Early Supplier Involvement for Reducing Lead Time in New Product Development

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The paper aims to investigate the impact of Early Supplier Involvement (ESI) on the lead time for placing a new product in the market, as lead time is crucial for the success of firms in the dynamic business world. Accelerated product development offers advantages like the first mover advantage, a longer product life cycle, and customer insights, making lead time reduction important for technology-based companies. The paper adopts a survey-based analysis methodology, where a questionnaire is formulated based on insights acquired from a pilot focus group discussion with experts in the product development field.

Keywords: New Product Development, Early Supplier Involvement, Lead Time

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1. Introduction

In the dynamic business world of recent decades, 'Time to Market' or the 'Lead Time' for New Product Development (NPD) has become an essential factor for the success or failure of the firms, or at least for the commercial goals of the product. Accelerated product development gives key benefits like a first-mover advantage, longer product life cycle, customer insights for further innovation and product improvement as demanded by customers, etc. Lead time has become imperative for technology-based companies; they sometimes consider their strategic competitiveness against their competitors based on this factor alone. A delay in lead time can drastically reduce the profitability of a new product.

Reducing the lead time for new product development is the utmost priority for most organizations. All such organizations are exploring different modalities of product development to minimize the time to market of their new products. If any proven methodology can be identified that grossly helps minimize the lead time, that can be an attractive tool for business managers.

2. Literature Review

In 1997, while introducing the Journal of Marketing Research's special issue on "Issues and Opportunities in New Product Development," Wind and Mahajan mentioned seven global "dramatic" shifts in business practices that require academic attention towards NPD. These dramatic alterations include technological development, globalization, changes in demographics, and increased government scrutiny of business. These social, political, and economic shifts have been greatly magnified in the last few decades. That explains why the approaches to NPD adopted by organizations and the theoretical perspectives built in this area have seen significant twists and turns. Takeochi and Nanoka [1], for instance, mentioned that "new product development" must involve a holistic process like the "rugby game" to ensure maximum speed, where the entire team, as a unit, tries to go the distance to meet the demands and achieve success. This approach has a stark difference from the previous "relay race" style of the 1970s, which involved the sequential functioning of specialists. The holistic approach incorporates six defining characteristics, including multi-learning, subtle control, and self-organizing project teams. One of the pioneering studies in this field [2] suggested that the success of new product development relies on internal and external organizational communication. In consonance, Cooper and Kleinschmidt [3], too, prescribed that, in addition to product superiority and project definition, the overall marketing synergy is critical for effective new product development. In terms of new product development success, multiple recommendations and theoretical underpinnings are available. Gatignon and Xuereb [4] found strategic management and innovation to be the key variables in product development success. On the other hand, Moorman and Miner [5] emphasized the integration of planning and execution.

Clark [6] has shown how the combination of in-house development and external development can impact the lead time in NPD for the auto industry in Japan. Several studies have successfully explored critical factors affecting the NPD. Brown & Eisenhardt [7] have listed some of the crucial aspects, such as

a. Team composition, team organization of work, and group processes
b. Project Leadership & Management Support
c. Product Concept & Effectiveness
d. Marketing issues
e. Supplier & Customer integration

In recent times, Shankar and colleagues [8] have defined NPD as a process of iteration since it requires the simultaneous gathering of information, creation, and evaluation. Despite having a rich history of marketing research in NPD, theorists like Urban and Hauser [9] have been skeptical and pessimistic about the overall improvement of product development; this calls for an in-depth analysis of NPD. The

literature reveals that both speed and quality are indispensable parts of NPD. In terms of speed, there are two significant concepts, i.e., cycle time [10] and lead time [11].

Lead time is the time gap between when a product or service has been requisitioned by the customer and when it is fulfilled or delivered. It is the sum of production and processing lead times and waiting times. The waiting time may vary based on how the production system responds to demands out of five widely accepted approaches, i.e., 1) Make to Stock (M.T.S.) 2) Assembly to Order (A.T.O.) 3) Make to Order (M.T.O.) 4) Resources to Order (R.T.O.) 5) Engineer to Order (E.T.O.) The production lead time is a combination of three sub-components, i.e., 1) manufacturing lead time, 2) assembly lead time, and 3) supplier lead time.

