From Data to Value: how are B2B companies working on the data-driven PSS transformation?

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Abstract: The shift from product to service-centric manufacturing companies has been considerably fostered by technological advancements and Smart Connected Product (SCP) adoption. In particular, the data collected at customers' locations supports the definition of innovative Product-Service System (PSS) solutions, defined as Data-Driven PSSs (DDPSSs), which provide a new source of value to both manufacturers and customers. In this context, the paper aims to provide an overview of how B2B industrial companies are approaching the path towards data-to-value transformation. To reach this aim, the paper presents and analyses seven empirical case studies, through the lens of an existing framework which depicts DDPSS characteristics. Specifically, it evaluates the dimensions that characterise DDPSS: data source, data visibility, response mechanism and decision ownership. As a result, the paper highlights the most frequently implemented features, as the collection of several data types and the areas on which companies are less ready, as the openness to the ecosystem, bringing out industrial needs and possible future research interests.

Keywords: Product-Service System, Data-Driven, Smart Connected Product, multiple case study.

1.Introduction

The increasing diffusion of smart connected products (SCP) (Porter & Heppelmann, 2015) opens up new opportunities for value creation, also in traditional product-centric context. In fact, by adopting new digital technologies, several opportunities are also emerging for manufacturers: one of the most relevant aspects to be considered is the possibility to retrieve a large amount of data from connected sources that, matched with effective data analytics tools, can become a key source of value creation in the context of service provision (Ardolino et al., 2018) and business model innovation (Adrodegari, Saccani, & Kowalkowski, 2016). Therefore, it is not surprising that an increasing number of manufacturers have started a process of integrating their traditional (product-centric) offerings with digital services, developing new capabilities to create value through data gathered from the SCP (Zambetti et al., 2021). The overall transformation towards services based on digital technologies is referred in the literature as digital servitization (Paschou, Rapaccini, Adrodegari, & Saccani, 2020), and the offering of digital products and services as Smart PSS (Pirola, Boucher, Wiesner, & Pezzotta, 2020). Considering, instead, the specific focus of data exploitation, despite opportunities and some successful implementations, the understanding of how to effectively use information in enabling and developing Smart PSS is still limited. Research has, therefore, been called to provide models aimed to support companies in approaching the path towards data-to-value transformation. A first step that has been stated is the need to investigate key components of data-driven services by analysing the commonalities represented in relevant works on the topic (Hunke and Engel 2018). To accomplish this aim, classification methods, and specifically taxonomies and typologies has been proposed in literature (Lim et al. 2018; Rizk et al. 2018), and specifically a Data-Driven PSS (DDPSS) conceptual framework has been proposed for B2B companies by Zambetti et al., (2021). Nevertheless, those frameworks provide a theoretical contribution to the topic, while clear evidence on the state of practice is still missing. Therefore, the presented work aims to investigate how real cases in B2B domain are approaching the transformation toward DDPSS. The authors decided to examine the service offers of real companied by mean of the above mentioned DDPSS framework (Zambetti et al., 2021). Besides use the framework to assess how companies are working on DDPSS, discussions have also been constructed to define benefits and challenges that DDPSS realization creates for companies.

The paper is structured as follow: Section 2 provides an overview of the background that motivates the research. Section 3 explains the adopted methodology. Section 4 presents the results of the application of the DDPSS framework to the multiple case study. Section 5 derives findings and research directions, and Section 6 concludes the work.

