Discount factor for durable goods: evidence from the Spanish automobile market

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Abstract

Incentives for car purchase have been a common concern for politicians in Spain. In this paper, I want to focus on the most recent policies: Plan VIVE and Plan 2000e, introduced in 2008 and 2009 respectively. The data of car purchase in Spain show that after the introduction of the Plan 2000e there was a significant increase in the number of vehicles sold in Spain. But that seems quite contradictory with the features of the aforementioned plans: if we assume an average consumer, that borrows money at a certain interest and that repays it in several years we can see that actually it is possible to save more money using the Plan VIVE rather than the Plan 2000e. The key to explain this puzzle cannot be other than time preference: car purchase, as it is the case of other durable goods, has a very strong intertemporal discount factor; a factor that was omitted by the authors that devoted papers to build theoretical models of car purchase. The hypothesis is demonstrated by the fact that, at least in Spain, people prefer an initial lump-sum payment in order to purchase a car rather than a financial program with better conditions.

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1 Introduction

Nowadays the automobile industry is a key sector in most of the advanced countries; in many cases, this sector is actually one the biggest generator of both direct and indirect jobs. The production and sale of cars has thus became one of the highest contributors to the value added of the industrial data in many countries as well as a major component of the GNP, capturing not only production but also the R&D investment. Considering these facts, it is not surprising that politicians all around the world have been worried about the evolution of this sector. Thus, since a few decades ago, Governments in many countries have tried to boost domestic car sales especially during periods of economic recession. In some cases these policies have been implemented in an indirect way; for instance, by providing the public sector only with domestic cars or by introducing barriers to the sales of foreign cars in the domestic market. But it is not a secret that in other cases these policies have directly tried to boost the sales by introducing monetary incentives, as subsidies or tax reductions, on the demand side. Therefore, in order to be successful, there are several relevant questions that policy designers should face before implementing these policies: how do potential buyers evaluate purchase decisions? Do they take into account all the possible elements prior to purchasing a durable good? Are they sure that one credit provides them with a more beneficial payments scheme with respect to another one? In summary, should we trust in the "Rational Consumer" model?

This paper presents a challenge to such "Rational Consumer" model; thus, following the trend that has begun in the last decades, I want to focus on the so-called behavioral elements. Among them, I want to study and evaluate how big is the time preference associated to the purchase of cars, as a durable good. Of course this is not new: since Irving and Samuelson formalized this time preference element for the first time in the Thirties, many authors have tried to identify and empirically estimate this factor associated to the purchase of durable goods. For instance, Hausman (1979), who studied the market of air conditioners in the US, estimated a discount rate of 20% on the basis of the tradeoff between capital costs versus operating costs of such machines. Nevertheless he was aware of a considerable variation across different income levels of consumers. In a similar way, but based on the market of refrigerators, Gately (1980) estimation yields discount rates ranging from 45% to 300%. Some other papers have tried to identify the specific discount factor associated to car purchase. For example, Dreyfus and Viscusi (1995) examine the role of time preference factor –derived from fuel efficiency, operating costs and safety as mortality and injury– as it relates to consumers' valuation of the fuel economy attributes of cars and the life and health effects of automobiles. Their estimation suggests a discount factor in between 11 and

17%. They conclude that such discount factor is consistent with the interest rate required for automobile purchase. Additionally Verboven (1997) analyzes the intertemporal choice problem between a gasoline car versus a diesel car. He estimates an implicit discount factor,[1] which tends to be positive but less than in other appliances. Another research study to take into account is the one conducted by Cohen (1998). In spite of this paper being more in line with a legal and juridical view, he recognized that a decreasing in the interest rate payments for car loans are not capable to clearly incentivize the purchase of automobiles. He presents some facts and data to support this statement.

Nevertheless, the aforementioned studies together with most of the earlier papers on time preference estimation were subject to many problems. Frederick et al. (2002) pointed out issues such as the lack of information among consumers –that was pretty clear for the appliance case, since it is really difficult to estimate the tradeoff between cost savings of the more efficient appliances– and hidden costs of the most efficient appliances –reduced convenience or reliability– make the time preference estimations too noisy.[2] In addition, Kurani and Turrentine (2004), as Frederick et al. (2002) did, argue that people generally have no idea about cost saving, so it is difficult to estimate a real time preference factor. Focused on the time preference associated to automobiles, Morton et al. (2011) indicate as well that the impact of search cost, incomplete information and bargaining disutility on the purchase of cars, which also can increase the noise of our estimation. An argument that is also supported by Greene (1983), who provides additional evidence in the same direction. In general, although not mentioned explicitly in the previous literature, I am aware of the problem generated by the existence of transaction costs in both forms implementation and execution, which tend to be underestimated or not taken into account by most of the models.

For that reason, I propose here a quite different scenario: what if the consumer is fully informed of the different alternatives? In particular, once the consumer is aware of the existence of different financing schemes, and she is fully informed about them (so she is able to compute easily the cost of each alternative) we still observe the existence of such a "weird" non-rational behavior. That is the case of the Spanish Plan VIVE and Plan 2000e. These two policies, implemented in 2008 and 2009 respectively, provided the consumer two clear different payments schemes for car purchasers: the former provided the purchaser a credit at a reduced interest rate[3]; the Plan 2000e was a lump-sum subsidy of $2,000$€, but there was no reduction in the interest rate applied for the amount of the credit. In this paper I

[1] Notice that in his paper Verboven used the term interest rate to refer to it.

[2] Other issues that these author mention are the disbelief among consumers that the cost savings will be as great as promised and the lack of expertise in translating available information into economically efficient decisions.

[3] As we see later, the interest rate was 0% for the first $10,000$€.

check that even though the first was in fact more beneficial for the consumer, it was a fully disaster. On the other hand, Plan 2000e was a great success. Why such difference? I want to point out that the key to understand this puzzle is the introduction of a time preference element in the purchase of durable goods. I also check that my position is in line with most of the literature both on time preference and on evaluation of policies for purchasing durable goods.

The rest of the paper is organized as follows: Section 2 contains a brief summary of the policies that have tried to boost car sales in Spain. Section 3 sets the comparison between the schemes I am interested in. For that purpose, it is included here the model and also the estimations of both schemes based upon our model. Section 4 discussed the actual impact of both plans. Section 5 presents our key finding, i.e. the introduction of a discount factor. Finally, Section 6 concludes.

2 The policies: Plan VIVE and PLAN 2000e

As mentioned above, the automobile industry is a key sector in many advanced countries; and Spain is not an exception. According to the Spanish Institute for Foreign Trade (ICEX), it represented 10% of the GDP, 17.7% of the total exports and generated more than 300,000 direct jobs in 2012. In addition, the National Association of Automobile and Trucks Manufacturers (ANFAC) indicated that by the same year Spain was the second largest car producer and the leader in production of small trucks in the European Union. Thus, it is not surprising that the Government reacted by implementing policies that boost car sales during the period of the economic crisis. Notice that the downturn was especially severe in Spain, and the car industry was one of the most affected sector. According to ANFAC the sales decrease by 28% in 2008, the greatest reduction in the history.

