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# Lessons from empirical studies in product and service variety management

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**Abstract:** For many years, a trend for businesses has been to increase market segmentation and extend product and service-variety offerings in order to provid more choice for customers and gain a competitive advantags. However, there have been relatively few variety-related, empirical studies that have been undertaken. In this research, two empirical studies are presented that address the impact of product and service variety on business and business function performance. In the first (service-variety) study, the focus concerns the relationship between service provision offered by UK-based, third-party logistics (3PL) providers and the operational and financial performance of those providers. Here, the results of a large survey identify the most important services offered by 3PLs and the most important aspects of 3PL operational performance. Also, the research suggests that the range of service variety offered by 3PLs does not directly influence the 3PLs' financial performance. The second (product-variety) study presents the findings from an analysis of data from 163 manufacturing plants where the impact of product variety on the performance of five business functions is examined. An increase in product variety was found to influence business functions differently depending on the combination of customisation and variety offered to customers.

**Key words:** *variety management, sku proliferation, mass customisation.*

## 1. Introduction

Success for many businesses is often dependent on their ability to innovate, develop new ideas and introduce new products and services. In modern, highly-competitive business environments it is difficult for sales to be maintained or grown from a fixed portfolio of products or services. Rather, sales growth is dependent on the ability of a business to stimulate an existing market or penetrate a different one by offering new choices. Consequently, product development has become more rapid, manufacturing systems have become more flexible and stock-keeping unit (sku) proliferation and variety continue to increase (Fisher & Ittner, 1999; Hu et al., 2011; Meyr, 2004) . Differentiation of products has gone beyond the simple and prosaic categories of age, size and gender to include regional and national tastes, personal attributes and personal lifestyle. The management of the complexity associated with wide product diversity has become is core to competitive advantage.

However, despite the fact that high product variety may lead to an increase in sales, it does not necessarily guarantee an increase in business profits or competitiveness. Moreover, product variety can have a positive effect on both sales and market share, but can also have negative consequences for business performance (Yeh & Chu, 1991). For example, higher product variety may increase manufacturing costs through an increase in the complexity of the production process. It can also cause higher complexity of the demand forecasting process and make obdurate the alignment of supply with demand in the supply chain (Whang & Lee, 1998; Randall & Ulrich, 2001). Many businesses have started to recognise that 'more' is not necessarily better and that a trade-off exists between product variety and business function performance (Thonemann & Bradley, 2002). Those increasing variety in their products and services should also, therefore, consider the impact of product variety on the performance and cost profile of their business functions.

Decisions relating to product variety can be viewed as focusing on how to innovate, engineer and produce products and services with the requisite level of customer choice. However, only by extending this focus to other business functions can the full implications of product variety be revealed (Ramdas, 2003). The fundamental question concerns the level of variety offered. The solution necessarily concerns the need to assess the benefits in relation to the increased cost and resource burden.

## 2. Empirical Studies

### 2.1. Study 1 – Service Variety Management

In recent years, many 3PL providers have extended their service range to include warehousing, freight forwarding, packaging and managing product returns. Extending service variety has increased competition amongst 3PL providers. The aim of this study is to provide an evaluation of the relationship between the variety of services offered by UK-based, third-party logistics (3PL) providers and the performance of those providers. The evaluation is based on a recent survey (Liu & Lyons, 2011).

To support the development of competitive strategies and for mitigating investment risks, logisticians need to understand the relationship that exists between 3PL performance and different logistics service offerings. Previous research concerning the relationship between service variety and performance has made only a limited contribution to understanding the relationship that exists between 3PL performance and the range of service provision. In addition, there has been relatively little attention given to empirical studies of both providers and customers. This research has set out to address these gaps by empirically exploring the relationships between service variety and performance from both a provider and customer point of view. The level of the provider's service capabilities should meet the customer's requirements. Therefore, the review of the service capabilities is based on both a provider and customer perspective.

The key phases of the study methodology are shown in figure 1.

