Intertemporal distinctiveness of product design:
How it influences the value of new and used products

ABSTRACT

This research develops a construct of *intertemporal distinctiveness* to capture the differences between a focal product's new design and its past designs that were introduced in the past but are still available in today's market. We stress that the available past designs in secondhand markets have emerged as an important reference set for comparing and evaluating new product designs. Moreover, the intertemporal distinctiveness of product design can influence the value of not only new products but also past products that are available in secondhand markets. Using image-processing software and a unique data set of new and used cars sold in the U.S. automotive market from 2002 to 2016, we found an inverted U-shaped relationship between the intertemporal distinctiveness of design and the market performance of new products. In contrast, a U-shaped relationship exists between the intertemporal distinctiveness of design and the preservation rate of used products. This study contributes to optimal distinctiveness research by theorizing intertemporal distinctiveness and exploring its effect on both new and used products, shedding light on the temporal dynamics of optimal distinctiveness.

Keywords: intertemporal distinctiveness, product design, product innovation, used products

1 INTRODUCTION

Product design has been increasingly recognized as an important source of competitive advantage for firms (Chan, Mihm, and Sosa, 2018; Eisenman, 2013; Katila and Ahuja, 2002). Today, design is not merely the look of products but also a vital factor in a firm's business success (Bloomberg, 2014; Cattani *et al.*, 2020). A product's aesthetic design, defined as a product's visual form or appearance (Homburg, Schwemmle, and Kuehnl, 2015), is especially important because it influences consumers' responses (Landwehr, Wentzel, and Herrmann, 2013; Rindova and Petkova, 2007), product performance (Bloch, 2011; Landwehr, Labroo, and Herrmann, 2011), and the market value of a firm (Xia, Singhal, and Zhang, 2016). As such, the question of "how to make product design successful?" has drawn considerable attention from both academics and practitioners.

Product design is usually evaluated based on comparisons with other designs (Bloch, 1995). Specifically, a product design that is distinct from other designs within its category can be perceived as novel and unique, enabling the product to stand out from competitors and attract consumers' attention (Cattani, Porac, and Thomas, 2017; Hekkert, Snelders, and Wieringen, 2003; Radford and Bloch, 2011; Talke *et al.*, 2009). On the other hand, a differentiated product design can elicit negative consumer responses because consumers may find it difficult to categorize this product due to unfamiliarity (Durand and Paolella, 2013; Loken and Ward, 1990; Veryzer and Hutchinson, 1998; Winkielman *et al.*, 2006). Given that distinctiveness can simultaneously generate competitive benefits by reducing competition and incur legitimacy loss by impeding categorization, a robust body of research has emerged around the notion of "optimal distinctiveness" and contends that a balance between typicality and differentiation can positively shape stakeholders' perceptions and lead to the best performance (Deephouse, 1999; Durand and Haans, 2022; Zhao *et al.*, 2017; Zuckerman, 2016).

To date, most research on optimal distinctiveness gauges the distinctiveness of a focal product by comparing it with contemporary peers, that is, other products that are introduced and appear in the market during the same time window as the focal product (Askin and Mauskapf, 2017; Bu *et al.*, 2022). To advance this research, a recent study by Chan, Lee, and Jung (2021) adopts a temporal perspective and compares a focal product design with not only *contemporary peers* but also *past designs*, that is, designs introduced in the past. By doing so, Chan *et al.* (2021) find that the distinctiveness between a focal new design and its past designs is detrimental to the value of the new design. This is because being different from past designs can reduce consumers' familiarity with the new design but can hardly enhance the new design's competitive advantages because the new design is not competing with past designs, which may "have retired from the marketplace" (Chan *et al.*, 2021: p.4). Therefore, a minimum level of distinctiveness in comparison to "unavailable past designs" (i.e., past designs that are not available in today's market) is considered optimal for a new product design.

The use of past designs as a benchmark is an important extension of optimal distinctiveness research. However, we recognize that not all past designs are unavailable in today's market. Instead, driven by the fast-growing secondhand markets, many past designs have become available today as consumers can still find them from used products in secondhand markets. Today, the rise of secondhand markets is a top global trend powered by consumers' desire for sustainability and affordability as well, as a surge in the use of digital resale platforms (Angus and Westbrook, 2022). The resale industry is expected to grow 11 times faster than the broader retail industry in the period to 2025 (Kumar, 2021). Products such as automobiles, electronics, fashion goods, and furniture have been increasingly traded in secondhand markets. Accordingly, we argue that "available past designs" – product designs introduced in the past but are still available in today's secondhand markets – have emerged as an important reference set that influences the evaluation of new product designs. However, our understanding of its influence remains limited. Unlike unavailable past designs, available past designs are still competing with a focal new product and th; thus,stinctiveness in comparison to available past designs can enhance the competitive advantages of the new product. Moreover, since available past designs still have value in secondhand markets, we argue that the distinctiveness between a new product design and its available past designs can also influence the value of used products, a phenomenon that has received little research attention.

To advance research on optimal distinctiveness, in this study, we adopt "available past designs" as a new benchmark and explore how the distinctiveness between a focal new design and its available past designs influences the value of both new and used products. Specifically, we develop a construct of *intertemporal distinctiveness*, which refers to the differences between a focal product's new design and its past designs that were introduced in the past but are still available in today's market. Given that intertemporal distinctiveness can increase competitiveness and reduce legitimacy for both new and used products, the relative strength of these two opposing mechanisms determines the effect of intertemporal distinctiveness. We argue that a key difference between new and used products is that while intertemporal distinctiveness generates competitive benefits for new products, it is less likely to do so for used products due to perceived obsolescence. Combining the competitiveness and legitimacy mechanisms, we predict that the value effect of intertemporal distinctiveness is an inverted U-shape for new products but is a U-shape for used products. After compiling and analyzing a data set of both new and used cars sold in the U.S. automobile market from 2002 to 2016, we found strong support for these predictions.

Our study makes several important contributions to optimal distinctiveness research. First, we introduce “available past designs” as a unique benchmark that is different from the “unavailable past designs” studied earlier. While prior research emphasizes the negative effect of distinctiveness as compared to unavailable past designs (Chan *et al.*, 2021), our research shows that being different from available past designs can not only reduce legitimacy but also enhance the competitive benefits of new products. Specifically, we find that the distinctiveness in comparison to available past designs has an inverted U-shaped relationship with the value of new product designs. Second, we conceptualize a new construct of *intertemporal distinctiveness* and examine its effect on the value of *used products*, an area that has been neglected in earlier research. Prior research has focused on the impact of distinctiveness on new products (Bu *et al.*, 2022; Rindova and Petkova, 2007). Our research extends this literature by demonstrating that design distinctiveness can influence not only the performance of new products but also the value of used products. Advancing our knowledge about the value of used products is imperative because used products play an increasingly important role in influencing firm performance and the sales of new products. Lastly, we address recent calls for understanding optimal distinctiveness as a temporally dynamic construct (Chan *et al.*, 2021; Zhao *et al.*, 2017). Our framework demonstrates that the effect of intertemporal distinctiveness differs depending on the temporal dimension of a focal product. A moderate level of intertemporal distinctiveness is optimal for a new product design introduced in the current year. However, for an old product design introduced in the past, a moderate level of intertemporal distinctiveness leads to the worst outcome. Our results suggest that practitioners should simultaneously consider the influence on new and used products when making product innovation decisions.

2 THEORY AND HYPOTHESES

2.1 Intertemporal distinctiveness: Linking new product market with secondhand markets

We develop the construct of *intertemporal distinctiveness* to capture the distinctiveness between a focal product's new design and its past design, which, although retired from the new product market, is available in the secondhand market. The simultaneous consideration of the secondhand market and the new product market is imperative because the fast-growing secondhand market has become a non-negligible factor considered by producers of new products. The rise of the secondhand market is driven by consumers' increasing awareness of environmental issues, which has encouraged the purchase of used products to help reduce waste and pollution (Drake, 2019). At the same time, buying secondhand saves money and is particularly helpful when the pandemic exacerbates economic uncertainty (Khusainova, 2021). Moreover, the plethora of digital platforms available to sell and buy used products is propelling secondhand shopping into the mainstream (Angus and Westbrook, 2022). Driven by these factors, secondhand retail has grown by 69% from 2019 to 2021, while the conventional retail sector has shrunk by 15% during the same period (Ho, 2021).

