"Effects of Competition over Quality-Adjusted Price Indexes: An Application to the Spanish Automobile Market"

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Using a newly constructed data set, we calculate quality-adjusted price indexes after estimating hedonic price regressions from 1988 to 2004 in the Spanish automobile market. The increasing competition was favoured by the removal of trade restrictions and the special plans for the renewal of the Spanish automobile fleet. We find that the increasing degree of competition during those years led to an overall drop in automobile prices by 20 percent which implied considerable consumer gains thanks to higher market efficiency. Additionally, our results indicate that loyalty relevance and discrepancies in automobile reliability declined during those years. This is captured through our estimated model-specific effect index that fell by 16 percent during the period selected for this analysis.

I. Introduction

The most relevant goals of economic policies are, among others, price stability and economic growth. In order to evaluate the effectiveness of these policies, price and production changes should be analysed accurately. For these purposes, conventional measures such as good 'matching' approach and the physical volume of production are often used. These measures are appropriate for many traditional product lines for which the pace of technological change is slow or is even not present (e.g. standardized raw materials and semi-fabricated products). However, this is not the case for some products such as refrigerators, PCs and automobiles. Competitive forces induce producers of this sort of goods to update the technology incorporated in their product lines. These continuous technological updates make the average level of quality improve across time. Consequently, the application of conventional price and quantity indexes to the underlying products will lead to considerable biases. To wit, economic growth will be downward biased and price changes will be upward biased.

Court (1939) was the first to highlight and overcome the limitations of traditional index methods. His novel approach consisted in the estimation of the hedonic function that related the observed price of the product to its characteristics. This alternative method, the hedonic method, had the advantage of isolating the pure price variations from those changes due to quality refashioning. Then, these pure price changes were used to construct quality-unbiased price indexes. These price indexes are the so-called quality-adjusted price (QAP) indexes.

Since Court's milestone to the present day, further relevant empirical and methodological research have been done in the field of QAP indexes[1]. Most of the empirical applications have centred on the automobile market. The great interest in this product rests on its continuous quality improvements across time (e.g. standard incorporation of certain attributes that ameliorate safety and comfort such as airbag, ABS, electric windows, air conditioning, power steering and microprocessors that improve reliability). In our empirical research in order to estimate the QAP indexes, we have also selected this market but in the Spanish context.

For this purpose, we have used a novel data set on prices and characteristics of petrol-automobiles sold in the Spanish market from 1988 to 2004. From a methodological point of view, we have used and compared time dummy variable methods (Court, 1939; Stone, 1956 and Griliches, 1961) taking into account the purchase distribution of these products. Therefore, we have given to each automobile model its economic importance in terms of its revenue market share.

The major reason that has motivated our analysis was that there were little empirical applications for the case of Spain in the field of hedonic prices (Izquierdo *et al*, 2001) and especially for the period considered in this analysis.

[1] See Triplett (2004) for an excellent review on this issue(2004)

The selected seventeen-year time frame is pertinent because it allows to capture the effects in the QAP indexes of an increasing competitive environment in the Spanish automobile market .Two evens are relevant during this period: the recent entrance of Spain in the European Community in 1986 that removed trade restrictions and the considerable automobile demand growth that favoured firm market participation.

Additionally, in order to calculate properly revenue weighting QAP indexes for Spanish automobiles, we have analyzed two methodological issues present in the hedonic price index literature. The first relates to the statistical significance of the bias in the QAP indexes when the assumption of temporal stability of the hedonic parameters does not hold. Shadow prices of product characteristics usually are too unstable over time (Pakes, 2003). This argument has been used to invalidate the major method employed for constructing hedonic price indexes: the pool time-dummy variable method or multi-period regression method (Schultze & Mackie, 2002). Therefore, the other alternative time dummy variable method, the adjacent-periods approach, has been generally preferred by researchers. This latter method is appropriate when the number of observations per year is limited for estimating annually the hedonic function. After testing formally the significance of the aforementioned assumption over the estimated price index trends, our results indicated that implicit price instability did not appear to always be relevant to disfavour the pool regression method. The second issue is concerned with the problem of downward bias in the QAP index due to unobserved attributes (e.g. reliability and prestige) that are valued by consumers. Previous literature has shown that controlling for model specific effects rather than brand effects help to overcome this bias (Requena-Silvente & Walker, 2006). Furthermore, the estimation of these model effects enabled us to analyse their trends across time. To anticipate results, according to our preferred specification (a multi-period pooled regression approach with model-specific fixed effects), the estimated average model effect, although positive, have eroded across time at an annual rate of 1 per cent. This finding indicated that quality related characteristics rather than loyalties have gained relevance in explaining relative prices across time. Additionally, the overall estimated drop in Spanish automobile prices counted up to almost 20 percent from 1988 to 2004. All these results were due to a higher degree of competition in the Spanish automobile market during those years.

