership, 24(2), 30-37.

Scannell, T.V., Vickery, S.K., Dröge, C.L., 2000. Upstream supply chain management and competitive performance in the Automotive supply chain industry. Journal of Business Logistics, 21(1), 23-48.

Schoenherr, T., Swink, M., 2012. Revisiting the arcs of integration: Cross-validation and extensions. Journal of Operations Management, 30(1/2), 99-115.

Sherman, J.D., Souder, W.E., Jenssen, S.A., 2000. Differential effects of the primary forms of cross functional integration on product development cycle time. Journal of Product Innovation Management, 17, 257-267.

Stank, T.P., Scott, B.K., Daugherty, P.J., 2001. Supply chain collaboration and logistics service performance. Journal of Business Logistics, 22(1), 29-48.

Stank, T.P., Crum M., Arango, M., 1999. Benefits of interfirm coordination in food industry supply chain. Journal of Business Logistics, 20(2), 21-41.

Swink, M.L., Narasimhan, R., Wang, C., 2007. Managing beyond the factory walls: Effects of four types of strategic integration on manufacturing plant performance. Journal of Operations Management, 25, 148-164.

Swink, M.L., Sandvig, J.C., Mabert, V.A., 1996. Customizing concurrent engineering processes: Five case studies. Journal of Product Innovation Management, 13(3), 229-245.

Terpend, R., Tyler., B.B., Krause, D.R., Handfield, R.B., 2008. Buyer-supplier relationships: Derived value over two decades. Journal of Supply Chain Management, 44(2), 25-55.

Tessarolo, P., 2007. Is integration enough for fast product development? An empirical investigation of the contextual effects of product vision. Journal of Product Innovation Management, 24, 69-82.

The Economist Intelligence Unit. 2010. Thailand automotive report, May, 2010.

Thompson, J., 1967. Organizations in action. McGraw-Hill, New York, NY.

Thun, J-H., 2010. Angles of integration: An empirical analysis of the alignment of internet-based information technology and global supply chain integration. Journal of Supply Chain Management, 46(2), 30-44.

Tracey, M., 2004. A holistic approach to new product development: New insights. Journal of Supply Chain Management, 40(4), 37-55.

Troy, L.C., Hirunyawipada, T., Paswan, A.K., 2010. Cross-functional integration and new product success: An empirical investigation of the findings. Journal of Marketing, 72, 132-146.

Turkulainen, V., Ketokivi, M. 2012. Cross-functional integration and performance: What are the real benefits? International Journal of Operations & Production Management, 32(4), 447 – 467.

Tushman, M.L., O’Reilly, C.A., 1996. Ambidextrous organizations: Managing evolutionary and revolutionary change. California Management Review, 38(4), 8-30.

Wong, C.Y., Boon-itt, S., Wong, C.W.Y., 2011a. The contingency effects of environmental uncertainty on the relationship between supply chain integration and operational performance. Journal of Operations Management, 29(6), 604-615.

Wong, C.W.Y., Lai, K.H., Cheng, T.C.E., 2011b. Value of information integration to supply chain management: Role of internal and external contingencies. Journal of Management Information Systems, 28(3), 161-199.

Wong, C.W.Y., Lai K.H., Lun, V.Y.H., Cheng T.C.E., 2012. A study on the antecedents of supplier commitment in support logistics operations. International Journal of Shipping and Transport Logistics, 40(1), 5-16.

Xia, T., Roper, S. 2008. From capacity to connectivity-absorptive capacity and exploratory alliances in biopharmaceutical firms: A US-Europe comparison. Technovation, 26, 776-785.

Verona, G., 1999. A resourced-based view of product development. Academy of Management Review, 24(1), 132-142.

Vijayasarathy, L.R., 2010. Supply integration: An investigation of its multi-dimensionality and relational antecedents. International Journal of Production Economics, 124, 489-505.

Zahra, S.A., George, G. 2002. Absorptive capacity: A review, reconceptualization, and extension. Academy of Management Review, 27, 185-203.

Zhao, X., Huo, B., Selen, W., Yeung, J.H.Y., 2011. The impact of internal integration and relationship commitment on external integration. Journal of Operations Management, 29(1/2), 17-32.

Zhu, Z., Chen, J. 2012. Balancing explorative and exploitative learning under open innovation: An empirical study in China. International Journal of Technological Learning, Innovation and Development, 5(4), 385-407.

