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A Family Hitch : Econometrics of the New and the Used Car Markets

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A Family Hitch: Econometrics of the New and the Used Car Markets

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Abstract

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 Scitovsky 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.

Keywords: second-hand market, automotive market, prices, causality, cyclical correlations, VAR.

JEL Classification: C32, E31, E37

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1 Introduction

Apples are non-durable goods. Out of the new market, they have no value. On the contrary, cars are durable goods. They are usually bought with the intention to be used for a limited time and then re-sold. A car owner can choose for a duration, and then re-sell the vehicle on a well developed secondary market. Thanks to the durability of the car, drivers can re-sell cars to each other, and buy new or used vehicles. Durability creates specific dynamics of overlapping generations of durable goods that are not present in non-durable markets, and brings the question of the interaction between primary and secondary markets.

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 losses² and benefits.

The paper is organized as follows. Section 2 reviews the literature related to the interdependence between primary and secondary markets, specifically in the automotive sector. Section 3 presents the data and our empirical setting. In Section 4, we empirically evaluate the interdependence between new and used cars for three major markets (France, the United Kingdom and the U.S.). Section 5 concludes.

2 Academic researches in the second-hand market are legion.

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. Some researches, like Scitovsky (1994), also exist into a Keynesian system.

²This article is part of a general study on resale market hedging (Prado, 2008). We aim to estimate the distribution of the resale price in order to include the depreciation behavior in a derivative product.

2.1 Why secondary markets exist?

Van Cayseel (1993) provides a framework: Second-hand markets are institutions dealing with transactions of durable goods³, and the durability constitutes their first condition of existence. As a second condition, the good utility needs sufficient volatility. For instance, an economic depreciation⁴ could appear if the consumer has no further need of the good or because the maintenance cost of the car increases⁵. Consequently, the second-hand market re-allocates goods from agents extracting a low utility to agents extracting a higher one. Mixing the condition of durability and a possible variance of utility, we can state that the longer the durability, the higher the probability for an asset to change of valuation. The longer the durability, the higher the probability for a consumer to drop the asset, and buy another one. The secondary market could also be a way for some users to drop goods with malfunctions and no functionality⁶. But dropping ‘lemons’ could only be an incentive for a minority of agents, otherwise the secondary market would collapse.

According to Van Cayseel (1993), the possibility of simultaneity of new and used markets constitutes the last condition, raising the question of benefits and constraints in the second-hand market for producers. In order to reduce the risk of competition with new products⁷, producers would try to prevent the existence of a secondary market (i.e. by only renting their equipment or reducing the substitutability between new and used markets). Fortunately, some incentives to tolerate and to even support a second-hand market, additionally exist for the producer. The first incentive would be the pressure created by other competitors with similar goods. Following researches on industrial regulation and anti-trust policies, a large amount of academic papers have studied durable goods in a monopolistic market⁸. The incentive could be a law committing the monopoly to sell his products. The existence of asymmetric information could also restrain the opportunity of

³On a broader definition of Van Cayseel, the key concept should be not used goods but resales.

⁴We are focusing on second-hand markets for automobiles. Most of the time there is a depreciation of the good over time. However, in some markets like art or financial product, the secondary market has a higher valuation than the primary market. Specific cars (luxury ones) could also gain value after some years because of collectors interests.

⁵Regarding maintenance, the second hand market could be a way to reallocate used goods with high maintenance cost to users who have a better maintenance technology or skills.

⁶It brings the problem of adverse selection discussed in the next section.

⁷The problem of Time Inconsistency is discussed in section 2.2.

⁸See Waldman (2003) for a large review in the microeconomy area.

leasing, because users are less careful with goods they do not own. Anderson and Ginsburgh (1994), through a microeconomic analysis and under a monopolistic assumption, show a beneficial effect of secondary markets for the producers: consumer heterogeneous tastes result in a segmented secondary market allowing producers to establish a system of indirect price discrimination (by setting higher prices, a producer extracts higher surplus from consumers with higher willingness to pay). In the automotive industry, manufacturers are selling both new and used cars⁹. They also rent and provide services of maintenance in order to benefit most of the needs related to their products (i.e. financing car ownership through their financial branch). Manufacturers aim to collect various revenues from all available channels.

Defining the automotive industry as a monopoly would be a strong assumption. According to the ACEA¹⁰ in 2008, more than 15 manufacturers (through more than 43 brands) were sharing the market in Western Europe, and none of them had more than 21 percent of the market share. In the US, more than 15 automotive makers are competing and none of them had more than 15 percent of market share¹¹. Paredes (2006) argues that cars are 'durable experience goods'. Before buying a car, a consumer can't evaluate all of its characteristics. As a consequence, Paredes states that a link exists between consumer loyalty, satisfaction and retention value. The existence of consumer loyalty (and non loyalty) implies that consumers are able to choose different manufacturers and that car markets are not monopolistic. As a conclusion, an automotive company could only be defined as a monopoly during the introduction of new vehicles (i.e. minivans in the US market¹²). Although we reject a monopolistic assumption, we take these studies into account by focusing on the highlighted mechanisms of interdependence.

Scitovsky (1994) adopts a macroeconomic approach to explain the existence of secondary markets. He argues that durable goods are valued by the services they provide to the consumers. Because of time and obsolescence, the amount of services included decreases. Therefore the secondary market has two functions:

⁹ usually through franchise dealer.

¹⁰ European Automobile Manufacturers' Association:
www.acea.be/index.php/news/news_detail/new_vehicle_registrations_by_manufacturer/

¹¹ Source: CRS report for congress.

¹² See Petrin (2002).

first, it mitigates the inequalities by allowing poor customers to buy a cheaper bundle of services to richer ones. Second, it stimulates the economy by facilitating the replacement of obsolete durable goods. Scitovsky's theory explains why there are bigger proportions of second-hand markets (i.e. clothes, household appliances) in developing countries. But used car markets have a significant size in countries with high standard of living. Indeed, automobiles are relatively expensive and, by increasing the price span, the second-hand market allows most of people to afford a car. The empirical analysis of Clerides (1998) on the welfare effects of trade liberalization¹³ in 1993 (by permitting the importation of Japanese cars in Cyprius second-hand market) confirms Scitovsky's opinion. Clerides concludes of significant gains that benefited predominantly for low-income consumers because of an increase in product variety.

2.2 The Akerlof effect and the car durability are linked.

The main area of research on durable goods comes from the most famous analysis on automotive second-hand market. Akerlof (1970) explained why used car valuation is so much lower than new car valuation. The automotive resale market is affected by something called the 'lemon effect'. A used car has a probability to be of a good quality or a bad one (i.e. *lemon*), and the uncertainty on quality implies a price adjustment. In the resale market, there is an asymmetry of information; the car owner has a better knowledge of the probability of bad *lemons*. If second-hand vehicles were valued like as new vehicles, then it would attract *lemons* (sellers of *lemons* would have the opportunity to sale their vehicles and buy a new one on the new vehicle market) and it would create an arbitraging opportunity. Akerlof used the automotive market as a best illustration and extended his idea to other markets (the cost of dishonesty...).

The Akerlof's article helps to understand why an adverse selection happens, as well as the large variance and the trends between new and second-hand prices. But some elements of the article have to be discussed.

First, the influence of new markets misses in the analysis. Hendel and Lizzeri (1999a) built a microeconomic model including a primary market and according to their conclusions, a sufficient level of trade could

¹³In spite of the limitation of the study focusing on a country without a national automotive industry.

reduce the adverse selection. Moreover, buying new cars and selling used cars are complementary activities: even if they give higher valuation to their used units, owners find optimal to sell their good quality cars; once their used car has been sold, owners place a higher value on purchasing a new car. Finally, Hendel and Lizzeri argue that new market prices could be increased thanks to the adverse selection. The first explanation would be that a used good becomes a worse substitute than a new one (in case of an average quality reduction on the used market). The second reason would be that the buyer of new goods gets an option value and he or she can decide to keep the high quality realization of the used car.

Empirical analyses give a second perspective. Winand and George (2002) provided a large review of empirical tests on the Akerlof effect and in various markets, as well as a specific analysis, in the second-hand car market of a Swiss canton. According to their conclusions, adverse selections are not always observed or could occur under a mitigated and non widespread form.

Car durability constitutes a third element. An increase of average durability, through the Akerlof analysis, could have either a negative or a positive effect. A better durability implies a better quality of cars producing a lower probability of 'lemons' on the second-hand market. On the other hand, consumers would keep their car longer and it would increase the proportion of 'lemons'. Whatever the consequence (positive or negative for profits), a manufacturer can impact the adverse selection effect through guaranteed warranties, buyback or by improving information on the second-hand vehicles. Similarly, by the beginning of the 90's, Peach et al. (1996) noticed an improvement of the information availability on the US second-hand market and an increase of car durability. At the same time, the used car market experienced an increase of sales and affordability. All in all, it suggests a positive correlation between quality, durability, and non-adverse selection.

To conclude, the Akerlof effect and the durability could explain the price trends through the structure of the market and the inner quality of cars. The questions of quality and optimal durability are developed in the next section.

2.3 Optimal durability and Time inconsistency are two areas of research.

Optimal durability constitutes another main area of research in the microeconomic analysis of durable goods. A non-competitive market might lead to a lower socially efficient durability of goods in order to constraint consumers to increase purchase frequency. Sieper and Swan (1973), however, argue for an absence of durability distortion: monopoly market and competitive markets will always produce at minimum cost and then consider the durability as a minor problem. Some articles, like Hendel and Lizzeri (1999b), contest these outcomes: although used goods create competition for new goods, a manufacturer would benefit from a well functioning used-goods market increasing the willingness of consumer to buy new goods easy to resale. At the same time, the producer could slightly reduce the durability (by under investing in durability, by directly reducing new units durability, by introducing frequent style changes and new products...): it alters the substitutability of new and used market and allows the firm to increase the price of new units. The maintenance market could also interfere. Rust (1986) argues that, in case of a competitive maintenance market and a monopolistic new market, most of consumers would prefer over maintained used goods.

Durability could have a positive impact on prices for both new and used market by increasing the quality of cars and therefore the utility of the consumer. At the same time, it has a negative impact on prices in the new market by improving the competition with the second-hand market. In the US market, by the beginning of the nineties, Peach and al (1996) observed that cars reliability, survival rate, and warranties durations have been rising simultaneously with car prices. Acknowledging that durability has not been the only factor impacting the level of price, graphical analyses show similar trends, from 1990 to 2008, of the median age and the average sale price of new cars. But their conclusions have to be strongly qualified: for used cars and light truck markets, similar trends are less visible¹⁴. Furthermore the Consumer Prices Index for cars (new and used), that adjust prices through obsolescence and representative constant mixes of vehicles, has been decreasing since 1990 in the US¹⁵.

