Market power, multimarket contact and pricing: some evidence from the US automobile market*

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Abstract

Multiple competition, or multimarket contact rivalry, has become very important in the contemporary competitive strategy literature. Multimarket contact is perceived to be one of those factors, which can facilitate and sustain implicit collusion. This multimarket contact effect has got relatively little attention in the previous literature, although the theoretical and empirical discussion has somehow revived in the 1990s. The present paper attempts to develop new approaches to study the interdependence of firm behaviour across markets, especially in the context of differentiated products industries. In particular, the paper looks whether the multimarket contact facilitates collusive (cooperative) arrangements, or reduces firm competition intensity. The paper asks how to conduct a test of the mutual forbearance hypothesis in principle, and how to apply it using particular data. The effect of cross-ownership on the firm competitive interactions is also investigated. The multimarket contact effects are studied within a structural oligopoly model for differentiated products for the US automobile market on the basis of the aggregate product-level data for 2001-2003. Different hypothesis on the firms' equilibrium interactions, including the hypothesis of collusive behaviour due to multimarket contact are tested in this paper. Non-nested procedures and goodness-of-fit criteria are then applied to choose between different models of the firm behaviour. Preliminary results suggest some support that multimarket contact influences competition in the automobile market and increases the firms' strategic interdependence. This effect is, however, difficult to disentangle from the effect of the market concentration and the specific structure of the US automobile market on the firm behaviour. The model specification of multiproduct firm behaviour for automotive manufacturer

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groups has not been found among the most preferred supply-side model specifications.

1 Introduction

Multimarket contact (alternatively, multimarket/multiple competition, multipoint rivalry) can be observed in a number of situations: a firm can produce multiple products, or a single-product firm can operate in a number of geographical markets, a conglomerate may be represented along several business lines. It is perceived to be one of those factors, which can facilitate and sustain implicit collusion, or facilitate oligopolistic consensus among firms engaged in noncooperative rivalry. From the theoretical point of view, there have been opposing opinions on the impact of the multimarket contact on collusion. On the one hand, there is a mutual forbearance hypothesis by Edwards (1955), defined as the situation when the multimarket contact leads to more cooperation in all the markets that are common to the rivals (i.e., strong interdependence across the markets). Besides, there is a view similar to the mutual forbearance hypothesis, "linked oligopoly theory", developed for the banking industry by Solomon (1970). According to this theory, the degree of linkage across the markets, or the presence of a firm in the multiple markets, is one of the important determinants of performance in the oligopolistic environment. Oligopolistic coordination can be strengthened as a result of the multimarket contact.

On the contrary to Edwards (1955) and Solomon (1970), according to the more traditional point of view, coordination is due to market concentration (internal factor, structure of the market, supply side), and not due to multimarket contact (external factor, firm behaviour) (Scherer and Ross, 1990). The increased concentration in the market creates barriers to entry and expands the possibilities for the interfirm coordination, thus, lowering the rates of entry and exit from the market. According to the strongest form of this approach, the multimarket firms behave like independent firms in each market, where competition is determined only by those market factors.

In general, this aspect of multiple competition, namely the relationship between the multimarket contact and firm behaviour, in particular, reduction in the firm competition intensity, or the facilitation of the mutual forbearance[1], has got relatively little attention in the previous literature, although the theoretical and empirical discussion has somehow revived in the 1990s.

The more recent theoretical literature on the mutual forbearance hypothesis is represented by the contributions by Bernheim and Whinston (1990), Verboven (1998), Spagnolo (1999), and Matsushima (2001). Bernheim and Whinston (1990) state that the multimarket contact may lessen the degree of the competition between the rivals, as the multiple competitors are more likely to recognize their mutual dependence, and to sustain collusion across the range of markets, in

[1] The terms 'mutual forbearance hypothesis', 'multimarket contact hypothesis', 'linked oligopoly theory' are synonyms in this paper as they are used by different authors to explain the same phenomenon.

