Volume 30, Issue 3

Macroeconomics of the New and the Used Car Markets

Sylvain M. Prado

EconomiX-CNRS, University of Paris Ouest, France and GE Capital Solutions Europe in London, UK

Abstract

The new cars of today are used cars of tomorrow and some people assume a competition between new and used markets. There are numerous, preconceived ideas and academic theories regarding the interactions between primary and secondary markets. To investigate the relations, we provide a macroeconomic analysis of the French, the British and the US car markets. We aim at answering the following questions. What are the interactions between the new and the second-hand car markets? Can we use the interactions to estimate the car prices of tomorrow? Our results indicate that the relations appear limited for France and the UK, whereas the US market faces a Scitovscky mechanism, defined by constant disequilibrium and multiple interactions between primary and secondary markets. Furthermore, they illustrate that the interrelations are not strong enough to fully explain and forecast market patterns.

1 Introduction

We aim to identify the relationship between new and used car markets in order to forecast car prices. For various industries the future car prices are of special interest. Indeed, among other things, used car market prices directly affect leasing companies losses and benefits.

There has been a significant amount of academic researches on the subject of durable goods in the second-hand market. The literature discusses why second-hand markets exist and highlights some mechanisms of interdependence between new and used markets, especially in the microeconomy area. It mainly focuses on three related axes of research: the Akerlof effect, the optimal durability and the time inconsistency[1]. Most of the articles assume a neoclassical economy driven by real factors and where money supply has no impact. Agents are optimizing their purchase and know the function to optimize. But Scitovsky (1994) adopts a Keynesian approach that includes uncertainty and the impact of disposable incomes on the overall economy.

Scitovsky investigates the destabilizing impact of secondary markets on the overall economy. They strengthen both recessions and recoveries. He first focuses on specific movements of prices: consumers often react to a modification of their income by shifting their demand between new markets and cheaper secondary ones. As a result, in case of a sufficient elasticity of goods substitution, new and second-hand markets become interdependent. A shock or a disequilibrium in each market impacts prices, demand and supply in the same direction. Additionally, both markets offset one another. The disturbed market excess demand (or supply) becomes equal to the other market excess supply (or demand) and prices are stabilized accordingly. Unfortunately, prices are stabilized only for a while.

A gap between demand and supply still exist in both markets and an opposite effect soon appears because of a slow adjustment of stock in the second-hand market. In the automotive sector, for instance, owners of used vehicles are more or less willing to hold their vehicles according to increases and decreases of prices. The slow variation of stock has the following consequences: the used market volume rises and reduces the level of price in the new market. So the interdependence disrupts the equilibrium in both markets.

To summarize, following disturbance disequilibrium in one market, a short-term effect of arbitraging creates a temporary obstacle to price movement and a move on the other market on the same direction. Then, on a second period, the second-hand market's disequilibrium slowly liberates constraints of an equilibrating price movement.

Scitovsky extends the discussion to the impact on the overall US economy. The effect depends of the size of the used market. It depends also on the length of time the secondary market is able to compensate the variation of the new market without impacting prices. Automobiles are exceptional durable goods because of the size of the second-hand market, but Scitovsky assumes that the influence of stocks would be limited to two months only[2] (Car owners are rarely relinquish and dealers stocks are quite limited).

---

[1]See Prado (2010) for a review of litterature and a complete analysis on the interactions between the new and the used car markets.

[2]According to Scitovsky, financial assets are the only exception. The destabilizing impact of financial

Other 'basic' mechanisms do not come from a specific literature and are implied in various contributions. We mention them for clarification purposes and to facilitate their identifications in the econometric analysis that will be implemented in the next section. All the theories evoked previously, and the consequences on prices and volumes, are listed in Appendix 1.

We study the automotive markets of France, the United Kingdom and the United States of America. The three countries are compared through four time series. We consider observations related to the Consumer Price Index (CPI) and the volume of registrations (or sales) for new and used cars[3]. The period of analysis has been standardized from January 1998 to June 2009.

In section 2, the econometric tools identify trends, cycles and correlations through various durations (short-term, very short-term, the whole ten years period). At the same time, we evaluate if the outcomes are in line with the theories. In section 3, we estimate the VAR models to investigate the relations between the markets and the possible forecasts[4]. Section 4 concludes.

2 The econometric analysis shows different results by country.

The French market looks rather stable, whereas the UK[5] and the US prices follow a negative trend and display a high volatility[6]. For the last ten years the trends of the US series seem negative and illustrate the crisis of the automotive sector in North America. All these characteristics remain through a growth rate perspective and after a seasonal adjustment.

To check this intuition, we apply the Augmented Dickey Fuller unit root test[7] to the growth rate of the series. The results show[8] that the French volumes and index prices have been stationary for the last ten years. On the contrary, the UK and the US have trends. Regarding the sale volumes, the trend analysis on the whole period illustrates the well known fact that the new cars of today are the used cars of tomorrow. In France and the UK, the new and the used car registrations share a similar stationnarity. In the US market, for the last ten years, the new and used sales have been declining. These results also weaken the 'advanced mechanisms' reported in Appendix 1. It is highly unlikely that the stability in

---

secondary markets would have no limit. Their sizes and shocks duration would significantly impact the overall economy.

[3] See Appendix 2 for data sources.

[4] The econometrical analysis is inspired by Chazi (2007) and Lescaroux & Mignon (2008).

[5] For UK, they are two big variances after 1999. There has been a change in the car registrations process after 1999. Prior to 1999, new plates were introduced in August. From 1999 onwards, there has been two plate changes, in March and September.

[6] See graphs in Appendix 3.

[7] A three-step process constitutes the Augmented Dickey–Fuller test (ADF), allowing the identification of Stationarity, Trend Stationarity (TS) and Difference Stationarity (DS). See Dickey & Fuller (1981).

[8] The results are reported in Appendix 4.

France and the UK, as well as the decline in the US, would be due to a global decrease of cars quality[9] (according to the *Akerloff effect*, the *Time inconsistency....*).

The correlation calculation provides a first insight on the simultaneity of market evolutions[10]. For France, a negative correlation between new CPI and used CPI suggests an arbitrage on prices (i.e. when prices decrease on the new market, they improve on the used market). The significant correlation between new and used registrations has a positive sign that might be caused by an *Income effect* on the volume of transactions. In other words, when drivers incomes (and demand) improve, the volume of sales increases on both markets. For the US, a strong positive correlation exists between new and used prices ($r = 0.54$) as well as a negative correlation between new and used transactions. The US market dynamics are converse to the French ones; it suggests an *Income effect* on a price perspective and an *Arbitraging effect* on a volume perspective. These results evoke a *Scitovsky*'s framework: in the new and the second-hand markets, prices move in the same direction but the variation of bid, offer and stocks in both markets lead to a constant disequilibrium.