We argue that *intertemporal distinctiveness* derived from the comparison between a new and a used product can influence the value of both products. This is because the new and the used products, when simultaneously appear in the market, can act as reference boundaries for each other and thus influence the evaluation of both products. In particular, advancing our knowledge of the evaluation of used products is important because as the secondhand market grows in popularity, the resale value of used products plays an increasingly important role in influencing the sales of new products and firm performance. First, consumers are forward-looking and are more willing to pay for a new product if they anticipate that they can resell it at a good price after use (Chevalier and Goolsbee, 2009). Moreover, the resale value of used products can directly influence firm performance because firms increasingly rely on *leasing* rather than selling new products to attract consumers and make profits (Bogoslaw, 2022; Patel, 2019; Pino, 2018). For instance, Feather, a furniture rental and leasing company, has seen significant growth in new leases of residential furniture since the start of the pandemic; and IKEA introduced a B2B edition of furniture subscriptions to explore leasing models (Bogoslaw, 2022). For another example, the number of new vehicles leased in the U.S. market has increased nearly four times from 2009 to 2016 (Barnard, 2018). Since firms' captive financial subsidiaries typically provide leases to their consumers, if used products' prices plummet after lease, it will be detrimental to firms because of greater than previously projected residual losses in the lease books (Root, 2020; Welch and Naughton, 2020).

To date, strategy research has primarily focused on how to improve firm performance in the new product market. However, despite the significance of used products' value in influencing firm performance and consumer responses, little research has been devoted to understanding the influential factors of used products' value in the secondhand market. In this study, we aim to address this lacuna by examining the role of intertemporal distinctiveness in influencing the value of used products. In the following sections, we develop theoretical arguments regarding the underlying mechanisms through which the intertemporal distinctiveness of product design influences the value of both new and used products.

2.1 The effects of intertemporal distinctiveness on new products

The intertemporal distinctiveness of a focal new product refers to the extent to which its new design departs from its past design, which also appears in today's market. Building upon the optimal distinctiveness literature, we argue that the intertemporal distinctiveness of a focal new product exerts two opposing mechanisms on the new product's competitiveness and legitimacy, thus influencing the performance of the new product. As illustrated in Figure 1(a), intertemporal distinctiveness can generate both competitive benefits derived from the increase of a new product's competitiveness and legitimacy loss due to the reduction of acceptability of the new product. We next explain these two mechanisms, which determine the performance implications of intertemporal distinctiveness for new products.

The intertemporal distinctiveness of a new product generates competitive benefits because it differentiates the new design of a focal product from its preceding design. Such differentiation increases the perceived newness and novelty of the new product, thus enhancing its competitiveness. The newness of a product is a central determinant of new product adoption and is strongly communicated through its design (Radford and Bloch, 2011). Because consumers tend to expect new products to have not only new features but also a new appearance, having a different new design is important to enhance a new product's identity of "being new" and meeting consumers' expectations. Moreover, a distinctive new product design can induce arousal, which makes consumers feel rewarded and pleasant (Berlyne, 1970, 1971). The increased arousal and perceived novelty will lead to positive consumer responses (Blijlevens *et al.*, 2012; Hekkert *et al.*, 2003; Talke, Müller, and Wieringa, 2017). Conversely, if a new product's design remains unchanged as compared to its predecessor, consumers may feel disappointed and lose interest. For example, the Apple iPhone 4S disappointed many consumers because its exterior design looked identical to its predecessor – iPhone 4 (Gilbert, 2011;

Tsukayama, 2011). In contrast, iPhone X was considered “exciting” because of its cutting-edge bezel-less design (Kelly, 2018). In line with previous optimal distinctiveness research (Haans, 2019; Taeuscher and Rothe, 2021), we represent the relationship between the intertemporal distinctiveness of a focal new product and the product’s competitiveness as an S-shaped curve, as illustrated in the solid black line in Figure 1(a). The increase of intertemporal distinctiveness generally increases the competitiveness of a new product. However, such an increasing effect levels off when intertemporal distinctiveness is very low because low distinctiveness is insufficient to differentiate a new product from its preceding one. When intertemporal distinctiveness is relatively high, a distinctly new design already meets consumers’ demand for novelty and thus further differentiation does not provide much competitive benefit.

The intertemporal distinctiveness of a new product can simultaneously lead to legitimacy loss of this new product because the increased distinctiveness can impede the categorization process of classifying the new and past designs of a focal product into the same category. A focal product’s new design (e.g., 2021 BMW X5) and past design (e.g., 2020 BMW X5), although introduced at different times, belong to the same category of the focal product (e.g., BMW X5). Categorization theory emphasizes that prototypicality is important in object identification (Barsalou, 1985; Loken and Ward, 1990; Rosch *et al.*, 1976). A product design similar to the typical design of its category evokes fluent cognitive processing and positive affective reaction (Landwehr *et al.*, 2011; Veryzer and Hutchinson, 1998; Winkielman *et al.*, 2006). In contrast, a highly distinctive product design can disrupt processing fluency and dampen consumers’ preferences (Landwehr *et al.*, 2013). Because a product’s past design has provided consumers with a clear and specific mental representation of this product category, consumers will have difficulty processing an extremely different new design because it violates their mental image. In turn, the consumers' frustration and difficulty with this categorization lead to negative attitudes toward the new design. For instance, when Chevrolet performed a facelift on its Camaro in 2019, former fans of this pony car found it hard to accept the drastic change in appearance (Smith, 2019). Similarly, the dramatic redesign of Kia's logo and frontal look made many consumers confused (Stapley, 2021). In Figure 1(a), we illustrate the legitimacy loss mechanism using the dotted black line. When a new product's intertemporal distinctiveness is relatively low, the legitimacy loss is minimal because a slightly distinct design is within the range of acceptability and still considered desirable and legitimate. The legitimacy drops rapidly when a new design is beyond the acceptable range of distinctiveness. The negative relationship between intertemporal distinctiveness and legitimacy of a new product flattens when intertemporal distinctiveness reaches a very high level because consumers already find an extremely distinct new product unfamiliar and unrecognizable, so this product does not suffer more legitimacy loss from further increases of intertemporal distinctiveness.

In summary, a new product's intertemporal distinctiveness from its past design can exert both a positive effect on performance by increasing competitiveness and a negative effect on performance by reducing legitimacy. Using the additive combination of latent mechanisms suggested in earlier research (Durand, Hawn, and Ioannou, 2019; Haans, Pieters, and He, 2016), we add the two opposing mechanisms together and derive an inverted U-shaped relationship between a new product's intertemporal distinctiveness and its performance, as illustrated in Figure 1(b). We argue that a new product with a moderate level of intertemporal distinctiveness in design as compared with its predecessor is optimal and can maximize market performance because it is preferred over both (1) an unchanged new design (i.e., low intertemporal distinctiveness) that lacks competitiveness and may disappoint consumers, and (2) a highly distinctive new design (i.e., high intertemporal distinctiveness) that deviates sharply from the preceding design and thus may frustrate consumers in categorization and suffer most from legitimacy loss. Accordingly, we propose the following:

> *Hypothesis 1: A new product's intertemporal distinctiveness of design in comparison with this product's past design has an inverted U-shaped relationship with its market performance.*

[Insert Figure 1 about here]

2.2 The effects of intertemporal distinctiveness on used products

The intertemporal distinctiveness of a focal used product refers to the extent to which its design is distinct from the newest design of the same product. Applying the optimal distinctiveness theory to the context of used products, we argue that the intertemporal distinctiveness of a used product can also generate competitive benefits by increasing a used product's competitiveness and trigger legitimacy loss by impeding the categorization of the used product. The mechanisms through which the intertemporal distinctiveness enhances competitiveness and reduces legitimacy for used products are illustrated in Figure 2(a). We next delineate these two mechanisms respectively and examine their combined effect on the value of used products.

First, we argue that intertemporal distinctiveness can enhance the competitiveness of a used product because it increases the perceived uniqueness of the used product through differentiation from its new version. However, the intertemporal distinctiveness of a used product can also lead to perceived obsolescence, which undermines the competitiveness of the used product. Obsolescence is defined as the relative loss in value due to changes or improvements in subsequent versions of the product (Levinthal and Purohit, 1989). Research suggests that aesthetic design change is an important factor determining the obsolescence of a used product because it influences consumers' psychological perceptions (Cooper, 2004). When a product launches a new version with a new design, consumers tend to consider the most recent design new and thus perceive the past designs that are different from the current design as outdated and unexciting. For example, the current trend of using bezel-less designs in electronic devices such as smartphones, monitors, and TVs has made their predecessors with wider bezels less attractive (Aleksandrova, 2020), reducing their value perceived by consumers. Therefore, we argue that the extent to which intertemporal distinctiveness enhances a used product’s competitiveness is minimal if the perceived obsolescence counteracts the competitive benefits derived from intertemporal distinctiveness.

