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Profitability, uncertainty and multi-product firm product proliferation: The Spanish car industry

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Abstract

This article studies how product introduction decisions relate to profitability and uncertainty in the context of multi-product firms and product differentiation. These two features, common to many modern industries, have not received much attention in the literature as compared to the classical problem of firm entry, even if the determinants of firm and product entry are quite different. The theoretical predictions about the sign of the impact of uncertainty on product entry are not conclusive. Therefore, an econometric model relating firms' product introduction decisions with profitability and profit uncertainty is proposed. Firm's estimated profits are obtained from a structural model of product demand and supply, and uncertainty is proxied by profits' variance. The empirical analysis is carried out using data on the Spanish car industry for the period 1990-2000. The results show a positive relationship between product introduction and profitability, and a negative one with respect to profit variability. Interestingly, the degree of uncertainty appears to be a driving force of entry stronger than profitability, suggesting that the product proliferation process in the Spanish car market may have been mainly a consequence of lower uncertainty rather than the result of having a more profitable market.

Keywords: Product introduction, entry, uncertainty, multiproduct firms, automobile

JEL codes: L11, L13

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1 Introduction

One of the main economic rationales for decisions of entry in a new market is profitability. The neoclassical theory of firm entry or investment is based on the net present value criterion, by which a firm will invest in new capital when it expects a non-negative stream of profits from that investment. Nevertheless, this may not be only motivation. For instance, following Dixit (1989), the literature has paid an increasing attention to the influence of uncertainty or investment irreversibility on firm's entry decisions, both from a theoretical and an empirical perspective. For example, Ghosal (1996) finds evidence that in several US manufacturing industries greater price uncertainty significantly reduces the number of firms.

However, the evidence on the determinants of new product introductions by multi-product firms is much more scarce. It seems natural to think that profitability will favor product entry, but it is not clear that more uncertainty could delay the introduction of a new product. Firstly, the fact that a firm is risk averse when deciding about entry does not necessarily imply that it has to show the same risk aversion for the commercialization of new products. One could think for example that a consolidated multi-product firm can go for a new, risky product to search for new market opportunities or enhance the image of the firm as a whole, counting on the support of its other products in case things go wrong. Secondly, apart from profitability and uncertainty, there could also be other strategic considerations underlying the decisions of product introduction, such as acquiring an early mover advantage or gaining market positioning. For instance, the real options literature on firm entry has recently recognized that uncertainty may have a positive effect on entry when any of these factors take place (Folta & O'Brien, 2004). In other words, the impact of uncertainty on entry is not clear and moreover the determinants for firm entry can be diverse and they need not be the same, a priori, than those for product introduction. Therefore, this paper contributes to fill the gap in the literature on the determinants of new product introduction by looking at its relation with profitability and uncertainty, a question that has received little attention. For that purpose the Spanish car market in the 1990's is considered. This is one of the most important car markets in Europe, showing high rates of product entry by multi-product global firms.

A reduced form econometric model where product introduction decisions are explained by profitability and profit uncertainty is proposed. It is not often the case where one can have a direct measure of profitability at the product level. In this case, such information is not available and therefore it is necessary to estimate a structural model of demand and supply in order to obtain estimates of profits that can then be used as explanatory variables in the econometric model. The demand side is modeled using the random utility framework, where the consumer buys only one unit of the product deciding first the segment and then choosing a model within that segment. The supply side is based on a model of multi-product price competing firms. The first order conditions for profit maximization can be rearranged to express profits as a function of market shares and demand parameters. Therefore, estimates for profits can be recovered from observed variables and estimated demand parameters. Then, the decision of introducing a new product can be modeled as a probit of entry on estimated profits and their variance (as a proxy for profit uncertainty). It is important to note that the data allows for the computation of product-specific measures of profitability and uncertainty, contrary to what happens for example, in many papers of the real options literature, where risk is usually proxied by the volatility of macroeconomic or industry specific variables of interest. In this way, the link between entry and profitability and uncertainty can be established much more clearly because both the dependent and explanatory variables refer to the same level of decision. The results show a positive relationship between profitability and product introduction, as expected, but they also show a negative relationship between entry and profit volatility. Interestingly, it seems that this second factor could have even more importance than profitability itself at the time of making the decision of entry. In other words, the results suggest that entry could be more likely in segments with lower variance of profits even if those segments are less profitable.

This paper relates to several branches of the literature on the determinants of entry. The empirical evidence shows a positive relation between firm entry and profitability (Siegfried & Evans, 1994), a negative relation between entry and uncertainty (Ghosal,

1996) although theoretical results are not so conclusive (see for example Appelbaum & Katz, 1986). At the product level evidence and results are much more scarce. Schmalensee (1978) analyzes the conduct in the ready-to-eat cereal industry with antitrust concerns, considering the introduction of new varieties as a tool for entry deterrence. This industry is revisited by Hitsch (2006) who builds a model of optimal product launch and scrappage in which both the degree of profitability and uncertainty have a positive effect on the number of products introduced. The intuition is that by launching a new product the firm gets some information about its profitability which is valuable for the firm, on top of the eventual profit made with the product itself. The higher the uncertainty the higher the value of that information. Therefore, in the context of increasing uncertainty it might be optimal to introduce more products to get more information about the market. Hitsch finds evidence of such type of behavior in the ready-to-eat cereal industry. However, the author recognizes that "the results cannot be simply generalized to any other market" (p.42) and it could be the case that for other industries the simple story of risk aversion holds at the product level, implying that more uncertainty leads to lower product introduction. Therefore it is important to have alternative evidence to shed more light on this question.

The literature on entry and competition in oligopolies has proposed frameworks to explain the number of firms a market can sustain and how many can enter/exit (Bresnahan & Reiss, 1991). It is possible to find two-stage models where first firms decide on entry and then compete (for example Berry, 1992 for the airline industry or Mazzeo, 2002 for the motel industry). Profits drive the decision of entry, and variable profits are function of market characteristics and market structure but do not explicitly depend on firms' strategies. Other papers propose models where profits depend more explicitly on firms' actions. For example, Ishii (2005) models banks' decisions on ATM network size. In Seim (2006) firms first decide on entry and then they differentiate by choosing geographic location. A general discussion of papers in this literature can be found in Toivanen & Waterson (2000). This paper is related to that literature in the sense that a structural model for the (second) stage of firm competition is also proposed. However, the approach here is different because that stage is not embedded into a structural model of entry. The econometric relationship between entry decisions and probability and uncertainty is estimated in order to determine their respective influence in explaining observed entry rates.