In this regard, the knowledge base of the main developing firm plays an important role [12]. In developing NPDs and getting some components developed by suppliers, the firm's internal knowledge base determines how capable it can become of acquiring knowledge from external stakeholders by leveraging R&D alliances. Many studies in the auto industry, mainly in Japan, have identified that through effective management of the supply chain, firms have maintained long and trustworthy relations among themselves and developed and designed components for new products [13] [14] [15]. The tendency to outsource for NPD is limited to buying components from suppliers; more attention is now being paid to system sourcing, which implies buying complex packaged solutions rather than only components [16].

3. Research Problem

The impact of Early Supplier Involvement (ESI) on Product Development and project scope in the auto industry in Japan has been nicely examined, and a model has been prepared to predict estimated development manhours based on project scope [6]. However, most traditional studies on ESI focused mainly on the outcome and not on the nitty-gritty of supplier relations like the tie between involvement and contract management, collaboration among top executives, and so on. R. McIvor and P. Humphreys [17] tried to develop a scale to measure the level of integration in ESI based on the constructs and items compiled in Table 1 below:

Table 1. Constructs and items for the level of integration in ESI

A. Extent of supplier involvement in product development	• Evolution of level of involvement in design process • Timing of supplier involvement • Functions involved from the buyer and supplier organizations • Information exchanged in design • Timing of supplier involvement in relation to purchased items • Degree of competition between suppliers • Influence of corporate level
B. Buyer-supplier relationships	• Supplier contract length • Evolution of buyer-supplier relationships • Influence of relationship categories on ESI • Approach to contract management • Culture effects • Influence of power dependency
C. Information exchange	• Communication links used in the supply chain • Level of information exchange in the supply chain • Operation of open book costing, cost transparency, and total cost of ownership in the supply chain • Manufacturing costing methods used by suppliers • Types of communication links between the Company and its key suppliers • Level of cross-functional communication between the Company and its

	suppliers • Nature of supplier involvement in cost analysis in the design process

The above constructs and items are established and can be used for designing a survey to measure the level of ESI in a product-developing firm and its suppliers. In this study, the lead time for NPD is the dependent variable (DV), and the above items are the independent variables (IVs). Efforts would be made to find whether there is any significant correlation between the above constructs or items and the dependent variable. As of now, the study is industry independent. However, if felt required in due course of the data collection, the study may be made industry-specific, like construction, IT, pharma, auto, FMCG, etc. The study would be made in the Indian context because the data would be collected in this sub-region and reflect the scenario only. Some more control variables have been identified that may affect the model's outcome. However, this list is not exhaustive and may go through any addition, deletion, or modification during the research. The control variables are market disruptions, volatility, IT resources available to the firms, and product complexity.

4. Hypothesis Development

Successful NPD depends extensively on the effective utilization of information and insights from internal and external knowledge bases. In such a scenario, timely collaboration may give the buyer an edge in terms of developing the targeted product with less lead time. So, the first hypothesis for the study is:

H1a: A negative relationship exists between the development lead time and the three main aspects of ESI.
Subhypotheses are:
H1b: The supplier lead time can be reduced by higher level of ESI
H1c: Once prototype is developed (NPD is successful), the same relation (H1a) will prevail in mass production phase

ESI and R&D alliances give access to broadened and heterogeneous knowledge bases, which in turn help immensely with NPD. But ESI also involves some transactional costs. because the suppliers engage their resource pull with some commercial objectives. Some of the knowledge bases at the supplier may be IP-protected and may require high transactional costs compared to developing them in-house. Especially when the required capability of the suppliers is crucial to developing a product that is desired by customers and very few suppliers have that capability, the transaction cost may be very significant and may impact the NPD cost plausibly in view of the quality requirement and market success of the product. Further, any resource with niche skills may remain idle for a significant period when a particular task is outsourced, while the same could have been utilized had the solution been developed in-house. So, any ESI may have a significant effect on the NPD cost as well. But, on the other hand, since the product can be launched in the market with very little time due to ESI, the total fixed overhead for the NPD may get considerably reduced due to ESI. Whether the transaction cost will surpass the commercial advantages gained from the ESI or vice versa is the next hypothesis of this study. The "Total Cost of Ownership" concept can be applied to testing this hypothesis. The hypotheses are:

H2a: ESI will have impact on the overall NPD cost
H2b: NPD cost will have negative relation with the aspects of ESI

The third dimension that may have a significant relationship with the product lead time is the quality of the product. In general, it is a trade-off between time-to-market for the product and the quality of the product. But with ESI, the firms try to gather more knowledge and utilize that knowledge base to put the desired attributes into the product. So, the trade-off between lead time and quality may not exist when resourceful suppliers are engaged through ESI. The third set of hypotheses are:

H3a: Product Quality will be impacted by ESI
H3b: Positive relations exists between the Product quality and Level of ESI

In view of the above three sets of hypotheses, there is one additional presumption, i.e., that a trilemma may exist between the lead time, NPD cost, and quality of the product. This essentially means it may not be possible to reduce the first two and increase the third at the same time by employing early supplier involvement (ESI). But testing the existence of any such trilemma may not be within the scope of this study.

5. Research Design

5.1 General Methodology

Out of the different research methodologies available, the survey-based analysis method has been adopted for this study. However, prior to formulating the questionnaire, a focus group discussion was carried out as a pilot to understand the nitty-gritty of the research topic. A number of experts from the product development field were consulted, and valuable insights were acquired from the discussion. This pilot work provided a basic framework for designing the questionnaire. As the main study, survey-based analysis has been adopted.

5.2 Sample Selection

Samples have been selected from the product development teams across the industry. The audience has been selected from across the industries to capture the differences among them, if any. As a first step, the prospective audience has been identified based on their professional background and profile. In addition to different industries, demographic details have been taken for types of organisations as well, like government, not-for-profit, for-profit, etc. Relationships with suppliers vary from organisation to organization. To capture the extent of engagement with suppliers, the frequency of supplier involvement has also been captured. The idea was to identify any dependence on or impact of that on the lead time reduction.

5.3 Data Gathering

There are number of methods for gathering required data for any research study. It can be Questionnaire, Interview, Focus group discussion, Case Study etc. For this study questionnaire has been formulated first primarily based on the Scale Developed by R. McIvor & P. Humphreys [17] in their study in 2003. The questionnaire was then converted into multiple choice question in Google Form for easy collection of data. The questionnaire link for the Google Form was then shared to the Selected Audience group through different communication platforms like Emails, WhatsApp, Text Messaging, LinkedIn etc.

6. Results and Discussions

Non-significant chi-square values indicate that the obtained model does not significantly differ from the hypothetical model. Therefore, a smaller and less significant chi-square value is preferred [18] [19]. However, it is rare to find non-significant chi-square values in social science research. Therefore, another criterion, i.e., the ratio between chi-square and degrees of freedom [20], is also considered. A score between 1 and 2 is acceptable [21].
Another widely used criterion is RMSEA (root mean square error of approximation) [22], which deals with the estimated population mean. The value of less than .08 was considered acceptable [23][24]and

less than .05 is considered a good fit.[25] [26]suggested that a value of .1 or more than that denotes a poor-fit model. For the present study, the upper limit of RMSEA is set at 0.06 [27].

Bentler Comparative Fit Index (CFI) is defined as "an incremental fit index that measures the relative improvement in the fit of the researcher's model over that of a baseline model, typically the independence model" [19]. A CFI value of .90 or more than that indicates a good model fit.

In the current study, a three-factor model of NPD showed good model fit indices, $\chi 2/df$ ratio = 1.143, CFI =.983, RMSEA =.052. The standardized regression coefficient of the three factors is presented in Table 1. The reliability coefficient of the extent of supplier engagement in NPD, buyer-supplier relationship, and information exchanged factors is measured through the assessment of the Cronbach alpha coefficient. The Cronbach alpha coefficient values for the extent of supplier engagement in NPD, buyer-supplier relationship, and information exchanged subscales are.879,.837, and.933, respectively.

One-way analysis of variance (ANOVA) to determine if differences exist in these three factors based on the type of organization, frequency of collaboration of the organization with the supplier, type of primary offering of the organization, upgrade or modification needs of the organization and/or development of new products due to competition, and involvement of lead time in developing new offerings by the company. The level of significance was set at p =.05. The Tukey Honest Significance Difference (HSD) test was performed after a significant difference was found.

