Investigating the Effect of Perceived Product Portfolio Innovativeness on Consumers´ Brand Perceptions

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Abstract— Portfolio innovativeness has been indicated as a crucial aspect of a firm's innovation efforts. However, research traditionally applies a firm-centric conceptualization of portfolio innovativeness, neglecting its signaling effect to consumers. Taking a different route, this study applies a consumer-centric approach to investigate consumer perceptions of portfolio innovativeness as an antecedent of their brand perceptions. We incorporate inconsistent insights on portfolio innovativeness by introducing a novel construct: portfolio innovativeness variety. It describes the degree of novelty concerning different new products and services in a firm's innovation portfolio. Drawing on signaling theory, the results of 691 completed questionnaires show that consumers' perceived portfolio innovativeness increases consumer-based brand equity. However, portfolio innovativeness variety moderates this relationship negatively. This study explores an inverted U-shaped relationship between portfolio innovativeness variety and brand equity. These insights suggest that large portfolio innovativeness variety confuses consumers about a brand's offerings and that portfolio management should incorporate these insights in order to offer a balanced and value-maximized innovation portfolio. This research offers novel insights into an unexplored aspect of portfolio innovativeness with complementary research on innovation portfolios from a consumer perspective.

Index Terms—Brand equity, brand perceptions, innovation portfolio, (innovation) portfolio innovativeness, signaling

I. INTRODUCTION

FIRMS that innovate their entire product portfolio can revitalize an entire brand: Firms like Audi, Volvo, or Apple have introduced an entire portfolio of new products and services to overcome a brand image that was perceived as drained and outdated and to renew their entire brand. In Apple's case, introducing the iMac and iPod radically changed the firm's innovation portfolio, increasing the firm's market share and profits [1]. Such a significant change in a firm's offering is typically characterized by high degrees of portfolio innovativeness [2], [3]. It is not surprising that management practice routinely communicates portfolio innovativeness to signal their claim to be innovative and influence (potential) consumers accordingly. Slogans like "créative technologie" (Citroën), "Advantage through technology" (Audi), "Innovations for everyone" (Volkswagen), or "Reinventing the automobile. Since 1886!" (Mercedes-Benz) suggest that the entire innovation portfolio represents pioneering work in terms of engineering and consumer benefit.

Despite the relevance of managing a firm's portfolio innovativeness for consumers' brand perceptions, the literature on innovation portfolio management (IPM) typically focuses portfolio innovativeness by applying a firm-internal perspective [3]–[8]. This internal perspective typically neglects that innovation portfolios can also provide a signal to consumers [9], [10] and that firms have to manage their brand purposefully in order to match their innovation strategy with consumers' expectations on a respective brand [11]. Initial insights on consumers' brand perceptions of a firm's innovation typically rely on a single new-product perspective [12], [13] or a marketing lens neglecting innovation portfolio and its innovativeness [11], [14], [15].

This lack impacts our understanding of management practices, as research indicates inconsistent insights on the relationship between innovativeness and subsequent firm outcomes. While high portfolio innovativeness enables differentiation from the competition [16], results in increased sales [3], or builds customer loyalty [9], it can also cause resistance, power struggles, and substantial organizational changes [2], [17], [18]. Since the potential costs of high portfolio innovativeness can outweigh its benefits, researchers argue that IPM needs to achieve an optimal degree of portfolio innovativeness [2]. While research advocates for such an optimum, the literature lacks on the investigation of potential contingency factors that can explain these differences.

To address this research opportunity, this study focuses on firms' portfolio innovativeness and its signaling influence on consumers' brand perceptions. We investigate the following research questions: How does a firm's portfolio innovativeness influence consumer-based brand equity? Brand equity describes a consumer's positive, strong, and exclusive associations with a branded (new) product or service, and attitudes toward it [19]. By applying signaling theory [20], we follow established research and conceptualize portfolio innovativeness as a signal to consumers [9], [10] that can reduce uncertainty about a brand's offerings and influence brand perceptions [21], [22]. The results of 691 completed questionnaires show that portfolio innovativeness functions as a signal that reduces consumer uncertainty about a brand's offered value, resulting in enhanced brand equity.

To incorporate the inconsistent impact of portfolio innovativeness on consumer perceptions, we introduce a novel construct: portfolio innovativeness variety. It describes the spread between the perceived novelty of its new products and services. In extreme cases, such portfolios with a high portfolio innovativeness variety are characterized by several incremental as well as radical innovations. The results show that portfolio innovativeness variety determines brand equity in an inverted U-shaped relationship and portfolio innovativeness variety negatively moderates the positive effect of portfolio innovativeness on brand equity.

Thereby, by drawing attention to portfolio innovativeness's signaling function, we contribute to and extend research on the management of portfolio innovativeness, IPM's effects on firm outcomes, and a brand's innovation activities. First, this study's signaling perspective complements research that focuses on the internal management of innovation portfolios [7], [17], [23]–[27], by introducing and testing a novel construct, portfolio innovativeness variety. Portfolio innovativeness variety offers a further explanation for contradicting insights on portfolio innovativeness effects on firm outcomes [28], [29] [18], [30]and thereby extend research on an optimal degree of innovativeness [2]. By showing that a moderate degree of portfolio innovativeness variety maximizes consumer-based brand equity, we complement research suggesting that a "right" mix of incremental and radical innovation projects enable value-maximizing portfolios [4], [7], [23], [29].

Second, we extend insights on the outcomes of IPM [7], [23], [29], [31] by showing how portfolio innovativeness and its variety influences consumer-based brand equity. In turn, consumer-based brand equity predicts sales-based brand equity [32]. Thus, we add a further performance indicator on how firms can maximize their innovation portfolio's value [23], [29].

Third, our insights extend the notion that not all brands can innovate similarly [11] by showing that an innovation portfolio needs a certain fit of the single new product's innovativeness to signal consistency and credibility to consumers. In particular, too high degrees of portfolio innovativeness variety can confuse consumers by signaling complexity and uncertainty about a brand's offerings. We, therefore, complement the literature on innovation and brand management [11], [14] by offering a deeper understanding of an innovation portfolio's effect on consumers' brand perceptions.

II. LITERATURE REVIEW

A. Innovation Portfolio Innovativeness

IPM research traditionally applies a firm-internal perspective [17], [23], [33], [34]. A central component of this research stream is portfolio innovativeness, as it is a crucial determinant of firm success [2], [35]. The research assesses portfolio innovativeness by relying on information provided by knowledgeable managers to develop guidelines for how firms should manage their innovation portfolios and the implications thereof [4], [6], [23].