¹⁴See graphs in Appendix 2.

¹⁵See graphs in Appendix 2.

A third large area of research on durable goods discusses the Time inconsistency. Optimal durability and the Time inconsistency problem are embedded. According to Coase (1972) a monopolist has to manage the dilemma that the price of units sold in the future will be affected by the characteristics of the units sold today. The Time inconsistency constitutes an issue for producers across planned obsolescence, R&D, and the introduction of new products on the market. Waldman (1996) argues that R&D could have a negative impact on new products because consumers expect a technological improvement in a later period. As a consequence, a monopolist should under invest in R&D and reduce the availability of the used goods (i.e. by reducing the durability of new unit, by repurchasing and scrapping the used units...) to maximize his profit. On the other hand, Fudenberg and Tirole (1998) argue that new and used units could become imperfect substitutes after the improvement of new goods. They conclude that R&D could have a positive impact on new goods prices, as well as a negative impact on second-hand cars¹⁶. As already mentioned, microeconomic studies usually make the strong assumption of a monopolistic market. But Schiraldi (2009) proposed a microeconomic model in an oligopolistic car market. She concluded on a possible collusion of manufacturers to increase prices on second-hand markets through leasing policy, warranty policy and buy-back policy in order to increase prices on new markets. By and large, microeconomic results lead to various conclusions, but they always bring the idea that new and used markets impact each other prices (and volumes) on a short and a long time perspective.

2.4 Scitovsky's mechanisms are part of a Keynesian framework.

Most of mentioned 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. Scitovsky (1994) adopts a Keynesian approach that includes uncertainty and the impact of disposable incomes on the overall economy.

¹⁶Petrin(2002)'s empirical analysis on the impact of introduction of the minivan in the US market does not include the second-hand market, but the study confirms the positive impact of innovation in a competitive market. When automotive firms are introducing new products, they are cannibalizing each other profits ignoring the externalities they create. In the end, new products can bring large profits to the innovator and substantial gains for the consumer.

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 only¹⁷ (Car owners are rarely relinquish and dealers stocks are quite limited).

From an empirical perspective, Peach et al (1996) also conclude that used markets intensify economic cycles. But they have another explanation: there has been a long-term shift of the US consumer demand

¹⁷According to Scitovsky, financial assets are the only exception. The destabilizing impact of fianacial secondary market would have no limit. Their sizes and shocks duration would significantly impact the overall economy.

from new to used car markets¹⁸. Franchised new car dealers have captured much of the second-hand market growth. They are collecting most of their profits from used cars and are less aggressive bidders on the demand side of auctions. Regarding the supply side, when demand for new cars increases, they accelerate the used car price reduction by sending more used cars to auctions. The mechanism become reversed when the demand for new cars decrease. At the end, car markets have more volatility. Pashigan (2001) observed that US used car prices index has much more volatility than the new car index. The supply curves are less elastic for used than for new cars and, as a consequence, contribute to a higher volatility.

2.5 There are implied mechanisms behind the academic theories.

Other mechanisms do not come from a specific literature and are implied in the previous contributions. We mention them for clarification purposes and to facilitate their identifications in the econometric analysis that will be implemented in the next section.

"The new market feeds the used market": as a result, volume and prices of today's used car market might be positively correlated with volume and prices of the past new market. The mechanism also interacts with renewals on the used and the new markets.

"Renewals": after some years, drivers have to renew their vehicles. Concentrations of renewals create cycles on both markets. Additionally, concentrations on the new market could create future concentrations on the used market.

"Volume effect": an increase of transaction volumes, if caused by a greater offer, could have a positive impact on the prices. An increase of transaction volumes, if caused by a greater demand, could have a negative impact on the prices.

"Price effect": a price increase could have a positive impact on the volume of transactions by improving offer, or a negative impact by decreasing demand.

"Arbitration": a driver can buy a car on the used market or on the new market. A car bought from

¹⁸There has been a shift, as mentioned in the previous section, consequently to an increase of durability and affordability of cars, as well as a higher level of available information for consumers.

one market cannot be bought from another market at the same time. When most of drivers choose to buy used vehicles, volumes (and prices) improve in the used market and, as a consequence, decrease in the new market.

"*Reallocation*": when prices are too high in the new market, the buyers move to the second-hand market. Consequently, used car prices increase. In other words, prices and volumes move in the same direction in both markets on a short term perspective. Scitovsky analyzed the reallocation mechanism by insisting on the threshold effects (due to stocks) on volumes and the lags creating constant disequilibrium.

The "*Income effect*": a decrease of income (or consumption or confidence) creates a decrease of demand, a decrease of transaction volumes, and a fall of prices in both markets¹⁹. Alternatively, it could create a shift of consumption from the new market to the used market. As a consequence, volumes and prices go down in the new market while they are increasing in the used market.

3 The macroeconomic times series need clarifications.

We aim to check the accuracy of the mechanisms mentioned in the previous sections using econometric tools. The interactions of the consumer price indexes and the volume of transactions of new and second-hand cars are analyzed in three countries. Following an interpretation of the relations between the academic theories on durables goods and the time series behavior, we define the limit of our macro-economic perspective.

3.1 Three countries are compared through four time series.

We study the automotive markets of France, the United Kingdom and the United States of America. We consider observations related to the Consumer Price Index (CPI) and the volume of registrations (or sales) for new and used cars²⁰. The US volumes make the difference: in 2007, used car sales volume was more than 41,4 millions for the US market. By comparison, it was 5.3 millions and 7 millions for France and the

¹⁹According to Scitovsky (1994), the *Income effect* causes cycles.

²⁰See Appendix 1 for data sources.

UK. Moreover, the passenger car populations in use for France, the UK, and the US were 30.7 millions, 30.1 millions, and 135.4 millions²¹.

We aim to analyze the interdependence between primary and secondary markets on a macroeconomic perspective. The quality of the car (to account for the Akerlof effect), informations regarding demand (i.e. consumer confidence) and offer (i.e. business confidence), the level of R&D (for the *Time inconsistency*), the mix of vehicles or the level of stocks constitute relevant explanatory variables. However, we only included four time series in our analysis (prices and volumes) because of the difficulty to collect standardized information and to allow a comparison from a country to another.

The National Statistical Institutes (INSEE for France, ONS for the UK, BLS for the US) provide the automotive Consumer Price Indexes. They reflect the general movement of prices on the new and the used car markets. The statistical institutes do not communicate a precise list of the items included in the samples used to construct the indexes. And the precise locations, where the observations are collected, are neither provided. They communicate, however, a general setting of their methodologies²². The frameworks are not always similar from a country to another, but share the same objectives. First, the CPI has to reflect the cost of life and to give an overview of price variation of the general expenditure across the country. Then prices are collected from various areas and the selected samples of cars aim to be representative of what people buy in these areas. Second, although goods and services are changing through time in their characteristics, the statistical institutes intend to measure the effects of price changes by keeping constant the other economic factors. The processes by which prices are adjusted to account for changes in product quality constitute an important subject of research and discussions in the automotive sector. The US applies the Grilitch methodology²³ for the quality adjustment of automotive observations: the Hedonic approach estimates the

²¹The number of new passenger car registrations in 2007 for France and UK was 2.0 millions and 2.4 millions. New vehicles sales in US were more than 13,6 millions. The average car age is 8.1 and 6.7 years for France and for UK. In US, the median age for automobiles is 9.2 years. See data sources in Appendix 1.

²²See Caillaud (98) for France

See www.statistics.gov.uk/articles/nojournal/CPISQR.pdf for UK.

See Reinsdorf & Triplett (2008) and also Pashigan(2001) who provides critical elements on the US CPI for used cars.

²³See Otha et Grilitch (1976) for additional details the Hedonic methodology in the automotive area and also Fixler et al (1999). See Prado (2009) for an application on the European used car market.

price of a good through the valuation of its attributes. France and the UK apply another methodology, the 'option costing', that can be used when a product changes in specification and when it is possible to value separately the components that have changed.

We use the volumes of registrations (for France and the UK) and sales volumes (for the US) as proxies of the total amount of transactions. They do not allow a distinction between the variations of offers and the variations of demands, and provide a slightly more ambiguous information than the CPI: an increase of sales could be either the consequence of an increase of demand, or an increase of offer, or a reduction of prices. The impacts of volumes on prices are also ambiguous. An increase of the volumes could cause either a reduction or an increase of prices. Following an improvement of the market size, for instance, the dealers could reduce their prices in order to increase their market share or to reduce fixed costs. They could also consider a high level of demand as an opportunity to improve their benefits by increasing prices.

3.2 How to connect the academic literature with a time series analysis?

We divide the economic literature, surveyed in Section 2, in three groups: the advanced mechanisms (Table 1), the Scitovsky theory (Table 2) and, the basic mechanisms (Table 3). Their consequences on the time series analyzed in our article are synthesized in the column 'Impact on Prices and Volumes'. The arrows (\Rightarrow \Leftrightarrow) indicate that a parameter affects or causes another one. In order to avoid any misunderstanding, we have to mention that we do not assume mechanical relations similar to a clockwork (or deterministic links), but we expect to identify probable interdependence between the new and the used markets (or stochastic links).

| 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 \uparrow or Information $\uparrow \implies$ Volumes Used \uparrow and/or Prices Used \uparrow |
| 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 \uparrow or Information $\uparrow \implies$ Volumes Used \uparrow and/or Prices Used \uparrow and Volumes New \uparrow and/or Prices New \uparrow |
| 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 $\uparrow \implies$ Volumes New $\downarrow \implies$ Prices New \downarrow and Volumes Used $\downarrow \implies$ Prices Used \uparrow |
| 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 $\uparrow \implies$ Volumes Used \uparrow and/or Prices Used \uparrow and Volumes New \downarrow and/or Prices New \downarrow |

Table 1: Advanced Mechanisms.

| 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 $\rightarrow \implies$ Prices New $\rightarrow \implies$ 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 $\uparrow \dots$ |

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 | <u>Positive Correlation:</u> Past New Volumes \iff Current Used Volumes / Past New Prices \iff Current Used Prices |
| Reallocation | Prices and volumes of New sales transactions correlated positively with prices and volumes of Used Sales transactions | <u>Positive Correlation:</u> New Volumes \iff Used Volumes / New Prices \iff Used Prices |
| Arbitration | A car bought in one market can't be bought, at the same time, in another market. | <u>Negative Correlation:</u> New Volumes \iff Used Volumes / New Prices \iff Used Prices |
| Renewals | Concentrations of renewals create cycles in both markets. Concentrations in the new market could create future concentrations on the used market. | <u>Cycles of Prices and volumes:</u> Past New Volumes $\uparrow \implies$ Current Used Volumes \uparrow and Past New Prices $\uparrow \implies$ 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 $\uparrow \implies$ Offer $\uparrow \implies$ Volume \uparrow or Demand $\downarrow \implies$ 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 $\uparrow \implies$ 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 $\downarrow \implies$ Demand $\downarrow \implies$ 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 $\downarrow \implies$ Demand New $\downarrow \implies$ Volumes New \downarrow and/or Prices New \downarrow and Demand Used $\uparrow \implies$ Volumes Used \uparrow and/or Prices Used \uparrow |

Table 3: Basics Mechanisms.