The Granger causality tests elaborate the assessments of the correlation analysis evaluating how much the previous six month information contained in a variable[11] could improve the prediction of another variable. The test suggests the existence of multiple relations between new and second-hand cars and shows a strong interdependence in the US markets by comparison to France and the UK. The causalities are more numerous in the US market: new car prices and used car prices help to predict each other; new car sales and new car prices help to predict used sales; at the same time, the new car sales help also to forecast new car prices. Again, the *Scitosky*'s theory, of constant disequilibrium from one market to another, constitutes a possible explanation.

In order to identify long-term trends of the series, we calculate Hodrick-Prescott filtered series[12]. The filter produces a smoothed non-linear representation of the time series that is more sensitive to long-term than to short-term fluctuations[13] and we evaluate the synchronizations of prices and volumes. For France, the graphs show larger cycles (of 2 years) for used car prices index by comparison to new car prices (6 months) and the volume of transactions. Similarly, second-hand price follows a longer and more visible cycles in the UK and the US car markets. The distinct pattern of the used car prices mitigates the validation of mechanisms involving prices and volumes moving in harmony (*Akerloff effect, Time inconsistency*). We report the strong correlations[14] in Appendix 8. For the US, markets cycles

---

[9]We can't believe, as well, that it would be due to a decreasing quality of information available for buyers.

[10]Details are given in Appendix 5. The econometrics tools are applied on the seasonally adjusted growth rates and stationnary time series.

[11]The Granger test has been set with six months lags. Results are given in Appendix 6.

[12]See HP filter cycle and trend graphs in Appendix 7.

[13]The sensitivity of the trend to short-term fluctuations is adjusted through a multiplier λ. From an Empirical perspective the suggested λ is equal to 14,400 for monthly data. See Hodrick & Prescott (1997).

[14]Following Fiorito and Kollintzas (1994), we measure the degree of co-movement of the series' cyclical components through the correlation coefficient ρ. If the correlation between the cyclical components of two series is positive, null or negative the series cycles are identified as procyclical, acyclical, or countercyclical.

are well interrelated. There are several pro-cyclical and counter-cyclical relations between prices and volumes. First of all, we identify a positive correlation between new car CPI and the used car CPI. In addition, the used car CPI, with 9 months and 12 month lags, appears countercyclical to the volume of used sales. Finally, the used sales volumes have a cyclical relation with new car prices. These results are still in line with the *Scitovsky* theory.

3 Vector Autoregressive (VAR) models clarify the previous results.

A Vector Autoregressive model[15] gives a straight perspective of the relation between prices and volumes in both markets[16]. The results are reported in Appendix 10 and show the usual greater interaction between the primary and the secondary markets for the US. Let us discuss the outcomes for each country.

For France, the used car prices mainly depend on their own lagged values[17]. The equation is in line with the Hodrick Prescott results displaying that used CPI cycles are different to other series cycles. For the new car prices equation, the model has a good fit to the data thanks to the relevant information from the previous month new prices and the constant. These results corroborate the graphical analysis revealing rigidity of new car prices by showing few fluctuations of the new car CPI.

Regarding the French volume equations, the new and the used cars registration models have a poor adjustment to the historical observations and none of the variables are statistically significant. In other words, none of the variables from one market are relevant to model the other market, and the VAR methodology does not identify the suggested relations of the previous section (correlation and arbitraging). Gautier (1995) attempted to identify new car registration cycles, which would be a characteristic of durable goods in the French market since 1945. He concluded that registration cycles are more the result of the economic activity (with additional volatility and sectorial events) than to the internal dynamics of car markets. It means that, in order to forecast the registrations in France, a model including variables related to the economic activity would be more relevant.

If $0.1 \, |\rho| < 0.23$ or $0.23 \, |\rho| < 1.0$ the cycles are classified as weakly correlated or strongly correlated. We also calculate $\rho(j)$ with $j \in \{\pm 3, \pm 6, \pm 9, \pm 12, \pm 24, \pm 36\}$ in order to identify lagged correlations.

[15] A cointegration test, the Engle-Granger two-step method (Engle & Granger (1987)), identifies a common long-term trend between new and used US sales. The Johansen test, however, rejects the presence of a cointegration relation (see the cointegration tests details in Appendix 9). In addition, the construction of an Error Correction Model (ECM) including the US volumes series did not provide a good adjustment. Therefore we concluded that the series are not cointegrated and that the model does not constitute a relevant tool to forecast the US volumes. We did not keep the ECM in the study. Moreover, the US market only has two identified Differentiated Stationarity (DS) time series. And we need a minimum of two series having a DS in order to build an ECM. For France, all the series are stationary. For UK, one variable only has a DS. Therefore, there is no possibility of a cointegration test and an ECM for France and the UK. As a consequence, we use a VAR for each country.

[16] We selected the best model using the Akaike and the Schwarz criteria.

[17] Previous months of used CPI variables have a high statistical significativity according to the τ student test.

4

For the UK, the used car CPI equation shows that, in a similar way to France having distinct cycles for used car CPI, the previous months used car prices information is statistically significant. The new market variables are also crucial, but they have smaller coefficients compared to used car prices lagged values. To be more specific, the coefficients of the variables from the new market have a positive effect and therefore confirm the results of the graphical and the correlation analyses, as well as the Granger causality test. It illustrates that the new CPI coefficient is less important because of the rigidity of new car prices created by production constraints. It also suggests that, in spite of the rigidity, dealers try to modify the prices according to the state of the economy. Regarding the new cars CPI equation, although the adjustment is poor, two variables appear significant (the used car price index and the used car registrations). But even with a new car CPI series positively correlated to the used car market, the weakness of the relation suggests that any involved mechanism would be quite limited.

For the British used cars registrations equation, the model has also a poor adjustment and registrations seem slightly and positively impacted by the used car prices: when prices go up, dealers and privates get an opportunity and they increase the volumes of sales, but stocks are limited and the evolution remains limited as well. Into the new cars registrations equation, though the used cars CPI and the constant constitute the only relevant information, the model adjustment is quite good. It strengthens the conclusion that economic readjustments are mainly made on the new market by volume (and on the used market by price): when the state of the economy improves, for instance, the volume of new cars and the prices of used cars react first and increase. The new car volumes are, however, limited by production constraints and consequently, the constant in the equations appears highly significant. The positive coefficient of the new car volume variable would only allow the existence of mechanisms with similar co-movements in both markets (*Income effect*, *Akerloff effect...*) on a short period.

From the previous results in the US market, we know that the used CPI follows specific cycles and, at the same time, was positively correlated to new car prices. Accordingly, in the used CPI equation, the lagged used car prices and the new car CPI (with a positive sign) are statistically significant. On the contrary to France and the UK, the new CPI equation is well fitted to the historical observations. New car prices are explained by the previous used car CPI and the previous new CPI. They are also positively impacted by the volume of transactions of the new market. Therefore the US car prices are connected in various ways with the new and the used market.

