

The Formation and Persistence of Automobile Brand Preferences*

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Abstract

Brand preferences in the automobile market demonstrate strong persistence. Such persistence has important implications for economics and public policy, as it implies that market conditions and policies that influence consumer purchases today will reverberate into the future. In this paper, we offer novel evidence from panel data that not only do individuals exhibit automobile brand persistence across purchases, but also that these preferences are correlated across households within families. Our analysis suggests that intergenerational brand preferences may arise from both sharing of information and endogenous taste formation, as adults' brand choices are influenced both by the vehicles driven by their parents when they were young and by their parents' contemporaneous vehicle choices. We then show that this intergenerational transmission of brand preferences may have substantial implications for vehicle manufacturers' product lines and pricing decisions. In ongoing research, we are adding an instrumental variables analysis and estimating a structural model of intergenerational preferences in order to recover utility parameters.

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1 Introduction

It might be said that the automobile market is marked by a focus on quantities over prices. The industry press is filled with discussions of market share, sales volumes and customer loyalty, often at the expense of profitability. Automakers are known to focus on “capture rates” – the percentage of new car buyers whose previous purchase was from a different manufacturer. The Big Three are said to sometimes sell vehicles at a loss to fleet buyers in order to hit quarterly sales targets. The chairman of Toyota, Akio Toyoda, offered volume targets as the explanation for why Toyota had a spate of safety recalls in 2009 and 2010, telling the US Congress that “Toyota has, for the past few years, been expanding its business rapidly. Quite frankly, I fear the pace at which we have grown may have been too quick...we were not able to stop, think, and make improvements as much as we were able to before.”¹ At the time, Toyota was within reach of becoming the global sales leader, usurping the title held by GM for more than seven decades.²

It is tempting to view a firm that maximizes sales instead of profits as misguided, but additional factors, chief among them brand loyalty, may justify such a focus. To the extent that automobile customers have strong brand loyalty, sales today represent an investment in the future. By developing brand loyalty among customers today, high sales (and low prices) constitute an investment that pays future dividends, when customer loyalty can be converted into higher profits. Our goal in this paper is to study the origins and persistence of consumers’ automobile brand preferences and to explore the implications of these preferences for automakers’ pricing and product offering decisions.

Our examination of brand preferences leverages information about vehicle ownership contained in the Panel Study of Income Dynamics (PSID). Amongst datasets on vehicle ownership, the PSID is unique in that it follows multiple households within each surveyed family. This panel structure allows us to not only study the persistence of a household’s preferences for automobile brands, but also to examine the correlations of brand choices *across* households within the same family. In particular, we study *intergenerational* correlations in brand choices across households within a family.

We find that brand preference within a household is quite strong: an individual who currently owns a particular brand is roughly twice as likely to choose that brand for a new purchase as the average consumer. We find that intergenerational correlations in brand choice are similarly strong: an individual whose parents own a particular brand are roughly twice as likely to purchase that brand as the average consumer. The magnitude, and robustness,

¹“ Toyota President Akio Toyoda apologizes for safety lapses” *Los Angeles Times*, February 24, 2010.

²Toyota did surpass GM in global sales in 2008.

of this result implies that intergenerational brand loyalty is an important feature of the car market. To the best of our knowledge, we are the first to document this correlation.

We define a *brand preference* as a situation in which a consumer's anticipated level of expected utility from buying a vehicle would change if the vehicle was produced under a different brand label, holding constant its physical attributes. Intergenerational correlations in brand choice could be due to the transmission of such brand preferences, or they could be due to correlations in household characteristics or geographic factors that increase the demand for vehicle attributes commonly offered by the brand. We argue that brand choice correlations are not driven simply by correlated characteristics based on the robustness of our results to extensive controls for observable geographic and household characteristics and to the limiting of our sample to brands that offer vehicles with similar attributes.

We posit that intergenerational transmission of brand preferences could be driven by two mechanisms: (1) information that is shared within families; or (2) the endogenous formation of tastes. While it is difficult to conclusively assign particular empirical correlations to particular mechanisms, we find evidence suggesting that both are at work. In support of the first mechanism, we find that parent's recent vehicle purchases influence the brand choices of their adult children. In support of the second mechanism, we show that there is a strong relationship between young adults' brand choices and the vehicles that their parents owned when the children lived with their parents.

After presenting our empirical evidence, we provide a heuristic model of the car market in order to show how the presence of intergenerational brand preference might influence the competitive behavior of automakers. In our model, consumers live for two periods, shopping for a car in a different market each period. For example, consumers might purchase an entry-level vehicle in the first period and then an upscale vehicle in the second. At the end of the second period, they have children, who may or may not inherit their parents' brand preferences. Firms compete in both markets. When individuals have a second-period brand preference based on their first-period choice, but brand preferences are not transmitted across generations, the game collapses to a two-period model, as in Klemperer (1987), where firms "invest" in the first period and "harvest" in the second period.

When brand preference is transmitted across generations, however, firms are less able to harvest loyalty in the second period because harvesting today shrinks the market for the next generation. In this case, the game can be characterized as an infinite period model, similar to the one analyzed by Dubé, Hitsch and Rossi (2009), who show that the presence of brand loyalty lowers firms' prices and profits for calibrated parameter values (the incentive to lower prices to invest in future profits outweighs the incentive to raise prices to increase current profits). In addition, our model suggests that there are complementarities between entry-

level and upscale vehicles that give automakers an incentive to develop vertical product lines. The benefits to an upscale seller of establishing a strong entry-level product are intuitive, but our model also shows that, when intergenerational preferences are strong, an entry-level seller can benefit from having an upscale vehicle that appeals to parents, who then pass on loyalty to their children.

The existence of brand loyalty and its transmission across generations gives automakers reason to focus on quantities and to develop vertical product offerings. Brand loyalty, and its intergenerational transmission, is certainly not the only explanation for why the automobile market has these characteristics. But, we think that the strength of the brand preferences that we document suggests that this mechanism is qualitatively important. In short, we believe that our results provide a plausible explanation as to why the automobile market is the way that it is, one that deserves further attention.

Our analysis relates to several existing literatures. First, there exist studies of brand loyalty in the automobile market, both in economics (Train and Winston 2007; Mannering and Winston 1985 1991) and in marketing. While these papers document within-household brand loyalty, the automobile literature has, to the best of our knowledge, never analyzed the intergenerational dimension of brand preference that we document here. Second, recent work on brand preferences in consumer packaged goods has demonstrated the impact of brand loyalty on the persistence in market shares of different brands across specific geographies (Bronnenberg, Dhar and Dubé 2009; Bronnenberg, Dubé and Gentzkow Forthcoming). As compared to the products studied there, the automobile sector differs both in its size and in the fact that its goods are highly heterogeneous. Brand loyalty in the automobile sector typically involves individuals purchasing significantly different goods that share a brand label, whereas the literature on packaged goods is better characterized as repeat purchases of the same item. For small purchases, brand loyalty may better be understood as a heuristic aid in quick decision-making, which is likely quite different from the role brands play in purchasing an automobile.

Our work also relates to an emerging literature on endogenous preference formation that analyzes how household experiences during childhood influence adult behaviors. Much of this literature is focused on food, which is surveyed in Birch (1999), with recent economic contributions in Logan and Rhode (2010) and Atkin (2011). Luttmer and Singhal (Forthcoming) argue that preferences for redistribution are formed in the cultural context of childhood. Fernández, Fogli and Olivetti (2004) provide a related analysis of how the labor supply of mothers influences the labor supply of the wives of their sons, which they explain as owing to preferences developed in childhood.

There is, of course, also a considerable literature on the intergenerational transmission

of earnings and education, much of which utilizes the PSID, as well as datasets from other countries that link outcomes of parents and children across generations.³ This literature studies the intergenerational transmission of IQ, occupations, welfare status, health, attitudes, social behavior, consumption, and wealth, nearly always finding a strong correlation between the outcomes of parents and their children (see Black and Devereux 2011). Our work also has parallels in the extensive peer-effects and social interactions literature (see Manski 1993 2000). Whereas much of this literature studies how individuals are influenced by the aggregate behavior and characteristics of a reference group, we focus on how parents and children are influenced by the behavior and choices of a small number of individual family members.

The results presented in this paper do establish that the automobile preferences of children are influenced by their parents' choices, but we are still pursuing two extensions that will significantly add to the analysis. First, we are exploring instrumental variables strategies that use changes in gasoline prices and the dates of openings and closings of automobile dealers at the local level as ways to further test the robustness of the brand preference correlations that we document. Second, we are building a structural model of consumer vehicle choice, which jointly models the parent's and child's discrete choice problem, in order to simulate how brand choice responds to quality shocks and policy interventions. This modeling exercise will require that we make additional assumptions about the structure of preferences, but we believe the results are valuable in complementing our reduced-form estimates and allowing for internally consistent simulations.

The balance of the paper is structured as follows. We describe our data in 2. In section 3, we document the strength of brand persistence within households, cross-sectionally and over time. In section 4 we provide a framework for interpreting across household correlations in brand choices, which we document empirically in section 5. Section 6 lays out a simple theoretical framework which provides intuition for the implications of intergenerational brand preference for firm pricing and product line choices. We expand on the work currently in progress in section 7. Section 8 concludes.

2 Data

Our data on vehicle ownership come from the Panel Study of Income Dynamics (PSID). In 1968, the PSID selected a nationally representative sample of households to survey, and since then it has asked them a battery of economic and demographic questions every other

³See Solon (1992) for a seminal contribution and Solon (1999) and Black and Devereux (2011) for recent reviews.

year.⁴ The PSID collects information on everyone who lives in a PSID household, but it also follows members of the original PSID sample households and their children, whenever those individuals leave one household and go to (or create) another. As a result, the survey now collects information on many households that are members of the same extended family.

The PSID began collecting information on vehicles in 1999. Respondents are asked the number of vehicles that they own or lease, and they are asked additional questions about three vehicles (provided that they have that many). These additional questions include vehicle make, model and vintage, as well as the date of purchase, price paid, and whether the vehicle was a gift. These data are available from surveys conducted in 1999, 2001, 2003, 2005 and 2007. The vehicle data contained in the PSID allow us to look not only at the fleet held at a particular point in time and how that fleet evolves over time, but also at how the vehicle choices made by one member of a family relate to the vehicle choices made by other family members who live in different households. To the best of our knowledge, the PSID is unique in providing such information for families in the United States.