Finally, this paper is also related to the real options literature on entry, which emphasizes the role of uncertainty as a deterrent of entry in combination with the degree of irreversibility of the required investment (see Folta *et al.*, 2006, for a recent example). The there focus has been, however, on the impact of profitability and uncertainty over firm entry in new industries, in new markets (Daunfeldt *et al.*, 2010), or on the impact over R&D decisions (Weeds, 2002). Their impact over firms' product proliferation decisions has been hardly treated. As mentioned before, this literature has recently started to question the monotonic negative relation between entry and uncertainty by exploring the positive effect that uncertainty may have on entry through the countervailing effect of "options to grow" (Folta & O'Brien, 2004) or the "fear of preemption" (Weeds, 2002). This paper is therefore aimed at clarifying what would be the impact of uncertainty on entry in the context of new product commercialization by multi-product firms.

Previous works have explored the influence that various factors have over entry or exit decisions in automobile markets. However, they do not consider uncertainty as a key determinant of such decisions. For example, Geroski & Murfin (1991) use a probit model to estimate the probability of entry in the UK car market as function of post-entry advertising shares. They find evidence that usually entrants go first to the higher segments and then to the smaller ones. Moreover, prior experience in the market has a small effect on entry. Geroski & Mazzucato (2001) explain entry as a function of advertising in the US automobile market. Requena-Silvente & Walker (2005) study the relation between model survival and competition in the UK. They find evidence that intra-firm competition determines the exit of car models in small and large family cars, while in the luxury/sport segment the relevant factor is inter-firm competition. The Spanish market has been studied from the point of view of pricing behavior (Jaumandreu & Moral, 2008), the role of advertising (Barroso, 2007) or the computation of quality adjusted price indexes (Matas & Raymond, 2009).

The paper is organized as follows. Section II describes the Spanish car industry and the massive product introduction process that took place in the decade of the 1990's. Section III presents the theoretical background underlying the empirical implementation, which is described in section IV. The results are presented and discussed in section V. Section VI concludes.

2 The process of product proliferation in the Spanish car market during the 1990's

2.1 Data description

I use a unique database of monthly car registrations in Spain over the period 1990-2000 (see Moral & Jaumandreu, 2007, for a detailed description of the data). The unit of observation is a car model as defined by its commercial name. The data set records the number of registrations, price and characteristics (such as power, speed, fuel consumption, size, Anti-lock Braking System (ABS) or air conditioning (AC) among others) of each car model sold in Spain on a monthly basis (16363 observations in total). Table 1 describes the characteristics used and their units of measure. The sample is filtered to exclude superluxe models (e.g. Ferrari, Rolls Royce) and cars with less than 10 registrations per month. Nevertheless, the sample covers more than 99% of total registrations during the sample period. Models are grouped in a 8-segment classification according to industry sources[1]: Small-Mini, Small, Compact, Intermediate, High-Intermediate, Luxury, Sport, and Minivan. I use these data for demand estimation.

Product entry is frequent during the sample period but having data in a monthly frequency would lower its importance. It seems more natural to think that firms will plan their product launching decisions having as reference a longer period of time. Moreover, the various segments could be considered to some extent as different markets, and firms

[1]See for example the industry report for Spain, ANFAC (2006).

may have different plans of product introduction for each of them. Therefore, in order to embody these two considerations, the original dataset is collapsed into another one where each observation corresponds to one firm (brand) in a given segment and year. If a firm does not have any car model at all in a given segment and year this particular combination does not count as an observation. Some firms enter the Spanish market during the decade and therefore they are not present at the beginning of the sample in any segment. Also, not all the incumbent firms are present in all segments from 1990. Therefore, this gives as a result an incomplete panel of 1073 observations (the *entry dataset*). A dummy variable, '*enter*', taking value 1 if a given brand has introduced a new model in a given segment and zero otherwise[2] is constructed in order to explore the relation between entry and profitability and uncertainty. Similarly, a variable '*exit*' can be constructed to record firms' product exit decisions. Firm's estimated profits in each segment and year are constructed from estimated demand parameters and first order conditions of firm profit maximization.[3] The variance of estimated profits is used as a measure of uncertainty.

2.2 Product introduction patterns in the Spanish car market

The period 1990-2000 shows an increasing trend in the number of models marketed (Figure 1). There are at least two potential explanations for this fact. Firstly, the opening of the Spanish market to foreign producers as a result of becoming a member of the European Community. Secondly, there is an intense process of product proliferation. I look at each one in more detail. The entry of Spain in the European Community implied a progressive reduction on the tariffs for imported cars in order to converge to the rates applied in the Union. This fostered the entry of many foreign producers.[4] The evolution of tariffs is shown in Table 2. 1993 is the critical point where tariffs stabilize at their minimum.

[2]Some brands introduce sometimes more than one model per year. However, they usually introduce just one model at the year-segment level. Therefore, it is reasonable to model the decision of product introduction with a dichotomous variable (in the entry data set, the proportion of no entry decisions is of 84.16%, the proportion of decisions of introducing one model in a given year-segment is of 14.91% and the proportion of decisions of introducing two models in a given year-segment is of 0.93%).

[3]See subsection 3.2 below.

[4]Firms with production plants in Spain are considered domestic, no matter their country of origin or ownership. European producers are those producing in Europe but not in Spain. All remaining firms are classified as non-European firms.

However, this does not appear to have a striking influence on the number of models marketed. Even if we consider that the introduction of a new model by a newcomer could be delayed until a commercial network is developed, i.e., effective entry may take some time after liberalization, this lag is not enough to explain the phenomenon of entry because the end date of commercial barriers was known and could have been anticipated. Figure 1 clearly shows how after 1996 the introduction of models speeds up, mainly due to the intense product proliferation in all segments (Figure 2), specially in the Compact and High-Intermediate ones. The entry dataset allows the computation of the rate of introduction of new products. Each firm could virtually decide to commercialize a new product every year in each of the segments where it is present. In practice, firms do not introduce new products every year, so we can define a rate of product entry as the percentage of entries over the total number of decisions to be made. In mathematical terms this is just the average of the dummy variable '*enter*'. The rate of product entry is around 15% (Table 3) meaning that in a 15% of cases where the firms had the opportunity to introduce a new product they actually did it. This ratio is quite stable across segments and, with the exception of the Minivan segment, it ranges from 12.5% in the luxury segment to the 16.4% of the compact segment. By economic origin domestic firms have a proportion of entries of 10% for a 20% of foreigners. Domestic firms, already present in most segments, just make a replacement effort and eventually enter new segments. By contrast, foreign firms (especially Asian) enter the Spanish market and also have to undertake model replacement.

Almost all firms maintain or increase the number of models for sale in the sample period, which is a clear indicator of the product proliferation process that takes place during the decade. The newcomers tend to enter as many segments as they can. For example, 6 out of 8 firms with no activity before January 1990 were present in at least 3 segments by the end of 2000 (e.g. Hyundai or Kia). The incumbents (e.g. Peugeot, Ford, Volkswagen) try to reinforce their presence in the market by either increasing the number of models for sale and the number segments where they are present, or with an intensive activity of product replacement. The process of exit decisions shows a more stable pattern over time (Figure 1).