This paper is organized into five sections. Section II deals with the description of the data. Section III shows the specification of the estimated hedonic function and the corresponding form of the QAP indexes. Then, it justifies how we have selected the automobile quality dimensions used as explanatory variables in the hedonic regression. Section IV shows our empirical results. Firstly, it analyzes the relevance of temporal stability of hedonic parameters for QAP indexes when the two time dummy variable methods are compared. Secondly, it presents the QAP indexes for Spanish automobiles and the model-specific effect trends according to our preferred hedonic function specification. Section V concludes.

II. Data Sources and Sample Construction

For the purposes of the present analysis, we have constructed a novel data set. The data consist of an unbalanced panel of 1388 observations on petrol-automobile models during the period 1988-2004. The car models selected account for at least 70 percent of the total annual market sales. Data of automobile sales comes from A.N.F.A.C *(Asociación Nacional de Fabricantes de Automóviles y Camiones).* For each car model, we have collected data on prices and characteristics as if this information was observed "once" per year. Data for each observation corresponds to the basic version of each car model. A model was considered different when at least one of its characteristics changed by 5 percent. This criterion led to classifying 242 different automobile models for the whole period considered. These data sets come from the edition of the specialized review *"Autopista"* released in the first week of March, when prices were observed to be more stable.

The aggregate car prices included in the estimations are then, listed prices in current terms and not transaction or "street" prices. In relation to this, transaction prices are frequently lower than listed prices. However, although these prices are in fact what consumers pay for the car, it is difficult to collect information about such "street" prices.

We have also assigned information about the characteristics of the base version to each petrol-car model. The information about characteristics gathered for each automobile model includes the following variables: a)-continuous characteristics- horsepower, cubic centimetres, maximum speed, height, width, length, fuel consumption-b) the presence of incorporated equipment "options" such as air-conditioning, climate control, ABS, electric windows, power steering, remote centralised locking, driver's airbag and twin airbag. Data statistics are summarised in Annex B.

III. General Model Specification

The Hedonic Function and Time Dummy Variable Methods

The Hedonic function maps the relation between prices of goods and the quantities of attributes contained in them:

$$P_{it} = f(C_{it}) \quad (1)$$

Where P_{it} is the observed aggregate price that consumers pay for good i in period t and C_{it} is a k-element vector of its embodied characteristics. This function is based on the hedonic hypothesis (i.e. economic behaviour is directly linked not to the good itself but rather to its characteristics (Rosen, 1974)).

In most cases, the form of the hedonic function is an empirical question (Triplett, 2004). Thus, after implementing PE-MacKinnon-Davidson tests for non-nested models, we have chosen the log-normal specification. Adding a random term in (1), the general model specification of our analysis is defined as:

$$\log P_{it} = r_0 + r_t + \sum_{k}^{K} b_k c_{kit} + w_{it} \qquad (2)$$

The term r_t are time fictitious variable parameters that measure the "pure" variations of the price with respect to the base year denoted by the sub index *0*. The coefficients b_k are the so-called hedonic parameters of the *k-th* attribute contained in product *i*. A weighted version of (2) uses a weighted least squares (WLS) estimator and weights v_{it} that is the revenue share of model *i* in period *t* (Diewert, 2002 and Silver, 2002).

The second term in (2), r_t, is what characterizes the Time Dummy variable methods used in this analysis. These direct methods can be defined as the hedonic price index approaches that use exclusively the information coming from the hedonic function and for which the variation in prices is a "residual" (i.e. not imputed to any concrete factor). Among the time dummy methods, we can differentiate two approaches: the pool regression method and the adjacent-two year method. In the former, the hedonic parameters are considered to remain constant across time while in the latter, this assumption is only considered for each pair of adjacent years.

According to the model specification selected in our analysis, the observed aggregate price follows a log-normal distribution. Thus, if the random term in (2), w_{it}, are independent drawings from a normal distribution with mean zero and constant variance, the average expected relative change in prices when quality remains constant is given by:

$$E\left[P_t / P_0 \right] = \exp \hat{r}_t \qquad (3)$$

Where the term $\exp \hat{r}_t$ is the QAP deflator for the base period .The proximity of this index to a true cost-of-living measure depends on the degree of temporal stability of both, the hedonic parameters and the product attributes (Berndt & Rappaport, 2001 and Silver & Heravi, 2004).

Selecting Quality Dimensions

Triplett (1969) pointed out the complexity when using the hedonic methods for constructing the QAP indexes for the case of automobiles. This author stressed that the characteristics that should be included in the hedonic regressions for automobiles should reflect the real quality dimensions of this product. These quality dimensions are what consumers value since they are the direct arguments of their utility function.

According to this statement, especially in the case of automobile performance, we have chosen weight relative measures. These relative measures are appropriate not only when seeking to avoid the technical correlation between automobile power and size but also when reflecting true automobile efficiency. In reality, this is what buyers take into account when valuating automobile performance.