Below, we focus on the relationship between an individual's brand choice and the brand holdings of their parents. To do this, we isolate the PSID sample to individuals who own a vehicle and whose mother is also in the PSID and is also a vehicle owner. We link individuals to their mother's household because we were able to match more individuals consistently with their mothers than with their fathers. Consistent with PSID terminology, we refer to these individuals, whose mothers also appear in the data, as household heads or wives (the PSID always labels the male in a couple as the household head).⁵

There are 6,798 heads or wives whose mothers are present in the data. Of these, 4,044 are vehicle owners and have mothers who own a vehicle. Because many of these individuals are siblings, there are 2,213 unique mothers in the data. Table 1 shows sample means for several variables for the full sample of individuals with mothers, those who remain after imposing vehicle restrictions, and the mothers themselves.

Restricting our sample to individuals who are either a parent or a child of a separate household reduces the sample size from the full PSID significantly. The households that remain are slightly older, slightly more educated, and they have higher income. Mothers are, obviously, older, with a mean age of 59, compared to the head or wife mean age of 36. Heads and wives have larger households and more kids at home. The households of mothers own somewhat fewer vehicles than their children's households.

⁴Surveys were conducted every year until 1997, just before the PSID began collecting vehicle ownership information.

⁵Throughout, we will refer to live-in significant others as wives and include them in our samples.

Table 1: Variable means in PSID

	All heads and wives with mothers	Final sample of heads and wives	Mothers in final sample
Age	33.6	35.8	59.3
Education	13.2	13.6	12.5
Annual family income	48,514	73,281	62,527
Number of kids	0.9	1.0	0.3
Household family size	2.7	3.0	2.3
Number of vehicles	1.5	2.1	2.0
Number of unique individuals	6,798	4,044	2,213
Number of individual-years	26,659	10,032	6,280

Table reports sample means. The first column reports all household heads and wives in the PSID where the individual's mother is also in the PSID. The next column restricts the sample to household heads (or wives) that have a vehicle, whose mother is in the data and whose mother owns at least one vehicle. The final column is the sample of mothers who have a vehicle and have at least one child who has a vehicle and is in our sample.

3 The strength of brand preferences *within* households

Brand preference, or brand loyalty, is a commonly used concept in marketing and sales. Its colloquial usage is familiar, but what precisely does it mean in a microeconomic choice model?

We say that a brand preference exists if and only if a consumer anticipates receiving a different level of expected utility (would be more or less likely to choose) a vehicle if, holding constant the vehicle's actual physical properties and performance, the vehicle was produced under a different brand label. This concept of brand preference allows for both tastes and information. An example of a brand preference stemming from taste is an individual who grew up in a household that drove Fords and experiences nostalgic pleasure from driving a Ford that would not be experienced if they drove a physically identical GM. An information example is an individual who has always driven Fords and therefore feels confident that they know the reliability of Fords but dislikes the greater uncertainty from buying a GM. Actual differences in reliability and performance are not brand preference, but *beliefs* about reliability and variability, conditional on actual reliability and variability may be a brand preference.⁶

Mathematically, we can write the expected utility of individual i from choosing vehicle k as a function of the individual's characteristics, the vehicle's attributes, and brand prefer-

⁶There is a large marketing literature on brand loyalty, which relates to our definition of brand preference. A seminal contribution is Jacoby and Chestnut (1978), which offers many definitions of brand loyalty, which share with us a presumption that consumer choice is influenced directly by brand, but they differ from our definition here in not beginning with a model of utility and in focusing on repeated purchases.

ences. Let vehicles be indexed by $j = 1, 2, \dots, J$. Each vehicle has a vector of characteristics \mathbf{X}_j of length K , which does not include brand, and a brand B_j . Brands are indexed by $b = 1, 2, \dots, \mathcal{B}$. Each consumer has a vector of characteristics \mathbf{D}_i , which includes demographics like age, income and family structure, as well as locational characteristics \mathbf{L}_i , like weather, terrain and the presence of particular automobile dealerships nearby. In keeping with tradition in the discrete choice literature, we write the utility of individual i choosing vehicle j as an interaction between the vehicle's attributes and consumer's characteristics, along with a random error term:

$$E[U_{ij}] = \beta_i \mathbf{X}_j + \sum_{b=1}^{\mathcal{B}} (\theta_{ib} \cdot 1(B_j = b)) + \varepsilon_{ij}, \quad (1)$$

where:

$$\beta_{ik} = \alpha_k + \alpha_{\mathbf{d}\mathbf{k}} \mathbf{D}_i + \alpha_{\mathbf{l}\mathbf{k}} \mathbf{L}_i + \pi_{ik} \quad (2)$$

$$\theta_{ib} = \xi_b + \eta_{ib}. \quad (3)$$

$1(\cdot)$ denotes the indicator function, ε_{ij} is an idiosyncratic random utility error term, π_{ik} is a preference for characteristic k that is independent of demographics D_i and location L_i , and η_{ib} denotes an individual-specific preference for brand b . Uncertainty is from the point of view of the individual consumer, whom we suppose is uncertain of the actual performance of a vehicle and has subjective beliefs regarding performance (which may be a function of brand). In this framework, individual i has a brand preference if $\eta_{ib} \neq 0$ for some b .

Standard marketing measures of brand loyalty involve correlating an individual's purchases over time, and we will replicate this type of correlation here. Clearly, however, correlations, even within an individual, in brand choice is not proof of brand preference according to our definition. Demographic characteristics (e.g., income, family size) and location (e.g., live near a Ford dealer, live in the mountains) will lead some consumers to consistently value certain attributes more or less than the average consumer to the extent that the α parameters do not equal zero. If attributes vary by brand (e.g., Toyotas are fuel efficient), then individual characteristics will lead certain consumers to prefer certain brands consistently, even in the absence of brand preference ($\eta_{ib} = 0$).

In this section, we demonstrate the persistence of brand choice *within a household*, looking both at the correlations of their brands within their fleet and at their brand choices over time. In subsequent sections, we move to an analysis of brand choice correlations across households within a family network, which allows us to look for brand preference spillovers and to pursue a different set of identification strategies that establish the existence of individual brand

Table 2: Cross-sectional correlation between brand ownership within PSID families

Vehicle 1	Vehicle 2						
	GM	Ford	Chrysler	Toyota	Honda	Other Asian	European
GM	49%	21	11	5	4	7	3
Ford	29	39	11	7	5	8	2
Chrysler	30	21	23	6	5	10	4
Toyota	20	17	9	25	9	14	6
Honda	20	16	7	16	22	12	6
Other Asian	24	17	12	9	9	25	5
European	17	16	10	10	10	8	28
Vehicle 2 Market Share	33	23	13	9	7	11	5

Table shows the percentage of two-vehicle households whose first listed vehicle is the brand listed in the row, whose second listed vehicle is the brand listed in the column. Rows sum to one hundred. Sample is restricted to PSID individual-year observations that own exactly 2 cars; N=24,758. Individuals may appear multiple times across waves, but are included only once per wave.

preference.

We begin here with a within household analysis to demonstrate that brand persistence is quite strong, even when controlling for geographic fixed effects and isolating the sample to individuals choosing from brands with similar product offerings, mitigating the concerns that correlation is driven by characteristics and attributes rather than brand preference. These estimates are also useful in offering a baseline against which to compare the strength of brand correlations across households.

To begin, table 2 shows the within fleet correlation in brand for households that own exactly two vehicles at the time of the survey. Respondents are asked to list up to three vehicles, in an order that they themselves determine, and to provide additional details on them. We focus here on households with exactly two vehicles to examine the correlation of brand choices within a household at a given time period, while putting aside mechanical issues about how to characterize uniformity for households with more than two vehicles. We take the respondents' decision on which vehicle to list first at face value and simply report correlations across the two positions.

The table shows the percentage of second vehicles that are of the column brand, conditional on the first vehicle being the row brand. For example, the first entry indicates that, of all households who list a GM as their first vehicle, 49% also have a GM for their second car. This compares to a 33% second car GM ownership out of everyone in the sample. Every brand demonstrates significant within fleet correlation; the conditional probability of owning a given brand for your second car is higher if your first car is that brand than if your first car is any other brand, in every instance. For smaller brands, the proportional difference is

striking; while only 5% of households have a European second car, a full 28% of those whose first car is European do.

These within fleet correlations do not control for demographic or locational factors. To take a further step, we run regressions of new brand choice on past ownership, in a sample of vehicles that represent net new additions to a household's fleet. We select the survey respondents who report a net increase in their fleet size between survey waves, who list a number of vehicles acquired since the last wave equal to the net increase in fleet size. Thus, we are isolating vehicles that represent a net new vehicle for the family. Restricting to this sample alleviates concerns that brand persistence might result from dealer preferences regarding trade-ins; if dealers pay more for vehicles of the brands that they sell, this could create persistence in trade-ins. Our sample isolates vehicles that represent an expansion of a household's fleet, and therefore are unlikely to have involved a trade-in.⁷

For this sample, we run linear probability models of the new brand choice on past brand ownership:

$$B_{ikb} = \alpha + \beta \cdot \text{EVER}_{ib} + \delta' \mathbf{X}_i + \varepsilon_{ib}, \quad (4)$$

where B_{ikb} is a dummy equal to 1 if newly acquired vehicle k , purchased by individual i is brand b ; EVER_{ib} is a dummy equal to 1 if i has ever reported owning a vehicle of brand b in prior years of the survey (including vehicles observed in the current wave that were reported to have been purchased in the past); \mathbf{X}_i are individual controls; and ε_{ib} is an error term. If β is positive, it implies that having owned a brand in the past is predictive of brand choice for new acquisitions.

Table 3 reports results from regressions with varying controls. Each coefficient is from a separate regression where the dependent variable equal to one if the newly acquired vehicle is the brand listed in the row. The final column reports the unconditional sample means. Individuals can appear more than once if they purchase multiple vehicles, so standard errors are clustered on individual. The first column includes no controls (beyond the constant term). For every brand, there is an economically large and statistically significant correlation between new brand choice and past ownership. For example, GM has a 32% share of all new vehicles, but someone who previously owned a GM is 16 percentage points more likely to buy a new GM than someone who has never owned a GM.

These correlations could be caused by brand preference, or they could be due to locational

⁷We have performed a very similar analysis on all vehicles (not just newly acquired ones), on all newly acquired vehicles (not just net fleet size increases), and using a measure of current brand ownership as the independent variable. In all instances, our results are qualitatively similar; the correlation between new brand and past ownership was strong, positive, statistically significant and economically large.