The explained variance of US volume equations are not as good: R^2 are equal to 20% and 47% for new and used sale equations. In the new sales equation the only important variables are the previous new sales; in the used sales equation the new and the used sales are significant variables. Scitovsky (1994) mentioned that the market adjustments were altered by the limited variation of volumes. He argued that used car market volumes were limited by stocks. In addition, we argue that new car volumes are limited by production constraints, and that the VAR results on volumes are fully in line with his theory.

5

4 To conclude, what kind of interdependence exists between the new and the second-hand car markets?

The aim of this paper was to investigate the interdependences between the new and the second-hand car markets in three countries: France, the UK and the US. The analysis was limited to a ten year period; since cars are durable goods that can be used for more than 20 years, it might have restricted the results to interdependences shorter than a decade. The econometric tools, however, show consistent outcomes all along the study. Results are synthesized in Appendix 11.

Initially, we argue that in all countries the new market of the past is linked to the used market of today, through volumes and prices. Secondly, the interrelations appear limited for France and the UK, whereas the US market is characterized by a *Scitovsky* dynamics, defined by constant disequilibrium and multiple interactions between primary and secondary markets. Thirdly, theories implying volumes and prices moving in the same direction (*Akerloff effect, Optimal durability, Time Inconsistency*) are difficult to confirm. Finally, for France, the UK, and the US the connections between primary and secondary car markets are not similar, but all markets experience a characteristic rarely mentioned in the literature: a rigidity of both the new car prices and the used car volumes of transactions. Another similar characteristic is that, for all countries, used car prices follow distinct cycles.

All things considered, our results illustrate that the interrelations between the new and used car markets are not strong enough to fully explain and forecast the market patterns. The use of macroeconomic variables related to the disposable income of buyers or the general state of the economy might improve the forecast accuracy, and is left for future research. Moreover, the study could be extended to other countries with developed car markets (Germany, Japan...).

References

Chazi, A. (2007) Is Default Risk Related to Inflation? Journal of Accounting. Business & Management, **14**(0).

Dickey, D. A. and Fuller, W. A. (1981) Likelihood Ratio Statistics for Autoregressive Time Series With a Unit Root. Econometrica, **49**, pp.1057-1072.

Engle R. F. and Granger, C. W. J. (1987) Cointegration and Error Correction: Representation, Estimation and Testing. Econometrica, **55**, pp.251-276.

Fiorito, R. and Kollintzas, T. (1994) Stylized Facts of Business Cycles in the G7 from a Real Business Cycles Perspective. European Economic Review, pp.235–69.

Gautier, B. (1995) Le marché automobile: un cycle spécifique ? Économie et Statistique, Année 1995, **282**(1), pp.65-90.

Hodrick, R. and Prescott, E. (1997) Postwar U.S. Business Cycles: An Empirical Investigation. Journal of Money, Credit, and Banking, **29**(1), pp.1-16.

Lescaroux, F. and Mignon, V. (2008) On the Influence of Oil Prices on Economic Activity and Other Macroeconomic and Financial Variables. Working Papers 2008-05, CEPII research center.

Prado, S. (2010) A Family Hitch : Econometrics of the New and the Used Car Markets. EconomiX Working Papers 2010-4, University of Paris.

Scitovsky, T. (1994) Towards a Theory of Second-Hand Markets. Kyklos, **47**(1), pp.33-52.

Appendix

Appendix 1: Mechanisms of interdependence between new and used markets[18]

Mechanisms	Descriptions	Impact on Prices and Volumes
Akerloff effect 1	An increase of quality or information in the Used Car Market creates an increase in price and demand on the used market.	Quality ↑ or Information ↑ $\Longrightarrow$ Volumes Used ↑ and/or Prices Used ↑
Akerloff effect 2	An increase of quality or information in the Used Car Market creates an increase in price and demand on the Used Car Market and the New Market.	Quality ↑ or Information ↑ $\Longrightarrow$ Volumes Used ↑ and/or Prices Used ↑ and Volumes New ↑ and/or Prices New ↑
Optimal durability	An increase of durability creates a decrease of demand of new cars; therefore, a decrease of prices in the New Car Market as well as a decrease of offers in the Used Car Market and an increase of prices.	Durability ↑ $\Longrightarrow$ Volumes New ↓ $\Longrightarrow$ Prices New ↓ and Volumes Used ↓ $\Longrightarrow$ Prices Used ↑
Time Inconsistency	An increase of durability creates a decrease of demand of new cars; therefore, a decrease of prices in the New Car Market as well as a decrease of offers in the Used Car Market and an increase of prices.	R&D ↑ $\Longrightarrow$ Volumes Used ↑ and/or Prices Used ↑ and Volumes New ↓ and/or Prices New ↓

Table 1: Advanced Mechanisms.

---

[18]The arrows ($\Longrightarrow$ $\Longleftrightarrow$) indicate that a parameter affects or causes another one.

The new market could experience different consequences from the *Akerloff effect*. Therefore we made a distinction between the *Akerloff effect 1* having only an impact on the used market and the *Akerloff effect 2* impacting both markets. There was a similar issue with the *Income effect* driving both markets in the same direction or in different ones. Another roadblock exists regarding the effect of demand. As an example, for the *Time inconsistency* effect, an increase of demand would create either an higher volume of transactions, or only an increase of prices, or both. It is identified every time there is an "and/or" in the table..

The *Akerloff*, the *Optimal durability* and the *Time inconsistency* effects are difficult to investigate because they involve additional information (quality, durability, R&D...). They could be invalidated, however, when series move in different directions than the ones listed in the tables. For instance, the improvement of quality in the *Akerloff* effect would take some time to spread across the population of cars and therefore could be identified by an increasing trend on volumes, or prices, or both. If the trends are decreasing, then the theory should be refuted.

| Mechanisms	Descriptions	Impact on Prices and Volumes
Scitovsky Theory	Interactions creating constant disequilibrium in the primary and secondary markets.	Volumes New $\downarrow$ (insufficient stocks) $\implies$ Prices New $\uparrow$ $\implies$ Volumes Used $\uparrow$ $\implies$ Prices Used $\uparrow$ $\implies$ Volumes New $\longrightarrow$ $\implies$ Prices New $\longrightarrow$ $\implies$ Volumes Used $\downarrow$ (insufficient stocks) $\implies$ Prices Used $\uparrow$ $\implies$ Volumes New $\uparrow$ $\implies$ Prices New $\uparrow$ and again $\implies$ Volumes Used $\uparrow$ $\implies$ Prices Used $\uparrow$....

Table 2: Scitovsky Theory.