TABLE I
RELEVANT DEFINITIONS OF INNOVATIVENESS

Constructs	Definitions	Selected literature
Firm innovativeness	It describes… a firm's enduring ability to develop and introduce value-added products and services in existing and new markets.	[39], [40]
Firm-level product innovativeness	… the combination of two distinct dimensions that encompass the degree of novelty and the (numerical) intensity of a firm's new products.	[5], [28]
Product innovativeness	… the superior advantage(s) of a new product, its perceived uniqueness, or a related behavioral change and learning effort of consumers in order to use the product.	[41], [42]
(New product) Portfolio innovativeness	… the novelty of a firm's new product portfolio that manifests itself in technology, market, internal, and external resource facets.	[2], [38]
Product program innovativeness	… the combination of two distinct dimensions, novelty and meaningfulness. Novelty refers to the difference between a firm's product program and existing alternatives, whereas meaningfulness describes the degree to which new products offer superior benefits and quality.	[33], [43]
Product portfolio innovativeness	... the number of new-to-the-firm products.	[3], [44]

As Table 1 shows, research offers numerous conceptualizations and measurements of portfolio innovativeness, which encompasses specific classifications, single facets, or multiple facets [2], [35], [36]. First, the literature assesses portfolio innovativeness as a classification that differentiates between incremental, moderate, and radical innovations [37]. Second, researchers conceptualize portfolio innovativeness according to a single facet, such as market-linked or technology-related aspects [23], [30]. Third, research also defines portfolio innovativeness as a continuum encompassing its market, technology, organizational, and environmental facets [2], [38], or it conceptualizes portfolio innovativeness in terms of novelty and intensity [5]. However, this perspective on firm-internal processes and behavior tends to neglect the consumer-related dimension of innovation.

To complement this firm-focused perspective on portfolio innovativeness, researchers have started to investigate the effect of the introduction of new products and services on consumers. One research stream in the marketing literature defines innovativeness on an aggregated level as a firm's ability to develop and introduce new products and services fast over a specific period [45]. Drawing on this conceptualization, recent research differentiates between development-centric open innovation, which describes "the acquisition, from external sources, of ideas or technologies to use in the development stage of the NPD process", and commercialization-centric open innovation, that is "the acquisition, from external sources, of market-ready products that a firm can introduce in the market without further physical development [3, p. 169]". Both open innovation practices are crucial antecedents of portfolio innovativeness, which in turn enhances a firm's sales. Portfolio innovativeness also improves customer satisfaction, depending on a firm's marketing strategy, market dominance, and competitive intensity [44]. Although this perspective offers valuable insights, its static and outcome-related understanding represents a highly aggregated proxy of the complex nature of portfolio innovativeness as it neglects the perceptual characteristics of portfolio innovativeness.

Instead, portfolio innovativeness can describe an innovation portfolio's enduring characteristics [45]. Kunz et al. [39] therefore conceptualize firm innovativeness as consumers' perceptions of a firm's enduring ability to develop creative, impactful, and novel ideas and solutions for the market. By conceptualizing perceived firm innovativeness in this manner, they show that functional as well as affective aspects result in consumer loyalty. Firm innovativeness can also create customer value, which is a crucial antecedent of customer satisfaction [40].

Another research stream on the creativity of new products complements these insights by differentiating between a new product's meaningfulness and novelty to understand its performance [46]. Applying this conceptualization, research supports the differentiated effects of portfolio innovativeness on customers' brand loyalty in a business-to-business (B2B) setting [9]: Whereas an innovation portfolio's novelty negatively affects customer loyalty, its meaningfulness enhances loyalty. Stock [10] supplements these insights by assessing portfolio innovativeness relatively to that of respective competitors. The portfolio innovativeness of services affects customer satisfaction following an inverted S-shaped relationship, whereas there is an inverted U-shaped relationship between the innovativeness of new products and customer satisfaction.

Summing up, researchers tend to investigate portfolio innovativeness by applying a firm-centric lens [2], [5], [42] that neglects consumer perceptions of innovation portfolios. Furthermore, marketing research either applies proxies, such as the number of new products [3], or it is rendered in a B2B context [9] and, and therefore, assesses portfolio innovativeness by surveying managers [9], [43]. Consequently, the extant literature neglects a consumer-centric perspective on portfolio innovativeness and its effect on consumer perceptions. To complement this perspective, we transfer the understanding of portfolio innovativeness as the "newness of the firm's new product portfolio" [2, p. 93] into a consumer-centric perspective. We therefore define a firm's portfolio innovativeness as consumers' perceived novelty of its range of new products and services that differentiate its offering from that of others on the market.

B. Understanding Consumers' Brand Perception by Applying Signaling Theory

We apply a signaling lens to investigate the impact of portfolio innovativeness on consumers' brand perceptions [9], [10], [47]. This theoretical perspective focuses on how a more informed sender (e.g., the innovating firm) provides information – the signal - to less informed receivers (e.g., consumers) and how the receivers search as well as interpret the signal [20], [48]. Consumers rely on signals provided by the firm, especially when they judge new products. Whereas firms have more information on their new products and thereby know their 'true' quality and performance, consumers lack comprehensive information on new products before adopting and experiencing them [48]. This lack is due to the characteristics of new products, such as complexity or compatibility. Thus, new products induce substantial ambiguity and complexity to consumers and thereby challenge the adoption of innovations [49], [50]. To reduce this barrier to innovation adoption, firms can provide signals to consumers.

Signals are, for instance, attributes or activities of a sender with privileged information [20] that improve the understanding of consumers and stimulate the adoption of new products [51]. To affect consumers, signals have to be observable and costly [12]. When a signal is unobservable to consumers, they cannot interpret the signal according to the firm's intention. Further, costly signals incentivize the firm to be genuine about their information provided because the negative consequences of disingenuous signals are greater than its advantages. Portfolio innovativeness fulfill these characteristics of signals because the innovativeness of new products is observable and - as any new product development outcome - costly for the firm.