We further recognize that a used product that looks different from the new design is not always considered obsolete or uncompetitive. In particular, when a used product design is highly distinct from the current design, it enables consumers to distinguish themselves and signal their uniqueness. An important benefit of shopping in secondhand markets is to find unique, one-of-a-kind used products, which are not available in the mass-produced new product market (Angus and Westbrook, 2022). Given that the used products were produced in the past and may have limited quantities in second-hand markets, the rarity can further enhance the perceived uniqueness of a used product if it looks highly different from the newest design. For example, vintage furniture’s distinctive design cannot be found in new furniture and thus is highly valued by consumers who want to differentiate and express individuality. Moreover, some old designs in the fashion industry are considered valuable today because they are highly distinct from the most recent design and give consumers a unique sense of nostalgia. As commented by Vogue, “the old Gucci look evokes restrained, genetically inherited taste” (Satestein, 2021). Accordingly, we argue that when a used product’s intertemporal distinctiveness is high, it provides a strong marginal benefit in enhancing the competitiveness of the used product because a highly distinctive old-fashioned design can meet consumers' demands to express themselves and stand out from the crowd.

As illustrated in the solid black line in Figure 2(a), we predict that a low and moderate level of intertemporal distinctiveness can hardly increase the competitiveness of a used product because the perceived obsolescence restrains the growth of competitiveness. In contrast, a high level of intertemporal distinctiveness can rapidly increase the competitiveness of a used product because the strong uniqueness demonstrated by a highly distinct used product reduces the obsolete feelings toward this used product.

Second, we argue that intertemporal distinctiveness can also reduce the legitimacy of a used product because it impedes the process through which consumers classify a used product into the same category as its new version. As product design evolves over time, consumers exposed to new designs will find it confusing to relate past designs and current designs together if they look significantly different from each other. Given that the inconsistency between new and past designs increases the burden of information processing and hinders the categorization process, we argue that intertemporal distinctiveness can reduce the legitimacy of both new and used products by making it uncomfortable to classify them into the same category. We illustrate the legitimacy loss mechanism for used products in the dotted black line in Figure 2(a). The negative relationship between intertemporal distinctiveness and the legitimacy of used products is only at a minimal degree when the intertemporal distinctiveness is relatively low because the small differences from new designs are still considered acceptable and recognizable. When intertemporal distinctiveness increases from a moderate level to a high level, the used products rapidly lose legitimacy because the differences between them and the new products are sufficient to impede the categorization of the used products. Moreover, the legitimacy loss finally flattens out at high levels of intertemporal distinctiveness at which a used product is already considered unacceptable.

Taken together, the intertemporal distinctiveness of a used product's design can simultaneously enhance the value of this used product by increasing its competitiveness and hurt the value of this used product by reducing its legitimacy. Since both competitiveness and legitimacy are beneficial for the value of used products, we adopt the additive manner by adding these two opposing mechanisms together. The overall relationship between the intertemporal distinctiveness of a used product's design and the value of this used product is represented as a U-shaped curve illustrated in Figure 2(b). Specifically, we use the preservation rate (i.e., current market value relative to the original value) to represent a used product's value. A used product with a moderate level of design distinctiveness as compared with the latest design represents the worst scenario and is associated with the lowest preservation rate. Therefore, we predict:

> *Hypothesis 2: A used product's intertemporal distinctiveness of design in comparison with this product's most recent design has a U-shaped relationship with its preservation rate.*

[Insert Figure 2 about here]

3 DATA

3.1 Data and Sample

Our theoretical arguments and empirical model for product design can be extended to a variety of products that have structured secondhand markets. In our empirical analysis, we focus on the passenger vehicle market in the United States for three reasons. First, as durable goods, cars' aesthetic designs are important to consumers because these designs remain visible to consumers for many years (Creusen and Schoormans, 2005). In particular, auto manufacturers fully redesign their car models about every five to seven years and also provide mid-cycle design updates

(Demuro, 2021). The time-series and cross-sectional variations in design allow us to estimate how design changes affect new and used cars. Second, the secondhand market for passenger vehicles has the advantage over many other secondhand markets in terms of the availability of large-scale and comprehensive data on used products. Finally, passenger cars are traded actively in secondhand markets, and thus provide us with sufficient data variations for model estimation. According to a McKinsey report (Ellencweig *et al.*, 2019), the U.S. used-car market is more than twice the size of the new-car segment and is outpacing it in growth.

We integrate our dataset from multiple sources of data relating to the U.S. automotive industry. First, we download car pictures from Edmunds.com, a website providing automotive information, to construct the car design variables. Second, we gather annual sales data for new cars from the *Automotive News Market Data* book. At the car model and model-year levels, we collect the annual average prices of used cars from the National Automobile Dealers Association (NADA). Third, for each car model, we obtain the manufacturer's suggested retail prices (MSRP) and cash rebates from *Ward's Automotive*. In addition, we collect data on car attributes such as manufacturer, horsepower, weight, miles per gallon, car size (length, width, and height), market segment (luxury vs. economy), and car classification (regular vs. sports or specialty) from *Ward's Automotive*. Finally, we compile vehicle safety and reliability ratings from the Insurance Institute for Highway Safety and *Consumer Reports*, respectively.

We analyze two final data samples. The first data sample is for new cars in the U.S. automobile market from 2002 to 2016, consisting of 259 sedan models (e.g., BMW 3 Series) and 1,991 observations at the model and year-sold levels (e.g., new BMW 3 Series sold in 2009). The prices of these new cars range from $8,642 to $224,605, with an average price at $33,308. The second data sample is for used cars with model years between 2001 and 2009 that were sold by auto dealerships in the U.S. market from 2002 to 2010. It consists of 197 sedan models (e.g., BMW 3 Series), 1,066 sedan models with a particular model year (e.g., 2002 BMW 3 Series), and 4,414 observations at the model, model-year, and year-sold levels (e.g., 2002 BMW 3 Series sold in 2009). The prices of these used cars range from $2,425 to $92,068, with an average price of $17,367. Overall, our data sample covers most sedan models in the U.S. market and is representative of the consumer population in the passenger car market.

3.2 Variables and Measures

Market performance variables. We use the market performance metrics as our dependent variables. In the new car market, we focus on annual unit sales, which is the number of units sold in the U.S. market of each car model every year. In the used car market, we focus on the preservation rate of each car model with a particular model year. The preservation rate is computed as the ratio of a used car's resale price in a given year to its original retail price. Further, we use the Federal Reserve's annual inflation rates to adjust the original retail price so that it is comparable to the car's resale price in a given year. For example, in 2010, the average resale price of a 2009 BMW 3 Series was $32,610, and its original price as a new car in 2009 was $34,225. The inflation rate from 2009 to 2010 is 1.6%. Thus, the preservation rate of the 2009 BMW 3 Series in 2010 is 93.8%.

We use preservation rate rather than unit sales to measure used cars' market performance since used cars are often sold by third-party dealers and private car owners; auto manufacturers typically do not earn high revenues from the sales of used cars. Instead, when making purchase decisions on new vehicles, a higher preservation rate can give consumers strong incentives to choose a particular car model and thereby benefit the auto manufacturers. The in-house leasing departments of auto manufacturers can also benefit directly from the higher resale prices of used cars. Therefore, the preservation rate calculated based on the resale prices of used cars is a relevant and important metric that influences consumers' purchase decisions and firms' revenues.

Product design variables. The key variable of interest is the intertemporal distinctiveness (ITD) of a car model's aesthetic design, which we measure for both new and used cars. It is important to note that the reference design of intertemporal distinctiveness for new and used cars is different. For new cars, we measure how their design differs from the design of the previous year. In 2009, for example, we compare the design of the 2009 BMW 3 Series with that of the 2008 BMW 3 Series. As robustness checks for new cars' ITD, we also measure how the design of new cars differs from the designs of the previous three or five years. For used cars, we measure how the product design of a used car differs from its new design in the current year. Again in 2009, for example, if our focal used car model is the 2002 BMW 3 Series, we compare the product design of the 2002 BMW 3 Series with that of the 2009 BMW 3 Series.

Specifically, we use the frontal car pictures downloaded from Edmunds to collect car design features because previous studies on car design indicate that the frontal view of cars is the most important aspect of car recognition (Ranscombe *et al.*, 2012). Following prior research, we use image-processing software to operationalize the product design variables in three steps (Landwehr *et al.*, 2011; Li and Liu, 2019). First, we define the center of the lowest frontal point of a car as the origin of a Cartesian coordinate system. Second, we normalize the size of each car by setting a car's width as one unit while maintaining its relative height-to-width ratio. Third, from each car's picture, we extract the positions of 50 of the most recognizable design feature points—such as grille, headlights, bumper, side mirrors, windshield, and body shape—to reflect the main elements of the frontal design of a car (see Figure 3 for positions of the 50 design feature points on a car model).

[Insert Figure 3 about here]

To represent the position of each design point, we use a two-dimensional vector of (x, y) coordinate values so that we can characterize a car's design using (x, y) coordinates of *k* = 1, 2, 3, …, 50 design points. Then we can quantify the design distinctiveness between any two cars by using the coordinate values of their design points. For each design point *k* (*k* = 1, 2, 3, …, 50), we compute the euclidean distance between the position of the design point in one car and the same design point in another car. The overall design distinctiveness is then measured by the summation of the euclidean distance over all 50 design points.