In summary, apart from trade liberalization, there are at least two reasons behind the entry and exit decisions of each producer: i) Product replacement decisions. Some product entry decisions are eventually followed by product exit of the same firm. The lifetime of a car model is limited and firms must keep on renewing their range of products in order to satisfy consumers' needs. The particular conditions of the market, such as profitability or uncertainty, surely determine the pace at which this entry for replacement occurs. ii) Net entries of firms in segments where they were not present. This is related to the emergence of new segments, for example the appearance of the Minivan or the increasing popularity of urban cars (Small-Mini segment). In general, product introduction patterns differ across segments and over time, probably as a reflection of firms' perception of potential profitability.

3 Theoretical background

3.1 Consumer's behavior

The demand side is based on random utility theory. Each consumer buys only one unit of the good, choosing the one that maximizes her utility, which depends on the price and characteristics of the product and on some idiosyncratic shock to preferences. Given that the Spanish car market shows a clearly segmented structure a nested logit approach is used to model the demand side. This means that consumer's tastes have a common component for products in the same group, allowing for richer correlation patterns than in the standard multinomial approach. Consumers first choose their preferred segment and then they choose a model within that segment. Among the various expositions of the nested logit present in the literature, I will follow the one proposed by Berry (1994). Thus, the utility that consumer i gets from product j can be expressed as: $U_{ij} = x_j\beta - \alpha p_j + \xi_j + \zeta_{ig} + (1-\sigma)\,\epsilon_{ij}$, where p, x and ξ are, respectively, prices, (a vector of) observed and unobserved product characteristics, ζ_g is a common factor to all products in group g , $\sigma \in [0,1]$ is a similarity parameter (as σ goes to one the degree of substitutability between products in a group increases, meaning that the groups are formed by similar products) and ϵ is a idiosyncratic shock to utility following an extreme value distribution. β represents consumers' valuation of observed characteristics and α is the marginal utility of income. Then, the choice probability of product j conditional on being in group g is:

$$s_{j/g} = \frac{\exp\left(\frac{x_j\beta-\alpha p_j+\xi_j}{1-\sigma}\right)}{\sum\limits_{j\in G_g}\exp\left(\frac{x_j\beta-\alpha p_j+\xi_j}{1-\sigma}\right)} \tag{1}$$

and the probability of choosing group g:

$$s_g = \frac{\left[\sum\limits_{j\in G_g}\exp\left(\frac{x_j\beta-\alpha p_j+\xi_j}{1-\sigma}\right)\right]^{1-\sigma}}{\sum\limits_{g}\left[\sum\limits_{j\in G_g}\exp\left(\frac{x_j\beta-\alpha p_j+\xi_j}{1-\sigma}\right)\right]^{1-\sigma}} \tag{2}$$

and therefore the choice probability of product j is the product of both:

$$s_j = s_g \cdot s_{j/g} \tag{3}$$

Denoting by M the market size it turns out that total demand will be: $D_j = Ms_j$. The outside good is assumed to be the only product of its group and its utility normalized to zero. Therefore, its market share is given by:

$$s_0 = \frac{1}{\sum\limits_{g}\left[\sum\limits_{j\in G_g}\exp\left(\frac{x_j\beta-\alpha p_j+\xi_j}{1-\sigma}\right)\right]^{1-\sigma}} \tag{4}$$

3.2 Firm's behavior

Each firm sells several models and competes in prices, internalizing the substitution effects among its own products. In general, we can expect that profitable products will be introduced, and non-profitable ones will be discarded, suggesting a positive relationship between entry and profitability. However, given that firms are multi-product and that they care about the maximization of total profits (not only the profit derived from the particular product to be introduced) it could be the case that introducing certain products is the best option for the firm even if they are not the most profitable alternatives. In this case the positive relation between entry and profitability could be broken. Therefore, from a theoretical point of view we have two opposite effects. The volatility of profits (uncertainty) also plays a role in this setup because higher volatility implies higher chances that realized profits depart from the expected ones. This could discourage entry if firms are risk averse.

The profit function for firm f is the sum of profits from each product j it owns:

$$\pi_f = \sum_{j \in G_f} (p_j - c_j)\, M s_j\,(p_1, \ldots, p_J, x_1, \ldots x_J) - F_f = \sum_{j \in G_f} \pi_j^v - F_f \tag{5}$$

where Π_j^v denotes the variable profit from product j . c_j represents a constant marginal cost of commercialization of good j. F_f is the fixed cost of firm f. G_f denotes the set of products of firm f and J is the total number of products. Therefore, the firm internalizes the impact of decisions on product j through the demand side. The first order conditions of profit maximization imply:

$$s_j + (p_j - c_j)\frac{\partial s_j}{\partial p_j} + \sum_{k \neq j,\ k \in G_f} (p_k - c_k)\frac{\partial s_k}{\partial p_j} = 0 \quad j = 1, \ldots, J \tag{6}$$

where the derivatives are given by:

$$\frac{\partial s_j}{\partial p_j} = -s_j \left[(1 - s_g)\, s_{j/g} + \frac{1}{1-\sigma}\left(1 - s_{j/g}\right) \right] \alpha \tag{7}$$

$$\frac{\partial s_k}{\partial p_j} = -s_j \left[(1 - s_g)\, s_{j/g} - \frac{1}{1-\sigma} s_{j/g} \right] \alpha \tag{8}$$

$$\frac{\partial s_k}{\partial p_j} = \alpha s_k s_j \tag{9}$$

This system of J equations is easier to solve if we use matrix notation. Following

Berry *et al.* (1995), let $\mathbf{\Delta}$ be a $J \times J$ matrix with elements of the form:

$$\mathbf{\Delta}_{jr} = \begin{cases} \frac{-\partial s_r}{\partial p_j}, & \text{if } r \text{ and } j \text{ are produced by the same firm} \\ 0\ , & \text{otherwise} \end{cases} \tag{10}$$

Then the first order conditions (6) can be written as:

$$\mathbf{S} - \mathbf{\Delta}\left(\mathbf{P} - \mathbf{C}\right) = 0 \tag{11}$$

such that the vector of price-cost margins can be expressed as: $\mathbf{P} - \mathbf{C} = \mathbf{\Delta}^{-1}\mathbf{S}$. Then we can multiply the price-cost margins by market size and the vector of market shares to obtain the vector of variable profits for each product j , $\mathbf{\Pi}^v = \left(\pi_1^v, \ldots \pi_j^v, \ldots \pi_J^v\right)'$:

$$\pi^v = M\left(\mathbf{P} - \mathbf{C}\right) .* \mathbf{S} = M\left(\mathbf{\Delta}^{-1}\mathbf{S}\right) .* \mathbf{S} \tag{12}$$

where $.*$ denotes the element-by-element product operator. Equation (12) shows that we can express variable profits as a function of observed market shares and estimated demand parameters (present in the matrix of derivatives $\mathbf{\Delta}$) without the need of computing marginal costs. This will be the key expression to compute the profitability variable for the probits of entry. The vector of total profits will then be:

$$\pi^v = M\left(\mathbf{\Delta}^{-1}\mathbf{S}\right) .* \mathbf{S} - \mathbf{F} \tag{13}$$

where $\mathbf{F}$ denotes the vector of fixed costs.