This study, validated by data, is an insightful source for the practitioner who are associated in project management or Product Management. It gives them good idea about how the early supplier involvement can be implemented effectively and which aspects/ items of ESI will be more effective in reducing the overall product lead time. It also helps them to understand how the Cost side and Quality side of the NPD gets affected by ESI. For any academician also it is a good document to start with further studies to find out any trilemma.

Table 2. Standardized regression coefficient of factors

Factor Name	Item	Standardized Regression Coefficient
Extent of supplier engagement in NPD	Evolution in relation between buyer and supplier (towards more information sharing) helps in reducing Lead time of NPD	.896
	Higher degree of competition among suppliers results into reduced Lead time of NPD	.727
	Enhanced trust and communication at corporate level of the Buyer and Seller will reduce the lead time for developing new offerings	.889
	Engagement of multiple functions (Contract, Procurement, Accounts etc.) reduces the Lead Time of NPD	.695
Buyer Supplier Relationship	Longer term contract between Buyer and Seller reduces the Lead time for NPD	.561
	Higher level of information sharing reduces the lead time in designing new offerings	.909
	More collaborative approach towards Contract Management helps in reducing the Lead Time of NPD	.924
	Cultural fitment between supplier and buyer helps in collaborating seamlessly and thus reduces Lead Time of NPD	.803
	Higher dependency between the buyer and supplier reduces the Lead Time for NPD	.311
	When product complexity is high, the more the collaboration between the product designer and supplier the less is the Time-to - market for the product	.471

Information Exchanged	Fast and easily accessible channel of communication for information sharing reduces the Lead Time required in NPD	.939
	Transparency in information sharing (Like cost information) improves the TCO of the Supply Chain and reduces the Lead Time for NPD	.967
	Higher level of cross functional information sharing reduces the Lead Time of NPD	.789
	Collaboration with part suppliers from early stages of product design helps in identifying potential problems in prototype and improve quality in final product	.896

The correlation coefficient in Table 2 shows the degree and direction of correspondence between two or more variables. Also, the structural equation model (SEM), depicting these correlations is shown in Figure 1. Bivariate correlations are calculated between the three factors of the study. The descriptive statistics and correlation coefficients are presented in Table 3.

Table 3. Descriptive statistics and correlation coefficients

	Extent of supplier engagement in NPD	Buyer Supplier Relationship	Information Exchanged	Mean (SD)
Extent of supplier engagement in NPD	1			23.12 (5.46)
Buyer Supplier Relationship	.733**	1		30.62 (7.86)
Information Exchanged	.741**	.674**	1	23.52 (5.55)

7. Managerial Implications

In today's competitive market in the product domain, this study can be a good reference point for formulating product development strategies. As the study suggests that all three constructs of ESI have a high load on product development lead time, the product development life cycle can be reduced by systematically implementing ESI. It will eventually create great value for the organization in terms of customer satisfaction and agility. Further, if the total lead time is broken into micro-lead times based on phases associated with the total cycle, even better ESI can be implemented. For example, when a product is in the design phase, a supplier's design wing can be involved for better layout design. Again, when the product is in the manufacturing or assembly phase, the collaboration and high level of coordination between the buyer's procurement team and the supplier's delivery team can reduce the production lead time by matching demands and supplies on time in the correct quantity. Again, during the distribution phase, close engagement with distribution partners will reduce delivery lead times. In combination with the reduced lead time of each phase, the overall time to market for the product may improve considerably.

The delivery schedule is a great matter of concern for procurement professionals today. Various intermediate quality check processes become a significant barrier to delivering materials in the shortest possible time. So, in industry, quality and lead time are positively correlated with high coefficients. So, it is a big challenge among business managers to optimize lead time without computerizing quality checks. Better coordination through ESI can unlock additional time for all suppliers involved. It can be done by designing a brilliant supply chain and minimizing movement. If all suppliers have a float in their delivery schedule as per the supply chain design, no supplier will waive quality checks. Thus, ESI is a boundary shifter concept as per the Kano Model because it pushes the boundary of the Quality vs. Probability of On-Time Delivery curve.
Although it is evident that improving the ESI score will help reduce the development lead time of a product, how the ESI score can be improved is a big question. Because in today's data-dominated