As discussed in section 2.2, 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 both²⁴.

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

²⁴It is identified every time there is an "and/or" in the table.

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.

Our attempt to translate the theoretical economic literature under an econometric analysis highlights a critical point: the timing. In most of academics papers, except the Scitovsky (1994)'s article, the period in which the mechanism has an effect was never explicit and the lags are not precisely defined. For instance, are the adjustments simultaneous in the *Arbitration effect* ? Or are they lagged ? Do they last for the next six months ? Do they last for a year ? The econometrics of the next section will provide an insight on timing.

3.3 We work on macroeconomic time series, a limited information.

The macroeconomic perspective presents four limits: the cross border sales, the availability of the historical observations, the usual critics on Consumer Prices Indexes, and the heterogeneity of the markets.

As a first concern, the cross border sales might affect the national prices and transactions of cars: the imported vehicles, for instance, could increase the competitiveness and reduce car prices. In the European market (including France) the existence of significant cross bordering transactions should lead to a price convergence. Gaullier and Haller (2000), however, did not notice mechanisms creating an automobile price convergence in European countries. They argue that exchange rate fluctuations explain a large share of the price dispersion dynamics²⁵. Parities between Euro-land countries were fixed in May 1998, so their study was too early to assess the long-term effects implied by the implementation of the single currency. Prado (2009), through an Hedonic analysis on the 2005-2009 period, shows that even with the Euro implementation, distinct national markets still constitute the European second-hand car market. Thanks to the right wheel vehicles, we have few concerns for the UK market regarding a possible interaction, on prices and volumes, with the other countries. As a conclusion, the impact seems limited for France and the UK. The US car

²⁵They confirm the conclusion of Goldberg and Verboven (1998) that prices follow exchange rates closely.

market has a size dramatically higher than the Mexican and the Canadian markets and we also expect a limited cross bordering impact.

As a second concern, we have to keep in mind that our results might be altered by the limited period of available observations. All in all, knowing that cars longevity can run up to 20 years, the study would hardly provide a long-term perspective. In France, the used car CPI is available since January 1998, while, in the UK, the used car Index is available since January 1996. In the US, the BLS has published the used car index since 1952 and, in order to reflect the cost of living of a representative household, light truck vehicles have only been included in the CPI since 1998. To standardize the analyses (for the UK), for consistency purpose (for the US), and to allow a comparison of the three countries, we selected the CPI samples from January 1998. Regarding the times series of volumes (number of registrations, number of sales), we did not apply the same criteria for the selection of the period: we included as much information as possible, regarding the number of registrations and sales, maximizing the opportunity to identify a relation between prices and past volumes (i.e. correlation between used cars and previous five years used cars sales). Most of the time, the volume of transactions has been included according to the series provided by the statistical institutes and, as a result, series of volumes are longer than CPI series²⁶ (except for the UK used car registrations). The time series for France, the UK and the US are presented in Appendix 3.

The relevance of the variables constitutes our third concern. Like any other statistical indicator, the Consumer Price Index has been the subject of several critics. In addition, because of the political and economical impacts on citizen (i.e. wage negotiations), there has always been a suspicion regarding the CPI accuracy. Two main critics show up: in the automotive area, people complain that Hedonic adjustments over deflate the movement of prices and that CPI does not reflect their 'feeling' of increasing prices. Greenlees and McClelland (2008) discussed the limits of those critics. They demonstrated the limited impact of Hedonic adjustment on CPI results²⁷. And a well known psychological 'loss aversion' could increase the sensibility to

²⁶France: New registrations and used car registrations since January 1987.

UK: New registrations since January 1987/ Used car registrations since January 2001.

US: New sales since January 1987/ Used car sales since January 1997.

²⁷Although there is no European study that would corroborate these results, we also assume a limited impact regarding the

increasing prices than to decreasing prices; because the CPI cannot reflect the consumption of a particular group of customers, they are defined as an average of the inflation rate. Consumers are always members of a specific group and they always have the feeling that the CPI is not in line with their specific consumption.

Fourth, speaking of different groups of customers, we have to clarify that, although we work at a country level, we do not assume heterogeneity of the markets: a national car market could be the sum of several sub markets involving very different populations of customers. A sub market might strongly impact the whole car market through a significant size or a high level of volatility. But we aim to provide a macro-economic perspective and intra market interactions do not constitute the subject of our study.

3.4 What do the series look like?

The period of analysis has been standardized from January 1998 to June 2009. The French market seems rather stable, whereas the UK²⁸ and the US prices follow a negative trend and display a high volatility²⁹. For the last ten years the trends of the US series look 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 adjustment³⁰.

At a glance, new car CPI are always more stable than used car CPI. Prices on the used market are the result of demands and offers, while new car prices are set by the dealers and manufacturers according to constraints of production and maximization of profits. If new car prices become too high, the number of sales decreases because of prices rigidity on the new market and the adjustment operates mainly by the volume of transaction³¹. As a result, registration (or sale) volumes are more volatile for new cars than second-hand cars, and new car prices are quite stable. The market readjustment through volumes explains why some economic institutions (i.e. OECD) use new car transactions as a short-term economic indicator. In contrast,

quality adjustment methodologies applied on the French and the UK Consumer Price Index.

²⁸For 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.

²⁹See graphs in Appendix 3.

³⁰Series are seasonally adjusted using X11 methodology. See graphs in Appendix 4.

³¹These conclusions should be confirmed by an analysis of the automotive production (does the manufacturers adjust the production according to prices ?) and stocks available (how the stocks impact the markets ?).

prices in the second-hand market are set through offer and demand. As a result, used car prices display more volatility than new car prices.

By the beginning of 2008, the time series falled sharply. The subprime crisis, a global economical event, appears as an opportunity to compare the reaction on the different markets and to confirm the previous statements. The new cars registrations (or sales for the US) are more impacted (by a stronger drop) than the used car registrations (or sales), and used car CPI is more impacted than new car CPI. As a first conclusion, it suggests that, in the case of an *Income effect*, the used car market has an higher probability to be impacted on a price perspective, whereas the new market would rather be impacted on a volume perspective because of a relative price rigidity from car manufacturers. The mechanisms mentioned as the *Feeds effect*, *Arbitration*, *Prices effect* and *Volume effect* might be similarly affected.

All in all, new car markets in the UK and the US have been declining for the last 10 years, while France has been a stable market.

4 The econometric analysis shows different results by country.

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 academic theories. At the end of the section, we estimate the VAR models to investigate the relations between the markets and the possible forecasts³².

4.1 The unit root tests undermine the advanced mechanisms.

As previously stated, France appears as a stable market. To check this intuition, we apply the Augmented Dickey Fuller unit root test to the growth rate of the series. The results are reported in Table 4 and show that the French volumes and index prices have been stationary for the last ten years. On the contrary,

³²The econometrical analysis is inspired by Chazi (2007) and Lescaroux & Mignon (2008).

the UK and the US have trends: new cars CPI in the UK, as well as the volume of new car and used car sales in the US, have a unit root (Difference Stationnarity or DS). According to the econometric theory, it means that a macroeconomic shock would have an impact on the trend series forever. In contrast, a trend stationnarity (TS) has been identified for the new car prices index in the US, implying that a macroeconomic shock would have a temporary effect on the prices. Finally, the used car CPI has no trend in every country.

| | | |
|------------------------------|----------------------------------|----|
| France | Used cars CPI | S |
| | New cars CPI | S |
| | Used cars Registrations | S |
| | New cars Registrations | S |
| UK | Used cars CPI | S |
| | New cars CPI | DS |
| | Used cars Registrations | S |
| | New cars Registrations | S |
| US | Used cars and light trucks CPI | S |
| | New cars and light trucks CPI | TS |
| | Used cars and light trucks Sales | DS |
| | New cars and light trucks Sales | DS |
| Stationarity (S) | | |
| Difference Stationarity (DS) | | |
| Trend Stationarity (TS) | | |

Table 4: Augmented Dickey Fuller Results.

The unit root test invalidates the assumption that, for the last ten years, prices and volumes have been moving in the same direction in the UK new car market (the new car CPI follows a DS process while the volume of used car sales was stable), and in the US new market (sale volumes and prices follow a different trend, a TS and a DS). Turning to the economic theories, it rejects the presence of mechanisms involving similar long-term trend on prices and volumes (like the *Akerloff effect*, the *Time inconsistency*...). As an example, the decreasing trend in the US might be explained by the *Optimal durability* effect: the demand for vehicles decreases because cars durability has improved. Drivers do not have to renew their vehicles as often as in the past. An improvement of cars quality should also lead to an expansion of the second-hand market, and in the same manner, an increase of used cars prices (and volumes). But the *Optimal durability* mechanism is invalidated by the stationnarity of the used car prices (and the decrease of used car volumes).

Focusing on car prices, the estimated trends refute several mechanisms and illustrate the absence of a long term relation between prices. The stability in France and the trends moving in the same direction in the UK invalidate the existence of a strong *Akerloff effect 2*, or an *Optimal durability effect*.

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, a cointegration test identifies a common long-term trend between new car and used car sales³³: for the last ten years, the new and used US sales have been declining. These results also weaken the mechanisms reported in Table 1. It is highly unlikely that the stability in France and the UK, as well as the decline in the US, would be due to a global decrease of cars quality³⁴ (according to the *Akerloff effect*, the *Time inconsistency*....).

4.2 The correlation analysis provides a one-month period perspective.

The correlation calculation provides a first insight on the simultaneity of market evolutions³⁵.

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 UK, there is a positive correlation between the new car registrations and the used car prices. These results are in line with the graphical analysis: Market adjustments are made through new volumes and used prices whereas constraints exist on new car prices and on the volumes of used car transactions; following an economic crisis, new sales and second-hand prices fall sharply while new prices and second-hand volumes remain relatively stable.

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

³³See cointegration test details in Appendix 9. The construction of an Error Correction Model (ECM) including the US volumes series did not provide a good adjustment. As a result, the model did not constitute a useful tool to forecast the volumes and we did not keep it in the study. Moreover, the US market only has two identified Differentiated Stationnarity (DS) time series. As a consequence, there is no possibility of a cointegration test and an ECM for France and the UK.