Table 3: Correlations between new vehicle brand and past ownership of that brand

	No controls	State fixed effects	Full controls	Brand share
GM	0.165*** (0.0145)	0.147*** (0.0145)	0.164*** (0.0157)	0.32
Ford	0.122*** (0.0147)	0.118*** (0.0149)	0.137*** (0.0159)	0.22
Chrysler	0.0711*** (0.0147)	0.0654*** (0.0146)	0.0681*** (0.0153)	0.13
Toyota	0.150*** (0.0186)	0.142*** (0.0186)	0.139*** (0.0196)	0.08
Honda	0.154*** (0.0198)	0.146*** (0.0199)	0.142*** (0.0213)	0.07
Other Asian	0.0922*** (0.0162)	0.0827*** (0.0164)	0.0956*** (0.0176)	0.13
European	0.229*** (0.0277)	0.220*** (0.0272)	0.192*** (0.0285)	0.04
N	10,013	10,013	9,266	

Each entry is from a separate linear probability model regression in which the dependent variable is a dummy coded as 1 if the vehicle is of the brand listed in the column. The table entry is the coefficient on a dummy variable coded as 1 if the individual has ever previously owned a vehicle of the same brand. The sample is restricted to vehicles that were newly acquired by the individual since the prior survey wave and that represent a net increase in fleet size. Individuals may appear more than once if they purchased multiple new vehicles. Standard errors (in parentheses) are clustered on the individual level. The “no controls” column includes only a constant term. The “state fixed effect” column includes state fixed effects. The “full controls” column includes demographic controls (age, education, income, urban dummy, gender, number of children in household and family size), state fixed effects, survey year fixed effects, and dummies for the number of vehicles owned by the individual.

or demographic characteristics that consistently lead individuals to prefer certain brands. We take several steps to explore the importance of such factors. First, in the second column of table 3, we add state fixed effects to control for geographic factors. These controls have very little impact on the estimated coefficients. Relevant geographical factors likely vary within state, and we would like to control for finer levels of aggregation but the sample size does not allow us to accurately measure market shares at a fine level.⁸ Nevertheless, the fact that state fixed effects have almost no impact is suggestive that brand persistence is not largely a story of geography.

In the third column of table 3, we add demographic controls, including age, education, family income, a dummy for urban residence, gender of respondent, number of children in the household and household family size, as well as year (of survey) fixed effects and dummies

⁸We are in the process of obtaining information about local market shares and the proximity of dealerships, but these data are not yet available.

Table 4: Correlations between new vehicle brand and past ownership of that brand for similar brands

<i>Sample with only GM & Ford vehicles</i>				
	No controls	State fixed effects	Full controls	Brand share
GM	0.169*** (0.0196)	0.163*** (0.0198)	0.186*** (0.0225)	0.60
Ford	0.160*** (0.0214)	0.162*** (0.0218)	0.194*** (0.0239)	0.40
N	5427	5427	5067	
<i>Sample with only Toyota & Honda vehicles</i>				
	No controls	State fixed effects	Full controls	Brand share
Toyota	0.176*** (0.0435)	0.197*** (0.0471)	0.223*** (0.0526)	0.52
Honda	0.190*** (0.0446)	0.204*** (0.0468)	0.198*** (0.0511)	0.48
N	1530	1530	1387	

Each entry is from a separate linear probability model regression in which the dependent variable is a dummy coded as 1 if the vehicle is of the brand listed in the column. The table entry is the coefficient on a dummy variable coded as 1 if the individual has ever previously owned a vehicle of the same brand. The sample is restricted to vehicles that were newly acquired by the individual since the prior survey wave and that represent a net increase in fleet size, and where the acquired vehicle is one of the two brands listed in each panel. Individuals may appear more than once if they purchased multiple new vehicles. Standard errors (in parentheses) are clustered on the individual level. The “no controls” column includes only a constant term. The “state fixed effect” column includes state fixed effects. The “full controls” column includes demographic controls (age, education, income, urban dummy, gender, number of children in household and family size), state fixed effects, survey year fixed effects, and dummies for the number of vehicles owned by the individual.

for the number of vehicles owned. Again, these demographic controls have almost no effect on the coefficients, suggesting that brand persistence is not simply due to demographic observables.

Finally, we also restrict our regressions to individuals who made a new vehicle choice from a set of very similar brands, to test whether or not brand persistence could be driven by individuals consistently preferring a type of vehicle that is offered by one brand but not the others. The two sets of brands that are the most similar in their offerings are GM and Ford, which both offer full lines emphasizing light trucks, and Toyota and Honda, which offer similar sedans, and have limited light trucks. Table 4 repeats the specifications of table 3 but limits the sample to GM and Ford acquisitions in the top panel, and to Toyota and Honda in the bottom panel. Coefficient estimates continue to be large and highly significant in these selected samples. Overall, coefficients are slightly **larger** in magnitude than when

looking across all brands.

These within household estimates indicate very strong brand persistence. While it is impossible to eliminate the possibility that these correlations are driven by unobservable demographic characteristics or local geographic factors, the fact that controlling for state fixed effects, controlling for demographic variables, and limiting the choice set to similar brands has minimal impact on the estimates makes a strong *prima facie* case for brand preference. We will add to the evidence in favor of significant brand preference below by showing that correlations across households within a family suggest brand preference spillovers (which are hard to rationalize in the absence of brand preference). Before doing so, however, we first provide a framework for understanding what factors might lead to brand correlations across households, including demographic and geographical correlations, as well as causal relationships between brand preference, in section 4.

4 Why might brands be correlated across households?

Above, we demonstrated that there are very strong correlations in brand choice within a household. Below, we show that there is also a very strong correlation in brand choice across households within a family. We are interested in determining whether or not this intrafamily correlation implies that brand preferences, in the sense defined above, are correlated across these households. If so, it implies that there are interesting network, or experience, effects that lead individuals to act upon brand preferences in ways determined by the choices made by other family members. Under what conditions does an intrafamily brand correlation imply correlated brand preferences? In this section we provide a formal framework of vehicle demand and brand preference in a simplified choice situation in order to clarify the interpretation of our empirical results and make clear the identification challenges we face.

We begin by modifying slightly the notation on the utility of an individual i from choosing a vehicle j that is of brand b that we introduced in section 3. We add a subscript to indicate that an individual is in family f , and we assume that each family has two members, so that $i = 1$ or 2 . We write the utility of the two members of family f as:

$$E[U_{1fj}] = \beta_{1f} \mathbf{X}_j + \sum_{b=1}^{\mathcal{B}} (\theta_{1fb} \cdot 1(B_{1fj} = b)) + \varepsilon_{1fj} \quad (5)$$

$$E[U_{2fj}] = \beta_{2f} \mathbf{X}_j + \sum_{b=1}^{\mathcal{B}} (\theta_{2fb} \cdot 1(B_{1fj} = b)) + \varepsilon_{2fj}, \quad (6)$$

where:

$$\beta_{1fk} = \alpha_k + \alpha_{\mathbf{dk}}\mathbf{D}_{1f} + \alpha_{\mathbf{lk}}\mathbf{L}_{1f} + \lambda_{fk} + \pi_{1fk} \quad (7)$$

$$\beta_{2fk} = \alpha_k + \alpha_{\mathbf{dk}}\mathbf{D}_{2f} + \alpha_{\mathbf{lk}}\mathbf{L}_{2f} + \lambda_{fk} + \pi_{2fk} \quad (8)$$

$$\theta_{1fb} = \xi_b + \phi_{bf} + \eta_{1bf} + \gamma \cdot 1(B_{2fj} = b) \quad (9)$$

$$\theta_{2fb} = \xi_b + \phi_{bf} + \eta_{2bf} + \gamma \cdot 1(B_{1fj} = b). \quad (10)$$

These equations differ from equation 1 in two ways. First, the β parameters are now functions of a λ_{fk} term that is common across households within each family. This term denotes unobserved demographic and locational features that are shared across these households that can induce cross-household correlation in brand choices. Second, the θ terms are now functions of a ϕ_{bf} term and a $\gamma \cdot 1(B_{2fj} = b)$ term. The first term captures correlated brand preferences while the second allows for a direct impact of family ownership on an individual's utility.

This formulation makes clear that two individuals in the same family might have correlated utility for a given vehicle j because the individuals have similar observable demographic characteristics (\mathbf{D}_{1f} correlated with \mathbf{D}_{2f}), similar locational characteristics (\mathbf{L}_{1f} correlated with \mathbf{L}_{2f}), similar unobservable characteristics ($\lambda_{fk} \neq 0$), correlated brand preference ($\phi_{bf} \neq 0$), or a direct ownership effect ($\gamma \neq 0$). Our interest is in isolating effects that operate through either correlated brand preferences or direct ownership effects, rather than correlated characteristics.

Clearly, demographic characteristics matter for vehicle choice. Members of the same family are well-known to have correlated characteristics like income, education and family size. These demographic characteristics will determine demand for particular vehicle attributes, like price, size and fuel economy. To the degree that vehicle attributes are distributed differently across different brands, brand choices will be correlated across individuals in the same family. Locational factors, like rural versus urban residence, weather or local supply for particular vehicles, will also influence demand for similar reasons. To the degree that members of the same family live in the same, or similar, places, this will also generate correlation in attribute demand that may result in correlated brand preferences.

Family members may also have correlated brand preferences, in the sense that we have defined it here ($\lambda_{fk} \neq 0$). A correlation in brand preference could be the result of past experiences. Suppose, for example, that a household had a strong preference for GM vehicles. A child who grew up in that household would have accumulated experiences with GMs. Driving a GM might conjure up nostalgic feelings, so that they experience driving a GM differently than driving a Ford with identical attributes. Or, in that same situation, the

child may feel that they have significant experience with a GM, so that they are confident that they know what the GM's quality and reliability will be. If individuals within a family have correlated brand preferences for any of these reasons, it will lead to correlation in the brand choices we observe.

These long-run correlations have close parallels in the intergenerational mobility literature, which estimates long-run correlations in earnings, education, and other outcomes of parents and their children. As this literature emphasizes, most studies give biased estimates for the correlation in lifetime earnings; lifetime earnings are usually not observed, and earnings over shorter periods are a noisy measure of lifetime earnings, leading to attenuation bias in estimated correlations. Moreover, estimated correlations can be sensitive to the ages of parents and children when earnings are observed, since both the size and persistence deviations between current and lifetime incomes, and therefore the attenuation bias, vary over the life-cycle (Solon 1999). For similar reasons, in our case, observed correlations in brand *choice* will likely underestimate the intergenerational persistence in brand *preference*, if short-run choices are a noisy measure of long-run preferences. Moreover, these estimates could be sensitive to the ages of parents and their children and whether we estimate correlations in vehicle acquisitions or vehicle holdings.

