Product renewal in platform-based ecosystems: The impact of product portfolio complexity in global derivative exchanges

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Abstract

Purpose - Theoretical advancements in ecosystem innovation have largely focused on platform-based ecosystems within high-technology industries. This study extends prior works by examining derivatives exchange platforms —a long-established, increasingly digitalized segment of global financial services—where transaction dynamics differ from traditional platforms, thereby uncovering important contingencies in the business-to-business (B2B) marketing and ecosystem management literature.

Design/methodology/approach - This study analyzes a sample of 119 derivative exchanges from 1996 to 2013 across 37 countries. Using a zero-inflated Poisson (ZIP) model, we examine how product portfolio complexity (PPC) influences new product introduction and removal, and how these effects vary with PPC magnitude.

Findings - Our findings indicate that there is a nonlinear S-shaped relationship between PPC and product renewal in the context of platform-based ecosystems. The study reveals that both new product introduction and product removal are essential strategies for managing a complex product portfolio within derivatives exchange platforms, highlighting the cumulative effects of the knowledge base and ecosystem dynamics.

Originality/value - This research contributes to B2B marketing and innovation research by exploring the unique dynamics of derivatives exchange platforms within platform-based ecosystems. By identifying the S-shaped relationship between PPC and product renewal, we provide valuable insights for practitioners and scholars seeking to navigate the complexities of ecosystem management and innovation strategies in digitalized B2B markets.

Keywords platform-based ecosystems, product portfolio complexity (PPC), new product introduction, product removal, derivatives exchange.

1. Introduction

How do platform-based ecosystems innovate? Over the past decade, platform-based business ecosystems have emerged as dominant organizational architectures, enabling direct interactions among multiple user groups—typically buyers and sellers—through digital infrastructures (Hagiu and Wright, 2015; McIntyre and Srinivasan, 2017). Initially conceptualized as a metaphor for joint value creation (Moore, 1993, 1996), the ecosystem construct has evolved into a strategic lens used across disciplines such as innovation (Gawer and Cusumano, 2014), technology governance (Wareham *et al.*, 2014), and increasingly, business-to-business (B2B) marketing (Aarikka-Stenroos and Ritala, 2017; Jacobides *et al.*, 2018). In B2B settings, an ecosystem structure offers firms increased flexibility and responsiveness in managing complex inter-organizational relationships (Aulkemeier *et al.*, 2019). It increasingly serves as "a way of making interdependencies more explicit" (Adner and Kapoor, 309), allowing firms to leverage collaboration and relationships across boundaries.

An important area of inquiry is understanding how the platform-based ecosystem form is itself the subject of value creation (cf. Kapoor, 2018; Pervin *et al.*, 2019). As of 2020, the seven top-ranked and platform-orientated firms (viz. Apple, Microsoft, Alphabet, Amazon, Facebook, Alibaba, and Tencent) generate US$6.3 trillion in market value (Cusumano *et al.*, 2020). Moreover, International Data Corporation (IDC) (2024) forecasts that over two-thirds (70%) of industry-specific B2B ecosystems will be orchestrated by small and medium-sized businesses by 2029. While research has primarily focused on high-growth sectors such as social media platforms, logistics, and online retail, less attention has been given to traditional B2B industries where platforms have long existed and offer equally rich insights. As a case in point, the global financial services sector—particularly derivative exchanges— has long functioned as a platform-based ecosystem, facilitating multilateral interactions among diverse actors including trading parties, clearinghouses, logistics providers, and financial institutions. These exchanges have adopted various growth strategies and rely on complex product portfolios to serve and coordinate these stakeholders. The Chicago Mercantile Exchange, for example, has evolved into a highly diversified derivatives platform for over a century across all major asset classes, including interest rates, equity indexes, foreign exchange, metals, and others. Conversely, the London Metal Exchange is the global hub for trading nonferrous (e.g., copper, aluminum, nickel, lead, zinc, and tin). Such patterns echo one salient feature of platforms – growing out of a complex product portfolio to serve heterogeneous users (Anderson, 2008; Eisenmann and Alstyne, 2006, 2011).

Despite growing research interest in ecosystems (Jacobides *et al.*, 2024; Kretschmer *et al.*, 2022; Leminen *et al.*, 2018; Zhang *et al.*, 2025), a critical gap remains in our understanding of how platform-based ecosystems—particularly in B2B contexts—manage product portfolio complexity (PPC) and how this complexity shapes their capacity for product renewal. PPC refers to the breadth and depth of product categories offered within a platform-based ecosystem (Fernhaber and Patel, 2012), reflecting both the variety of offerings and the range of options within each category. Managing PPC complexity is essential for platform ecosystems to introduce new products, retire outdated ones, and remain adaptive in dynamic environments. To conceptualize this relationship, we draw on ecological insights, where species richness—the number of distinct species in a system—is a foundational condition for ecosystem functionality (Downing and Leibold, 2002; Pimm, 1984). In platform ecosystems, PPC can be seen as a form of species richness that reflects the need to serve diverse, interdependent stakeholders (Rong *et al*., 2018; Pervin *et al.*, 2019). As PPC increases, it amplifies the overall complexity of the ecosystem, which in turn compels complementors to innovate or optimize their offerings in response to heightened interdependencies—adapting "their products so as to account for great interdependence between their products and other components or subsystems within the ecosystem" (Kapoor and Agarwal, 2017: 536).

Hence, the level of PPC within a platform-based ecosystem can serve as a key driver of ecosystem innovation (i.e., introducing new products to the existing ecosystem) and optimation (i.e., removing the existing product from the ecosystem). Together, these two processes constitute what we refer to as product renewal strategies, which reflect the platform's adaptive response to evolving interdependence and stakeholder needs. The literature suggests that such strategies involve both benefits and costs, including the ability to leverage distributed knowledge embedded across various actors within the ecosystem—such as platform owners, complementors, and service providers—and to capitalize on broader network effects, as well as the adjustment and coordination costs associated with managing complex product portfolios (Fernhaber and Patel, 2012; Jacobs and Swink, 2011). Building on this, we theorize how PPC influences product renewal strategies through mechanisms of knowledge integration and ecosystem coordination. We test our predictions using a dataset of 119 global derivative exchanges from 1996 to 2013. This context is especially well-suited because, as part of global financial services, it operates through platform-based ecosystems where knowledge management and innovation play a central role (e.g., Kauffman *et al.*, 2015; Yang *et al.*, 2023). Their long-standing and well-documented operations provide a rich, underexplored setting for examining PPC and product renewal in platform ecosystems, especially in the B2B context.

We contribute to the B2B marketing and innovation literature in two ways. First, we advance ecosystem innovation research by illustrating that the relationship between PPC and new product introduction is driven by two key mechanisms. One is the knowledge base effect, which reflects the platform actors' ability to effectively apply and integrate the diverse knowledge embedded within a complex product portfolio (Roper and Hewitt-Dundas, 2015).

The other is the ecosystem effect, capturing the advantages gained from a broad and heterogeneous base of platform users and stakeholders (Jacobides *et al.*, 2018). In contrast, the link between PPC and product removal reveals the costs associated with complexity, particularly adjustment and coordination challenges (Hashai, 2015; Zahavi and Lavie, 2013). By emphasizing ecosystem structure as a driver of product renewal, our study offers new insights into how B2B platforms navigate complex inter-organizational relationships through strategic portfolio decisions. Second, we conceptualize new product introduction and product removal as essential product renewal strategies that allow platform-based ecosystems to effectively manage complexity. Our findings uncover an S-shaped relationship between PPC and product renewal, highlighting the nonlinear dynamics through which complexity influences both innovation and optimization. This perspective diverges from much of the existing ecosystem literature, which has largely focused on innovation alone (e.g., McIntyre and Srinivasan, 2017), and directly addresses calls within B2B marketing research for a deeper understanding of ecosystem management and innovation processes (Gölgeci *et al.*, 2022; Ojha *et al.*, 2021).

The rest of the paper is organized as follows – we first detail the literature review in the theoretical background section leading to the hypothesis development section. Next, the methods, data, and estimation process are presented. Results and discussion sections follow these sections. Finally, we conclude this paper.

2. Theoretical background

2.1. Product portfolio complexity

PPC arises from the variety and interconnectedness of product design elements within a firm's offerings (Closs *et al*., 2008; Fernhaber and Patel, 2012). In platform-based ecosystems, expanding the product portfolio can reduce dependence on a limited set of products, enhancing resilience against uncertainty and technological shifts (Day, 2007).

However, as ecosystems build their product portfolio, over time, the costs of coordination and management will outweigh the benefits derived from the broad portfolio (Closs *et al*., 2008; Shunko *et al.*, 2018; Thompson *et al*., 2005). Hoole (2006) notes that firms with higher complexity have on average three percent lower profit margins than other firms. Researchers assert that the benefits of PPC are realized at the expense of coordination costs (Jacobs and Swink, 2011; Kekre and Srinvasan, 1990) and adjustment costs (Hashai, 2015). Only when the platform-based ecosystems are endowed with specific competencies (Closs *et al*., 2008) or learning mechanisms (Fernhaber and Patel, 2012) can they absorb the benefits of PPC and overcome the high liability of high PPC.