2.Background

Digital servitization is an already established research field, focused on the transformation of the way firms offer services based on technological advancement (Lerch & Gotsch, 2015). This trend has been studied especially considering the value that digital technologies can provide to the customers based on the benefit generated for the service provider. Indeed, it has been shown that digitization facilitates the development of cost-efficient operations and is an enabler of service quality through better resource allocation and more accurate information sharing inside and outside the boundaries of the firm (Kindström & Kowalkowski, 2014). Although several studies can be found on this topic, the links between digital technologies and servitization transformation still remain under-investigated (Paschou et al., 2020) and the importance of better understanding this transformation is highlighted (Parida et al., 2019; Tronvoll et al., 2020). Among the different benefits provided by technologies, data availability is a key factor in the transition towards servitization. Indeed, a large amount of data can be retrieved for several connected devices and external sources, and matching it with effective data analytics tools, can become a key source of value creation (Rymaszewska, Helo, & Gunasekaran, 2017). In particular, collecting and elaborating data from the installed base has been recognized as a key aspect for manufacturers to servitize as it can enable sophisticated service offerings and new service-oriented business models (Adrodegari et al., 2016). The utilization of data coming from SCP at customers location as the major source of information had led to the definition of Data-Driven PSS (DDPSS), which is considered a "PSS solution, composed by a hardware part made of one or more SCPs, and a service part which is provided and delivered thanks to the data that the product and sensors at customer locations gather as the primary data source, and also implies the creation of value for some actors through data exchange and analytics" (Zambetti et al., 2021). Those services are characterized by specific differences with respect to the traditional ones, indeed products connectivity enables manufacturers to offer new services with new value propositions (Sambit, Vinit, & Joakim, 2016). The manufacturer has the possibility to continuously auditing customer's operations and expands value creation within the field of product use including services at the client's operation level (Kamp, Ochoa, & Diaz, 2016). Smart connected product is seen as a service component, and a platform as a bridge from customer, product and service provider (Shin, Jeon, & Park, 2016). Data should be shared with the service provider, and particularly if applications are into a business context, the need of a culture of trust with business partners, customer and users increasingly emerges, since clients have no intrinsic interest in sharing operational data with machine tool contractor and to hook them up to their data gathering and processing systems (Kamp, Ochoa, & Diaz, 2016), because of different privacy and security issues. The technological advancement in product connectivity led to the offering of complex solutions rather than traditional PSS, and companies often wish to extend service, but lacking the knowledge about the possibilities that data analytics can provide in the context of those new services. On this topic, limited research is devoted to the definition of the unique characteristics of DDPSS services (Klein, Biehl, & Friedli, 2018), and most of the works that deal with data utilization to support services are focused on technologies, technical development of solutions, and they usually refer to prototypes or demo, demonstrating that commercialized applications are few (M. Zambetti, Pinto, & Pezzotta, 2020). Therefore, it emerges the need to investigated DDPSS, to fill the gap that has been highlighted in the understanding of the role of data and information in enabling servitization and value creation (Cenamor, Rönnberg Sjödin, & Parida, 2017), especially considering real cases.

3.Methodology

Case research has consistently been one of the most powerful research methods, and more significant employment of field-based research methods has been called to cope with the growing frequency and magnitude of changes in technologies and managerial procedures. Cross-case studies are recommended to support a broader pattern of conclusions than possible from any single case study (Yin, 1984). In this work, multiple cases have been conducted exploring service offering characteristics as proposed in the framework by Zambetti et al., (2021), that identifies fourteen categories, grouped in four dimensions that are:

- ***Data source*** which investigated the collection of data at different levels, considering if companies are more focused on product-related data, or instead if they are moving toward the collection of the data that will allow the expansion of their service portfolio;
- ***Data Visibility***, which represents the level of visibility and access to data from different actors;
- ***Response mechanism,*** which describes the output of the data analytic phase, that may support customer decision-making or actuate autonomous reaction; and
- ***Decision Ownership,*** which identifies who perform the decision. Particularly, this dimension defines if service providers adopt a passive or proactive strategy towards service provisions and determine who is responsible for the decisions and assumes the risk of it.

Those dimensions have been evaluated for each of the company in the multiple case study, looking for within-group similarities and differences.

3.1 Sample selection

The companies participating in the multiple case study have been chosen in Business-to-Business (B2B) contexts, considering heterogeneity between the different cases. This has been defined as a requirement for the model validation since it ensures the completeness and generalisation of the framework and enables a general overview in evaluating the state of practice. The differences in the companies can be noticed at several levels: the maturity into the service path, the products and the application domains, technological readiness, and the position into the network. Table 1 reports a brief description of all the companies and introduces their digital servitization path. Semi-structured interviews have been performed with all the companies, following a specific research protocol to enhance validity and reliability of data collected. The protocol has been used to derive the framework and assess all the companies on the framework's dimension. For each company, two interviews have been performed, a first one consisting in the declaration of project objectives and the framework, including a preliminary investigation on their digital servitisation path. Then, a more in-depth interview has been carried out with service managers and/or the responsible for the digitalisation process. Each interview lasted around two hours and at least two researchers were present and later on rescripted them, to avoid bias in the analyses. The main evidence, even considering the evaluation of the dimensions, was shared with each company, and discussed. After consensus has been reached on all the information derived, an inter-company workshop has been carried out, to finally validate results.

