"Model-Specific Effects and Quality-Adjusted Price Indexes: An Application to the Spanish Automobile Market: 1988-2004"

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Using a newly constructed data set, we calculate quality-adjusted price indexes after estimating hedonic regressions from 1988 to 2004 for the Spanish automobile market. Over those years, we find an overall drop in automobile prices by 20 percent which implied considerable consumer gains. Additionally, our results indicate that prestige relevance and the discrepancies in automobile reliability declined. This is captured through our estimated model-specific effect index which fell by 16 percent. These findings may be supported by increasing competition in the automobile market and special plans for the renewal of the Spanish fleet in the period considered.

I. Introduction

The most relevant goals of economic policies are, amongst 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 the good 'matching' approach[1] 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 of other products such as refrigerators, PCs and automobiles. Competitive forces induce producers of these sorts of goods to update the technology incorporated in their product lines. These continuous technological updates cause average levels of quality to improve across time. Consequently, the application of conventional price and quantity indexes to the underlying products will lead to considerable biases. Therefore, 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 pure price variations from those changes due to quality refashioning. Then, these pure price

[1] The good "matching" approach consists of comparing the prices of those goods that have the same embodied characteristics in different periods.

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 has been carried out in the field of QAP indexes[2]. Most empirical applications have centred on the automobile and computer sectors. The great interest in these products rests on their continuous quality improvements across time. Within the Spanish context, it is worth noting the analysis carried out by Izquierdo et al (2001) for the case of automobiles and by Izquierdo and Matea (2004) for the case of personal computers.

In our empirical research in order to estimate the QAP indexes, we have selected the Spanish automobile market. For this purpose, we have used a newly constructed data set on prices and characteristics of gasoline-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 each automobile model an economic importance in terms of its revenue market share.

The main reason that has motivated our work is the lack of any hedonic empirical application in the literature for the case of Spain that analysed the automobile model effects and their implications on the estimated QAP indexes. Previous comparable analysis (Izquierdo et al 2001) only controlled for the

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

automobile brand effect when estimating hedonic regressions. Automobile brand effects have been considered to be related to automobile reputation and reliability (Griliches and Ohta, 1976). Reputation and reliability influence automobile prices since they make demand less elastic. However, recent empirical research has shown that there were many other unobservable characteristics that were automobile model specific (Requena-Silvente and Walker, 2006). Therefore, not only do the model-specific effects incorporate brand effects but also other unobservable product attributes valued by consumers. In fact, the omission of these model specific effects leads to a considerable downward bias in the estimated QAP indexes. Furthermore, the estimation of these model effects in this analysis enabled us to estimate their trends over the period considered.

Additionally, we have analysed a methodological issue present in the hedonic price index literature. This issue 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 are usually too unstable over time (Pakes, 2003). This argument has been used to invalidate the most common method employed for constructing hedonic price indexes: the pool time-dummy variable method or multi-period regression method (Schultze and 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 in order to carry out efficient annual estimations. After formally testing the significance of the aforementioned assumption on the estimated price index trends, our results indicated that implicit price instability did not appear to always disfavour the pool regression method.

This paper is organized in 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, we go on to justify how we have selected the automobile quality dimensions used as explanatory variables in the hedonic regression. Section IV shows our empirical results. Firstly, we analyse the relevance of temporal stability of hedonic parameters for QAP indexes when the two time dummy variable methods are compared. Secondly, we present 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 gasoline-automobile models during the period 1988-2004. The car models selected account for at least 70 percent of the total annual market sales. Data on 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. Since automobile models are updated, a model was considered different when its version observation had differing characteristics. This criterion led to the classification of 242 different automobile models for the whole period considered. These data sets come from the edition of the specialized journal *"Autopista"* published in the first week of March, when prices were observed to be more stable.

The aggregate car prices included in the estimations are therefore, list prices in current terms and not transaction or "street" prices. In fact, transaction prices are frequently lower than list prices. However, although these prices are what consumers actually 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 model of gasoline automobile. The information about the 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 airbags. 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:

$$P_{it} = f(C_{it}) \qquad t = 1,....,T \tag{1}$$

Where P_{it} is the observed 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, the choice of the semi-log model was determined by implementing PE-MacKinnon-Davidson tests for non-nested models. Adding a random term in (1), the general model specification of our analysis is defined as:

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

The term r_t are time dummy variable parameters that measure the "pure" variations of the price with respect to the base year denoted by the sub-index *0***.** Thus, we observe *T+1* periods. 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} which 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 variable 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 the whole period while in the latter, this assumption is only considered for each pair of adjacent years.