Given the challenges in developing an optimal product portfolio (Fisher and Ittner, 1999; O'Cass and Heirati, 2015; Shunko *et al.*, 2018), studies have identified three key dimensions of PPC: multiplicity, diversity, and interrelatedness (Jacobs and Swink, 2011; Kang and Montoya, 2014; McNally *et al.*, 2013). *Multiplicity* implies the creation of groupings of products such that it would entice consumers to buy these groupings rather than consider buying the single product on its own. These groupings generate higher sales as consumers assign higher buying attractiveness to these combinations of products. Yet, platform-based ecosystems need to strategically balance popular products with slower-moving or new offerings—poor bundling can diminish customer value and hurt revenues. *Diversity* or unrelatedness between the products can generate extra sales for the platform-based ecosystems by offering a large choice set to the customers, but this comes at a high cost to the platform-based ecosystem as they have to develop, coordinate and manage a large set of products. *Interrelatedness* involves complementary products that drive cross-selling; yet, without effective integration, such strategies risk user dissatisfaction. Therefore, platform-based ecosystems must carefully balance these three dimensions to maximize their product portfolio's benefit.

2.2. Product portfolio complexity, knowledge base, and ecosystem effects

Whether broad or deep, a complex product portfolio exposes a platform-based ecosystem to a higher stock of knowledge and facilitates knowledge integration or application in creating new products and facilitating innovation (cf. Roper and Hewitt-Dundas, 2015). Platform-based ecosystems with high levels of product portfolio breadth usually draw widely on different categories of knowledge. One primary benefit from this is economies of scope that entail productive integration of knowledge across product categories and combinatory search in creating new products (Zahavi and Lavie, 2013). It also encourages new technological experimentation, preventing platform-based ecosystems from locking into a narrow knowledge scope (Xu, 2015). Conversely, platform-based ecosystems with high product portfolio depth levels usually repeat their use of knowledge within product categories. Such platform-based ecosystems are familiar with the technology within their technical expertise and related customer needs. Benefiting from scale economies, they can apply existing knowledge to create new products (Xu, 2015). Also, greater product portfolio depth reduces the likelihood of errors and false starts, making new product introductions more predictable (Katila and Ahuja, 2002).

The ecosystem effect, akin to network externality, denotes a phenomenon where the value of the product does not depend on the product itself but on other complementary products or users with whom the customer can interact (Jacobides *et al.*, 2018; Koski, 1999). The ecosystem effect of PPC is specific to platform-based ecosystems. Such an effect is demand-side economies of scope and scale with increasing returns (Saloner *et al.*, 2001). This ecosystem effect is separate from the interrelatedness dimension of PPC. The ecosystem effects are complementarity effects outside the platform-based ecosystems, whereas the interrelatedness dimension of PPC is within the product portfolio of the platform-based ecosystem (cf., Jacobs and Swink, 2011; Jacobides *et al.*, 2018).

2.3. Product portfolio complexity, adjustment costs, and coordination costs

Adjustment costs refer to the costs incurred when a platform-based ecosystem misallocates or inappropriately transfers resources that are well-suited to one product but poorly aligned with the requirements of others (Hashai, 2015; Levitt and March, 1988; Zahavi and Lavie, 2013). These costs are usually acute in the initial growth of PPC for the following two reasons. First, platform-based ecosystems at low PPC levels have a limited knowledge base and an absence of routines to deal with PPC (Barnett and Freeman, 2001). Prior studies have pointed out that resources are sometimes category- or product-specific and cannot readily be redeployed in other categories or products (Eggers, 2012; Fernhaber and Patel, 2012). Platform-based ecosystems with a high product focus have difficulty identifying the relevant resource when diversifying into other product categories or bringing within-category knowledge to a deeper level. Second, platform-based ecosystems at low levels of PPC lack legitimacy and reputation in the operation of additional product categories or more products within product categories. Compared to their counterparts who already provide a complex product portfolio, they are placed in a disadvantageous position—they are less likely to win the customer loyalty and trust of their stakeholders.

On the other hand, coordination costs are imposed by creating and handling complex linkages between product categories or between products within a single product category (Hashai, 2015; Zahavi and Lavie, 2013). The coordination costs of PPC are analogous to those in diversification (Williamson, 1975) and internationalization (Lu and Beamish, 2004), all of which originate from limited cognitive capacity, information asymmetry, and incentive misalignment. Coordination costs are not salient at low levels of PPC and steeply grow as PPC reaches a critical point (Hashai, 2015; Lu and Beamish, 2004). As Jacobs and Swink (2011) note, diversity and interrelatedness generate additional costs for platform-based ecosystems. Unless the platform-based ecosystems are capable of offsetting these higher costs with increased revenues, these dimensions of PPC can indicate value-destroying propositions for the platform-based ecosystems.

3. Hypotheses development

3.1. Product portfolio complexity and new product introduction

Creating new products is an essential source of competitive advantage because offering distinctive product attributes can provide unique benefits to a platform's key stakeholders, such as business customers, complementors, and end-users, thereby increasing their satisfaction and engagement (Kim *et al*., 2013; O'Cass and Heirati, 2015). New product introduction is a major strategy for organizations pursuing growth under competition (Penrose, 2009; Si *et al*., 2022). A platform-based ecosystem's performance in a new product introduction is a function of its internal knowledge base, the breadth and depth of which play a critical role (Katila *et al*., 2015; Yayavaram and Chen, 2015). Specific to a platform-based ecosystem, creating new products is confined within the ecosystem boundary. Both its customers and partners get involved in the product development process (Eisenmann and Alstyne, 2006). Therefore, PPC affects a platform-based ecosystem's new product introduction in two ways. On the supply side, a complex product portfolio is enhanced by the *knowledge base* upon which a platform-based ecosystem relies on introducing new products (Eggers, 2012). On the demand side, a complex product portfolio is a heterogeneous *ecosystem* composed of platform users and partners, contributing inspiration and channels for new products (Cucculelli and Ermini, 2012; Krishnan and Gupta, 2001).

The positive effects of both product portfolio breadth and depth, a supply-side effect, on new product introductions may be subject to diminishing returns. Too broad or too deep, a product portfolio leads to information overload and complexity in knowledge management. Given high product portfolio breadth levels, products are tenuously linked, drawing on a disparate knowledge base (Quelch and Kenny, 1994; Roper and Hewitt-Dundas, 2015). In this situation, platform-based ecosystems struggle to find common knowledge across product categories, making knowledge integration impossible (Xu, 2015). Similarly, as the product portfolio further deepens, the possibility of creating products based on the same set of knowledge declines. This fosters core rigidity and deters new product introduction (Yayavaram and Chen, 2015).

As the product portfolio broadens or deepens, a larger and more heterogeneous user base comes into play. These users are spread all over different product categories or along with a product category. Their diverse backgrounds and direct user experience make them even better champions for new products than the platform providers. Through intensive connections between platform users, new ideas for product development are developed and channeled to platform-based ecosystems. Once new products are listed, platform users are fiercely devoted to new product usage and provide valuable product improvement suggestions. Furthermore, greater PPC enhances platform value, making it costly for users to switch to other platforms (Farrell *et al.*, 1998).

Figure 1a illustrates how the integration of our ideas leads to our prediction about the relationship between PPC and new product introduction. The red dotted line represents the knowledge base effect of PPC. Both knowledge breadth and depth benefits increase with PPC, up to the point of diminishing returns. The blue dotted line represents the ecosystem effect of PPC. Such an effect is expected to be initially flat and grow as PPC reaches a critical point. The knowledge base and ecosystem effects collectively create a solid blue line.

[Insert Figure 1a & 1b about here]

At low levels of PPC (Phase 1), platform-based ecosystems primarily benefit from knowledge breadth and depth in new product introduction. They gain little from the ecosystem since the outside links have not formed. At medium levels of PPC (Phase 2), information overload and rigidity problems deter platform-based ecosystems from effective knowledge management; however, the ecosystem effect is still absent. Therefore, the new product introduction stabilizes. At high levels of PPC (Phase 3), the network of heterogeneous platform users eventually forms. The growing ecosystem effect offsets the decline of the knowledge base effect. Again, new product introduction quickly increases with PPC. When embracing both the knowledge base effect and the ecosystem effect, we posit:

Hypothesis 1: The relationship between PPC and new product introduction is nonlinear, with the slope positive at low levels of PPC, leveling off at medium levels of PPC, and positive at high levels of PPC.