Mechanisms	Descriptions	Impact on Prices and Volumes
New market feeds used market	Past volumes of new sales transactions correlated positively with the current volumes of Used Sales transactions. Past prices of New Sales transactions correlated positively with current prices of Used Sales transactions	Positive Correlation: Past New Volumes $\Longleftrightarrow$ Current Used Volumes / Past New Prices $\Longleftrightarrow$ Current Used Prices
Reallocation	Prices and volumes of New sales transactions correlated positively with prices and volumes of Used Sales transactions	Positive Correlation: New Volumes $\Longleftrightarrow$ Used Volumes / New Prices $\Longleftrightarrow$ Used Prices
Arbitration	A car bought in one market can't be bought, at the same time, in another market.	Negative Correlation: New Volumes $\Leftrightarrow$ Used Volumes / New Prices $\Leftrightarrow$ Used Prices
Renewals	Concentrations of renewals create cycles in both markets. Concentrations in the new market could create future concentrations on the used market.	Cycles of Prices and volumes: Past New Volumes $\uparrow \Longrightarrow$ Current Used Volumes $\uparrow$ and Past New Prices $\uparrow \Longrightarrow$ Current Used Prices $\uparrow$
Price effect	A price increase could have a positive impact on the volume of transactions by improving offers/sales, or a negative impact by decreasing demand.	Prices $\uparrow \Longrightarrow$ Offer $\uparrow \Longrightarrow$ Volume $\uparrow$ or Demand $\downarrow \Longrightarrow$ Volume $\downarrow$
Volume effect	A volume increase could have a positive impact on the prices if caused by a greater offer or a negative impact, if caused by a greater demand.	Volume $\uparrow \Longrightarrow$ Prices $\downarrow$ or Prices $\uparrow$
Income effect 1	A decrease of consumers' income (or business activity or confidence) reduces the demand for new cars and used cars decreasing in prices and volume in both markets.	Income $\downarrow \Longrightarrow$ Demand $\downarrow \Longrightarrow$ Volumes $\downarrow$ and/or Prices $\downarrow$
Income effect 2	A decrease of consumers income (or business activity or confidence) reduces the demand for new cars and creates a shift to the used car market It's decreasing prices and volumes in the new market and an increase in the used market	Income $\downarrow \Longrightarrow$ Demand New $\downarrow \Longrightarrow$ Volumes New $\downarrow$ and/or Prices New $\downarrow$ and Demand Used $\uparrow \Longrightarrow$ Volumes Used $\uparrow$ and/or Prices Used $\uparrow$

Table 3: Basics Mechanisms.

Appendix 2: Data sources of time series[19]

| CPI FR	Www.bdm.insee.fr/bdm2/serie/AffichRechDirecte.do Identifiant: 000638803 000638804
CPI UK	Www.statistics.gov.uk/statbase/tsdtimezone.asp Consumer prices indices DE78 DE79
CPI US	Www.data.bls.gov/cgi-bin/srgate Series Id: CUSR0000SS45011 CUSR0000SETA02
New Car Reg FR	Www.statistiques.developpement-durable.gouv.fr/rubrique.php3?id_rubrique=122
New Car Reg UK	Www.smmt.co.uk/dataservices/vehicleregistrations.cfm
New car sales US	Www.bea.gov/national/xls/gap_hist.xls
Used car Reg FR	Www.statistiques.developpement-durable.gouv.fr/rubrique.php3?id_rubrique=122
Used car Reg UK	Driver and Vehicle Licensing Agency Www.dvla.gov.uk/
Used car sales US	CNW Marketing Research Www.cnwmr.com/