Among the quality dimensions, we have also included automobile reliability. This unobserved quality attribute is considered to be a permanent effect associated to each automobile brand (Griliches and Ohta, 1976). In addition, these effects reflect also brand reputation and prestige that are transitory and not directly related to any quality dimension. Brand reputation and prestige lead to loyalties. These loyalties give rise to higher prices since they make the demand of the brand associated product less elastic. Then, since these brand-related transitory and permanent effects influence automobile prices, we have controlled for them in our hedonic function. In our preferred specification, the model-specific fixed effect approach, reliability and prestige were better described using the automobile model dimension (i.e. strategies to improve loyalties such as advertising are related to the model and less specifically to the brand)

Lastly, Sport automobiles are considered to be more expensive since they have a special body design. In the brand effect specification, we have included a dummy variable in order to control for this automobile market segment.

Thus, the quality dimensions selected and their related automobile physical characteristics[2] for estimating equation (2) are summarised in table 1.

Table1. Selected Quality Indicators

QUALITY DIMENSIONS	***INDICATORS***
PERFORMANCE	*CONSUMPTION EFFICIENCY*: Gasoline consumption relative to weight. *POWER EFFICIENCY*: Horsepower relative to weight.
RELIABILITY	*BRAND EFFECT* *MODEL EFFECT*
DESIGN	*SPORT AUTOMOBILE EFFECT*
POWER	*CYLINDER CAPACITY*
SAFETY	*DRIVER AIRBAG* *ABS*
CONFORT	*POWER STEERING* *AIR CONDITIONING* *CLIMATE CONTROL* *SIZE (VOLUME)*

[2] Some binary automobile characteristics such as electric windows, remote centralized locking and twin airbag were dropped from the final specification since they do not add any significant explanatory power to the model.

IV. Results

Relevance of temporal stability of hedonic parameters for QAP indexes

As explained in section II, the assumption about temporal stability of hedonic parameters is less restrictive in the adjacent-two year method than in the pool regression method. Consequently, as mentioned above, in empirical work the most flexible specification has been preferred. However, when the critical factor is the price index and not the coefficients; there is not a conceptual basis for rejecting the pool regression method (Triplett, 2004). In this section we have proved that it is possible the non-existence of an empirical basis.

The WLS estimated coefficients for each automobile attribute using the pool regression method are reported in Table 2. In the pool regression model, all the hedonic coefficients turned out to be significant and with the expected signs. When applying the adjacent-two year approach, the estimated hedonic coefficients varied considerably in their signs and their values across time (See Annex A). We have used the Chow test in order to compare the two alternative time dummy variable methods in terms of parameters stability. Our results indicated that the variation of hedonic parameters was significant from 1988 to 2004. Although explaining the causes of parameters instability is out of the scope of this analysis, previous literature has justified this later result in two ways. The first justification is purely statistical and it is linked to multicollinearity and sampling fluctuation (Triplett, 2004). The second justification is economic and it is related to changes in market power (Pakes, 2003) and technological progress of the industry (Dulberger, 1989).

Table2. Hedonic Parameters of the Pool Regression Method. Brand effect and Model-specific effect approach.

Automobile Attribute	***With Brand Fixed Effects***	***With Model-Specific Fixed Effects***
Volume	7.04×10^{-8} (21.37)	9.82×10^{-9} (2.29)
Cylinder Capacity	3.70×10^{-4} (20.32)	6.68×10^{-5} (2.93)
Power Efficiency	3.72 (15.65)	4.91 (18.24)
Consumption Efficiency	-24.35 (-7.65)	-34.63 (-12.64)
Sport	0.11 (4.62)	***No***
Power Steering	0.05 (6.85)	0.03 (5.41)
ABS	0.05 (6.44)	0.03 (5.30)
Airbag	0.01 (1.09)	0.01 (1.24)
Climate Control	0.93 (8.48)	0.10 (10.82)
Air Conditioning	0.06 (6.55)	0.03 (5.19)
Time dummies	***Yes***	***Yes***
Make dummies	***Yes***	***No***
Model dummies	***No***	***Yes***
Adj-R^2	***0.960***	***0.985***

Once the temporal instability of the hedonic parameters has been proved to be present; we addressed the following question: is this finding statistically relevant for the QAP indexes?. In Table 3 we have reported the nominal and real QAP indexes and the real year-on-year changes of these indexes. When comparing the QAP index trends using alternatively the two time dummy variable methods, the discrepancies were small. In order to know if these discrepancies were statistically significant, the hypothesis that has been formally tested was the following:

$$H_0 : \dot{I}_t^{Pool} = \dot{I}_t^{Adj} \qquad (4)$$

Where $\dot{I}_t^{Pool}$ and $\dot{I}_t^{Adj}$ are respectively the annual rates at which the estimated QAP indexes changed according to the pool regression method and the adjacent-two year method. When testing hypothesis (4), we have assumed that these differences were distributed as:

$$D_t = \dot{I}_t^{Pool} - \dot{I}_t^{Adj} \sim NID(0, \sigma^2) \qquad (5)$$

According to the definition of the chi-squared distribution:

$$\sum_{t=1}^{T} \left(\frac{D_t}{\sigma} \right)^2 \sim \chi_T^2 \qquad (6)$$

In our analysis, the chi-squared statistic, χ_T^2, was 15.13. For a chi-squared with 16 degrees of freedom, the minimum size for which the null hypothesis presented in (4) would have still been rejected was 0.4. Therefore, our results indicate that the reason why the pool regression method was disfavoured does not appear to always be relevant for the estimation of the QAP indexes. The reasons behind this result can be inferred from the comparison between the model specifications of the two alternative time dummy methods. If there is a compensation mechanism within the components of quality across time (i.e. some quality dimensions gain relevance and others loose it across periods), the differences between the QAP index trends will converge to zero.

Table3. QAP indexes of Spanish Automobiles (1988-2004). Pool regression Method and Adjacent-two year Method. Brand Effect specification.

	Pool Regression Method			*Adjacent-two year Method*		
Year	*Non-Deflated QAP indexes*	*Deflated QAP indexes*	*QAP indexes Year-on-Year variations*	*Non-Deflated QAP indexes*	*Deflated QAP indexes*	*QAP indexes Year-on-Year variations*
1988	100.00	100.00	n.a	100.00	100.00	n.a
1989	104.66	98.00	-1.99	108.51	101.61	1.61
1990	108.42	95.13	-2.86	112.70	98.88	-2.72
1991	110.96	91.90	-3.22	115.20	95.41	-3.47
1992	108.65	84.96	-6.94	112.97	88.34	-7.07
1993	112.28	83.96	-0.99	116.75	87.30	-1.03
1994	117.97	84.24	0.28	121.58	86.82	-0.48
1995	124.56	84.97	0.73	128.83	87.89	1.07
1996	131.56	86.66	1.68	136.34	89.81	1.92
1997	132.39	85.52	-1.14	136.78	88.36	-1.44
1998	129.57	82.20	-3.32	133.69	84.81	-3.54
1999	128.57	79.73	-2.46	132.45	82.13	-2.68
2000	127.16	76.22	-3.50	130.00	77.93	-4.20
2001	127.21	73.62	-2.60	130.37	75.44	-2.48
2002	129.60	72.77	-0.85	132.18	74.22	-1.22
2003	131.41	71.61	-1.16	134.03	73.03	-1.18
2004	133.73	70.72	-0.88	136.45	72.16	-0.87

Spanish automobiles QAP indexes 1988-2004:

Overcoming the problem of unobservable attributes

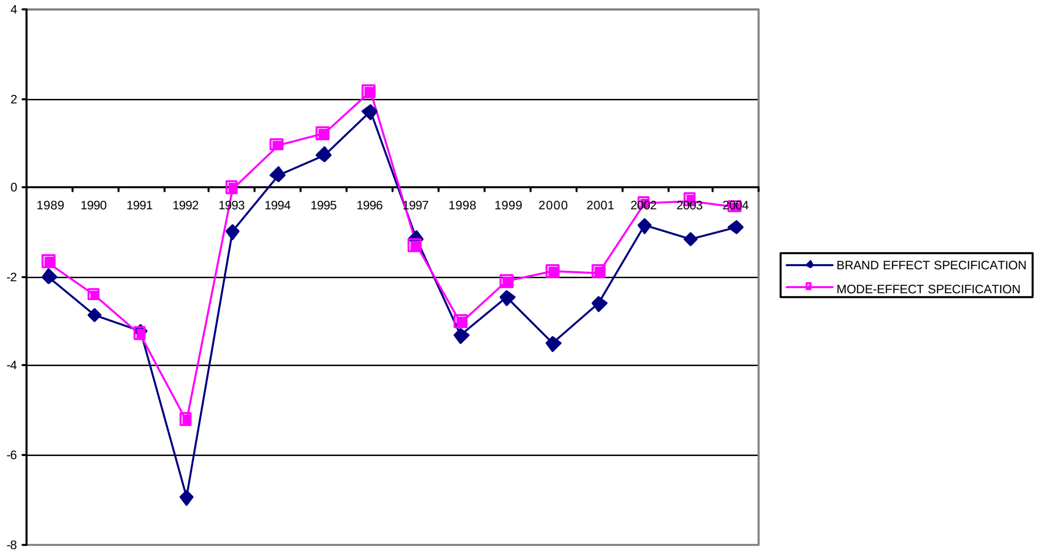
The complexity of estimating hedonic functions for the specific case of automobile has been highlighted by previous researchers along time (Griliches, 1961; Griliches & Ohta, 1976 and Tripplet, 2004). The large variety of services that these products can provide makes the task of selecting and collecting all their valuable attributes infeasible. This is specially the case of those attributes that are highly correlated to product differentiation strategies. In most of the markets, as in the automobile market, there is a combination between horizontal or variety differentiation and vertical or quality differentiation. The degree of vertical differentiation is captured by the measurable quality variables introduced in the hedonic function. However, as mentioned above, it is not possible to get all the quality-related data. This is because sometimes it is not observed by researchers (e.g. automobile reliability). In the case of horizontal differentiation, brand prestige and brand reputation have an important role. As mention in section III, differentiation of this sort also influences automobile prices .If researchers do not control for these relevant quality and non-quality automobile characteristics in hedonic functions, the QAP indexes will be biased. Griliches and Ohta (1976) in a study of U.S automobile overcame this undesirable result by introducing in the hedonic function the so-called make or brand effects. These authors considered that these brand effects captured the aforementioned *"left-out"* characteristics. Although, the research of these authors was a relevant contribution, later research has shown that the automobile model was a much better unit of classification for this purpose (Requena-Silvente & Walker, 2006).

