Re-manufacturing networks for tertiary architectures

Innovative organizational models towards circularity

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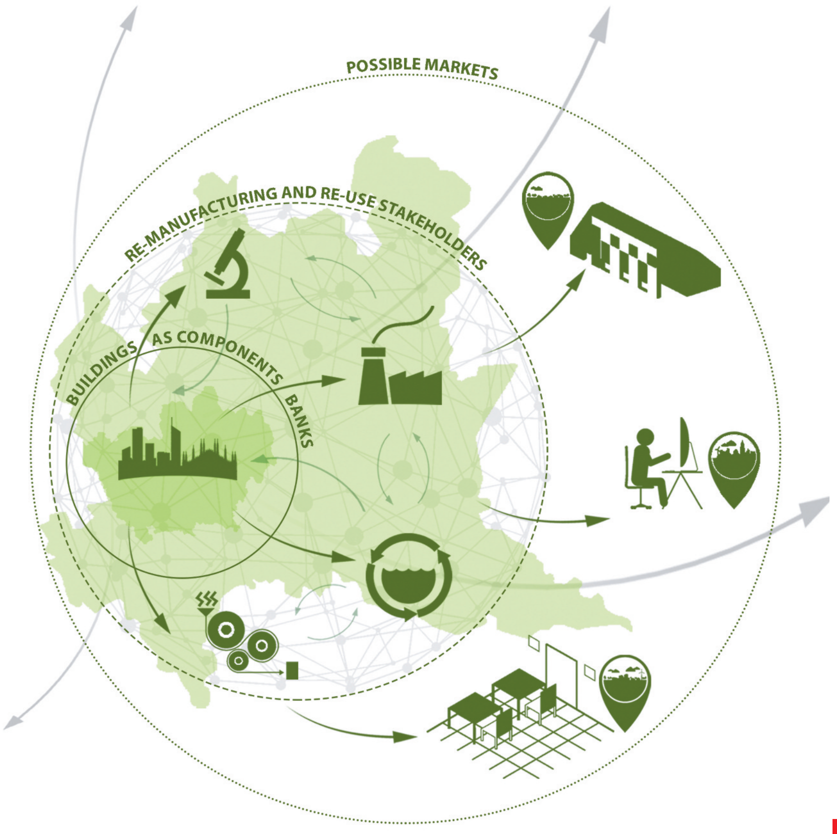

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diretta da Giovanni Zannoni (Università di Ferrara)

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The book presents the results of the project "*Re-NetTA (Re-manufacturing Networks for Tertiary Architectures). New organizational models and tools for re-manufacturing and re-using short life components coming from tertiary buildings renewal*", developed at Politecnico di Milano (2018-2021) and supported by Fondazione Cariplo, grant n° 2018-0991 (Call "Circular Economy for a sustainable future 2018").

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by *Marika Arena, Sara Ratti, Luca Macrì, Carlo Vezzoli*

14.1 Collaborative organizational models for circularity: a Product-Service System approach

In a circular perspective the imperative is to establish a certain level of decoupling between the economic output and the environmental impact that is attached to the production and consumption of the good or service. A circular vision necessarily questions the dynamics ruling the current production and consumption systems, considered in the mainstream economic model as linear flows of inputs and outputs and by nature not compatible with a circular-oriented approach.

In this regard, the Sustainable Product Service System (S.PSS) has been studied since the end of XXI century as promising organizational and offer models coupling environmental and economic benefits. Specifically, S.PSS is defined as follows (Vezzoli *et al.*, 2021):

«Sustainable Product-Service System (S.PSS) is an offer model providing an integrated mix of products and services that are together able to fulfil a particular customer/user demand (to deliver a "unit of satisfaction"), based on innovative interactions between the stakeholders of the value production system (satisfaction system), where the ownership of the product/s and/or the life cycle services costs/responsibilities remain with the provider/s, so that the same provider/s continuously seek/s environmentally and/or socio-ethically beneficial new solutions, with economic benefits».

