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[International Journal of Industrial Engineering & Production Research June 2024 Vol. 35, No. 2: 1-13 DOI: 10.22068/ijjepr.35.2.1929 RESEARCH PAPER The Product-Service Systems Supply Chain Agility Readiness: an Exploratory Analysis of a Development of Construct and Instrument](#)
Yustinus Budi Hermanto¹, [Dian Retno Sari Dewi^{2*}](#), Martinus Edy Sianto³, Ig. Jaka Mulyana⁴, Ivan Gunawan⁵ & Dian Trihastuti⁶ [Received 4 February 2024; Revised 10 April 2024; Accepted 6 May 2024; © Iran University of Science and Technology 2024 ABSTRACT](#) [Supply chain agility \(SCA\) has emerged as a significant focus for industries and businesses, serving as a cornerstone for gaining a competitive edge and playing a pivotal role in supply chain management. This importance is further underscored in the context of Product-Service Systems \(PSS\), which involve the development of both products and services. Despite the existing body of research on SCA and PSS, there has been a notable dearth of empirical studies examining the readiness of PSS SCA. This study makes a substantial contribution by developing a valid and reliable framework to assess the readiness of PSS for supply chain agility. The process involves defining domains, generating items, analyzing agreement among raters, testing for response bias, and conducting exploratory and confirmatory factor analyses. Using structural equation modeling, the model's validity and reliability were evaluated through an online survey with 405 participants from official motorcycle service partners. The findings identify six key capability constructs: collaboration, knowledge transfer, service partner development, information sharing, logistic integration and supply chain agility. This examination of PSS SCA readiness and its constructs provides a validated tool for industry practitioners to enhance their supply chain agility. KEYWORDS: Supply chain agility; Instrument development; Product-service systems; Logistics; Information sharing; Dynamic capabilities.](#) 1. Introduction [Supply chain agility has been seen as a prominent factor for long-term profitability and competitiveness to sustain global competition \[1\]. Research on SCA is even more demanded than ever, especially in the uncertain, unpredictable, and full of disrupting business environments such as now, right after the COVID-19 pandemic \[2\]. Agility is the firm's capability to adapt to fluctuating quickly, erratic, and unstable working environments \[3\]. Thus, being agile means having characteristics of innovativeness, flexibility, * Corresponding author: Dian Retno Sari Dewi dianretnosd@ukwms.ac.id 1. Faculty of Economics and Business, Universitas Katolik Darma Cendika, Surabaya Indonesia. 2. Department of Industrial Engineering, Universitas Katolik Widya Mandala, Surabaya Indonesia. 3. Department of Industrial Engineering, Universitas Katolik Widya Mandala, Surabaya responsiveness, and delivery speed \[4\], \[5\]. Hence, agility benefits companies to stay ahead of competitors to survive and win in the changing situation. PSS is an integrated marketable value bundle of products and services to satisfy customer expectations \[6\]. Implementing PSS is anticipated to simultaneously deliver a product and services \[7\]. The capabilities required to provide PSS should include](#)

product and service development [8]. Hence, long-term collaboration among stakeholders (manufacturers, intermediaries, and Indonesia. 4. [Department of Industrial Engineering, Universitas Katolik Widya Mandala, Surabaya Indonesia](#). 5. [Department of Industrial Engineering, Universitas Katolik Widya Mandala, Surabaya Indonesia](#). 6. [Department of Industrial Engineering, Universitas Katolik Widya Mandala, Surabaya Indonesia](#).

service partners) in the supply chain (SC) to neither been initiated in the literature nor studies deliver PSS is crucial because the required have conceptualized as a valid model to measure capabilities to provide PSS have been built within it. An extensive literature review has been done to SC network to achieve the SC goals, not examine both literature PSS and SCA to develop individual stakeholders' goals within SC. an instrument for PSS SCA readiness. The In its competition with other companies, objective of this study relate to the following manufacturers focus on supply chain management research question: to ensure that their products remain competitive RQ1 How to create a tool for assessing the and agile. Several previous studies have identified readiness of PSS SCA? the capabilities needed, including collaborating RQ2 Do the six capabilities, which encompass with key suppliers, internal and external collaboration, knowledge transfer, service partner integration, logistics process integration, and development, information sharing, logistic information sharing [4, 9–12]. integration, and supply chain agility, form part of Creating and delivering a combination of products the instrument for assessing PSS SCA readiness? and services necessitates a supply chain that Hence, this study aims to develop the construct previously concentrated solely on products to and instrument for measuring the PSS SCA pivot its attention towards both products and readiness through the six capabilities that the services [13]. Consequently, with the aid of other stakeholders in the SC build to deliver PSS. Six stakeholders in the supply chain, particularly capabilities include collaboration, knowledge service partners, it significantly aids in addressing transfer, service partner development, information the manufacturer's incapacity in downstream sharing, logistic integration, and SCA. This network capabilities, specifically services. contributes to the intersection between PSS and Research conducted by Story et al [14] for 19 UK Supply Chain Management (SCM) literature, manufacturers indicates that essential capabilities which is now an under-research area. This are required, including PSS innovation, customer- research could help practitioners understand the centric design, cooperation with service partners, factors that influence the company's agility as a and assistance for service partners. Ultimately, all network and how to improve agility in its SC, these crucial capabilities can only be adequately including This involves determining how to met by providing service partner development and prioritize capabilities according to the standard transferring knowledge to them. loadings obtained from this study. Several other studies have also confirmed the same findings, emphasizing the importance of 2. Literature Review and A Conceptual knowledge transfer and service partner Background development, especially to achieve effective It is prominent to consider broader aspects of the alignment between products and services [15–17]. SC to deliver PSS, as providing a bundle of Specifically, it is mentioned that service partner Products and services requires a collaboration of development can be accomplished by providing service partners, intermediaries, and detailed training related to the products. manufacturers. The intermediaries, known as the Additionally, service partners can assist main dealers, as a term in the motorcycle industry, manufacturers in the implementation of services have a role as a mediator between manufacturers closely linked to understanding customer as producers and service partners as service expectations and market characteristics. providers [18]. The motorcycle industry is used as There has been limited exploration of a model that a context in this study. Service partners are direct combines the supply chain capabilities of agents to provide