Appendix 3: Raw data
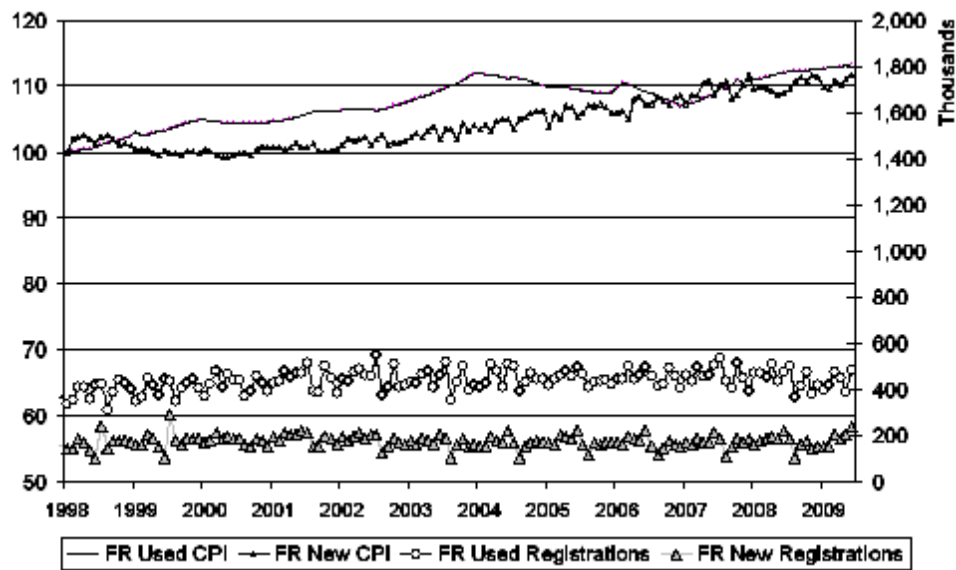
FR

---

[19]A special thanks to Tom Webb (Www.manheimconsulting.com/) for his support on US data.
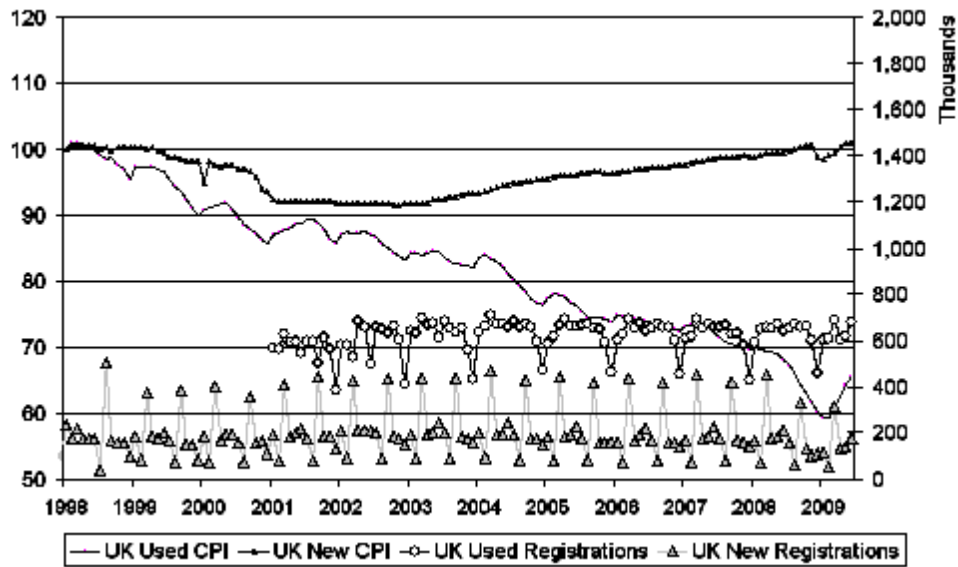
UK
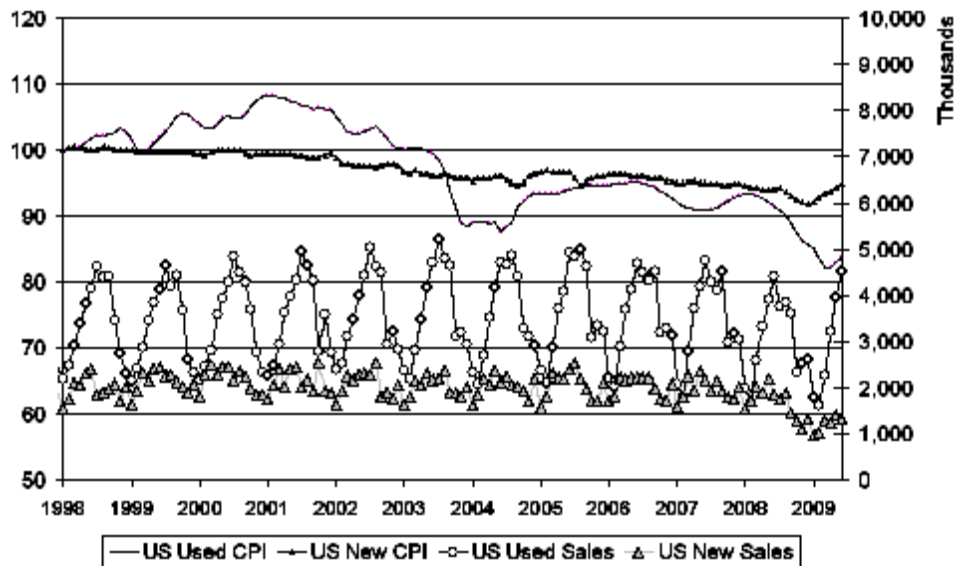
US (CPI data provided by the BLS are seasonally adjusted.)

Appendix 4: Augmented Dickey Fuller Results

		Augmented Dickey-Fuller test statistic	Test critical values 5% level	Degree of integration[1]	Results
France	Used cars CPI	-2.57	-1.94	I(0)	Stationarity (S)
	New cars CPI	-5.44	-3.45	I(0)	Stationarity (S)
	Used cars Registrations	-2.47	-1.94	I(0)	Stationarity (S)
	New cars Registrations	-11.16	-1.94	I(0)	Stationarity (S)
UK	Used cars CPI	-3.88	-2.88	I(0)	Stationarity (S)
	New cars CPI	-5.22	-1.94	I(1)	Difference Stationarity (DS)
	Used cars Registrations	-8.99	-3.46	I(0)	Stationarity (S)
	New cars Registrations	-3.09	-1.94	I(0)	Stationarity (S)
US	Used cars and light trucks CPI	-2.57	-1.94	I(0)	Stationarity (S)
	New cars and light trucks CPI	-4.09	-1.94	I(0)	Trend Stationarity (TS)[2]
	Used cars and light trucks Sales	-14.71	-1.94	I(1)	Difference Stationarity (DS)
	New cars and light trucks Sales	-11.54	-1.94	I(1)	Difference Stationarity (DS)

Table 4: Augmented Dickey Fuller Results.

[1]The degree of integration refers to the degree of differencing required to make a time series stationary.

[2]The deterministic trend has to be removed.

Appendix 5: Correlation Analysis

	USED_CARS_CPI	NEW_CARS_CPI	USED_CARS_VOL	NEW_CARS_VOL
USED_CARS_CPI	1.00	-0.31	-0.03	0.10
NEW_CARS_CPI	-0.31	1.00	-0.13	-0.17
USED_CARS_VOL	-0.03	-0.13	1.00	0.44
NEW_CARS_VOL	0.10	-0.17	0.44	1.00

France

	USED_CARS_CPI	NEW_CARS_CPI	USED_CARS_VOL	NEW_CARS_VOL
USED_CARS_CPI	1.00	0.16	0.05	0.35
NEW_CARS_CPI	0.16	1.00	-0.09	0.01
USED_CARS_VOL	0.05	-0.09	1.00	0.16
NEW_CARS_VOL	0.35	0.01	0.16	1.00

UK

	USED_CARS_CPI	NEW_CARS_CPI	USED_CARS_VOL	NEW_CARS_VOL
USED_CARS_CPI	1.00	0.54	-0.01	-0.01
NEW_CARS_CPI	0.54	1.00	0.02	0.04
USED_CARS_VOL	-0.01	0.02	1.00	-0.28
NEW_CARS_VOL	-0.01	0.04	-0.28	1.00

US

Appendix 6: Granger Test

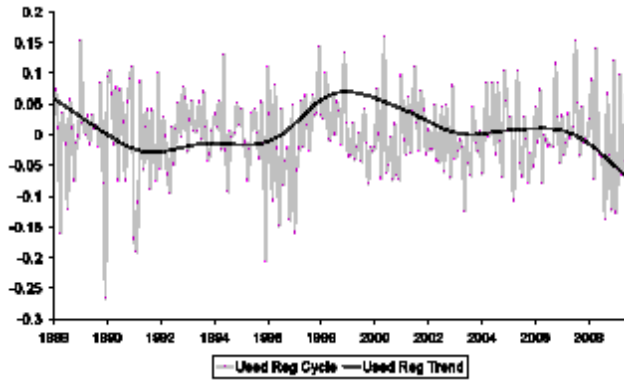| France |
|---|
| Used cars CPI $\implies$ Used cars Registrations |
| Used cars CPI $\implies$ New cars Registrations |
| Used cars Registrations $\iff$ New cars Registrations |
| **UK** |
| Used cars CPI $\implies$ New cars Registrations |
| New cars CPI $\iff$ New cars Registrations |
| **US** |
| Used cars CPI $\iff$ New cars CPI |
| New cars CPI $\implies$ Used cars Sales |
| New cars Sales $\implies$ New cars CPI |
| New cars Sales $\implies$ Used cars Sales |
| $\implies$: Significant Causality |
| $\iff$: Significant causality in both directions. |