In relation to the definition of S.PSS, three main model characteristics may be outlined:

– **From product sale to "unit of satisfaction" provision**. S.PSS shifts the business focus from selling (only) products to offering so-called

"unit of satisfaction", i.e., a combination of goods and services jointly capable of meeting the satisfaction of the final user.
- **Innovation integrating the stakeholder interaction level**. S.PSS addresses at first the innovation at a stakeholder interaction level, then it moves to a technological one. In this regard, multiple innovative stakeholder configurations can apply (i.e., a product offer combined with all-inclusive product life cycle services to customer; offer as enabling platform for customers; final result offer to customers).
- **From ownership to accessibility**. S.PSS shifts the value perceived by he customer from individual ownership to access to goods and services.

S.PSS characteristics are aligned with one of the approaches promoted by the European Union within the Circular Economy Action Plan (2020) based on "incentivising product-as-a-service or other models where producers keep the ownership of the product or the responsibility for its performance throughout its lifecycle"(European Commission, 2020).

Three main S.PSS approaches to system innovation have been studied, adapted and listed as favourable for eco-efficiency, including lifespan extension and in particular re-manufacturing and reuse (Hockerts & Weaver, 2002; Tukker, 2004; UNEP, 2002; Vezzoli *et al.*, 2014).

a) Product-oriented S.PSS.
b) Use-oriented S.PSS.
c) Result-oriented S.PSS.

14.1.1 A Product-oriented S.PSS (type I): adding value to the product life cycle

In summary, a Product-oriented S.PSS innovation adding value to the product life cycle is defined as (Vezzoli *et al.*, 2021):

> a company/organization (alliance of companies/organizations) that provides all-inclusive life cycle services – maintenance, repair, upgrading, substitution, re-manufacturing and product take-back to guarantee the life cycle performance of the product/semi-finished product (sold to the customer/user).

A typical service contract would include all-inclusive maintenance, repair, upgrading, substitution, re-manufacturing and product take-back services over a specified period of time. The customer/user responsibility is reduced to the use and/or disposal of the product/semifinished product (owned by the customer), since she/he pays all-inclusively for the product with its life cycle services, and the innovative interaction between the company/organization and the customer/user drives the company/organization's economic interest in continuously seeking environmentally beneficial new solutions, i.e. the economic interest becomes something other than only selling a larger amount of products.

14.1.2 Use-oriented S.PSS: offering enabling platforms for customers (type II)

In summary, a use-oriented S.PSS innovation offering an enabling platform to customers is defined as (Vezzoli *et al.*, 2021):

> a company/organization (alliance of companies/organizations) that provides access to products, tools and opportunities enabling the customer to get their "satisfaction". The customer/user does not own the product/s but operates them to obtain a specific "satisfaction" (and pays only for the use of the product/s).

Depending on the contract agreement, the customer/user could have the right to hold the product/s for a given period of time (several continuous uses) or only for one use. Commercial structures for providing such services include leasing, pooling or sharing of certain goods for a specific use. The customer/user consequently does not own the products but operates on them to obtain a specific final satisfaction (the client pays for the use of the product). Again, in this case, the innovative interaction between the company/organization and the customer/user drives the company/organization to continuously seek environmentally beneficial new solutions together with economic benefits, e.g., to design highly efficient, long-lasting, reusable and recyclable products.

14.1.3 Result-oriented S.PSS: offering final results to customers (type III)

In summary, a result-oriented S.PSS innovation offering final results to customers is defined as (Vezzoli *et al.*, 2021):

> a company/organization (alliance of companies/organizations) that offers a customized mix of services, instead of products, in order to provide a specific

final result to the customer. The customer/user does not own the products and does not operate on them to obtain the final satisfaction (the customer pays the company/organization to provide the agreed results).

The customer/user benefits by being freed from the problems and costs involved in the acquisition, use and maintenance of equipment and products. The innovative interaction between the company and the customer/user drives the company's economic and competitive interest to continuously seek environmentally beneficial new solutions, e.g., highly efficient, long-lasting, reusable, easy-to-re-manufacture and recyclable products.