³⁴We can't believe, as well, that it would be due to a decreasing quality of information available for buyers.

³⁵Details are given in Appendix 6. The econometrics tools are applied on the seasonally adjusted growth rates and stationnary time series.

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.

4.3 The Granger causality tests elaborate the assessments of the correlation analysis.

To investigate the interdependence between new and used car markets, we first apply the Granger causality test³⁶ evaluating how much the previous six month information contained in a variable could improve the prediction of another variable. Results are given in Table 5.

| 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.

In the French market, new and used cars registrations are interrelated : the null hypothesis, that the volume of used car registrations does not Granger cause the volume of new car registrations, has not been rejected at the 5% significant level. In addition, the volume of new car registrations Granger causes the volume of used car registrations³⁷. It confirms the *Income effect* mentioned in the correlation analysis. Furthermore, the Granger test indicates that the used car CPI helps to predict used car registrations and new cars registrations: rising used car prices improve drivers willingness to resale their cars and to buy a

³⁶The Granger test has been set with six months lags.

³⁷See the detailed Granger test results in Appendix 5.

new one, as a result, the number of registrations goes up.

For the UK, the used car CPI helps also to predict new cars registrations. The results corroborate the graphical and the correlation analyses and emphasize that the adjustments on the new market are more on volumes than on prices. Nevertheless, it seems that dealers and manufacturers try to adjust prices and volumes according to the state of the market, because new car registrations and new car prices also help to predict each other.

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. 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. To be specific, the *Scitosky's* theory, of constant disequilibrium from one market to another, constitutes a possible explanation.

4.4 The Hodrick-Prescott filter reveals economic cycles.

In order to identify long-term trends of the series, we calculate Hodrick-Prescott filtered series³⁸. The filter produces a smoothed non-linear representation of the time series that is more sensitive to long-term than to short-term fluctuations³⁹.

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 evaluate the synchronizations of prices and volumes fluctuations. Following Fiorito and Kollintzas

³⁸See HP filter cycle and trend graphs in Appendix 7.

³⁹The 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).

(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. 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. We report the strong correlations⁴⁰ on Table 6.

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

Table 6: Cycles Correlations.

The filter, applied to the French car prices series, allows the assumption of a *Feed effect*: there is a 36 month pro-cyclical movement of new prices with used prices⁴¹. The new prices of the past 36 months impact the second-hand prices of today. Furthermore, the filter indicates a critical correlation between new cars and used cars registrations⁴²: the cycles of new and second-hand transactions increase and decrease

⁴⁰The complete results are reported in Appendix 8.

⁴¹ $\rho = 0.34$

⁴² $\rho = 0.42$

simultaneously. As a result, like the correlation analysis of Section 4.2, the Hodrick-Prescott filter identifies an *Income effect* on a volume perspective.

On the UK market, the filter also confirms the existence of a *Feed effect*: used car prices cycles are pro-cyclical to new car prices through lags of 3 to 12 and 36 months⁴³. The absence of strong correlations on registrations cycles with other series reduces the probability of a *Scitovsky* mechanism.

For the US, markets cycles 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 in line with the *Scitovsky* theory.

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

A Vector Autoregressive model gives a straight perspective of the relation between prices and volumes in both markets. We selected the best model using the Akaike and the Schwarz criteria. 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 values⁴⁴. 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

⁴³ At the same time, new car prices with a lag of 3 to 12 and 36 months are counter-cyclical to used car prices.

⁴⁴ Previous months of used CPI variables have a high statistical significance according to the τ student test.

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.

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 reinforce the conclusions of the graphical and the correlation analyses (the new CPI coefficient is less important because of the rigidity of new car prices created by production constraints), as well as the Granger causality test (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. Again, it strengthens the previous conclusions 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 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 study⁴⁵.

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. Our contribution also highlighted that, depending of a short-term or a long-term perspective, interactions are different. 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.

⁴⁵Results are synthesized in Appendix 9, Tables 7, 8, and 9.

APPENDIX

APPENDIX 1: Data sources

The Time series⁴⁶:

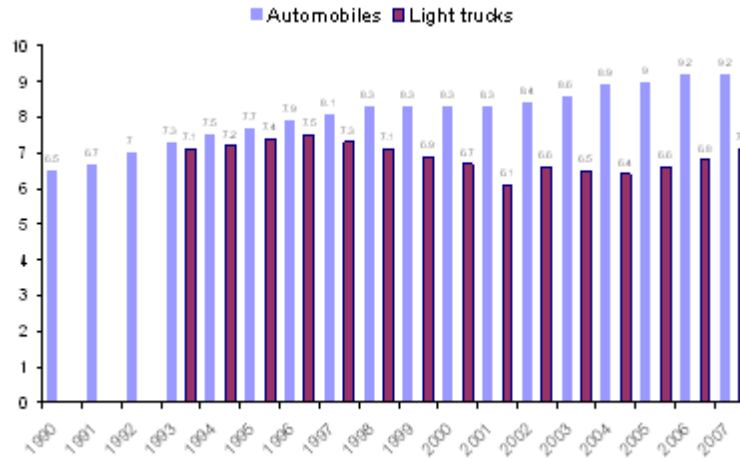
| | |
|-------------------|--|
| CPI FR | www.bdm.insee.fr/bdm2/serie/AffichRechDirecte.do Identifiant: 000638803 000638804 |
| CPI UK | www.statistics.gov.uk/statbase/tsdtimezone.asp Consumer prices indices DE78 DE79 |
| CPI US | www.data.bls.gov/cgi-bin/srgate Series Id: CUSR0000SS45011 CUSR0000SETA02 |
| New Car Reg FR | www.statistiques.developpement-durable.gouv.fr/rubrique.php3?id_rubrique=122 |
| New Car Reg UK | www.smmr.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/ |

Others Statistics:

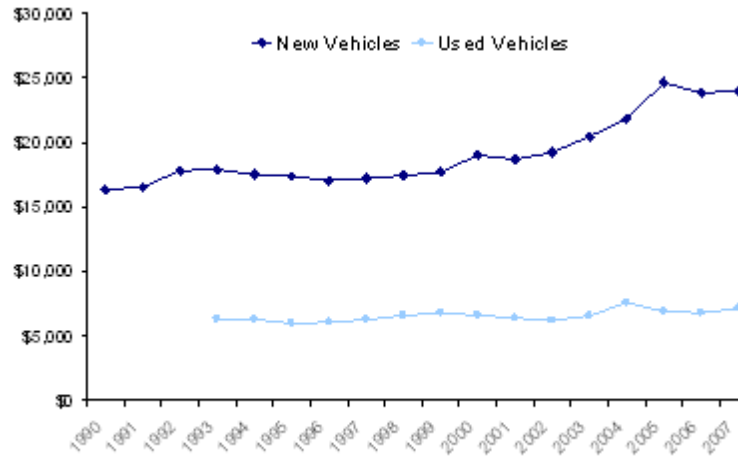
| | |
|--|--|
| France and UK, new registrations and vehicles in use | ACEA www.acea.be/index.php/collection/statistics |
| France second-hand registrations | Fichier central des automobiles www.statistiques.developpement-durable.gouv.fr/rubrique.php3?id_rubrique=32 |
| UK second-hand registrations | British Car Auctions Used Car Market Report www.bca-europe.com/ |
| US new and used average sale price | National Transportation Statistics from the US department of statistics. www.bts.gov/publications/national_transportation_statistics/ |
| US car on use | National Automobile Dealers Association www.nada.org/NR/rdonlyres/0FE75B2C-69F0-4039-89FE-1366B5B86C97/0/NADADData08_no.pdf |
| US median age | www.nada.org/NR/rdonlyres/0FE75B2C-69F0-4039-89FE-1366B5B86C97/0/NADADData08_no.pdf |

⁴⁶A special thanks to Tom Webb (www.manheimconsulting.com/) for his support on US data.

APPENDIX 2: Median Age and Average Sales price in the US (see data source in Appendix 1)