In this vein, research indicates that the innovativeness of the portfolio can bridge the gap between what consumers know and what they would like to know [9], [11], [52]. Before the adoption of new products, portfolio innovativeness can reduce ambiguity and uncertainty by signaling new products' quality, functionality, features, and aesthetics [13], [47], [51], [53]. Moreover, portfolio innovativeness signals the consumers that the firm is able and willing to maintain a long-term relationship that fulfills their needs and expectations [9], [43]. For instance, when firms offer an innovative portfolio of new products, they provide a costly signal to consumers that they are willing and able to fulfill consumers' needs by making steady investments into innovation. Thereby, consumers are capable of using innovative products to adapt their behaviors to the developments in an increasingly dynamic environment [10].

Given this theoretical foundation, the literature on engineering, technology, and innovation management shows that portfolio innovativeness provides an effective signal to the consumers influencing their satisfaction, loyalty, and perceived equity of the brand [9], [15], [54], [55]. This influence can be explained by the following cognitive mechanism.

Portfolio innovativeness links specific cues to consumers' cognition. In turn, these cues trigger informational nodes that are and/or get connected to a firm's brand image in the consumers' memory [53], [54]. The informational nodes enable consumers to evaluate the quality and utility of new products that affect their perceptions of the brand [21]. The greater the expected utility from this relationship, the higher is the likelihood that consumers will associate the brand with high brand equity [9], [54]. In turn, firms can change consumers' expectations in their favor by indicating that they innovate and are capable of providing consumers additional utility.

Thus, a firm's portfolio of new products offers the opportunity to create compelling consumers experiences and develop pleasant associations, initially with new products, which can later be transferred to the brand [56]. Through this lens, consumer-based brand equity describes the "value of a brand signal to consumers" [57, p. 132]. Since the "power of a brand lies in what their customers have learned, felt, seen and heard about the brand" [22, p. 9], the development and offer of new products and services are crucial to a firm in order to maintain, (re-)vitalize, and even broaden the brand(s) meaning [1], [11], [58].

III. Hypothesis development

Recapitulating, we theorize that a brand's content and clarity credibility functions as a signal to consumers and determine perceived brand equity. In the following, we hypothesize that a firm's portfolio innovativeness influences brand content and that portfolio innovativeness diversity is associated with brand clarity, determining consumers' perceived brand equity (Figure 1).
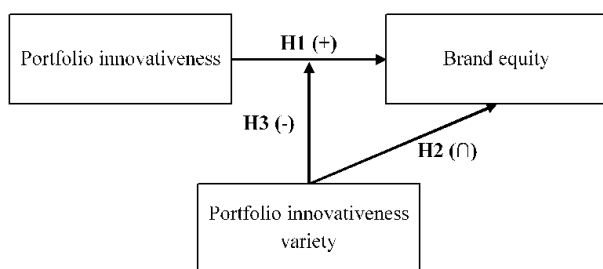

Fig. 1. Framework of Hypotheses

A. The Effect of Portfolio Innovativeness on Brand Equity

The clarity and credibility of a brand's product positioning function as signals that decrease perceived risks and information costs, increase the perceived brand quality, and therefore enhance consumers' expected utility from interactions with said brand [21], [22]. Accordingly, firms can reduce consumers' uncertainty regarding brand equity by providing the evidence that they are able to develop and introduce a range of innovative new products and services.

Portfolio innovativeness is therefore a signal to consumers [9], [10] and firms utilize it to facilitate consumers' development of expectations about unobservable product quality [59]. In other words, offering a portfolio of innovative (and new) products and services signals to consumers that a firm invests significant resources in fulfilling their needs. For instance, radical new products allow consumers to solve problems they cannot easily take care of by using existing ways [60]. This lets consumers obtain new benefits or receive existing benefits in new ways [61]. Moreover, high levels of portfolio innovativeness can represent a cue to consumers that is associated with a particular advantageousness. Such a perceived product advantage differentiates a highly innovative product from existing alternatives, giving consumers a stronger reason to buy, inhibiting commoditization, and reducing price sensitivity [62], [63].

Consequently, highly innovative products can potentially be priced at a premium, enabling consumers to reflect an elevated socio-economic status. As higher degrees of portfolio innovativeness are also associated with the most recent technological and/or functional developments, consumers are also likely to perceive higher degrees of portfolio innovativeness as a long-lasting effect that strengthens the brand's proposed utility and competitive positioning [10]. Moreover, an innovative portfolio signals the brand's innovation leadership and high quality to consumers [18], increasing their loyalty [39]. Highly innovative innovation portfolios therefore contribute to reducing information asymmetries

between an innovating firm (sender) and consumers (receivers), as a firm demonstrates its ability to address consumers' needs. Consequently, we hypothesize:

H1: Portfolio innovativeness positively influences a firm's consumer-based brand equity.

B. Portfolio Innovativeness Variety

In the following, we argue that the variety of portfolio innovativeness influences the clarity and credibility of a brand, and therefore functions as a signal to consumers [21], [22]. Portfolios with substantial innovativeness variety exhibit differences in perceived innovativeness among their individual new products [44] that can have positive as well as negative effects on consumers' brand perceptions.

Portfolio innovativeness variety enables a firm to differentiate its products according to consumer preferences. Portfolios with high degrees of innovativeness can then target new customers as well as consumers that seek radical innovations, while also addressing existing customers that prefer incremental innovations [64]. High degrees of innovative portfolio differentiation (IPD) enable firms to offer novel and consumer-specific value tailored to different consumer needs. This can result in consumers perceiving a useful and meaningful innovation, leading to a higher perceived value of the innovation portfolio [65], increased customer loyalty [9], or improved brand equity [12]. High portfolio innovativeness variety can therefore signal to consumers that a firm is able to offer value to different segments and can differentiate the firm from competitors.

High portfolio innovativeness variety may however also negatively affect consumers' brand perceptions through a lack of information about all the different new products [48]. A large number and diversity of offered new products characterize high degrees of variety. This signals a highly complex portfolio that may overwhelm consumers, who may experience information overload and may develop potentially conflicting perceptions of a firm's offerings [66]. Consumers may then feel uncertain about a firm's ability to fulfill their needs [67]. Such high degrees of portfolio innovativeness variety can induce unclear brand perceptions that diminish the brand's credibility and negatively affect consumers' brand perceptions [21], [22]. These insights suggest that portfolio innovativeness variety affects consumers' brand perceptions negatively.

