

# Diffusion Challenges of Circular Economic Products (Abstract)

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## Problem Identification

Today's technology already allows some of the commercial products to be fully recycled through a closed loop supply chain, dramatically improving the natural resource effectiveness. However, despite many technological and commercial effort, and even though consumers' environmental consciousness has been growing, such "circular economic" products are often prone to low market penetration and fail to reach a critical mass before their businesses become self-sustaining. In order to investigate why and to gain an insight for policies aimed at a smoother diffusion, a simple model case of polyester garment market is conceptualized by the author and analyzed.

## Model Overview

The focus of the research is limited to investigate the listed hypothesis which are thought to be important hurdles for diffusion of circular economic products in general. For simplicity, the model market is fixed in total size with 10,000 adopters and assumed to be consisting of 2 types of products; the conventional Linear Economic Product (LEP, polyester garment made from virgin resource such as crude oil and incinerated at the end of use) and the Circular Economic Product (CEP, polyester garment made from recycled polyester via closed loop supply chain). Fig. 1 shows an overview of the main model structure as a Causal Loop Diagram (CLD).

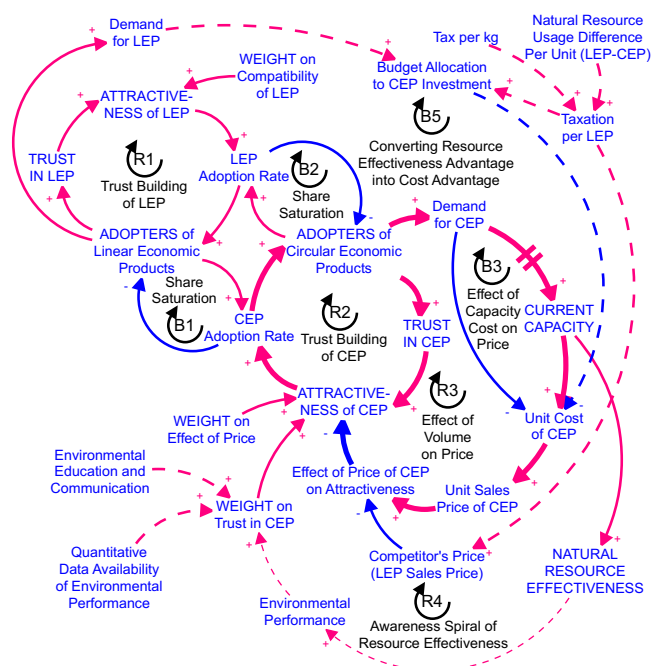
## Hypothesis

- (1) As with any product, the market growth of LEP and CEP are both enabled and constrained by reinforcing loops originating from economies of scale, learning curve and accumulation of social recognition such as trust in the product (Loop R1, R2 and R3 in CLD). Thus, the nature of the CEP diffusion process is path dependent, eliminating any accumulated effort below the tipping point.

- (2) Compared to LEP, CEP bears a disadvantage of significantly higher fixed cost since it has to invest both in production and recycling capacity. This forces higher initial cost and unit price, higher risk and increased difficulty to adjust to changes of the demand.
- (3) The standard accounting and economic system will be biased against investments to improve environmental performance because the costs of investment will be accounted for while its long term benefit will not be reflected to market prices.

Fig. 1 Causal Loop Diagram\* of the model case

\*dashed arrows indicate suggested policy intervention



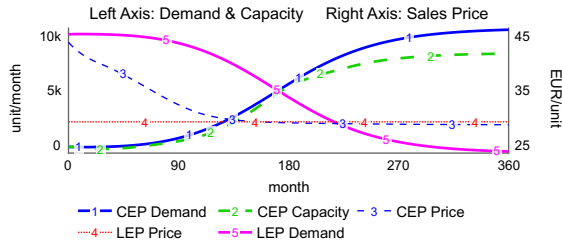
## Analysis

The initial state represents an LEP dominant market with 95% market share, enabling LEP a unit price of €30, which is used as a constant competitor's price in the simulation. On the contrary, CEP business has only limited market share, trust and capacity, with an

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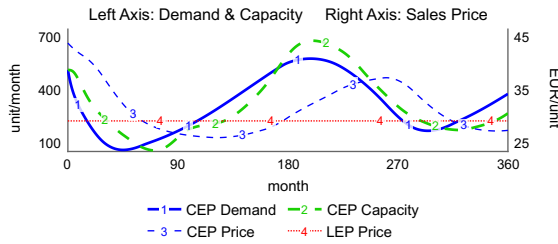
initial price of €43. The behavior of CEP demand can be categorized into two basic patterns, determined by the parameter value of “weight on trust in CEP” which affect consumer’s purchasing choices.