4 Empirical strategy

The estimation strategy proceeds in two steps. First, the demand for cars is estimated to obtain parameter estimates for the marginal utility of income and the degree of similarity. Then, they are plugged in $\mathbf{\Delta}$ and (12) to get estimated profits for each product in the sample, and also their variance. In the second step the entry dataset described in subsection 2 2.1 (including the measures of profitability and uncertainty of the first step) is used to fit a probit of entry on profitability and volatility.

4.1 Demand estimation

Berry (1994) shows that it is possible to obtain an analytical inverse of market shares which is linear in parameters, allowing the use of standard regression techniques in the estimation of the nested logit. More precisely, taking logs on the ratio $\frac{s_j}{s_0}$ yields, after some algebra, the estimation equation:

$$\ln s_j - \ln s_0 = x_j\beta - \alpha p_j + \xi_j + \sigma \ln s_{j/g} + \varepsilon_j \tag{14}$$

where ε is an econometric error term. Assuming that unobserved product characteristics are time invariant implies we can treat ξ_j as a product fixed effect.[5] This also allows the unobserved product effect to be correlated with the observed product characteristics. The panel structure of the data can then be exploited by using the so called within estimator, which removes the fixed effect through time demeaning of equation (14), thus allowing consistent estimation of β, α and σ.

The set of product characteristics includes the size of the car, power, fuel efficiency measured in kilometers per liter of fuel and dummies for air conditioning and ABS. p and $\ln s_{j/g}$ are interacted with dummies for segment (DG_g) to estimate segment-specific price coefficients and similarity parameters. A control for the existence of tariffs is also included. Therefore, the equation taken to the data is:

$$\begin{aligned}\ln s_j - \ln s_0 &= \beta_0 + \beta_1 carsize + \beta_2 HP + \beta_3 KmL + \beta_4 AC + \beta_5 ABS - \sum_g \alpha_g p_j DG_g \\ &+ \sum_g \sigma_g \ln s_{j/g} DG_g + \beta_6 Tariffs + \xi_j + \varepsilon_j\end{aligned} \tag{15}$$

[5]The Hausman test comparing the fixed effects and the random effects estimators clearly rejects the null hypothesis that random effects are adequate.

Both p and the conditional market share are endogenous so the use of instrumental variables techniques is required. The set of instruments includes the number of products in each segment, the characteristics of the product (x_j's), the sum of characteristics of other products of the firm $\left(\sum_{k \neq j, k \in G_f} x_k \text{ 's}\right)$ and the sum of characteristics of products of other firms $\left(\sum_{k \notin G_f} x_k \text{ 's}\right)$, as proposed in Berry *et al.* (1995). In addition, the 12-month-lagged deviation of prices with respect to their individual time mean is included,[6] as proposed in Bhargava & Sargan (1983). The set of instruments is interacted with segment dummies, as are the endogenous variables. The parameters of the model are identified through variation of product characteristics, prices and market shares.

4.2 Probits of entry and exit

Plugging the estimated α's and σ's into equation (12) we can construct a measure of profitability of each car model in each period of time. We are interested in knowing how firm's new product introduction relates to profitability and uncertainty. The important thing is not the level of profits itself, but how profits vary across firms and with product entry decisions, which is what will allow the identification of the sensitivity of entry to variations in the degree of profitability and uncertainty.[7] As argued above, it seems more appropriate to perform this analysis on a yearly basis at the brand level because we are interested in firm's incentives for product entry, and not just on the incentives for introducing a particular product. It also seems reasonable to assume that firms take the natural year as the reference point for their commercialization plans. I distinguish entry decisions across segments because they can be seen as separate, though related, markets, and therefore entry patterns could differ too.

[6]For instance, $\tilde{p}_{it}$ lagged 12 months is used as instrument, where $\tilde{p}_{it} = p_{it} - \frac{1}{T_i} \sum_{t=1}^{T_i} p_{it}$, and T_i is the number of time observations of good i.

[7]Notice that profitability here is computed from Equation (12) and therefore the fixed costs will be implicitly subsumed in the constant term of Equation (16) below and will not be explicitly recovered. The objective of this probit analysis is to assess the impact that the variability in profitability has on entry decisions, rather than the explicit recovery of fixed costs.

Therefore, using the entry dataset I propose an econometric model which explains the firm's decision to introduce a new product as a function of firm's profits (π) and profits' volatility (σ^{π}), adding controls for year, segment, the existence of tariffs and origin of car producer. Given that the decision of entry is made before the effective introduction of the product takes place, profits and variances are lagged one period. Current profits and variables are also added to test the relation between entry and post-entry profits. More specifically, the estimating equation is:

$$\Pr\left(entry_{it}=1\right)=\Phi\left(\theta_0+\theta_1\pi_{it-1}+\theta_2\sigma^{\pi}_{1t-1}+\theta_3\pi_{it}+\theta_4\sigma^{\pi}_{1t}+\mathbf{Z}_{it}\phi\right) \tag{16}$$

where Φ is the standard normal cumulative distribution function and $\mathbf{Z}$ is the vector of control variables.

We can also use the same approach to study the probability of exit. In this case, the appropriate measures of profitability are current profits (and their variance) because the exit decision is made at the end of the period, after the firm has earned the correspondent amount of profits:

$$\Pr\left(exit_{it}=1\right)=\Phi\left(\delta_0+\delta_1\pi_{it}+\delta_2\sigma^{\pi}_{1t}+\mathbf{Z}_{it}\lambda\right) \tag{17}$$

5 Results

The results of demand estimation are presented in Table 4. All coefficients have the expected signs and are accurately estimated, with the exception of the coefficient on fuel efficiency and the price coefficients of segments Small-Mini and Small. The similarity parameter of the Minivan segment is very small, perhaps due to the fact that this was a segment that appeared in the Spanish market during the 1990's and the type of cars that entered this commercial category at the beginning were probably more diverse than others in more mature segments. The higher standard error of that coefficient reinforces this impression. Apart from that, the other similarity parameters are quite high, suggesting that the segment classification in the industry is actually consistent with what we observe in the data. The Sargan-Hansen test for overidentifying restrictions has a *p-value* of 0.1, thus we cannot reject the null hypothesis that the instruments are valid.[8]