To buffer the crisis of the sector, in June 2008 the Government implemented the so-called Plan VIVE (first part)[4] that would expire in July 2010 or before if there was a run out of the money the Government planned to use for it. Now the benefit was to obtain a loan for car purchase at a 0% interest rate for the first $5,000$€ and a reduced interest rate[5] for the rest of the money needed up to $20,000$€. Several requirements were necessary: first, it was necessary to scrap a more than 15 years old car. Additionally the new car must be labeled as "intelligent", i.e., it must include an electronic control system of stability, belt sensors in the front seats and its CO_2 emissions must be equal or less than 140 g/km; or as

[4]Included in the Spanish Agreement of the Cabinet of Ministers *Acuerdo del Consejo de Ministros de 27 de junio de 2008* and included in the Spanish Official State Gazette of June 28^{th}, 2008.

[5]A maximum rate of 2.5% plus one-year euribor.

"ecological", that is, its CO_2 emissions must be equal or less than 120 g/km. It was also possible to purchase a used vehicle as long as their initial registration occurred within the previous five years. This credit, that could accommodate individuals as well as autonomous entrepreneurs and SMEs (Small and medium enterprises),[6] was given for a maximum period of 5 years and the price of the car could not exceed $30,000$€.

Due to the bad performance of the previous plan, there was a new and more interesting modification of the Plan VIVE (which is the second part of it).[7] Starting from November 2008, this time it was possible to obtain a credit up to $10,000$€ at a 0% interest rate for car purchase; additionally a consumer could order up to $20,000$€ more for the purchase at a reduced interest rate.[8] It was necessary to scrap a car with 10 or more years since its first registration (so there was a reduction of this requirement in 5 years) or regardless of the age of the car, it could be scrapped any car as long as it had traveled more than $250,000$ km. Two more benefit were included: with some restriction, it was also possible to use Plan VIVE in order to buy a used car; and the definition of "intelligent" car was expanded, including now also vehicles with CO_2 emissions lower than 140g/km that incorporates 3-way catalyst for gasoline vehicles or exhaust gas recirculation EGR device for diesel vehicles. Again, the maximum price of the car could not exceed $30,000$€and the credit was given for a maximum period of 5 years. Of course, apart from this, it could be used personal funds to purchase the car. It was also possible to buy an industrial car[9] and also to purchase a used car with similar conditions to those described above for the Plan VIVE (I).[10] The deadline of the plan remained as before. It is important to remark that a person who benefits from the Plan VIVE (I) could change into the new conditions any time.

Finally, the Government of J.L. Rodríguez Zapatero implemented the Plan 2000e in mid-May 2009; [11] the expectation was that the plan would last one year unless the funds ran out before that date. The main change with respect the previous one is that now, in spite of obtaining nice conditions for the credit, there was a lump-sum reduction in the price of the car. The amount of such reduction was $2,000$€. The rest of the details were very

[6] The definition of SME is given by the Spanish Ministry of Industry according to the European standards. For more details see the Official Gazette of the European Union May, 20^{th} 2003, L124/36.

[7] Included in the Spanish Agreement of the Cabinet of Ministers and included in the Spanish Official State Gazette of November 21^{st}, 2008.

[8] The Agreement specified that the interest rate could not exceed a reference interest rate given by the Spanish Official Credit Institute (ICO) plus up to 2.5%. According to the official information, that interest rate suppose an Annual Percentage Rate (APR) of about 5.65%.

[9] The car included here were those which are used for the carriage of goods and having a maximum weight not exceeding 3.5 tones.

[10] In this case, the buyer must scrap a more than 15 years old car.

[11] Introduced by the Spanish Royal Decree-Law *Real Decreto 898/2009* and included in the Spanish Official State Gazette of May 23^{rd}, 2009.

similar to the Plan VIVE (II): it was necessary to purchase a car labeled as “intelligent” or “ecological”(similar definitions as above); it was valid for used cars[12] as well as for small trucks purchased by SME; and the maximum price of the purchased car could not exceed $30,000$€. In January 2010 there was an expansion of this plan until September,[13] but due to lack of public funds it finished in June 2010.

Since we are going to focus in the last two policies, and to make it clearer, Table 1 summarized the main features of both the Plan VIVE (second part) and Plan 2000e. Additionally, Appendices I and II includes two car purchase contracts using both Plan VIVE and Plan 2000e respectively. In the next section, I set up the rational individual choice using each of the plans.

3 The Theoretical Model

For a rational consumer, I want to quantify the cost derived from purchasing a car using Plan VIVE versus Plan 2000e. I am especially interested in the relationship between both payments schemes, as the latest implies a lump-sum subsidy on the amount of the credit and the former provides much better financial conditions. Thus, I construct the model including the total cost of the purchase that includes not only the price of the car but also other cost associated to it (including financial charges). At least from a theoretical point of view, consumer must be indifferent between both plans as long as the costs of both are the same.

I assume –as it is in reality– that car purchase is a two-step decision; in the first one, the individual decides which car to purchase based on several factors: price, tax, size, speed, load capacity, fuel efficiency, etc. A comprehensive study on this factors is developed by Train (1986); a more recent one is Hennessy and Tol (2011), whose model is particularly rich. In the second step, the consumer decides how to finance the purchase of the car; i.e. she decides how much is going to be the down payment and the deferral amount (the credit).[14] This time, I want to focus on this second step; hence, let's assume that the individual has chosen car model $\bar{h}$ in the first stage. Now the decision for her is how to finance the purchase. Thus, the maximization problem becomes:

$$\max_{j} U_j^i[y^i - p_j, \overline{B}_{\bar{h}}^i] \tag{1}$$

[12]For this case the scrapped car must be a 12 years old car, reducing in three years the requirement.

[13]Introduced by the Spanish Royal Decree-Law *Real Decreto 2031/2009* and included in the Spanish Official State Gazette of January 8^{th}, 2010.

[14]Typically this decision is made with the assistance of a bank or the financial institution associated to the dealer from where the car was purchased.

Table 1: Main features of Plan VIVE (II) and Plan 2000e

	Plan VIVE (II)	Plan 2000e
Dates	From 11/17/2008 until 05/17/2009	From 05/18/2009 until 09/30/2010
Deadline specified at the beginning	√	√
Early finish if funds run out?	√	√
Main features	A credit up to 10,000€ at a 0% interest rate (i.r.); between 10,000 and 30,000€ at a reduced i.r.	A lump-sum subsidy of 2,000€ given when the car is purchsed
Mandatory to scrap an old car?	√ (a 10 or more years old car or a car with more than 250,000 km.)	√ (a 10 or more years old car or a car with more than 250,000 km.)
Cars that can be purchased	M1, N1	M1, N1
Maximum price of the car purchased	30,000€	30,000€
Features required for the car purchased (M1)	CO_2 emissions lower than 120g/km or CO_2 emissions lower than 140g/km including an electronic control system of stability and belt detectors in front seats or CO_2 emissions lower than 140g/km plus 3-way catalyst for gasoline vehicles or exhaust gas recirculation EGR device for diesel vehicles	CO_2 emissions lower than 120g/km or CO_2 emissions lower than 140g/km including an electronic control system of stability and belt detectors in front seats or CO_2 emissions lower than 140g/km plus 3-way catalyst for gasoline vehicles or exhaust gas recirculation EGR device for diesel vehicles
Possibility to purchase a used car?	√ (must be less than 5 years old)	√ (must be less than 5 years old)