We calculate the intertemporal distinctiveness of a new car as the euclidean distance between the 50 design points of the new car and those of its previous year's design. Similarly, the intertemporal distinctiveness of a used car is given by the Euclidean distance between the 50 design points of the used car and those of its new design in the current year.

$$\text{New Car:} ITD_{it} = \sum_{k=1}^{50} \sqrt{(x_{it}^k - x_{i,t-1}^k)^2 + (y_{it}^k - y_{i,t-1}^k)^2},$$

$$\text{Used Car:} ITD_{ijt} = \sum_{k=1}^{50} \sqrt{(x_{ij}^k - x_{it}^k)^2 + (y_{ij}^k - y_{it}^k)^2},$$

where x_{it}^k and y_{it}^k represent the coordinates of design point *k* for car model *i* with model year *t*, $x_{i,t-1}^k$ and $y_{i,t-1}^k$ represent the coordinates of design point *k* of car model *i* with model year *t-1*, and x_{ij}^k and y_{ij}^k represent the coordinates of design point *k* of car model *i* with model year *j*. In Figure 4, we use pictures of Ford Focus and Nissan Sentra as two examples to demonstrate how our design variable, ITD, quantifies the intertemporal distinctiveness of the car's product design.

These examples clearly show that the magnitude of ITD is consistent with the visual difference between the two car models.

[Insert Figure 4 about here]

In addition to our key variable of interest, we also control for contemporary distinctiveness (CD), which measures how the aesthetic designs of new and used cars differ from the contemporary designs of their competitors. In particular, we compute the contemporary distinctiveness of a car as the distinctiveness between the design of a focal car and the designs of other cars with the same model year and in the same market segment (luxury vs. economy) as the focal car. For example, if our focal car is the 2002 BMW 3 Series, we compare the product design of the 2002 BMW 3 Series with the designs of all other luxury cars introduced in 2002. This variable is given by the Euclidean distance between the 50 design points of the focal car and those of the average look of all other cars with the same model year and in the same market segment as the focal car.

$$\text{New Car:} CD_{it} = \sum_{k=1}^{50} \sqrt{(x_{it}^k - \bar{x}_{ct}^k)^2 + (y_{it}^k - \bar{y}_{ct}^k)^2}$$

$$\text{Used Car:} CD_{ijt} = \sum_{k=1}^{50} \sqrt{(x_{ij}^k - \bar{x}_{cjt}^k)^2 + (y_{ij}^k - \bar{y}_{cjt}^k)^2},$$

where $\bar{x}_{ct}^k$ and $\bar{y}_{ct}^k$ represent the average values of design point *k*'s coordinates for competitors of car model *i* with model year *t*, and $\bar{x}_{cjt}^k$ and $\bar{y}_{cjt}^k$ represent the average values of design point *k*'s coordinates for competitors of car model *i* with model year *j* in sold year *t*.

Control variables. We control for a variety of car characteristics and fixed effects that could affect the market performance of new and used cars (Berry, Levinsohn, and Pakes, 1995; Sudhir, 2001): *safety ratings* on a four-point scale; *reliability ratings* on a five-point scale; *horsepower-to-weight ratio*, which measures a car's power; *miles per gallon*, which measures a car's fuel efficiency; and a car's *length*, *width*, and *height*. Next, we control for the market segment of a car model by including a dummy variable, *luxury*, which equals 1 if a car model is luxury and 0 otherwise. Due to the "liability of newness" (Freeman, Carroll, and Hannan, 1983; Singh, Tucker, and House, 1986), new car models are more likely to fail than established models. As a result, we control for *model age*, which is the number of years elapsed since a model's launch. In addition, we control for the manufacturer's fixed effects by including a series of dummy variables indicating whether a car model is manufactured by the corresponding company (e.g., BMW). We also include dummy variables for year-fixed effects.

Finally, we control for the price of a new car, which is operationalized by deducting cash rebates issued by manufacturers and dealers from the manufacturer-suggested retail price (MSRP) (Zettelmeyer, Morton, and Silva-Risso, 2006). Given that we use the resale price of a used car to calculate its preservation rate, which is the dependent variable, the resale price does not appear as a control variable in our model. For used cars, we control for the age of cars in the used car market. In order to control for the rarity of used cars, we include the total number of sold cars when they were new cars. The descriptive statistics of our variables are reported in Table 1.

[Insert Table 1 about here]

4 EMPIRICAL MODEL

We employ the two-stage least square (2SLS) model to estimate the effect of intertemporal distinctiveness of product design in the new car market. The 2SLS model enables us to account for the potential endogeneity issue of the price variable for new cars. For car model *i* in year *t*, we model its market performance as follows:

$$LogSales_{it} = \beta_0 + \beta_1 ITD_{it} + \beta_2 ITD_{it}^2 + \beta_3^{'} x_{it} + \beta_4 Price_{it} + \varepsilon_{it}$$

$$Price_{it} = \alpha_0 + \alpha_1^{'} z_{it} + e_{it}$$

where $LogSales_{it}$ is the log value of unit sales; ITD_{it} is the intertemporal distinctiveness of a new car's design, and ITD_{it}^2 is its quadratic term. We mean center the variable ITD_{it} so that it is easier to interprete the nonlinear effects of ITD_{it}. x_{it} represents the car characteristics as well as manufacturer fixed effects and year fixed effects. We use the year fixed effects to control for time-related factors such as seasonality and economic trends that could affect car sales. $Price_{it}$ is the price of the car model. ε_{it} is an idiosyncratic error term that captures all determinants of $LogSales_{it}$ that our model omits, and ε_{it} follows a normal distribution. We report the correlation matrix of our variables in Table 2.

[Insert Table 2 about here]

Importantly, we use instrumental variables, z_{it}, to account for the endogeneity issue of the price variable. In addition to all covariates that appeared in the equation of log sales (i.e., product design variable, car characteristics, manufacturer fixed effects, and time fixed effects), we further use the average of characteristics of other cars produced by the same manufacturer and the average of characteristics of rival cars produced by other manufacturers as instruments for the price variable(Berry *et al.*, 1995; Sudhir, 2001). Following previous literature, we argue that these instruments are relevant because the characteristics of selected cars can shift a focal car's equilibrium markup and thus its pricing. The instruments satisfy the exclusion restrictions because the characteristics of selected cars are usually determined long before consumers' demand shock. As a result, the characteristics of selected cars should not correlate with the demand shock directly conditional on the focal car's characteristics, manufacturer fixed effects, and time fixed effects we have controlled for.

For each car model, we first focus on other cars in the same market segment (luxury or economy) as its relevant products. Next, we create four subsets of relevant products for each car model based on their manufacturer, country of origin, and car classification (regular vs. sports or specialty): cars of the same manufacturer from the same country, cars of other manufacturers from the same country, cars of the same manufacturer and the same classification, and cars of other manufacturers but the same classification. Finally, we generate our instrumental variables by computing the average values of four car attributes (horsepower-to-weight-ratio, MPG, reliability, and safety) for each subset of competitive cars. In total, we derive 4 x 4 = 16 instrumental variables for new cars' prices. The coefficient estimates of the first-stage equation for prices are reported in Table WA.1 in the Web Appendix. We show that the instruments are jointly significant in the first-stage equation by performing partial F tests on the instruments ($p=0.000$), indicating the instruments are strong.

For the used car market, we adopt a linear regression model to estimate the relationship between cars' preservation rates and the intertemporal distinctiveness of car design. For car model *i* with model year *j* in year *t*,

$$PreservationRate_{ijt} = \gamma_0 + \gamma_1 ITD_{ijt} + \gamma_2 ITD_{ijt}^2 + \gamma_3' x_{ijt} + \xi_{ijt},$$

where $PreservationRate_{ijt}$ is the preservation rate; ITD_{ijt} is the intertemporal distinctiveness of a used car's design, and ITD_{ijt}^2 is its quadratic term. We mean center the variable ITD_{ijt} so that it is easier to interprete the nonlinear effects of ITD_{ijt}. x_{ijt} includes the car characteristics and year fixed effects. Similarly, ξ_{ijt} is an idiosyncratic error term following a normal distribution. We report the correlation matrix of the variables in Table 3.

[Insert Table 3 about here]

Moreover, we estimate the 2SLS model for new cars and the linear model for used cars simultaneously and allow their error terms to be correlated: $E\left[\varepsilon_{it}\xi_{ljs}\right]\neq 0, \forall i, t, l, j, s$. This structure of error terms allows us to account for any unobserved correlations between the new car market and the used car market as some consumers may consider both new cars and used cars as their purchase options.