Fig. 2 base case A (above the tipping point)



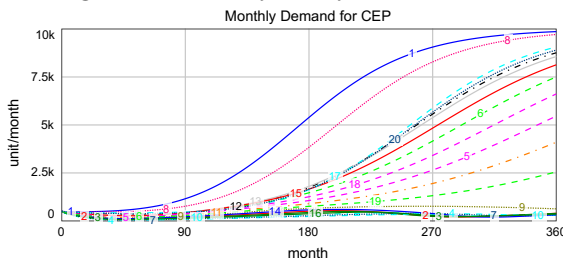
Base case A represents a swift transition scenario from an LEP dominant to a CEP dominant market, enabled by consumers putting a high enough priority on trust in environmental advantage of CEP, which always outweighs CEP’s large price disadvantage for a long time. However, this does not represent today’s struggle of CEP business, indicating that the majority of consumers are usually more sensitive to price.

Fig. 3 base case B (below the tipping point)



Base case B describes a more realistic behavior of CEP demand stagnating at a low level, which aligns with the problem statement. Consumers are assumed to put weight on trust in CEP just enough to choose CEP if they are only slightly more expensive than LEP. A slight growth of CEP demand initiates the capacity expansion to satisfy demand, which will come in operation and takes effect on price with a significant delay (loop B3), generating a limit cycle.

Fig. 4 Sensitivity Analysis of base cases



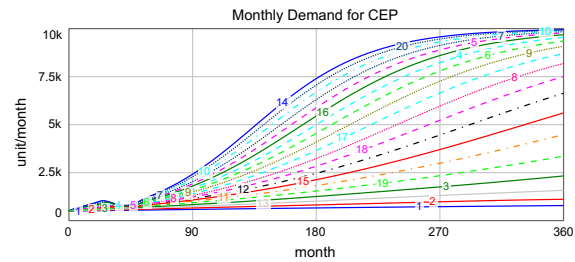
As hypothesized in (1), the problem for diffusion lies within the path dependent nature of the market itself. A sensitivity analysis by changing the weight on trust in CEP shows an uneven distribution of CEP demand, suggesting a strong dominance of reinforcing loops over the system, strictly separating scenarios below

or above the tipping point. This “Either Or” situation severely limits the chance of diffusion, since small but firm efforts and results of CEP businesses cannot accumulate in the system. Moreover, if CEP had the same cost requirements as LEP (higher material cost, much lower capacity cost), the diffusion above the tipping point would be quicker and the oscillation below the tipping point would be less amplified. CEP is destined to bear a disadvantage of cost structure from the beginning, as hypothesized in (2).

## Policy

While its cost disadvantages are fully accounted for in the market, CEP’s remarkable advantage that no other product has – the extension of effective lifetime of natural resources for multiple times – is largely left for consumers to evaluate. Intangible benefit as such is even more difficult to appreciate when heavy investments are meant for reverse logistics, what is not for direct improvement of the product itself. One policy suggestion is to enhance the weak link in CLD to fully activate the awareness spiral loop (R4) by education and improved information transparency.

Fig. 5 Sensitivity Analysis of tax allocation policy



Aligning with hypothesis (3), H. Lehmann et al. (Factor X, 2018) points out that market prices are wrong due to discounted externalities, and economic instruments should be deployed to facilitate a shift away from overheads on labor and towards taxing raw materials. Nevertheless, it is physically possible to measure resource consumption of LEP and CEP quantitatively. Fig.5 demonstrates a policy where per kg crude oil consumption is taxed and redistributed to the less consuming product (loop B5). It shows that such policies based on so called “material added tax” could function as a powerful balancing loop that allows to address a fundamental market problem.

## Limitation

In this model, the physical stock and flow structure of the closed loop supply chain, the dynamics of LEP price and adopters disaggregation were intentionally omitted for simplicity. Further research is required to capture the interactions with suggested policies.