[a] *M1 stands for vehicles used for the transport of persons having, in addition to the driver's seat, eight seats at most.*

[b] *N1 stands for vehicles used for the carriage of goods and having a maximum weight not exceeding 3.5 tonnes.*

where j indicates the financial scheme; p is the total amount paid by the consumer for model h, including the initial payment as well as the monthly payments generated by the credit using scheme j;[15], y is the disposable income for consumer i, and B is the net benefit that consumer i obtains for owning car h. Since $\bar{h}$ is given (solved in the first step), $\overline{B}_{\bar{h}}$ is fixed, so the maximization is:

$$\max_{j} U_j^i[y^i - p_j] \tag{2}$$

Then, assuming that the income for individual i is given, the previous maximization problem is equivalent to the following minimization problem:

$$\min_{j} p_j = Do_j + De_j(r_j) = Do_j + \sum_{n=0}^{N} \sum_{k=0}^{12} M_{n,k}(r_j) \tag{3}$$

In other words, the rational consumer wants to minimize the price to pay, which is going to be divided into a down payment (or initial payment), Do, an a sequence of monthly payments M during N years at an interest rate r.[16] Both are going to depend on the scheme chosen. To be consistent with the Spanish Contract Law and with *de factor* common legal practice, I am going to assume that the repayment or amortization system for the credit is the constant quota one or, at it is called in Spain, the "French method"; in other words, the credit is going to generate equal monthly payments until it is totally repaid. Hence the monthly payments are calculated as follows:

$$M = De \frac{I_K(1 + I_K)^{nK}}{(1 + I_K)^{nK} - 1} \tag{4}$$

where

$$I_K = \frac{r_j}{100K} \tag{5}$$

with r_j being the interest rate applicable –that will depend on the scheme chosen– and $K = 12$.[17]

Thus, plugging equation (4) into equation (3), we obtain that the cost of using scheme j is going to be:

[15] Notice that the monthly payments include the financial charges.
[16] De stands for the total deferred amount (the credit).
[17] Recall that K is the numbers of months in a year. I.e. $K = 12$.

$$\min_j p_j = Do_j + De_j \frac{I_K(1+I_K)^{nK}}{(1+I_K)^{nK}-1} NK \tag{6}$$

To wrap up, the rational individual will choose the plan that minimize the value of the initial payment plus the monthly payments that will be generated through scheme j. Notice that the Spanish Contract Law requires the APR (Annual Percentage Rate) to be the interest rate applicable to the purchase. The APR is the interest rate taking into account commissions and fees from the bank. So in order to obtain r_j departing from the APR, it is necessary to apply the following formula:

$$APR = 100\left(1 + \frac{r_j}{100K}\right)^K - 1 \tag{7}$$

To make it simpler, let us restrict our scenario to two possible financial schemes: one based on Plan VIVE conditions and the other on Plan 2000e conditions. In other words, the tradeoff faced by the individual is whether to use Plan VIVE scheme or Plan 2000e scheme to acquire the $\bar{h}$ car model. I.e. $j = \{v, e\}$ where v stands for Plan VIVE and e refers to Plan 2000e. Let us first consider the Plan VIVE. As we already know from Section 2, in this scheme there is no interest rate for the first $10,000$€ for the credit the consumer needs to buy the car. If she needs more money to purchase the car, it is possible to get an additional amount up to $30,000$€ at a reduced interest rate. This interest rate could not exceed a reference rate given by the Spanish Official Credit Institute (ICO) plus 2.50%. From the information provided by ICO we know that the actual APR applied for the amount borrowed lying between $10,000$ and $30,000$€ was 5.65%. Thus, if a person buys a car using the Plan VIVE, there are two possible scenarios:

1. The credit amount requested (De_v) is less than or equal to $10,000$€: $De_v \leq 10,000$

   In this case the interest rate applicable to the credit that consumer needs to purchase a car is 0%. In other words, there are not going to be any financial charges.[18] Thus,

$$p_v = Do_v + De_v(0) \quad \text{if} \quad De_v \leq 10,000 \tag{8}$$

2. The credit amount requested (De_v) is greater than $10,000$€: $De_v > 10,000$

   In that case the interest rate applied is the aforementioned 5.65%, but it will be

[18] In fact in this case the most beneficial situation is to have an initial payment (Do_v) equal to zero. Consider that it is always possible to put the disposable income in a deposit so the consumer could obtains some yield. Nevertheless, since this scenario is negligible, we are going to ignore it.

applicable only to the part of the credit that exceeds 10,000€. Hence, the price that a consumer pays for the car is given by 10,000€, $De_{v,1}$ (which corresponds to the first 10,000€ of the credit at a 0% interest rate), plus the amount paid at the beginning, Do_v (if any), plus the summation of the monthly payments (including financial charges) generated by the part of the credit that exceeds 10,000€, $De_{v,2}$. Thus,

$$p_v = Do_v + De(r_v) = Do_v + De_{v,1}(0) + De_{v,2}(r_v) \quad \text{if} \quad De_v > 10,000 \tag{9}$$

Hence, combining together equations (8) and (9) we have that the cost associated to a car purchase for a consumer i that uses scheme *vive* is:

$$p_v = \begin{cases} Do_v + De_v(0) & \text{if } De_v \leq 10,000 \\ Do_v + De_v(r_v) = Do_v + De_{v,1}(0) + De_{v,2}(r_v) & \text{if } De_v > 10,000 \end{cases} \tag{10}$$

where $De_v = De_{v,1} + De_{v,2}$ and $De_{v,1}(0) = 10,000$

Let us now consider the cost of a car for a consumer that uses Plan 2000e. As we already know, in this case there is no reduction in the interest rate applicable to the credit requested. On the contrary, there exists a 2,000€ lump-sum discount on the price of the car. Thus, the cost of the car is going to be given by the initial payment, Do_e, plus the payment deferred including financial charges (the credit), De_e, minus 2,000€; thus,

$$p_e = -2,000 + Do_e + De_e(r_e) \tag{11}$$

I am specially interested in the comparison between both schemes; for that reason, I analyze the difference between Plan VIVE and Plan 2000e in order to compare which one is more beneficial for consumer i. Assuming that a potential consumer has saved the enough money to pay an initial payment for the car equal to $\overline{Do}$, i.e. the assuming $\overline{Do} = Do_v = Do_e$ difference between both schemes is going to be given by:

$$\kappa = p_v - p_e \tag{12}$$

And again I analyze two possible cases:

1. If $De_j \leq 10,000$, then
$$\kappa = 2,000 + [De_v(0) - De_e(r_e)] \tag{13}$$

2. If $De_j > 10,000$, then
$$\kappa = Do + De_{v,1}(0) + De_{v,2}(r_v) - [-2,000 + Do_e + De_e(r_e)]; \tag{14}$$

and since $De_{v,1}(0) = 10,000$,

$$\kappa = 10,000 + De_{v,2}(r_v) - [-2,000 + De_e(r_e)];$$

$$\kappa = 12,000 + [De_{v,2}(r_v) - De_e(r_e)] \tag{15}$$

Combining together equations (13) and (15) we have that κ is given by:

$$\kappa = \begin{cases} 2,000 + [De_v(0) - De_e(r_e))] & \text{if } De_j \leq 10,000 \\ 12,000 + [De_{v,2}(r_v) - De_e(r_e)] & \text{if } De_j > 10,000 \end{cases} \tag{16}$$

where $De_v(0) = 10,000$

As it is possible to observe in equation (16), the difference between both schemes is going to be given by the summation of the monthly payments generated by the credit. In other words, the advantage of one plan over the other lies in the amount of the credit borrowed by the consumer. Following this model, I analyze the difference between the two schemes for a reasonable range of car prices and credit quantities requested. As it is indicated by the data offered by the Association of Automobile Dealers (Faconauto) the average time required in Spain to repay the amount borrowed for car purchase was 7 years (84 months) in 2007, and 7.5 years (92 months) in 2008. In spite there is not data available for the critical years (2009 and 2010) the data highlight us that it is possible to expect for those years that the average consumer will employ at least 5 years to repay the debt. Recall that the Plan VIVE did not allow to take the 0% interest rate credit for more than 5 years so I use this (5 years) as the lower bound.[19]Taken the previous into account, Table 2 presents the values of κ for a 5 years term credit; a reasonable range of credit amounts was selected for that table (De).[20]

We can check that, for all our sample data, the value of κ is negative, i.e., using the Plan 2000e, which offers an initial lump-sum discount on the car price, the consumer is losing money compared to the benefits that the same consumer could obtain using the Plan VIVE. The only exception is when the amount of the credit is $6,000$€. Furthermore, following the data provided by the BBVA-Research group we know that the average amount borrowed in Spain for car credit during the first three quarters of 2010 was equal to $12,700$€.[21] As it is

[19]Notice that the consumer could always obtain credit for more years from a retail bank, so this 5-years limit is not an upper bound.

[20]The range was chosen using the following rule of thumb: according Faconauto, the average price paid for a car in 2010 was $20,370$€. Additionally, and as it is going to check later on, we know that the average credit amount for buying new car in Spain during the first three quarters of 2010 was $12,700$€. Considering that the price of the cheapest car is around $9,000$€, expanding the same ratio, the lower credit amount we can expect is around $6,000$€. The greater amount we could expect is just the maximum price of the car permitted by both plans, which is equal to $30,000$€.

[21]That number is consistent with the information given by the *Asociación Nacional de Establecimientos*

Table 2: Differences between Plan VIVE and Plan 2000e for a selected range of credit amounts

	Cost of the credit (De_j)		
Credit amount (De)	Plan VIVE	Plan 2000e	κ
6,000	6,000	5,792.85	207.15
7,000	7,000	7,091.65	−91.65
8,000	8,000	8,390.46	−390.46
9,000	9,000	9,689.27	−689.27
10,000	10,000	10,988.08	−988.07
11,000	11,146.58	12,286.88	−1,140.31
12,000	12,293.15	13,585.69	−1,292.54
13,000	13,439.73	14,884.50	−1,444.77
14,000	14,586.30	16,183.31	−1,597.00
15,000	15,732.88	17,482.11	−1,749.24
16,000	16,879.45	18,780.92	−1,901.47
17,000	18,026.03	20,079.73	−2,053.70
18,000	19,172.61	21,378.54	−2,205.93
19,000	20,319.18	22,677.34	−2,358.16
20,000	21,465.76	23,976.15	−2,510.39
21,000	22,612.33	25,274.96	−2,662.63
22,000	23,758.91	26,573.77	−2,814.86
23,000	24,905.48	27,872.58	−2,967.09
24,000	26,052.06	29,171.38	−3,119.32
25,000	27,198.64	30,470.19	−3,271.55
26,000	28,345.21	31,768.00	−3,423.79
27,000	29,491.79	33,067.81	−3,576.02
28,000	30,638.36	34,366.61	−3,728.25
29,000	31,784.94	35,665.42	−3,880.48
30,000	32,931.52	36,964.23	−4,032.71

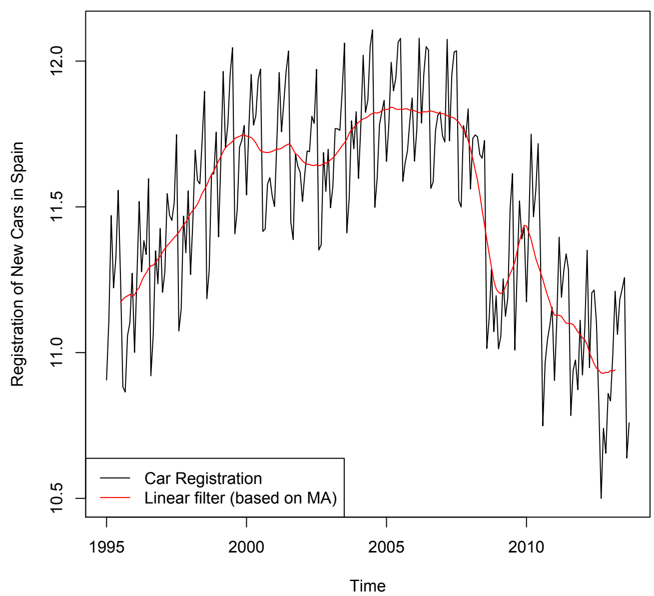
trivial to see, that amount is much higher than 6,000€, which is in fact for the only amount for which Plan 2000e was more beneficial. Thus, provided that the average credit given for car purchase in the aforementioned period was 12,700€ I can state that the average value of κ is equal to $-1,399.10$, which is the value that we expect an average consumer is losing by using Plan 2000e rather than Plan VIVE.

Financieros de Crédito (ASNEF). According to it, the average credit for car purchase in Spain in 2010 was around 13,000€.

4 The Impact of the Policies

According to the previous section, a rational individual will prefer, for a reasonable wide range of car prices, to purchase the car using Plan VIVE rather than Plan 2000e. Now the goal is to analyze how was the actual response of the consumers. To explore this, I use monthly data on registration of new cars in Spain, which proxies car sales. Figure 1 displays the evolution of such variables from 1995 until 2013.

Figure 1: Registration of New Cars in Spain (1995-2013)



From the data, it is possible to infer a couple of facts; first of all, the registration of new cars displays a high seasonal pattern. Usually, the best months for car sales are right before the summer, typically in April, May and June. On the other hand, the poor months for the sector are usually August, September and January. Second, the data present certain tendency; to check it, a moving-average based filter is included, which removes the seasonal noise from the raw data. Thus, there is a clear upward pattern in the registration from 1995 until right before the beginning of the 2008 crisis. Afterward, the trend in the registration dramatically changes and becomes negative. Nevertheless, after 2008 –in 2009 and 2010– there is a short period in which the registration has a peak. This period exactly coincides with the introduction of Plan 2000e. I.e. it seems in the raw data that Plan VIVE was unable to modify the negative tendency of the sales; however, there it also seems that Plan 2000e was effective when it was introduced.