Table 1: Company description

	Description	Digital servitization path
CASE1	Case 1 is the biggest Italian dealer of one of the world's largest equipment manufacturer of construction machinery and engines.	The digital journey of the company started from the manufacturer in 2016, combining the on-board technology of the machines with dashboards to show to the customers and final user data and information. The dealer has recognised the difficulties of customers in accessing data and their interpretation; therefore, he has created a platform for condition monitoring in which manufacturers' data is integrated, and a lot of other customer information is also gathered. This enables the dealer to offer proactive services, interpret customer data, and provide them with prescriptive approaches and supports on the decision to take.
CASE2	Case 2 is part of a Swedish multinational company operating in the appliance market for professional use.	Their digitalization process is in development as well as the implementation of DDPSS, despite for a specific product line data were collected at a local level from a long time, and some successful case has been already developed. Their process is based on the following three strategic points: connectivity, webshop and community. The aim is to enable the customers to manage all their operations, via the unique interface, using connected and synchronised products and services, to create business value.
CASE3	Case 3 is an Italian company that offers industrial galvanising plants engineering and realization.	As far as digital solutions are concerned, the company has developed several software packages to support the customer in monitoring the entire plant, considering both the material handling and logistics part and the material processing phases. They developed a proprietary software they divided into three modules: Productivity, Chemical and MES. The first module providers elaborations about the productivity of the plant. The Chemical module manages the data of the chemical process of raw materials. The last module allows managing the entire information flow from the reception of the material to be processed to deliver the galvanised material.
CASE4	Case 4 is an Italian software provider offering a cloud-based platform to support the delivery and sale of intelligent services, based on connected product data.	The company embraces the concept of generality, trying to make generic needs that seem specific, thus managing to configure the platform for different types of products. The software architecture is modular, and each client decides which modules they want to use and offer to the end customer. Moreover, this enables the company to address companies' digital project at each stage, from the ones that start with connecting products, to the ones that want to implement advanced pay-per-use services.
CASE5	Case 5 is a subsidiary of Japanese multinational engineering, electrical equipment and electronics which manufacture and maintenance organic Rankine cycle machines	The company allows customers to view machine data through a SCADA system for several years and the local system also collects data to process trends and statistics describing the measured quantities. This system has also been designed to show data remotely to technicians and perform diagnostic analysis at the customer's request. Moreover, where customers allow, data is also recorded and shared in a database, which uses it to provide preventive and predictive maintenance services. The company is now selecting a technology provider to develop a cloud-based platform for data visualization and analysis.
CASE6	Case 6 is an Italian company leader in the design, manufacture and installation of complete equipment for the retail sector	Already in 2012, the company, among various innovative projects, started the study of new ergonomics for refrigerators with integrated energy-saving systems; and a web-based control system for the performance of refrigerators was implemented. Now, the offer of digital aid on the product is successfully implemented for maintenance and energy management purposes. The company is still working on the continuous improvement of the offer and is experimenting with predictive and advanced analytics.
CASE7	Case 7 is a business unit of a multinational company leader in electrification products, robotics and motion, industrial automation and power grids	The company has undertaken a digital transformation program that, starting from the introduction of connectivity and the creation of a cloud-based platform, is leading to the development of new services based on this continuous data flow from several products. Analytics they can perform vary from maintenance and spare parts to energy management systems. The company is now defining the right dashboards and widget to offer in the platform as well as the service that should be provided to customers.

3.2. Dimensions evaluation

The different categories have been evaluated considering a qualitative scale that has been defined according to three different levels, which are clearly explained in Table 2. Those levels do not refer to good or wrong behaviours of companies but evaluate if specific action has been explored and undertaken or not.

Table 2: Evaluation criteria

Level	Description
Low	It indicates that the company has not yet begun activities regarding the category or is starting to make only preliminary evaluations. It also includes the cases where the company has decided not to take action about the category.
Medium	It indicates that the company has started to consider the category in the design phase or has already started to work on it partially. This category can then be expanded or further refined.
High	This indicates that the company has experienced the full progress of a category.