customers with a Product and manufacturers, and service partners to provide service bundle. However, service partners usually PSS. The supply chain of products focuses on have limited resources to develop their product distribution and product supply chain capabilities [7]. [On the other hand, the](#) management, while [the supply chain](#) of services is manufacturer, as the SC's powerful partner, limited to the development of supply chain required service partner expertise to deliver PSS. management focused on services, primarily on the Hence, the manufacturers collaborate with downstream supply chain. This study explores the intermediaries to support their service partners to capabilities needed from both the product and develop their capabilities to deliver PSS. service aspects, an area that has been relatively From the PSS and SCM, this research combines underexplored until now. both two concepts. PSS literature mostly looks This research investigates PSS SCA readiness from a service perspective [10, 11], while SCM is construct and instrument development, this has the management of Product and data flow, starting from raw material procurement, production and significantly impacts how the SC prepares for transportation to final destination, mostly looks handling the disruption [27]. from a product perspective [20]. In the case of The flow of information sharing is as important as PSS, the supply chain scope is the flow of Product, the flow of material [28]. The existence of both service, and data. This study examines the flow, information, and material is better in pair capabilities required for delivering PSS to than standing itself [26]. A high level of improve SC agility readiness. coordination and integration among SC From the perspective of multi-actor collaboration stakeholders is usually characterized by increased in the SC network for delivering PSS, long-term logistics-related communication and information collaboration among stakeholders in the SC is sharing [29]. Thus, logistics integration refers to compulsory [21]. For example, if manufacturers the capability to integrate logistics activities to cannot deliver service by themselves. Cooperation create overall value for customers throughout the with service partners is necessary. Lensed by the value stream [30]. The important thing is that the dynamic capabilities (DC) [22], it fits this study's right amount of goods at the right place and time development construct and instrument. should be available to customers immediately. Cooperation with two or more companies enables Abdelilah, El Korchi and Amine Balambo [31] them to quickly collaborate to modify the also addressed that logistics integration became operational capabilities to face the rapid changes one of the predominant factors in supply chain in the market [23]. Dalenogare et al. [17] agility readiness. supported that collaboration with service partners SCA is defined as the SC capability to adapt is a prominent part of delivering PSS. Further, quickly to fluctuating, erratic and unstable Baah et al. [12] showed that SC collaboration working environments. This capability is positively impacts supply chain readiness. paramount to preparing for supply chain agility To support service partners, manufacturers, as the readiness. With the role of multi-actor more powerful parties, assist their service partners collaboration in the SC, the capacity to adapt to through intermediaries for knowledge transfer and erratic situations is better than working alone. service partner development because SCA has several characteristics: flexibility, manufacturers, as producers, own the technical innovativeness, speed, and responsiveness [25], knowledge [13]. Ayala et al.[15] confirmed that [32]. knowledge transfer and service supplier The crucial stage for enhancing a valid and development significantly improves PSS reliable construct and instrument is determining a development. Likewise, Rana and Ha-Brookshire theoretical construct and items by arguing that [24] and Ayala, Gerstlberger and Frank [19] found PSS has offered a bundle of Products and services, that knowledge transfer and supplier development the capabilities required for improving supply were confirmed to be positively related to supply chain agility readiness that focuses on product and chain agility readiness. service development capabilities.

Hence, the PSS is a concept of providing a bundle of products capabilities needed for PSS and SCA have shown and services; thus, from the product side, supply the capabilities for network collaboration among chain integration, both material and information, service partners, intermediaries, and is essential and plays the primary role in manufacturers. improving SCA readiness. Kim and Chai [25] and Baah et al. [12] showed that information sharing 3. Research Methods affects SCA. Most studies highlight that This section describes the development of information sharing reduces costs, increases creating questionnaire items to form a survey for operational performance, and enhances product examining the construct and instrument quality [26]. Still, they ignore the close development for PSS SCA. A valid and reliable relationship between information sharing and the instrument is a significant concern in quantitative capability to prevent disruption related to SCA's research. The step of this research is in Figure 1. readiness [12]. Dealing with information sharing Literature review Research question Data collection Method : Questionnaire Scaling : Likert & rating scale Content validity for instrument development & validation [1. Specify domain of construct](#) [2. Generate sample of items](#) [3. Pre-testing](#) [4. Pilot testing](#) [5. Items screening](#) Sampling design Method : random sampling Size Area : 950 : Indonesia Data examination Missing data, outliers & normality Data analysis - Exploratory data analysis - Confirmatory data analysis - Discriminant validity - Reliability Synthesizing results Fig. 1. The step of research The instrument validation procedures in this research are adopted from Lewis, Templeton and Byrd [33], including five steps to ensure validity and reliability. The first step is the domain definition of each construct. The next step is generating a sample of items. Pretesting, pilot testing and interrater agreement are steps three to five. Then, after the five steps, data examination and preparation were conducted, including missing data, outliers and normality. Assessment of validity and reliability assessment are crucial steps after the data has been examined and evaluated. Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were employed as the validity tests. Initially, the EFA The five-point rating scale was utilized to examine was utilized with SPSS version 26 to assess the the relevance of each item in the constructs (i.e., 4 scale's dimensionality, followed by running the = extremely relevant, 3= substantially relevant, CFA in AMOS version 26 to look at the 2=moderately relevant, 1= minimally relevant, 0 convergent and discriminant validity. Further, to = not relevant). evaluate the reliability, coefficient H, construct Finally, step five is interrater agreement. There reliability (CR), and Cronbach's alpha were used. were three criteria proposed for deleting items In the end, a standard method bias was assessed based on: (1) drop items when their mean value is by CFA. below the mean center, (2) drop items left from (1) when $p > 0.05$, and (3) 4. Results drop items left from (2) if power < 0.8 [30, 31]. A domain specification is needed to convey each The results indicate a mean value of 3.05–3.70, all construct in terms of understandable meaning and p -value < 0.05 , and a power of 0.80–1. For the definite (step 1). The existing literature review three criteria above, all items are within the must be transparent to ensure the implementation criteria, so no items are carried away from the list, of its operationalization is correct. All domain and 34 items are kept for the final questionnaire. definitions were adjusted to the context of PSS Data collection commenced from December 2022 and SCA for the motorcycle industry in Indonesia. to June 2023. The questionnaire was developed All domain definitions are in Table 1. Based on a using a six-point Likert and rating scale. It is thorough review of the literature on capabilities distributed as an online survey using Google and substantial discussion with four academics, an Forms. A sampling frame was generated from initial pool operationalization of 34 items was about 8,450 official motorcycle service partners. produced, step 2 (Table 1). A head of the branch has represented a respondent The pretesting was aimed at