Table 5: Granger test Results.
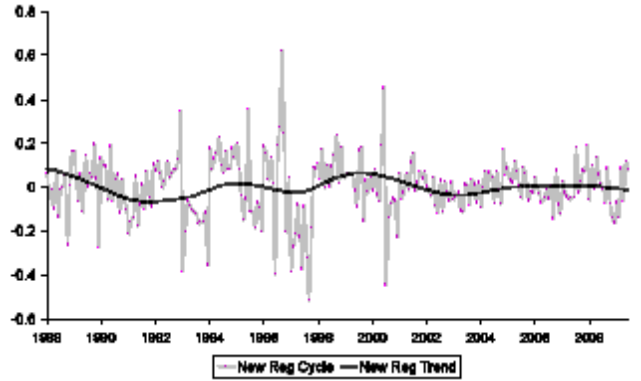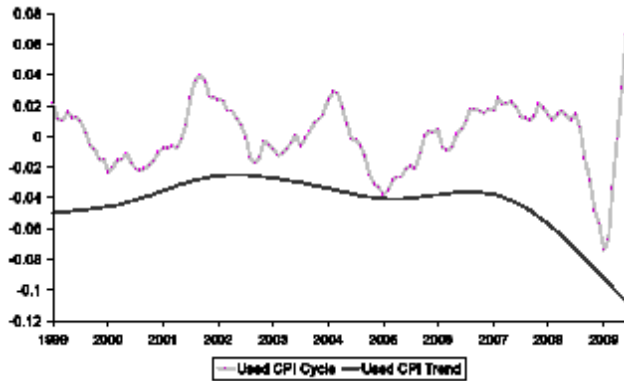
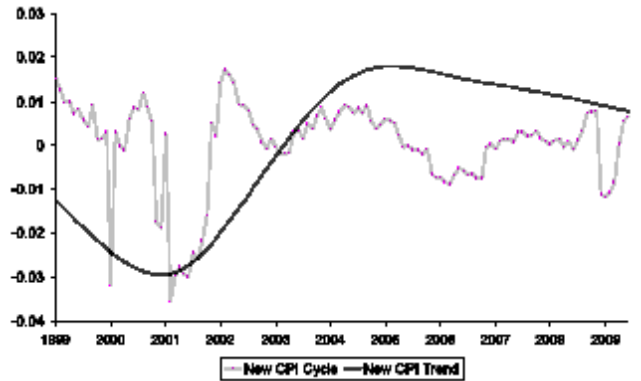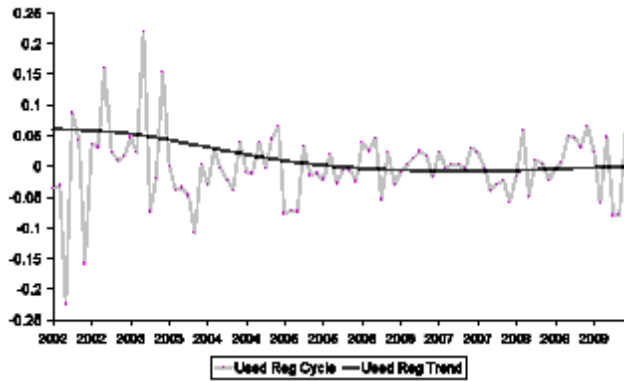**Appendix 7:** Hodrick-Prescott Filter, cycles and trends
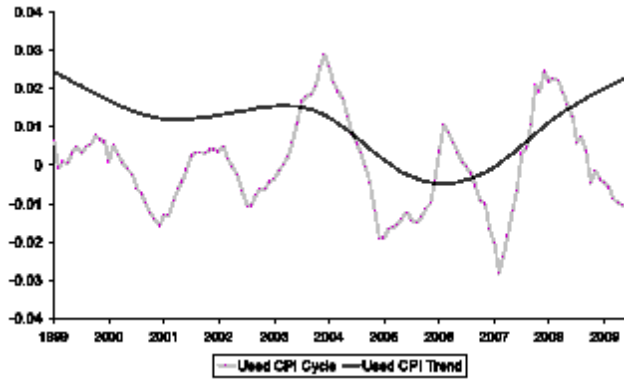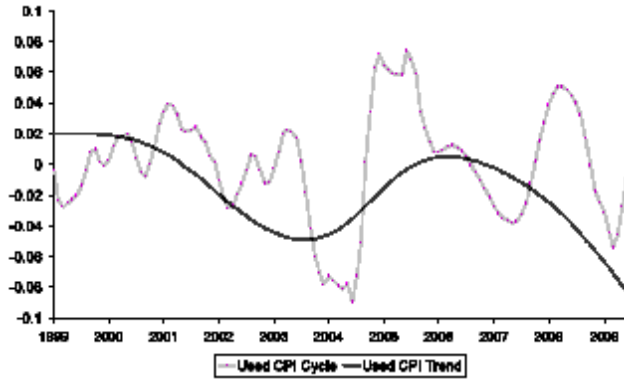