Following on these arguments, research also indicates more complex and non-linear effects of portfolio innovativeness on consumers' brand perceptions. For instance, Stock (2011) shows that inconsistent insights about the effect of portfolio innovativeness can be explained by a convex relationship between portfolio innovativeness and customer loyalty [10]. This valuable result is corroborated by research indicating that different dimensions of portfolio innovativeness have counteracting effects on consumer loyalty [9].

Incorporating these insights, we argue that consumers perceive two opposing partial effects that are influenced by the variety of portfolio innovativeness. On the one hand, up to a certain degree of variety, consumers perceive the signal that a firm's innovation portfolio can fulfill their current and future needs, resulting in the brand's ability to fulfill their needs over a long period in time. On the other hand, when the variety becomes too high, consumers perceive an inconsistent signal of complexity that influence uncertainty about the innovation portfolio's expected utility and diminishes the clarity and credibility of the brand. We therefore hypothesize that this trade-off between both partial effects results in an inverted U-shaped relationship between the variety of portfolio innovativeness and consumer-based brand equity:

H2: The perceived portfolio innovativeness variety has an inverted U-shaped relationship with a firm's brand equity.

Moreover, we argue that portfolio innovativeness variety is also likely to affect the strength of the positive relationship between portfolio innovativeness and brand equity. Such positive effects can be diluted if consumers only associate positive attributes with a few new products from the portfolio, while the remainder is not perceived to be innovative at all. The existence of less innovative products in the portfolio may detract from consumers' perception of a brand's innovation authenticity and credibility, and may lead to inferior brand association and awareness [68]. Such differences

in a portfolio's innovativeness make it challenging to assess the signal a firm is sending with its portfolio innovativeness. As the variety of portfolio innovativeness increases, consumers perceive a low fit between the new products at each end of the innovativeness continuum, resulting in fewer comparable new products, fewer favorable positive attitudes spill-over effects from one new product to the other, and a confusing brand positioning [11], [14], [58].

Such consumer perceptions can also interfere with the brand's quality signal. A new product's attributes typically function as a quality signal that enhances consumers' recognition of a specific brand by reducing the perceptions of uncertainty associated with the new product [69]. Although offering a great variety of products can enhance consumers' quality perceptions, the product options have to be compatible and should require similar category expertise [15]. High portfolio innovativeness variety counteract this effect, as highly innovative and less innovative new products are less comparable and require different expertise of consumers than low portfolio innovativeness variety. Portfolio innovativeness variety can therefore dilute the clarity and credibility of the quality signal of an innovation portfolios' attributes, such as its portfolio innovativeness. This can result in a negative moderation effect on the relationship between portfolio innovativeness and brand equity. We therefore hypothesize:

> *H3: The positive relationship between portfolio innovativeness and brand equity is negatively moderated by portfolio innovativeness variety.*

IV. METHODOLOGY

A. Sampling

We chose the automobile industry as a research context for the following reasons: First, automotive firms represent established brands that enjoy high awareness among the consumer population and these brands' actions function as signals to consumers [51], [70]. Second, each automotive firm offers a clear portfolio of comparable and interdependent new products [70], [71]. Third, the automotive context is established regarding research on consumer behavior with respect to innovative products and services [72], [73] or business model innovation [54].

The questionnaire was sent to twenty experts from research and practice for pretesting. Small revisions were made based on their comments. To collect the data, we followed established procedures (e.g., provide clear instructions, ensuring strict confidentiality, order of questioned constructs in the survey) [74] and recruited graduate students from a major European university that encouraged individuals to participate in the study [75]. We ensured that the sample selection captured respondents of all relevant target groups in the automobile sector. Potential participants received an email containing an embedded URL to a website with an online questionnaire.

Each participant was asked to complete a questionnaire comprising measures for perceived innovativeness and brand equity for two different yet similar automobile brands. The respondents were randomly assigned and either evaluated the innovativeness of middle-class brands (Opel and Toyota) or upper-class brands (Porsche and Mercedes), resulting in 691 complete responses.

We choose middle- and upper-class brands because these brands typically apply an innovation strategy that has a strong commitment to innovation. These brands are more likely to include high degrees of innovativeness in their innovation portfolio to differentiate themselves from competitors and to gain a revenue premium [11], [19], [76]. In contrast, low-class brands typically innovate by enhancing their operations' internal efficiency to follow a cost-leader and innovation-following strategy [11]. Thus, low-class brands tend to imitate established products at lower costs. To do so, they focus on innovations in the production process that are not transparent to consumers [77]. Thus, consumers are likely to perceive the product portfolio of low-class brands, such as Dacia, as not innovative. According to this argumentation, this study focuses on middle- and upper-class brands.

We searched the dataset for multivariate outliers. Two cases showed Mahalanobis distances (D2) of 103 and 90 and $\Delta D2=26/14$ in the case with the next largest value. Further, we eliminated outliers with an uniform response style (i.e., zero standard deviations in their answers across all items). After excluding these respondents [54], [73], our final dataset contained 656 responses, equaling 1,312 cases. Our sample covered respondents with an age range of 18 to 80 years and a mean of 26.8 years; 63.9% were male and 32.4% female. Income and occupation covered a wide range of characteristics (Table 2).

TABLE 2
SAMPLE CHARACTERISTICS

n=656 respondents	Mean	Median	SD or relative frequency[a]
Industry familarity	4.37	4.5	1.62
Occupation			
Employee			21.6%
Public official			4.8%
Self employed			6.2%
Student			59.7%
Unemployed			1.5%
Gender			
Male			63.9%
Female			32.4%
Income			
<1,000			38.0%
1,001-2,000			15.5%
2,001-3,000			14.0%
3,001-4,000			7.4%
>4,001			10.4%
Age			
<20			34.3%
21-30			44.4%
31-40			15.4%
41-50			2.2%
51-60			1.7%
61-70			1.7%
71-80			0.1%
>80			0.1%

Note: [a]If percentages do not add up to 100%, some answers were missing

To keep the questionnaire manageable, we selected a representative subset of car models from each brand. We excluded specific variations within one model (e.g., station wagon or convertible). The subsets included at least one specific car model for each car segment (following the categorization used by the German Federal Office for Motor Vehicles), which is addressed by the brand in the German market. By drawing on Schultz et al. [2, p. 97], who define portfolio innovativeness as "the average innovativeness of a firm's new product developments in the three years prior to the year of the study", we selected car models that were either newly released or overhauled in the three years prior to the study. Thereby, we ensured that each car model was novel to some degree as a sufficient condition for evaluating the innovation portfolio [2]. Table 3 provides an overview of the categorization used, as well as the respective car models.