3.2. Product portfolio complexity and product removal

Product removal is also a critical aspect of innovation (Sorenson, 2000). Most studies have theoretically posited that platform-based ecosystems remove products as an internal selection mechanism to cope with environmental selection pressures (Henderson and Stein, 2004; Khurana *et al.*, 2022). In platform-based ecosystems, product removal decisions can be made either by supply-side actors based on their own strategic considerations or by the platform's governing body that oversees and manages the overall ecosystem to maintain its competitiveness and efficiency (e.g., Wei *et al.*, 2021; Zhu *et al.*, 2022). From this perspective, the decision to eliminate a product does not necessarily imply failure of the product but represents a managerial action—whether by individual suppliers or the platform governance—to optimize competitive chance (De Figueiredo and Kyle, 2006; Ingram and Roberts, 1999). A platform-based ecosystem can reap efficiency benefits by removing obsolete, redundant, or over-priced products. Relevant empirical evidence has demonstrated that product removal improves platform-based ecosystem survival (Henderson and Stein, 2004; Sorenson, 2000).

Importantly, product removal and new product introduction can coexist, enabling PPC to grow even as some products are cut to manage costs (Hvam *et al.*, 2020). At the early stages of increasing PPC, product removal primarily addresses adjustment costs by eliminating incompatible or underperforming products (e.g., Khessina and Carroll, 2008; Yang *et al.*, 2023), thereby facilitating portfolio expansion. As adjustment and coordination costs stabilize, the need for product removal decreases, allowing PPC to increase steadily. At high levels of PPC, coordination costs—such as product cannibalization and managerial attention overload—rise sharply, triggering selective removal of redundant or obsolete products to preserve portfolio efficiency. Such removal does not fully offset new product introductions. Instead, it may support continuous portfolio renewal and growth. Following this logic, our study views product removal as a strategic response to mitigate two key types of costs, including adjustment costs and coordination costs (e.g., Hashai, 2015; Zahavi and Lavie, 2013).

At low levels of PPC, platform-based ecosystems face negative transfer and legitimacy challenges when attempting to increase portfolio complexity. These challenges, emerging from adjustment costs, usually yield undesirable product quality (Eggers, 2012) and poor platform-based ecosystem performance (Hashai, 2015). In this situation, product removal provides a tool for performance improvement (Carroll *et al.*, 2010). By removing ill-performing or incompatible products, platform-based ecosystems can increase ecosystem-wide profits at the expense of losing the returns on specific products. Therefore, we expect that the propensity for product removal, along with adjustment costs, will initially increase with PPC and then decline as the internal knowledge base and external legitimacy are gradually established over time.

We focus on two key situations where product removal helps reduce coordination costs at high levels of PPC. The first situation is product cannibalization or intra-firm competition, which takes place as PPC increases (Carroll *et al*., 2010). Under this circumstance, a platform-based ecosystem's own products compete not only for the same group of customers in the external market but also for human and financial resources within an organization. Overcrowded products create information overload problems as managers distribute their limited attention between different products, increasing maintenance and coordination costs. For example, designers can feel overwhelmed as the number of products proliferates without limit within the platform-based ecosystem (Dowell, 2006). Therefore, platform-based ecosystems have the propensity to improve performance by internally removing competing products.

Second, as PPC increases, diverse platform users generate new ideas, leading to product introductions with often high failure rates (Cooper and Kleinschmidt, 1987; Cooper *et al*., 2001). Timely removal of new products that fail is essential to reduce costs and prevent resource drain, ensuring the ecosystem maintains quality and meets customer needs (Dowell and Swaminathan, 2000; Giarratana and Fosfuri, 2007). Figure 1b illustrates how the interplay between the adjustment and coordination costs results in our prediction about the relationship between PPC and product removal, displayed by the solid blue line. The red dotted line represents the adjustment costs of PPC, and the blue dotted line represents the coordination costs of PPC. At low levels of PPC (Phase 1), platform-based ecosystems heavily rely on product removal to reduce adjustment costs because of negative transfer and legitimacy challenges. At medium levels of PPC (Phase 2), adjustment costs decline, and coordination costs are still not salient. The need to deal with either type of cost through product removal is not urgent. At high levels of PPC (Phase 3), coordination costs go up steeply with PPC, which calls for product removal in portfolio management. Taking both adjustment and coordination costs into account, product removal targets underperforming or redundant products while new introductions drive portfolio growth, allowing PPC to increase despite simultaneous product introduction and removal. We propose:

Hypothesis 2: The relationship between PPC and product removal is nonlinear, with *the slope positive at low levels of PPC, leveling off at medium levels of PPC, and positive at high levels of PPC.*

4. Methods

4.1. Data and sample

We conducted our empirical analysis within the context of global derivatives exchanges. A derivatives exchange is a central marketplace for trading standardized futures or options products. It provides infrastructure and rules that facilitate the transaction between derivative buyers and sellers (cf. Gawer and Cusumano, 2014). The derivative market is a natural monopoly industry, where customer base and product variety are key success factors for exchanges. As a result, there exist only a handful of, if not one or two, exchanges in any one specific country. Even in the United States, there were only around 20 derivative exchanges during our research period, and more than 70 percent of exchanges were affiliated with a larger exchange group so as to exploit potential synergy from integration. The development of derivative markets varies across countries. The U.S. accounts for a disproportionate share of trading volume and derivative product offerings, suggesting its long-standing competitive position as a global financial center. The European derivatives exchanges, taken collectively, have been salient players in the global derivatives markets. Since the 1990s, the derivative markets in emerging markets have made remarkable progress, with their exchanges moving up the trading volume ranking. These exchanges aspire to gain a competitive position in the global competition, despite regulatory constraints and technological disadvantages.

We chose the global derivative exchange industry as a relevant empirical context for two main reasons. First, this industry features complex B2B service innovations that require close customer relationships and advanced risk management. These factors make it more important for companies to have product portfolios that balance variety and specialization

(Dotzel and Shankar, 2019). Second, its unique monopoly structure allows us to explore how limited competition shapes strategic decisions around product introduction and removal—particularly how firms manage trade-offs in portfolio complexity to maintain relevance and competitive advantage (Kolb and Overdahl, 2006).

We used product data of derivative exchange from the Global Futures and Options Volume Database from 1996 to 2013. The longitudinal dataset was collected by the Futures Industry Association (FIA) from its member exchanges and recoded all exchange-traded futures and options contracts, together with the yearly trading volumes of each contract. We employed four sets of information (contract name, relevant categories, the exchange for listing, and trading unit) in the FIA database to identify a particular futures or options contract (Sandor, 1973; Silber, 1981). The firm data were drawn from public resources on the Internet (including exchange websites, Wikipedia, and related news reports)[1]. We searched the exchange information (including founding year, location, and M&A events) and identified the countries where the exchanges are located. Finally, we collected country-level economic data from the World Bank database, cultural data from GLOBE's national culture index, and institutional data from the Worldwide Governance Indicators Project and the KOF Globalization Index.

Given the national idiosyncrasies of the financial markets, we considered an organization responsible for product portfolio management as being historically embedded within a national institutional environment. We adopted an exchange-location pair as the unit of analysis (Fabrizio and Thomas, 2012). We employed four rules to identify the exchange-location pair. Our first rule was to separate the exchanges within any business group in the same nation since such affiliated exchanges usually have their product strategy. For instance, we classified CBOE (Chicago Board Options Exchange), C2 (C2 Options Exchange), and

[1] Since several exchanges ceased trading during our study period, we were unable to access their official websites and thus relied on Wikipedia and other secondary sources to collect the relevant information.

CFE (CBOE Futures Exchange), which have the same holding company (CBOE Holdings), as independent units. Our second rule was to separate exchange subsidiaries in different countries. For instance, we tabulated the London-based ICE Futures Europe, ICE Futures U.S., and ICE Futures Canada, all of which are operated by ICE (Intercontinental Exchange), as three independent derivative exchanges in the U.K., the USA, and Canada. Our third rule was to separate exchanges merged into another exchange later during our study period if both parties' product lists were not merged in the FIA database. Besides, we created a dummy variable to control for the potential group or parent-firm effect on exchange performance. Finally, we excluded NYMEX (New York Mercantile Exchange) for the years 2003-2013 because it has listed OTC contracts cleared on the NYMEX ClearPort platform since 2003. We also excluded observations of seven transnational exchanges (e.g., OMX exchanges and Nord Pool) whose products could not be specified in one nation.

These procedures finally yielded a sample that consisted of 119 derivative exchanges and an unbalanced panel with 898 observations (exchange-years) for studying new product introduction and 900 observations (exchange-years) for product removal decisions from 1996 to 2013. These derivative exchanges operated in 37 countries or areas (including 24 developed—the Organization for Economic Co-operation and Development (OECD) member countries or areas—and 13 developing ones—non-OECD member countries or areas). First, a derivative exchange is an atypical platform firm providing a marketplace for buyers and sellers. It brings together individuals, companies, and institutions in risk management (Gawer and Cusumano, 2014). Second, product introduction and removal play a vital role in the success of derivative exchanges. Our study is primarily based on the FIA database, which provides detailed information about the entry and exit of every product in the global derivative exchanges from 1996 to 2013 (Su and Si, 2015). Derivative product introduction is vibrant, with constant product renewal. For example, it is estimated that less than 50 percent of futures products remain viable after three years, and only 20 percent remain viable after five years (Kolb and Overdahl, 2006). Such data provide an ideal context for studying product renewal strategy. Third, our database contains heterogeneous exchanges with varying levels of PPC. The recent consolidation trend has made several big derivative marketplaces the most diverse in history; examples are the Chicago Mercantile Exchange and New York Stock Exchange-Euronext. However, a number of exchanges remain specialized in small niche markets, offering a limited number of products. The divergent features make it possible to examine the effects of PPC and product renewal.