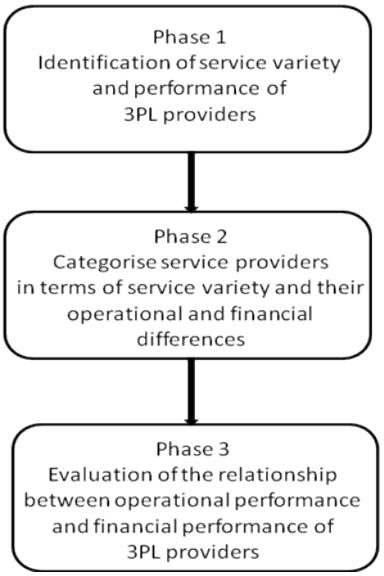


**Figure 1.** Study 1 methodology.

In summary, the methodology concerned the identification of the performance and service capabilities of 3PL providers. This consisted of a review of previous studies and the development of a survey questionnaire. Cluster analysis was used to distinguish 3PLs in terms of service variety. A one-way analysis of variance (ANOVA) was used to test whether there were significant differences in 3PL operational and financial performance. A simple regression analysis was used to evaluate the relationship between operational performance and the financial performance of 3PL providers.

**Table 1.** Financial and operational performance indicators.

| Items |
|---|
| f1. Gross profit margin |
| f2. Sales growth |
| o1. To deliver expedited shipments/speed of delivery |
| o2. To offer short delivery lead-time |
| o3. On time and accurate delivery |
| o4. Higher customer satisfaction ratings |
| o5. To enhance customer success |
| o6. Lower customer complaints (percentage of total sales) |
| o7. To deliver goods in an undamaged state |
| o8. To accommodate special or non-routine requests |
| o9. To handle unexpected events |
| o10. To provide quicker response to customers |
| o11. To operate with low overall operating cost as a percentage of sales |
| o12. To improve the rate of utilisation of facilities/equipment/manpower in providing the services |
| o13. Aggressiveness in increasing the value-added content of services |
| o14. Aggressiveness in the reduction of order cycle time |
| o15. To provide new and better services/ speed of introduction for new services |

 

**Table 2.** Service variety indicators.

| | | | |
|---|---|---|---|
| s1. Inbound transportation | s9. Inventory management | s17. Simple processing | s25. Selection of software |
| s2. Outbound distribution | s10. Pick and pack | s18. Bar code scanning | s26. Interfacing with ERP systems |
| s3. Merge in transit | s11. Order fulfilment | s19. RFID | s27. Invoicing/billing function |
| s4. Rate negotiation | s12. Cross-docking | s20. EDI capability | s28. Freight bill auditing/ payment |
| s5. Carrier selection | s13. Product returns | s21. Electronic commerce | s29. Billing the final customer |
| s6. Freight forwarding | s14. Labelling/marking | s22. Tracking and tracing | s30. Insurance service |
| s7. Storage | s15. Packaging | s23. Logistics information systems | s31. Consulting services |
| s8. Storage of special requirements | s16. Relabeling/ repackaging | s24. Order management systems | s32. Management reports |

A postal survey was used as the principal method of data collection for this study. Financial performance was measured on a two-item scale: gross profit and sales margin. The fifteen indicators for operational performance were identified by referring to previous logistics research (Ellinger *et al.*, 2002; Fawcett & Smith, 1995) and from discussions with logistics academics and practitioners (see table 1). The 32 service variety indicators were identified by referring to previous logistics research (Lai, 2004; Murphy & Poist, 2000; Stefansson, 2006) and by conducting personal interviews with practitioners (see table 2).

621 3PLs that provided transportation and warehouse-related services were contacted as part of the survey. A further 595 large manufacturing customer companies were also contacted. For 3PLs, the effective population size was reduced to 513 as 93 respondents indicated that their companies only provided services for internal users, 11 service providers did not provide any transportation/ warehousing or value-added related services and 4 of the respondents did not provide services for manufacturing. The total usable number of responses was 112. Therefore, the overall response rate was 21.8% (112/513). For customers, 168 usable questionnaires were obtained. Therefore, the total response rate was 28.2 per cent (168/595).

The reliability of a questionnaire is associated with the consistency of responses to questions. Reliability is usually expressed on the basis of the Cronbach's alpha coefficient. Levels of 0.70 or more are generally accepted as representing good reliability (Hair *et al.*, 2006). With the exception of financial performance for the 3PLs (0.605), all of the reliability scores exceeded this minimum reliability standard of 0.70.