The next two subsections provide some evidence on this hypothesis; time series techniques are applied. In the first one, it is analyze the evolution of the car registration using predictions based on the Holt-Winters filter. In the second one, some other relevant variables are taking into account, so the predictions are based on the Kalman filter. Overall, the result obtained confirm the hypothesis: the peak observed during 2009-2010 has no other explanation but the success of the Plan 2000e itself.

4.1 Univariate analysis

As mentioned above, the registration of new cars in Spain presents two main components: a seasonal pattern and a trend pattern. Thus, following Harvey and Durbin (1986) let us define the following structural equation:

$$y_t = \mu_t + \gamma_t + \varepsilon_t \tag{17}$$

where y_t is the (log)registration of new cars in Spain at t; μ_t is the trend component, γ_t is the seasonal component and w_t is the irregular component. The trend component is characterized as follows:

$$\mu_t = \mu_{t-1} + \eta_t \tag{18}$$

where ε_t and η_t are independent white noise terms. The seasonal component is characterized using a standard trigonometric smoothing technique, according to the following specification:

$$\gamma_y = \sum_{j=1}^{s/2} \gamma_{jt} \tag{19}$$

where s is equal to the number of periods per year –in this case $s = 12$– and

$$\begin{bmatrix} \gamma_{j,t} \\ \gamma^*_{j,t} \end{bmatrix} = \begin{bmatrix} \cos\phi_j & \sin\phi_j \\ -\sin\phi_j & \cos\phi_j \end{bmatrix} \begin{bmatrix} \gamma_{j,t-1} \\ \gamma^*_{j,t-1} \end{bmatrix} + \begin{bmatrix} \omega_{j,t} \\ \omega^*_{j,t} \end{bmatrix} \tag{20}$$

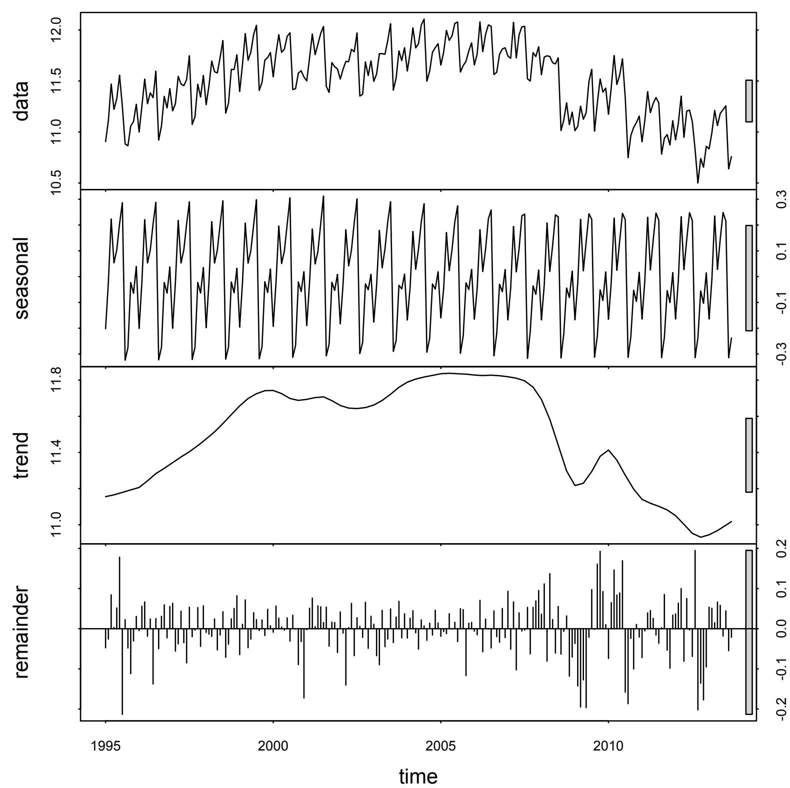
$$\phi_j = \frac{2\pi j}{s} \tag{21}$$

$$\gamma_{j,t} = (\cos\phi_j)\gamma_{j,t-1} + \omega_{j,t}, \text{ with } j = \frac{1}{2}s \tag{22}$$

for $j = 1, ..., \frac{1}{2}s - 1$ and with $\omega_{j,t}$ and $\omega^*_{j,t}$ are iid, normally distributed according to $N(0, \sigma^2_\omega)$ and independent of each other.

Figure 2 captures the decomposition of the (log)registration of new cars data into the aforementioned three component. The seasonal time series confirms the existence of a notable degree of seasonality in the data, whose peaks are achieved right before the summer. The trend line displays a similar pattern to the previous moving-average based linear filter, confirming the existence of two opposite trend in the data pre and post financial crisis. Finally the remainder –the error term– is displayed at the bottom; from a visual check, one can assert that it follows a quite stable white noise process from 1995 until 2008. After this year it becomes more volatile, suggesting that there is some pattern in the data that is not only explained by the seasonal and the trend components. Such a clue put us in the right direction.

Figure 2: Registration of new cars decomposition (1995-2013)



For the univariate analysis of the new car registration time series I use the Holt-Winter filter technique based on exponential smoothing. The advantage of such methodology is that allows to captures both the trend and the seasonal components in the data. Thus I fit the data from 1995 to 2009 and then based on the filter I make predictions on the post Plan 2000e (after May 2009) data to check what is the expected evolution of the data and compare it with the actual numbers. Thus, reconsider equation (17); the h-period ahead prediction

$\hat{y}_{t+h}|_t$ is constructed as follows:

$$\hat{y}_{t+h}|_t = \hat{\mu}_t + \hat{\gamma}_t \tag{23}$$

where

$$\hat{\mu}_t = \hat{\alpha}_t + h\hat{\beta}_t \tag{24}$$

and

$$\hat{\gamma}_t = c(\hat{y}_t - \hat{\alpha}_t) + (1-c)(\hat{\gamma}_{t-12}) \tag{25}$$

Plugging equations (24) and (25) into equation (23) it is obtained:

$$\hat{y}_{t+h}|_t = \hat{\alpha}_t + h\hat{\beta}_t + \hat{\gamma}_t \tag{26}$$

where

$$\hat{\alpha}_t = a(y_t - \hat{\gamma}_{t-12}) + (1-a)(\hat{\alpha}_{t-1} + \hat{\beta}_{t-1}) \tag{27}$$

$$\hat{\beta}_t = b(\hat{\alpha}_t - \hat{\alpha}_{t-1}) + (1-b)(\hat{\beta}_{t-1}) \tag{28}$$