4.2. Variables and measures

New Product Introduction

For the first dependent variable, *new product introduction*, we considered a particular futures or options contract as newly listed if it had not been listed in year *t-1* but was subsequently added to the list of contracts traded in the focal exchange in year *t*. Furthermore, we conducted two additional procedures to ascertain that the new contract was a new product. First, if a contract was missed in a certain year, we double-checked the contract list in year t-2 to ensure that the new contract appeared for the first time in two years. Second, we checked the exchanges merged into one organization in our database to see whether the new contract had been newly acquired or newly introduced (e.g., the Budapest Stock Exchange acquired the Budapest Commodity Exchange in 2006). Based upon the above procedures, we created a dummy variable, a new contract, with respect to each contract (1 if it was newly listed and 0 otherwise) and calculated *new product introduction* by the number of new contracts newly listed by exchange *i* in year *t*.

Product Removal

The dependent variable, *product removal*, was measured by the number of products removed from the market in exchange *i* in year *t*. We defined a particular futures or options contract as removed if it had been listed in year *t* but disappeared from the contract list of the focal exchange in year *t+1*. If a contract was missed in a certain year, we double-checked the contract list in year *t+2* to ensure that the disappearing contract did not turn up two years later.

Product Portfolio Complexity

We measured PPC by both product portfolio breadth and depth (Katila and Ahuja, 2002; Eggers, 2012; Xu, 2015). Product portfolio breadth is measured as the count of product categories in which a derivative exchange has products. Since all the derivative exchanges belong to a single industry, we cannot classify derivative products by the Standard Industry Code. Alternatively, we adopt the FIA's approach that divides derivative products into 18 categories, including equity, individual equity, currency, interest, agriculture, energy, precious metal, non-precious metal, and other futures or options, respectively. Product portfolio depth is an average of a derivative exchange's products in each category.

Control variables

We included several exchanges-, industry-, and country-level control variables in addition to year dummies in the panel data models. We controlled for the effects of log-transformed size (the trading volume of the exchange), log-transformed age (the number of years since the exchange was founded), and business group affiliation (a dummy which equals 1 if an exchange belongs to an exchange group and 0 otherwise). Gawer and Cusumano (2014) have noted that both small and large platform providers build a place for transactions, and we controlled this potential difference emerging from the size of the exchanges. The age of the firm has traditionally been found to impact most business activities (LiPuma *et al.*, 2013). Similarly, studies have shown the impact of business group affiliation on performance (Carney *et al.*, 2011). As for industry-level controls, we accounted for total exchange density (the number of exchanges across the world) and national exchange density (the number of exchanges in the specific country where the focal exchange is located) as potential sources of competitive pressure (Gilsing *et al.*, 2008).

At the country level, we included the GDP growth (an indicator for national GDP growth rate), uncertainty avoidance (a national cultural dimension that reflects the extent to which members of a society attempt to cope with anxiety by minimizing uncertainty), control of corruption (national perceived extent to which public power is exploited for private gain), and political globalization (national diffusion of government policies). The effect of GDP growth is controlled because economic growth is considered as a driver of derivative market innovation (Su and Si, 2015). Similarly, societal norms regarding risk-taking can affect business transactions (Hofstede, 2001). For example, uncertainty-avoiding countries are found to be less innovative than uncertainty-accepting countries (Shane, 1995). Scholars have also shown the effect of the institutional environment on business activities (North, 1986, 1993). While control of corruption increases domestic innovation activity by fostering trust and reducing transaction costs (Anokhin and Schulze, 2009), political globalization brings down discrimination against foreign investors and thus promotes futures market development (Muratova *et al.*, 2025). In addition, year dummies are included to control the time effect. Definitions and data sources for the variables used in the analysis are given below in Table 1.

[Insert Table 1 about here]

4.3. Estimation model

Since the dependent variables of our study are non-negative integers, a count model is used. Because our dependent variables, *product introduction* and *product removal*, exhibit overdispersion (standard deviation to mean ratios of 1.937 and 1.958, respectively) and a high proportion of zero values (39.98% and 46.56%, respectively), we followed the decision tree with count-based dependent variables (Blevins *et al.*, 2015; Shen *et al.*, 2022) to run the Vuong test and find that the zero-inflated Poisson (ZIP) model was superior to the basic

Poisson model. Although the zero-inflated negative binomial (ZINB) model demonstrates a superior fit compared to both the negative binomial and the ZIP model based on likelihood-ratio test, we adopted the ZIP model in our main analyses due to the convergence failure of the ZINB model (Sichko *et al.*, 2025). In addition, we implemented mixed effects Poisson regressions (mepoisson in Stata) with robust standard errors to account for repeated observations across exchanges and time-invariant cultural and institutional controls (Acharya and Pollock, 2020; Shymko and Roulet, 2017).

Standard errors were clustered at the cultural region level. Multicollinearity diagnostics revealed variance inflation factors (VIF) below the conventional threshold of 10 (Gujarati and Porter, 2003), indicating no concerning collinearity issues. Following Tandon and Toh (2022), we standardized the independent variables (product portfolio breadth and depth) and control variables by subtracting the mean and dividing by the standard deviation before constructing the squared and cubic terms. This standardization is prior to constructing the squared and cubic terms.

$$New\ Product\ Introduction_{i,t+1} = \alpha + \beta_1 product\ porfolio\ breadth_{i,t} + \beta_2 product\ porfolio\ breadth_{i,t}^2 + \beta_3 product\ porfolio\ breadth_{i,t}^3 + \beta_4 product\ porfolio\ depth_{i,t} + \beta_5 product\ porfolio\ depth_{i,t}^2 + \beta_6 product\ porfolio\ depth_{i,t}^3 + \beta_7 Control_{i,t} + \delta_i + \delta_t + \varepsilon_{i,t} \quad (1)$$

$$Product\ Removal_{i,t+1} = \alpha + \beta_1 product\ porfolio\ breadth_{i,t} + \beta_2 product\ porfolio\ breadth_{i,t}^2 + \beta_3 product\ porfolio\ breadth_{i,t}^3 + \beta_4 product\ porfolio\ depth_{i,t} + \beta_5 product\ porfolio\ depth_{i,t}^2 + \beta_6 product\ porfolio\ depth_{i,t}^3 + \beta_7 Control_{i,t} + \delta_i + \delta_t + \varepsilon_{i,t} \quad (2)$$

5. **Results**

5.1. Descriptive statistics

Table 2 presents the descriptive statistics for the dependent, independent, and principal control variables. We can observe from the table that the correlation coefficients among the independent variables are low, indicating that multicollinearity is not a concern. The means of new product introduction and product removal are 3.13 and 2.31, respectively, indicating that a derivative exchange introduces nearly 3.13 products and removes 2.31 products in a year, on average. The product portfolio breadth mean values are 4.15 in Panel A and 4.14 in Panel B, while the depth mean value is 4.3, suggesting that a typical derivative exchange operates nearly in 4.15 to 4.14 product categories with 4.3 products per category. It is interesting to note a relatively weak correlation between product portfolio breadth and depth (r = 0.14).

[Insert Table 2 about here]

5.2. Regression results

Tables 3 and 4 report the results of the primary analyses—zero-inflated Poisson and mixed effects Poisson regressions—on new product introductions (Models 1–8) and product removals (Models 17–24), respectively. Model 1 in serves as the baseline specification, including only control variables. Building on this, Models 2 to 4 sequentially add the linear, squared, and cubic terms of product portfolio breadth, while Models 5 to 7 do the same for product portfolio depth. Model 8 presents the full specification with all independent and control variables, and our primary interpretations are based on this model. For robustness, we report results from the mixed effects Poisson models in Models 9 to 16. Wald tests were conducted to assess the joint contributions of linear, squared, and cubic terms, which yield significant improvements in model fit across all specifications in Models 8 and 16, following the approach of Lu and Beamish (2004). Consistent patterns emerged across Models 17 to 32, with Wald test results lending additional support for the hypothesized S-curve relationship.

[Insert Table 3 & 4 about here]

H1 proposes that the relationship between PPC and new product introduction is an S-shape. This hypothesis receives consistent support for both product portfolio breadth and depth in Model 8 of Table 2. New product introduction was positively related to the linear term of product portfolio breadth ($p < 0.01$), then negatively related to the square term of product portfolio breadth ($p < 0.01$), and eventually positively related to the cubic term of product portfolio breadth ($p < 0.05$). A similar pattern is observed for the effects of product portfolio depth, with the linear, squared, and cubic terms all showing significant effects (the p-values are all smaller than 0.01).