14.2 The implementation of Product-Service Systems in re-manufacturing contexts: challenges and opportunities for product durability

S.PSS might overcome the criticalities emerging from the application of a linear and traditional sale organizational model to a circular business proposition. Indeed, in a traditional product supply and demand chain, economic benefits mainly derive from the sales volume (directly related to the amount of goods sold). According to this view, product durability is a characteristic that potentially threatens the sales volume, hence the economic revenues, by reducing the number of sold units. Hence manufacturers might not encourage the extension of product lifespan, being not incentivized from an economic point of view.

Differently, an S.PSS implies that the origin of economic revenues of a product or service provider shifts from the sole sale of good to an offer of products and services, paid per unit of user's satisfaction. By offering services oriented to extend the product lifespan (i.e., maintenance, repair, upgrade, substitution, re-manufacturing), the longer durability of product or its components, the higher probability of avoidance or postponement of provider's disposal costs or costs attached to the production and selling of new product (economic benefits). In this setting, producer/providers are driven by economic interests to offer products and services oriented to fulfil customers' needs, rather than the product sale. This implies the motivation to lengthen product lifespan duration, hence minimizing environmental impact of businesses and favouring circular business propositions, such as re-manufacturing.

In relation to the specific context of re-manufacturing, the main opportunities connected to a Product-Service System can be summarized as: environmental optimization of product lifecycle through product and material lifespan extension and manufacturers' ownership. These will be briefly discussed.

As anticipated in the previous paragraph, the promotion of product lifespan extension is a key aspect of S.PSS that fits with the primary objective of a circular business proposition, such as re-manufacturing-based ones. In particular, as far as the S.PSS provider is offering the product, retaining the ownership and being paid per unit of satisfaction, or providing an all-inclusive product-service offer (i.e., maintenance, repair and upgrade and substitution), the longer the product/s or its components durability (environmental benefits), and the more the provider avoids or postpones the disposal costs plus the costs of pre-production, production and distribution of a new product substituting the disposed one (economic benefits). Hence the providers are driven by economic interests to design (offer) for lifespan extension of product/s.

In a similar way, the approach to both the design and use of materials and components are driven by the objective to extend their usability and durability as long as possible. Indeed, as far as the product-service provider is selling the product all-inclusive of end-of-life services, she/he will try to recycle or extend the lifespan of materials to avoid or to limit the costs attached to landfill or to the purchase of new primary material, energy or compost.

Consistently, the S.PSS focal aspect on accessibility in substitution of user's product ownership advances potential synergies with a re-manufacturing approach, both from the manufacturer's and user's side. Indeed, by retaining the ownership and/or the responsibility for life cycle services/costs of the products or its parts, the manufacturers have an intrinsic interest in designing products for longer lifecycles, to enable re-manufacturing opportunities after the use phases. Moreover, by only exploiting the functions of the products, not having the ownership on the physical goods, the user's acceptance for a re-manufactured good is enhanced, hence increasing potential demand for these types of products.

Despite the numerous potential synergies between Product-Service Systems and re-manufacturing, some criticalities are recognized largely in practice, leaving the implementation of re-manufacturing-based S.PPS limited to some experiences. Main challenges and barriers associated to Product-Service Systems and re-manufacturing are connected to the market acceptance, the management and forecast of cost and revenue flows and the approach to organizational changes (Copani and Benham, 2020).

One of the major barriers encountered by re-manufactured products is related to market attractiveness. Indeed, the evaluation of possible outdated performance and aesthetics might make customers more uncertain in front of re-manufactured alternatives. This aspect proves the reality that re-manufactured products are currently sold in business-to-business sectors, in the contexts of spare part substitution or secondary market segments: in these contexts, function is preferred than aesthetics and other cultural aspects and the market attractiveness is mainly driven by cost convenience and performance.