empirical feedback to who participated in this survey. The respondent evaluate the instrument (step 3). This research must have more than one year of experience as a recruited six academic experts in the SC as pretest head of the branch office. Nine hundred fifty participants. The pretest participants were asked invitations were delivered to the service partners' to fill and complete the instrument, then followed email addresses using a simple random sampling this up with criticism and suggestions about within the sampling frame. Two follow-up emails content, understandability, terminology, ease of were delivered as a necessary reminder. As a understanding and time taken. Furthermore, the result, 405 responses were collected to be further pretest participants were expected to contribute analyzed. The following are the critical advanced suggestions, including content demographics from the survey participants' enhancements or specific items to be added or profiles. The leading players of a particular brand removed. As a result, several items' wording was of Indonesia's motorcycle industry have become changed to simplify the meaning for participants the majority of participants in this research to understand the questionnaire better. (72,6%). Likewise, as Indonesia's most populated A pilot test is step four, aiming to purify the island, most participants are from Java island instrument. Fifteen experts from the industry were (70.6%). Most service partner companies could be asked to complete the questionnaire. After characterized as small enterprises with fewer than completion, they were asked to discuss the ten employees (89.6%) and have a long-term difficulties related to the instrument for enhancing partnership (more than ten years) with their the wording of the questionnaire statement. All manufacturer (67.2%). The participants are almost participants fully understood all statements in the exclusively males (95.8%) and most have at least questionnaire; hence, no wording adjustment was a senior high school education (99.3%). required to the instrument. Levene's test for equality of variance and a t-test Content validity testing, such as interrater for equality of means analysis was conducted to agreement analysis, is the final step in the investigate potential non-response bias by instrument development. The participants for comparing early and late participants. Each interrater agreement in this research were a group returned questionnaire was recorded complete of experts who knew the concepts involved. with the date received. The early participants in Twenty people with PSS and SC expertise were the first round were 232 participants, while the asked to participate. They were asked to fill out latter who responded in round 2 were 173 the questionnaire. Then, the statistical output of participants. The results of the 2 test were their responses was evaluated, and the items with considered non-significant as p-values have more low agreement were dropped from the instrument. than 0.05 for six constructs in the model. This confirmed that there is no bias detected in this constructs made a one-factor solution that study. explicated 54.1 to 69.4% of a variance. Hence, the EFA validates the dimensionality of the EFA process resulted in the deletion of one item instrument, identifies opportunities for data of C7. reduction, and investigates the relationships This study used CFA to assess the convergent between variables. Data is factorable if validity. First, Goodness of Fit (GOF) indices KMOMSA is between 0.5 and 1 [36]. The were examined for all the constructs. All factorability assessment results tested using constructs must meet recommended cut-off values Kaiser's criterion confirmed that data is factorable to indicate good fit values: $p > 0.01$, norm $2 \leq 2$, with all constructs with KMOMSA above 0.843. RMSEA < 0.05, SRMR < 0.07, CFI > 0.96 and Maximum likelihood extraction and rotation using TLI > 0.95 [33, 34]. A model best fits when it Promax were used. One item C7, was dropped due produces a suitable sample covariance matrix. to insignificant factor loading. Six independent Tab. 1. Theoretical domain of constructs and items Code Domain of Construct and Items References Collaboration (C) is defined as a partnership activity of creating new resources where two or more parties jointly work together to

achieve mutual benefit C1 We sense and seize a long-term collaborative relationship with [39] our main dealer partner based on mutual trust C2 We work jointly on the PSS planning with our main dealer [39] partner C3 We collaborate with our main dealer partner to reconfigure PSS [40] offering C4 We collaborate with our main dealer partner to identify and [7] understand the customers' need C5 We have many different channel to communicate [39] C6 We have agreement on the same SC agility readiness goals [21] C7 We exchange knowledge and relevant information [39] Knowledge transfer (KT) is defined as the capability to transfer and access knowledge among stakeholders in the SC KT1 Our main dealer partner transfer its knowledge of PSS to us [15] KT2 Our main dealer partner share its knowledge about the benefit [21] of being agile as our goal KT3 We receive knowledge about information technology that we [18] use to deliver PSS KT4 Our main dealer partner continuously support us to share about [18] our customers' expectations KT5 Our main dealer partner constantly transfer knowledge of [15] innovations for a bundle of product and service Service partner development (SPD) is defined capability to develop partner capacity by providing variety of training and reconfigure overall performance within SC SPD1 Our main dealer partner has ceaselessly upgrade our knowledge [18] SPD2 Several training courses has been prepared to us to increase our [18] speed, flexibility, responsiveness and innovativeness SPD3 A service partner development programs has been provided by [19] our main dealer partner SPD4 Our main dealer partner strengthen our capabilities to achieve [19] supply chain agility SPD5 Variety training courses of product and technical service has [41], [42] been supplied to us Information sharing (IS) s defined as capability to sense and seize SC information for any stakeholders in the SC IS1 We share delicate information to our service partner [43] IS2 Our main dealer partner are transparent to share any [28] information IS3 Information interchange is continuing and repeatedly [25] IS4 Our main dealer partner continuously update us with recent [25] information IS5 Our main dealer partner keep frequent meeting and [25] communication Logistics integration (LI) Is defined as the capability to integrate logistics activities to create overall values to customers LI1 Our supply chain logistics activities are strictly collaborated [44] LI2 Our main dealer partner logistics routines are effectively [44] coordinated with ours LI3 We have a smooth coordination of logistics activities with our [44] main dealer partner LI4 Our logistics coordination is specified by outstanding [44] warehouse facilities and distribution LI5 The incoming and outgoing coordination of product [44] distribution is completely harmonize Supply chain agility (SCA) as the SC capability to quickly adopt to fluctuating, erratic and unstable working environment SCA1 We always quickly improve our PSS level of customer [25] satisfaction SCA2 We always quickly improve our PSS delivery reliability [25] SCA3 We always quickly reconfigure PSS SC capabilities to adopt [25] with changing market needs SCA4 We always quickly reconfigure SC resource capacity to [45] respond to uncertain demand SCA5 We always quickly adapt PSS SC operation to decrease service [21] lead time SCA6 We always quickly reconfigure our capabilities to customize [11] customer order SCA7 We always quickly innovate our PSS offerings new Conversely, the model requires re-specification if errors are found. The standardized residual covariance and modification indices (MI) are examined to re-specify the model. A considerable value of residual covariance was advisable because the hypothesized model did not establish a particular covariance well. This can be carried on by dropping one of the related items and re- running the measurement model [36]. The MI indicates that the model structure may need to be changed. A MI value greater than 4 is a potential source of model re-specification [46]. However, as a caution, the items deleted from the constructs should have low validity, which can be checked from the result of the interrater agreement so that the deletion of the items has not obstructed the meaning of the construct. The model re- specification process resulted in

the deletion of 4 items: C6, SPD1, IS5 and LI5. Finally, the convergent validity result is displayed in Table 2. Tab. 2. Convergent validity test result

Compo	nents	C	KT	SPD	IS	Items	C1	C2	C3	C4	C5	KT1	KT2	KT3	KT4	KT5	SPD2	SPD3	SPD4	SPD5	IS1	IS2	IS3	Factor loading	p	2	RMSE	A	SRMR	CFI	TLI	CR	Cronba	ch's	alpha	H																																																												
0.823	0.817	0.752	0.796	0.825	0.04	2.00	0.05	0.034	0.993	0.991	0.900	0.899	0.903	0.856	0.842	0.844	0.807	0.840	0.191	1.485	0.035	0.014	0.998	0.997	0.922	0.922	0.923	0.872	0.843	0.808	0.814	0.179	1.635	0.040	0.009	0.998	0.996	0.901	0.901	0.905	0.797	0.733	0.843	0.394	1.037	0.010	0.001	1.00	1.00	0.873	0.871	0.878	IS4	0.804	LI1	LI	LI2	LI3	LI4	0.739	0.725	0.853	0.842	0.147	1.698	0.042	0.021	0.996	0.995	0.872	0.867	0.881	SCA	SCA1	SCA2	SCA3	SCA4	SCA5	SCA6	SCA7	0.810	0.842	0.824	0.833	0.873	0.657	0.788	0.012	1.898	0.045	0.027	0.987	0.992	0.928	0.928	0.935