As we wanted to prevent potential threats of reversed causality, it was necessary to ensure that participants evaluated the perceived innovativeness of a particular car and not their subjective assumptions about the brand. We therefore provided participants with neutral portraits of each car. The portraits included regular features, a standardized angular front picture of a white model against a white or light grey background. We further offer more details by providing detailed information on the characteristics of each car model (e.g., linking the respective website of the car manufacture). Each participant then separately assessed the innovativeness of each car.

TABLE 3
OVERVIEW OF CATEGORIZATION AND RESPECTIVE CAR MODELS

Car segment	Opel	Toyota	Porsche	Mercedes-Benz
TOTAL	5 car models	6 car models	4 car models	7 car models
Micro-car	Agila	iQ Aygo		
Small car	Corsa	Yaris		
Compact car	Astra	Auris		A-Class
Midsize	Insignia	Avensis		C-Class

	Ampera	Prius		
Full-size				E-Class
Large car			Panamera	S-Class
Sports car			Boxster	SLK
SUV			Cayenne	M-Class
Luxury sports car			911	SLS

B. Measurements

We measured each latent construct on a seven-point Likert-type scale ranging from 1 (do not agree) to 7 (strongly agree).

Portfolio innovativeness. We measured the perceived portfolio innovativeness from a consumer perspective and operationalized perceived innovativeness on an established multi-item scale adapted from Moreau [78]: "The car model is completely different from other models in the same market segment", "The car model contains many new product features", and "The car model is highly innovative". In particular the first two of these items capture more objective aspects of innovation, reducing potential individual bias in assessing innovativeness. Respondents were asked to separately rate the perceived innovativeness of major car models in each brands' current product portfolio. We calculated the portfolio innovativeness as the mean value of all items over all car models in each brand.

Portfolio innovativeness variety: Similarly to new product diversity, which is operationalized as the spread or entropy of characteristics related to the product [79], [80], we used the standard deviation of the innovativeness of a brand's car models to measure portfolio innovativeness variety.

Brand equity. Brand equity was conceptualized as a reflective, second-order construct. At the first-order level, we measured three constructs that were shown to conceptualize brand equity and were not necessarily linked to being a customer of the product or brand: product quality, brand awareness, and brand association [81]. We used Tong and Hawley [82]'s scale to measure brand equity.

Controls. To strengthen the models specification and mitigate potential endogeneity issues we included several control variables [83]. We first controlled for the four car brands that were assessed in our survey. These were characterized by many more unobserved characteristics in addition to portfolio innovativeness and diversity (e.g., environmental friendliness, affordability, sportiveness, and customer service) that might influence brand equity. Moreover research indicates that the brand itself provides an effect signal determining consumers' perception [12], [13], [48]. Therefore, three brands were dummy-coded (0/1). Second, we controlled for gender, as a fascination with automobiles is likely to be higher for males. Moreover, we also controlled for the familiarity of the respondents with the industry because this personal characteristics can determine their attachment to a respective brand [54], [73]. Finally, we controlled for the effects of age and income on brand equity.

C. Estimating Procedure

We used covariance-based structural equation modeling (CBSEM), using MPLUS 6 [84] to test our measurement and structural models. CBSEM has several advantages for our study. In particular, it deals with endogeneity as it simultaneously estimates intercorrelations among covariates. It furthermore has the benefit that latent variables are associated with measurement error, in contrast to ordinary least squares regression, for example, which is based on the assumption that variables are measured perfectly. To select an adequate estimator, we assessed two assumptions for regular maximum likelihood (ML) estimation:

We assessed the distributions for all metric variables. Univariate normal distribution of variables with skewness and kurtosis measures $|< 1|$ was substantiated for all variables. In a second step, however, Mardia's normalized estimate of multivariate kurtosis and Small's omnibus test of multivariate normality significantly ($p<0,001$) rejected the assumption of the multivariate normality of our data. The assumption of our data's non-independence could be violated as we assessed two brands per respondent, therefore sequential correlations could lead to biased standard errors. We tested if there were significant zero-order correlations between the ratings for the two brands assessed by one respondent regarding the overall rating for portfolio innovativeness and the subconstructs of brand equity. As these correlations were all positive and significant, sequential correlation with the respondents could be an issue.

To cope with the abovementioned issues, we applied the robust maximum likelihood (MLR) estimator to obtain the standard errors for our parameter estimates. This estimator was shown to provide robust estimates in cases of non-normality and can cope with non-independence if non-independent groups (each respondent in our case) were identified [84]. MLR further yielded the Satorra-Bentler-scaled chi-square statistic, which adjusted the model fit for the degree of multivariate kurtosis. We checked the ratio of observations to model-implied parameters to determine the achieved power levels for varying model complexities. Considering our sample size, we fulfilled Bentler's 10:1 rule for SEM under multivariate non-normality and for applying MLR-scaled estimations.

D. Robustness Checks

To ensure the robustness of our findings, we performed several tests to examine the robustness of the results. Due to the proportionally high number of students in our sample, key informant bias could be a threat in our study. Therefore, we first assessed respondents' familiarity with the industry. This construct achieved an average value of 4.37, indicating high adequacy among the respondents. Second, we did not intend to predict adoption intention, adoption, or its barriers [13], [49], [50] nor sales or purchasing behavior related to new cars. Instead, we focused on perceived brand equity that reflects a brand's value [21], [22]. The literature on this construct shows typically no difference in the results in relation to age and income [54]. Third, we compared the mean values of the main constructs (portfolio innovativeness and subconstructs of brand equity) between respondents of different ages (in groups of 10 years each) via an analysis of variance with the Scheffé post-hoc test, without finding significant differences (p>0.1).

We also controlled for gender, age, and income and did not find any significant influence on brand equity (see Table 7). Moreover, we validated the dependent variable brand equity by correlating it with the actual sales of the innovation portfolio. Results indicate a strong correlation between brand equity and sales, suggesting a valid measurement of the dependent variable. Further, this result is in line with the literature indicating that sales-based and consumer-based brand equity are correlated but distinctive [32].

To assess the potential issue of non-response bias, we compared early and late respondents with a series of chi-square tests. We compared the respondents' demographic variables (age, gender, and income) between the first third and the last third of the received responses without detecting any significant differences (p>0.05).