Product-Service Systems and re-manufacturing imply also to rethink the economic stream flows, such as costs and revenues. Indeed, the introduction of the product return, in a post-consumer phase, implies an additional aspect given the augmented unpredictability related to both the timing and to the conditions of the returned good, hence increasing overall information asymmetries. Also, a Product-Service System, grounded on the provision of a service along a specific period of time, requires a revisited and adjusted demand forecasting system in order to determine the optimal pre-determined price. In general, the complexity of the sales forecasting is amplified and more sophisticated capability to capture evolving market needs is significant in the revenue and cost management system.

Moreover, the complex nature of financial stream management required in a re-manufacturing-based Product-Service System imposes the arrangement for significant changes at organizational level. For instance, the competences and resources needed to assess the financial value of the returned goods, given the multiple uncertainty factors in the system, cover more significant roles in the organization. Hence the different financial management also require the organizational willingness to rethink functions roles and management.

14.3 Product-Service System models in relation to re-manufacturing value chain of tertiary architecture industries

The various categories of tertiary buildings are characterized by short renewal times, accelerated obsolescence of equipment and interior fittings, prevalence of dry assembled and highly performing components. Moreover, tertiary buildings are mostly managed by facility management integrated with service providers that are generally responsible for real estate, representing large volumes of components, requiring repair or disposal in case of building renewal. These intrinsic elements of the tertiary sector within the construction industry represent key premises for the applicability of re-manufacturing, oriented to reduce the current significant environmental impact of the business.

Considering the various synergic elements between re-manufacturing and Product-Service Systems, Re-NetTa research project aimed at investigating the opportunities of a re-manufacturing-based S.PSS model into the tertiary architecture context, by formulating and discussing potential innovative organizational schemes together with practitioners. In particular, this has been carried out through engagement activities – i.e., semi-structured interviews and roundtable sessions – with companies and stakeholders from different areas of the tertiary architecture sector (exhibition, office, retail). In this section, key insights related to the lesson learnt from this study are summarized, distinguishing the opportunities, the challenges, and the needs.

In relation to enabling elements retrieved in the tertiary architecture context, two major value chain aspects are presented.

One element is connected to the procurement strategy, oriented to activate the provision of the necessary cores for re-manufacturing or re-processing operations. This deals with the establishment of a contractual relationship with the user that ensures the possibility and the conditions to re-collect the product after a use-cycle. Consistently, through the formulation of business models for re-manufacturing for the tertiary construction industry, multiple procurement strategies for activating a reverse supply chain have been presented and discussed.

Specifically leasing-based contracts and service contracts have been selected as proper commercial strategies with customers of tertiary construction sectors, for securing the relationship with customer that is embedded in a service-oriented business model, rather than a single-payment and solely product-oriented one. Surcharge-based (based on a surcharge payment at the return of the sold product) and buy-back mechanisms (based on an offered price to the customer for the return of the sold product) were not identified as suitable strategies in the tertiary architecture applications, mainly due to the relatively low value of the product post-consumption and the service-based orientation of the relationship with the customer.

Specifically, leasing-based systems are recognized to be a reality in some businesses when there is a relevant driver related to fiscal advantages for the customer: this is the case of the leasing of furniture components for corporate offices. As emerged from the interaction with key stakeholders, leasing-based arrangements are also considered potential tools for enabling close-loop business models for selected categories of products within the office environment – which are characterized by a low level of customization and a strong customer focus on the resource function.

A second element retrieved in the value chain of some tertiary architecture contexts that might be in line with a Product-Service System offer logic is the shift towards "accessibility" moving away from the sole "product ownership" concepts.

Specifically, the way supply chain actors interact is currently linked to a sale, through which the ownership and the life cycle responsibility over the good is transferred from the provider to the recipient. Differently, the Product-Service System logic challenges this existing interaction structure, by moving beyond the ownership and/or the life cycle responsibility concept and leveraging on the access to a specific experience of product use (through a product, or a service, or a combination of both). In relation to this aspect, some industrial contexts of tertiary architectures emerged to be more ready for a Product-Service System logic than other ones.

For instance, in exhibition fitting sector, some experiences proved that the retention of product ownership in the hands of the provider assumes a significant role in the viability of a circular business offer, since the design and the management of the business proposition are defined for a product lifecycle extension ex-ante: this again fits with inherent features of S.PSS offer models.