There could be a correlation of brand choices without brand preference, however, if there are direct ownership effects ($\gamma \neq 0$). Imagine an intervention that allocated a particular brand to one member of a family. Would this influence the brand choice of other members of the same family? Recent brand acquisitions by one household in a family could influence other members of the family by making them aware of the new brand or providing experience with it, directly or by word of mouth. This type of short-term phenomenon is potentially distinct from the long-term preference formation we mean to embody in the correlated preferences. Such an effect is, however, conceptually indistinguishable from a more general model in which brand preference is a function of family brand ownership.

These direct, short-run ownership effects have close parallels in the peer effects literature, which often estimate the contemporaneous or near-contemporaneous effects that the choices or characteristics of one's reference group has on one's own choices. A key challenge to identification in this context, as first formalized by Manski (1993), is the reflection problem. In a large-group setting, with *aggregate* choices and characteristics of one's reference group influencing one's own choice, the reflection problem typically manifests as an inability to determine whether it's the average *choices* of one's reference group, or rather the group's average *characteristics*, that determines one's own choice. This indeterminacy arises because the individual choices of one's peers are also a direct function of their individual characteristics. In our small-group setting, since a mother's preferences are potentially a function

of her child's choice, and vice-versa, the reflection problem manifests as a correlation between the child's unobserved preference shifters and the mother's choice, which enters as a right-hand-side variable for the child. In effect, our estimates are subject to standard simultaneous equations bias. As described below, we attempt to mitigate this bias by exploiting the distinct timing of when mothers and their children make their choices, as well relying on instruments that we argue satisfy the exclusion restriction, only affecting the child's choice indirectly via the mother's choice.

Below, we walk through a number of empirical exercises that attempt to tease apart brand correlations driven by correlated attributes and those driven by brand preference correlation, be it from a long-run endogenous preference formation or from information transmission, which may occur in the long or short run. We begin by showing the strength of the raw correlation, which may be driven by brand preferences or correlated characteristics. We then control for a rich set of demographic variables, as well as state fixed effects meant to capture locational factors nonparametrically, and demonstrate that these controls account for only a modest fraction of the raw correlation. While suggestive, these results are nevertheless subject to the critique that important characteristics may be omitted from the analysis. So we next focus our attention to two brands that have very similar attributes, Ford and GM. Our idea in doing so is to isolate the choice set to vehicles that have very similar attributes, which mitigates any correlation driven by the interaction between brand attributes and individual characteristics, whether they are observed or unobserved.

Then, we attempt to look separately at short and long-run mechanisms by looking at how parental vehicle ownership when a child lived in their parents' household impacts the brand choices that the child makes when they form their own independent household. This speaks to the way that past experiences create a persistent brand preference later in life. We also use individual fixed effects to test whether or not recent changes in parental ownership are correlated with child brand choices. Finally, we use an instrumental variables strategy that attempts to identify exogenous shocks to parental brand choices to see if such choices impact child brand choice.

With the exception of the instrumental variables approach, all of our varied econometric strategies reveal positive, economically large, statistically significant relationships between parental brand choice and child brand choice. We interpret this body of evidence as suggesting that correlated brand preferences or direct ownership impacts are significant drivers of the sizable intra-family correlation in brand choice. The instrumental variables approach we explore below yields imprecise estimates. All other approaches provide robust evidence of strong intra-family brand correlations.

5 How and why are brand choices related *across* households?

In this section, we develop a linear probability model for the brand choice of children and demonstrate how children’s brand choices are related to their parents’ brand choices, using a variety of specifications that try to distinguish correlated brand preference from more mundane causes such as correlated demographics. Future versions of this paper will use a discrete choice model, which confers the advantages that its estimated parameters can be interpreted as parameters of a utility function and that predicted choice probabilities are constrained to the unit interval. For now, however, the linear probability model is valuable in that it can establish the qualitative strength of intra-family correlation in brand choices and explore the robustness of that correlation to a variety of control structures. The linear probability model is also computationally simpler to estimate, particularly given the large number of fixed effects in many of our specifications.⁹ In our instrumental variable specifications, the linear probability model also confers the advantage that it does not require a specification of the joint distribution of the mothers’ and childrens’ unobserved demand parameters.

In section 3, we demonstrated the persistence of brand choices within households using linear probability model regressions for each brand, one at a time. This approach is useful in retaining an intuitive setup, but it is limiting in other respects. Here, we generalize this approach to allow us to study all brands in a single regression. Specifically, we categorize all vehicle choices as being one of the seven “brands” that we used above: GM, Ford, Chrysler, Toyota, Honda, Other Asian and European. Grouping smaller Asian automakers and European manufacturers together ensures that each brand is chosen frequently enough to yield meaningful estimates in a linear probability framework and to be economically interesting. In particular, these brand definitions imply that their choice probabilities lie in the 3 - 20% range in the raw data. For every child in our data, we classify each vehicle that we observe them owning, across the various survey waves, as a unique choice opportunity. For each choice opportunity, we expand the original data sample to include seven lines of data. The first is for the brand that was chosen by the individual, and this line has the dependent variable coded as one. The other six are observations with a zero dependent variable, one for each of the six brands not chosen. To avoid this expansion of the data set unduly shrinking our standard error estimates, we cluster all standard error calculations on the individual (child) level. This clustering also accounts for correlation in

⁹With most of the fixed effects considered here, such as the brand-by-year or brand-by-state dummy variables, the only concern with a discrete choice model is computational time. With the brand-by-individual fixed effect specification, however, the discrete choice model also suffers from inconsistent estimates due to the incidental parameters problem.

the individual's choices across choice situations (vehicles purchased).

We do not allow for an outside good, which would be interpreted as the option not to purchase a vehicle at all. This is a standard step in discrete choice modeling, but here we are interested in knowing whether or not a child, conditional on purchasing a vehicle, decides to buy a brand that is the same as the one owned by members of his or her family. Inclusion of an outside good would mix together correlations in choice that determine whether or not individuals purchase vehicles, and what brand they choose when purchasing a vehicle, which are distinctly different economic phenomena.

5.1 Brand correlations within family networks

We begin by showing simple correlations, in order to demonstrate the strength of the intrafamily relationship, and then demonstrate the impact that controlling for observable characteristics has on the results. Table 5 reports results from several specifications of our linear probability model, where the dependent variable for each observation (each brand choice possibility for a child) is coded as 1 if the child selected that brand, and the independent variable of interest is coded as 1 if the mother chose that brand, for her most recently purchased vehicle that was purchased before the child's choice in question.¹⁰ Column 1 reports the raw correlation, with only year-brand fixed effects included, which control for the overall share of each brand during each period. All standard errors are clustered on the individual level to allow for arbitrary correlation across the choices of each individual, which are mechanically related. The coefficient estimate is 0.104 and is precisely estimated. This coefficient is economically very large. There are 7 brands in our choice set, so the average brand is selected 14.3% of the time. Our estimate therefore indicates that a consumer's mother purchasing a brand increases the likelihood that that consumer purchases the brand by over 70%, on average.

In columns 2 through 7 of table 5, we introduce a set of controls. Recall from our discus-

¹⁰Throughout, we focus on the mother-child relationship because of our superior ability to match such households in the data. A regression on just the father's choice yields an estimate that is similar to the mother's choice alone, the coefficients are not statistically different. For a regression in which both the mother's and father's most recent purchase is included each coefficient is around half of the coefficient in column 1 of table 5. For individuals whose parents both live in the same household, the brand dummy for the mother is the same as the brand dummy for the father, which makes this relationship intuitive. For individuals whose parents live in separate households, the effect of one parent changing their brand choice is less powerful. We have also experimented with a variety of ways of characterizing the mother's choice given that mothers may own multiple vehicles. We have used the share of mother's vehicles of a specific brand, and we have done one to one vehicle matching across mothers and children using the order that they are listed in the survey. In all cases, our qualitative results are quite similar. We prefer the most recent vehicle purchased by the mother before the child's purchase because the interpretation of a dummy variable is more transparent, and this selection accords with the causal model we have in mind.

Table 5: Correlations between child brand choice and parental brand choice

Dependant Variable: Child's Brand						
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Mother's Brand	0.104*** (0.006)	0.098*** (0.006)	0.097*** (0.007)	0.085*** (0.007)	0.063*** (0.006)	0.059*** (0.006)
Mother's Previous Brand					0.053*** (0.006)	0.046*** (0.006)
Mother's Second Previous Brand						0.033*** (0.007)
Child's Previous Brand					0.164*** (0.007)	0.148*** (0.006)
Child's Second Previous Brand						0.108*** (0.006)
Brand x year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Child's demographics	No	Yes	Yes	Yes	Yes	Yes
Mother's demographics	No	No	Yes	Yes	Yes	Yes
State x brand fixed effects	No	No	No	Yes	Yes	Yes
Observations	95,914	86,170	77,777	77,777	77,777	77,777
R-squared	0.084	0.098	0.102	0.124	0.146	0.152

Standard errors clustered by individual in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Each column is a linear probability model where each individual-year-vehicle enters the data 7 times, once for each brand. The brands include: GM, Ford, Chrysler, Toyota, Honda, Other Asian, and European. Child's and mother's demographics include annual household income, urban/rural status, age, number of kids in the household, and total family size.

sion in section 4 that we wish to isolate correlations across households that are not due to demographic and locational factors that cause related families to demand similar attributes. To check for the importance of such drivers, we first introduce a set of demographic controls for the *child* and their household in column 2: family income, urban versus rural dummy, age, sex, education, number of kids in the household, household size, and the gasoline price when the child purchased the vehicle. We interact each of these with our seven brand dummies, and we include year-brand fixed effects to capture average market shares. We drop observations that are missing information in the relevant survey year for any of these demographic controls, which reduces our sample size. The coefficient changes very little; even after controlling for a rich set of demographics, a child whose mother's most recent vehicle acquisition was of a particular brand is on average 69% more likely to choose that brand than one whose mother did not.

In column 3, we introduce a matching set of demographic controls for the *mother* and her household. This drives down the correlation by a very small amount. In column 4 we add state cross brand fixed effects, which allow the average market share of each brand to differ for each state. Our idea here is to capture locational factors in a nonparametric fashion.