H2 hypothesizes an S-shaped relationship between PPC and product removal. As shown in Model 24, in both the effects of product portfolio breadth and depth, the linear terms are significantly positive, the squared terms are significantly negative, and the cubic terms are significantly positive, all at a significance level of $p < 0.01$. Therefore, H2 is also supported.

To evaluate how the effects vary based on the magnitude (Wiersema and Bowen, 2009), we graph the average marginal effects on new product introduction and product removal separately at different points along with the range of PPC in Figures 2 and 3. The average marginal effects on new product introduction in Figures 2a and 2b are calculated separately from the linear, quadratic, and cubic terms of product portfolio breadth and depth. Similarly, the average marginal effects on product removal in Figures 3a and 3b are derived from the three terms of product portfolio breadth and depth. Figures 2a and 2b display that the relationship between PPC and new product introduction (prior to standardization) is nonlinear, which displays an S-shape. Also, Figures 3a and 3b show the relationship between PPC and product removal (prior to standardization) and illustrate a sigmoidal (S-shaped) curve. The geometric properties of these curves reveal important inflection points but no physically meaningful local extrema. Our empirical analyses indicate that the acceleration of portfolio breadth on new product introduction begins to boost when the number of categories approaches 8.19. This threshold closely aligns with a corresponding acceleration in product removal rates, which begins to accelerate at around 7.85 categories. Meanwhile, with respect to portfolio depth, the acceleration of new product introductions increases when the number of products per category attains 15.23, whereas the acceleration of product removals does not appreciably boost until depth reaches 17.34 products per category. Our results underscore the importance of managers adopting a strategic outlook on their derivative portfolios.

[Insert Figure 2a, 2b, 3a, & 3b about here]

5.3. Robustness checks

We conducted additional procedures to check the robustness of our analyses, which are available upon request. First, we replaced or added to the current set of cultural and institutional controls by Hofstede's (2001) uncertainty avoidance, economic freedom from the Heritage Foundation (Su and Si, 2015), future orientation, and R&D expenditure. The results remained consistent with these in the main analysis. Second, we re-ran our regressions by statistical models such as the ZIP, ZINB, mixed effects negative binomial, and mixed effects Poisson models with country dummies. These model specifications yielded additional evidence, substantiating the robustness of our primary findings across multiple analytical approaches.

6. Discussion

Existing research has widely recognized the role of platform-based ecosystems in effectively integrating resources to capture product value (Gawer, 2014). Despite this, empirical research remains limited on how PPC influences product renewal within platform-based ecosystems. Our study fills this gap by extending the understanding of PPC through an in-depth analysis of its impact on product removal and new product introduction. By identifying an S-shaped relationship between PPC and product renewal, we enrich the literature and offer valuable insights for practitioners and scholars navigating the complexities of ecosystem management and innovation strategies in digitalized B2B markets.

6.1. Theoretical contributions

Our study makes important contributions to research in both B2B marketing and platform management. First, we examined the underlying conditions and mechanisms in product introductions and removal for platform-based ecosystems. Our key theoretical contribution is the clear distinction between the ecosystem effect and the knowledge base effect (Roper and Hewitt-Dundas, 2015). While the ecosystem effect exhibits increasing returns, the knowledge base effect faces diminishing returns. This interplay explains how highly complex platform-based ecosystems can continuously introduce new products without becoming hindered by information overload or organizational rigidity—insights particularly relevant to B2B platforms managing diverse, customized offerings. Moreover, the relationship between PPC and product removal indicates two types of costs associated with PPC, namely, adjustment and coordination costs (e.g., Hashai, 2015; Zahavi and Lavie, 2013). Distinguishing these costs advances ecosystem optimization research by highlighting how strategic product removal can reduce redundancy and inefficiencies (Rong *et al.*, 2018), thereby strengthening competitiveness—an especially critical concern for B2B platforms, where customized solutions and complex buyer-supplier relationships are the norm.

Second, the discovery of an S-shaped relationship between PPC and product renewal deepens our understanding of innovation trajectories in platform ecosystems. Our findings reveal that at low PPC, product renewal rises as firms capitalize on an expanding knowledge base despite adjustment costs. At moderate PPC levels, renewal plateaus due to balancing diminishing returns and persistent costs. At high PPC, renewal accelerates again as ecosystem effects outweigh coordination challenges (Agrawal *et al.*, 2016). This nuanced pattern provides strategic guidance for decision-makers in platform ecosystems on effectively managing innovation portfolios within the growing complexity of B2B markets. In addition, while prior research on product portfolio management has largely focused on single developed countries (e.g., Dowell, 2006; Fernhaber and Patel, 2012), with limited attention to developing economies (Li and Atuahene-Gima, 2010), our multi-country study broadens the geographical scope of product strategy research. Our work also advances methodological rigor by incorporating both product portfolio breadth and depth in measuring PPC, addressing limitations in existing research that relied predominantly on breadth (Fernhaber and Patel, 2012; Haishai, 2015).

In addition, product innovation strategies for platform-based ecosystems represent an emerging research area of ecosystem research (Kapoor and Agarwal, 2017 ; Rong *et al.*, 2018), largely due to empirical data limitations. Our study contributes to this gap by leveraging publicly available and reliable secondary data from global derivative exchanges, offering a unique empirical context in which products are relatively standardized and innovation processes are more transparent. While the derivatives market centers on standardized products, the core mechanisms of PPC—including adjustment costs, coordination challenges, and ecosystem effects—are also relevant to other B2B platforms offering differentiated products and services. In domains such as software or industrial solutions, customization and intricate buyer-supplier dynamics may further intensify these challenges. Accordingly, our analytical framework offers valuable insights into how different platform ecosystems influence product portfolio innovation and complexity. We thus contribute a broadly applicable perspective relevant to both standardized and differentiated B2B contexts. Future research should extend and validate these findings across more varied platform environments.

6.2. Managerial implications

Product innovation research calls for an increased understanding of how firms can better manage higher levels of PPC (Closs *et al*., 2008; Fernhaber and Patel, 2012; Shunko *et al.*, 2018; Si *et al.*, 2022). Our study contributes to this conversation by offering actionable insights for practitioners managing product portfolios within platform-based ecosystems in B2B contexts. Our study provides timely empirical findings to assist practitioners in making new product introduction and product removal decisions. In line with Hagiu and Rothman (2016), our results emphasize that the relationship between PPC and product renewal (i.e., introduction and removal) is not linear, as often assumed, but governed by complex, nonlinear trade-offs. These trade-offs are driven by mechanisms such as ecosystem effects, knowledge base effects, adjustment costs, and coordination costs. The findings show that platform-based ecosystems experience different effects of PPC on product innovation depending on their stage of PPC development. That is, practitioners' decisions to introduce or remove products should be strategically aligned with the platform's stage of PPC development.

Further, when introducing new products, executives of platform-based ecosystems should be aware that the knowledge base effect does not keep accumulating but instead starts decreasing in the long run along with the increase of PPC. Meanwhile, the ecosystem effect starts taking effect gradually. Likewise, when phasing out existing products, practitioners need to understand that adjustment costs tend to rise with increasing PPC but begin to decline after reaching a certain threshold of portfolio complexity. However, at more advanced stages, rising coordination costs—stemming from the need to manage more intricate inter-organizational relationships—can offset these gains and create new operational challenges.

While these findings are based on the global derivative exchange market, we believe the underlying mechanisms apply broadly to other platform-based ecosystems and even more traditional B2B sectors. For example, industries like industrial manufacturing and logistics platforms also experience increasing PPC as they expand their offerings and customer base. In these settings, managers should anticipate similar challenges, such as diminishing returns from accumulated knowledge and rising coordination costs. To succeed, they should also carefully balance portfolio growth with the operational complexities that accompany it, adapting their strategies to sector-specific factors like customization demands and regulatory requirements.

6.3. Limitations and future research

Some limitations of the study need to be acknowledged, and these also indicate possible future research directions. Among these limitations, first, our unique empirical context of derivative exchange limits the generalizability of our study. We call for future studies to extend our theoretical framework to other industry settings, including platform-based ecosystems and traditional alternative firms (e.g., vertically integrated firms, resellers, or input suppliers). For example, scholars (Hagiu, 2007; Hagiu and Wright, 2015) have clearly distinguished the different business models between the platform and merchant firms. The former has two key features, that is, direct interaction between buyers and sellers, and both buyers and sellers are affiliated with the platform. In so doing, platforms are more likely to be affected by the ecosystem effect than these alternative firms where reselling is the crucial function. Therefore, these alternative firms might have a different relationship between PPC and product renewal. Furthermore, derivatives exchanges have limited product portfolio diversity compared to traditional firms. This difference between the traditional platform-based ecosystems and derivatives exchanges needs to be noted. We present these results with the caveat that while our study's results support our theoretical position, its generalizability needs to be verified by other studies on platform-based ecosystems that extend beyond this industry.