world, protecting one's own proprietary data while engaging closely with the supplier is a tall challenge for all executives. For most product-based companies, some information or data is highly controlled. If such documents are misused, the company may face a huge business impact. So, formulating the right modality for ESI while protecting controlled information is imperative. Information exchanged is the main construct for measuring the degree of ESI. So, naturally, the more data shared, the higher the level of ESI. Because data exchange facilitates time-right decision-making and building strong trust, segregating which information is to be exchanged from those that is controlled and treating them separately is what business managers should ponder upon. It may vary based on how the data is captured. If it's in hard form, it is relatively safe from multiple undesired reproductions. But here, the risk of destruction of the data remains. If data is maintained in an organization in a weakly secured soft format, it is difficult to control documents while implementing ESI. Companies that maintain data in soft form may opt for more ingenious security techniques like multi-bit encryption, high-security cloud storage, etc.

A reduction in lead time in NPD can create more value for customers by improving the agility of the supply chain. In addition, postponement strategies can be effectively and brilliantly implemented if ESI is adopted in a designed manner. This will obviously vary across industries and may not always be true. However, such a complex supply network can be designed using a combination of ESI constructs, postponement strategies, push-pull strategies, etc. This can create tremendous value for the organization by serving customers profitably.

8. Recommendation and Future Scope

The paper recommends the importance of Early Supplier Involvement (ESI) on the lead time for placing a new product in the market, which is crucial for the success of firms and the commercial goals of new product development. It also provides insights into how ESI can be effectively implemented and which aspects of ESI are more effective in reducing the overall product lead time. The study also explores the relationship between ESI and the cost and quality aspects of new product development, offering valuable information for business managers and practitioners in project and product management.

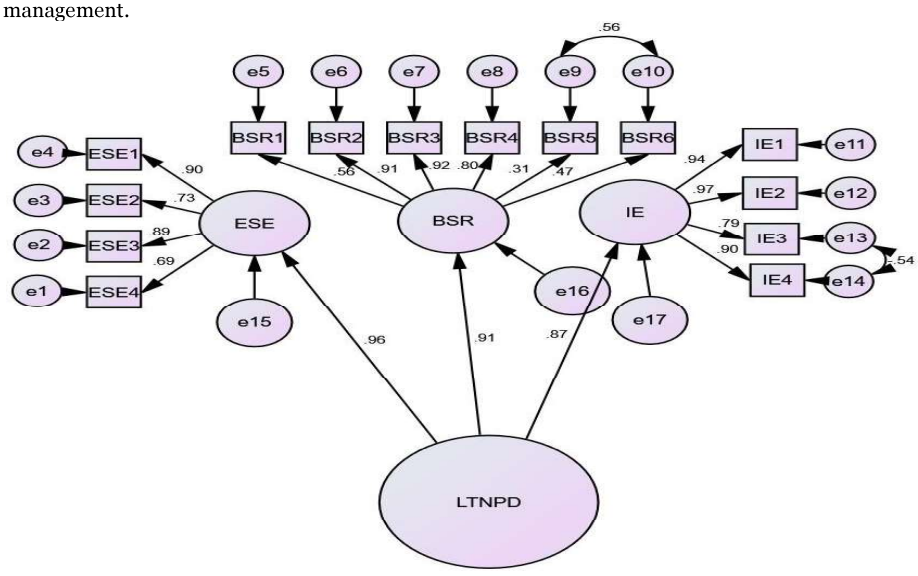

Figure 1. SEM Model

In this study, the lead time for NPD has been measured by direct questions. This could have been done in the indirect method as well. Like we adopted an established scale for measuring the ESI factors, a similar scale with constructs and items measuring the lead time could have been an even better way of exploring this study. This would also have given a more practical and reliable scale for measuring the lead time. Also, the impact of ESI on the quality aspect of the product is another area that is not concluded in this study. This can be an equally important area of study for many researchers.

The impact of ESI on the Intellectual Property Rights (IPR) of an organization can be a very interesting area to study. In today's digital world, and especially with the post-COVID trend of virtual operation of organization can pose a great threat to their data protection capabilities while implementing ESI for creating value. For ease of operations, everyone is now going digital for each of the business activities. But what is the impact of such a drive on the global IPR scenario? That might be a good area to explore.

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