The engagement of field actors and experts also led to the understanding of main hindering elements of product-service-oriented models for re-manufacturing.

A major barrier was identified in the increasing level of product customization and branding. If on one hand, these trends might stimulate long-term customer relationships and customer retention strategies, on the other hand they are not often consistent with a product re-manufacturing and reuse approach.

A second issue deals with the flow of materials coming from maintenance, renewal or demolition processes of tertiary buildings. The research led to the understanding of experiences from tertiary architectures, that often demonstrated that the volumes of materials are not sufficiently high to determine the birth of side circular businesses, and the re-organization of existing linear practices. As highlighted among the recognized challenges associated to Product-Service Systems, the demand forecasting covers a relevant role in the design and management of a PSS offer. Therefore, a market characterized by a high demand instability (recorded in terms of types of components and quantity) does not represent a promising arena for the implementation of a product-service-oriented model for re-manufacturing products.

The understanding of hindering factors attached to the tertiary architecture context put the basis for the definition of the key needs for the application of possible circular organizational models based on a Product-Service System logic.

First, in order to mitigate the customization trend, a relevant need is identified in the formulation of market solutions characterized by a fair balance between modularity and customization. By promoting modularity and standardization of technical elements, post-consumer operations, such as assembling and disassembling, product retrieval, maintenance, repair and replacement, are facilitated. Moreover, more standardized products are more easily to destinate to different markets, opening further opportunities for the product lifecycle extension. This issue shed the light on the enabling role of design phase within the value chain oriented to extend product lifecycle. It is worth to stress that the design of modular and more standardized products should consider the potential threat of a low market attractiveness of those products. Indeed, as explained in 14.2.2, the low market acceptance emerged to be a challenging aspect for the diffusion of re-manufactured products.

Secondly, market players recognize that the shift to a re-manufacturing model requires relevant changes in the structure and dynamics of the existing supply chain, hence a support from the policy and regulatory frameworks is demanded in this regard. Specifically, the operations of a re-manufacturing business model request the availability of various resources (both economic, physical resources and intellectual capital) that are missing or scant in the existing network: hence, the definition and the support for new professional figures with proper cross-sectoral skills, including eco-design and circular practice management linked to the building process along the whole product life cycle.

Further policy tools and incentives are called in relation to the promotion of innovative and circular practices within existing market mechanisms. For example, environmental requirements introduced in the tender definitions are recognized to be a driver for moving existing players toward the experimentation of more sustainable practices.

The investigation of the state-of-art of industrial systems within the office, retail and exhibition arenas led also to the understanding that a set of guidelines of procedure and methodological guidelines are demanded to have a comprehension about possible opportunities for re-manufacturing. Also, more interventions are needed in the aspects of regulations, for the definition of procedures and entities for ad-hoc certifications associated to re-manufactured goods.

References

Copani G. and Behnam S. (2020), *“Re-manufacturing with Upgrade PSS for New Sustainable Business Models”. CIRP Journal of Manufacturing Science and Technology*, 29: 245-256.

European Commission (2020), *Circular Economy Action Plan: For a Cleaner and more Competitive Europe*, Publications Office of the European Union, available at: https://data.europa.eu/doi/10.2779/05068.

Hockerts K. and Weaver N. (2002), *Towards a Theory of Sustainable Product Service Systems – What Are the Dependent and Independent Variables of Spss?*

Tukker A. (2004), “Eight types of Product-Service System: Eight Ways to Sustainability? Experiences from SusProNet”, *Business strategy and the environment*, *13*, 4: 246-260.

Vezzoli C., García Parra B. and Kohtala C. (2021), *Designing Sustainability for All: The Design of Sustainable Product-Service Systems Applied to Distributed Economies* (p. 142). Springer Nature.

Vezzoli C., Kohtala C., Srinivasan A., Diehl J.C., Fusakul S., Liu, X. and Sateesh D. (2014), *Product-Service System Design for Sustainability.*

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