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 (i.e. the QAP deflator for the base period) is given by:

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

Selected Automobile Quality Dimensions

Triplett (1969) pointed out the complexity of using hedonic methods in the construction of 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 and more specifically in the case of automobile performance related characteristics, we have chosen automobile size relative measures (e.g. automobile weight). These relative measures are appropriate when seeking to avoid the positive technical correlation between automobile size and its power and between automobile size and gasoline consumption. For this reason, each automobile's power and gasoline consumption are expressed relative to its weight. We have called these two relative automobile attributes respectively power efficiency and gasoline consumption efficiency. In reality, this is what buyers take into account when evaluating automobile performance.

As mentioned in the introduction, among automobile characteristics there are many brand specific attributes (e.g. prestige and reliability) that are already included in the model-specific effect. In the estimation of the hedonic equation, brand and model effects were considered to be fixed for the period considered in each hedonic regression.

Lastly, sport cars are considered more expensive since, among other reasons, 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. In the model-specific approach, the model effect itself already controlled for this segment.

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

Table1. Quality dimensions and its Indicators

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

IV. RESULTS

Relevance of temporal stability of hedonic parameters for QAP indexes

As explained in section II, the assumption about the 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 relevant factor is the QAP 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 an empirical basis does not always exist.

The WLS estimated coefficients for each automobile attribute using the pool regression method are reported in Table 2. The first column refers to the brand fixed effects specification. The second column reports the results using the model-specific fixed effects approach. 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 with brand fixed effects[3], the estimated hedonic coefficients varied considerably in their signs and their values over 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 an explanation of the causes of parameter instability is outside 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).

[3] The adjacent-two year methodology could not be applied when controlling for the model-specific effect approach because of lack of degrees of freedom for an efficient estimation of the parameters.

Table 2. 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)b	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***

(b)T-statistics between brackets.

Once the temporal instability of the hedonic parameters has been shown 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 their real year-on-year changes. When comparing the QAP index trends using the two time dummy variable methods alternatively, the discrepancies were small. In order to know if these discrepancies were statistically significant, we have used the Hausman test (1978). The hypothesis that has been formally tested was the following:

$$H_0 : q = \hat{P}^{Pool} - \hat{P}^{Adj} = 0 \quad (4)$$

Where q is the $T*1$ vector that contains the differences between the estimated annual variation rate of the QAP indexes according to the pool regression method, $\dot{P}^{Pool}$, and the adjacent-two year method, $\dot{P}^{Adj}$. Under the null hypothesis, the difference vector covariance matrix between the estimated annual variation rates is:

$$V\left(\hat{\dot{P}}^{Pool}-\hat{\dot{P}}^{Adj}\right)=V\left(\hat{\dot{P}}^{Pool}\right)-V\left(\hat{\dot{P}}^{Adj}\right) \tag{5}$$

Consequently, in our case, the Hausman test statistic is defined as:

$$x_H=\hat{q}'\hat{V}(\hat{q})^{-1}\hat{q} \tag{6}$$

This statistic follows an asymptotic chi-squared distribution with T degrees of freedom. In our results, the Hausman statistic was 15.13. For a chi-squared with 16 degrees of freedom, the minimum size for which the null hypothesis presented in (4) would still have been rejected was 0.4. Therefore, our results indicate that the rejection of parameter stability does not always imply significant bias in the QAP indexes. The reason behind these results is a compensation mechanism within the components of quality across time (i.e. some quality dimensions gain and others lose relevance over periods). This mechanism could be due to changes in consumer preferences as well as the presence of multicollinearity which is difficult to avoid in hedonic regressions. In fact, the results of our test indicated that when estimating QAP indexes, it is more relevant to control for the average effect of quality on prices over time than to control for the temporal variance within quality components. For this reason, although this experiment could not be repeated in the case of the model-specific effect approach due to the lack of degrees of freedom, the same conclusions of this section were applied.