5 RESULTS

5.1 Effects of New Cars' Intertemporal Distinctiveness of Product Design

Table 4 presents the results of our 2SLS model in estimating the impact of new cars' intertemporal distinctiveness of product design on market performance. In Table 4, Model 1 excludes the intertemporal distinctiveness and its quadratic term; and Model 2 is the full model showing the effects of intertemporal distinctiveness.

[Insert Table 4 about here]

Hypothesis 1 predicts that the intertemporal distinctiveness of a new car's design has an inverted U-shaped relationship with its market performance. In support of Hypothesis 1, Model 2 shows that the effect of intertemporal distinctiveness is positive and significant ($\beta=0.521, p=0.000$). At the same time, the coefficient of the quadratic term of intertemporal distinctiveness is significantly negative ($\beta=-0.183$, $p=0.005$), indicating a nonlinear effect of intertemporal distinctiveness on new car sales.

Moreover, following Haans et al. (2016), we test the slopes at both ends of the data range and estimate the 95 percent confidence interval of the turning point. We show that, at the low end of intertemporal distinctiveness ($ITD_{Low}=0$), $\beta_1+2\beta_2 ITD_{Low}$ is positive ($value=0.521, p=0.000$). At the high end of intertemporal distinctiveness ($ITD_{high}=3.45$),

$\beta_1 + 2\beta_2 ITD_{High}$ is negative ($value = -0.740$, $p = 0.083$). The turning point is at $ITD = 2.270$, and its 95 percent confidence interval is between 1.384 and 3.164, which is within our data range from 0 to 3.45. Therefore, our findings are consistent with the prediction in Hypothesis 1.

When we plot the relationship between new cars' intertemporal distinctiveness and log sales in Figure 5, we can see an inverted U-shaped relationship between these two variables: the sales of new cars will increase if the level of intertemporal distinctiveness increases. However, when the level of intertemporal distinctiveness becomes too high, the sales of new cars will decrease as the level of intertemporal distinctiveness increases, supporting Hypothesis 1.

[Insert Figure 5 about here]

5.2 Effects of Used Cars' Intertemporal Distinctiveness of Product Design

Table 5 displays our linear regression model's results in estimating the effects of used cars' intertemporal distinctiveness of product design on market performance. In Table 5, Model 1 excludes the intertemporal distinctiveness and its quadratic term; Model 2 is the full model that estimates the main effects of intertemporal distinctiveness of product design.

[Insert Table 5 about here]

Hypothesis 2 proposes that the intertemporal distinctiveness of a used car's design negatively affects its preservation rate, whereas the negative effect is mitigated when intertemporal distinctiveness increases. In line with Hypothesis 2, Model 2 shows that the effect of intertemporal distinctiveness is significantly negative ($\beta = -1.677$, $p = 0.000$). Further, the effect of the quadratic term of intertemporal distinctiveness is positive and significant, indicating a nonlinear effect of intertemporal distinctiveness on the preservation rate of used cars ($\beta = 1.001$, $p = 0.000$).

Moreover, we test the slopes at both ends of the data range and estimate the 95 percent confidence interval of the turning point. We show that, at the low end of intertemporal distinctiveness ($ITD_{Low}=0$), $\beta_1+2\beta_2 ITD_{Low}$ is negative ($value=-1.677, p=0.000$). At the high end of intertemporal distinctiveness ($ITD_{high}=3.46$), $\beta_1+2\beta_2 ITD_{High}$ is negative ($value=5.250, p=0.000$). The turning point is at $ITD=1.684$, and its 95 percent confidence interval is between 1.490 and 1.878, which is within our data range from 0 to 3.46. As a result, our findings are consistent with the prediction in Hypothesis 2.

We plot Figure 6 to show the relationship between the intertemporal distinctiveness of used cars and the preservation rate. Initially, the preservation rate of a used car will decrease if its intertemporal distinctiveness increases. When the level of the used car's intertemporal distinctiveness becomes higher and higher, the preservation rate will reach its lowest point and then increases with the intertemporal distinctiveness. Thus, Figure 6 exhibits a U-shaped relationship between the intertemporal distinctiveness of used cars and the preservation rate, supporting Hypothesis 2.

[Insert Figure 6 about here]

Taken together, these results support the key findings of our research: Although a relatively high level of changes in the design of a new car can increase sales in the new car market and thus produce higher revenues for auto manufacturers, major design changes can hurt the preservation rate of this car model and reduce the motivation for consumers to purchase it. As a result, it is important for manufacturers to consider both the new car market and the used car market when they make design decisions about new cars.

5.3 Robustness Checks and Additional Analyses

To ensure that our findings are robust, we perform a variety of additional analyses. The estimation results of robustness checks are provided in the Web Appendix.

First, we have dropped 12 observations of new cars and 96 observations of used cars because of outlier values in intertemporal distinctiveness (i.e., $ITD > 3.5$). As a robustness check, we replicate main analyses on the data samples for the new-car and used-car markets with outlier observations included and find consistent results (see Table WA.2).

Second, we measure the intertemporal distinctiveness of new cars in comparison with designs of the same car model in the previous three or five years. The alternative measures ensure that our results are robust to different time windows for reference designs. As our estimation results indicate, the effects of intertemporal distinctiveness are robust (see Table WA.3).

In addition, we estimate our model using fixed-effect panel models to ensure that our findings are robust to alternative model specifications. In particular, we include car-specific fixed effects as additional controls, which account for any time-invariant unobserved factors that can affect the market performance of new and used cars. The used car fixed effects also absorb the effects of most car attributes (e.g., horsepower-to-weight ratio and ratings) as they do not vary over time for the same used car. We find robust coefficient estimates from the fixed-effects panel models (see Table WA.4).

Finally, how much intertemporal distinctiveness should a car manufacturer choose when introducing a new design? To answer this question, we conduct a scenario analysis and examine the optimal level of intertemporal distinctiveness for cars. Because we were unable to observe each car manufacturer's profit share from new car sales and used car prices, we explore the optimal intertemporal distinctiveness under various profit structures (e.g., 80% of profits depend on new car sales and 20% of profits depend on used car prices). In addition, we focus on one-year-old used cars so that the ITD of new cars and the ITD of used cars refer to the same metric: the difference between a new car's design and its design in the previous year. Then we use the coefficient estimates of our main model to simulate the percent changes in manufacturers' profits and determine the optimal ITD. Table 6 reports the optimal intertemporal distinctiveness of car design based on different assumptions about the profit structure. When most profits depend on new car sales, the optimal ITD is 2.274, which is close to the optimal ITD for new cars. When most profits depend on used car prices, the optimal ITD increases to 2.844, which is much larger than the optimal ITD for new cars. Overall, the optimal level of ITD rises as the importance of the used car price grows for car manufacturers given the U-shape relationship between ITD and preservation rates of used cars.

[Insert Table 6 about here]

6 DISCUSSION AND CONCLUSION

In this paper, we investigate the effect of intertemporal distinctiveness of product design on the new and the used product markets. Compiling a data set of both the new car market and the used car market in the U.S., we show an inverted U-shaped relationship between the intertemporal distinctiveness of design and the market performance of new products and a U-shaped relationship between the intertemporal distinctiveness of design and the preservation rate of used products.

6.1 Implications for Research

Our research contributes to the burgeoning literature on optimal distinctiveness in several important aspects. First, we identify an increasingly important yet understudied reference group

– “available past designs” (i.e., product designs introduced in the past but are still available in today’s secondhand markets). The reference points used for comparisons play an important role in influencing the evaluation of a focal product (Barlow, Verhaal, and Angus, 2019; Gouvard and Durand, 2022). While most research around the notion of optimal distinctiveness uses contemporary peers as the reference group, recent research began to consider temporally distant counterparts as a reference set (Chan *et al.*, 2021). We extend this line of research by introducing “available past designs” as a unique and relevant reference set for many products that have structured secondhand markets. Our study shows that “available past designs” and “unavailable past designs” are different reference sets and can influence the evaluation of a new product design differently. While distinctiveness as compared to “unavailable past designs” has a negative effect on new product design value (Chan *et al.*, 2021), distinctiveness as compared to “available past designs” can generate competitive benefits and incur legitimacy loss, leading to an inverted U-shaped relationship with new product design value.

Second, we theorize a new construct of intertemporal distinctiveness and examine its effect on both new and used products. Given that the secondhand market is growing rapidly today, understanding the evaluation process of used products is important because the residual value of used products can (1) directly influence firm performance as firms rely more on leasing products today, and (2) influence the sales of new products as consumers are generally forward-looking. The mechanisms through which intertemporal distinctiveness influences the value of new and used products are different because used products suffer from increased obsolescence and are less likely to derive competitive benefits from intertemporal distinctiveness. Our research shows that the intertemporal distinctiveness that is optimal for new products may be detrimental to used products. The contrasting effects of intertemporal distinctiveness in the new and used product markets emphasize the importance for firms to consider these two markets simultaneously in making the optimal decisions for product design innovation.

