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## **From technological demonstrator to sustainable supply chain demonstrator: a conceptual framework**

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New products are becoming increasingly complex, involving an increasing number of stakeholders. Consequently, innovation cannot always be driven by the company alone. Research suggests that it is often a collective and open process (Boly, Camargo, et Morel 2016). Indeed, the development of a new product often requires new resources, a new delivery method, and a distribution of implementation tasks among several companies. As a result, innovation occurs within large systems of collaboration between customers and suppliers (Maniak and Midler 2008) or between end customers and companies (Vánca et al. 2011). Therefore, it is important to have a vision of the sequence of actors (i.e. the supply chain) involved in launching an innovation (Boly, Camargo, and Morel 2016).

Several studies argued that the product launch and launch conditions are not considered as success factors for innovation. However, recent research works emphasize that supply chain design is part of the new product development process (NPDP) (Sharifi, Ismail, et Reid 2006; Marche 2018). Thus, one of the major industrial challenges is to anticipate the design of the innovative product chain in order to define, at the design stage, an appropriate supply chain capable of supporting this new product.

Furthermore, these challenges are amplified by new additional environmental and societal issues that need to be considered in the NPDP. Companies are more inclined to integrate environmental concerns throughout their production chains to cope with the pressure of environmental regulation (European Commission 2019) and the evolving demand from consumers who are increasingly aware of the conditions in which products are produced and distributed (Teuteberg and Wittstruck 2010). In this context, scientific research is increasingly focusing on the notion of sustainable supply chains in which production and distribution systems are more environmentally efficient (Genovese et al. 2013). Closed-loop processes, eco-design, recycling, reuse, re-manufacturing of end-of-life products etc., are all strategies that characterize the sustainable supply chain and integrates within the R9 circular economy framework (from Refuse -R0- to Recovery -R9-) (Morseletto 2020). With these strategies the sustainable supply chain remains an important unit of action for the transition to circular economy (Aminoff et Kettunen 2016; Liu et al. 2018), with the purpose of tackle current linear economy logic "take-make-use-dispose" that caused negative environmental effects. The integration of circular strategies within the NPDP reduces environmental impacts but also generates economic benefits for companies (reduced material inputs and associated labour and energy costs) and promotes the creation of new markets through the production of new eco-innovative products (Ellen Macarthur Foundation 2012; Kasmi 2018).

The development of such eco-innovative product requires time, investment and important functional and structural changes involving new supply chain management modes based on circular economy principals. As a result, companies are seeking to demonstrate its technological, commercial and industrial feasibility before it is launched on the market using prototypes, models and demonstrators.

The notion of demonstrator refers to an innovation operated at or near full scale in a realistic environment (OECD 1993). The demonstration can be both part of the experimental development phase of R&D and the industrial emergence phases (Phaal et al. 2011). It consists in operationalizing the knowledge acquired through research or experimentation with the aim of testing and evaluating the conditions allowing the realization of a technological innovation project. The literature on the industry life cycle identifies several types of demonstrators and highlights their potential role in supporting the transition from new science to technology and finally to the market (Phaal et al. 2011; Moultrie 2015). These

works emphasize the capacity of the demonstration phase in improving the potential of future application of a new technology/innovation.

However, these studies remain focused on the technical aspects of the innovation demonstration (technological demonstrators, commercial demonstrators, price-performance demonstrators...), while the organisational and structural aspects related to the management of the adapted supply chain capable of supporting this technology are less studied. In this paper, we particularly focus on the notion of demonstrator considering not only the new technology/product but also all the relations and synergies between the stakeholders involved in its supply chain. Thus, based on the couple formed by a product and its supply chain (Marche 2018), how to design the sustainable supply chain demonstrator favouring the circular economy in order to ensure their feasibility before their deployment on an industrial scale?

To answer this question, a theoretical framework defining the sustainable supply chain demonstrator will be proposed based on a combination of the literature on demonstrators and sustainable supply chains. This theoretical analysis will be completed with the results obtained in the scope of the European project INEDIT<sup>1</sup>. The results of this analysis is a conceptual framework in order to formalize the invariants and requirements beyond the technical aspects that needs to be considered prior to a pre-industrial stage.

This research aims to:

- Provide a more precise theoretical definition of the notion of "sustainable supply chain demonstrator", describing in particular the attributes of a sustainable supply chain demonstrator;
- Specify the links between technology demonstrators and supply chain demonstrators (translation of technology demonstrator requirements into supply chain demonstrator requirements);
- Highlight relevant indicators specific to the circular economy, thus enabling stakeholders (companies, laboratories, territorial bodies) to assess the transition from technological demonstrator to a sustainable supply chain demonstrator and to validate whether industrialization is feasible, identifying the opportunities and challenges to overcome in the industrialization stage

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<sup>1</sup> <https://cordis.europa.eu/project/id/869952>

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