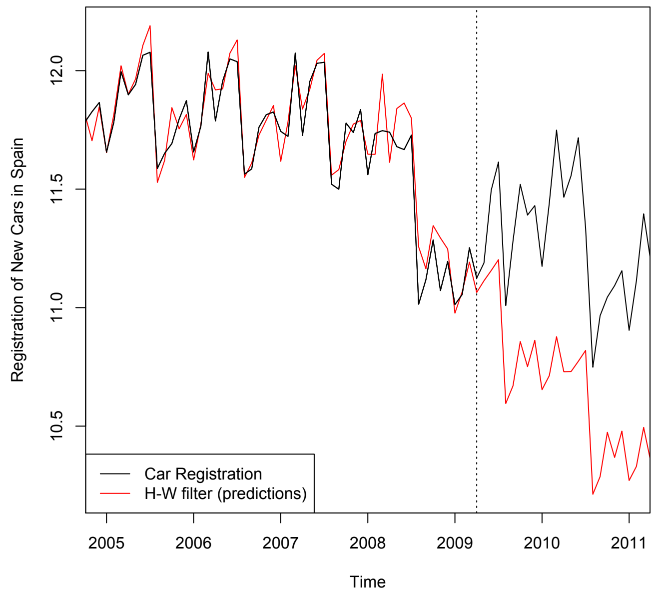
$$\hat{\gamma}_t = c(\hat{y}_t - \hat{\alpha}_t) + (1-c)(\hat{\gamma}_{t-12}) \tag{29}$$

Therefore, plugging equations (27), (28) and (29) into (26) I arrive to the following expression:

$$\hat{y}_{t+h}|_t = a(y_t - \hat{\gamma}_{t-12}) + (1-a)(\hat{\alpha}_{t-1} + \hat{\beta}_{t-1}) + hb(\hat{\alpha}_t - \hat{\alpha}_{t-1}) + (1-b)(\hat{\beta}_{t-1}) + c(\hat{y}_t - \hat{\alpha}_t) + (1-c)(\hat{\gamma}_{t-12}) \tag{30}$$

whose smoothing parameters can be estimated using standard techniques; thus, following an implementation similar to Petris and Petrone (2011), I obtain Figure 3, which displays the result of my estimation. As we can see, the actual registration of new cars –represented by the black line– was notably higher in comparison to the predicted values obtained with the H-W filter methodology – represented by the red line. In other words, even though the forecast based on the trend and the seasonal components of the data suggests that the car registration would decrease after May 2009 there is a positive tendency in the market, which cannot be explained by neither of the previous components. This fact gives support to the hypothesis that the increase in the car sales in Spain during 2009-2010 was due to the introduction of the Plan 2000e.

Figure 3: Holt-Winters filter fitting and prediction



4.2 Multivariate analysis

The previous analysis only captures the movements of the registration of new cars itself; but of course, it is possible to argue that this is not enough. The main reason is that we can think that this change in the tendency of the car sales was due to other factors, namely changes in the macroeconomic conditions in Spain. For that reason, the present section develops an analysis based on the well-known methodology developed by Kalman et al. (1960). Using it, I can include in the model other variables that may explain the changes in car sales. Thus, let us redefine the structural equation as follows:

$$y_t = \mu_t + \gamma_t + \sum_{j \in J} \delta_j x_{j,t} + \varepsilon_t \tag{31}$$

where again y_t is the (log)registration of new cars at t; μ_t is the trend component, γ_t is the seasonal component; w_t is the irregular component (all characterized as before) and where $x_{j,t}$ is the value of the jth explanatory variable at time t. Next, I need to choose the variables that may explain the movement in car sales after 2009. Following Train (1986) I consider the following two key explanatory variables: disposable income and car prices. The former is proxied by data on Spanish wages provided by the National Statistics Institute (INE). To measure car prices, I use the Harmonized Index of Consumer Prices (HIPC) index for the item "Motor Cars" in Spain from Eurostats. Since there is no data for HIPC in 1995, my analysis is restricted for the years 1996-2012. Following Hennessy and Tol (2011) other variables, such as taxes, are relevant to explain car sales. However, during the period we are interested in, there are no remarkable changes them in Spain.

Reconsidering the methodology in Kalman et al. (1960), let us define a state equation

$$y_t = A'x_t + H'h_t + w_t \tag{32}$$

and a transition Equation

$$h_{t+1} = Fh_t + v_t \tag{33}$$

where y_t is the (log)registration of new cars in Spain at t, x_t is the matrix including the aforementioned explanatory variables and h_t captures the unobservable variables that affect y_t; and where

$$E(w_t w_\tau) = \begin{cases} R & \text{if } t = \tau \\ \bar{0} & \text{o.w.} \end{cases} \tag{34}$$

and

$$E(v_t v_\tau) = \begin{cases} Q & \text{if } t = \tau \\ \bar{0} & \text{o.w.} \end{cases} \tag{35}$$

being R and Q positive semidefinite, finite matrices.

To obtain the expression of the one-period ahead forecast, $\hat{h}_{t+1}|_t$, the standard way to proceed is by the following three stages: first, calculate h_t, for which it is necessary to make inference for $t = 0$. Second, calculate matrices F, Q, A, H and R by standard techniques. Finally, the goal is to obtain the update rule (the Kalman "gain matrix") that allows to make predictions. Thus, the one-period ahead forecast is obtained as follows:

$$\hat{y}_{t+1}|_t = A'x_{t+1} + H'\hat{h}_{t+1}|_t \tag{36}$$

where

$$\hat{h}_{t+1}|_t = Fh_t \tag{37}$$

To obtain the update rule (Kalman "gain matrix") define

$$\hat{P}_{t+1}|_t = FP_tF' + Q \tag{38}$$

and

$$\eta_{t+1}|_t = y_{t+1} - \hat{y}_{t+1}|_t = y_{t+1} - A'x_{t+1} - H'\hat{h}_{t+1}|_t \tag{39}$$

and

$$E[(y_{t+1} - \hat{y}_{t+1}|_t)(y_{t+1} - \hat{y}_{t+1}|_t)'] = H'\hat{P}_{t+1}|_tH + R \tag{40}$$

Then the final expression for the Kalman "gain matrix" is obtained as follows:

$$\hat{h}_{t+1}|_{t+1} = \hat{h}_{t+1}|_t + \hat{P}_{t+1}|_t(H'\hat{P}_{t+1}|_t H + R)^{-1}\eta_{t+1}|_t \quad (41)$$

where

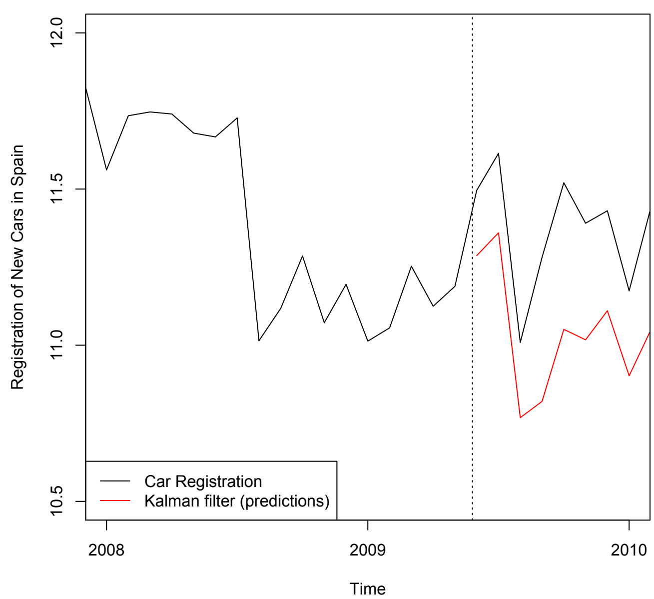
$$K_t = \hat{P}_{t+1}|_t(H'\hat{P}_{t+1}|_t H + R)^{-1} \quad (42)$$

and

$$\hat{P}_{t+1}|_{t+1} = \hat{P}_{t+1}|_t - K_{t+1}H'\hat{P}_{t+1}|_t \quad (43)$$

To actually obtain the predictions, I implement the previous equations following Commandeur and Koopman (2007). Figure 4 displays the result of the estimation. Again, even considering the potential influence of the dependent variables introduced, car registration in Spain after May 2009 was higher in comparison to what we should expected according to the prediction based on the Kalman filter. A fact that provides further and stronger evidence to support my hypothesis; i.e. to state that the positive evolution of the car sales after May 2009 was not due to changes in car prices or disposable income, but just because of the introduction of the Plan 2000e.