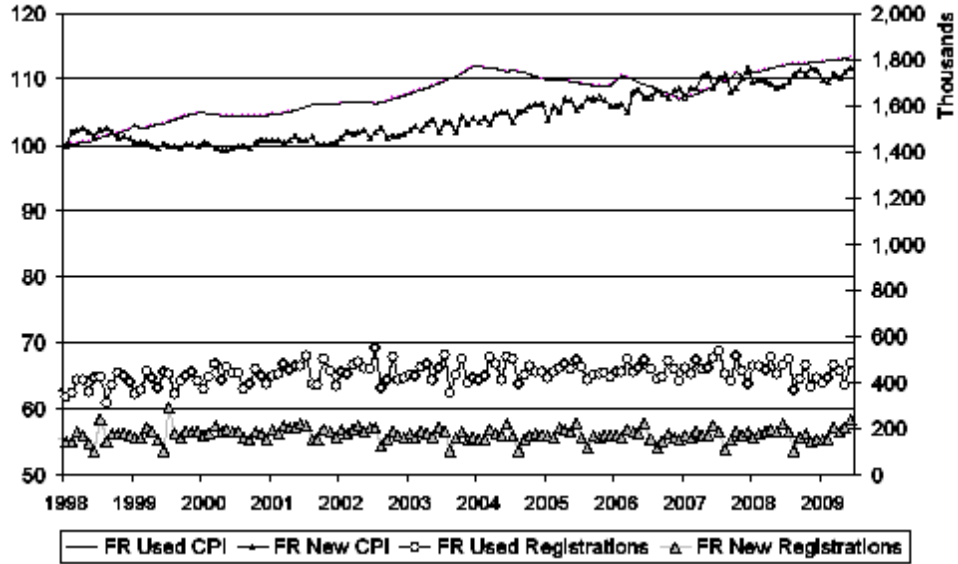


Median Age in US market

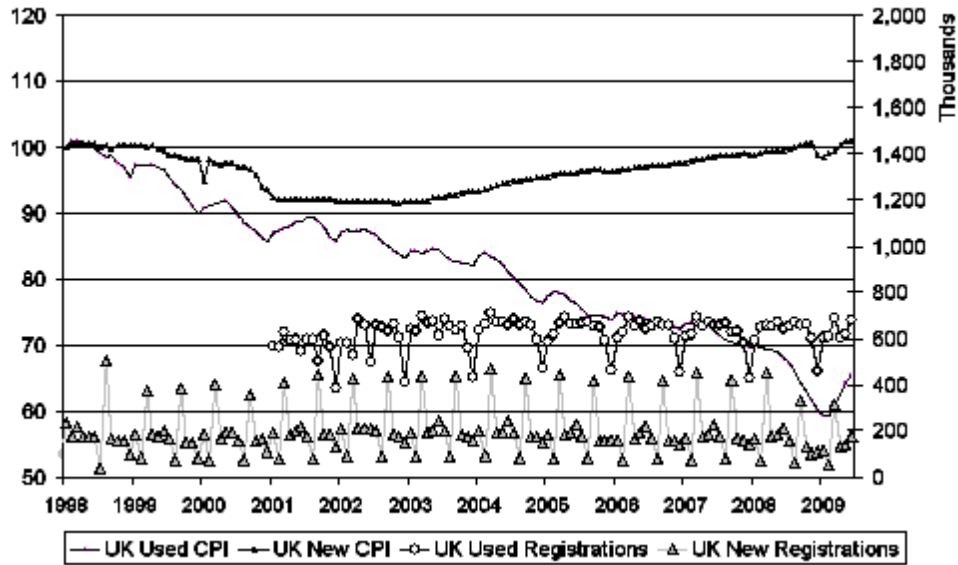


Average Sale Price Real US \$

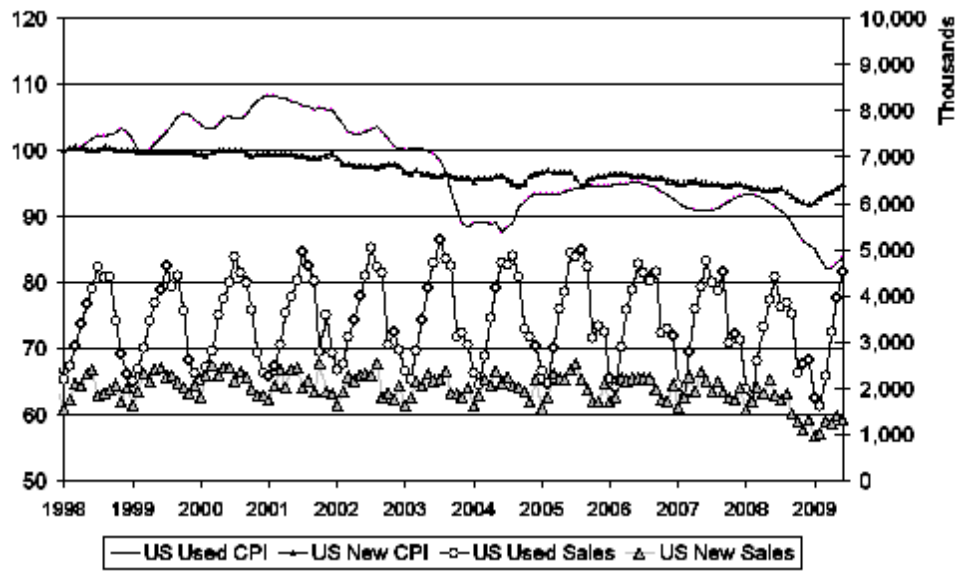
APPENDIX 3: Raw data (see data source in Appendix 1)



FR

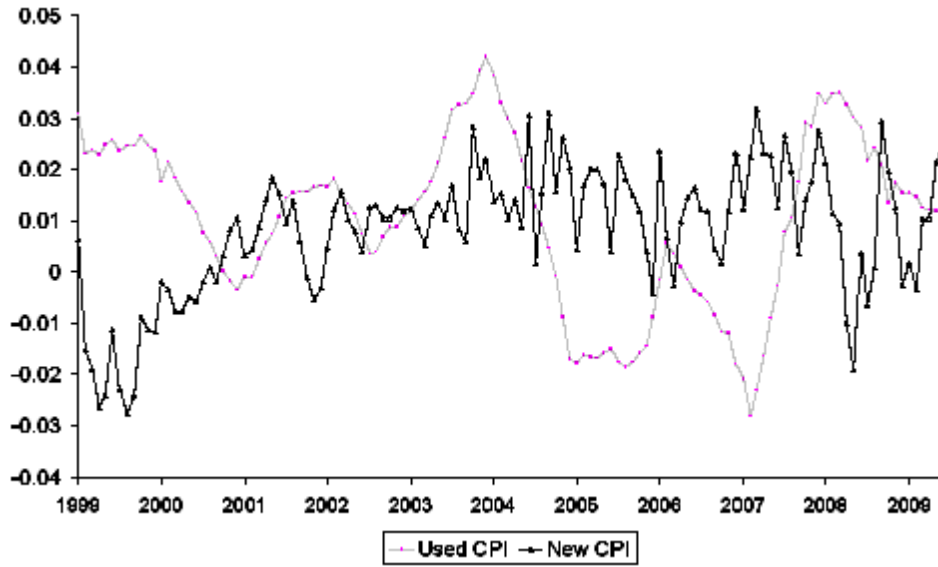


UK

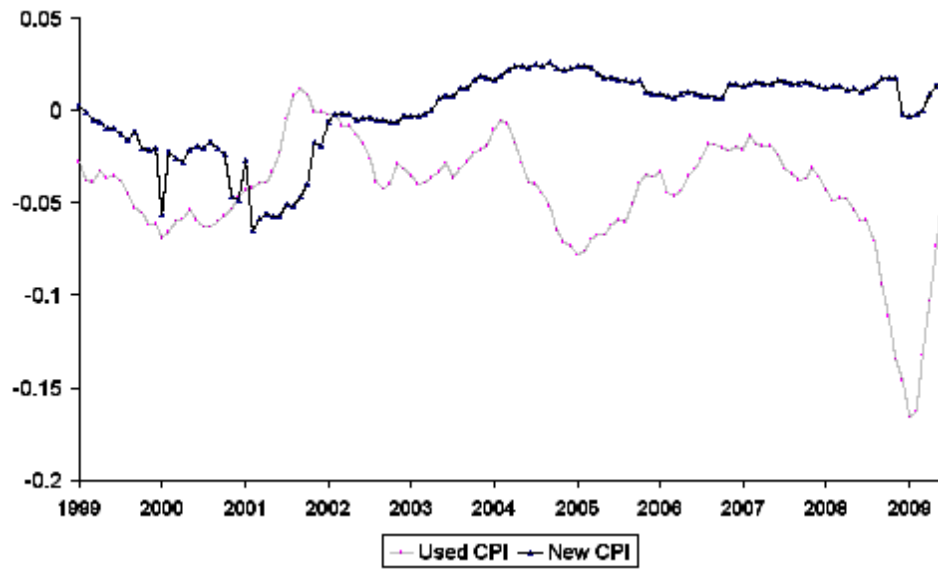


US (CPI data provided by the BLS are seasonally adjusted.)

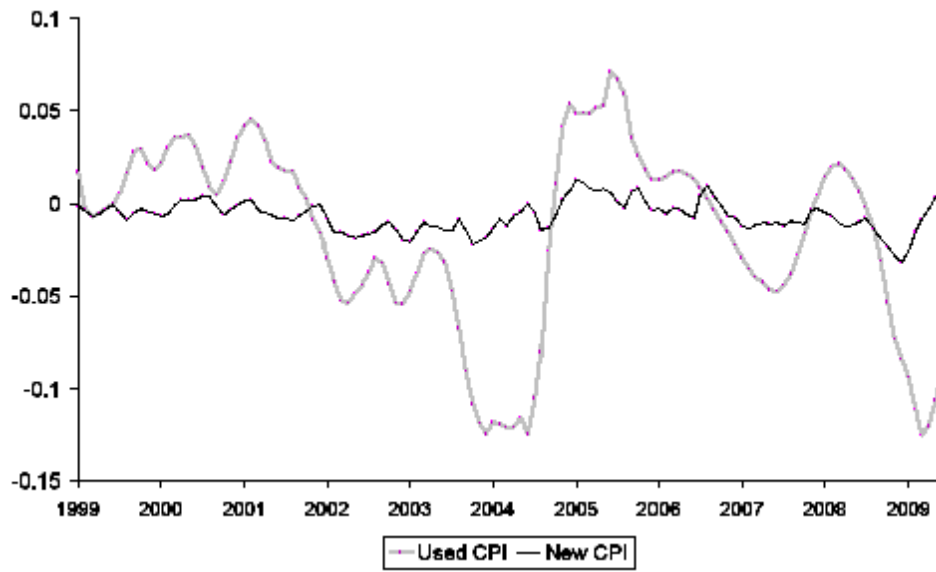
Appendix 4: Growth rate and seasonally adjusted times series