This drives down the coefficient again by a small amount. Comparing the raw correlation of 0.104 with the fully saturated estimate of 0.085 in column 4, we see that our complete set of rich controls moves the raw correlation less than one quarter. Including these controls has minimal impact on the estimate. While there are certainly other demographic factors that one would like to include, this is a fairly rich set of individual and household characteristics. Thus, we believe that the fact that the coefficients are so little affected is important evidence that demographic and locational factors are not the primary driver of intrafamily brand choice correlations.

The coefficient in column 4 combines the fact that mothers and children may have similar past experience with vehicle brands, and therefore the mother's brand coefficient may be capturing something about the child's own brand loyalty.¹¹ To better understand whether the mother's most recent purchase is correlated with the child's brand purchase controlling for the mother's and child's past brand purchases, we include lagged purchases by both the mother and child in column 5 of table 5. The lagged variables are equal to one if the previous purchase observed in the data was of the brand and zero otherwise. If there is no previous vehicle purchase by the mother or child in our dataset, then the lagged variables are equal to zero for all observations. When all three variables are included, by far the largest effect is for the child's lagged brand purchase, with a coefficient of 0.164, meaning that a child purchasing a particular brand more than doubles the likelihood that she will purchase that brand for her next vehicle on average. However, even after controlling for the child's previous brand purchase, both of the mother's last two brands purchased significantly increase the likelihood that the child will purchase that brand. The mother's most recent purchase has a coefficient of 0.063 and the mothers' second most recent purchase has a coefficient of 0.053, both of which are statistically different from zero. This provides strong evidence that it is the actual purchase behavior of the mother, rather than just lagged correlations between the mother's and child's brand purchases, that is correlated with the child's current brand choice. The specification in column 5 will be our base specification moving forward, since it pulls apart the within-individual brand loyalty from the intergenerational transmission of brand preference.

Finally, in column 6 we show the same specification as in column 5, but we add a second lag of both the child's and mother's brand choices. Again, all of the coefficients are

¹¹In order to test whether the correlation across generations is coming from a correlated preference for brand (e.g. Ford) or sub-brand (e.g. Ford, Lincoln, Mercury), we have run the regression in column 4 of Table 5 with 41 sub-brands instead of the 7 brands (and the consumer demographics interacted with the 41 sub-brands). We find that both the overall brand and the sub-brand of the mother have a statistically significant correlation with the sub-brand chosen by the adult child. The brand coefficient is 0.00633 (0.00097) and the sub-brand coefficient is 0.0489 (0.0043). The number of observations jumps to 466,662 and the R^2 jumps to 0.146.

statistically different from zero and the child's own previous brand choices have a larger correlation with her current brand choice than the mother's brand choices. For both the mother and child, the size of the correlation with the child's current brand choice is decreasing in the number of lags.

5.2 Suggestive Heterogeneity

One interesting aspect of the PSID is that while we can follow an extended family over time, new consumers are constantly marrying into the family. We do not observe the family histories of these new family members, which complicates our understanding of how couples are affected by the purchasing behavior of their collective parents. Since we observe the vehicle purchases of the mother of one member of a couple but not the other, if the mother's brand purchases are actually affecting the child's brand purchases, then we would expect this result to be stronger for single children than for children who are part of a couple.¹² Table 6 shows exactly this result. Column 1 replicates column 5 from table 5 and then in column 2 we run this regression only for single adult children. Column 3 shows the result only for coupled adult children. While the child's own lagged brand choice is not statistically different between single and coupled children, the effect of the mother's previous choices is sharply lower for coupled children than for single children. The mother's previous brand purchase coefficient drops from 0.109 to 0.052 for single versus coupled children, while the mother's second most recent brand purchase correlation drops from 0.073 to 0.049. This does seem to suggest that when a couple is considering a vehicle to purchase, they are influenced by the recent purchases of both sets of parents, and since we only observe one of those sets of purchases, the correlation between mother's purchases and coupled childrens' purchases is substantially lower than for single childrens' purchases.

5.3 Similar Brands

Of principle concern is that demographic or locational characteristics of children and mothers will be correlated, and that these characteristics drive demand for vehicle attributes, which are correlated with brand. For example, individuals who live in rural areas, work in construction jobs, or live in areas that receive heavy snowfall, may all be more likely to prefer light trucks to passenger cars. Because GM's fleet is more heavily tilted towards light trucks than Toyota's, such people will be more likely to buy a GM, even in the absence of any brand preference. Above, we showed that controlling for many observable characteristics

¹²Coupled adults include both those who are married as well as those who are living with a significant other but not married.

Table 6: Correlations between child brand choice and parental brand choice for subsamples

Dependant Variable: Child's Brand			
VARIABLES	All	Single	Coupled
Mother's Brand	0.063*** (0.006)	0.109*** (0.013)	0.052*** (0.007)
Mother's Previous Brand	0.053*** (0.006)	0.073*** (0.014)	0.049*** (0.007)
Child's Previous Brand	0.164*** (0.007)	0.153*** (0.015)	0.160*** (0.008)
Brand x year fixed effects	Yes	Yes	Yes
Child's demographics	Yes	Yes	Yes
Mother's demographics	Yes	Yes	Yes
State x brand fixed effects	Yes	Yes	Yes
Observations	77,777	16,590	61,187
R-squared	0.146	0.182	0.149

Standard errors clustered by individual in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Each column is a linear probability model where each individual-year-vehicle enters the data 7 times, once for each brand. The brands include: GM, Ford, Chrysler, Toyota, Honda, Other Asian, and European. Child's and mother's demographics include annual household income, urban/rural status, age, number of kids in the household, and total family size.

had limited impact on the coefficients, but concerns about unobserved factors remains.

Here, we employ a different strategy, which is to isolate the choice set to brands that are very similar. Ford and GM are both full-line automakers that compete directly with each other in every vehicle segment. Because they offer very similar lineups of vehicles, we would expect intrafamily brand correlations to be quite weak in the absence of correlated brand preference, when we limit our sample to a set of children who choose either a GM or a Ford. Similarly, Toyota and Honda tend to produce strong cars and fuel efficient entries into the SUV and truck markets, so if correlated preferences for vehicle attributes are driving our results in Table 5 then we would expect the correlation to disappear when we limit our sample to the set of children who chose either a Toyota or a Honda. Table 7 repeats the specifications from table 5 for these two subsamples. Specifically, we keep all instances where a child chose either a Ford or GM (or a Toyota or Honda),¹³ and we code the mother's choice as before, isolating our study to the vehicle that her household purchased most recently prior to the date of the child's purchase. The sample size is different than the results in table 5 both because we limit to these choice situations, but also because we restrict the choice set to Ford or GM (or Toyota or Honda), moving from 7 brand choices (and hence 7 observations

¹³Around 56% of our original sample chose a Ford or GM and 14% of our original sample chose a Toyota or Honda

Table 7: Correlations between new vehicle brand and parental brand choice for similar brands

Dependant Variable: Child's Brand			
VARIABLES	All Brands	Just Ford/GM	Just Toyota/Honda
Mother's Brand	0.063*** (0.006)	0.064*** (0.013)	0.124*** (0.035)
Mother's Previous Brand	0.053*** (0.006)	0.056*** (0.013)	0.097** (0.040)
Child's Previous Brand	0.164*** (0.007)	0.202*** (0.013)	0.181*** (0.032)
Brand x year fixed effects	Yes	Yes	Yes
Child's demographics	Yes	Yes	Yes
Mother's demographics	Yes	Yes	Yes
State x brand fixed effects	Yes	Yes	Yes
Observations	77,777	12,672	2,974
R-squared	0.146	0.128	0.150

Standard errors clustered at the child level in parentheses. *** p<0.01, ** p<0.05, * p<0.1 Columns 2 and 3 are linear probability models where each individual-year-vehicle enters the data 2 times, once for GM and once for Ford or once for Toyota and once for Honda. The data is restricted to only children who own a GM or a Ford and whose mother owns a GM or a Ford (or a Toyota or Honda). Child's and mother's demographics include annual household income, urban/rural status, age, number of kids in the household, and total family size.

per choice) to 2 brand choices (and hence 2 observations per choice).

The results in table 7 are positive, economically large, and statistically different from zero for both Ford vs GM and Toyota vs Honda. Both specifications include the full complement of controls from Table 5, and column 5 from that table is reproduced as column 1 here for comparison. In column 2 a child whose mother's most recently purchased vehicle was a GM when the child acquired a new vehicle was 6.4 percentage points more likely to buy a GM, conditional on the child's previous brand choice and the mothers second most recent brand choice. In this subsample, the choice share of GM is 61% and Ford is 39%. This intrafamily brand correlation therefore would raise the odds that a child purchased that brand by about 10% for GM and 15% for Ford. These impacts are smaller than the corollaries from table 5, which are approximately 20% for GM and 30% for Ford. This is intuitive given that Ford and GM are generally closely substitutable, and it does suggest that characteristics correlations that drive attribute demand may be important, but a strong intrafamily brand correlation remains, even in this selected sample.

Taken together, our demographic controls, the heterogeneity across single versus coupled children, and our isolation of the choice set do appear to play some role in driving the raw correlation in intrafamily brand choices, but a large fraction of the correlation, which is

economically and statistically significant, remains. This suggests a critical role for brand preference.

5.4 Intrafamily brand influence through past experience

If there is indeed a link between the brand preference of parents and the brand preference of children, as we suppose, then this could operate in one of several ways. First, the brand preferences of children might be formed by their experiences when they lived in their parents' homes. Above, we studied the correlation across members of a family who live in different households, based on their recent purchases. We could alternatively use the panel structure of the data to examine people who are living with their parents at the time of a survey wave, and then see whether or not the brand holdings of their parent's household while they lived there predict their brand choice once they leave the household. This is indicative of an endogenous preference formation based on past experiences.

To examine this, we select a sample of children whom we at some point observe leaving in their parents' household, but later observe living in their own household. We restrict this sample further to include individuals who did not form their own household until they were at least 18 years old, and who were not living with their parents past age 23. For this sample, we then identify the brand ownership of their parents, at the last time we observe them living in their parents' household. That is, we identify the brand holdings of their parents when the children last lived with their parents.

In table 8 we report linear probability model regressions that predict the child's brand choice (once they have established their own household) using a dummy variable for whether or not any of the parents' vehicles at the time the child left the household were a given brand. To avoid counting vehicles that the child took with them from their parents home, we drop all children who reported that any of the vehicles in their fleet had been received as a gift. The independent variable of interest is different in this regression than in our other tables. Now, the coefficient from column 1, for example, indicates that an individual is 6 percentage points more likely to own a given brand if their mother's household owned that brand somewhere in their fleet, when they last lived with in their mother's household.