For this section, we have used the results of the pool regression method due to the conclusions obtained in the previous one. Furthermore, with this method we had greater degrees of freedom to estimate more efficiently the model-specific effect trends. Although, these model-specific effects are considered to fluctuate across time, we were just interested in their average trends.

In the brand effect specification as well as in the model effect approach, in our results both effects turned out to be statistically and economically significant. When both specifications were compared, the F-test indicated that the differences in the adjusted-R^2 between the brand effect approach and the model-specific effect one were significant at any level. This statistical result showed that the aforementioned unobserved attributes (i.e. reliability and prestige) were better captured using the automobile model-specific effects. In other words, there were significant distinctions between models of the same brand once quality discrepancies were controlled for. As expected, these model-specific effects were positive.

Once we have shown that model-specific effects existed, the question that we wanted to address was how not controlling for these effects influenced the estimated automobile QAP indexes. In figure 1, we have presented the year-on-year variations of the deflated Spanish automobile QAP indexes from 1988 to 2004 under the two alternative pool hedonic regression specifications: with brand effects and with model-specific effects. When including model-specific effects rather than just brand effects, the fluctuation of the average annual rate variation of the estimated QAP indexes, although large, was more tenuous than when using the alternative. Under the brand effect approach, the QAP indexes for Spanish automobiles fell up to 29.3 percent from 1988 to 2004 while under the alternative model the overall drop counted up to 19.7 percent. Therefore, neglecting model-specific effects gave rise to a considerable downward bias in the estimated automobile hedonic price indexes.

FIGURE 1.REAL YEAR-ON-YEAR CHANGES IN SPANISH AUTOMOBILE QAP INDEXES (1988-2004)
MODEL-SPECIFIC EFFECTS VERSUS BRAND EFFECTS.



Then, we were interested in analyzing the trends of the average model-specific effect across periods. Table 4 depicts the nominal and real model-specific effect indexes as well as their real annual variations. According to the interpretation of the model-specific effects, these indexes inform about changes in the real economic consumer valuation of prestige and differences in reliability. This valuation has dropped considerable across time. The overall decline of the model-specific effect counted up to 16 percent. This is not a surprising result because the average automobile reliability has been improving across time and the related discrepancies between producers have been fallen. This was due to the mass incorporation of new less-costly technologies by producers related to automobile reliability (i.e. innovations in automobile microprocessors and robotics). At the same time, the relevance of brand prestige has been eroded since the variety of brands and models has augmented in the automobile market. In particular, in the automobile Spanish market, in 1988 the number of makes counted up to 36 brands while in 2004, there were 58 brands participating in this market. Consequently, with more brands, producers had incentives to reduce differences in perceived measurable quality when the latter is the competition variable. The entry of new firms in the market causes shrinkage in each firm share. This fact induced firms to adjust quality upward in order to increase their sales (Lawrence, 1953). Thus, it was the increasing competition in the Spanish market during from 1988 to 2004 what explains these results.

Table4. Pool regression method with Model-Specific Effects:
Model-specific effect index and QAP Indexes of Spanish automobiles (1988-2004).

	Model-Specific Effect Indexes			***QAP Indexes***		
Year	*Non-Deflated*	*Deflated*	*Real Year-on-Year variations*	*Non-Deflated*	*Deflated*	*Real Year-on-Year variations*
1988	100.00	100.00	n.a	100.00	100.00	n.a
1989	104.66	98.01	-1.98	104.99	98.31	-1.68
1990	108.65	95.33	-2.67	109.30	95.90	-2.41
1991	108.63	89.98	-5.35	111.81	92.61	-3.29
1992	106.62	83.37	-6.60	111.76	87.39	-5.22
1993	111.02	83.02	-0.35	116.82	87.36	-0.02
1994	114.58	81.82	-1.19	123.66	88.30	0.94
1995	124.33	84.81	2.99	131.21	89.51	1.20
1996	129.92	85.58	0.76	139.14	91.66	2.14
1997	128.20	82.82	-2.76	139.87	90.35	-1.30
1998	135.07	85.68	2.86	137.65	87.32	-3.03
1999	135.20	83.84	-1.84	137.40	85.20	-2.11
2000	145.24	87.07	3.22	138.97	83.31	-1.89
2001	147.52	85.37	-1.69	140.66	81.40	-1.91
2002	152.93	85.87	0.49	144.35	81.05	-0.34
2003	158.13	86.16	0.29	148.21	80.76	-0.28
2004	160.67	84.97	-1.19	151.87	80.31	-0.44