## 2.2. Study 1 Results

For customers, outbound distribution was viewed as the most important service capability by respondents, followed by order fulfilment, rate negotiation, tracking and tracing and interfacing with ERP systems (mean scores were derived from a seven-point scale where 1 represented very unimportant and 7 signified very important). Table 3 highlights the ten services identified as being the most important for customers.

On-time and accurate delivery was viewed as the most important aspect of operational performance by respondents for customers, followed by undamaged state delivery, and higher customer satisfaction. Table 4 presents an importance ranking and highlights the top five most-important items.

In order to classify the 3PLs according to the variety of their service provision, a cluster analysis was undertaken using the 32 items. There are two approaches that are most-widely used for this procedure: the hierarchical method and the non-hierarchical method. In this research, a hierarchical

**Table 3.** Importance of 3PL service capabilities to customers.

| Rank | Service capabilities | Mean |
|---|---|---|
| 1 | s2. Outbound distribution | 6.288 |
| 2 | s11. Order fulfilment | 6.119 |
| 3 | s4. Rate negotiation | 5.966 |
| 4 | s22. Tracking and tracing | 5.774 |
| 5 | s26. Interfacing with ERP systems | 5.770 |
| 6 | s23. Logistics information systems | 5.690 |
| 7 | s7. Storage | 5.689 |
| 8 | s32. Management reports | 5.669 |
| 9 | s9. Inventory management | 5.593 |
| 10 | s29. Billing the final customer | 5.590 |

**Table 4.** Importance of 3PL operational performance to customers.

| Rank | Operational performances | Mean |
|---|---|---|
| 1 | o3. On time and accurate delivery | 6.62 |
| 2 | o7. Undamaged state delivery | 6.57 |
| 3 | o4. Higher customer satisfaction | 6.10 |
| 4 | o6. Lower customer complaints (percentage of total sales) | 5.99 |
| 5 | o1. To deliver expedited shiments/speed of delivery | 5.85 |

cluster analysis, by way of Ward's (1963) partitioning technique and the Squared Euclidean Distance-method, was used, and provided the most suitable number of clusters. All responding firms were assigned initially to these clusters. A non-hierarchical technique, that is, K-means cluster analysis was subsequently used to re-assign the respondents into the most appropriate clusters through an iterative process.

The 92 responding firms (in order to conduct a K-means cluster analysis, 20 of the 112 were excluded due to missing data) were assigned to three clusters: 36 in cluster 1, 21 in cluster 2 and 35 in cluster 3. A one-way ANOVA was used to examine which of the service capabilities differed across the three clusters. 27 items were found to significantly differ. Only five items (s1: inbound transportation, s2: outbound distribution, s6: freight forwarding, s29: billing the final customer and s30: insurance service) did not significantly differ across the three clusters.

The first type (cluster 1, n=36) accounts for 39.1% of the sample. These types of 3PL achieved a medium-level of capability concerning transportation-related services (s1, and s3~s6), warehousing-related (s9~s13), value-added services (s14~s17), information technology (s21~s25), finance-related (s27~s30) and other services (s31 and s32). Compared to cluster 3, they have a much higher capability in warehousing-related, valued-added and information technology-related services.

The second type (cluster 2, n=21, 22.8%) possesses a high level of capability in most of the 32 logistics service items. This suggests that they are comprehensive 3PLs.

The final type of 3PL (cluster 3, n=35, 38.0%) possesses a medium-level of capability in carrying out the three aspects of transportation-related service (s1, s2 and s4), the one aspect of warehousing-related (s7), all of the finance-related services (s27~s30) and one aspect of other services (s32). This type of 3PL under-performed in most warehousing-related, value-added, and information technology aspects of provision. These firms are traditional transportation companies.

To determine if 3PL clusters differ in terms of financial and operational performance, another one-way analysis of variance (ANOVA) was undertaken. The ANOVA results presented in Table 5 indicate that statistically significant differences, that is $p < 0.05$,