France
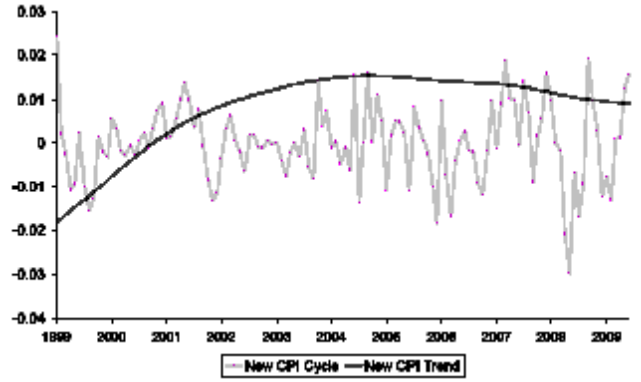
France

France

France

UK

UK

15

UK

UK

US

US

US

US

16
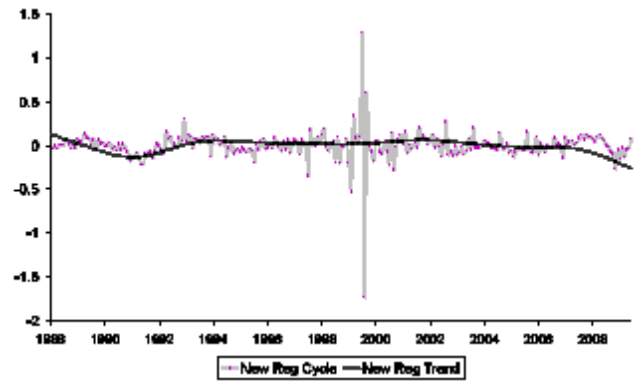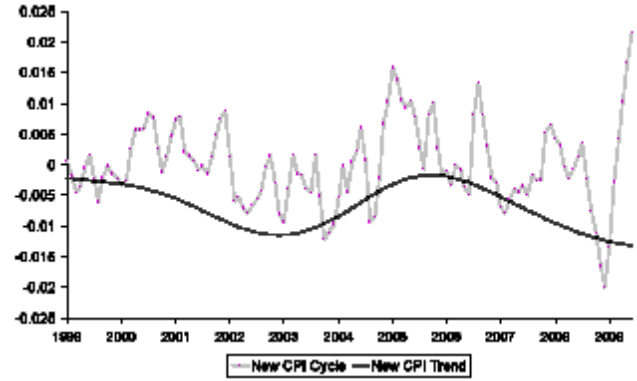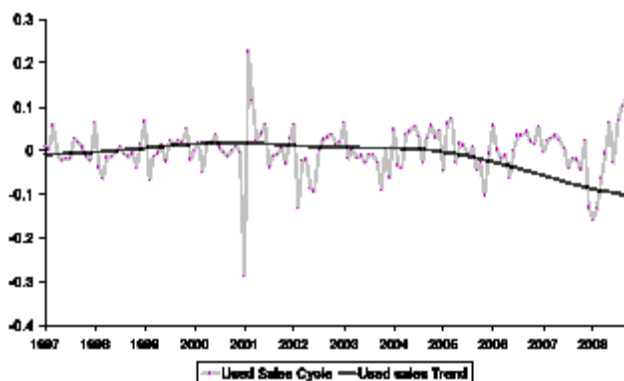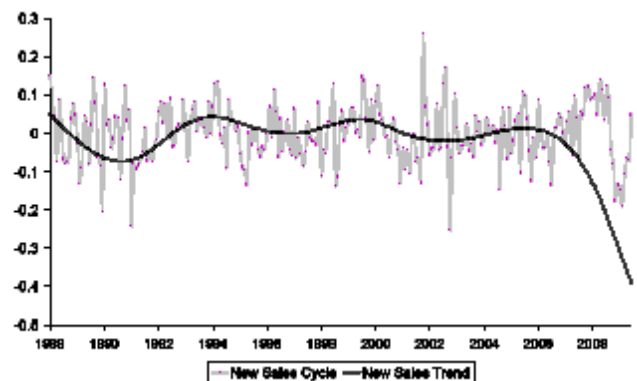
Appendix 8: Cycles Correlations

France
New Car CPI ⊕ Used Car CPI (+9, +36 months)
Used Car Registrations ⊗ New Car registrations
New Car CPI (-12) ⊗ New Car registrations
Used Car Registrations (-24) ⊗ Used Car Registrations
New Car registrations (-12) ⊗ Used Car Registrations
Used Car CPI ⊕ Used Car CPI (+12, +18)
Used Car CPI (-3) ⊗ Used Car CPI
New Car CPI (-36) ⊕ Used Car CPI
Used Car Registrations (-36) ⊗ Used Car Registrations
New Car Registrations (-36) ⊕ New Car Registrations
UK
New Car CPI ⊕ Used Car CPI (+3, +6, +9,+12)
Used Car CPI (-3, -6, -9, -12, -36) ⊕ New Car CPI
New Car CPI (-12) ⊗ New Car CPI
New Car CPI (-36) ⊗ Used Car CPI
Used Car Registrations ⊗ Used Car Registrations (-12)
US
New Car CPI ⊕ Used car CPI (0, +3, +9)
Used Car CPI (-9, -12) ⊗ Used Sales Volume
Used Sales Volume ⊕ New Car CPI
New Car CPI (-24) ⊗ New Car CPI
Used Sales Volume (-12, -36) ⊗ Used Sales Volume
New Car CPI (-24) ⊕ New Sales Volume
New Sales Volume (-24) ⊗ New Sales Volume
New Sales Volume (-36) ⊕ New Sales Volume
⊕ Strong Pro-cyclic Correlation
⊗ Strong Counter-cyclic Correlation

Table 6: Cycles Correlations.

Appendix 9: Cointegration tests

Engle-Granger two-step method

us_used_sls_ = C(1) + C(2)* us_new_cars_trk_s_

Null Hypothesis: RES_US_REG has a unit root

Exogenous: None

Lag Length: 0 (Automatic based on SIC MAXLAG=13)			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-9.46	0.00
Test critical values:	1 prct level	-2.58		
	5 prct level	-1.94		
	10 prct level	-1.62		

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(RES_US_REG)

Method: Least Squares Included observations: 140 after adjustments

Sample (adjusted): 1997M11 2009M06

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RES_US_REG(-1)	-0.79	0.083	-9.46	0.00
R-squared	0.39	Mean dependent var	0.00	
Adjusted R-squared	0.39	S.D. dependent var	0.077712394	
S.E. of regression	0.06	Akaike info criterion	-2.76	
Sum squared resid	0.51	Schwarz criterion	-2.74	
Log likelihood	194.28	Durbin-Watson stat	2.06	

Johansen test

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.133119	25.95227	15.49471	0.0009
At most 1 *	0.0442	6.23848	3.841466	0.0125

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Appendix 10: Vector AutoRegressions

Sample (adjusted): 1999M03 2009M06

Included observations: 124 after adjustments

Standard errors in ( ) & t-statistics in [ ]	USED_CARS_CPI	NEW_CARS_CPI	USED_CARS_VOL	NEW_CARS_VOL
USED_CARS_CPI(-1)	1.4762	0.0239	0.8313	-0.5555
	0.0779	0.2139	1.6743	2.5929
	[18.9538]	[0.11189]	[0.49652]	[-0.21425]
USED_CARS_CPI(-2)	-0.5125	-0.1174	-1.1977	0.5550
	0.0781	0.2145	1.6787	2.5997
	[-6.56302]	[-0.54729]	[-0.71347]	[0.21350]
NEW_CARS_CPI(-1)	-0.0436	0.5419	-1.2443	-1.8822
	0.0328	0.0901	0.7050	1.0919
	[-1.32844]	[6.01583]	[-1.76494]	[-1.72388]
NEW_CARS_CPI(-2)	0.0543	0.1146	0.7396	0.6650
	0.0322	0.0885	0.6926	1.0726
	[1.68695]	[1.29516]	[1.06796]	[0.61996]
USED_CARS_VOL(-1)	-0.0002	-0.0231	-0.0297	0.1378
	0.0049	0.0135	0.1055	0.1635
	[-0.04434]	[-1.71260]	[-0.28129]	[0.84324]
USED_CARS_VOL(-2)	-0.0001	-0.0112	0.0473	-0.1840
	0.0051	0.0140	0.1098	0.1700
	[-0.02689]	[-0.80195]	[0.43093]	[-1.08192]
NEW_CARS_VOL(-1)	-0.0030	-0.0004	0.0370	0.0512
	0.0032	0.0088	0.0685	0.1061
	[-0.94334]	[-0.04168]	[0.53933]	[0.48245]
NEW_CARS_VOL(-2)	0.0033	-0.0074	0.0361	0.1151
	0.0032	0.0088	0.0688	0.1066
	[1.02733]	[-0.84026]	[0.52384]	[1.08021]
C	0.0003	0.0044	0.0165	0.0132
	0.0005	0.0013	0.0098	0.0152
	[0.61639]	[3.48989]	[1.68583]	[0.86933]
R-squared	0.9644	0.5524	0.0488	0.0678
Adj. R-squared	0.9619	0.5212	-0.0173	0.0030
Sum sq. resids	0.0012	0.0087	0.5353	1.2838
Akaike information criterion	-19.5345			
Schwarz criterion	-18.7158			