Second, our study does not distinguish the new product introduction and removal types. For example, radical and incremental product innovation may be salient at different levels of PPC; the rationale for voluntary product removal might differ from that for an involuntary one. Scholars may find research opportunities in a more refined taxonomy of product renewal in further studies. Finally, although this study focuses on the direct relationship between product renewal and portfolio complexity, we expect the moderating role of external institutional environmental and internal organizational characteristics (cf. Gawer and Cusumano, 2014; McNally *et al*., 2013). We expect future studies to introduce additional contingencies that may deepen our understanding of product renewal.

7. Conclusion

In conclusion, our specific focus on the relationship between PPC and product renewal represents a new approach to investigating the costs and benefits of PPC in platform-based ecosystems. Specifically, we investigate how platform-based ecosystems introduce and remove their products at different levels of PPC as a way to absorb the benefits and reduce the costs of PPC. Our empirical findings support the hypothesized S-shaped effects of PPC on new product introduction and removal. Our study contributes to B2B and innovation research by advancing our understanding of PPC and by revealing its interactive outcome and linkage with platform-based ecosystems.

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Table 1. Data source and definitions

Variable	Definition	Data Source
Dependent variables		
New product introduction	the number of new contracts that are newly listed by exchange *i* in year *t*	FIA
Product removal	the number of products removed from the market in exchange *i* in year *t*	FIA
Independent variables		
Product portfolio breadth	the count of product categories in which a derivative exchange has products	FIA
Product portfolio depth	an average of a derivative exchange's products in each category	FIA
Control variables		
Log size	the log-transformed trading volume of the exchange	FIA
Log age	the log-transformed number of years since the exchange was founded	Public resources
Group affiliation	a dummy that equals 1 if an exchange belongs to an exchange group and 0 otherwise	Public resources
Total exchange density	the number of exchanges across the world	FIA
National exchange density	the number of exchanges in the specific country where the focal exchange is located	FIA
GDP growth	a country's GDP growth rate	World Bank
Uncertainty avoidance	the extent to which members of a society attempt to cope with anxiety by minimizing uncertainty	GLOBE
Control of corruption	a country's perceived extent to which public power is exploited for private gain, encompassing both petty and grand corruption, as well as state capture by elites and private interests	Worldwide Governance Indicators
Political globalization	the diffusion of government policies within a country	KOF

Notes: FIA stands for the Futures Industry Association.

Table 2. Summary statistics

Variable	Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8	9	10	11
Panel A: New product introduction															
1. New product introduction	3.13	6.07	0.00	59.00											
2. Product portfolio breadth	4.15	2.59	1.00	13.00	0.443										
3. Product portfolio depth	4.30	3.94	1.00	30.00	0.484	0.141									
4. Log(size)	16.88	2.63	1.39	21.51	0.306	0.407	0.306								
5. Log(age)	3.00	1.47	0.00	5.53	0.050	0.156	0.118	0.045							
6. Group affiliation	0.26	0.44	0.00	1.00	0.132	0.109	0.155	0.129	-0.291						
7. Total exchange density	66.53	8.21	56.00	82.00	0.033	0.038	0.092	0.173	-0.145	0.346					
8. National exchange density	6.27	6.05	1.00	20.00	0.100	-0.111	0.256	0.157	0.171	0.057	0.042				
9. GDP growth	2.89	3.22	-10.89	14.52	-0.046	-0.011	-0.081	0.082	-0.012	-0.191	-0.092	-0.170			
10. Uncertainty avoidance	4.23	0.48	2.88	5.37	0.002	-0.047	0.029	0.064	-0.081	0.083	-0.053	-0.134	0.187		
11. Control of corruption	1.14	0.85	-1.13	2.44	0.073	0.024	0.135	-0.090	0.187	0.075	-0.249	0.231	-0.287	0.448	
12. Political globalization	87.36	10.21	27.87	96.79	0.090	-0.063	0.197	0.027	0.028	0.151	-0.007	0.247	-0.100	-0.014	0.066
Panel B: Product removal															
Variable	**Mean**	**S.D.**	**Min**	**Max**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1. Product removal	2.31	4.53	0.00	51.00											
2. Product portfolio breadth	4.14	2.59	1.00	13.00	0.473										
3. Product portfolio depth	4.30	3.94	1.00	30.00	0.498	0.141									
4. Log(size)	16.87	2.63	1.39	21.51	0.265	0.408	0.304								
5. Log(age)	3.00	1.47	0.00	5.53	0.024	0.155	0.116	0.043							
6. Group affiliation	0.26	0.44	0.00	1.00	0.185	0.110	0.156	0.129	-0.293						
7. Total exchange density	66.52	8.21	56.00	82.00	0.063	0.040	0.092	0.175	-0.147	0.346					
8. National exchange density	6.26	6.05	1.00	20.00	0.143	-0.109	0.257	0.157	0.168	0.058	0.043				
9. GDP growth	2.89	3.23	-10.89	14.52	-0.024	-0.009	-0.082	0.087	-0.014	-0.189	-0.088	-0.168			
10. Uncertainty avoidance	4.22	0.48	2.88	5.37	-0.028	-0.045	0.030	0.065	-0.086	0.085	-0.050	-0.131	0.188		
11. Control of corruption	1.14	0.85	-1.13	2.44	0.037	0.026	0.135	-0.087	0.183	0.077	-0.246	0.233	-0.282	0.450	
12. Political globalization	87.35	10.20	27.87	96.79	0.108	-0.063	0.197	0.026	0.028	0.152	-0.007	0.247	-0.100	-0.013	0.067

Notes: N=898 and significant at the 0.01 level (two-tailed tests) when the absolute value of Pearson correlations > 0.090 (Panel A). N=900 and significant at the 0.01 level (two-tailed tests) when the absolute value of Pearson correlations > 0.087 (Panel B).

Table 3. Regression Results for Predicting New Product Introduction

	Zero-Inflated Poisson Regression								Mixed Effects Poisson Regression							
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Log(Size)	0.675***	0.318**	0.324***	0.311**	0.524***	0.498***	0.491***	0.070	0.958***	0.516***	0.518***	0.516***	0.719***	0.669***	0.670***	0.215***
	(0.171)	(0.126)	(0.119)	(0.125)	(0.091)	(0.067)	(0.085)	(0.063)	(0.189)	(0.151)	(0.147)	(0.149)	(0.094)	(0.065)	(0.085)	(0.050)
Log(Age)	0.039	-0.078**	-0.077**	-0.077**	-0.022	-0.044	-0.053	-0.152***	0.023	-0.118***	-0.121***	-0.121***	-0.047	-0.066	-0.065	-0.184***
	(0.037)	(0.034)	(0.035)	(0.038)	(0.040)	(0.045)	(0.040)	(0.029)	(0.111)	(0.040)	(0.044)	(0.043)	(0.087)	(0.078)	(0.075)	(0.029)
Group affiliation	0.157	0.026	0.018	0.027	0.052	0.057	0.042	-0.127*	0.125	-0.015	-0.032	-0.030	0.043	0.085	0.096	-0.143
	(0.172)	(0.170)	(0.169)	(0.170)	(0.143)	(0.135)	(0.127)	(0.076)	(0.236)	(0.168)	(0.170)	(0.171)	(0.228)	(0.202)	(0.194)	(0.088)
Total exchange density	0.011	0.028	0.032	0.024	-0.099*	-0.065	-0.096	-0.133*	0.037	-0.050	-0.036	-0.039	-0.015	0.124	-0.022	-0.084
	(0.084)	(0.053)	(0.051)	(0.047)	(0.060)	(0.056)	(0.070)	(0.069)	(0.314)	(0.405)	(0.394)	(0.400)	(0.349)	(0.338)	(0.264)	(0.299)
National exchange density	-0.104	0.042	0.046	0.059	-0.097	-0.132	-0.149	0.036	-0.099	0.068	0.084	0.089	-0.126	-0.185*	-0.209*	0.016
	(0.140)	(0.137)	(0.133)	(0.129)	(0.096)	(0.098)	(0.099)	(0.056)	(0.144)	(0.128)	(0.120)	(0.117)	(0.100)	(0.100)	(0.108)	(0.061)
GDP growth	0.046	0.026	0.022	0.029	0.088	0.086*	0.066	0.054	0.029	0.049	0.042	0.045	0.106	0.108**	0.087	0.079
	(0.081)	(0.098)	(0.093)	(0.093)	(0.060)	(0.051)	(0.052)	(0.063)	(0.106)	(0.107)	(0.103)	(0.104)	(0.068)	(0.054)	(0.063)	(0.057)
Uncertainty avoidance	-0.231	-0.097	-0.096	-0.093	-0.259*	-0.250**	-0.225*	-0.084	-0.235	-0.108	-0.104	-0.103	-0.322*	-0.311**	-0.288**	-0.120
	(0.241)	(0.258)	(0.256)	(0.248)	(0.132)	(0.107)	(0.115)	(0.092)	(0.327)	(0.293)	(0.292)	(0.290)	(0.169)	(0.130)	(0.143)	(0.113)
Control of corruption	0.315**	0.255	0.244	0.256	0.248***	0.241***	0.214***	0.166**	0.339**	0.258	0.235	0.238	0.268***	0.258***	0.232**	0.141**
	(0.152)	(0.184)	(0.172)	(0.169)	(0.067)	(0.054)	(0.077)	(0.065)	(0.168)	(0.186)	(0.168)	(0.169)	(0.081)	(0.071)	(0.095)	(0.063)
Political globalization	0.162***	0.200**	0.204**	0.208**	0.060***	0.040**	0.017	0.069**	0.133**	0.157**	0.165**	0.167**	0.017	-0.005	-0.023	0.029
	(0.057)	(0.081)	(0.086)	(0.084)	(0.019)	(0.016)	(0.019)	(0.028)	(0.060)	(0.072)	(0.081)	(0.082)	(0.017)	(0.017)	(0.029)	(0.019)
Product portfolio breadth		0.367***	0.415***	0.437***				0.634***		0.500***	0.597***	0.601***				0.729***
		(0.046)	(0.054)	(0.071)				(0.094)		(0.048)	(0.081)	(0.091)				(0.066)
Product portfolio breadth squared			-0.025	-0.121				-0.285***			-0.049	-0.084				-0.263***
			(0.041)	(0.100)				(0.103)			(0.058)	(0.119)				(0.095)
Product portfolio breadth cubed				0.031				0.060**				0.011				0.045*
				(0.020)				(0.024)				(0.022)				(0.024)
Product portfolio depth					0.534***	0.837***	1.194***	1.158***					0.716***	1.144***	1.550***	1.410***
					(0.144)	(0.274)	(0.136)	(0.167)					(0.164)	(0.267)	(0.133)	(0.150)
Product portfolio depth squared						-0.136*	-0.567**	-0.468***						-0.205***	-0.787***	-0.624***
						(0.080)	(0.226)	(0.166)						(0.079)	(0.265)	(0.160)
Product portfolio depth cubed							0.097*	0.095***							0.138**	0.127***
							(0.057)	(0.033)							(0.068)	(0.034)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	1.001***	0.942***	0.957***	1.005***	0.989***	1.035***	1.094***	1.168***	0.237	0.449	0.465	0.483	0.177	0.113	0.373	0.635
	(0.133)	(0.144)	(0.157)	(0.163)	(0.123)	(0.112)	(0.143)	(0.123)	(0.612)	(0.681)	(0.650)	(0.676)	(0.610)	(0.582)	(0.473)	(0.462)
Log-likelihood	-2523.09	-2352.41	-2351.16	-2348.70	-2325.92	-2304.45	-2285.95	-2051.39	-3050.93	-2697.18	-2691.62	-2691.23	-2662.61	-2608.39	-2564.34	-2217.78