Lastly, our study sheds light on the temporal dynamics of optimal distinctiveness. Recent studies have recognized that it is imperative to consider temporality in the evaluation of optimal distinctiveness and adopt a dynamic perspective (Chan *et al.*, 2021; Zhao *et al.*, 2017). While prior research has only examined the temporality of reference sets (e.g., whether a focal product is compared with its contemporary peers or is compared with its past versions) (Chan *et al.*, 2021), our research shows that not only the temporality of reference sets but also the temporality of the focal products can influence the optimal level of distinctiveness. If a focal product is a new product introduced in the current year, a moderate level of distinctiveness of this product compared with its past version is considered optimal. Conversely, if a focal product is a used product introduced in the past, a moderate level of distinctiveness of this product as compared with its newest version is related to the lowest preservation rate. Earlier research shows that the optimal level of distinctiveness is contingent depending on external contexts (Gupta, Crilly, and Greckhamer, 2020; Haans, 2019), the category level (Bu *et al.*, 2022; Cudennec and Durand, 2022), and the dimensions being compared (Cattani *et al.*, 2017). Our research contributes to this literature by showing that the temporality of the focal product (i.e., whether it is new or used) is also important in influencing the evaluation process.

6.2 Implications for Practice

From a managerial perspective, our findings suggest that available past designs are important reference boundaries that must be taken into account by managers when developing new product designs. Specifically, a moderate level of distinctiveness in comparison to available past designs leads to the best market performance for new products. However, it may not be ideal for firms to determine their new product designs solely based on the new product market because the optimal design level of intertemporal distinctiveness for new products could lead to the worst level of preservation rate for used products, and thus hurt the overall interests of firms. Today, the increasing popularity of the secondhand markets has pushed consumers to consider the future resale price when deciding on buying a new product. Therefore, a product's low resale price in the secondhand market may thwart consumers' motivation to buy a new version of this product. Moreover, firms have become increasingly dependent on leasing products rather than selling them. Therefore, the residual value of used products after the lease term plays an important role in influencing a firm's performance. A report by Cox Automotive (2018) shows that the number of new vehicles leased in the U.S. market has increased nearly four times from 2009 to 2016. In particular, the lease penetration rates by some luxury automakers (e.g., BMW) topped 60% in 2016. Our research provides implications for firms that heavily rely on the residual value of used products for profits, suggesting that these firms should either adopt minimal design innovation (i.e., low intertemporal distinctiveness) to avoid obsolescence costs of used products or adopt radical design innovation (i.e., high intertemporal distinctiveness) to successfully distinguish between used and new products.

Our theory of intertemporal distinctiveness, although tested in the U.S. automotive industry in this study, can generalize to products in other industries where a structured secondhand market exists. For example, in the furniture industry, the secondhand market is on the rise in the face of supply chain issues and is driven by consumers' desire for sustainable home furnishing options (Crawford, 2021). A growing number of digital platforms (e.g., Kaiyo and AptDeco) have emerged to make online shopping for secondhand furniture easy; meanwhile, the industry giant IKEA has recently launched the buyback and resell service for consumers to sell and buy secondhand IKEA furniture (Segran, 2021). With more consumers expecting to resell their used furniture or adopt furniture leasing, the resale value of used furniture is naturally important to both firms and consumers. As a result, furniture manufacturers such as IKEA should also consider the value of used furniture when developing design strategies for new furniture. Likewise, the popularity of resale platforms such as ThredUp and TheRealReal has made consumers more comfortable with shopping the secondhand fashion goods such as handbags, apparel, footwear, watches, and jewelry. Our findings provide important practical implications for products that have an increasingly active secondhand market and suggest to their manufacturers how to preserve the resale value in the secondhand market.

6.3 Limitations and Future Research

This paper also has several limitations that could be addressed in future research. First, we only use pictures of the fronts of cars to assess the intertemporal distinctiveness of car design because previous research has demonstrated that the frontal view of cars is the most recognizable aspect of car design. It would also be challenging to collect pictures of the side, back, and interior views of all car models in our sample (259 in total) over a long period (from 2002 to 2016). Future researchers, on the other hand, will be able to delve further into the intertemporal distinctiveness of design if they can develop a comprehensive measurement of products' aesthetic design. Another limitation of this research is that we cannot integrate the analysis of the new car market and that of the used car market to identify one single optimal level of intertemporal distinctiveness of design. This is because we do not have access to car manufacturers' profits from the new car market and the used car market, respectively. Instead, we quantify our managerial implications by performing a scenario analysis based on different assumptions about car manufacturers' profit structures. In the future, scholars will be able to determine the optimal level of intertemporal distinctiveness with additional data on firms' profits from both the new and used product markets.

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Table 1 Descriptive Statistics

Variables	Obs.	Mean	SD	Min	Max
New Car Market					
Unit sales	1,991	49,678	74,673	0	473,108
Intertemporal distinctiveness	1,991	0.4	0.72	0	3.45
Within-category distinctiveness	1,991	1.95	0.92	0	13.98
Safety ratings	1,991	3.67	0.35	1	4
Reliability ratings	1,991	3.17	1.07	1	5
Horsepower-to-weight ratio	1,991	0.06	0.02	0.01	0.2
Miles per gallon	1,991	25.92	5.78	15.5	67.5
Length (inch)	1,991	182.83	13.81	109.4	221.4
Width (inch)	1,991	71.42	3.2	50.8	83.3
Height (inch)	1,991	56.25	3.13	44	76.5
Luxury	1,991	0.44	0.5	0	1
Model age (years)	1,991	6.49	4.22	0	16
Price ($)	1,991	3.33	2.33	0.86	22.46
Used Car Market					
Preservation rate (%)	4,414	0.56	0.21	0.09	1.47
Intertemporal distinctiveness	4,414	1.05	0.97	0	3.46
Within-category distinctiveness	4,414	1.87	0.74	0	6.53
Safety ratings	4,414	3.64	0.56	1	4
Reliability ratings	4,414	3.11	0.93	1	5
Horsepower-to-weight ratio	4,414	0.06	0.01	0.02	0.13
Miles per gallon	4,414	25.9	5.88	15.5	64.5
Length (inch)	4,414	183.15	13.83	109.4	221.4
Width (inch)	4,414	70.74	3.15	62.6	83.3
Height (inch)	4,414	55.71	2.61	46.1	64.7
Luxury	4,414	0.43	0.49	0	1
Model age (years)	4,414	3.24	2.11	0	9
Age of car (years)	4,414	3.33	2.09	1	9
Unit sales as new cars	4,414	66,179	83,389	178	473,108

Table 2 Correlation Matrix (New Car Market)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Log of unit sales	1	0.17	-0.21	0.03	0.04	-0.33	0.22	0.08	-0.14	0.31	-0.31	0.04	-0.41
2 Intertemporal distinctiveness		1	-0.04	0.04	0.00	0.02	0.02	0.01	0.03	0.04	0.00	0.14	0.00
3 Within-category distinctiveness			1	-0.01	0.05	0.23	-0.05	-0.21	-0.03	-0.12	0.01	-0.15	0.18
4 Safety ratings				1	0.05	0.02	-0.06	0.07	0.09	0.12	0.10	0.04	0.03
5 Reliability ratings					1	0	0.13	-0.06	-0.11	0.05	-0.01	0.13	-0.03
6 Horsepower-to-weight ratio						1	-0.59	0.15	0.43	-0.51	0.52	0.12	0.70
7 Miles per gallon							1	-0.39	-0.49	0.26	-0.41	0.00	-0.46
8 Length								1	0.62	0.19	0.21	0.08	0.23
9 Width									1	-0.14	0.39	0.15	0.46
10 Height										1	-0.3	0.05	-0.37
11 Luxury											1	0.02	0.68
12 Model age												1	0.09
13 Price													1

Table 3 Correlation Matrix (Used Car Market)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Preservation rate	1	-0.42	0.04	0.12	0.10	0.09	0.13	-0.24	-0.10	0.02	-0.02	0.30	-0.83	0.00
2 Intertemporal distinctiveness		1	0.05	0.03	0.04	-0.05	0.06	-0.05	-0.08	-0.06	-0.01	-0.09	0.52	0.15
3 Within-category distinctiveness			1	0.07	-0.01	0.20	-0.05	-0.12	0.12	-0.15	0.00	-0.08	-0.03	-0.16
4 Safety ratings				1	0.10	0.10	-0.07	0.05	0.13	0.16	0.18	0.18	-0.04	-0.02
5 Reliability ratings					1	0.05	0.18	-0.09	-0.12	0.00	0.04	0.03	0.02	0.09
6 Horsepower-to-weight ratio						1	-0.54	0.14	0.33	-0.40	0.56	0.10	-0.06	-0.29
7 Miles per gallon							1	-0.44	-0.49	0.13	-0.45	-0.02	0.02	0.25
8 Length								1	0.66	0.31	0.15	0.05	-0.02	0.12
9 Width									1	0.07	0.31	0.15	-0.08	-0.11
10 Height										1	-0.22	0.10	-0.07	0.16
11 Luxury											1	0.06	0.03	-0.41
12 Model age												1	-0.36	0.01
13 Age of car													1	0.06
14 Unit sales as new cars														1