Changes in the degree of competition in the Spanish automobile market were also the reason that justifies the trends of the estimated QAP indexes. In Table 4, we have also summarized the results obtained using the model-specific effect approach. From 1989 to 1992, the average year-on-year percentage reduction in the deflated hedonic price index was around 4 percent. The overall fall in automobile prices irrespective of quality variations during these years summed up to 12.60 percent. This is more than a half of the overall decline during the whole period considered. Taking into account the historical context of our analysis, this substantial drop in prices was a consequence of the entrance of Spain into the European Community in 1986. The Membership Treaty established a period of seven years (1986-1993) during which all the trade restrictions for industrial products should be removed progressively. Consequently, the new treatment of automobile imports favoured the entrance of nineteen new brands in the Spanish market during these four years. Then, from 1993 to 2000, the QAP indexes showed more variation that could be explained by the continuous market entries and exists. This process took place due to the considerable growth in demand thanks to three Spanish government plans during the nineties: Renove I (1994), Renove II (1995) and Prever (1997). The aim of these plans was the renewal of the Spanish fleet of automobiles. The increase of new automobile purchases counted up to 72 percent in Spain during those years. Then, the entry-exit process stopped in 2001 where the same 58 brands remained in the market till 2004. In fact during the latter sub-period, the year-on-year variation in the estimated hedonic price index was observed to be smaller.

V. Conclusions

Using a novel data, we have examined the extent to which a more competitive environment in the Spanish automobile market affected trends in the revenue weighted QAP indexes as well as in the average model-specific effect from 1988 to 2004. For this purpose, we have used the time dummy variable pool regression method including model-specific effects.

The entrance of Spain in the European Common Market and the governmental plans for the renewal of the automobile fleet during the nineties favoured and intensified competition. The first even removed trade restrictions and consequently, eased firm participation in the Spanish automobile market. The latter even stimulated new automobile demand and thus, firm entry. These two facts implied an increase in market efficiency that led to an overall decline of around 20 percent in the estimated automobile QAP indexes during the whole period considered. Additionally, we have shown that increasing competition reduced the estimated average automobile model-specific effect by 16 percent. This effect enabled to capture the impact that loyalties and automobile reliability discrepancies (i.e. unobserved attributes) had over relative automobile prices. According to our findings, average automobile reliability has improved while quality related characteristics have increased their relevance in explaining aggregate relative prices. Therefore, all these results informed that consumers gains were considerable during the period considered.

Additionally, in order to obtain the aforementioned empirical results, we have analyzed the statistical relevance over the QAP indexes of the following assumptions. Namely: a) the temporal stability of the hedonic parameters and b) the existence of model-specific effects. Regarding the relevance of the first assumption, we have formally tested the differences in the estimated hedonic price index trends between the two time dummy approaches: the pool regression method and the adjacent-two year method. Our results indicated that the discrepancies found were not significant due to the presence of an inter-temporal compensation mechanism within the quality indicators considered. These findings open up again the discussion about the applicability of multi-period pooled regressions to estimate QAP indexes and in general about the relevance of temporal constancy of parameters in hedonic function for constructing these price indexes. Concerning the second assumption, as found in recent research, brand effects were not enough to capture unobserved automobile attributes. In relation to this, we have shown that there were significant differences between models of the same brand. In our results, the omission of model-specific effects biased downward the estimated automobile QAP indexes by 9.6 percent. Thus, neglecting these model-specific effects led to an overestimation of pure price falls.

Therefore, we can conclude from our analysis that the QAP indexes can be very informative in terms of competition effects. We have shown that it can be more relevant to reflect in the hedonic regressions how firms compete and price in the market than relaxing assumptions about hedonic parameter stability.

ANNEX A.

Hedonic Parameters of Adjacent-Year Regression Method. Brand effect specification