We coped with the issue of common method bias (CMB) and therefore first followed the recommendations of Podsakoff et al. [85] for reducing CMB ex-ante. As the survey was conducted online, full respondent anonymity was ensured. We pretested the survey in order to reduce item complexity as well as ambiguity. Second, the nature of our theoretical model includes an interaction effect that increases the general robustness against CMB. Hence, it is unlikely that a respondent anticipated our hypothesized model. Third, an ex-post-test for CMB was conducted. We applied the correlational marker technique based on the work of Lindell and Whitney [86]. We therefore used a theoretically unrelated variable of our dataset and tested if it had a significant influence on the correlations among our model variables. We asked respondents about the degree of professional connection to the automotive industry. The zero-order correlations among the model constructs were not substantially affected in size ($|\Delta r|<0.01$) and all significant zero-order correlations remained significant at the same level after the partial correlation adjustment with the marker variable was made. We found no strong indication that common method variance seemed to bias model results

Finally, we calculated an alternative model to assess the robustness of our results. First, we tested whether the unequal distribution of the respondents among the different brands can affect our results. We therefore applied a weighting vector (in the relationship from 33 to 66) to assign a weight to each observation that controls for the sampling differences. The resulting path coefficients and their significances did not substantially differ from the reported model. Second, we tested a model in which we operationalized the diversity of the portfolio innovativeness with a measure of the range of the innovativeness in an individual brand portfolio instead of the variance (i.e. as the variance is a function of the mean and thus related to the portfolio innovativeness). This alternative model showed robust results for all hypothesized effects in our model. Detailed results of these additional analyses are available from the authors upon request.

V. RESULTS

A. Measurement Model Results

We first conducted separate analyses for each of the first-order constructs (industry familiarity, product quality, brand awareness, and brand association). The resulting standardized factor loadings, indicator reliabilities (IR), composite reliabilities (CR), and average variance extractions (AVE) are all above the commonly agreed cut-offs and indicate a valid measurement of these constructs [87]. As there could be differences in the measurements between the car brands in our sample, we also separately assessed the values for all four brands. Reliability and validity requirements (factor loading > 0.7, p<0.001) were met for all groups.

We then tested the postulated structure of perceived brand equity by means of a second-order confirmatory factor analysis [88]. In this model, perceived brand equity is the second-order factor reflected by three first-order dimensions. The loadings of the second-order construct on its respective dimensions were all high and significant (Table 4).

The global fit criteria indicate a good overall model fit: CFI = .970, TLI=0.952, RMSEA = .056 (90% confidence interval= $0.052 - 0.060$), SRMR = .043. The value of the arbitrary $\chi 2/df$ ratio (5.374) itself is above the often advocated threshold of ≤ 3. However, it does meet the less restrictive cut-off threshold of 10. Because of our large sample (N = 1,382), the $\chi 2$ value is naturally inflated and therefore does not necessarily indicate a model misfit [89]. To assess if the sample size primarily causes this high value, we re-estimated our second-order CFA model based on a set of five hold-up samples, each consisting of 350 randomly selected cases (approximately a quarter of our final sample). In contrast, our model results remained consistent (Δ factor loadings < 0.07), $\chi 2/df$ ratios ranged between 1.426 and 1.770 and were therefore all at an acceptable level. Hence, we do not consider the $\chi 2/df$ ratio for further analyses of the full dataset.

TABLE 4
LATENT VARIABLE MEASURE

First-order constructs and indicators[a]	Std. factor loadings	t-value (MLR)	IR
Industry familiarity (CR=0.893; AVE=0.737)			
I am very familiar with the automotive industry and its products	0.854	663.080	0.714
I regularly inform myself about new products and innovations in the automotive industry	0.898	667.502	0.795
I am very interested in cars and motorsports	0.841	862.769	0.696
Product quality (CR = .941; AVE = .841)			
I trust the quality of products from X.	0.904[b]	87.593	0.828
Products from X are of a high quality.	0.894	109.165	0.801
Products from X offer excellent features.	0.944	125.665	0.890
Brand awareness (CR = .861; AVE = .675)			
I can quickly recall some characteristics of X.	0.880[b]	80.294	0.758
I can easily recognize X among competing brands.	0.826	66.325	0.687
I am familiar with X brand.	0.742	42.674	0.576
Brand association (CR = .872; AVE = .694)			
I respect and admire people who drive X.	0.858[b]	72.982	0.742
I like the X's brand image.	0.807	71.333	0.645
I like and trust the company that makes X cars.	0.825	58.622	0.700
Second-order constructs and indicators			
Brand equity (CR = .930; AVE = .817)			

TABLE 5
CORRELATIONS AND FORNELL-LARCKER ASSESSMENT

#	Constructs/ Variables	1	2	3	4	5	6	7	8	9	10	11
1	Industry familiarity	0.858										
2	Product quality	0.271***	0.917									
3	Brand awareness	0.260***	0.740***	0.822								
4	Brand association	0.305***	0.867***	0.831***	0.833							
5	Portfolio innovativeness	0.222***	0.878***	0.842***	0.607***							
6	Portfolio innovativeness Variety	0.138***	0.540***	0.518***	-0.047†	-0.083***						
7	Age	0.047***	0.010	-0.040	0.011	-0.039*	0.116***					
8	Gender	0.328***	0.015	0.010	0.017	-0.010	0.024	0.033				
9	Income	0.206***	0.031	0.030	0.035	0.021	0.075**	0.175***	0.002			
10	Mercedes	0.061†	0.094***	0.090***	0.105***	0.044	-0.101***	0.010	0.034	0.037		
11	Opel	-0.077*	-0.368***	-0.353***	-0.413***	-0.195***	0.213***	-0.013	0.029	0.033	0.017***	
12	1 = Toyota	-0.077*	-0.241***	-0.231***	-0.271***	-0.179***	0.045	-0.013	0.029	0.032	0.017***	0.000

Note: †=p<0.1, * = p<0.05, ** = p>0.01, *** = p<0.001; bold numbers on the diagonal show the square root of the average variances extracted for latent variables

Product quality	0.878[b]	78.358	0.772
Brand awareness	0.842	50.975	0.710
Brand associations	0.987	87.267	0.973

Note: [a]X means the specific automobile brand; [b]initial loading fixed to 1 to set the scale of the construct

We further assessed the discriminant validity of the first-order factors included in our overall research model by comparing the square root of the average variance extracted for each construct with the correlation of that construct with all other constructs. Brand awareness and brand association did not slightly meet the Fornell-Lacker criterion (Table 5). However, as the first order constructs were aggregated into a reflective-reflective higher order construct, this slight deviation of discriminant validity is not considered to be critical.