which they meet. The firms can distribute their market power through pooling the incentive constraints across the markets (the so-called strategic effects): they can decrease prices and give up profits in the more collusive markets in order to facilitate collusion, raise prices and increase profits in the more competitive markets, as long as their total profits are maximized. Verboven (1998) looks at the relationship between localized competition, multimarket operation and collusive behaviour. In case of localized competition, firms meet with different sets of rivals. As a result, there are problems of private information concerning the past actions of the firms. Strategies with sufficiently lenient punishments should be adopted by firms because of the resulting communication problems. Spagnolo (1999) gives the more general conditions for the effect of the multimarket contact on collusion, and argues that multimarket contact always leads to collusion, independently from asymmetries between markets and firms, when a firm's static objective function is strictly concave, which makes the market supergames to be interdependent: a firm's payoff in each market is dependent upon how it is doing in the other markets. Matsushima (2001) investigates the issue of the multimarket contact under imperfect monitoring, and finds support for the existence of the multimarket contact effect on collusion as well[2].

There have been several experimental studies on the effects of the multimarket contact on collusion. For example, Phillips and Mason (1992) find the experimental support for the game-theoretic predictions by Bernheim and Whinston (1990). In another study, Phillips and Mason (1996) state that due to the multimarket contact, some regulatory action in one market will impact the other market.

The existing empirical studies (e.g., Heggestand and Rhoades, 1978, Scott, 1982, Evans and Kessides, 1994, Parker and Röller, 1997), which are mostly done for airlines and banking industry, have failed to give conclusive evidence about the existence, sign and significance of the multimarket contact effect on collusion. These are mainly the cross-sectional studies. They concentrate on testing the multimarket contact effect, based on the construction of some multimarket contact measure, on the firm's performance (i.e., the so-called reduced-form approach), while there have been virtually no studies done on the multimarket contact effect on collusion within a structural model of firm behaviour (the only exceptions are the papers by Jans and Rosenbaum (1996) and Parker and Röller (1997) for the homogenous products). The existing empirical studies have a major problem to distinguish between internal (e.g., concentration, demand conditions, barriers to entry) and external effects (e.g., multimarket contact) upon the firm performance (Bernheim and Whinston, 1990). Furthermore, the multimarket contact measure may be inappropriate for testing the multimarket contact effects on collusion in case of heterogenous products. The literature on the strategic effects of the multimarket contact is even more scarce and contradictory (Scott, 1982, Jans and Rosenbaum, 1996, Fernandez and Marin, 1998),

[2] Recently there has been some emerging theoretical literature stating that multimarket contact may not facilitate collusion (e.g., Thomas and Willig, 2006). This may be attributed to the imperfect monitoring of adherence to cooperation, which is observed in the situation of asymmetric information about rivals' actions.

offering completely different evidence on the redistribution of the market power due to the multimarket contact[3].

The major objective of this paper is to quantify the existence and significance of the effect of the multimarket contact on the tacit collusion, through developing a new methodology, or approaches. The given paper addresses two major issues: how to conduct the test of the mutual forberance hypothesis in principle (to solve the problem of the previous inconclusive empirical evidence and address the weaknesses of the previous empirical studies), and how to implement a test using particular data.

Competition policy has exhibited growing interest in empirical oligopoly models to quantify the competitive effects of mergers, study market conduct, estimate the welfare effects of the introduction of new products, or of deregulation, etc. In this paper, the multimarket contact effects on collusion are tested on the basis of the structural oligopoly model for differentiated products and estimated on the basis of the market-level data on prices, quantities, and product characteristics. The differentiated products demand is derived from the discrete choice framework. With a complete specification of the demand and cost conditions, the hypothesis of the mutual forbearance and of the traditional view of no interdependence of the firm behaviour across the markets can be tested directly. Different hypothesis on the firms' equilibrium interactions, including the hypothesis of collusive behaviour due to multimarket contact are tested in this paper through imposing specific assumptions on the firms' equilibrium interactions. Given the absence of the publicly available information on price-cost margins or marginal costs, it is important to look at the results of several tests or goodness-of-fit criteria to choose the most preferred specification for the supply side. Non-nested procedures (MacKinnon, Davidson, and White, 1983) are in particular applied to choose between different models of the firm behaviour.