**Table 5.** ANOVA analysis of performance differences across the three clusters.

| Items | 1 (n=36) | 2 (n=21) | 3 (n=35) | F |
|---|---|---|---|---|
| f1. Gross profit margin | 4.57 | 4.62 | 4.09 | 1.630 |
| f2. Sales growth | 4.36 | 5.05 | 4.37 | 2.183 |
| o1. To deliver expedited shipments/speed of delivery | 5.26 | 5.52 | 5.26 | 0.696 |
| o2. To offer short delivery lead-time | 5.50 | 5.55 | 5.17 | 1.325 |
| o3. On time and accurate delivery | 5.64 | 5.90 | 5.54 | 1.043 |
| o4. Higher customer satisfaction ratings | 5.61 | 6.05 | 5.49 | 3.465* |
| o5. To enhance customer success | 5.31 | 5.90 | 5.14 | 4.515* |
| o6. Lower customer complaints (percentage of total sales) | 5.53 | 5.86 | 5.29 | 1.763 |
| o7. To deliver goods in an undamaged state | 5.77 | 6.05 | 5.50 | 2.376 |
| o8. To accommodate special or non-routine requests | 6.11 | 6.10 | 5.76 | 1.484 |
| o9. To handle unexpected events | 6.00 | 6.19 | 5.97 | 0.422 |
| o10. To provide quicker response to customers | 5.89 | 6.14 | 5.62 | 2.550 |
| o11. To operate with low overall operating cost as a percentage of sales | 4.67 | 4.81 | 4.26 | 1.654 |
| o12. To improve the rate of utilization of facilities/ equipment/manpower in providing the services | 4.86 | 5.33 | 4.50 | 5.081* |
| o13. Aggressiveness in increasing the value-added content of services | 4.63 | 5.38 | 4.49 | 5.422* |
| o14. Aggressiveness in the reduction of order cycle time | 4.57 | 5.30 | 4.41 | 5.421* |
| o15. To provide new and better services/speed of introduction for new services | 5.00 | 5.38 | 4.55 | 3.814* |
| Overall operational performance** | 5.36 | 5.70 | 5.13 | 6.319* |

* represents significant level $p < 0.05$
** means the average of all aspects of operational performance.
*** pairwise differences shown are significant at the 0.05 level.

existed among the three 3PL clusters in some of the operational performance items.

Results of a chi-square analysis revealed that total sales volume and number of employees significantly differed across the three clusters at the $p < 0.05$ significance level.

## 2.3. Study 1 Conclusions

A positive and significant relationship was found between operational performance and the 3PL financial performance. This finding suggests that if 3PLs can improve their operational performance, they will increase the financial performance of their businesses. It implies that customers will be more satisfied with using their services. The influences of service variety on 3PL operational performance were partially supported. It appears that 3PL clusters with a wide service variety offering generally have better operational performance. Results showed the ratings differed significantly in six of the fifteen aspects of operational performance. Aligning high levels of operational performance with quality (i.e., o4 and o5) and innovation (i.e., o13~o15) was found to be a necessary strategy for the UK's 3PL providers.

However, the impact of service variety on the 3PL providers' financial performance was not supported. This implies that the range of service provision offered by 3PLs cannot directly influence the 3PLs' financial performance. Through a better operational performance, 3PL providers with a broader range of service provision that correspond to the key priorities of customers will gain superior financial performance.

## 2.4. Study 2 – Product Variety Management

The key aim of this second study was to explore and compare the impact of product variety on business function performance.

Five business functions were examined: Engineering, Manufacturing, Purchasing, Logistics and Marketing. A questionnaire composed of 37 questions concerning the impact of product variety on business function performance and 5 questions related to product variety and customisation were sent to 1,500 manufacturing companies. All target companies were large enterprises (LEs) with total sales values in excess of £2 million. LEs were selected as the intention was to target manufacturers that had resources to invest in increasing product variety. Individuals from 163 companies with increasing variety responded to the impact of product variety questions from the survey questionnaire, which is an acceptable, overall response rate overall of 15%. Respondents were asked to "Indicate the impact of increased product variety on each item where the manufacturer had had a variety increase in its main product family during the past five years" using a 1-10 scale, on which 1 indicated the lowest increase and 10 the highest increase.