To guarantee that the construct has the most substantial relationships with its items and not with any other construct in the structural model [47], discriminant validity among six constructs was attained, with AVE value of each construct bigger than the square correlation values (Table 3). Coefficient H, construct reliability (CR) and Cronbach's alpha were used for reliability measurement. The results for coefficient H in this study ranged from 0.878 to 0.935, CR values from 0.872 to 0.928, and Cronbach's alpha results from 0.867 to 0.928 confirmed a satisfactory outcome for reliability (Table 2). Tab. 3. AVE and square inter-construct correlation

Construct	IS	C	KT	SPD	LI	SCA	IS	0.795	C	0.392	0.802	KT	0.385	0.759	0.838	SPD	0.373	0.705	0.777	0.834	LI	0.634	0.474	0.454	0.513	0.794	SCA	0.508	0.315	0.336	0.433	0.680	0.806
The six constructs corroborated standard factor loading of 0.657–0.873, p-value 0.02–0.39, RMSEA 0.01–0.045, SRMR 0.02–0.055, CFI 0.987–1.0, and TLI 0.991–1.0. After fulfilling the requirements of dimensionality, convergent, and discriminant validity, this study investigates <u>factorial validity, which</u> examines whether <u>a set of latent variables</u> demonstrates <u>an underlying pattern</u> . The results <u>of the full CFA model</u> affirmed <u>a good fit of the measurement model</u> with <u>normed $\chi^2 = 1.505$, SRMR = 0.019, RMSEA = 0.035, CFI = 0.978, and TLI = 0.975</u> .																																	

5. Discussions The PSS, SCM, and dynamic capabilities theories have been developed to conceptualize the model for this study to measure PSS SC agility readiness. Further, the development of constructs and items, along with definitions, assist the application of PSS, as a SC network collaboration among manufacturers, intermediaries (main dealers), and service partners to improve the SC agility readiness. This study has developed a ready instrument for Product-Service Systems Supply Chain Agility readiness with six constructs: collaboration, knowledge transfer, service partner development, information sharing, logistics integration, and supply chain agility, comprising 29 items. Such a structure evaluates PSS agile readiness at different levels among SC stakeholders.

- The collaboration consists of items that describe the partnership relationship of creating new capabilities for all stakeholders in the SC: manufacturers, main dealers, and service partners. These items relate directly to the manufacturer's inability to deliver PSS by itself. Then, the manufacturer requires close partners to work hand in hand to provide customers with a Product and service bundle. The collaboration requires long- term partnerships to plan, join, and have many different channels to communicate closely.
- Knowledge transfer reflects the company's capability to transfer and give access to knowledge to SC stakeholders, including knowledge of delivering a bundle of products and services, innovation, customers' expectations, and the capability of being agile.
- Service partner development embraces the capability of all stakeholders in the SC to have the same capabilities to improve SC agility readiness. The most influential stakeholder in the SC is manufacturers; they usually support the leading dealers and the primary dealers, as intermediaries, support the service partners. The manufacturers have continuously provided training courses on technical Products and services to increase speed, flexibility, responsiveness, and innovativeness.
- Information

sharing can sense and seize information from any stakeholder in the SC. These capabilities have strongly affected the SC agility readiness, including sharing delicate information, transparent sharing, information interchange, and continuously updating recent information to service partners. • Logistic integration is crucial to the SC agility readiness to coordinate all logistic activities in the SC effectively. This construct relates directly to the collaboration of supply chain activities, logistics routines coordination with main dealer partners, smooth logistics activities, and excellent warehouse facilities and distribution. • Supply chain agility embraces the capability to quickly adapt to speed delivery, innovation, flexibility, and responsiveness. These items highly relate to the SC agility readiness. 6. Conclusions This study has revealed the capabilities required for PSS SC agility readiness. It proposes 29 PSS SCA measurements with six capabilities: [collaboration](#), [knowledge transfer](#), [service partner development](#), [information sharing](#), [logistics integration](#), and [supply chain agility](#). The [model is developed based on the](#) capabilities shared among SC networks, including service partners, intermediaries, and manufacturers, to improve supply chain agility readiness. Further, this study contributes to the theory by improving knowledge about the power of capabilities built in the SC network collaboration among stakeholders. Likewise, this study clearly defines each capability construct that contributes to improving supply chain agility readiness. Finally, this study contributes a ready instrument whose item parameters are adequately validated based on DC theory. As a result, the practitioner can utilize the instrument for planning and decision-making, managing and measuring the current capabilities to move forward with improved capabilities. Further, the standard loadings of items related to supply chain capabilities to gauge the importance of each capability in enhancing SCA can also be used by the practitioners to determine the priority based on the resources. Given the knowledge-intensive nature of the motorcycle industry, it's crucial to establish long- time collaboration and transfer of knowledge and service partner development that reflects the capability of the SC to cooperate in delivering PSS. Likewise, [information sharing](#), [logistic integration and supply chain agility](#) are the other three capabilities to shape the PSS SCA readiness. Despite contributions having been explained, the instrument measurement in this study has been dedicated to the motorcycle industry in Indonesia. Thus, broader industries and geographical areas may have resulted in different outcomes. Also, the dynamic changing of an environment may affect capabilities over time, which should be looked at in future research using the study's longitudinal approach. To the best of our knowledge, research examining capabilities in the SC network is developing, so only a few studies have focused on developing PSS SC agility readiness capability. Thus, this study provides rigorous theory and validated PSS SC agility readiness instruments. References [1] Humdan, E. Al, Shi, Y., Behina, M., Chowdhury, M. M. H., and Mahmud, A. K. M. S., "The role of innovativeness and supply chain agility in the Australian service industry: a dynamic capability perspective," *International Journal of Physical Distribution & Logistics Management*, Vol. 53, No. 11, (2023), pp. 1-25. [2] Wang, M. and Wang, B. (Bill), "Supply chain agility as the antecedent to firm sustainability in the post COVID-19," *The International Journal of Logistics Management*, (2023). [3] Gligor, D. M. et al., "Examining the rigor of SCM research: the case of supply chain agility," *Supply Chain Management: An International Journal*, Vol. 28, No. 3, (2023), pp. 522-543. [4] Raj, A., Sharma, V., Shukla, D. M., and Sharma, P., "Advancing supply chain management from agility to hyperagility: a dynamic capability view," *Annals of Operations Research*, (2023). [5] Aldhaheri, R. T. and Ahmad, S. Z., collaboration on supply chain "Factors affecting organisations' supply performance," *Benchmarking: An chain agility and competitive capability*, *International Journal*, Vol. 29, No. 2, *Business Process Management Journal*, (2022), pp. 434-455. Vol. 29, No. 2, (2023), pp. 505-527. [13] Dewi, D. R. S. and Hermanto, Y. B., [6] Kurpiela, S. and

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The Product-Service Systems Supply Chain Agility Readiness: an Exploratory Analysis of a Development of Construct and Instrument

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RESEARCH PAPER

1
The Product-Service Systems Supply Chain Agility Readiness: an Exploratory Analysis of a Development of Construct and Instrument