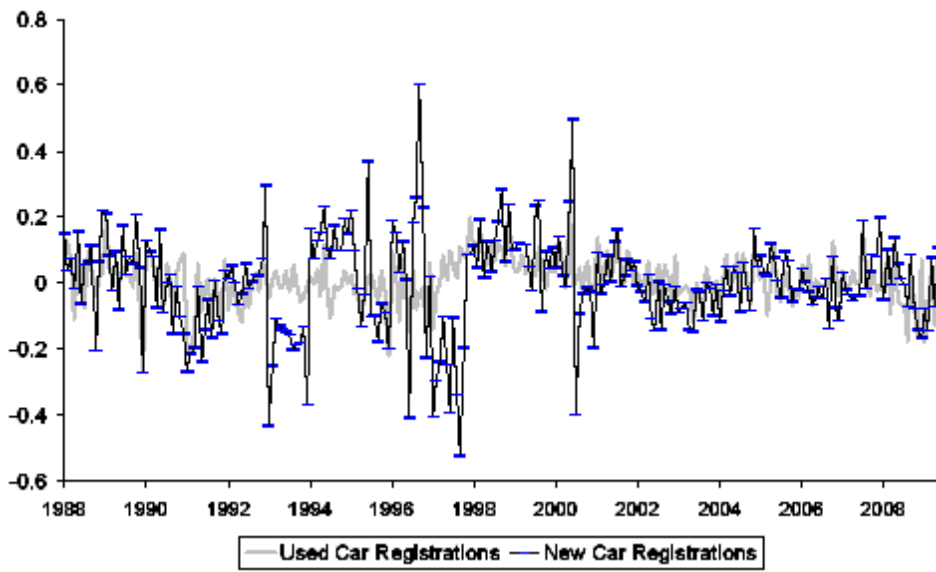
FR



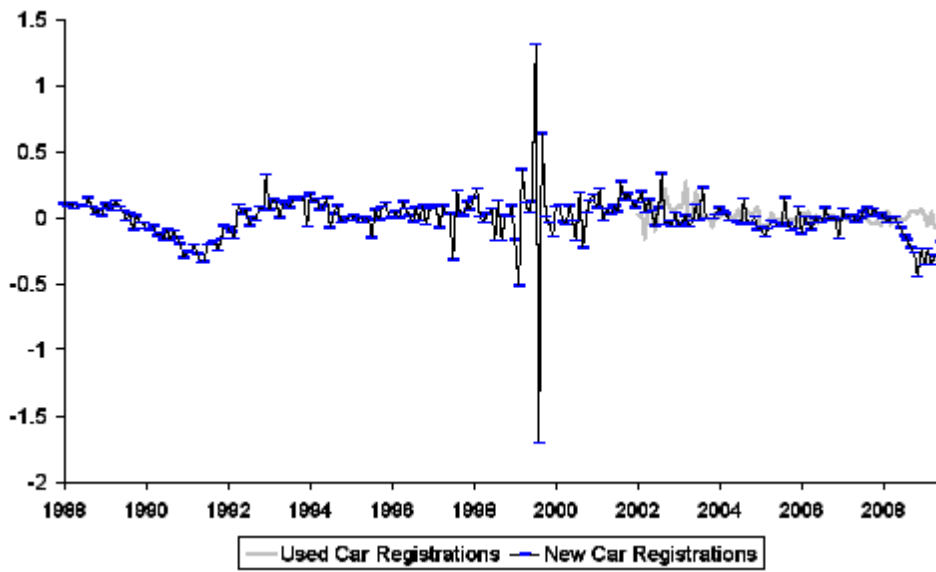
UK



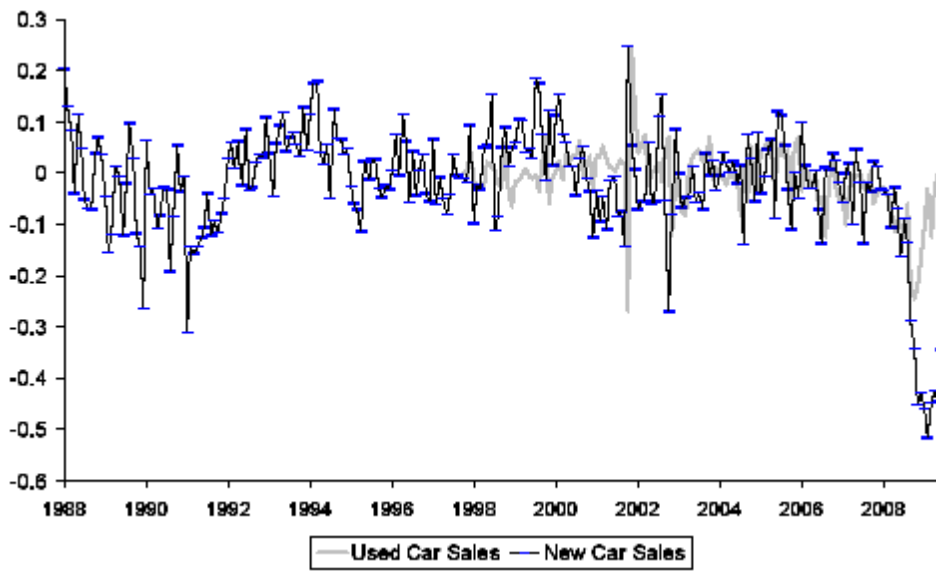
US



FR



UK



US

APPENDIX 5: Granger Test

| Pairwise Granger Causality Tests | | | |
|--|-----|-------------|-------------|
| Lags: 6 | | | |
| Null Hypothesis: | Obs | F-Statistic | Probability |
| NEW_CARS_CPI does not Granger Cause USED_CARS_CPI | 120 | 1.0125 | 0.4212 |
| USED_CARS_CPI does not Granger Cause NEW_CARS_CPI | | 0.3615 | 0.9017 |
| USED_CARS_VOL does not Granger Cause USED_CARS_CPI | 120 | 0.5774 | 0.7476 |
| USED_CARS_CPI does not Granger Cause USED_CARS_VOL | | 2.5318 | 0.0248 |
| NEW_CARS_VOL does not Granger Cause USED_CARS_CPI | 120 | 0.8105 | 0.5640 |
| USED_CARS_CPI does not Granger Cause NEW_CARS_VOL | | 2.6519 | 0.0194 |
| USED_CARS_VOL does not Granger Cause NEW_CARS_CPI | 120 | 0.8364 | 0.5444 |
| NEW_CARS_CPI does not Granger Cause USED_CARS_VOL | | 0.9842 | 0.4397 |
| NEW_CARS_VOL does not Granger Cause NEW_CARS_CPI | 120 | 1.0053 | 0.4258 |
| NEW_CARS_CPI does not Granger Cause NEW_CARS_VOL | | 0.8752 | 0.5158 |
| NEW_CARS_VOL does not Granger Cause USED_CARS_VOL | 252 | 2.1592 | 0.0477 |
| USED_CARS_VOL does not Granger Cause NEW_CARS_VOL | | 3.8416 | 0.0011 |

France

| Pairwise Granger Causality Tests | | | |
|--|-----|-------------|-------------|
| Lags: 6 | | | |
| Null Hypothesis: | Obs | F-Statistic | Probability |
| NEW_CARS_CPI does not Granger Cause USED_CARS_CPI | 119 | 0.5688 | 0.7543 |
| USED_CARS_CPI does not Granger Cause NEW_CARS_CPI | | 0.8581 | 0.5283 |
| USED_CARS_VOL does not Granger Cause USED_CARS_CPI | 84 | 1.5144 | 0.1859 |
| USED_CARS_CPI does not Granger Cause USED_CARS_VOL | | 1.7610 | 0.1196 |
| NEW_CARS_VOL does not Granger Cause USED_CARS_CPI | 120 | 0.7487 | 0.6117 |
| USED_CARS_CPI does not Granger Cause NEW_CARS_VOL | | 3.5091 | 0.0033 |
| USED_CARS_VOL does not Granger Cause NEW_CARS_CPI | 84 | 0.8961 | 0.5027 |
| NEW_CARS_CPI does not Granger Cause USED_CARS_VOL | | 0.4179 | 0.8648 |
| NEW_CARS_VOL does not Granger Cause NEW_CARS_CPI | 119 | 10.6495 | 0.0000 |
| NEW_CARS_CPI does not Granger Cause NEW_CARS_VOL | | 0.3673 | 0.8982 |
| NEW_CARS_VOL does not Granger Cause USED_CARS_VOL | 84 | 1.5057 | 0.1888 |
| USED_CARS_VOL does not Granger Cause NEW_CARS_VOL | | 0.7780 | 0.5899 |

UK

| Pairwise Granger Causality Tests | | | |
|--|-----|-------------|-------------|
| Lags: 6 | | | |
| Null Hypothesis: | Obs | F-Statistic | Probability |
| NEW_CARS_CPI does not Granger Cause USED_CARS_CPI | 120 | 3.2097 | 0.0062 |
| USED_CARS_CPI does not Granger Cause NEW_CARS_CPI | | 2.3908 | 0.0331 |
| USED_CARS_VOL does not Granger Cause USED_CARS_CPI | 120 | 1.6204 | 0.1485 |
| USED_CARS_CPI does not Granger Cause USED_CARS_VOL | | 1.7257 | 0.1219 |
| NEW_CARS_VOL does not Granger Cause USED_CARS_CPI | 120 | 0.7601 | 0.6028 |
| USED_CARS_CPI does not Granger Cause NEW_CARS_VOL | | 0.4233 | 0.8621 |
| USED_CARS_VOL does not Granger Cause NEW_CARS_CPI | 120 | 0.3855 | 0.8869 |
| NEW_CARS_CPI does not Granger Cause USED_CARS_VOL | | 2.5894 | 0.0221 |
| NEW_CARS_VOL does not Granger Cause NEW_CARS_CPI | 120 | 2.0814 | 0.0613 |
| NEW_CARS_CPI does not Granger Cause NEW_CARS_VOL | | 1.2774 | 0.2738 |
| NEW_CARS_VOL does not Granger Cause USED_CARS_VOL | 134 | 4.2343 | 0.0007 |
| USED_CARS_VOL does not Granger Cause NEW_CARS_VOL | | 1.7096 | 0.1244 |

US

Appendix 6: 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

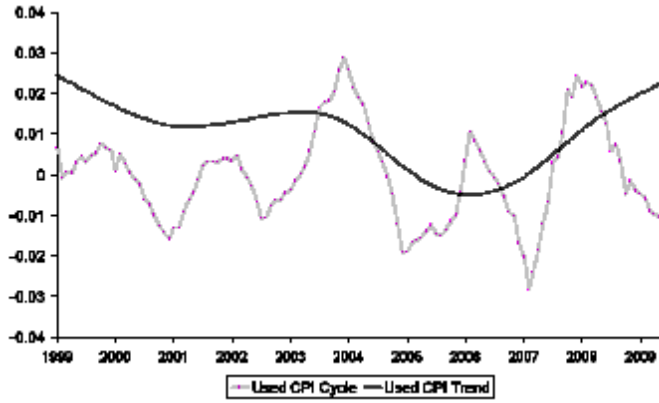
| | USED_CARS_CPI | NEW_CARS_CPI | USED_CARS_VOL | NEW_CARS_VOL |
|---------------|---------------|--------------|---------------|--------------|
| USED_CARS_CPI | 1.00 | 0.16 | 0.05 | 0.35 |
| NEW_CARS_CPI | 0.16 | 1.00 | -0.09 | 0.01 |
| USED_CARS_VOL | 0.05 | -0.09 | 1.00 | 0.16 |
| NEW_CARS_VOL |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

UK

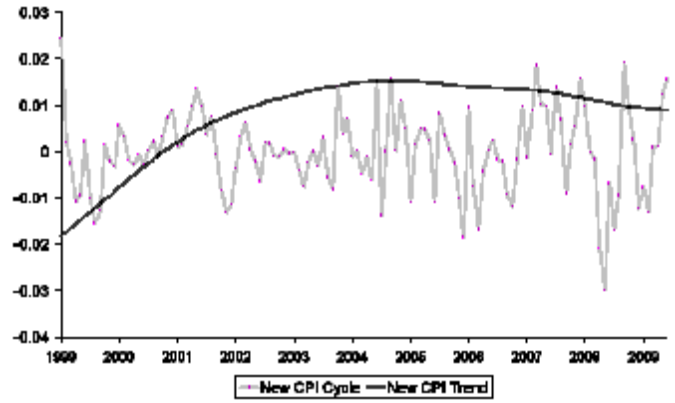
| | USED_CARS_CPI | NEW_CARS_CPI | USED_CARS_VOL | NEW_CARS_VOL |
|---------------|---------------|--------------|---------------|--------------|
| USED_CARS_CPI | 1.00 | 0.54 | -0.01 | -0.01 |
| NEW_CARS_CPI | 0.54 | 1.00 | 0.02 | 0.04 |
| USED_CARS_VOL | -0.01 | 0.02 | 1.00 | -0.28 |
| NEW_CARS_VOL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