Figure 1: Theoretical model

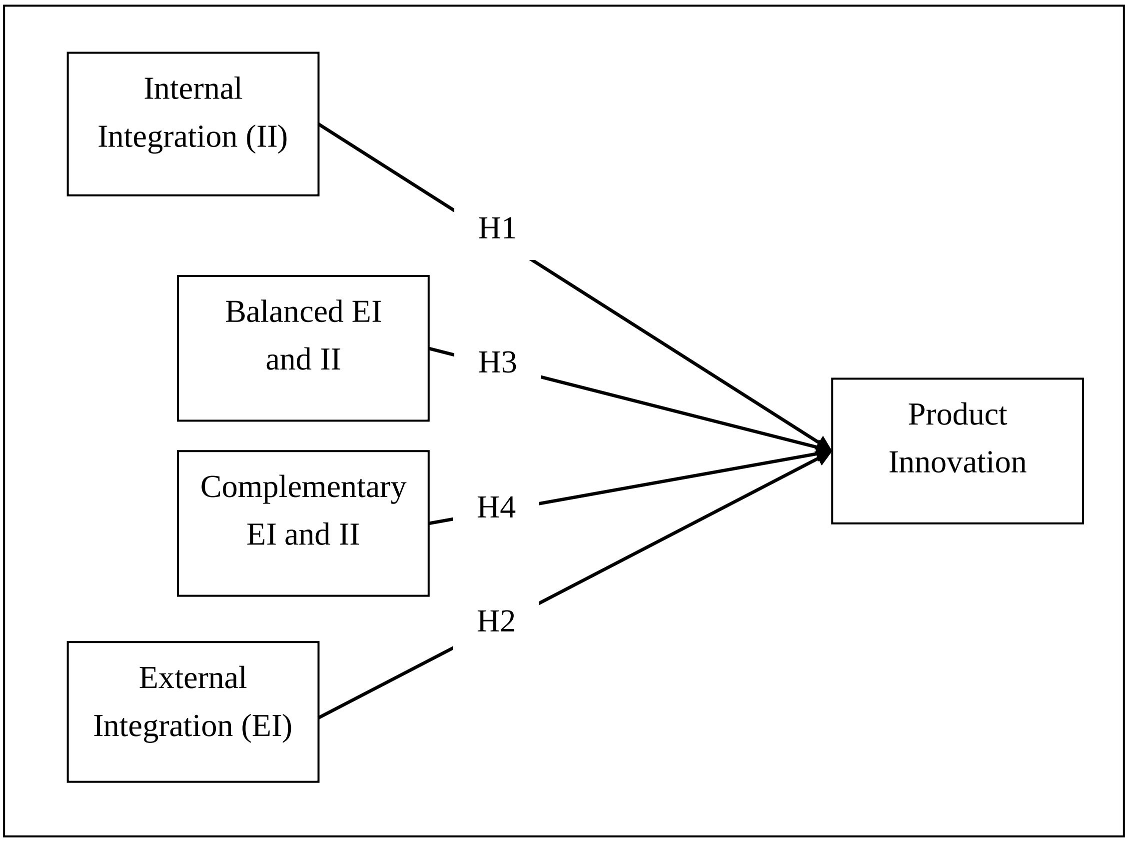

Table 1 Demographic characteristic of respondents

Demographic characteristics	Percentage of samples (%)
Position of respondents	
Supply chain manager	40
Purchasing / logistics manager	22
General manager	22
Production manager	8
President / managing director	8
Ownership	
100% Thai Owned	48
Thai-foreign joint ventures	34
Foreign owned	18
Number of employees	
>700	16
351 – 250	23
201 – 250	23
101 – 200	18
51 – 100	16
< 50	4

Table 2 Means, standard deviation and correlations

Variables	Mean	S.D.	II	EI	Product innovation
Internal Integration (II)	3.75	0.69	*.74*		
External Integration (EI)	3.74	0.78	.58**	*.79*	
Product Innovation	3.69	0.72	.27**	.44**	*.79*
Years of employment (marker variable)	2.91	1.01	.07	.01	.08

*Note: ** Correlation is significant at the 0.01 level (two-tailed); the numbers in italic are the square-rooted AVE of the construct.*

Table 3 Results of structural equation modelling: Standardized path coefficients

Hypothesis	Path coefficient (t-value)	Conclusion
H1: Internal Integration (II) → product innovation	.12 (1.57)	H1 not supported
H2: External Integration (EI) → product innovation	.47**(2.79)	H2 supported
H3: Balanced II and EI → product innovation	.06 (0.97)	H3 not supported
H4: Complementary II and EI → product innovation	.23** (2.82)	H4 supported

*Note: ** $p < 0.01$;*

Appendix A – Construct measurement, reliability and validity

Construct (Source) / Indicator	**Loading**	**Reliability and validity**
Internal integration (Stank et al., 2001; Narasimhan and Kim, 2002; Flynn et al., 2010) Have a high level of responsiveness within our plant to meet other department's needs	0.74	Goodness-of-fit indices: $\chi2$ = 11.67, df = 2, $p < 0.001$; CFI = 0.96; IFI = 0.96; TLI = 0.90; RMSEA = 0.06; Cronbach's alpha = 0.83; Composite reliability = 0.83; AVE = 0.55.
Have an integrated system across functional areas under plant control	0.83	
Within our plant, we emphasise information flows among purchasing, inventory management, sales, and distribution departments	0.67	
Within our plant, we emphasise physical flows among production, packing, warehousing, and transportation departments	0.72	
External integration (Narasimhan and Kim, 2002; Flynn et al., 2010; Vijayasarathy, 2010; Dröge et al., 2012) We emphasise physical flow with our major suppliers/customers	0.78	Goodness-of-fit indices: $\chi2$ = 10.93, df = 2, $p < 0.001$; CFI = 0.94; IFI = 0.91; TLI = 0.93; RMSEA = 0.06; Cronbach's alpha = 0.79; Composite reliability = 0.89; AVE = 0.63.
Share information to major suppliers through information technologies	0.82	
Have a high degree of strategic partnership with major suppliers	0.72	
Share information to major customers through information technologies	0.80	
Have a high degree of joint planning and forecasting with major customers to anticipate demand visibility	0.85	
Product innovation (Rondeau et al., 2000; Koufteros et al., 2005)		Goodness-of-fit indices: $\chi2$ = 12.37, df = 5, $p < 0.001$; CFI = 0.98; IFI = 0.98; TLI = 0.95; RMSEA = 0.07; Cronbach's alpha = 0.89; Composite reliability = 0.89; AVE = 0.62.
Respond well to customer need for "new" product features	0.69	
Develop unique product features to our customer needs	0.75	
Develop new product features into the market quickly	0.77	
Develop new product features to our customers	0.85	
Change product offered to meet customers' needs	0.86	