This difference in the independent variable means that we cannot directly compare the coefficients to our previous estimates. Qualitatively, the results from this analysis are quite similar. Child brand choice is positively correlated with mother's ownership of a brand when the child was most recently in the mother's household, and the relationship is economically large and statistically significant. The coefficient falls by more than one third when all of the demographic and state fixed effects are added, a decline which is slightly larger than

Table 8: Correlations between new vehicle brand and parental ownership at time when child lived with parents

VARIABLES	(1) Child's Brand	(2) Child's Brand	(3) Child's Brand
Mother Owned Brand	0.0617*** (0.0147)	0.0606*** (0.0150)	0.0375*** (0.0172)
Brand x year fixed effects	Yes	Yes	Yes
Child's demographics	Yes	Yes	Yes
Mother's demographics	No	Yes	Yes
State x brand fixed effects	No	No	Yes
Observations	2,912	2,898	2,898
R-squared	0.119	0.132	0.250

Standard errors clustered at the child level in parentheses. *** p<0.01, ** p<0.05, * p<0.1 Each column is a linear probability model where each individual-year-vehicle enters the data 7 times, once for each brand. The data is restricted to only children who were observed as a dependent in a household in the sample when he or she was under 23 and then the head (or wife) of a household later in the sample. Child's and mother's demographics include annual household income, urban/rural status, age, number of kids in the household, and total family size.

in prior tables. This suggests that there is a strong link between brand experience during adolescence and brand choice in adulthood. This is suggestive of long-run endogenous brand preference formation.

6 Implications of brand preferences for the vehicle market

What might the persistence of brand preferences imply for market outcomes in the automobile industry? We begin by considering the implications of brand preferences for automakers' pricing strategies. We study a symmetric model in which two firms compete in two different product markets (a market for young consumers and a market for older consumers), and consumers live two periods, purchasing once from each market. If first period choices determine brand loyalty in the second period, then firms will "invest" in customers in the first period by charging lower prices, and then "harvest" the consumer loyalty in the second period. This suggests that we would expect to see higher markups on vehicles in the second-period market (for older, higher income consumers).

If brand preferences are intergenerational, however, the firm's ability to harvest in the second period market is limited. We show that, when intergenerational transmission is strong, our stylized automobile market is directly analogous to infinite-period models that

have been analyzed in the literature. This literature suggests that the presence of brand loyalty actually lowers firm profitability, as the competitive pressure to “invest” in future consumers outweighs the benefit of “harvesting” the loyalty.

Next we consider a case with asymmetric product offerings, where one firm competes in only one product market, while the other competes in both. We show that intergenerational transmission of brand preference causes the firm that does not compete in both markets to suffer lost profits, even in the market in which it does compete. This gives firms a strong incentive to sell vertical product lines.

The importance of investing in future brand preference aligns with stylized facts about the automobile market, where the industry appears to measure success by sales volumes, as often as by period profits. The value of vertical product lines also accords with stylized facts about the automobile market, where firms evolve to offer full product lines and attempt to move consumers through their various models over the lifecycle. As such, we believe that our model highlights ways in which the existence of strong brand preference, and the intergenerational transmission of it, offer insights into the nature of the car market.

6.1 Optimal prices in a symmetric model

A substantial literature, dating back to Klemperer (1987), studies the effect of brand preferences on firms’ prices in equilibrium. This literature most often refers to what we call brand preferences as “switching costs”, though the concept is often operationalized in the same way as is done here.¹⁴ Our approach is closest in spirit to that of Dube, Hitsch, and Rossi (2009), hereafter DHR, in that we model an infinite horizon game in which brand preferences are of a sufficiently modest magnitude that some households do switch brands in equilibrium. Our primary difference from DHR and the preceding literature is that we model firms as having two products that cater to two types of consumers: the young and the old. We model multi-product firms both to better relate the model to the automobile market, in which nearly all manufacturers produce a range of models tailored to consumers in different stages of their life-cycle, and to better highlight the role that intergenerational preference transmission can play in determining automobile prices in equilibrium.¹⁵

¹⁴Some papers model switching costs as an increase in utility from purchasing the same brand as that purchased last period (our approach), while others model switching costs as a decrease in utility from purchasing a different brand. Dube, Hitsch, and Rossi (2009) examines both models and finds that they produce identical predictions in the absence of an outside good. In the presence of an outside good, the second formulation yields lower prices in equilibrium, as switching costs make the outside good relatively more appealing.

¹⁵With single product firms, the distinction between models with and without intergenerational preference transmission becomes a distinction between a model of infinitely-lived consumers and an infinite-horizon OLG model (without price discrimination) in which “new” consumers without brand preferences appear

Models of pricing under brand preferences generally require a numerical solution under a Markov perfect equilibrium (MPE) framework, as in DHR. Here, we adopt a very simple model that allows for an analytic solution in the case of no intergenerational preferences and, more generally, is helpful in articulating intuition. In future work, we hope to study, using numerical methods, a more general model that can be more closely calibrated to the automobile industry.

In our model, there are two symmetric firms, denoted j and k that compete in a differentiated brand pricing game. We adopt an infinite horizon overlapping generation (OLG) framework in which households live for two periods. In each period, there are unit masses of two types of households: young (type A) and old (type B). All consumers are born as type A , become type B in the second period of their lives, and then die, creating a new type A consumer (offspring) upon death.

A key feature of the model is that the type A and type B consumers purchase different kinds of cars. Both firms are aware of this fact, and both sell two vehicle models catering to the two types. Thus, there are four vehicles in the market: jA , jB , kA , and kB . A and B cars can be thought of as cars preferred by younger versus older consumers, or entry level versus upscale, or single persons versus family vehicles. The key feature is that an individual can be expected to first purchase an A vehicle and then purchase a B .

For clarity, we assume that type A households only consider vehicles jA and kA and that type B households only consider vehicles jB and kB . Clearly this is an abstraction, as there will be some substitution across any of the markets we described. Still, in a survey of over 22 thousand consumers by a market research firm described in Langer (2011), the Cadillac Deville and Lincoln Town Car had over 100 purchasers over the age of 60 and none under the age of 40 while the Scion tC had over 100 purchasers under 40 and only 6 over 60.¹⁶ Clearly there are vehicles that appeal strongly to specific age groups. We hope to explore the implications of relaxing the assumption of perfect separation of the A and B types in future work.

Without intergenerational transmission of brand preference, the perfect separation of types implies that the prices set by the firms for the jB and kB cars do not have future implications. Thus, prices in equilibrium can be solved for using a two-period model, despite the fact that the game is infinite-horizon. We first examine the prices for the type B cars

each period and “old” consumers with brand preferences eventually die off. DHR considers the former case while Doganoglu (2010) considers the latter. While the models of the two papers are not otherwise identical, both papers find that the introduction of moderately-sized brand preferences lowers equilibrium prices. These similar results suggest that at least qualitatively, the implications of intergenerational brand preferences for single product firms (or more generally, for firms without multiple products specifically tailored to young and old consumers) may not be substantial.

¹⁶In that same survey, only 5% of consumers who admit to purchasing a Buick are under the age of 40.

as a function of the type A demand in the previous period and then study prices for type A cars, where firms' incentive to increase their type B demand in the subsequent period must be accounted for.

Let the utility of a particular consumer i of type B that purchases vehicle jB be given by:

$$U_{ijB} = V - P_{jB} + \mu 1\{b_{iA} = j\} + \varepsilon_{ijB},$$

where, V is a baseline utility that is common across the two brands, P_{jB} is the price of vehicle jB , and $1\{b_{iA} = j\}$ is an indicator for whether consumer i purchased brand j when he/she was a type A last period. μ denotes the strength of persistence of brand preferences. The utility from purchasing vehicle kB is given similarly. All type B households purchase exactly one vehicle, and there is no outside good.¹⁷

The random utility component ε_{ijB} is assumed to be i.i.d over individuals i , brands j and k , and types A and B . The strongest of these independence assumptions is that over types, as it implies that a given household's random preference when it is a type A is uncorrelated with its random preference when it is a type B in the subsequent period. The implication of this assumption is that the only source of persistence in brand purchases must come from the brand preference term μ . While strong, this assumption is consistent with most models of automobile demand since Berry, Levinsohn and Pakes (1995), which allow persistent preference heterogeneity over vehicle attributes but not over brands. The assumption can be relaxed in numerical modeling, per DHR.

A type B household i that purchased vehicle jA in the previous period will choose brand j again if and only if:

$$\begin{aligned} U_{ijB} &\geq U_{ikB} \Rightarrow \\ \varepsilon_{ikB} - \varepsilon_{ijB} &\leq P_{kB} - P_{jB} + \mu. \end{aligned}$$

However, if the household purchased vehicle kA in the previous period, it will now choose brand j if and only if:

$$\varepsilon_{ikB} - \varepsilon_{ijB} \leq P_{kB} - P_{jB} - \mu.$$

¹⁷With symmetric firms and no outside good, it becomes irrelevant whether households are forward looking when they are of type A . With forward looking consumers and an outside good, appendix E of DHR, which considers an OLG model in which firms can third degree price discriminate across young and old consumers, shows that the equilibrium price charged to the old consumers in the presence of persistent brand preferences can be lower than that charged in the absence of brand preferences. Prices to young consumers are still lower than those charged to old consumers.

Let F denote the cdf of $\varepsilon_{ikB} - \varepsilon_{ijB}$. To create tractable solutions for illustration, we make the standard Hotelling assumption and let F be uniform on $[-.5, .5]$, so that $F(x) = 0.5 + x$ and $f(x) = 1$. Note that this choice of distribution, with finite support, implies that μ must be less than 0.5 in order for there to be any brand switching in equilibrium. Denote the share of type B individuals who arrive at a period with a brand preference for j as ϕ . The demand for vehicle jB can now be written as:

$$\begin{aligned} D_{jB}(P_{jB}; P_{kB}, \phi) &= \phi F(P_{kB} - P_{jB} + \mu) + (1 - \phi)F(P_{kB} - P_{jB} - \mu) \\ &= P_{kB} - P_{jB} + 1/2 + \mu(2\phi - 1). \end{aligned}$$

Let the marginal production cost for all four vehicles be constant and given by c . Firm j 's profit maximization problem from the type B consumers can now be written as:

$$\begin{aligned} \max_{P_{jB}} \pi_{jb} &= (P_{jB} - c) \cdot D_{jB}(P_{jB}; P_{kB}, \phi) \\ &= (P_{jB} - c) \cdot (P_{kB} - P_{jB} + 1/2 + \mu(2\phi - 1)). \end{aligned}$$

Taking first order conditions for both firms and finding the intersection of the two best response curves yields the equilibrium prices for the type B cars:

$$\begin{aligned} P_{jB} &= 0.5 + c + 1/3(2\phi - 1)\mu \\ P_{kB} &= 0.5 + c + 1/3(1 - 2\phi)\mu \\ D_{jB} &= 0.5 + 1/3(2\phi - 1)\mu \\ D_{kB} &= 0.5 + 1/3(1 - 2\phi)\mu. \end{aligned}$$

As a result of the uniform distribution assumption, if the initial brand loyalty share is given by $\phi = 0.5$, then the presence of brand preferences ($\mu > 0$) does not affect type B prices. Intuitively, as brand loyalty (μ) rises, the density of consumers that are indifferent between the brands does not change under the uniform assumption ($f(X)$ is always equal to 1). This result does not hold, however, for normal or logit errors, for which brand preferences increase type B prices since the indifferent consumer's location moves to a less dense part of the distribution, decreasing the elasticity of demand.