B. Structural Model Results

We tested our final structural model via stepwise MLR estimation (Table 6). First (Model 1), only control variables were added. Whereas socio-demographic variables of the respondents (age, gender, and income) did not exert significant effects, the industry familiarity and the individual brands showed a significant influence on the degree of brand equity. The results indicate that the dummy-coded brands Mercedes, Opel, and Toyota all show significantly lower brand equity compared to the reference category Porsche. The controls together explain 40.9% of the variance of perceived brand equity.

In Model 2, we added the two main effects of portfolio innovativeness and portfolio innovativeness variety to the model. Both effects were positive and significant, and the variance explanation of brand equity increased to 58.1%. In Model 3, we added the interaction term between portfolio innovativeness and portfolio innovativeness variety as well as squared portfolio innovativeness variety to the model. This model explains 58.5% of the variance.

Comparing the three models, we see that most of the effects of the previous models remained consistent after adding more predictors. Interestingly, the main effect of portfolio innovativeness variety, although already significant in Model 2 (β=0.063, p<0.01), significantly increased (β=0.365, p<0.01) in height after adding the interaction with portfolio innovativeness. Our complete model (Model 3) shows good overall fit criteria (CFI=0.954, TLI=0.941, RMSEA=0.056, and SRMR=0.043).

The model supports our hypotheses. We found a significant, positive relationship between portfolio innovativeness and brand equity (β=0.492, p<0.001). We further found a positive relationship between portfolio innovativeness variety and brand equity (β=0.365, p<0.01). However, this positive effect turns negative if the level of portfolio innovativeness

variety is too high. We found a negative quadratic effect of portfolio innovativeness variety on brand equity (β=-0.169, p<0.01), indicating an inverted U-shape effect. Finally, we find some support for the negative moderating effect of portfolio innovativeness variety on the relationship between portfolio innovativeness and brand equity (β=-0.154, p<0.1)

TABLE 6
STRUCTURAL MODEL RESULTS[A,B,C]

Independent variable	Model 1	Model 2	Model 3	Hypotheses
Industry familiarity	0.264*** (0.025)	0.157*** (0.023)	0.158*** (0.034)	
Age	-0.007 (0.018)	0.008 (0.017)	0.008 (0.017)	
Gender (1 = male)	-0.047* (0.021)	-0.014 (0.020)	-0.015 (0.020)	
Income	-0.011 (0.025)	-0.008 (0.021)	-0.006 (0.022)	
Brand[d] (1 = Mercedes)	-0.228*** (0.031)	-0.164*** (0.026)	-0.166*** (0.026)	
Brand[d] (1 = Opel)	-0.558*** (0.027)	-0.450*** (0.025)	-0.449*** (0.024)	
Brand[d] (1 = Toyota)	-0.437*** (0.028)	-0.328*** (0.026)	-0.330*** (0.026)	
Portfolio innovativeness		0.446*** (0.021)	0.492*** (0.034)	H1 accepted
Portfolio innovativeness variety		0.063** (0.021)	0.365** (0.117)	
Portfolio innovativeness variety ²			-0.169** (0.053)	H2 accepted
Portfolio innovativeness x portfolio Innovativeness variety			-0.154† (0.093)	H3 accepted
R² (Δ R²)	0.409	0.581 (0.172)	0.585 (0.004)	
RMSEA	0.065	0.062	0.056	
(C.I. 90%)	(0.060-0.069)	(0.058-0.066)	(0.052-0.060)	
CFI	0.956	0.953	0.954	
TLI	0.942	0.940	0.941	
SRMR	0.045	0.043	0.043	

Note: [a] Standardized coefficients are reported, [b] significant at: *** p < 0.001, **p < 0.01, *p < 0.05, †p< 0.1
[c] Numbers in parentheses represent standard errors of coefficients, [d] Porsche is the reference category

VI.   DISCUSSION

This study integrates former disconnected research streams on firm-internal portfolio innovativeness [3], [5], [6] and consumer perceptions of innovation portfolio innovativeness [12], [13] by investigating portfolio innovativeness from a consumer-centric perspective. We apply signaling theory [20], [57], [90] and conceptualize that a firm's portfolio innovativeness functions as a signal to consumers and determines their perceptions of brand equity.

First, the results show that high degrees of portfolio innovativeness signal high brand equity to consumers. This positive relationship between portfolio innovativeness and brand equity supports the notion that high portfolio innovativeness indicates to consumers that a brand invests significant resources to fulfill consumers' needs by creating unique product advantages and offering superior innovation quality [10], [18], [39]. Consequently, portfolio innovativeness can reduce consumers' uncertainty about a firm's innovations, resulting in a positive brand perception of the firm.

Second, high portfolio innovativeness variety has an inverted U-shaped effect on consumers' perceived brand equity. This result can be explained by the fact that portfolio innovativeness variety signals to consumers that a firm can address different consumer needs. However, when the portfolio innovativeness variety is too high, consumers perceive conflicting signals and may become confused. Research in a B2B context also supports such a convex relationship between portfolio innovativeness and customer loyalty [9], [10]. Consequently, we show that the clarity and credibility of portfolio innovativeness influence the perceived brand equity. Further, the results indicate that the variety of portfolio innovativeness that is too extreme can confuse consumers and result in less positive brand perceptions.

Finally, the results indicate a negative moderation effect of portfolio innovativeness on the relationship between portfolio innovativeness and brand equity. This insight supports the notion that consumers who perceive a poor fit between different innovations of a portfolio have less favorable attitudes towards a firm's innovation portfolio [14], [58]. Moreover, high degrees of variety impede consumers' ability to compare different innovations with each other, as highly innovative and incremental innovative new products and services require consumers to have or develop a

totally different skill set [15]. Thereby, we complement new product development research on customer integration [91].

A. Theoretical implications

This study responds to ongoing calls for further research on consumer perceptions of portfolio innovativeness [9], [10] and related constructs [39], [40]. By addressing these calls, our results offer three central contributions to portfolio innovativeness, IPM's effects on firm outcomes, and a brand's innovation activities.