The estimated price coefficients and intra-group correlation parameters are plugged into equation (12) along with market shares to obtain variable profit estimates. The estimated yearly variable profits for the whole national industry range from approximately 5000 million euro in 1993 to around 8800 million euro in 1999. This is an estimate of the aggregate variable profits of the car commercialization vertical chain that goes from the wholesale level of the factory tier to the car retailing level. It is difficult to find comparable figures for car commercialization activity aggregated at the brand level. Nevertheless, Rodrguez Enrquez (2002) reports accounting profits for a sample of Spanish car dealer firms in 2000, which would represent just part of the total profit of the whole retailing chain. A conservative extrapolation of his results to a national level would imply aggregate profits of around 450 million euro for the sector of small car retailers. In order to make a comparison with the estimated profits in this paper we should therefore add to this figure the amount of profits that brands earn from selling to their networks of retailers and all the fixed costs involved. Altogether, it seems that the value of estimated variable profits, even if being high, may be reasonable.[9]

Table 5 reports the marginal effects at the means of the explanatory variables resulting from alternative probit specifications.[10] Higher profits in $t-1$ increase the probability of

[8]The final set of instruments if formed by: the number of products, the 12-month-lagged time-demeaned prices, the sum of carsize, HP, KmL, AC and ABS for other products of the firm, the sum of AC and ABS for products of other firms. All of them interacted with dummies for segment. In order to not have too many overidentifying restrictions the interacted sum of carsize, HP and KmL for products of other firms has been dropped. It turns out that this particular choice of instruments does not have an impact on results. Many possible combinations of instruments have been tried with similar results. This particular set has been chosen just because it yields more accurate estimates and has a Sargan-Hansen statistic with a higher *p-value*.

[9]Anecdotal evidence from the industry suggests that actual margins, understood as the difference between consumer and factory prices, are in line with the estimated margins implied by demand estimation in Table 4. See for example http://www.elmundo.es/elmundomotor/2006/12/11/empresas/1165842875.html, where the president of Opel admits margins of 5000 euro per unit in its Opel Astra model.

[10]A random effects probit model was also estimated as an additional robustness check, exploiting the panel structure of the data, i.e., $\Pr\left(entry_{it}=1\right)=\Phi\left(\theta_0+\theta_1\pi_{it-1}+\theta_2\sigma^{\pi}_{1t-1}+\mathbf{Z}_{it}\phi+\nu_i\right)$, where ν_i is a time-invariant individual random effect normally distributed, $\nu\sim N\left(0,\sigma^2_{\nu}\right)$, assumed to be independent of the other explanatory variables. However, the results were similar and a likelihood-ratio test comparing the pooled and the panel probits fails to reject the null hypothesis that the estimates are equal, so I omit the presentation of these results.

introducing a new product in t , and higher volatility of profits in $t-1$ has the opposite effect. Therefore, in the basic specification (1), the coefficient of 5.03×10^{-7} on lagged profits [11] means that and increase in profits of 10 million euros rises the probability of entry by 0.503% . These results show that automobile firms are less willing to introduce new products in segments of lower profits perspectives, as a decrease in profitability implies a decrease in the probability of product entry. On the contrary, lower volatility favors the commercialization of new products. We can interpret this as evidence of some risk aversion of the firm. A firm maximizing the expected discounted value of future profits could think that an increase in today's profitability is transitory if volatility is also high, and therefore be less willing to introduce a new product because its expectations of future profitability are lower. These results also suggest that, for this sample, new product commercialization decisions of automobile firms do not seem to be primarily driven by strategic reasons other than profitability, as could be for example obtaining better information of the market, better brand positioning, or exploiting options of growth. The results are compatible with a view of car manufacturers as firms caring for the recovery of their (usually large and sunk) investments, contrary to other industries where entry may be easier and other strategic considerations in the management of the portfolio of products may have more weight.

Entry decisions are also likely to be related to current profits and volatility. Their inclusion in specifications (2)-(7) shows that the relationship is the opposite to the lagged ones. Higher profits in t are negatively related to the probability of entry. If lagged profits foster entry next period then we could expect that more competition will reduce profitability leading to this negative correlation. In the same line, the variance of profits increases, leading to a positive relation between current volatility and entry. It is interesting to note that this relation between entry and profitability and volatility is robust to the introduction of several control variables. Adding controls for origin, tariffs, segment or year effects do not alter the qualitative relation between entry and profitability/volatility, and

[11] Profits are measured in thousand euros.

quantitatively they become higher and more precise as standard errors are now lower.[12] The estimates in Table 5 show for instance that being a non-domestic brand has a positive impact on the probability of introducing new products while the existence of tariffs has a negative one. For segments, it seems that only luxury and sportive cars have a negative impact on the probability of entry as compared to high-intermediate cars, the base segment.

In order to provide a complementary view to the analysis of entry decisions, Table 6 shows the marginal effects of the probit model of exit decisions. It is clear that the higher the profits in period t the lower the probability of making an exit decision that period, and also as volatility increases the probability of exit increases as well. These results are robust to the inclusion of alternative control variables and they are coherent with the interpretation of the results for the probits of entry.

The coefficient estimates show that higher lagged profitability and lower lagged volatility both favor entry, but it is difficult to infer which one is the leading factor in influencing product entry decisions (both marginal effects are quite similar across specifications). In order to address this question Figure 3 plots the relation between the number of entries and estimated profits and volatility, by segment. Each plot depicts how the ranking of the segment in profitability, volatility and entry has evolved during the decade. For example, we can see that the Small segment in 2000 was ranked in first position among all segments in profitability, it was the third in number of entries that year and the fifth in terms of profits variance. As it was argued above, it is the variability across brands and segments what allows for the identification of the model, not the levels. Therefore, by looking at rankings we can get some additional insight on the relation between entry and profitability if we observe variability across segments and years. The plots show that there is not much variability in the ranking in profitability, according to the model estimates the Small segment is always the most profitable and the High-Intermediate always the second

[12] This qualitative relation between entry and lagged profits/volatility and current profits/volatility also holds if they are not used in the estimating equation. Running specifications (2) - (7) without current profits and volatility still yields the same signs for the coefficients of lagged profits and volatility. The same occurs if lagged profits and volatility are dropped instead.

most profitable. Surprisingly, the Compact segment is almost always the fourth in terms of profitability, while being on the top in total number of entries (Table 3) and almost always the first or the second in the yearly ranking of entry. The issue becomes more interesting if we look at the evolution in the rankings of profit volatility, then it is quite clear that all segments tend to be higher ranked in terms of product introduction when they are ranked lower in terms of lagged volatility (i.e., when their volatility is higher). As the variability in the ranking of profitability is very small for all segments, this suggests that what is influencing the most the process of new product introduction is actually the level of profit variance or uncertainty, rather than profitability. This approach does not constitute a formal hypothesis test but it provides a clear insight on the issue. The fact that a market is highly profitable over time will not guarantee alone product proliferation if uncertainty is also very high.