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

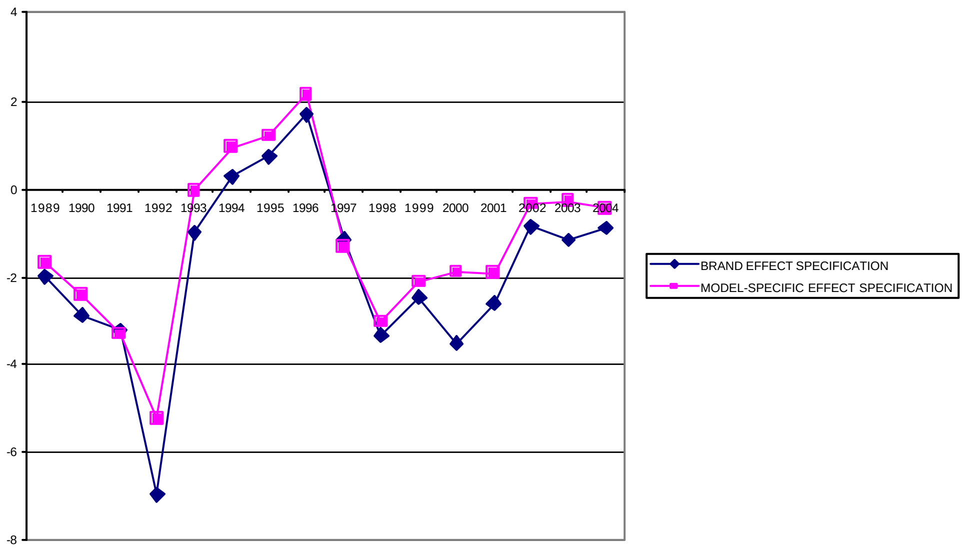
The complexity of estimating hedonic functions for the specific case of automobile has been highlighted by previous researchers (Griliches, 1961; Griliches & Ohta, 1976 and Tripplet, 2004). The wide variety of services that these products can provide makes the task of selecting and collecting all their 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. In the case of horizontal differentiation, brand attributes play an important role. However, the degree of vertical differentiation is captured by the measurable quality variables introduced in the hedonic function. As mentioned above, it is not possible to obtain all the price determinant variables because sometimes they are not observed by researchers. Previous research has shown that these "*left-out*" characteristics were automobile model-specific. (Requena-Silvente & Walker, 2006).

In this section, we have used the results of the pool regression method due to the conclusions reached above. 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 over time, we were only interested in their average trends. For this reason, in our model specification, these model-specific effects are fixed across time.

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 and the model-specific effect approaches were significant at any level. In other words, there were significant distinctions between models of the same brand once observed quality discrepancies were controlled for. As expected, these model-specific effects were positive.

Once we had shown that model-specific effects existed, we wanted to analyse the impact of omitting these effects over 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 by up to 29.3 percent from 1988 to 2004 while under the alternative model the overall drop amounted 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 analysing 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 our interpretation of the model-specific effects, these effects incorporate brand attributes such as prestige and reliability. Therefore, model-specific effect indexes also inform about changes in the economic consumer valuation of these attributes. This valuation has dropped considerable across time. The overall decline of the model-specific effect amounted to 16 percent. This is not a surprising result given that average automobile reliability has been improving over time and associated discrepancies between producers have been fallen. This was due to the mass incorporation of new less-costly technologies 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 considerably in the Spanish automobile market. As an example, in 1988 the number of brands amounted to 36 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's share. This fact induced firms to adjust quality upward in order to increase their sales (Lawrence, 1953). Thus, increasing competition in the Spanish market during from 1988 to 2004 could explain 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 could also be the reason that justifies the trends of the estimated QAP indexes. In Table 4, we have also summarized the estimated QAP indexes obtained using the model-specific fixed 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 amounted to 12.60 percent. This is more than half the overall decline during the whole period considered. Taking into account the historical context of our analysis, this substantial drop in prices could be attributed to 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 were to be removed progressively. Consequently, the new treatment of automobile imports favoured the entrance of 19 new brands in the Spanish market during these four years. Then, from 1993 to 2001, the QAP indexes showed more variation that could be due to the continuous flow of market entries and exits. This process took place due to the considerable growth in demand (i.e. market entrance opportunity increased) 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 amounted to 72 percent in Spain during those years. Then, the entry-exit process stopped in 2002 where the same 58 brands remained in the market until 2004. In fact during this 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 set, we have estimated revenue weighted QAP indexes as well as the model-specific effect indexes for the Spanish automobile market from 1988 to 2004. For this purpose, we have used the time-dummy variable-pool regression method including model-specific fixed 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 former removed trade restrictions and consequently, facilitated firms' participation in the Spanish automobile market. The latter stimulated new automobile demand and thus, firms' entry to the market. These two facts implied an increase in market efficiency that could explain 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 could also justify the reduction by 16 percent in the estimated average automobile model-specific effect.

Additionally, in order to obtain the aforementioned empirical results, we have analysed the statistical relevance on 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 **QAP** index trends between the two time dummy variable approaches: the pool regression method and the adjacent-two year method. Our results indicated that the discrepancies found were not significant. These findings may be due to the presence of an inter-temporal compensation mechanism within the quality indicators considered. These results open up once more the discussion about the applicability of multi-period pooled regressions to estimate QAP indexes and in general about the relevance of the temporal constancy of parameters in hedonic function for constructing these price indexes. Concerning the second assumption, as found in recent research, there are many unobserved attributes which are model-specific. 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 led to an overestimation of real pure price falls by 9.6 percent.

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)
Gasoline 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)	Height (Cm)	Width (Cm)	Weight (Kgms)	Air Condition.	Gasoline Consump (Litres /100Km)	Power Steering	Driver Airbag	Twin Airbags	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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