Notes: N=898. *p < 0.1, **p < 0.05, ***p < 0.01 (two-tailed tests). Standardized regression coefficients are shown. Robust standard errors in parentheses.

Table 4. Regression Results for Predicting Product Removal

Variable	Zero-Inflated Poisson Regression								Mixed Effects Poisson Regression							
	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)
Log(Size)	0.403***	0.007	0.010	0.001	0.275**	0.223	0.220	-0.283***	0.652***	0.124	0.128	0.121	0.419***	0.335**	0.334**	-0.195***
	(0.146)	(0.073)	(0.068)	(0.074)	(0.114)	(0.160)	(0.186)	(0.058)	(0.166)	(0.096)	(0.095)	(0.097)	(0.126)	(0.145)	(0.153)	(0.063)
Log(Age)	-0.002	-0.168***	-0.162***	-0.157***	-0.009	0.007	0.011	-0.113*	0.013	-0.196***	-0.201***	-0.201***	-0.037	-0.062	-0.057	-0.184***
	(0.067)	(0.043)	(0.047)	(0.042)	(0.059)	(0.061)	(0.071)	(0.058)	(0.143)	(0.066)	(0.074)	(0.068)	(0.122)	(0.103)	(0.105)	(0.052)
Group affiliation	0.346	0.181	0.168	0.179	0.339	0.432	0.411	0.331*	0.411	0.171	0.144	0.150	0.355	0.469	0.475	0.169
	(0.238)	(0.160)	(0.155)	(0.151)	(0.250)	(0.277)	(0.311)	(0.174)	(0.377)	(0.187)	(0.188)	(0.186)	(0.348)	(0.310)	(0.323)	(0.136)
Total exchange density	0.190*	0.254***	0.265***	0.258***	0.107	0.111	0.085	0.085*	-0.283	-0.400	-0.373	-0.387	-0.340	-0.173	-0.237	-0.256
	(0.111)	(0.086)	(0.093)	(0.089)	(0.073)	(0.088)	(0.115)	(0.045)	(0.540)	(0.307)	(0.349)	(0.335)	(0.480)	(0.556)	(0.599)	(0.427)
National exchange density	0.040	0.218***	0.221***	0.229***	0.024	-0.116	-0.137*	0.050	0.043	0.242***	0.264***	0.279***	0.027	-0.133	-0.149*	0.083***
	(0.101)	(0.079)	(0.071)	(0.073)	(0.066)	(0.072)	(0.072)	(0.030)	(0.125)	(0.076)	(0.076)	(0.088)	(0.087)	(0.085)	(0.086)	(0.023)
GDP growth	0.085	0.086	0.059	0.056	0.130*	0.121**	0.101**	0.100***	0.063	0.075	0.058	0.064	0.132*	0.111*	0.094	0.052
	(0.093)	(0.110)	(0.095)	(0.094)	(0.076)	(0.056)	(0.051)	(0.035)	(0.099)	(0.111)	(0.101)	(0.102)	(0.079)	(0.062)	(0.064)	(0.047)
Uncertainty avoidance	-0.121	0.018	0.015	0.009	-0.155*	-0.123**	-0.092	0.012	-0.221	-0.050	-0.043	-0.043	-0.300**	-0.248***	-0.232***	-0.015
	(0.164)	(0.184)	(0.175)	(0.167)	(0.087)	(0.062)	(0.087)	(0.036)	(0.254)	(0.184)	(0.182)	(0.177)	(0.129)	(0.077)	(0.089)	(0.030)
Control of corruption	-0.001	-0.033	-0.058	-0.041	-0.050	-0.040	-0.050	-0.032	0.194	0.102	0.061	0.072	0.115	0.098	0.082	-0.003
	(0.122)	(0.189)	(0.161)	(0.153)	(0.059)	(0.074)	(0.112)	(0.048)	(0.187)	(0.188)	(0.175)	(0.162)	(0.130)	(0.087)	(0.097)	(0.024)
Political globalization	0.261**	0.315*	0.325*	0.326**	0.129	0.053	0.009	0.068	0.209*	0.255	0.274	0.274	0.059	-0.011	-0.038	0.029
	(0.109)	(0.170)	(0.166)	(0.164)	(0.087)	(0.072)	(0.059)	(0.052)	(0.113)	(0.167)	(0.177)	(0.172)	(0.055)	(0.036)	(0.034)	(0.038)
Product portfolio breadth		0.491***	0.633***	0.665***				0.851***		0.667***	0.843***	0.860***				0.892***
		(0.060)	(0.125)	(0.128)				(0.073)		(0.081)	(0.124)	(0.128)				(0.071)
Product portfolio breadth squared			-0.069	-0.176				-0.455***			-0.089*	-0.188				-0.449***
			(0.043)	(0.111)				(0.141)			(0.054)	(0.158)				(0.128)
Product portfolio breadth cubed				0.033				0.104***				0.032				0.099***
				(0.029)				(0.039)				(0.040)				(0.034)
Product portfolio depth					0.525***	1.529***	2.091***	2.257***					0.736***	1.879***	2.304***	2.298***
					(0.154)	(0.280)	(0.165)	(0.148)					(0.174)	(0.256)	(0.126)	(0.119)
Product portfolio depth squared						-0.474***	-1.185***	-1.264***						-0.596***	-1.278***	-1.282***
						(0.116)	(0.238)	(0.131)						(0.093)	(0.266)	(0.108)
Product portfolio depth cubed							0.181***	0.214***							0.193***	0.219***
							(0.055)	(0.024)							(0.069)	(0.022)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.556***	0.374***	0.397***	0.448***	0.481***	0.479***	0.538***	0.598***	0.858	1.083**	1.103*	1.166*	0.785	0.702	0.863	1.163
	(0.135)	(0.140)	(0.145)	(0.142)	(0.124)	(0.116)	(0.118)	(0.101)	(0.713)	(0.550)	(0.599)	(0.622)	(0.714)	(0.900)	(0.975)	(0.830)
Log-likelihood	-2076.13	-1879.15	-1872.32	-1870.37	-1943.15	-1838.77	-1805.44	-1524.72	-2548.71	-2105.00	-2091.50	-2089.12	-2218.50	-2003.80	-1961.64	-1579.07

Notes: N=900. *p < 0.1, **p < 0.05, ***p < 0.01 (two-tailed tests). Standardized regression coefficients are shown. Robust standard errors in parentheses.