First, we extend research that focuses IPM's internal aspects, such as decision-making [17], [23], flexibility [24], [25], [92], process formalization [23], [29], or strategic buckets [7], [26], by introducing and testing a novel construct, portfolio innovativeness variety. This construct can offer a potential explanation for contradicting insights on portfolio innovativeness. Research controversially discusses the potential positive and negative effects of portfolio innovativeness on firm outcomes and performance. While high portfolio innovativeness can enable firms to gain a revenue premium [28], [29], a portfolio of innovative products face internal challenges, such as organizational barriers and high uncertainty [18], [30], [93], which costs outweigh portfolio innovativeness' potential benefits. We extend this perspective by supporting the insights on an optimal degree of innovativeness [2], suggesting that a "right" mix of incremental and radical innovation projects enable value-maximizing portfolios [4], [23], [29]. In particular, we show that portfolio innovativeness positively affects consumer-based brand equity. The results also indicate that a variety of portfolio innovativeness that is too extreme negatively impacts brand equity. Consequently, a moderate degree of portfolio innovativeness variety maximizes consumer-based brand equity.

Second, by showing that portfolio innovativeness can provide a signal to the consumer's brand perceptions, we draw attention to a less researched outcome of IPM. Research on IPM typically investigates the antecedents of IPM outcomes, such as value maximization, balance, strategic fit [7], [23], [29], [31], or innovation performance, such as revenues from new products [3], [94]. We extend these insights by showing that portfolio innovativeness affects consumer-based brand equity. Since consumer-based brand equity predicts sales-based brand equity [32] that can maximize the portfolio's value [23], [29], we draw the attention of research on IPM to a further, essential parameter for IPM.

Third, our insights suggest that IPM is a pivotal step to vitalize brands and that, therefore, firms should take brand perceptions into account when managing a portfolio of innovations. Although the initial research already understands portfolio innovativeness as an indication to a firm's consumers that affects customer loyalty [9], [10], we extend these insights by applying a signaling perspective on portfolio innovativeness. Whereas research indicates positive, negative, and non-linear effects of portfolio innovativeness on B2B-customers' brand perceptions [9], [10], we show that variety in portfolio innovativeness can explain these different relationships as it mitigates the brand equity building effect of portfolio innovativeness and directly affects brand equity in an inverted U-shaped relationship. We, therefore, complement research suggesting that not all brands can innovate the same way [11] by showing that a firm's innovation portfolio needs a certain fit in order to signal consistency and credibility to consumers. Opposing, extreme degrees of portfolio innovativeness variety can be associated with consumers' uncertainty about a firm's offering, thereby confusing them about the expected utility of a brand's offerings. These insights supplement existing research on consumers' brand perceptions that either tends to investigate single new products and services [12], [13] or to apply a marketing perspective that neglects portfolio innovativeness [11], [14], [15]. This study, therefore, also extends the literature by offering a deeper understanding of how the configuration of an innovation portfolio affects consumer perceptions of a firm's brand equity.

B. Practical implications

Our study clearly advocates for the development of innovation portfolios where each single innovation project enjoys a high level of innovativeness, as perceived by consumers. In developing such consumer perceptions, technology-related as well as market-related aspects are of critical relevance. For innovation and marketing managers, such findings highlight the necessity of innovation strategies that are not only focused on the constant development of innovative new products and services, but also aim to ensure that consumers perceive their novelty.

The message of product novelty must therefore be adequately signaled to consumers in order to foster a firm's brand equity. Innovation strategies that aim at launching only a few, very innovative new product "stars" and expect the entire portfolio of products to benefit from an enhanced brand-based innovation image are not supported by our results.

Advertising campaigns that are focused on "lighthouse" products may disappoint consumers if they expect consistent innovation and find varying degrees of innovativeness across the innovation portfolio. This may send a mixed signal about the firm's commitment to innovation. Consequently, new features should preferably be implemented into the entire range of innovations on offer and marketing campaigns should approach novelty as a new product and service attribute that characterizes all innovation in the portfolio.

Finally, our research highlights the importance of having a consumer-centric perspective when assessing portfolio innovativeness to aid managers in building stronger brands and fostering a positive product evaluation. To do so, managers must take into account that portfolio innovativeness and portfolio innovativeness variety send a signal to consumers, determining their brand perceptions. IPM should therefore be aware of the underlying effects of portfolio innovativeness on consumers' brand perceptions in order to ensure a balanced and value-maximizing portfolio.

C. Limitations and future research

As we applied a cross-sectional research design, future research should have a look into the stability of our findings over time. For instance, a firm builds brand equity over time, and there may be a delay before changes in the product portfolio influence consumer perceptions [39]. Consequently, realizing higher levels of portfolio innovativeness may not immediately increase brand equity and, if portfolio innovativeness decreased, a negative impact on brand equity may not be directly observed. A longitudinal research design may open promising directions for future research.

The consumer-centric focus and the perception-based measurement method add value to the discussion on portfolio innovativeness. Nevertheless, we did not investigate the extent to which the perceived level of product innovativeness differs from actual, objective product innovativeness across the portfolio. In this respect, a firm's advertising activities, social contagion, and general publicity [12], [13] can represent additional factors that impact how consumers perceive a product portfolio. Moreover, experimental research could further validate the causality of the relationship between portfolio innovativeness and consumers' brand perceptions by incorporating further covariates (e.g., marketing instruments and innovation strategies) [11], [13]. Further, it is reasonable that the consumers' perceptions and behavior can cause spillover effects to the firms' new product development. Thus, other theoretical perspectives, such as innovation resistance [95] or framing [96], can inform future research.

While our results indicate that high degrees of portfolio innovativeness variety can absorb the positive of portfolio innovativeness on brand equity, other adverse effects of portfolio innovativeness on employees and customers can occur. Since high degrees of portfolio innovativeness are associated with a significant change in the firm and the external environment [2], employees can resist the necessary changes in the organization [97]. Similarly, consumers can be overwhelmed by the change in their values, habits, and behaviors that is required to adopt an innovation. Thus, research on the dispositional inclination (e.g., consumer innovativeness, resistance to change, technological affinity) of employees and consumers can open up valuable directions for further (experimental) research on portfolio innovativeness variety [13], [49], [95], [98]. Further, research can also investigate the relationship between brand perceptions and the adoption of a single innovation project since it is reasonable that there are spillover effects of consumers' brand perceptions and the adoption process of innovations [49], [73].

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