Figure 4: Kalman filter fitting and prediction



5 Time preference estimation

I began the analysis departing from the assumption of a rational consumer, embodied in the model of Section 3. Then I observed that for an average consumer the Plan VIVE was considerably more advantageous than the Plan 2000e. In other words, consumers saved more money using the scheme that provided more advantageous credit conditions rather than the scheme which offered an initial lump-sum subsidy. This hypothesis was refuted by data in Table 2. However, as it was checked in Section 4, after the introduction of Plan 2000e sales experienced a remarkable growth relatively to the poor performance displayed by the previous Plan VIVE. Additionally, I have analyzed some control variables to make sure that this increasing in car purchases was not due to an improvement of the Spanish economy.

So the question is: how can it be understood the fact that people respond positively to a plan which, as we have seen, is less advantageous for the consumer? The answer to this puzzle cannot be other: time preference. Indeed the consumer appreciates the fact that the lump-sum discount was done automatically at the time the purchase occurs, rather than to be done in small portions elongated in time. Thus assuming that the Do (Down Payment) remains constant whatever scheme the consumer chooses and considering that lump-sum subsidy applies to the amount deferred we have:

$$U_j^i = y^i - p_j = y^i - Do_j - \frac{De_j}{1+\gamma}$$

implying that

$$\frac{\partial U_j^i}{\partial \gamma} > 0$$

In other word, the highest is γ, the more is going to prefer the consumer the initial lump-sum subsidy. Since for the plan VIVE the value of γ is equal to 0 (there is no initial subsidy) I am able to estimate the value of γ that is implicit for the initial lump-sum subsidy introduced by the plan 2000e. Thus, an average consumer that purchases a car at a price of $20,370$€, taking a credit for value of $12,700$€, it is going to present a value for γ equal to 0.1068. Data for a larger range of credit amounts are displayed in Table 3.[22] The results are consistent: for a wide range of credit amounts (De), namely, between $11,000$ to $30,000$€, the value obtained for γ is around 0.1023 to 0.1225 and that is, the discount factor estimated is between 10.23 % and 12.25 %.[23]

[22] This time I do not include the case when the credit amount De is equal to $6,000$€, since it was the only case for which ρ was positive (i.e. Plan 2000e was more beneficial).

[23] The deviation of the value of γ from the other values when De is equal to $7,000$, $8,000$, $9,000$ and $10,000$€ is coherent, since there was a notable gap between the payment when the credit is less or equal to $10,000$€ and when it is greater than $10,000$€.

Table 3: Estimation of the discount factor for a selected range of credit amounts

Credit amount (De)	γ	Credit amount (De)	γ
7,000	0.0131	19,000	0.1161
8,000	0.0488	20,000	0.1169
9,000	0.0766	21,000	0.1178
10,000	0.0988	22,000	0.1185
11,000	0.1023	23,000	0.1191
12,000	0.1051	24,000	0.1197
13,000	0.1075	25,000	0.1203
14,000	0.1095	26,000	0.1208
15,000	0.1112	27,000	0.1213
16,000	0.1126	28,000	0.1217
17,000	0.1139	29,000	0.1221
18,000	0.1151	30,000	0.1225

6 Conclusion

I began this paper by reviewing the policies that recently have sought to boost car sales in Spain. Among them, I have focused on the study of the two most recent policies, namely, Plan VIVE (second part) and Plan 2000e. I have checked that, despite the rational individual who analyzes the costs that implies buying a car prefers the former over the latter, the data tell us something very different; in fact the Plan 2000e, based on a lump-sum subsidy, was able to promote more sales than the Plan VIVE, based on credit facilities. Given the conditions of both policies, I concluded that in order to understand this puzzle it is necessary to introduce an element of time preference. Additionally, I have estimated this element for the case of car sales in Spain. My estimations yield a discount factor between 0.10 and 0.12 for a wide range of car prices.

As discussed in Section 1, there have been many criticisms to the papers that have attempted to identify and estimate the existence of an element of time preference in the utility function of individuals. Many of these criticisms was referred to the existence of asymmetric information and searching costs which prevent consumers for reaching optimal decisions.[24] This issue was pretty clear for air conditioners case[25], in which is really difficult for a consumer to know how much she could save if she buys a more efficient machine in terms of energy utilization that presents higher initial price versus less efficient appliances at a relatively cheaper price. However, this time the scenario is quite different: the potential purchaser now has easy and cheap access to relevant information. First, because the information

[24] See Kurani and Turrentine (2004), Frederick et al. (2002) and Morton et al. (2011).

[25] Hausman (1979).

about the different plans is not only published by the Government through the Spanish Official Gazette, but also because such plans, as they are part of political programs, enjoy a high level of diffusion in media. Thus the way they work is relatively well-known for the vast majority of the population. And second, because the cost associated to each plan for different car prices can be easily estimated: a simple query to a bank would let a potential consumer know how much she needs to pay every month. So a potential purchaser can know the value of De (the credit amount) simply by multiplying that value by the number of months of the duration of the credit. Thus, I do not believe that this scenario can be criticized from the point of view of the existence of elements of asymmetric information, lack of expertise or search costs, which were the critical elements in papers that, like this one, have attempted to identify and estimate time preference factors.

Overall, with this finding I am able to achieve up to three goals. First, the analysis gives us evidence to support the existence of such a factor of time preference in the purchase of durable goods. An element that was omitted by the neoclassical economic theory, and that was challenged by many authors as we see in Section 1. Second, I get support for the introduction of such time preference factor in the demand and/or utility functions used by the relevant literature related to the automotive sector. This element, in fact, has been excluded in the functions built by plenty of authors devoted to modeling vehicle demand from a micro and disaggregate perspective –see Train (1986).[26] Third, I was able to clarify the direction that should be taken by future policies. Thus, in order to boost demand for cars in a more effective way, I believe that the schemes should be more in line with the Plan 2000e, so it is possible to take advantage of this increase in utility that produces an immediate discount produced by the existence of a time preference factor. Not surprisingly, the new policy that the Spanish Government implemented by the end of 2012 –the so-called Plan PIVE– was again based on a lump-sum subsidy for car purchase.