4. Cross-case analysis

In the following, for each of the framework dimensions, the results of the evaluation of the categories are reported as the average results of the company sample. Specifically, for each of them, Figures represents the average position of the sample for each category in the dimension, followed by a brief discussion.

4.1.Data source

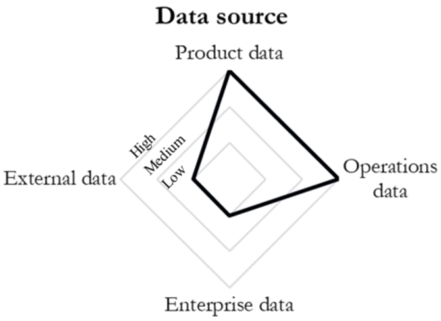

Figure 1: Sample evaluation - data source

Looking at Figure 1, it is possible to notice how the companies are focusing on the ***product data*** category since they own the know-how necessary to exploit data and because it is the most accessible source of data to be collected. In particular, a large part of the sample has active initiatives on collecting data relating to its products, including data on the state of health or the state of the consumables, which are used mainly to provide maintenance and diagnostic services. Several cases also collect ***operations data,*** understand the use of the products, and give indications of productivity and efficiency about the function performed by the product itself. Most of the times, those data are used to enhance products efficiency, but they can also be related to spheres not directly related to the product itself, like energy consumption for appliances or road travelled for vehicles, which supports customers in their operations. ***Enterprise data*** are less common to be collected, nevertheless, some company in the sample collect them to provide information that can be derived only by matching field data with data from management systems. ***External data*** are also collected from a small part of the sample, both considering data such as temperatures, weather conditions, material weight operating, etc. and data that allow the definition of the customer concerning its location, layout, maintenance history etc.

The trend that is possible to notice shows that data collection cannot be limited to product data but should include customer data. The integration of data from different sources allows companies to process complete information, rich in attributes that enable the operator or intelligent automated systems to correlate the different occurrences and trace back to the root of the problems. This leads to the great advantage for the product service provider of improving product performance both in the design phase and in product activity, allowing to act in advance to ensure up-time and guarantee the customer customized solutions, as well as being able to include new services in its portfolio. CASE1 is a perfect example of data collection at all the different levels and demonstrate how it is possible to benefit from it. They collect all the data related to the health of the machine, providing maintenance and diagnostic services. Moreover, they can collect and process data useful to understand the use of the machine, to give indications of productivity, efficiency, operators performances and to suggest to the customer how better to organise their work or the utilisation of machinery.

Nevertheless, data collection is not limited here; indeed, the company gives the customers the possibility to integrate, through APIs, customer management data and matching all information together, supporting them manage their work and order plans. Information is received from the machinery that helps the operator in the working operations. This is also possible thanks to the collection of additional data related to maintenance history, location and the layout of the client site and other sensor data that are positioned on the machinery.

4.2.Data visibility

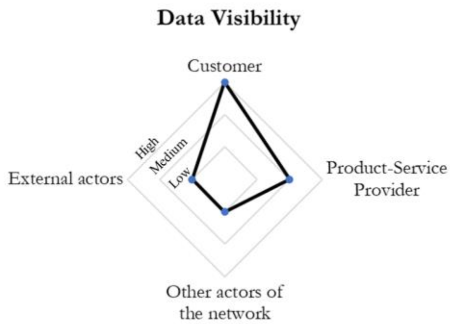

Figure 2: Sample evaluation - data visibility

Considering “Data visibility”, whose categories are represented in Figure 2, industrial realities has been found to have different situations. It strongly emerges that there is an interest in collecting data of other actors but that there is also a brake in the opposite direction, i.e. in sharing proprietary data. In fact, not all the companies in the sample manage to have visibility of the customer's data, and very few of them, once obtained this data, are working to give visibility to other actors in the network, both internal and external. In particular, it is possible to notice that for the majority of the companies, ***the data is made visible to the customer*** since much of the sample has structured front-end data and information visualization platforms for the customer. Despite this, not all data is always available to the customer, who may have access only to a specific subset of the available data. In general, ***data is also visible to the product-service provider***, but not all companies have full visibility on the data, in fact, some customers do not allow access to data to the manufacturer, especially if these are related to the economic sphere. Some of the companies are well structured to differentiate ***data visibility among different actors in the network*****,** sharing with them only necessary data for their activities. In the end, few companies allow ***data visibility to external service provider***s to provide services on the collected data.