Yustinus Budi Hermanto¹, Dian Retno Sari Dewi^{2*}, Martinus Edy Sianto³, Ig. Jaka Mulyana⁴, Ivan Gunawan⁵ & Dian Trihastuti⁶

8
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ABSTRACT

Supply chain agility (SCA) has emerged as a significant focus for industries and businesses, serving as a cornerstone for gaining a competitive edge and playing a pivotal role in supply chain management. This importance is further underscored in the context of Product-Service Systems (PSS), which involve the development of both products and services. Despite the existing body of research on SCA and PSS, there has been a notable dearth of empirical studies examining the readiness of PSS SCA. This study makes a substantial contribution by developing a valid and reliable framework to assess the readiness of PSS for supply chain agility. The process involves defining domains, generating items, analyzing agreement among raters, testing for response bias, and conducting exploratory and confirmatory factor analyses. Using structural equation modeling, the model's validity and reliability were evaluated through an online survey with 405 participants from official motorcycle service partners. The findings identify six key capability constructs: collaboration, knowledge transfer, service partner development, information sharing, logistic integration and supply chain agility. This examination of PSS SCA readiness and its constructs provides a validated tool for industry practitioners to enhance their supply chain agility.

KEYWORDS: Supply chain agility; Instrument development; Product-service systems; Logistics; Information sharing; Dynamic capabilities.

10
1. Introduction

Supply chain agility has been seen as a prominent factor for long-term profitability and competitiveness to sustain global competition [1]. Research on SCA is even more demanded than ever, especially in the uncertain, unpredictable, and full of disrupting business environments such as now, right after the COVID-19 pandemic [2]. Agility is the firm's capability to adapt to fluctuating quickly, erratic, and unstable working environments [3]. Thus, being agile means having characteristics of innovativeness, flexibility,

responsiveness, and delivery speed [4], [5]. Hence, agility benefits companies to stay ahead of competitors to survive and win in the changing situation.

PSS is an integrated marketable value bundle of products and services to satisfy customer expectations [6]. Implementing PSS is anticipated to simultaneously deliver a product and services [7]. The capabilities required to provide PSS should include product and service development [8]. Hence, long-term collaboration among stakeholders (manufacturers, intermediaries, and

* Corresponding author: Dian Retno Sari Dewi
dianretnosf@iains.ac.id

1. Faculty of Economics and Business, Universitas Katolik Darma Cendika, Surabaya Indonesia,
2. Department of Industrial Engineering, Universitas Katolik Widya Mandala, Surabaya Indonesia,
3. Department of Industrial Engineering, Universitas Katolik Widya Mandala, Surabaya

- Indonesia,
4. Department of Industrial Engineering, Universitas Katolik Widya Mandala, Surabaya Indonesia.
5. Department of Industrial Engineering, Universitas Katolik Widya Mandala, Surabaya Indonesia.
6. Department of Industrial Engineering, Universitas Katolik Widya Mandala, Surabaya Indonesia.

service partners) in the supply chain (SC) to deliver PSS is crucial because the required capabilities to provide PSS have been built within SC network to achieve the SC goals, not individual stakeholders' goals within SC.

In its competition with other companies, manufacturers focus on supply chain management to ensure that their products remain competitive and agile. Several previous studies have identified the capabilities needed, including collaborating with key suppliers, internal and external integration, logistics process integration, and information sharing [4, 9–12].

Creating and delivering a combination of products and services necessitates a supply chain that previously concentrated solely on products to pivot its attention towards both products and services [13]. Consequently, with the aid of other stakeholders in the supply chain, particularly service partners, it significantly aids in addressing the manufacturer's incapacity in downstream network capabilities, specifically services. Research conducted by Story et al [14] for 19 UK manufacturers indicates that essential capabilities are required, including PSS innovation, customer-centric design, cooperation with service partners, and assistance for service partners. Ultimately, all these crucial capabilities can only be adequately met by providing service partner development and transferring knowledge to them.

Several other studies have also confirmed the same findings, emphasizing the importance of knowledge transfer and service partner development, especially to achieve effective alignment between products and services [15–17]. Specifically, it is mentioned that service partner development can be accomplished by providing detailed training related to the products. Additionally, service partners can assist manufacturers in the implementation of services closely linked to understanding customer expectations and market characteristics.

There has been limited exploration of a model that combines the supply chain capabilities of manufacturers, and service partners to provide PSS. The supply chain of products focuses on product distribution and product supply chain management, while the supply chain of services is limited to the development of supply chain management focused on services, primarily on the downstream supply chain. This study explores the capabilities needed from both the product and service aspects, an area that has been relatively underexplored until now.

This research investigates PSS SCA readiness construct and instrument development, this has

neither been initiated in the literature nor studies have conceptualized as a valid model to measure it. An extensive literature review has been done to examine both literature PSS and SCA to develop an instrument for PSS SCA readiness. The objective of this study relate to the following research question:

RQ1 How to create a tool for assessing the readiness of PSS SCA?

RQ2 Do the six capabilities, which encompass collaboration, knowledge transfer, service partner development, information sharing, logistic integration, and supply chain agility, form part of the instrument for assessing PSS SCA readiness? Hence, this study aims to develop the construct and instrument for measuring the PSS SCA readiness through the six capabilities that the stakeholders in the SC build to deliver PSS. Six capabilities include collaboration, knowledge transfer, service partner development, information sharing, logistic integration, and SCA. This contributes to the intersection between PSS and Supply Chain Management (SCM) literature, which is now an under-research area. This research could help practitioners understand the factors that influence the company's agility as a network and how to improve agility in its SC, including This involves determining how to prioritize capabilities according to the standard loadings obtained from this study.

2. Literature Review and A Conceptual Background

It is prominent to consider broader aspects of the SC to deliver PSS, as providing a bundle of Products and services requires a collaboration of service partners, intermediaries, and manufacturers. The intermediaries, known as the main dealers, as a term in the motorcycle industry, have a role as a mediator between manufacturers as producers and service partners as service providers [18]. The motorcycle industry is used as a context in this study. Service partners are direct agents to provide customers with a Product and service bundle. However, service partners usually have limited resources to develop their capabilities [7]. On the other hand, the manufacturer, as the SC's powerful partner, required service partner expertise to deliver PSS. Hence, the manufacturers collaborate with intermediaries to support their service partners to develop their capabilities to deliver PSS.

From the PSS and SCM, this research combines both two concepts, PSS literature mostly looks from a service perspective [10, 11], while SCM is the management of Product and data flow, starting

from raw material procurement, production and transportation to final destination, mostly looks from a product perspective [20]. In the case of PSS, the supply chain scope is the flow of Product, service, and data. This study examines the capabilities required for delivering PSS to improve SC agility readiness.

From the perspective of multi-actor collaboration in the SC network for delivering PSS, long-term collaboration among stakeholders in the SC is compulsory [21]. For example, if manufacturers cannot deliver service by themselves. Cooperation with service partners is necessary. Lensed by the dynamic capabilities (DC) [22], it fits this study's development construct and instrument. Cooperation with two or more companies enables them to quickly collaborate to modify the operational capabilities to face the rapid changes in the market [23]. Dalenogare *et al.* [17] supported that collaboration with service partners is a prominent part of delivering PSS. Further, Baah *et al.* [12] showed that SC collaboration positively impacts supply chain readiness.