Automobile Attribute	*1989/1988*	*1990/1989*	*1991/1990*	*1992/1991*	*1993/1992*	*1994/1993*	*1995/1994*	*1996/1995*	*1997/1996*	*1998/1997*	*1999/1998*	*2000/1999*	*2001/2000*	*2002/2001*	*2003/2002*	*2004/2003*
Volume	4.28×10^{-8} (2.43)	3.00×10^{-8} (1.93)	4.86×10^{-8} (3.93)	6.75×10^{-8} (5.58)	8.58×10^{-8} (7.72)	9.86×10^{-8} (9.26)	10.03×10^{8} (10.36)	6.80×10^{8} (7.04)	6.33×10^{8} (6.88)	6.92×10^{8} (8.04)	7.40×10^{8} (8.61)	5.20×10^{8} (6.10)	6.16×10^{8} (7.15)	6.77×10^{8} (7.28)	7.01×10^{8} (7.28)	7.46×10^{8} (7.93)
Cylinder Capacity	5.85×10^{-4} (6.51)	5.13×10^{-4} (6.01)	4.76×10^{-4} (6.77)	4.54×10^{-4} (6.43)	2.47×10^{-4} (3.22)	2.69×10^{-4} (3.61)	3.85×10^{-4} (5.74)	4.92×10^{-4} (8.55)	4.24×10^{-4} (7.23)	2.93×10^{-4} (5.30)	2.75×10^{-4} (5.22)	4.00×10^{-4} (7.70)	3.74×10^{-4} (7.84)	3.82×10^{-4} (8.67)	3.12×10^{-4} (7.63)	2.70×10^{-4} (6.96)
Power Efficiency	4.17 (4.25)	4.14 (4.04)	3.36 (3.70)	3.34 (3.92)	3.95 (4.26)	1.90 (2.31)	0.11 (0.17)	0.67 (0.96)	1.96 (2.52)	4.04 (5.57)	4.06 (6.63)	3.72 (5.50)	4.16 (6.53)	3.34 (4.63)	3.47 (5.15)	4.50 (6.71)
Consumption Efficiency	-8.25 (-0.72)	-42.32 (-3.38)	-43.08 (-3.94)	-23.07 (-2.11)	-28.07 (-2.76)	-16.80 (-1.70)	-15.15 (-1.45)	7.55 (0.82)	1.88 (0.31)	-48.17 (-3.95)	-16.31 (-1.27)	-12.30 (-0.80)	-24.57 (-1.87)	-40.44 (-2.74)	-39.32 (-2.65)	-44.47 (-2.71)
Sport	0.24 (1.54)	0.29 (2.59)	0.20 (2.97)	0.20 (2.97)	0.19 (2.84)	0.10 (1.21)	0.14 (1.58)	0.17 (1.43)	-0.07 (-0.87)	0.11 (1.73)	0.21 (4.37)	0.18 (3.32)	0.22 (3.36)	0.12 (2.19)	0.09 (2.07)	0.04 (1.04)
Power Steering	0.27 (0.92)	0.03 (0.88)	0.05 (2.39)	0.05 (2.39)	0.11 (4.23)	0.11 (4.41)	0.03 (1.62)	0.06 (3.02)	0.07 (3.05)	0.07 (3.55)	0.09 (4.77)	0.04 (3.00)	-0.03 (-1.14)	-0.06 (-1.50)	0.00 (0.17)	0.03 (0.60)
ABS	0.02 (0.20)	0.21 (0.26)	0.04 (0.75)	0.04 (0.75)	0.03 (0.86)	0.13 (3.77)	0.04 (1.93)	0.13 (4.51)	0.11 (3.83)	0.10 (3.93)	0.14 (7.15)	0.10 (5.40)	0.05 (2.92)	0.04 (1.86)	0.02 (1.17)	0.05 (3.01)
Airbag					-0.01 (-0.31)	0.01 (0.29)	-0.01 (-0.82)	0.01 (0.88)	0.03 (1.78)	0.01 (0.11)	0.01 (0.26)	0.08 (3.50)	0.08 (2.74)	0.03 (0.79)	0.05 (1.18)	0.03 (0.68)
Climate Control					0.12 (0.88)	0.15 (1.33)	0.07 (1.03)	0.01 (0.19)	0.03 (0.57)	0.02 (0.08)	0.06 (2.41)	0.04 (2.20)	0.14 (5.60)	0.12 (4.97)	0.13 (5.71)	0.09 (4.19)
Air Conditioning	0.07 (0.37)	0.09 (1.33)	0.08 (1.58)	0.08 (1.58)	0.05 (2.00)	0.08 (1.58)	0.06 (2.78)	0.06 (3.09)	0.03 (1.96)	0.00 (0.08)	0.06 (3.14)	0.10 (3.60)	0.05 (2.62)	0.07 (3.34)	0.10 (4.81)	0.06 (3.27)
Time dummies	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Model dummies	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*
Brand dummies	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Adj-R^2	0.965	0.963	0.971	0.971	0.967	0.969	0.977	0.979	0.979	0.964	0.971	0.958	0.963	0.960	0.966	0.969

ANNEX B.

Data Statistics: Mean and variance.