As it could be observed, outside the scope of this study has been the temporal aspect of the discount rate. In other words, I am aware that the variable t (representing time) has not appeared in the new model in Section 5. The key here is that I assume two different schemes with the same time frame but in which one offers a lump-sum discount on the amount deferred, but that generates a stream of payments relatively high, while the other, without offering any initial discount, generates a sequence of smaller payments. Unfortunately, this restriction does not allow to address issues of "hyperbolic discounting", but as described, the aim here is not testing the shape of the function of consumer preference rather than test

[26] As pointed Frederick et al. (2002), "For each domain, economists choose the utility function that is the best able to incorporate the essential considerations for that domain, and then evaluate whether the inclusion of specific considerations improves the explanatory power of a model".

the actual existence of an element of time preference, vastly ignored by the literature.

Additionally, the findings open the door to many interesting questions that are still unresolved. For example, once the Plan 2000e ended there was a sudden drop in car sales.[27] For that reason, many car dealers started to offer lump-sum discount in their offered vehicles. But the answer of the consumers was virtually negligible. The immediate questions are: is there a difference in a discount when it is offered by the public administration versus by companies in a private sector? Is it possible that there exists something we might call "public expenditure premium"? Or rather than that, do people realize that the subsidy is actually funded with the taxes they pay, so they want to take advantage of it? Again, these questions lie outside the scope of the paper so I leave them open for further research.

[27] For instance, between January and July 2010, when the Plan 2000e was feasible, the average car registrations per month was 99,646 cars; but for the second half of the year 2010, once the Plan 2000e, the average car registrations per month drop to 60,498 per month; a reduction of 39.29%. Similarly, while for year 2010 there were 1,000,010 new car registered, for 2011 there were only 817,688; a reduction by 18.23%.

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Appendix I: Example of car purchase contract using the Plan VIVE

CITROËN

OFERTA FINANCIERA (CONTRACT)

Por la presente BANQUE informa a D. Manuel ..
que su solicitud de financiación N° ha sido Aceptada en los siguientes términos:

CARACTERISTICAS DEL VEHICULO .... **FEATURES OF THE CAR**

TIPO: Turismos MATRICULA:
MODELO VEHICULO: C4 5 puertas HDi 90 Cool

CARACTERISTICAS OFERTA FINANCIERA .... **FEATURES OF THE CONTRACT**

PRECIO VEHICULO:	19.946,25 EUR	.... PRICE OF THE CAR
ENTRADA:	9.946,25 EUR	.... DOWN PAYMENT
GASTOS DE APERTURA FINANCIADOS:	0,00 EUR	.... DEFERRED DOWN PAYMENT
CAPITAL FINANCIADO:	10.000,00 EUR	.... DEFERRED PAYMENT
GASTOS DE APERTURA AL CONTADO (*):	0,00 EUR	.... OTHER DOWN PAYMENT
PLAZO AMORTIZACION:	60	.... REPAYMENT PERIOD
CUOTA FINANCIERA:	166,67 EUR	.... PAYMENT PER PERIOD
CUOTA SERVICIOS:	MESES (MONTHS)	.... PERIOD

TOTAL SERVICIOS (Si regular):

CUOTA MENSUAL TOTAL (Si regular):	166,67 EUR	.... MONTHLY PAYMENT
IMPORTE FINANCIACION ULTIMA CUOTA:	0,00 EUR	.... FINANCIAL CHARGE (LAST PAYMENT)
TIN:	0,00 %	.... NOMINAL INTEREST RATE (NIR)
TAE:	0,00 %	.... ANNUAL PERCENTAGE RATE (APR)
INTERESES POR APLAZAMIENTO:	0,20 EUR	.... INTEREST ON DEFERRED
IMPORTE TOTAL PRESTAMO:	10.000,20 EUR	.... TOTAL AMOUNT OF THE CREDIT

CADENA DE PAGOS .... **PAYMENTS**

Año / Mes (Year/Month)	2009	2010	2011	2012	2013	2014	
Enero		166,67	166,67	166,67	166,67	166,67	January
Febrero		166,67	166,67	166,67	166,67	166,67	February
Marzo		166,67	166,67	166,67	166,67	166,67	March
Abril		166,67	166,67	166,67	166,67	166,67	April
Mayo	166,67	166,67	166,67	166,67	166,67		May
Junio	166,67	166,67	166,67	166,67	166,67		June
Julio	166,67	166,67	166,67	166,67	166,67		July
Agosto	166,67	166,67	166,67	166,67	166,67		August
Septiembre	166,67	166,67	166,67	166,67	166,67		September
Octubre	166,67	166,67	166,67	166,67	166,67		October
Noviembre	166,67	166,67	166,67	166,67	166,67		November
Diciembre	166,67	166,67	166,67	166,67	166,67		December

Esta oferta se considerará vincula a BANQUE por un plazo de 10 días hábiles desde la fecha de este documento, y será exigible una vez confirmada la veracidad de la información aportada, la existencia y vigencia de la documentación acreditativa de la solvencia e identidad de los intervinientes, y siempre y cuando se mantengan las garantías aportadas en la referida solicitud.

En C , a 03/2009

Información de carácter no contractual

(*).- En el caso de gastos de apertura al contado, estos se abonarán en el primer vencimiento.

Appendix II: Example of car purchase contract using the Plan 2000e

CITROËN

AENOR
Empresa Registrada
ER - 0137/2/00

CERTIFIED QUALITY SYSTEM IQNet

14... CORDOBA
DNI

FACTURA NUM. : V
FECHA : /11/2009

NRO EXPEDIENTE :

N.º Baremo o Referencia	CONCEPTO	Ctdad. o N.º Horas	Precio Unitario	Código		TOTAL
	DATOS VEHICULO .... FEATURES OF THE CAR					
	Marca: CITROEN					
	Matricula:					
	Modelo: C4PI HDI110COOL					
	No. Chasis:					
	PVP, OP, PE. VN. Y TPTE...... PRICE OF THE CAR					20.500,55
	Opciones: RUEDA SOCORRO 1PRJK LOOK					
	DESCUENTOS .... DISCOUNTS					-2.111,42
	DTO.FABRIC.PLAN E .... MANUFACTURER DISCOUNT (PLAN E)					-1.000,00
	BASE IMPONIBLE .... TAX BASE					17.389,13
	IVA Tipo%: 16 .... VAT (16%)					2.782,26
	TOTAL FACTURADO: .... TOTAL BILLED					20.171,39
	SUPLIDOS:					
	GEST.,MAT.,TASA,IMPTO.MATR.,IMC,ETC. .... OTHER CHARGES					608,61
	DTO.ESTATAL PLAN E .... STATE DISCOUNT (PLAN E)					-500,00
	DTO.AUTONOMI. PLAN E .... REGINAL DISCOUNT (PLAN E)					-500,00
	TOTAL COBRADO .... TOTAL AMOUNT					19.780,00

Firma y sello

La Red Comercial de AUTOMOVILES CITROËN ESPAÑA, S.A., garantiza sus reparaciones por DOCE MESES en piezas y mano de obra sin límite de