6 Concluding remarks

The literature on entry has mainly focused on the determinants of firm entry in a market, as for example profitability and uncertainty. Less attention has been paid to the determinants of the introduction of new products in the context of multi-product firms. This paper contributes to this line of research by determining how profitability and volatility relate to new product introduction in the Spanish car industry. The multi-product dimension adds additional strategic considerations to the simple criterion of entering a market if it is profitable and staying out otherwise, because firm's decisions could sometimes be motivated by a global strategy and not just by the profitability of the particular product alone. The relation between entry and profitability becomes in this case an empirical question.

It is usually difficult to obtain direct measures of profitability at the firm level, and perhaps even more difficult at the product level. Here, a two-step approach is proposed where first, estimates of relative profitability across products are obtained from a model of product demand and supply, using just data on prices, shares and product characteristics. These estimates can then be used in a second step to estimate a reduced form model of the probability of entry as a function of profitability and profit volatility.

The results indicate that higher profitability and/or lower profit variance rise the probability of introducing new car models, while lower profitability or higher volatility increase the probability of making an exit decision. The results also suggest that profits will diminish after entry takes place due to increased competition. Interestingly, profit volatility seems to be a more important determinant of entry decisions than profitability. This suggests that the product proliferation process witnessed by the Spanish car market, specially during the second half of the 1990's, may have been a consequence of lower uncertainty rather than the result of having a more profitable market. In this sense, we could say that the expansion of the market would be more favored by following policies oriented to the development of a stable business framework than it would be by just using profitability enhancing policies.

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Tables

Table 1. Characteristics and units of measure

Characteristic:	Description
Real price	Thousand euros
CarSize	Length times width (m^2)
HP	Itself
KmL	Kilometers per liter
AC	Dummy for Air conditioning
ABS	Dummy for ABS

Table 2. Evolution of Tariffs

Spain	Tariffs on cars from:	1990	1991	1992	1993 onwards
	EU	12.4	8.3	4.1	0
	Non EU	23.6	18.7	13.8	10.3

EU	Tariffs on cars from:	1990	1991	1992	1993 onwards
	EU	0	0	0	0
	Non EU	10.3	10.3	10.3	10.3

Table 3. Rate of new product introduction by segment and firm origin

Segment	Domestic (%)	European (%)	Non-European (%)	Total # entries
Small-Mini	14.8	16.7	.	7
Small	6.5	18.6	24.3	22
Compact	10.8	19.2	20.3	32
Intermediate	17.9	14.9	15.8	17
High-Intermediate	6.3	16.5	17.9	27
Luxury	3.8	18.8	13.9	22
Sport	18.2	12.0	16.7	17
Minivan	16.3	36.4	40.5	26
Total	10.3	17.4	21.3	170

Table 4. Demand estimation results. Fixed effects (within) IV regression

Real price coefficients:		Coefficient	Std. Err.
	Small-Mini	-0.0688	0.0666
	Small	-0.0282	0.0305
	Compact	-0.1638	0.0181
	Intermediate	-0.1059	0.0234
	High Intermediate	-0.0938	0.0132
	Luxury	-0.0630	0.0084
	Sport	-0.1310	0.0132
	Minivan	-0.1793	0.0226
Intra-Group correlation:			
	Small-Mini	0.7767	0.0275
	Small	0.6798	0.0480
	Compact	0.7436	0.0283
	Intermediate	0.7643	0.0247
	High Intermediate	0.2867	0.0408
	Luxury	0.9507	0.0317
	Sport	0.5529	0.0478
	Minivan	0.0330	0.0293
Characteristics:			
	Car Size	0.2146	0.0244
	HP	0.0091	0.0006
	KmL	0.0062	0.0045
	Air Conditioning	0.0386	0.0177
	ABS	0.1841	0.0174
	Constant	-10.0873	0.2441
Controls:			
	Tariffs	0.0528	0.0024

Table 5. Marginal effects for alternative probit specifications

VARIABLES	(1) Pr(entry)	(2) Pr(entry)	(3) Pr(entry)	(4) Pr(entry)	(5) Pr(entry)	(6) Pr(entry)	(7) Pr(entry)
Lagged profit	5.03e-07	2.03e-05	2.02e-05	1.89e-05	1.92e-05	1.94e-05	1.88e-05
	(2.40e-06)	(4.10e-06)	(4.18e-06)	(4.29e-06)	(4.29e-06)	(4.22e-06)	(4.30e-06)
Lagged volatility	-6.27e-06	-2.96e-05	-2.85e-05	-2.71e-05	-2.81e-05	-2.87e-05	-2.82e-05
	(7.32e-06)	(1.01e-05)	(9.70e-06)	(9.38e-06)	(9.87e-06)	(9.85e-06)	(9.91e-06)
Current profit	-	-2.75e-05	-2.67e-05	-2.54e-05	-2.64e-05	-2.66e-05	-2.67e-05
	-	(4.31e-06)	(4.43e-06)	(4.54e-06)	(4.42e-06)	(4.39e-06)	(4.54e-06)
Current volatility	-	2.76e-05	2.57e-05	2.42e-05	2.61e-05	2.65e-05	2.62e-05
	-	(4.79e-06)	(4.82e-06)	(4.88e-06)	(4.89e-06)	(4.87e-06)	(4.88e-06)
Controls:							
European	-	0.0186	0.0172	0.0168	0.0172	0.0197	-
	-	(0.0141)	(0.0129)	(0.0134)	(0.0146)	(0.0150)	-
Non-European	-	0.00547	0.00358	0.00228	0.0182	0.00469	-
	-	(0.0138)	(0.0123)	(0.0119)	(0.0230)	(0.0138)	-
Tariffs	-	-	-	-	-0.00140	-	-
	-	-	-	-	(0.00152)	-	-
Year dummies	No	No	Yes	Yes	No	No	No
Small-Mini	-	-	-	-0.00229	-0.00180	-0.00145	-0.00351
	-	-	-	(0.0196)	(0.0222)	(0.0228)	(0.0207)
Small	-	-	-	0.00168	-0.000243	-0.000290	0.00246
	-	-	-	(0.0172)	(0.0184)	(0.0186)	(0.0190)
Compact	-	-	-	0.0107	0.0126	0.0124	0.00730
	-	-	-	(0.0158)	(0.0176)	(0.0177)	(0.0157)
Intermediate	-	-	-	0.00523	0.00380	0.00233	0.000478
	-	-	-	(0.0169)	(0.0180)	(0.0176)	(0.0164)
Luxury	-	-	-	-0.0102	-0.00997	-0.0101	-0.0119
	-	-	-	(0.0104)	(0.0120)	(0.0122)	(0.0113)
Sport	-	-	-	-0.0163	-0.0181	-0.0182	-0.0197
	-	-	-	(0.00956)	(0.0109)	(0.0110)	(0.0104)
Minivan	-	-	-	0.00257	0.00480	0.00622	-0.00205
	-	-	-	(0.0176)	(0.0203)	(0.0211)	(0.0163)