	Price (Current ptas)	Cylinder Capacity (Cm^3)	Length (Cm)	Heigth (Cm)	Wide (Cm)	Weight (Kgms)	Air Condition.	Fuel Consump (Litres /100Km)	Power Steering	Driver Airbag	Twins Airbag	ABS	Horse power	Sample sales over Population sales (%)	Number of Brands
1988	2,251,905	1,726.057	422.16	139.64	166.1	1,020.86	0.056	7.65	0.301	0	0	0.037	100.51	0.89	36
	1,112,342	446.9293	37.84	3.59	7.59	207.47	0.233	1.07	0.463	0	0	0.192	34.29		
1989	2,285,692	1,720.704	423.537	139.74	166.48	1,023.57	0.0925	7.75	0.314	0	0	0.055	100.62	0.84	37
	1,011,406	405.203	34.938	3.51	6.95	178.29	0.292	1.108	0.468	0	0	0.231	30.99		
1990	2,355,021	1,709.607	422.64	139.66	166.41	1023.46	0.125	7.85	0.321	0	0	0.107	102.66	0.91	43
	1,032,088	438.230	35.25	2.705	7.19	186.08	0.333	1.185	0.471	0	0	0.312	33.72		
1991	2,353,691	1,690.57	423.83	139.77	167.26	1042.06	0.1803	7.832	0.442	0	0	0.147	101.19	0.91	44
	1,061,831	429.59	37.79	2.95	7.15	201.36	0.387	1.203	0.50	0	0	0.357	33.33		
1992	2,305,412	1,698.86	422.54	139.54	167.14	1045.73	0.294	7.79	0.632	0.0147	0	0.191	101.08	0.94	44
	977,741.7	415.07	38.21	3.22	7.09	193.27	0.459	1.131	0.48	0.121	0	0.396	32.92		
1993	2,398,695	1,712.23	420.83	139.73	167.17	1,051.08	0.315	7.84	0.616	0.027	0	0.219	102.47	0.94	55
	1,164,251	444.78	40.757	2.86	7.17	203.19	0.467	1.152	0.489	0.164	0	0.416	36.38		
1994	2,494,488	1,698.657	422.134	139.92	167.58	1,075.95	0.283	7.80	0.686	0.238	0	0.268	104.194	0.935	52
	1,160,378	402.24	37.17	2.819	6.24	194.77	0.454	1.074	0.467	0.429	0	0.446	34.80		
1995	2,688,829	1,720.015	423.73	141.10	168.29	1,098.809	0.264	7.70	0.735	0.411	0	0.308	105.86	0.906	52
	1,213,230	403.81	37.99	6.12	6.73	211.52	0.444	1.05	0.44	0.495	0	0.465	34.66		
1996	2,792,963	1,711.36	426.57	141.79	169.76	1,140	0.28	7.62	0.782	0.579	0.014	0.304	106.68	0.84	66
	1159707	366.12	38.20	7.85	7.43	216.70	0.457	1.022	0.415	0.497	0.12	0.463	31.79		
1997	2,706,423	1,681.93	424.82	144.46	170.30	1,155.3	0.315	7.59	0.789	0.657	0.23	0.276	104.44	0.84	64
	1,045,125	360.97	37.87	11.91	7.38	230.42	0.467	1.06	0.410	0.477	0.427	0.45	30.84		
1998	2,938,717	1,729.446	428.46	144.97	177.23	110.08	0.304	7.83	0.869	0.793	0.478	0.423	1203.81	0.75	64
	1,291,617	386.32	38.44	13.01	7.79	32.90	0.462	1.18	0.338	0.40	0.502	0.496	245.47		
1999	2,954,617	1,713.32	426.47	145.42	171.33	1,202.53	0.291	7.85	0.912	0.825	0.524	0.456	108.94	0.86	56
	1,422,224	420.661	40.39	12.58	7.98	248.01	0.456	1.20	0.283	0.381	0.501	0.500	35.24		
2000	3,215,549	1,753.861	429.74	146.29	172.34	1,225.28	0.324	7.94	0.944	0.898	0.564	0.583	113.51	0.84	58
	1,740,240	482.22	39.40	12.65	8.67	254.50	0.47	1.31	0.23	0.303	0.498	0.495	39.55		
2001	3,267,128	1,745.95	428.794	147.00	172.35	1,226.43	0.289	7.83	0.971	0.934	0.747	0.635	115.33	0.83	58
	1,783,493	494.75	38.65	11.04	8.76	236.89	0.45	1.22	0.165	0.248	0.436	0.483	42.41		
2002	3,358,946	1,770.078	431.631	148.89	173.49	1,257.24	0.291	7.85	0.99	0.99	0.79	0.66	118.19	0.78	58
	1,754,286	486.30	37.59	11.30	8.81	242.03	0.456	1.19	0.098	0.098	0.40	0.472	41.20		
2003	3,490,120	1,784.33	432.85	149.59	174.02	1274.63	0.306	7.82	0.979	0.979	0.846	0.775	120.65	0.78	58
	1,724,920	494.29	38.02	11.53	8.93	242.12	0.463	1.24	0.142	0.142	0.361	0.419	41.44		
2004	3,613,500	1,799.667	434.85	150.41	192.21	1,301.73	0.977	7.84	0.977	0.966	0.922	0.811	122.45	0.70	58
	1,761,246	494.50	38.55	11.78	25.49	241.83	0.148	1.23	0.148	0.18	0.269	0.393	41.82		

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