## 2.5. Study 2 Results

Performance within each function was captured from a number of individual items: four in Engineering ($\alpha$=0.866), sixteen in Manufacturing ($\alpha$=0.952), three in Purchasing ($\alpha$=0.883), nine in Logistics ($\alpha$=0.946) and five in Marketing ($\alpha$=0.891). The average impact of an increase in product variety on each of the different business functions was found to be as follows: Marketing (M=4.86), Engineering (M=4.65), Manufacturing (M=4.05), Purchasing (M=4.03), and Logistics (M=3.87). Items can be regarded as both the cost and non-cost related aspects of business function performance. Cost-related items have strong correlations with each other ($p$<0.01). Non-cost related performance can be either positive or negative: 1) positive: competitive advantage; customer satisfaction; market share; product flexibility; utilisation of standardised parts; postponement; outsourcing, 2) negative: demand forecast uncertainty; scheduling complexity; design complexity; manufacturing complexity; part variety; supervision effort; total quality control; manufacturing lead time; process variety; work-in-process inventory; finished goods inventory; purchased component/part variety; purchased part inventory; delivery time; order process complexity.

One of the most significant motivations for an increase in product variety is the ability to customise the product. Thus, with regard to customisation, the first of these factors, a high level of customisation is expected to have a corresponding high level of product variety and a level of variety that is higher than a low level of customisation. The three dimensions (fundamental, intermediate and peripheral) of variety were tested in relation to each customisation type (pure standardisation, segmented standardisation, customised standardisation, tailored customisation, pure customisation) using a one-way analysis of variance (ANOVA). Table 6 depicts the results. The results show significant statistical differences at the .05 and .01 levels. Typically, high customisation types were expected to display higher product variety than low customisation types with a general increase in variety across the PS to

**Table 6.** Anova analysis of variety differences according to customisation type.

| | Fundamental variety | Intermediate variety | Peripheral variety |
|---|---|---|---|
| **Mean** | | | |
| PS | 3.19 | 3.23 | 2.94 |
| SS | 3.09 | 3.47 | 3.29 |
| CS | 3.75 | 4.02 | 4.02 |
| TC | 4.14 | 4.24 | 4.05 |
| PC | 3.77 | 3.80 | 3.70 |
| Tot | 3.67 | 3.83 | 3.69 |
| F | 4.400** | 3.016* | 3.885** |
| Sig | 0.002 | 0.019 | 0.005 |

PC continuum. However, unexpectedly, tailored customisation (TC) displayed the highest level of product variety. This can be explained by the fact that empirically PC industries do not typically use their full variety-producing capabilities.

To examine the different impacts of increased product variety on the performance of the different business functions, a one-way analysis of variance (ANOVA) was undertaken. The ANOVA results (Table 7) indicate that statistically significant differences exist among the different customisation types. PS typically is impacted upon the most by an increase in product variety, followed by SS, CS, TC and PC. That is, the impact of increased product variety decreased across the PS to PC continuum. This is as expected and is attributable to an increase of the business function flexibility in the more-customised types. Overall, 7 items ($p < 0.01$), 11 items ($p < 0.05$) and 5 items ($p < 0.1$) out of the 37 items showed significant differences according to customisation type.

## 2.6. Study 2 Findngs

The unit cost of the product exhibited a significant difference across the continuum of customisation types for the Engineering function. Increased overhead, direct labour and material costs owing to increased product variety lead to a higher unit cost. However, customised standardisation (CS) and tailored customisation (TC) often use component sharing in the design of product families, which reduces overhead cost and the increase of the unit cost of a product can be reduced compared with pure standardisation (PS) and segmented standardisation (SS) even allowing for PS and SS making use of appropriate economies of scale.

Manufacturing, material and process technology investment cost displayed statistically significant differences across the customisation types, and in accordance with the expected trend across the continuum. PS incurs the highest escalation in manufacturing and material costs, followed by SS, CS, TC, and PC. The results highlight that a flexible manufacturing system and supporting business function design are essential factors to mitigate the trade-off between product variety and increased manufacturing cost. In the case of process technology investment cost, PC is affected less than CS, followed by TC, SS, and PS.

The ANOVA test demonstrates the highest increase in the use of standardised parts for PS, followed by CS, SS, TC, and PC. It is worthy of note that CS had the highest increase in the use of postponement, followed by PS, SS, TC, and PC. The result implies that the CS environments typically employ an assemble-to-order (ATO) production logic and are heavily reliant on postponement strategies and modularisation.

As expected, with respect to product flexibility, low customisation types such as PS and SS are affected more than high customisation types due to an increase in the use of standardised material. Process and part variety, manufacturing complexity and lead time are most adversely affected for the PS and SS types with an increase in product variety.

