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# Platform flexibility strategies: R&D investment versus production customization tradeoff

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ABSTRACT

Product platforms are assets that are shared by multiple products. We study the optimal investment in platform flexibility. Each platform type is characterized by its functionality that determines its R&D investment and unit production cost, as well as the customization cost to produce the end products from the platform. The firm can invest in a portfolio of specialized platforms that align with the functionalities of a specific product and flexible platforms that cover the functionalities of a product range at lower customization cost. We characterize the optimal platform portfolio strategy using an ex-ante investment versus ex-post production customization tradeoff curve and show comparative statics of these costs, demand forecast, and the decision maker's regret and risk attitude. Flexible platforms provide operational hedging for risk-averse decision makers who thus should invest *more* than risk-neutral counterparts. In contrast to manufacturing flexibility, the regret of sub-optimal investments increases as demand is more negatively correlated.



## 1. Introduction

Product platforms are 'the collection of assets (i.e., components, processes, knowledge, ...) that are shared by a set of products' (Robertson and Ulrich, 1998, p. 20). These flexible assets facilitate cost-efficient product variety that is increasingly desired in markets characterized by more customer heterogeneity, fiercer competition, and fast evolving technology.

Much has been written on the benefits and disadvantages of product platforms in production and supply chain management (see e.g., Desai, Kekre, Radhakrishnan, & Srinivasan, 2001; Krishnan & Gupta, 2001; Simpson, Jiao, Siddique, & Hölttä-Otto, 2014). Little research attention, however, has been devoted to a key decision in platform-based product development: how much investment in platform flexibility is desirable? Which type of platform, or which portfolio of flexible platforms should be developed, and how are these decisions impacted by demand and cost uncertainty and a manager's attitude towards risk?

Platform development often requires substantial R&D investments: Volvo invested over USD 11 billion in its scalable platform architecture, which from 2016 onwards is used to derive all its different car models (Volvo, 2014). At the same time, evolutions in the automotive industry force firms to adapt their platform portfolio: in 2019, Volvo plans to bring its first all-electric vehicle to the market, based on a new modular electrification platform (Lambert, 2017). GM announced to reduce its number of platforms from 30 in 2010, down to four platforms by 2025 (Financial Times, 2012; 2015). These platform R&D investment decisions are frozen far in advance of knowing actual product demand and can have large cost implications. In this article, we present a stylized model to gain insight in the value-maximizing platform portfolio decision and its robustness, dependent on the demand forecast characteristics (demand scale, product scope, forecast uncertainty, and correlation between products), the cost structure of the fixed platform development versus the variable production and customization costs to end products, and the manager's regret and risk avoidance.

We develop a stochastic model with recourse of a two-product firm that offers a low-end and high-end product (product $j \in \{L, H\}$). In the first stage (ex-ante) the firm must decide which portfolio of platforms it should develop knowing only a product demand forecast. In the second stage (ex-post), the firm observes the actual demand $D = (D_L, D_H)$ and fulfills the demanded number of products by producing $D_L + D_H$ platforms and subsequently customizing them to the end products. The ex-ante investment in platform

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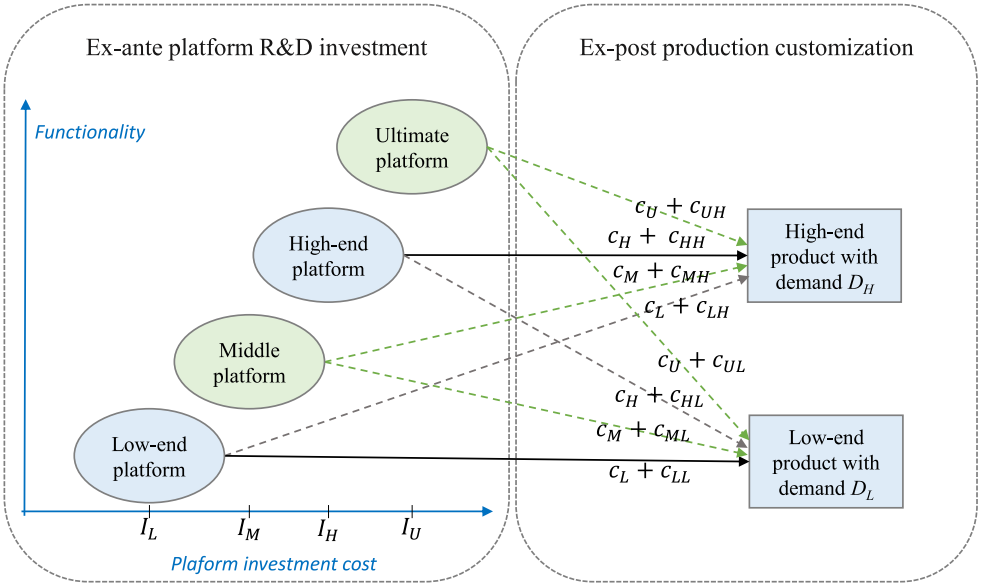