US

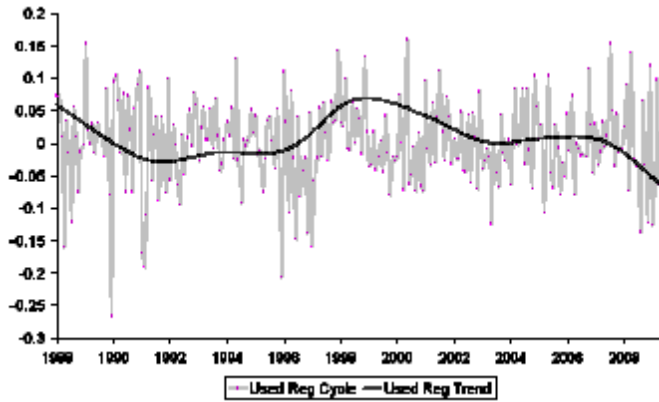
Appendix 7: Hodrick-Prescott Filter, cycles and trends



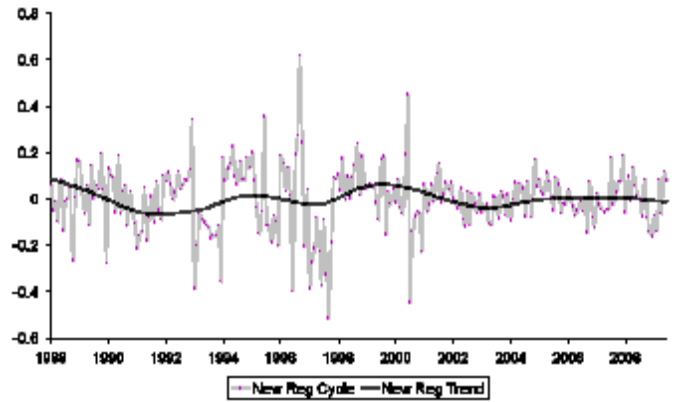
France



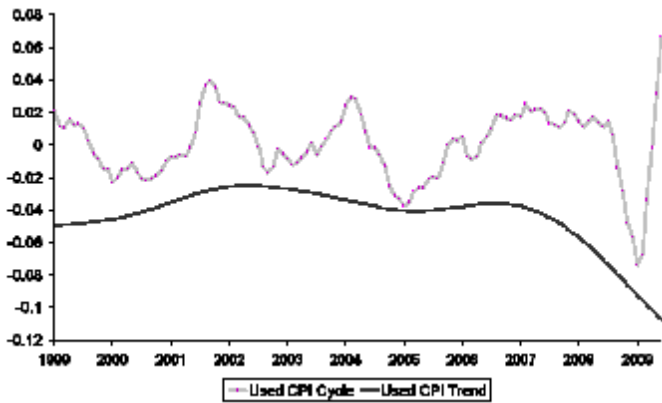
France



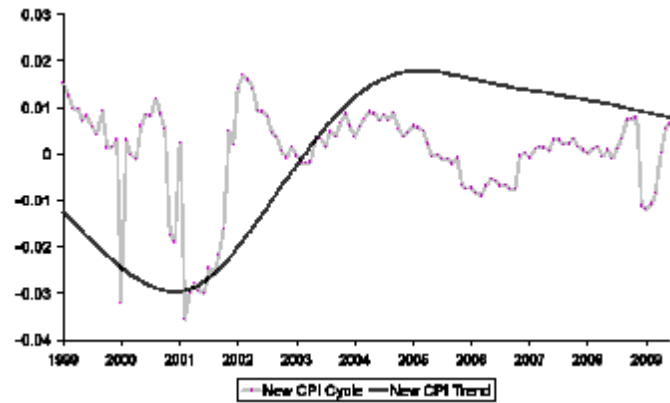
France



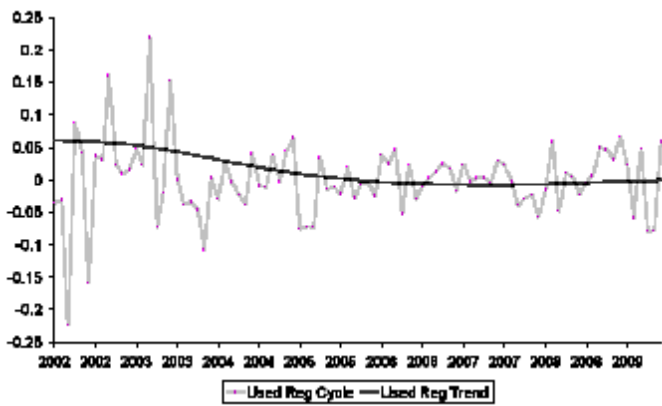
France



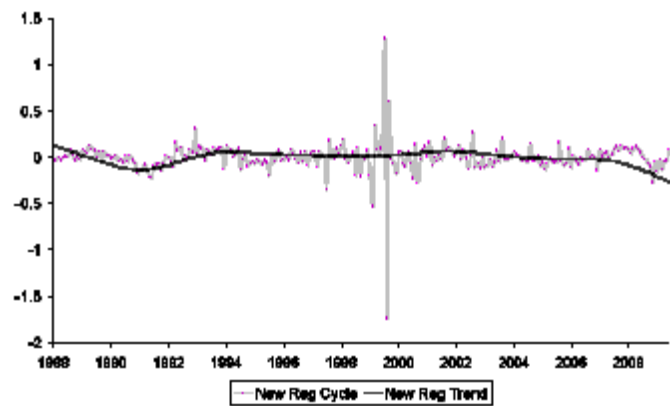
UK



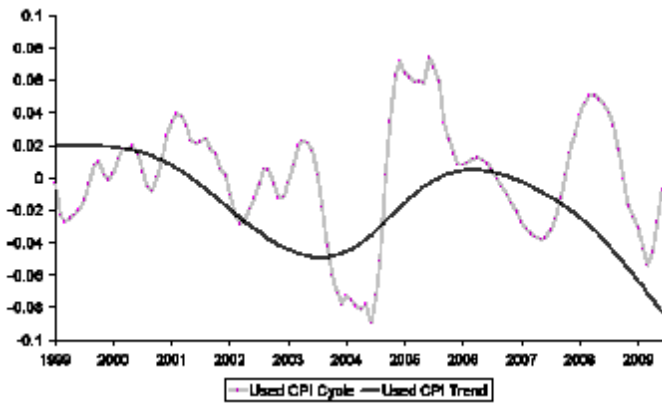
UK



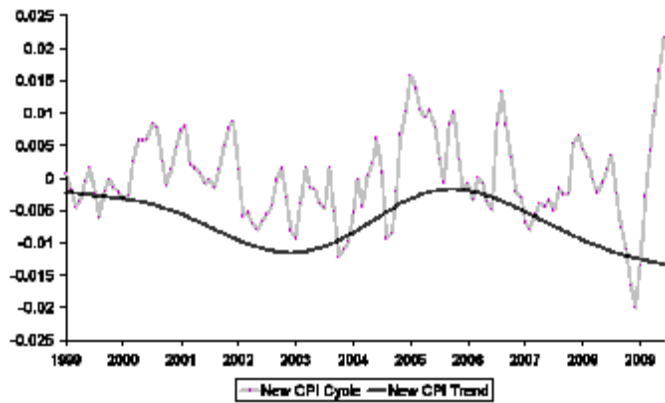
UK



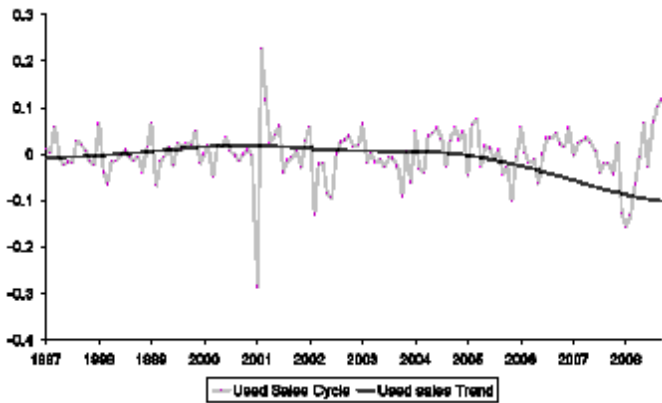
UK



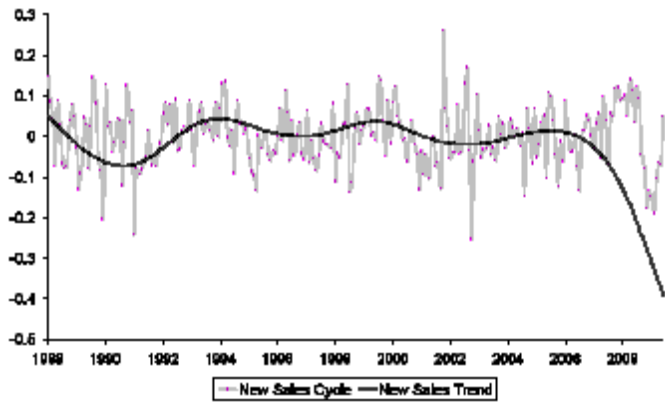
US



US



US



US

Appendix 8: Cycles Correlations

| | NEW_CARS_CPI | USED_CARS_VOL | NEW_CARS_VOL | USED_CARS_CPI |
|--------------------|--------------|---------------|--------------|---------------|
| NEW_CARS_CPI | 1.000 | 0.082 | 0.058 | 0.087 |
| USED_CARS_VOL | 0.082 | 1 | 0.421 | 0.14 |
| NEW_CARS_VOL | 0.058 | 0.421 | 1 | 0.179 |
| USED_CARS_CPI | 0.087 | 0.14 | 0.179 | 1 |
| USED_CARS_CPI(36) | 0.341 | 0.068 | 0.206 | -0.158 |
| USED_CARS_CPI(24) | -0.137 | -0.068 | -0.005 | -0.169 |
| USED_CARS_CPI(18) | -0.107 | -0.077 | -0.065 | -0.371 |
| USED_CARS_CPI(12) | -0.116 | -0.085 | -0.223 | -0.321 |
| USED_CARS_CPI(9) | 0.298 | -0.078 | -0.145 | -0.116 |
| USED_CARS_CPI(6) | 0.215 | 0.128 | -0.094 | 0.101 |
| USED_CARS_CPI(3) | 0.049 | 0.156 | 0.101 | 0.513 |
| USED_CARS_CPI(-3) | -0.119 | 0.101 | 0.018 | 0.513 |
| USED_CARS_CPI(-6) | -0.06 | 0.011 | -0.013 | 0.101 |
| USED_CARS_CPI(-9) | -0.012 | 0.066 | 0.04 | -0.116 |
| USED_CARS_CPI(-12) | 0.008 | -0.001 | 0.058 | -0.321 |
| USED_CARS_CPI(-18) | -0.019 | -0.181 | -0.107 | -0.371 |
| USED_CARS_CPI(-24) | -0.07 | -0.084 | 0.019 | -0.169 |
| USED_CARS_CPI(-36) | 0.217 | 0.077 | -0.065 | -0.158 |
| NEW_CARS_CPI(-6) | -0.068 | 0.116 | 0.195 | 0.215 |
| USED_CARS_VOL(-6) | 0.041 | 0.152 | 0.085 | 0.128 |
| NEW_CARS_VOL(-6) | -0.079 | -0.114 | 0.006 | -0.094 |
| NEW_CARS_CPI(-12) | -0.392 | -0.032 | 0.035 | -0.116 |
| USED_CARS_VOL(-12) | -0.038 | -0.155 | -0.012 | -0.085 |
| NEW_CARS_VOL(-12) | -0.015 | -0.16 | -0.447 | -0.223 |
| NEW_CARS_CPI(-24) | -0.171 | 0.021 | -0.235 | -0.137 |
| USED_CARS_VOL(-24) | -0.026 | -0.299 | -0.064 | -0.068 |
| NEW_CARS_VOL(-24) | 0.047 | -0.102 | 0.045 | -0.005 |
| NEW_CARS_CPI(-36) | -0.07 | -0.131 | 0.117 | 0.341 |
| USED_CARS_VOL(-36) | 0.047 | -0.258 | -0.18 | 0.068 |
| NEW_CARS_VOL(-36) | -0.072 | -0.067 | -0.205 | 0.206 |

Hodrick-Prescott Correlations France

| | NEW_CARS_CPI | USED_CARS_VOL | NEW_CARS_VOL | USED_CARS_CPI |
|--------------------|--------------|---------------|--------------|---------------|
| NEW_CARS_CPI | 1 | -0.192 | -0.042 | 0.085 |
| USED_CARS_VOL | -0.192 | 1 | 0.026 | -0.132 |
| NEW_CARS_VOL | -0.042 | 0.026 | 1 | 0.176 |
| USED_CARS_CPI | 0.085 | -0.132 | 0.176 | 1 |
| USED_CARS_CPI(36) | 0 | -0.05 | -0.018 | -0.158 |
| USED_CARS_CPI(24) | 0.1 | -0.209 | -0.005 | -0.169 |
| USED_CARS_CPI(18) | -0.043 | -0.032 | -0.047 | -0.371 |
| USED_CARS_CPI(12) | -0.283 | 0.192 | -0.059 | -0.321 |
| USED_CARS_CPI(9) | -0.389 | 0.117 | -0.053 | -0.116 |
| USED_CARS_CPI(6) | -0.447 | 0.052 | 0 | 0.101 |
| USED_CARS_CPI(3) | -0.315 | -0.143 | 0.13 | 0.513 |
| USED_CARS_CPI(-3) | 0.258 | 0.055 | 0.132 | 0.513 |
| USED_CARS_CPI(-6) | 0.339 | -0.036 | 0.081 | 0.101 |
| USED_CARS_CPI(-9) | 0.347 | 0.071 | -0.015 | -0.116 |
| USED_CARS_CPI(-12) | 0.333 | 0.134 | -0.131 | -0.321 |
| USED_CARS_CPI(-18) | 0.137 | 0.141 | -0.177 | -0.371 |
| USED_CARS_CPI(-24) | -0.208 | -0.067 | -0.139 | -0.169 |
| USED_CARS_CPI(-36) | 0.281 | -0.024 | -0.144 | -0.158 |
| NEW_CARS_CPI(-6) | 0.116 | 0.181 | -0.051 | -0.447 |
| USED_CARS_VOL(-6) | -0.058 | -0.007 | -0.037 | 0.052 |
| NEW_CARS_VOL(-6) | -0.156 | 0.069 | 0.152 | 0 |
| NEW_CARS_CPI(-12) | -0.333 | 0.146 | -0.18 | -0.283 |
| USED_CARS_VOL(-12) | 0.125 | -0.542 | 0.073 | 0.192 |
| NEW_CARS_VOL(-12) | 0.078 | 0.035 | -0.183 | -0.059 |
| NEW_CARS_CPI(-24) | -0.224 | -0.094 | 0.039 | 0.1 |
| USED_CARS_VOL(-24) | 0.123 | -0.161 | -0.179 | -0.209 |
| NEW_CARS_VOL(-24) | -0.016 | -0.132 | -0.16 | -0.005 |
| NEW_CARS_CPI(-36) | -0.066 | -0.083 | 0.15 | 0 |