To support service partners, manufacturers, as the more powerful parties, assist their service partners through intermediaries for knowledge transfer and service partner development because manufacturers, as producers, own the technical knowledge [13]. Ayala *et al.* [15] confirmed that knowledge transfer and service supplier development significantly improves PSS development. Likewise, Rana and Ha-Brookshire [24] and Ayala, Gerstlberger and Frank [19] found that knowledge transfer and supplier development were confirmed to be positively related to supply chain agility readiness.

PSS is a concept of providing a bundle of products and services; thus, from the product side, supply chain integration, both material and information, is essential and plays the primary role in improving SCA readiness. Kim and Chai [25] and Baah *et al.* [12] showed that information sharing affects SCA. Most studies highlight that information sharing reduces costs, increases operational performance, and enhances product quality [26]. Still, they ignore the close relationship between information sharing and the capability to prevent disruption related to SCA's readiness [12]. Dealing with information sharing

significantly impacts how the SC prepares for handling the disruption [27].

The flow of information sharing is as important as the flow of material [28]. The existence of both flow, information, and material is better in pair than standing itself [26]. A high level of coordination and integration among SC stakeholders is usually characterized by increased logistics-related communication and information sharing [29]. Thus, logistics integration refers to the capability to integrate logistics activities to create overall value for customers throughout the value stream [30]. The important thing is that the right amount of goods at the right place and time should be available to customers immediately. Abdelilah, El Korchi and Amine Balambo [31] also addressed that logistics integration became one of the predominant factors in supply chain agility readiness.

SCA is defined as the SC capability to adapt quickly to fluctuating, erratic and unstable working environments. This capability is paramount to preparing for supply chain agility readiness. With the role of multi-actor collaboration in the SC, the capacity to adapt to erratic situations is better than working alone. SCA has several characteristics: flexibility, innovativeness, speed, and responsiveness [25], [32].

The crucial stage for enhancing a valid and reliable construct and instrument is determining a theoretical construct and items by arguing that PSS has offered a bundle of Products and services, the capabilities required for improving supply chain agility readiness that focuses on product and service development capabilities. Hence, the capabilities needed for PSS and SCA have shown the capabilities for network collaboration among service partners, intermediaries, and manufacturers.

3. Research Methods

This section describes the development of creating questionnaire items to form a survey for examining the construct and instrument development for PSS SCA. A valid and reliable instrument is a significant concern in quantitative research. The step of this research is in Figure 1.

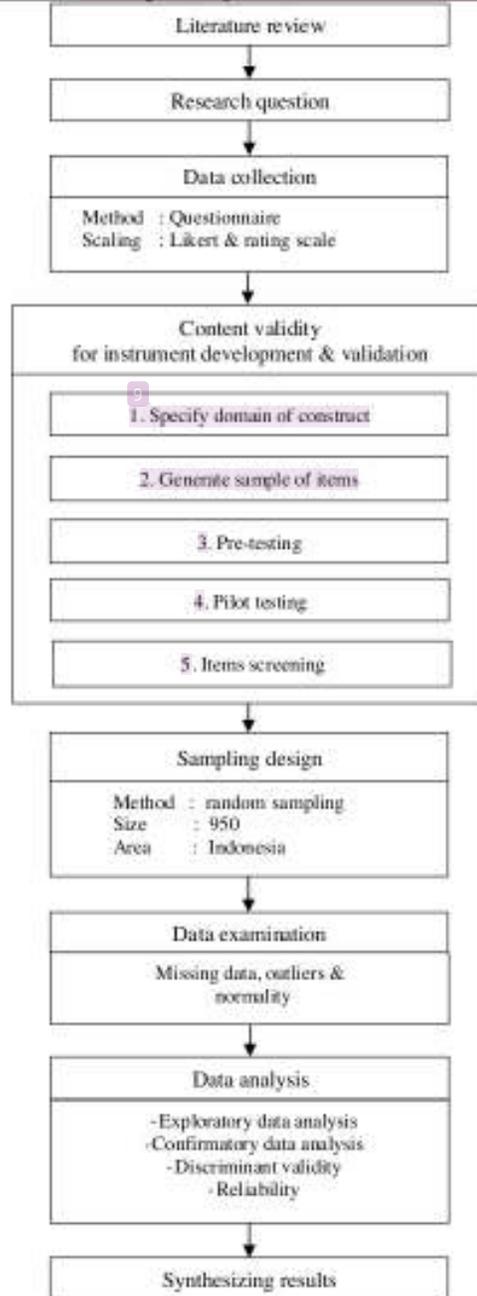


Fig. 1. The step of research

The instrument validation procedures in this research are adopted from Lewis, Templeton and Byrd [33], including five steps to ensure validity and reliability. The first step is the domain definition of each construct. The next step is generating a sample of items. Pretesting, pilot testing and interrater agreement are steps three to

five. Then, after the five steps, data examination and preparation were conducted, including missing data, outliers and normality.

Assessment of validity and reliability assessment are crucial steps after the data has been examined and evaluated. Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were

employed as the validity tests. Initially, the EFA was utilized with SPSS version 26 to assess the scale's dimensionality, followed by running the CFA in AMOS version 26 to look at the convergent and discriminant validity. Further, to evaluate the reliability, coefficient H, construct reliability (CR), and Cronbach's alpha were used. In the end, a standard method bias was assessed by CFA.

4. Results

A domain specification is needed to convey each construct in terms of understandable meaning and definite (step 1). The existing literature review must be transparent to ensure the implementation of its operationalization is correct. All domain definitions were adjusted to the context of PSS and SCA for the motorcycle industry in Indonesia. All domain definitions are in Table 1. Based on a thorough review of the literature on capabilities and substantial discussion with four academics, an initial pool operationalization of 34 items was produced, step 2 (Table 1).

The pretesting was aimed at empirical feedback to evaluate the instrument (step 3). This research recruited six academic experts in the SC as pretest participants. The pretest participants were asked to fill and complete the instrument, then followed this up with criticism and suggestions about content, understandability, terminology, ease of understanding and time taken. Furthermore, the pretest participants were expected to contribute advanced suggestions, including content enhancements or specific items to be added or removed. As a result, several items' wording was changed to simplify the meaning for participants to understand the questionnaire better.

A pilot test is step four, aiming to purify the instrument. Fifteen experts from the industry were asked to complete the questionnaire. After completion, they were asked to discuss the difficulties related to the instrument for enhancing the wording of the questionnaire statement. All participants fully understood all statements in the questionnaire; hence, no wording adjustment was required to the instrument.

Content validity testing, such as interrater agreement analysis, is the final step in the instrument development. The participants for interrater agreement in this research were a group of experts who knew the concepts involved. Twenty people with PSS and SC expertise were asked to participate. They were asked to fill out the questionnaire. Then, the statistical output of their responses was evaluated, and the items with low agreement were dropped from the instrument.