**Fig. 1.** We model a firm that can develop a portfolio of four possible platforms $i \in \{L, M, H, U\}$ (left panel). Each platform can be customized to produce two vertically-differentiated products $j \in \{L, H\}$. Each platform has its own functionality and investment cost $I_i$, ex-post unit production cost $c_i$ and ex-post unit customization cost $c_{ij}$.

development is fixed in that it is independent of the later production quantities. In contrast, the ex-post production and customization costs are variable and incur a unit cost per unit produced.

We consider a platform portfolio that can include four types of platforms $i \in \{L, M, H, U\}$, respectively, denoting a low-end, middle, high-end and ultimate platform. Each platform type $i$ is characterized by its functionality that determines the R&D investment cost $I_i$ and the unit production cost $c_i$ to produce platform $i$, as well as the customization costs $c_{ij}$ to produce product $j$ from platform $i$, visualized in Fig. 1. The low- and high-end platforms are specialized for respectively the low- and high-end products (therefore we will call them the two '*specialized*' platforms). Developing only a low-end platform requires minimal investment and production costs, but it is under-designed for the high-end products and incurs high customization costs when it is upgraded to derive high-end products (Van den Broeke, Boute, & Samii, 2015). Developing a high-end platform requires higher investment and production costs, but incurs lower customization costs when it is downgraded to derive low-end products. The middle platform functionality is 'in-between' the low-end and high-end products. Consequently, its investment, production, and customization costs are both somewhere between these two platform types. Finally, the ultimate platform is the most flexible according to the notion of flexible products by Alptekinoglu and Ramachandran (2015) and Chen, Vakharia, and Alptekinolu (2008) (where, for example, a firm can choose to offer a selection of specialized golf clubs or golf clubs with reconfigurable lofts that can be adapted by the consumer to her needs). The ultimate platform's ex-ante investment and ex-post production costs exceed the high-end platform costs, but its customization cost to derive either product is negligible, as the ultimate platform already contains the functionalities of each product. The ultimate platform is thus overdesigned for both the low- and high-end product. In contrast to the specialized low- and high-end platforms, the middle and ultimate platforms do not bet on one specific product. Therefore, we will refer to them as '*flexible*' platform investment strategies because they retain the flexibility to cost-efficiently deliver both the low-end and high-end product.

Our paper contributes in the following way:

1. We present a platform flexibility model and analytically characterize the optimal platform portfolio that minimizes total costs. Our analysis prescribes a firm's platform R&D investment using an investment versus production and customization tradeoff curve. We show under which conditions it is optimal to develop a low-end or high-end platform (which we refer to as 'single specialized platform strategies'), a middle or ultimate platform (referred to as 'single flexible platform strategies'), or multiple platforms (i.e., a 'combined platform strategy').
2. We incorporate risk considerations by (i) evaluating regret, defined by the potential loss when making a sub-optimal platform investment, and (ii) risk, defined by the variance of ex-post production customization costs. We evaluate the value of perfect demand information and we identify the mean-variance frontier to incorporate the decision-maker's risk attitude.
3. We show that investing in the development of a flexible (i.e., the middle or ultimate) platform can be optimal, even in the absence of demand uncertainty and *a fortiori* in the presence of risk aversion. Flexible platforms are effective operational hedges, meaning that they can reduce the variance of the future costs, while the expected costs increase only marginally. The latter effect is stronger in environments with higher demand uncertainty, higher development-intensity of the platforms, and more negative correlation between product demands. Under negative correlation we find that the regret of developing a suboptimal platform portfolio increases. These insights are opposite to investments in manufacturing flexibility, such as flexible capacity investments.

Our research question spurs from a need at several companies to determine their optimal platform flexibility strategy. Barco, for instance, is a global technology company that introduced platforms in the design and production of its medical displays (Boute, Van den Broeke, & Deneire, 2018). The printed circuit board (PCB) was defined as the product platform. The different product variants are then obtained by adding electronic and mechanical components to the PCB. A key question is which platforms (PCBs) should be developed to serve their portfolio of products. For instance, the company has non-Fusion and Fusion displays, respectively, seen as a low-end and high-end product, where the latter is capable of showing two images simultaneously. The required fea-

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