Table 4 Effects of New Cars' Intertemporal Distinctiveness of Product Design

Variables	Log Sales 1	Log Sales 2
Intertemporal distinctiveness (ITD)		0.521
		(0.065)
ITD^2		-0.183
		(0.066)
Contemporary distinctiveness (CD)	-0.143	-0.125
	(0.061)	(0.060)
Safety ratings	0.201	0.166
	(0.124)	(0.122)
Reliability ratings	-0.031	-0.020
	(0.044)	(0.043)
Horsepower-to-weight ratio	9.255	8.314
	(5.456)	(5.336)
Miles per gallon	0.038	0.034
	(0.010)	(0.010)
Length	0.029	0.029
	(0.005)	(0.005)
Width	-0.016	-0.017
	(0.021)	(0.021)
Height	0.110	0.106
	(0.019)	(0.019)
Luxury	-0.738	-0.711
	(0.182)	(0.177)
Model age	0.046	0.035
	(0.013)	(0.013)
Price	-0.318	-0.316
	(0.107)	(0.104)
Constant	-0.025	0.993
	(1.741)	(1.721)
Manufacturer fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Log-likelihood	-22436.25	-22363.62
AIC	45162.51	45029.24
BIC	46143.41	46050.73
Observations	1,991	1,991

Notes. Standard errors in parentheses.

Table 5 Effects of Used Cars' Intertemporal Distinctiveness of Product Design

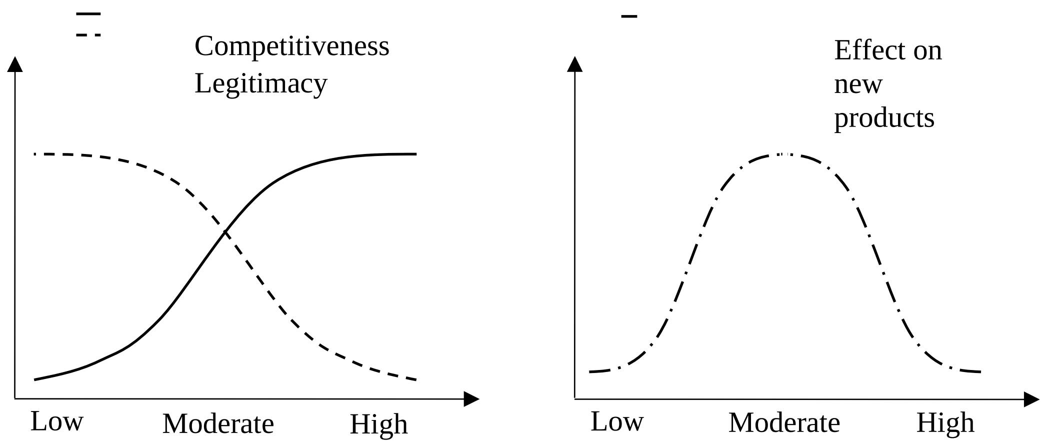
Variables	Preservation Rate 1	Preservation Rate 2
Intertemporal distinctiveness (ITD)		-1.677
		(0.197)
ITD^2		1.001
		(0.152)
Contemporary distinctiveness (CD)	0.609	0.493
	(0.200)	(0.203)
Safety ratings	1.508	1.538
	(0.255)	(0.254)
Reliability ratings	0.062	0.113
	(0.163)	(0.162)
Horsepower-to-weight ratio	140.707	139.337
	(13.693)	(13.587)
Miles per gallon	0.259	0.246
	(0.032)	(0.032)
Length	-0.289	-0.290
	(0.017)	(0.017)
Width	-0.002	-0.049
	(0.068)	(0.067)
Height	0.319	0.354
	(0.068)	(0.068)
Luxury	-1.076	-0.928
	(0.420)	(0.417)
Model age	-1.240	-1.206
	(0.098)	(0.098)
Age of car	-9.430	-9.148
	(0.104)	(0.111)
Unit sales as new cars	0.190	0.202
	(0.019)	(0.019)
Constant	106.466	106.097
	(5.238)	(5.199)
Manufacturer fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Log-likelihood	-22436.25	-22363.62
AIC	45162.51	45029.24
BIC	46143.41	46050.73
Observations	4,414	4,414

Notes. Standard errors in parentheses.

Table 6 Optimal Intertemporal Distinctiveness of Design

Profit Structure (New Car vs. Used Car)	Optimal ITD
90% vs. 10%	2.274
80% vs. 20%	2.280
70% vs. 30%	2.283
60% vs. 40%	2.292
50% vs. 50%	2.300
40% vs. 60%	2.318
30% vs. 70%	2.357
20% vs. 80%	2.435
10% vs. 90%	2.844

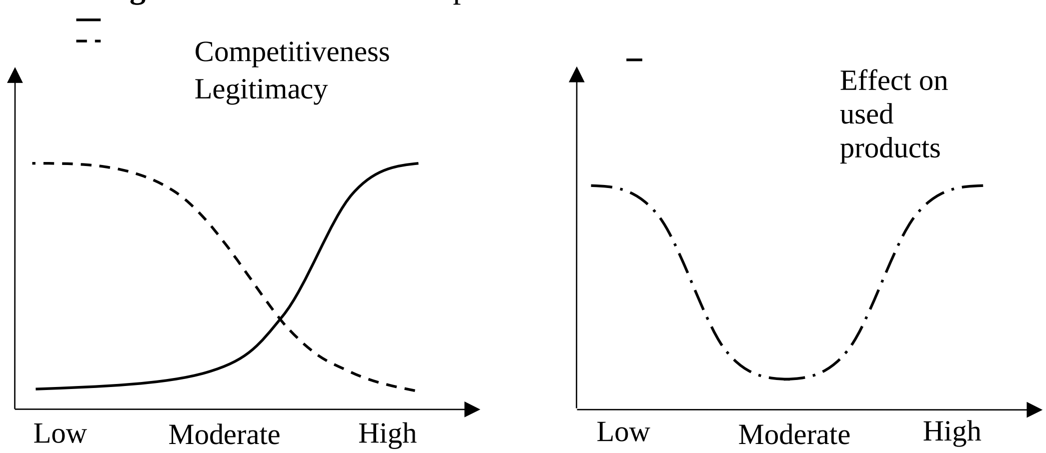
Figure 1 Effect of Intertemporal Distinctiveness on New Products



(a) Intertemporal distinctiveness of a new product design

(b) Intertemporal distinctiveness of a new product design

Figure 2 Effect of Intertemporal Distinctiveness on Used Products



(a) Intertemporal distinctiveness of a used product's design

(b) Intertemporal distinctiveness of a used product's design

Figure 3 Illustration of Design Feature Points

Figure 4 Illustration of Intertemporal Distinctiveness

A: High Level of Intertemporal Distinctiveness (ITD = 2.83)

2014 Ford Focus

2015 Ford Focus

B: Low Level of Intertemporal Distinctiveness (ITD = 0.32)