| USED_CARS_VOL(-36) | -0.263 | 0.158 | -0.011 | -0.05 |
| NEW_CARS_VOL(-36) | 0.002 | 0.011 | -0.051 | -0.018 |

Hodrick-Prescott correlations UK

| | NEW_CARS_CPI | USED_CARS_VOL | NEW_CARS_VOL | USED_CARS_CPI |
|--------------------|--------------|---------------|--------------|---------------|
| NEW_CARS_CPI | 1 | 0.299 | 0.044 | 0.421 |
| USED_CARS_VOL | 0.299 | 1 | -0.048 | 0.055 |
| NEW_CARS_VOL | 0.044 | -0.048 | 1 | 0.136 |
| USED_CARS_CPI(36) | 0.097 | 0.139 | 0.196 | 0.19 |
| USED_CARS_CPI(24) | -0.134 | -0.164 | -0.171 | -0.087 |
| USED_CARS_CPI(18) | 0.016 | -0.02 | 0.025 | -0.22 |
| USED_CARS_CPI(12) | -0.105 | 0.023 | 0.096 | -0.522 |
| USED_CARS_CPI(9) | 0.146 | 0.054 | 0.068 | -0.213 |
| USED_CARS_CPI(6) | 0.369 | 0.123 | 0.047 | 0.201 |
| USED_CARS_CPI(3) | 0.445 | 0.048 | 0.12 | 0.69 |
| USED_CARS_CPI | 0.421 | 0.055 | 0.136 | 1 |
| USED_CARS_CPI(-3) | 0.206 | 0.024 | -0.027 | 0.69 |
| USED_CARS_CPI(-6) | -0.113 | -0.034 | -0.127 | 0.201 |
| USED_CARS_CPI(-9) | -0.176 | 0.034 | -0.238 | -0.213 |
| USED_CARS_CPI(-12) | -0.178 | 0.027 | -0.287 | -0.522 |
| USED_CARS_CPI(-18) | -0.051 | -0.082 | 0.06 | -0.22 |
| USED_CARS_CPI(-24) | -0.222 | -0.006 | 0.266 | -0.087 |
| USED_CARS_CPI(-36) | 0.067 | -0.15 | 0.104 | 0.19 |
| NEW_CARS_CPI(-6) | -0.122 | -0.09 | -0.033 | 0.369 |
| USED_CARS_VOL(-6) | -0.108 | -0.037 | 0.038 | 0.123 |
| NEW_CARS_VOL(-6) | -0.237 | -0.137 | 0.066 | 0.047 |
| NEW_CARS_CPI(-12) | -0.159 | 0.079 | -0.169 | -0.105 |
| USED_CARS_VOL(-12) | -0.137 | -0.289 | 0.052 | 0.023 |
| NEW_CARS_VOL(-12) | 0.144 | -0.05 | -0.407 | 0.096 |
| NEW_CARS_CPI(-24) | -0.472 | -0.117 | 0.27 | -0.134 |
| USED_CARS_VOL(-24) | -0.075 | -0.174 | 0.113 | -0.164 |
| NEW_CARS_VOL(-24) | -0.054 | 0.139 | -0.256 | -0.171 |
| NEW_CARS_CPI(-36) | -0.066 | -0.215 | 0.08 | 0.097 |
| USED_CARS_VOL(-36) | 0.098 | -0.24 | -0.061 | 0.139 |
| NEW_CARS_VOL(-36) | -0.105 | 0.035 | 0.245 | 0.196 |

Hodrick-Prescott correlation US

APPENDIX 9: Cointegration test

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)

Augmented Dickey-Fuller test statistic

Test critical values:

| | t-Statistic | Prob.* |
|---------------|-------------|--------|
| | -9.46 | 0.00 |
| 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 | |

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 0.0779 [18.9538] | 0.0239 0.2139 [0.11189] | 0.8313 1.6743 [0.49652] | -0.5555 2.5929 [-0.21425] |
| USED_CARS_CPI(-2) | -0.5125 0.0781 [-6.56302] | -0.1174 0.2145 [-0.54729] | -1.1977 1.6787 [-0.71347] | 0.5550 2.5997 [0.21350] |
| NEW_CARS_CPI(-1) | -0.0436 0.0328 [-1.32844] | 0.5419 0.0901 [6.01583] | -1.2443 0.7050 [-1.76494] | -1.8822 1.0919 [-1.72388] |
| NEW_CARS_CPI(-2) | 0.0543 0.0322 [1.68695] | 0.1146 0.0885 [1.29516] | 0.7396 0.6926 [1.06796] | 0.6650 1.0726 [0.61996] |
| USED_CARS_VOL(-1) | -0.0002 0.0049 [-0.04434] | -0.0231 0.0135 [-1.71260] | -0.0297 0.1055 [-0.28129] | 0.1378 0.1635 [0.84324] |
| USED_CARS_VOL(-2) | -0.0001 0.0051 [-0.02689] | -0.0112 0.0140 [-0.80195] | 0.0473 0.1098 [0.43093] | -0.1840 0.1700 [-1.08192] |
| NEW_CARS_VOL(-1) | -0.0030 0.0032 [-0.94334] | -0.0004 0.0088 [-0.04168] | 0.0370 0.0685 [0.53933] | 0.0512 0.1061 [0.48245] |
| NEW_CARS_VOL(-2) | 0.0033 0.0032 [1.02733] | -0.0074 0.0088 [-0.84026] | 0.0361 0.0688 [0.52384] | 0.1151 0.1066 [1.08021] |
| C | 0.0003 0.0005 [0.61639] | 0.0044 0.0013 [3.48989] | 0.0165 0.0098 [1.68583] | 0.0132 0.0152 [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

| Sample (adjusted): 2002M03 2009M06 | | | | |
|--|---------------|----------------|---------------|--------------|
| Included observations: 88 after adjustments | | | | |
| Standard errors in () & t-statistics in [] | 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

| Sample (adjusted): 1999M03 2009M06 | | | | |
|--|---------------|----------------|-----------------|----------------|
| Included observations: 124 after adjustments | | | | |
| 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 9: 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.

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