PS displays the highest increase in purchasing costs with product variety increases. PS suffers from a policy that typically requires the purchase of high volumes from selected suppliers and is consequently more adversely affected by increased parts and material variety than the more customised types. Further down the continuum, TC demonstrates the greatest increase in purchasing costs. Similarly, PS displays the highest increase in purchased components and materials, followed by CS, SS, TC and PC.

Market mediation costs, including inventory holding, mark-down, and lost sales, are primarily influenced by demand uncertainty. Although uncertainty of demand increases and forecasting accuracy decreases generally from a make-to-stock (MTS) to a design-to-order (DTO) strategy, the PS type may be affected more in the cost of inventory holding, mark-downs, and lost sales due the position of its decoupling point. PC typically has low market mediation cost because of the upstream decoupling point that allows inventory holding and stock-out costs to be affected less by an increase in variety. PS incurs a higher increase in transportation costs than the more customised types. The results indicate that the increased costs of the low customisation types may exceed the increased costs associated with less-than-truck-loads (LTL) in

 

high customisation types. As a consequence, the rate of increasing LTL cost due to disaggregated shipping is likely to decrease as product variety increases. In addition, high customisation types often require the delivery of products directly to customers, imposing delivery cost on the end customer, which could feasibly reduce the overall cost associated with transportation. Purchased parts, finished goods and work-in-process inventory such as semi-finished parts, exhibited the highest increases in cost with the low-level customisation types.

### 2.7. Study 2 Conclusions

The impact of product variety on the performance of five business functions (Engineering, Manufacturing, Purchasing, Logistics and Marketing) was examined through a study of 163 manufacturing plants. Each plant was classified as one of five customisation types: pure standardization (PS), segmented standardisation (SS), customised standardisation (CS), tailored customisation (TC) or pure customisation (PC) which provided a continuum across which performance trends could be assessed. The relationships between business function performance, degree of customisation and the level of product variety offered were also researched. An increase in product variety was found to influence business functions differently depending on the existing combination of the degree of customisation and the level of product variety offered. Overall, the Marketing function was found to be impacted the most by an increase in product variety, followed by the Engineering, Manufacturing, Purchasing and Logistics function.

The research also revealed that an increase in product variety in low customisation types increases customer satisfaction, market share and competitive advantage more than in high customisation types. However, product variety increases in low customisation types also impose higher costs than high customisation types. Furthermore, product variety increases in low customisation types were found to lead to a higher take-up of variety control strategies (for example, the use of standardised parts, postponement, and product flexibility) than in high customisation types. Also, the prevailing degree of customisation was found to be a more significant factor than the existing level of product variety for determining the impact of a variety increase on a number of key functional attributes including manufacturing cost, material cost, transportation cost, manufacturing complexity, manufacturing lead time and demand forecast uncertainty.

## 3. Conclusions

In this research, two empirical studies were presented in order to provide a consolidated piece of work that addressed the impact of product and service variety on business and business function performance. In the first (service-variety) study, the relationship between service provision offered by UK-based, third-party logistics (3PL) providers and the operational and financial performance of those providers was analysed. The study found that the range of service variety offered by 3PLs does not directly influence the 3PLs' financial performance. This study makes a significant contribution to the prevailing knowledge of both logistics and variety management by providing an approach that links service variety with the operational and financial performance of 3PLs. The study findings have implications for practice and research. A limitation of this study is that the results can only be generalised to large manufacturers and the study itself was carried out a single point in time.

The second (product-variety) study presented the findings from an analysis of data from 163 manufacturing plants where the impact of product variety on the performance of five business functions was examined. An increase in product variety was found to influence business functions differently depending on the combination of customisation and variety offered to customers. Marketing performance was found to be most dramatically affected by an increase in product variety, followed by Engineering, Manufacturing, Purchasing and Logistics performance. A key limitation of this study is that the research focused on the main customisation type of each manufacturing plant. However, mixed rather than single customisation types commonly occur. The implications, trade-offs and synergies associated with such multiple scenarios have not been considered.

An appropriate topic for future variety-management research concerns the examination of how manufacturers can optimise the provision of multiple products with different decoupling points, different levels of variety and different degrees of customisation. Also, future research could concern qualitative case studies to understand the development of service capabilities and operational performance for 3PLs and how structural equation modelling (SEM) could be used to understand if there are any cause and effect relationships between service dimensions and performance.

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