The five-point rating scale was utilized to examine the relevance of each item in the constructs (i.e., 4 = extremely relevant, 3= substantially relevant, 2=moderately relevant, 1= minimally relevant, 0 = not relevant).

Finally, step five is interrater agreement. There were three criteria proposed for deleting items based on: (1) drop items when their mean value is below the mean center, (2)

drop items left from (1) when $p > 0.05$, and (3) drop items left from (2) if power < 0.8 [30, 31].

The results indicate a mean value of 3.05–3.70, all p -value < 0.05 , and a power of 0.80–1. For the three criteria above, all items are within the criteria, so no items are carried away from the list, and 34 items are kept for the final questionnaire.

Data collection commenced from December 2022 to June 2023. The questionnaire was developed using a six-point Likert and rating scale. It is distributed as an online survey using Google Forms. A sampling frame was generated from about 8,450 official motorcycle service partners. A head of the branch has represented a respondent who participated in this survey. The respondent must have more than one year of experience as a head of the branch office. Nine hundred fifty invitations were delivered to the service partners' email addresses using a simple random sampling within the sampling frame. Two follow-up emails were delivered as a necessary reminder. As a result, 405 responses were collected to be further analyzed. The following are the critical demographics from the survey participants' profiles. The leading players of a particular brand of Indonesia's motorcycle industry have become the majority of participants in this research (72.6%). Likewise, as Indonesia's most populated island, most participants are from Java island (70.6%). Most service partner companies could be characterized as small enterprises with fewer than ten employees (89.6%) and have a long-term partnership (more than ten years) with their manufacturer (67.2%). The participants are almost exclusively males (95.8%) and most have at least a senior high school education (99.3%).

Levene's test for equality of variance and a t-test for equality of means analysis was conducted to investigate potential non-response bias by comparing early and late participants. Each returned questionnaire was recorded complete with the date received. The early participants in the first round were 232 participants, while the latter who responded in round 2 were 173 participants. The results of the χ^2 test were considered non-significant as p -values have more than 0.05 for six constructs in the model. This

confirmed that there is no bias detected in this study.

EFA validates the dimensionality of the instrument, identifies opportunities for data reduction, and investigates the relationships between variables. Data is factorable if KMOMSA is between 0.5 and 1 [36]. The factorability assessment results tested using Kaiser's criterion confirmed that data is factorable with all constructs with KMOMSA above 0.843. Maximum likelihood extraction and rotation using Promax were used. One item C₇ was dropped due to insignificant factor loading. Six independent

constructs made a one-factor solution that explicated 54.1 to 69.4% of a variance. Hence, the EFA process resulted in the deletion of one item of C₇.

This study used CFA to assess the convergent validity. First, Goodness of Fit (GOF) indices were examined for all the constructs. All constructs must meet recommended cut-off values to indicate good fit values: $p > 0.01$, norm $\chi^2 \leq 2$, RMSEA < 0.05, SRMR < 0.07, CFI > 0.96 and TLI > 0.95 [33, 34]. A model best fits when it produces a suitable sample covariance matrix.

Tab. 1. Theoretical domain of constructs and items

Code	Domain of Construct and Items	References
<i>Collaboration (C) is defined as a partnership activity of creating new resources where two or more parties jointly work together to achieve mutual benefit</i>		
C ₁	We sense and seize a long-term collaborative relationship with our main dealer partner based on mutual trust	[39]
C ₂	We work jointly on the PSS planning with our main dealer partner	[39]
C ₃	We collaborate with our main dealer partner to reconfigure PSS offering	[40]
C ₄	We collaborate with our main dealer partner to identify and understand the customers' need	[7]
C ₅	We have many different channel to communicate	[39]
C ₆	We have agreement on the same SC agility readiness goals	[21]
C ₇	We exchange knowledge and relevant information	[39]
<i>Knowledge transfer (KT) is defined as the capability to transfer and access knowledge among stakeholders in the SC</i>		
KT ₁	Our main dealer partner transfer its knowledge of PSS to us	[15]
KT ₂	Our main dealer partner share its knowledge about the benefit of being agile as our goal	[21]
KT ₃	We receive knowledge about information technology that we use to deliver PSS	[18]
KT ₄	Our main dealer partner continuously support us to share about our customers' expectations	[18]
KT ₅	Our main dealer partner constantly transfer knowledge of innovations for a bundle of product and service	[15]
<i>Service partner development (SPD) is defined capability to develop partner capacity by providing variety of training and reconfigure overall performance within SC</i>		
SPD ₁	Our main dealer partner has ceaselessly upgrade our knowledge	[18]
SPD ₂	Several training courses has been prepared to us to increase our speed, flexibility, responsiveness and innovativeness	[18]
SPD ₃	A service partner development programs has been provided by our main dealer partner	[19]
SPD ₄	Our main dealer partner strengthen our capabilities to achieve supply chain agility	[19]
SPD ₅	Variety training courses of product and technical service has been supplied to us	[41], [42]
<i>Information sharing (IS) is defined as capability to sense and seize SC information for any stakeholders in the SC</i>		
IS ₁	We share delicate information to our service partner	[43]
IS ₂	Our main dealer partner are transparent to share any information	[28]
IS ₃	Information interchange is continuing and repeatedly	[25]
IS ₄	Our main dealer partner continuously update us with recent information	[25]
IS ₅	Our main dealer partner keep frequent meeting and communication	[25]

Logistics integration (LI) is defined as the capability to integrate logistics activities to create overall values to customers

LI ₁	Our supply chain logistic activities are strictly collaborated	[44]
LI ₂	Our main dealer partner logistics routines are effectively coordinated with ours	[44]
LI ₃	We have a smooth coordination of logistics activities with our main dealer partner	[44]
LI ₄	Our logistics coordination is specified by outstanding warehouse facilities and distribution	[44]
LI ₅	The incoming and outgoing coordination of product distribution is completely harmonize	[44]

Supply chain agility (SCA) as the SC capability to quickly adopt to fluctuating, erratic and unstable working environment

SCA ₁	We always quickly improve our PSS level of customer satisfaction	[25]
SCA ₂	We always quickly improve our PSS delivery reliability	[25]
SCA ₃	We always quickly reconfigure PSS SC capabilities to adopt with changing market needs	[25]
SCA ₄	We always quickly reconfigure SC resource capacity to respond to uncertain demand	[45]
SCA ₅	We always quickly adapt PSS SC operation to decrease service lead time	[21]
SCA ₆	We always quickly reconfigure our capabilities to customize customer order	[11]
SCA ₇	We always quickly innovate our PSS offerings	new

Conversely, the model requires re-specification if errors are found. The standardized residual covariance and modification indices (MI) are examined to re-specify the model. A considerable value of residual covariance was advisable because the hypothesized model did not establish a particular covariance well. This can be carried on by dropping one of the related items and re-running the measurement model [36]. The MI indicates that the model structure may need to be

changed. A MI value greater than 4 is a potential source of model re-specification [46]. However, as a caution, the items deleted from the constructs should have low validity, which can be checked from the result of the interrater agreement so that the deletion of the items has not obstructed the meaning of the construct. The model re-specification process resulted in the deletion of 4 items: C6, SPD1, IS5 and LI5. Finally, the convergent validity result is displayed in Table 2.