France

19

	USED_CARS_CPI	D_NEW_CARS_CPI	USED_CARS_VOL	NEW_CARS_VOL
USED_CARS_CPI(-1)	1.6667	0.1319	-1.1669	2.3730
	0.0837	0.0384	0.8668	1.0948
	[19.9143]	[3.43778]	[-1.34627]	[2.16748]
USED_CARS_CPI(-2)	-0.8040	-0.1377	1.6949	0.0023
	0.0814	0.0373	0.8432	1.0650
	[-9.87489]	[-3.68942]	[2.01019]	[0.00218]
D_NEW_CARS_CPI(-1)	0.4491	0.0432	0.6233	-3.5862
	0.2331	0.1068	2.4139	3.0491
	[1.92667]	[0.40414]	[0.25820]	[-1.17616]
D_NEW_CARS_CPI(-2)	-0.2309	-0.0620	-0.0753	-3.1484
	0.2165	0.0992	2.2418	2.8317
	[-1.06681]	[-0.62490]	[-0.03357]	[-1.11182]
USED_CARS_VOL(-1)	-0.0195	-0.0002	0.0987	-0.1313
	0.0108	0.0050	0.1119	0.1414
	[-1.80368]	[-0.03842]	[0.88211]	[-0.92857]
USED_CARS_VOL(-2)	0.0205	0.0138	0.0985	-0.0892
	0.0110	0.0050	0.1134	0.1433
	[1.87362]	[2.74116]	[0.86878]	[-0.62270]
NEW_CARS_VOL(-1)	0.0196	0.0048	0.0183	0.0546
	0.0085	0.0039	0.0883	0.1116
	[2.29991]	[1.22077]	[0.20680]	[0.48897]
NEW_CARS_VOL(-2)	0.0029	-0.0002	-0.1376	0.1367
	0.0086	0.0039	0.0891	0.1126
	[0.33404]	[-0.04041]	[-1.54390]	[1.21433]
C	-0.0053]	0.0000	0.0300	0.0798
	0.0016	0.0008	0.0170	0.0215
	[-3.25706]	[0.00034]	[1.76809]	[3.72193]
R-squared	0.9681	0.2140	0.1032	0.5926
Adj. R-squared	0.9649	0.1344	0.0123	0.5514
Sum sq. resids	0.0030	0.0006	0.3260	0.5202
Akaike information criterion	-20.7465			
Schwarz criterion	-19.7330			

UK

Standard errors in ( ) & t-statistics in [ ]	USED_CARS_CPI	T_NEW_CARS_CPI	D_USED_CARS_VOL	D_NEW_CARS_VOL
USED_CARS_CPI(-1)	1.7377	0.1028	0.3162	0.0314
	0.0563	0.0291	0.4835	0.7147
	[30.8611]	[3.53556]	[0.65400]	[0.04391]
USED_CARS_CPI(-2)	-0.8157	-0.0927	-0.3825	-0.3123
	0.0567	0.0293	0.4865	0.7192
	[-14.3961]	[-3.17087]	[-0.78621]	[-0.43428]
T_NEW_CARS_CPI(-1)	-0.1029	1.2245	1.7836	1.5587
	0.1570	0.0810	1.3477	1.9923
	[-0.65553]	[15.1115]	[1.32336]	[0.78235]
T_NEW_CARS_CPI(-2)	0.3920	-0.4502	-1.5271	0.4293
	0.1655	0.0854	1.4211	2.1008
	[2.36873]	[-5.26886]	[-1.07455]	[0.20437]
D_USED_CARS_VOL(-1)	-0.0090	0.0013	-0.5381	0.0561
	0.0104	0.0054	0.0897	0.1326
	[-0.85890]	[0.23630]	[-5.99859]	[0.42267]
D_USED_CARS_VOL(-2)	-0.0162	0.0016	-0.3109	0.0176
	0.0094	0.0049	0.0811	0.1199
	[-1.71557]	[0.32981]	[-3.83257]	[0.14687]
D_NEW_CARS_VOL(-1)	-0.0067	0.0007	0.2928	-0.4083
	0.0075	0.0038	0.0640	0.0946
	[-0.90506]	[0.18388]	[4.57437]	[-4.31499]
D_NEW_CARS_VOL(-2)	0.0098	0.0079	0.0870	-0.3029
	0.0080	0.0041	0.0683	0.1009
	[1.22991]	[1.93390]	[1.27397]	[-3.00055]
C	-0.0010	0.0003	0.0012	-0.0103
	0.0007	0.0003	0.0056	0.0083
	[-1.59204]	[1.02893]	[0.21004]	[-1.23258]
R-squared	0.9832	0.8380	0.4405	0.1968
Adj. R-squared	0.9820	0.8267	0.4016	0.1409
Sum sq. resids	0.0053	0.0014	0.3906	0.8535
Akaike information criterion	-20.4271			
Schwarz criterion	-19.6083			

US

Appendix 11: General Results

Mechanisms	Results and Comments
Akerloff effect 1 / Akerloff effect 2 / Optimal durability / Time Inconsistency	All these mechanisms might be altered by rigidity on the new car prices and constraints on the used car transaction volumes. However, we can't validate any of them: The main reasons are the stable prices and volumes in France, as well as the decrease of used car prices in UK and US.

Table 7: General Results on Advanced Mechanisms.

Scitovsky Theory	Links are too weak in the French and the UK markets to allow the possibility of a situation similar to the one described by Scitovsky article. In contrast, most of the statistical analyses identified multiple and significant relations between new and used cars in the US market and therefore, are in line with the assumption of a Scitovsky mechanism.

Table 8: General Results on Scitovsky Theory.

Mechanisms	Results and Comments
New market feeds used market	The trend analysis illustrates a feed effect on a volume perspective in all markets. For the US market, new and used car sales time series are cointegrated. Additionally, the Hodrick-Prescott filter suggests that used car prices of today are related to new car prices of yesterday.
Reallocation	Correlation calculations suggest an instantaneous Reallocation effect, between the new and the used market, on volumes in France and on prices in the US
Arbitration	Correlation calculations suggest an instantaneous Arbitration effect, between the new and the used market, on prices in France and on volumes in the US.
Renewals	The Hodrick-Prescott filter did not allow a clear identification of a renewal effect in any of the three countries, neither in the new or the used market. It is may be due the limited sample (ten years) used in the study.
Price effect / Volume effect	They are no significant results for France and the UK. Regarding the US market, we noticed that in line with Scitovsky theory, prices impact volumes in both directions.
Income effect 1 / Income effect 2	Although our results suggest some income effects, it needs to be confirmed through a proper analysis of the relations between disposables incomes and car market volatility.

Table 9: General Results on Basics Mecanisms.