(Standard errors in parentheses)

Table 6. Marginal effects for alternative probit specifications

VARIABLES	(1) Pr(exit)	(2) Pr(exit)	(3) Pr(exit)	(4) Pr(exit)	(5) Pr(exit)	(6) Pr(exit)	(7) Pr(exit)
Current Profit	-1.03e-05	-9.39e-06	-8.11e-06	-3.39e-06	-4.76e-06	-4.58e-06	-6.54e-06
	(3.99e-06)	(3.94e-06)	(3.75e-06)	(2.48e-06)	(3.03e-06)	(2.99e-06)	(3.59e-06)
Current volatility	1.09e-05	9.63e-06	8.28e-06	3.21e-06	4.52e-06	4.36e-06	6.51e-06
	(4.48e-06)	(4.27e-06)	(4.03e-06)	(2.38e-06)	(2.93e-06)	(2.89e-06)	(3.69e-06)
Controls:							
European	-	-0.00186	-0.00153	-0.00169	-0.00270	-0.00228	-
	-	(0.00317)	(0.00270)	(0.00157)	(0.00228)	(0.00199)	-
Non-European	-	-0.00823	-0.00700	-0.00289	-0.00275	-0.00391	-
	-	(0.00552)	(0.00494)	(0.00258)	(0.00244)	(0.00322)	-
Tariffs	-	-	-	-	-0.000257	-	-
	-	-	-	-	(0.000254)	-	-
Year dummies	No	No	Yes	Yes	No	No	No
Small-Mini	-	-	-	-0.000274	-0.000573	-0.000562	0.00237
	-	-	-	(0.00163)	(0.00231)	(0.00216)	(0.00613)
Small	-	-	-	0.00204	0.00266	0.00237	0.00297
	-	-	-	(0.00325)	(0.00427)	(0.00393)	(0.00542)
Compact	-	-	-	-0.000429	-0.000599	-0.000627	-0.000514
	-	-	-	(0.00113)	(0.00169)	(0.00157)	(0.00268)
Intermediate	-	-	-	0.00192	0.00289	0.00223	0.00673
	-	-	-	(0.00297)	(0.00421)	(0.00357)	(0.00771)
Luxury	-	-	-	-0.00207	-0.00301	-0.00286	-0.00352
	-	-	-	(0.00187)	(0.00246)	(0.00238)	(0.00283)
Sport	-	-	-	-0.00161	-0.00230	-0.00220	-0.00313
	-	-	-	(0.00151)	(0.00199)	(0.00193)	(0.00271)
Minivan	-	-	-	-0.00221	-0.00342	-0.00316	-0.00488
	-	-	-	(0.00209)	(0.00293)	(0.00275)	(0.00387)

(Standard errors in parentheses)