In the absence of intergenerational transmission, there is no brand preference in the A market. But firms know that stage B profits are an increasing function of ϕ , which will give the firms an incentive to lower prices in the first stage. Firm j 's total profits from the type A and B consumers are given by the expression below in which the type B prices are the

outcome of the type B game discussed above given ϕ , where ϕ is the demand for jA :

$$\pi_j(P_{jA}, P_{kA}) = (P_{jA} - c) \cdot D_{jA}(P_{jA}; P_{kA}) + \delta(P_{jB} - c) \cdot D_{jB}(P_{jB}; P_{kB}, \phi),$$

where δ is a discount factor.

Taking first order conditions for the type A prices and intersecting the best response functions yields the equilibrium prices for the type A vehicles:

$$P_{jA} = P_{kA} = 0.5 + c - 2/3\mu\delta.$$

The symmetry of the firms' costs and households' valuations of their vehicles yields a 50/50 split of demand. Type A prices decrease as brand preferences and firms' discount factor increase because these parameters strengthen the link between the type A demand and future profits obtained when these households become type B 's.

Thus, even though the game we model is of infinite horizon, the outcome in the absence of intergenerational brand preferences mirrors the "bargain and rip-offs" outcome from two-period brand preference models such as Klemperer (1987). In our simplified model with uniformly distributed random utility differences and the presence of some switching in equilibrium, brand preferences actually make the firms unambiguously worse off because they lower type A prices without affecting type B prices. With other distributions, such as the normal or logit, type B prices may increase so that firms may be better off under brand preferences, though type A prices will still be lower than in the case of no brand preference.¹⁸

In the absence of intergenerational preferences, we should see higher markups on cars intended for older, type B households than on cars intended for young, type A households. What happens if intergenerational preferences are introduced? Here, we focus now on the case in which intergenerational brand preferences are as strong as within-household brand preferences. In our dynamic pricing game, intergenerational transmission eliminates the distinction between type A 's and type B 's because both types pass their brand loyalty on to the opposite type in the following period (a distinction of degree would be restored if intergenerational transmission were imperfect) and because the vehicle types are modeled symmetrically. Thus, the infinitely repeated game with intergenerational preference transmission can be modeled as a game with infinitely-lived consumers and one product per firm, which becomes the case studied by DHR.

There is one state variable each period: ϕ , the fraction of consumers with a brand

¹⁸It can be shown that the result of lower type A prices holds if random utility differences are continuously distributed, μ does not exceed the support of this distribution, and demand is such that prices are strategic complements and the best response functions have a slope less than one (so that the Bertrand equilibrium is stable).

preference for j . The firms' control functions are their prices, which in an MPE framework are functions of ϕ . As was the case for the type B households in the model above without intergenerational preferences, per-period profits are given by:

$$\pi_j(P_j, P_k, \phi) = (P_j - c) \cdot D_j(P_j, P_k, \phi).$$

Firm j 's Bellman equation is:

$$V_j(\phi) = \max_{P_j} \{\pi_j(P_j, P_k, \phi) + \delta V_j(\phi')\}$$

where $\phi' = D_j(P_j, P_k, \phi)$. If the difference in random utility terms is logit, this model matches that of DHR, for which existence of an MPE is proven.

Steady state prices cannot be solved for analytically and require a computational solution. We save this step, both for this model and for more general variants, for future work. However, two important qualitative points about the introduction of intergenerational brand preferences to the model can still be made. First, it is clear that the markups for the type A and type B vehicles will now be equal; type B 's no longer face a price premium because firms recognize that these households will pass their preferences on to the next generation of type A 's. Intergenerational linkages limit automaker's ability to cash in on brand preference in the older (upscale, family) market.

Second, DHR finds that brand preferences lower equilibrium prices for a wide range of brand preference magnitudes. It is only when brand preferences are so large that virtually no switching occurs in equilibrium that prices increase.¹⁹ Despite the strength of the brand preferences we observe in the PSID data, it is clear that there is still substantial switching in equilibrium, strongly suggesting per DHR that brand preferences reduce automakers' prices and profits. It may seem intuitive that the brand loyalty would raise automaker profitability, but our framework suggests the opposite is more likely. When intergenerational transmission is strong, automakers will always face a pressure to invest in future market share today, which the literature suggests will outweigh the benefit to harvesting the brand loyalty for most plausible parameter values.

¹⁹Cabral (2009) provides analytical intuition for this result: as switching costs increase from zero, the incentive to invest in future customers by lowering prices is of first-order importance while the incentive to harvest profits from existing customers by raising prices is second-order.

6.2 Optimal prices in an asymmetric model

Above, we focused our attention on how the presence of intergenerational brand preferences could influence market outcomes in a symmetric duopoly model. Here, we introduce a key asymmetry – one firm competes in only one of the two product markets – in order to show how intergenerational brand preferences give firms an incentive to offer a vertical line of products. It is not surprising that, in our model, within household brand preference gives firms that wish to sell in the older, upscale B market an incentive to also offer entry level A product, in order to build brand preference.

What is less obvious, but emerges clearly from the model, is that intergenerational linkages in brand preference create the same incentive for the entry level market. A firm that wishes to compete in the entry level will benefit from competing in the upscale market because future generations of entry level consumers will have inherited a brand preference. As we discuss in greater detail below, the value of offering a full line of products accords with key facts about the evolution of the auto industry.

Our asymmetric model setup is the same here as in section 6.1, except that we assume that firm k does not offer a B type automobile. As a result, firm j is a monopolist in the B market. We do not endogenously model the decision of the k not to enter market B . This can be motivated by the marginal cost of production for firm k of a B vehicle being prohibitively high, or allowing that k must pay a fixed cost to enter the B market that proves to be too high to warrant entrance.

In period B , firm j will be a monopolist. In our prior setup, we did not have an outside good, without which the monopolist could charge an infinite price. Thus, we now assume that there is some outside good, normalized to zero. Consumers will buy the good if it has a positive net value ($V - P_{jB} + \mu 1\{b_{iA} = j\} + \varepsilon_{ijB} \geq 0$), otherwise they will choose the outside good. This creates a downward sloping demand curve for j in the B market. Let $G(\cdot)$ be the distribution of ε_{ijB} , which has finite support on $[\alpha, \beta]$.²⁰ We can write j 's demand curve, which is kinked, in the B market as follows:

$$D_{jB}(P_{jB}, \phi) = \begin{cases} 1 & \text{if } \alpha + V \geq P_{jB} \\ \phi + (1 - \phi)G(P_{jB} - V) & \text{if } V + \mu + \alpha \geq P_{jB} > V + \alpha \\ \phi G(P_{jB} - V - \mu) + (1 - \phi)G(P_{jB} - V) & \text{if } V + \beta \geq P_{jB} > V + \mu + \alpha \\ \phi G(P_{jB} - V - \mu) & \text{if } V + \mu + \beta \geq P_{jB} > V + \beta \\ 0 & \text{if } P_{jB} > \beta + V + \mu. \end{cases}$$

²⁰We assume that $\mu \leq \beta - \alpha$, although the problem merely simplifies if this assumption is violated.

For convenience, we focus on the case where j chooses a corner solution in which no one chooses the outside good, so that $P_{jB}^* = \alpha + V$. This will happen if V is sufficiently large relative to the outside good. Intuitively, this means that prices are sufficiently high so that increasing the price on all remaining customers is worth less to the monopolist than retaining the type with the lowest valuation and their descendants.

This is a convenient case to study because it means that j will capture 100% of the B market, which in turn means that the game “resets” at every A round, in which j will inherit 100% brand preference. This allows us to get analytical solutions regarding our phenomenon of interest, how an advantage in market B could influence outcomes in the A entry market.²¹ If firm j captures only a portion of the B market, because some choose the outside good, then our model will be similar, but it will remain fully dynamic and therefore not yield to analytic solutions. We focus on the case of complete market share here for heuristic value.

Under the assumption that no one chooses the outside option in the B market, the game collapses to a series of disjointed two-period games because firm j always arrives at each A period with complete market share. That is, the game has no memory beyond 2 rounds, and we can just analyze the two-period game, which will be repeated infinitely.

Consumers in the A market will be forward looking. Knowing that they will purchase a j brand vehicle in the second period, this will push them towards j in the A market, because they will gain a loyalty bonus in the second period. That is, consumer i will choose jA if and only if:

$$V - P_{jA} + \mu + \varepsilon_{ijA} + \delta E[V - P_{jB} + \mu + \varepsilon_{ijB}] \geq V - P_{kA} + \varepsilon_{ikA} + \delta E[V - P_{jB} + \varepsilon_{ijB}] \Rightarrow \\ \varepsilon_{ikA} - \varepsilon_{ijA} \leq P_{kA} - P_{jA} + (1 + \delta)\mu.$$

Because $\phi=1$ at the start of the A period, the demand curve has a single term. All consumers inherit a brand loyalty for j . And, all consumers know that they will benefit from being loyal to j in the B market, where they will certainly buy a j vehicle. As a result, consumers must be offered a significant discount or have substantially different errors to choose kA .

²¹As an alternative, we can motivate a 100% market share in the B market for firm j by supposing that it can achieve perfect first degree price discrimination when it is a monopolist. This case is slightly different from the one we focus on, but it yields a very similar final punchline. In this case, the firm will capture 100% of the market so that the game “resets” for every A . Consumers will behave myopically in the A round because any advantage they gain from establishing brand loyalty will be captured by the monopolist, and firm j will act to undercut firm k in the A market in order to boost brand loyalty in the B market, which it can harvest. Equilibrium outcomes are very similar to the ones that we describe in the high valuation case.