Having visibility on data can be of great value for the product service provider, who can monitor customer behaviour, improve the product and the service delivery. Data visibility also supports the enhancement of advanced business models (e.g., pay per use, pay per result), considering the possibility to achieve control over the customer. It must be added the possibility of outsourcing technical activities and complimentary services to external service providers, or the co-design of services with these other providers, opportunities that also bring benefits in terms of "network effects" due to the presence of several actors in the network. In this case, companies' behaviour varies, and only CASE 4, a software provider, is proposing a solution that allows the achievement of all the pre-mentioned categories. Indeed, they provide an infrastructure to continuously gather data from the machinery and enable customer and service providers to monitor data and make regular data analysis. The service provider is also supported in the possibility to suggest to the customer intervention for maintenance, performance optimisation, proactively and predictively. The platform is developed considering different users' interfaces, and most of the OEMs adopting such platform give to internal and external field service partners access to data of their competences, to save cost and time for interventions. The platform also gives the possibility to share data through APIs to external selected actors, which allow the customer to benefit from multiple services from several companies.

4.3.Response mechanism

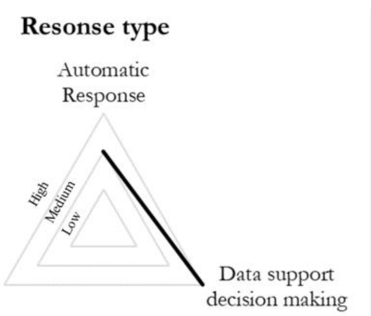

Figure 3 Sample evaluation - response mechanism

Results for the "Response mechanism" are shown in Figure 3. They demonstrate that a good part of the sample has implemented ***automatic response****,* i.e. the data is used to provide new functionality to the product based on data flow. When those functionalities are not implemented is sometimes related to the fact that critical applications do not allow some controls to be implemented for example considering the activation or deactivation of circuit breakers. At the same time, in other cases it is not possible to delegate a decision to an automated system due to its complexity and the need for domain knowledge. This also explains why all companies in the sample actively worked on data visualization as a mean to ***support decision making***.

Data availability has always played a central role in the analysis of a situation and support the best decision. Having access to data, data elaboration and information gives the customers and the service provider the possibility to facilitate the interpretation of situations, even to not expert personnel and lead to best-informed decisions, leading to cost and time savings. When those decisions can be delegated to automatism, those saving can be even more significant. In this regard, CASE3 shows the implementation of both categories for different activities, providing benefits for the customer and its service engineers. A high level of automation that the system can perform thanks to specific data: by setting input data like the weigh and the typology of the raw material, the system computes the time that each phase of the process should last in the different galvanised tanks, providing customers intrinsic knowledge on that the operators may not own. Moreover, it is also able to define which tank to use in accordance with the usage rate and to the status of the chemical solution inside the tanks, optimising the utilisation of all of them and the duration of the chemical solutions. Nevertheless, not all decisions can be provided autonomously, and activities related to the enhancement of customer productivity cannot be automatized, nevertheless, a set of information has been structured to support the customer and the service engineers to find inefficiency and proposing action for improvement.

4.4.Decision ownership

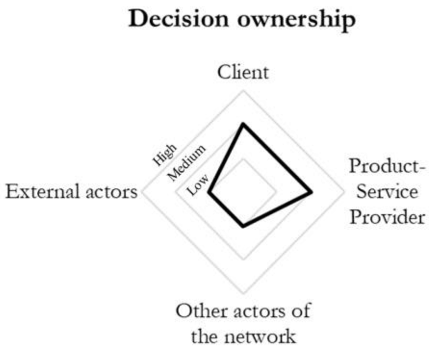

Figure 4: Sample evaluation -decision ownership

Looking at the last dimension in Figure 4, it is possible to see that companies are focused on the first two categories, i.e. client and product service provider. Similar to the data visibility, a lot of autonomy is given to the customer, since usually, ***decisions are taken from the customer***. Much of the sample has structured front-end data and information visualization platforms, allowing them to use those data for informed decisions. A good percentage of the sample is also working on providing proactive services, therefore, **decisions are taken from the product-service provider**, who acts based on data collected. This change in the active interventions from the service provider is related both to data availability and to the lack of knowledge from the customer side to interpret data. Some of the companies delegate some services to ***actors in the network who can also take decisions*** to operate, and also few of them give the possibility to ***external actors to perform decisions,*** providing complementary services to customers.