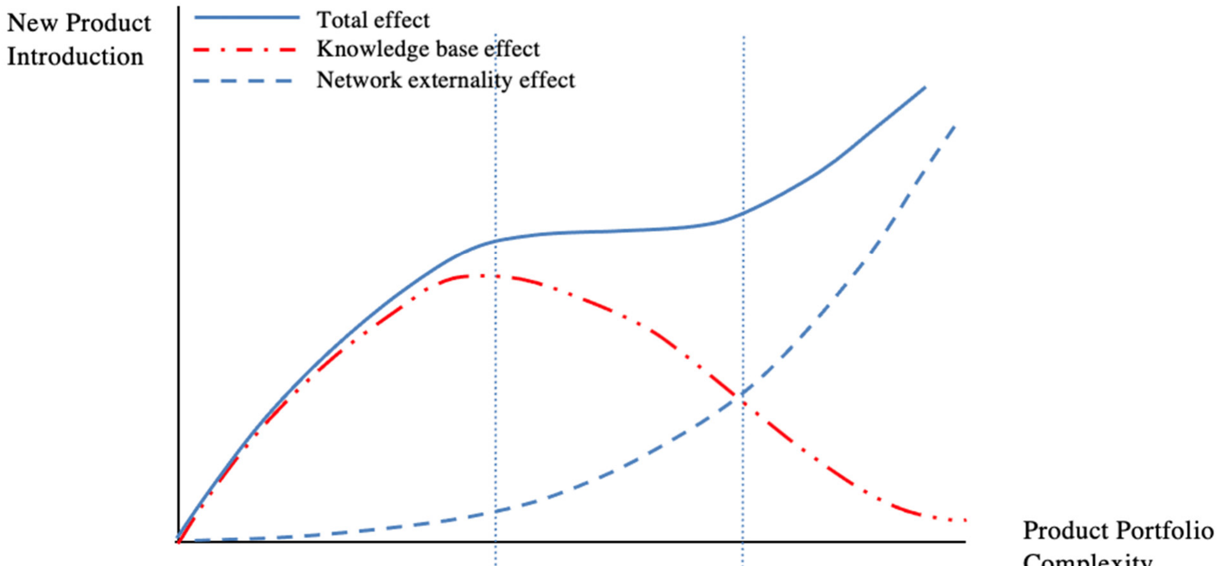

Figure 1a Product portfolio complexity and new product introduction

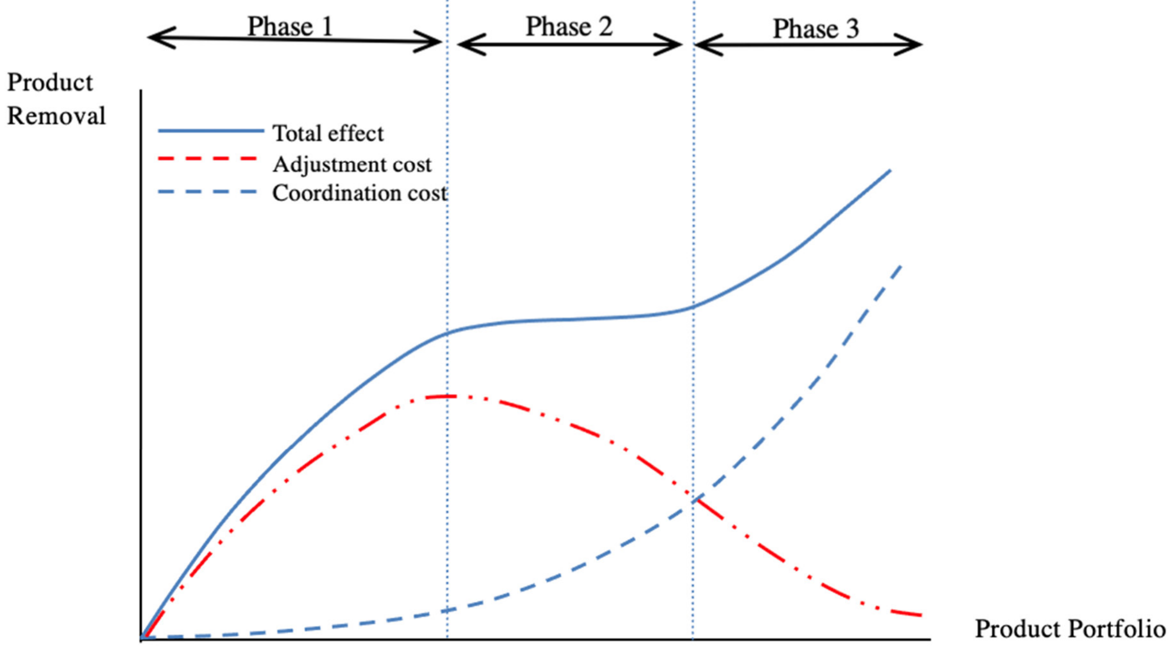

Figure 1b Product portfolio complexity and product removal

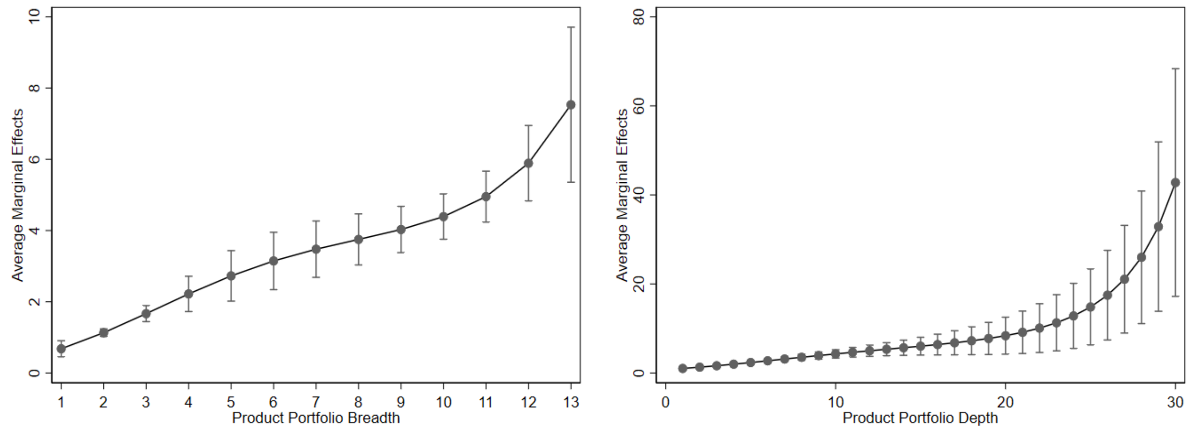

Figure 2a & 2b Average Marginal Effects of Product Portfolio Complexity for New Product Introduction with 95 Percent Confidence Intervals

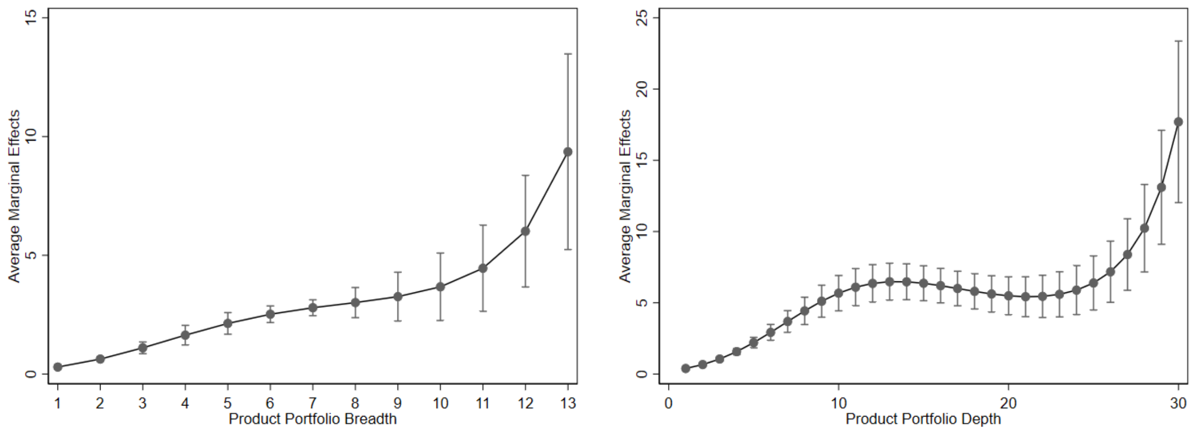

Figure 3a & 3b Average Marginal Effects of Product Portfolio Complexity for Product Removal with a 95 Percent Confidence Interval