In this model, firm k has only a single choice, P_{kA} , made to maximize its period A profits:

$$\begin{aligned}\max_{P_{kA}} \pi_{kA} &= (P_{kA} - c) \cdot D_{kA}(P_{jA}, P_{kA}; \phi) \\ &= (P_{kA} - c) \cdot (1 - F(P_{kA} - P_{jA} + (1 + \delta)\mu)).\end{aligned}$$

Under the assumption that firm j optimally captures the whole market in B , π_{jB} will not be a function of B 's market share in period A , provided that firm k has greater than zero market demand. The reason is that the marginal consumer will be one who choose kA . So long as some one chooses kA , firm j will choose $P_{jB} = \alpha + V$ and profit will be $\alpha + V - c$, which does not depend on ϕ .

Given that, firm j 's first period problem is to choose P_{jA} to maximize first period profits:

$$\begin{aligned}\max_{P_{jA}} \pi_{jA} &= (P_{jA} - c) \cdot D_{jA}(P_{jA}, P_{kA}; \phi) \\ &= (P_{jA} - c) \cdot F(P_{kA} - P_{jA} + (1 + \delta)\mu)\end{aligned}$$

Again, because $\phi = 1$ the demand function has one term.

The first order conditions for period A prices are:

$$\begin{aligned}\frac{\partial \pi_{jA}}{\partial P_{jA}} &= F(P_{kA} - P_{jA} + (1 + \delta)\mu) - (P_{jA} - c)f(P_{kA} - P_{jA} + (1 + \delta)\mu) = 0 \\ \frac{\partial \pi_{kA}}{\partial P_{kA}} &= (1 - F(P_{kA} - P_{jA} + (1 + \delta)\mu)) - (P_{kA} - c)f(P_{kA} - P_{jA} + (1 + \delta)\mu) = 0.\end{aligned}$$

There are differences across the firms' first order conditions that result from differences in brand preference of consumers, which will lead them to have different prices.

If we assume a functional form of $F(\cdot)$, then we can solve for explicit values. Under the uniform Hotelling assumption we used in section 6.1, $F(x) = .5 + x$ and $f(x) = 1$. In that case, the equilibrium prices are:

$$\begin{aligned}P_{jA}^* &= 1/2 + c + (1 + \delta)/3 \cdot \mu \\ P_{kA}^* &= 1/2 + c - (1 + \delta)/3 \cdot \mu.\end{aligned}$$

First period demand, given equilibrium prices, is:

$$\begin{aligned}D_{jA}(P_{jA}^*, P_{kA}^*; \phi = 1) &= 1/2 + (1 + \delta)/3 \cdot \mu \\ D_{kA}(P_{jA}^*, P_{kA}^*; \phi = 1) &= 1/2 - (1 + \delta)/3 \cdot \mu.\end{aligned}$$

These equations tell us that firm k charges lower prices in market A than does firm j , but it still captures a lower market share. (Recall that $0 < \mu < .5$ in order for the problem to have an interior solution for our distributional assumption.) Thus, firm k , which has only an entry market vehicle, has lower profits in the entry market despite having identical costs as firm j , which is vertically diversified.

Firm k and firm j both think myopically, only maximizing A period profits. Two features of demand, however, create intertemporal linkages that harm k 's profitability. First, forward-looking consumers anticipate purchasing a j vehicle in the B market, and so they prefer to establish brand loyalty (to "get used to" firm j). This is an outcome of brand preference, but not of intergenerational transmission. Second, period A consumers inherit a brand preference for A from the prior generation, which has a similar impact on their preference in the A market. Because j dominates the B market, it arrives at the A market holding an incumbent advantage from inherited brand loyalty.

Both of these channels will create a barrier to entry for a firm that specializes in the entry car market. Note that, under our symmetric assumptions about demand for A and B type cars, the model would be exactly the same if we considered a firm that specialized in B cars. That is, our model suggests that brand loyalty will make either Hyundai (specializes in A) or BMW (specializes in B) be less profitable when competing against full-line automakers. Brand loyalty without intergenerational preferences could be used to explain the challenge to BMW, but without intergenerational factors, the relative challenge to Hyundai would not be based on brand loyalty from a previous period, but rather anticipated brand loyalty in the future.

6.3 Implications for the automobile market

The media in the automobile industry is filled with stories about market share, sales volumes, and conquest rates. Anecdotally, automakers are said to focus on hitting quarterly sales targets, which frequently leads them to discount vehicles and even dump some at a loss in fleet sales. The chairman of Toyota, Akio Toyoda, offered growth targets as the explanation for why Toyota had a spate of safety recalls in 2009 and 2010, telling the US Congress that "Toyota has, for the past few years, been expanding its business rapidly. Quite frankly, I fear the pace at which we have grown may have been too quick...we were not able to stop, think, and make improvement as much as we were able to before." At the time, Toyota was able to overtake GM as the global market share leader, unseating the US company for the first time in eight decades. It is natural for an economist to view the prioritization of sales volumes over profitability as a mistake.

When brand preferences are present, however, firms must make trade-offs between period profits and future profits, justifying a focus on volume. When brand preferences are transmitted intergenerationally, this enhances the importance of brand preference. It also sharply limits the automakers ability to harvest brand preference later in life, as harvesting jeopardizes the loyalty of future generations. This intergenerational linkage makes it plausible that strong competition in brand loyalty is a sort of prisoner's dilemma for the auto industry. There is a strong pressure to cut prices today to compete on market share, but it is difficult to ever reap the rewards of this customer loyalty.

Our model also harkens back to the debate over product strategies that shaped the initial competition between Ford and GM. Early in the twentieth century, Ford's strategy was to create a single vehicle that was affordable to all, driving down costs through economies of scale. There was no interest in vertical brand lines. Henry Ford famously quipped that "people can have a Model T in any color – so long as it is black." This is akin to firm k , which offers only an entry market vehicle in our model.

In contrast, GM's strategic plan was to build a variety of cars that fit people at different life stages and income levels, embodied by the famous quote from Alfred Sloan that GM would sell "a car for every purse and purpose." GM is akin to firm j in our model, which competes in the entry market but also dominates the upscale market.

The insight derived from our model is that intergenerational transmission of brand preferences will give GM an advantage in the *entry* market, the market for good A . By dominating the upscale market, GM gains an advantage in the entry market in future generations, as individuals will arrive at the entry market with a taste for GM vehicles inherited from their parents. As such, intergenerational transmission of brand preferences can cause barriers to entry, and incentives to expand, for firms locating in an entry level market where consumers might be purchasing their first vehicle.

It is intuitive to expect that brand preferences give upstream producers an incentive to develop entry level offerings that will "lead" consumers to their profitable upscale goods. The intergenerational link inverts this reasoning and shows how discount automakers will have an incentive to develop upscale product lines in order to "lead" future generations to their entry product. These forces may be useful in understanding why Ford eventually deviated from its original strategy and became a full-line automaker. And, it may help explain the slow growth of firms like Toyota and Honda in the 1980s and 1990s, and Hyundai today, who offer entry level vehicles of high quality at low prices.

Clearly, intergenerational brand preference is not the only factor that may explain why automakers have vertical product lines or care about market share, why there are barriers to entry, or why the market evolves as it does. Rather, our analysis suggests a linkage that is not

obvious *a priori*, while there may be others. But, given the strength of the intergenerational brand preferences that we document in our empirical analysis, it seems that the mechanisms related to intergenerational brand preference likely warrant greater study.

7 Ongoing Research

We have shown that brand preferences exist for vehicles and that these preferences are correlated across generations. We have also suggested that this intergenerational transmission of brand preference could have profound impacts on the structure of the automotive industry. We are currently pursuing supplementary results that reinforce and extend our findings in several directions. First, we have located a data set that details the openings and closings of auto dealers, by brand, county and year. We will use these openings and closings as instruments in order to add an instrumental variables analysis and improve our ability to distinguish among causal mechanisms.

In addition, above we focused exclusively on intergenerational preference transmission from parents to children, but the PSID allows us to also look at correlations across siblings and at preference formation that flows from children to parents. We are in the process of analyzing these relationships, and we anticipate that this additional analysis will aid us in testing auxiliary predictions of our model and testing between transmission mechanisms.

We are also building a joint discrete-choice model of *family* vehicle demand. This is a challenging problem because joint modeling rapidly expands the choice set and creates computational barriers. A discrete choice model will require us to make much stronger assumptions about the form of intrafamily brand preferences, but we believe that this exercise will complement our reduced form analysis and enable us to perform simulations that show how vehicle choice would respond to brand quality shocks or various policy interventions.

Finally, we are pursuing a numerical Markov-perfect equilibrium for our simple asymmetric model of manufacturer competition to better understand the conditions that are necessary for intergeneration transmission of brand preferences to have a substantial impact on firm pricing and product line decisions. By pairing this result with the empirical results showing that intergenerational brand preferences exist, we intend to provide considerable evidence that the intergenerational nature of preferences impacts how firms price and market product lines.

8 Conclusion

Our analysis of the PSID shows that brand persistence in the automobile sector is strong. Within household persistence makes an individual roughly twice as likely to purchase a vehicle of a particular brand if they have already purchased that brand. The strength in the correlation across households, within a family, are approximately as strong. That correlation remains economically large and precisely estimated through various specifications. Together, this paints a picture of strong brand preference that filters throughout personal networks.

The strength of brand preferences for automobiles may be surprising, as compared to similar brand persistence in other goods. Automobiles are the largest or second-largest purchase that most households make, which means that a reliance on brand as a convenient heuristic for simplifying choice seem an unlikely explanation for brand persistence. Automobiles are also highly heterogeneous goods, which makes it surprising for an individual to consistently choose models from the same brand unless brand preference (as opposed to just attribute selection) is at play.

The strength of brand preferences has important implications for industry dynamics. It suggests that market shares will evolve slowly, that firms that have experienced relative declines in quality may remain in the market for a long time, and that industry shocks will be mitigated through brand loyalty. For example, if fuel economy regulations are tightened significantly, or retail gasoline prices rise sharply, the market may shift towards firms that have a comparative advantage in fuel economy or fuel economy improvements. The shift in market shares will be mitigated by loyalty towards the incumbent firms. The effects, and welfare implications, of policies are thusly influenced by the stock of brand preferences that have accumulated at any given time.

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