2011 Nissan Sentra

2012 Nissan Sentra

Figure 5 Effect of Intertemporal Distinctiveness of New Cars

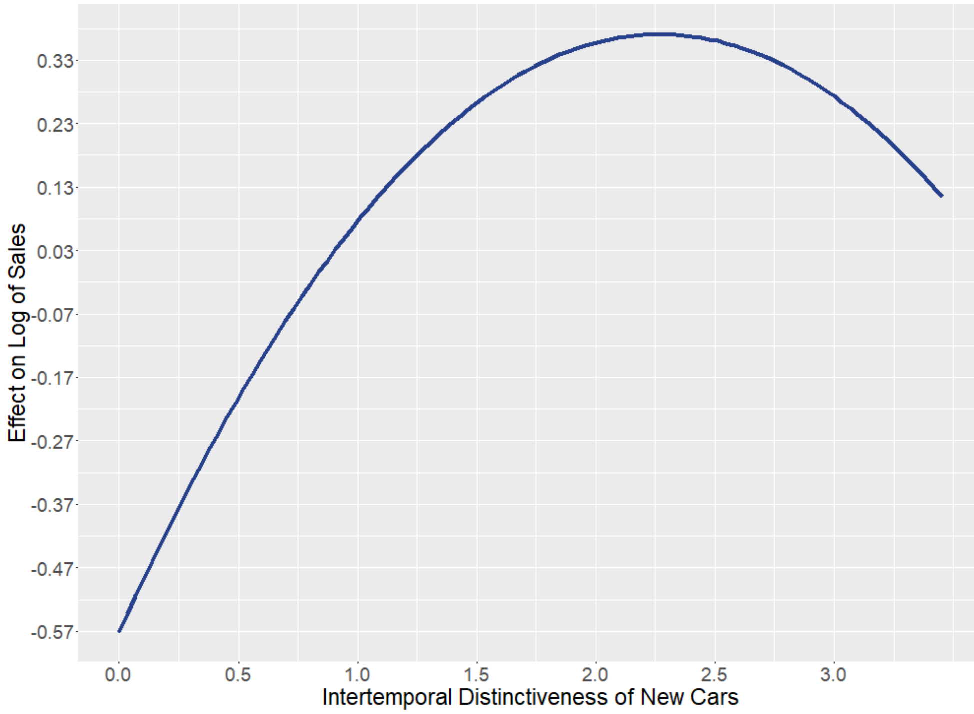
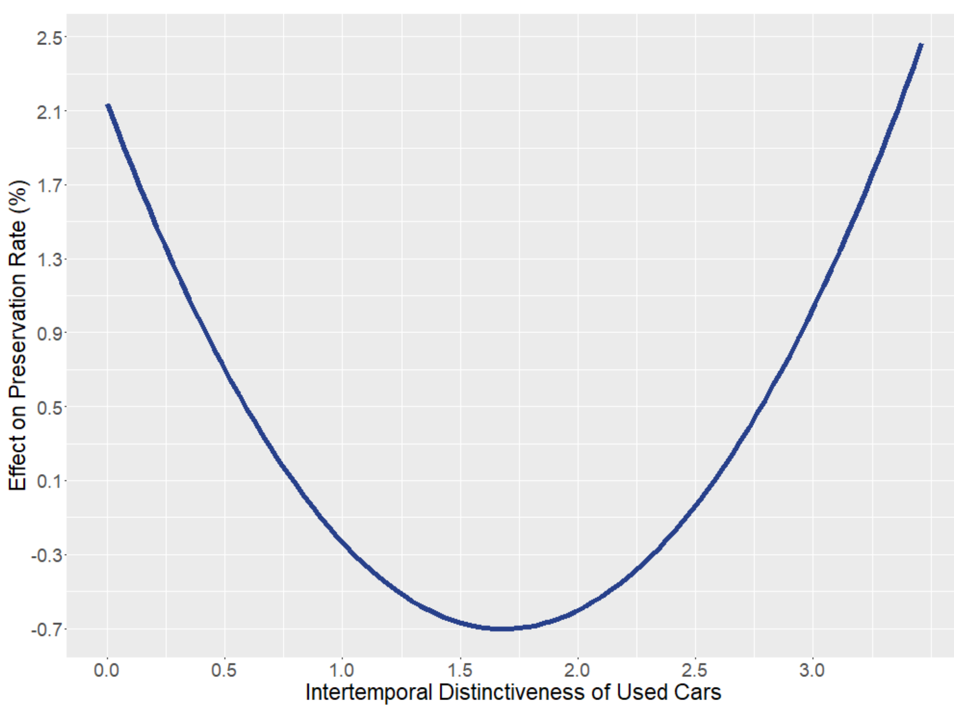


Figure 6 Effect of Intertemporal Distinctiveness of Used Cars



WEB APPENDIX

Table WA.1 Coefficient Estimates of the First-Stage Equation for Price

Variables	Coefficients	Variables	Coefficients
Instruments from Subset 1		**Covariates in Second-Stage Equation**	
Safety ratings	1.951	Intertemporal distinctiveness (ITD)	-0.106
	(0.405)		(0.043)
Reliability ratings	-0.201	ITD^2	0.061
	(0.086)		(0.044)
Horsepower-to-weight ratio	32.297	Contemporary distinctiveness (CD)	0.359
	(5.913)		(0.033)
Miles per gallon	-0.006	Safety ratings	-0.264
	(0.021)		(0.099)
Instruments from Subset 2		Reliability ratings	-0.003
Safety ratings	0.496		(0.041)
	(0.264)	Horsepower-to-weight ratio	50.859
Reliability ratings	0.205		(2.867)
	(0.088)	Miles per gallon	0.021
Horsepower-to-weight ratio	-16.234		(0.009)
	(6.686)	Length	0.029
Miles per gallon	0.026		(0.003)
	(0.023)	Width	0.067
Instruments from Subset 3			(0.013)
Safety ratings	-1.574	Height	0.023
	(0.385)		(0.014)
Reliability ratings	0.112	Luxury	1.130
	(0.080)		(0.275)
Horsepower-to-weight ratio	-46.792	Model Age	-0.022
	(5.986)		(0.009)
Miles per gallon	-0.006	Constant	-21.409
	(0.020)		(2.339)
Instruments from Subset 4		Manufacturer fixed effects	Yes
Safety ratings	0.271	Year fixed effects	Yes
	(0.422)		
Reliability ratings	-0.047	Log likelihood	-22363.62
	(0.222)	AIC	45029.24
Horsepower-to-weight ratio	69.892	BIC	46050.73
	(5.420)	Observations	1,991
Miles per gallon	0.150		
	(0.033)		

Notes. Standard errors in parentheses.

Table WA.2 Robustness Check for Including Outlier Observations

Variables	Log Sales 1	Preservation Rate 2
Intertemporal distinctiveness (ITD)	0.507	-1.523
	(0.061)	(0.186)
ITD^2	-0.170	0.735
	(0.046)	(0.112)
Contemporary distinctiveness (CD)	-0.126	0.487
	(0.059)	(0.201)
Safety ratings	0.167	1.601
	(0.122)	(0.256)
Reliability ratings	-0.019	0.119
	(0.043)	(0.162)
Horsepower-to-weight ratio	7.909	131.449
	(5.318)	(13.544)
Miles per gallon	0.032	0.255
	(0.010)	(0.032)
Length	0.029	-0.294
	(0.005)	(0.016)
Width	-0.016	-0.011
	(0.021)	(0.066)
Height	0.104	0.301
	(0.019)	(0.068)
Luxury	-0.723	-1.095
	(0.177)	(0.418)
Model age	0.036	-1.215
	(0.013)	(0.098)
Price	-0.315	-
	(0.103)	-
Age of car	-	-9.155
	-	(0.111)
Unit sales as new cars	-	0.205
	-	(0.019)
Constant	1.121	107.424
	(1.715)	(5.164)
Manufacturer fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	2,003	4,510

Notes. Standard errors in parentheses.

Table WA.3 Robustness Check for Alternative References of New Cars' TD

Variables	Reference: Design in Previous Three Years 1	Reference: Design in Previous Five Years 2
Intertemporal distinctiveness (ITD)	0.809	0.648
	(0.078)	(0.074)
ITD^2	-0.263	-0.161
	(0.059)	(0.060)
Contemporary distinctiveness (CD)	-0.115	-0.126
	(0.059)	(0.059)
Safety ratings	0.193	0.206
	(0.121)	(0.122)
Reliability ratings	-0.002	-0.003
	(0.043)	(0.043)
Horsepower-to-weight ratio	8.124	8.947
	(5.236)	(5.249)
Miles per gallon	0.031	0.031
	(0.010)	(0.010)
Length	0.030	0.030
	(0.005)	(0.005)
Width	-0.017	-0.013
	(0.020)	(0.021)
Height	0.092	0.094
	(0.019)	(0.019)
Luxury	-0.710	-0.690
	(0.175)	(0.176)
Model age	0.010	0.001
	(0.013)	(0.014)
Price	-0.328	-0.349
	(0.102)	(0.102)
Constant	1.595	1.160
	(1.699)	(1.706)
Manufacturer fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	1,991	1,991

Notes. Standard errors in parentheses.

Table WA.4 Robustness Check for Panel Model with Car Fixed Effects

Variables	Log Sales 1	Preservation Rate 2
Intertemporal distinctiveness (ITD)	0.401	-1.895
	(0.062)	(0.221)
ITD^2	-0.131	2.270
	(0.036)	(0.208)
Contemporary distinctiveness (CD)	-0.135	-
	(0.120)	-
Safety ratings	-0.497	-
	(0.277)	-
Reliability ratings	0.013	-
	(0.048)	-
Horsepower-to-weight ratio	14.915	-
	(8.348)	-
Miles per gallon	0.031	-
	(0.033)	-
Length	0.006	-
	(0.015)	-
Width	0.029	-
	(0.027)	-
Height	0.166	-
	(0.059)	-
Model age	-0.174	-
	(0.032)	-
Price	-0.561	-
	(0.438)	-
Constant	0.254	92.888
	(4.941)	(0.724)
Car model fixed effects	Yes	-
Car model and model year fixed effects	-	Yes
Year fixed effects	Yes	Yes
Observations	1,991	4,414

Notes. Standard errors in parentheses.