Tab. 2. Convergent validity test result

Components	Items	Factor loading	<i>p</i>	χ^2	RMSEA	SRMR	CFI	TLI	CR	Cronbach's alpha	H
C	C ₁	0.823	0.04	2.00	0.05	0.034	0.993	0.991	0.900	0.899	0.903
	C ₂	0.817									
	C ₃	0.752									
	C ₄	0.796									
	C ₅	0.825									
KT	KT ₁	0.856	0.191	1.485	0.035	0.014	0.998	0.997	0.922	0.922	0.923
	KT ₂	0.842									
	KT ₃	0.844									
	KT ₄	0.807									
	KT ₅	0.840									
SPD	SPD ₂	0.872	0.179	1.635	0.040	0.009	0.998	0.996	0.901	0.901	0.905
	SPD ₃	0.843									
	SPD ₄	0.808									
	SPD ₅	0.814									
IS	IS ₁	0.797	0.394	1.037	0.010	0.001	1.00	1.00	0.873	0.871	0.878
	IS ₂	0.733									
	IS ₃	0.843									

	IS _a	0.804									
LI	LI ₁	0.739									
	LI ₂	0.725	0.147	1.698	0.042	0.021	0.996	0.995	0.872	0.867	0.881
	LI ₃	0.853									
	LI ₄	0.842									
SCA ₁	0.810										
SCA	SCA ₂	0.842									
	SCA ₃	0.824									
	SCA ₄	0.833	0.012	1.898	0.045	0.027	0.987	0.992	0.928	0.928	0.935
	SCA ₅	0.873									
	SCA ₆	0.657									
	SCA ₇	0.788									

To guarantee that the construct has the most substantial relationships with its items and not with any other construct in the structural model [47], discriminant validity among six constructs was attained, with AVE value of each construct bigger than the square correlation values (Table 3). Coefficient H, construct reliability (CR) and

Cronbach's alpha were used for reliability measurement. The results for coefficient H in this study ranged from 0.878 to 0.935, CR values from 0.872 to 0.928, and Cronbach's alpha results from 0.867 to 0.928 confirmed a satisfactory outcome for reliability (Table 2).

Tab. 3. AVE and square inter-construct correlation

Construct	IS	C	KT	SPD	LI	SCA
IS	0.795					
C	0.392	0.802				
KT	0.385	0.759	0.838			
SPD	0.373	0.705	0.777	0.834		
LI	0.634	0.474	0.454	0.513	0.794	
SCA	0.508	0.315	0.336	0.453	0.680	0.806

The six constructs corroborated standard factor loading of 0.657–0.873, p-value 0.02–0.39, RMSEA 0.01–0.045, SRMR 0.02–0.055, CFI 0.987–1.0, and TLI 0.991–1.0. After fulfilling the requirements of dimensionality, convergent, and discriminant validity, this study investigates factorial validity, which examines whether a set of latent variables demonstrates an underlying pattern. The results of the full CFA model affirmed a good fit of the measurement model with normed $\chi^2 = 1.505$, SRMR = 0.019, RMSEA = 0.035, CFI = 0.978, and TLI = 0.975.

5. Discussions

The PSS, SCM, and dynamic capabilities theories have been developed to conceptualize the model for this study to measure PSS SC agility readiness. Further, the development of constructs and items, along with definitions, assist the application of PSS, as a SC network collaboration among manufacturers, intermediaries (main dealers), and service partners to improve the SC agility readiness. This study has developed a ready instrument for Product-Service Systems Supply

Chain Agility readiness with six constructs: collaboration, knowledge transfer, service partner development, information sharing, logistics integration, and supply chain agility, comprising 29 items. Such a structure evaluates PSS agile readiness at different levels among SC stakeholders.

- The collaboration consists of items that describe the partnership relationship of creating new capabilities for all stakeholders in the SC: manufacturers, main dealers, and service partners. These items relate directly to the manufacturer's inability to deliver PSS by itself. Then, the manufacturer requires close partners to work hand in hand to provide customers with a Product and service bundle. The collaboration requires long-term partnerships to plan, join, and have many different channels to communicate closely.

- Knowledge transfer reflects the company's capability to transfer and give access to knowledge to SC stakeholders, including knowledge of delivering a bundle of products and services, innovation, customers' expectations, and the capability of being agile.

- Service partner development embraces the capability of all stakeholders in the SC to have the same capabilities to improve SC agility readiness. The most influential stakeholder in the SC is manufacturers; they usually support the leading dealers and the primary dealers, as intermediaries, support the service partners. The manufacturers have continuously provided training courses on technical Products and services to increase speed, flexibility, responsiveness, and innovativeness.
- Information sharing can sense and seize information from any stakeholder in the SC. These capabilities have strongly affected the SC agility readiness, including sharing delicate information, transparent sharing, information interchange, and continuously updating recent information to service partners.
- Logistic integration is crucial to the SC agility readiness to coordinate all logistic activities in the SC effectively. This construct relates directly to the collaboration of supply chain activities, logistics routines coordination with main dealer partners, smooth logistics activities, and excellent warehouse facilities and distribution.
- Supply chain agility embraces the capability to quickly adapt to speed delivery, innovation, flexibility, and responsiveness. These items highly relate to the SC agility readiness.

6. Conclusions

This study has revealed the capabilities required for PSS SC agility readiness. It proposes 29 PSS SCA measurements with six capabilities: collaboration, knowledge transfer, service partner development, information sharing, logistics integration, and supply chain agility. The model is developed based on the capabilities shared among SC networks, including service partners, intermediaries, and manufacturers, to improve supply chain agility readiness. Further, this study contributes to the theory by improving knowledge about the power of capabilities built in the SC network collaboration among stakeholders. Likewise, this study clearly defines each capability construct that contributes to improving supply chain agility readiness. Finally, this study contributes a ready instrument whose item parameters are adequately validated based on DC theory. As a result, the practitioner can utilize the instrument for planning and decision-making, managing and measuring the current capabilities to move forward with improved capabilities. Further, the standard loadings of items related to supply chain capabilities to gauge the importance of each capability in enhancing SCA can also be

used by the practitioners to determine the priority based on the resources. Given the knowledge-intensive nature of the motorcycle industry, it's crucial to establish long-time collaboration and transfer of knowledge and service partner development that reflects the capability of the SC to cooperate in delivering PSS. Likewise, information sharing, logistic integration and supply chain agility are the other three capabilities to shape the PSS SCA readiness. Despite contributions having been explained, the instrument measurement in this study has been dedicated to the motorcycle industry in Indonesia. Thus, broader industries and geographical areas may have resulted in different outcomes. Also, the dynamic changing of an environment may affect capabilities over time, which should be looked at in future research using the study's longitudinal approach. To the best of our knowledge, research examining capabilities in the SC network is developing, so only a few studies have focused on developing PSS SC agility readiness capability. Thus, this study provides rigorous theory and validated PSS SC agility readiness instruments.

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