Decision ownership can create multiple benefits, and beside the sharing of the risk from the customer side and the outsourcing of activities, the product service providers can change their approach towards service provision from responsive to proactive. This also enhances the programming and management of interventions (maintenance, supply, etc.) and the decision-making process in terms of time and costs. The decision ownership to other parties, again gives the benefit to outsourcing technical activities that can also be automatized thanks to the real-time data flows. CASE1, for example, demonstrate how it is possible to proactively perform maintenance services in a preventive way, and how a service provider of machinery can oversee the complete conduction of the customer operations. CASE7 instead represents an example in which the company provides an expected date for the next maintenance needed, computed by a dedicated algorithm, but let the customer the responsibility to call for an intervention, since at now the company has not an organization that can dedicate time to this process. It is also possible to see, in CASE4, how consumables and spare parts information can send trigger directly to the right suppliers that may refurnish the customer or the service provider without the need to control those parameters, saving time and money avoiding shortage.

5. Discussion and findings

Observing the position of the different companies in the sample, it is possible to notice that most of them are oriented to the product, offering more functional services than operational or business ones. It is also worthy of highlighting that the least explored categories are related to the possibility of leveraging the expertise and resources of third parties, which imply opening and reshaping their value chain. During the final validation of cross-cases results in an inter-company workshop, the company has also been asked to provide feedback on how much it is important to invest into one specific category before the group evaluation results were shown to them. It has been possible to notice how companies evaluate beneficial some of the category less explored, but several challenges are still hindering their implementation.

One interesting output is that companies evaluate as a necessary step to move into the data source categories and underline the importance of collecting data from the complete customer reality, including data from other products. Nevertheless, the critical aspect is how to incorporate data that comes from products of competitors in segments where no standard protocols are applied, and if it is right to cover data acquisition to all customer reality. This led to the definition of an interesting research area, that can investigate where the "decoupling line" between the system integrators and the DDPSS providers should be, that also depends on the specific sector.

Another insight comes with the data visibility: all of the companies in the sample believe that sharing data will create enormous potential. Nevertheless, they are reluctant, as well as their customer, to share data. The reason is on one side the privacy and security issue, but another emerging fear is that all actors do not want to lose their role in the value chain. Some companies are debating this topic with partners, trying to define role and policy to share information and not data, maintaining their central position in transforming data into useful information. This also enables them to rely on external actors to perform non-core activities and outsource decision. Moreover, providing a complete solution to the customers, which can only be achieved from the cooperation between different actors, enables all of them to retain customer loyalty. This led to the need to better address the ecosystem perspective, defining a focus in the definition of role and rules in a DDPSS value chain. Moreover, different data sharing options should be delineated to provide evidence on the different existing extend in the data visibility and, consequently, decision ownership.

Companies' organization for data analysis has also been discussed: indeed, one of the most important points in providing proactive service is the development of a structured back-end and an organization dedicated to those activities. Nevertheless, companies are not yet all structured to examine data and act proactively, either considering the organization and how they analyse data that usually remains time-consuming and manual edit. This suggests defining different possible analytics and information that could match decision-making levels and necessary skills that the final users should have, to better comprehend how to develop data analysis and visualization for the different possible internal and external consumers.

6. Conclusion

Starting from an existing typology on DDPSS, the presented work gives an overview of how B2B companies are approaching the transition towards those service type, providing evidence on the overall sample direction and enriching the discussion with several specific examples. The paper also discusses interesting insights that emerged from practitioners' feedbacks and derived future research direction. The work also presents some limitations, indeed, the company assessment is related to a predefined framework, but it is possible to consider also other frameworks that incorporate different aspects, such as the business model perspective, to have a more complete view of the companies' behaviours. Another limitation comes with the sample, which considers seven cases working into heterogeneous contexts, a further study may choose a single application field and gather information from multiple actors working in it, to derive sectoral implications.

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