Figures

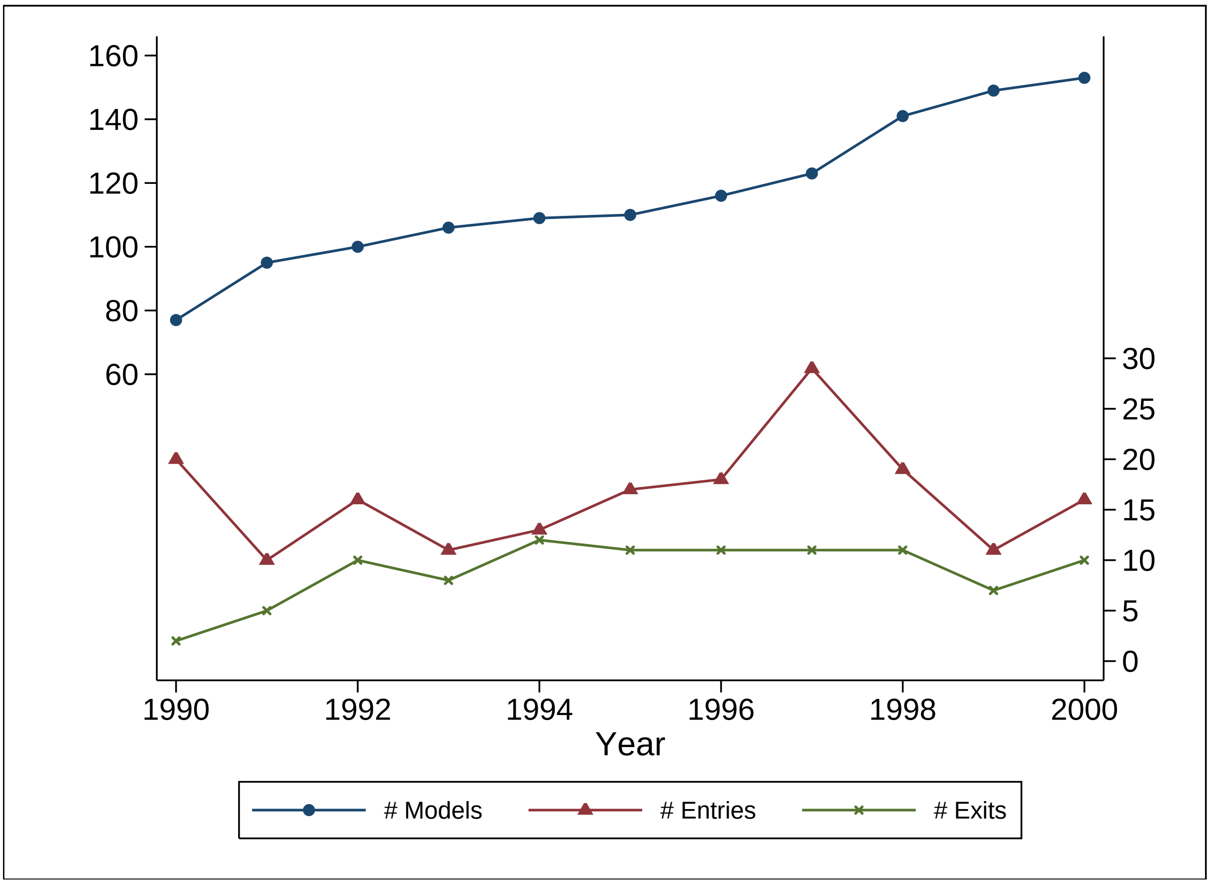

Figure 1. Evolution of the number of models

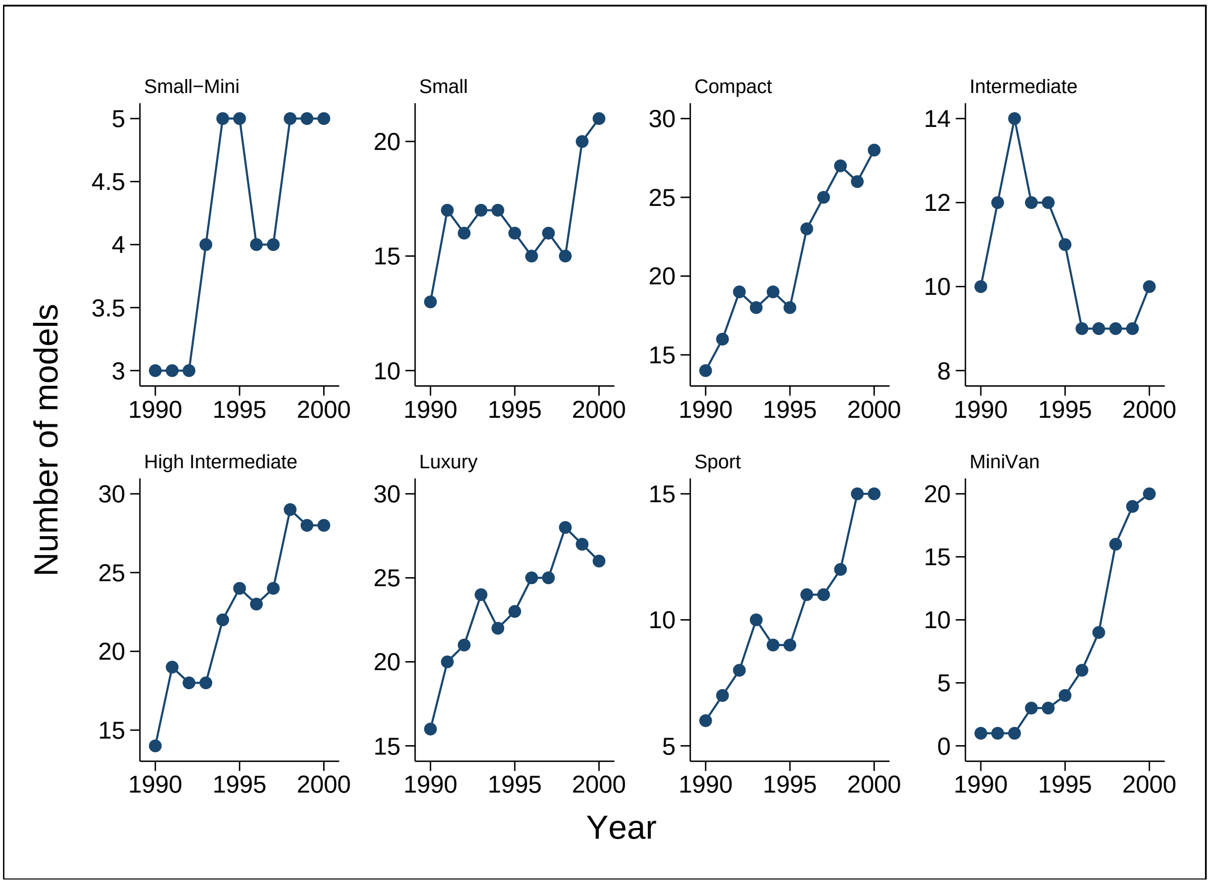

Figure 2. Evolution of the number of models by segment

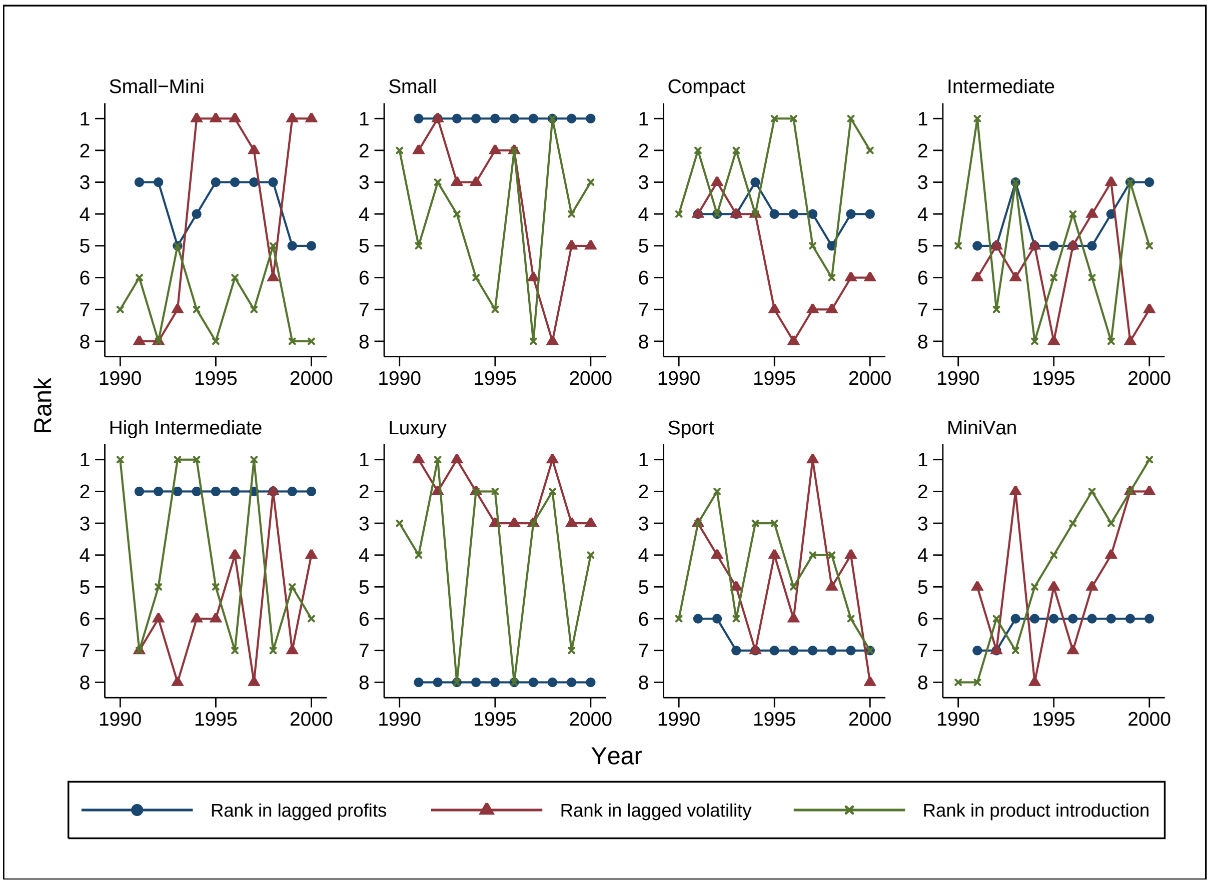

Figure 3. Relation between entry and estimated profitability and volatility by segment