The multimarket contact effects on oligopolistic coordination are tested for the automotive industry, on the basis of the product-level data for the US light vehicles market for 2001-2003. The automotive industry appears to be an interesting case for studying the above mentioned effects both across the product and geographical markets dimension. The industry has undergone a significant consolidation process, which resulted in about 14 major independent OEMs, which are present in virtually all market segments. The automotive industry has become a subject of empirical studies at the product level starting with Bresnahan (1987), and later a number of studies appearing after Berry (1994) and Berry, Levinsohn and Pakes (1995) papers, relying on the advances in the discrete choice literature. Some automotive industry papers study the equilibrium firm interactions (e.g., Bresnahan, 1981, 1987, Feenstra and Levinsohn, 1995, Verboven, 1996, 1999, Sudhir, 2001, Goldberg and Verboven, 2001, Brenkers and Verboven, 2004), but only a few of them study (directly, or indirectly) col-

[3]Fernandez and Marin (1998) find lower prices in the markets where it is easier to collude, and higher prices in the markets where it is more difficult to reach collusive agreements. Scott (1982) and Jans and Rosenbaum (1996) find a more pronounced effect of multimarket contact on collusion in the more concentrated markets, and higher impact of concentration on collusion in the markets characterized by the more extensive multimarket contact.

lusive behaviour (e.g., Bresnahan, 1981, 1987[4], Verboven, 1996, Sudhir, 2001, Goldberg and Verboven, 2001)[5]. In the automotive industry studies, which are based upon the estimation of the structural oligopoly model, Bertrand-Nash equilibrium is usually assumed, which may be not quite correct as the repeated interaction between the automotive firms may destroy the Bertrand outcome. In some studies, Cournot equilibrium, or some "mixed" equilibrium is tested (e.g., Feenstra and Levinsohn, 1995).

The literature on the firm behaviour in different automotive market segments is scarce, the only exception is the paper by Sudhir (1991)[6]. The author studies the competitive pricing behaviour in the US automobile market and competition interactions in each segment of the market using the conjectural variations approach (this is different to the other papers, which estimate the average competitive interactions across all automobile market segments). Cooperative or aggressive behaviour is measured based on the degree of deviation from the Bertrand prices. The author finds the following firm behaviour patterns: aggressive behaviour in the minicompact and subcompact segments (target young or first-time customers), cooperative behaviour in the compact and mid-size segments, which is consistent with prior expectations, and Bertrand behaviour in the full-size segment. The greater concentration in the larger-car segments leads to more cooperation in these segments. The smaller-car segments are characterized by greater uncertainty in consumer demand. The customers are more loyal and less price-sensitive in the segments targeted to older or repeat customers, where the gains from the new customers could be more than offset by the profit margins losses from the existing customer base. The presence of the Bertrand price competition for the full-size segment is contrary to the prior expectations of cooperative behaviour. The author attributes this effect to the high volatility in this segment, which prevents from cooperation. This volatility is addressed to the declining market share of this segment, so that to preserve the market shares, the firms price aggressively, and the firm behaviour is close to the Bertrand short-run equilibrium. More empirical evidence on this issue and, in particular, more studies on the firm behaviour across different market segments could be necessary. As it is mentioned by Bernheim and Whinston (1990), in the case of heterogenous products, there will be different degrees of collusion in different markets based on the demand and cost conditions due to the multimarket contact.

Automobile firms do not only meet in multiple markets (both product and geographical). The global automobile market is characterized by a great degree of cross-ownership (as it has been mentioned at present there are about 14

[4]Bresnahan (1981) studies the firm behaviour in the American car market in 1977 and 1978 and estimates the price-cost margins for this period of time, as well looks at the impact of import competition on the margins. Bresnahan (1987) investigates a supply-side shock in the American automobile market in 1995 and attributes this shock to the price war, while in the neighbouring years the firm behaviour could be characterized as collusive.

[5]Verboven (1996) and Goldberg and Verboven (2001) study the European car market.

[6]Brenkers and Verboven (2006) estimate correlation parameters (two-level nested logit) across the market segments for the European car market and make some inferences about the competition pattern in each market segment.

independent manufacturers) and different interfirm relationships. A number of empirical studies, which do not take into account the effects of partial ownership arrangements (POAs), finds some evidence that the degree of collusion is very similar in both Japanese, where POAs are common, and American car markets (e.g., Odagiri and Yamawaki, 1986, Yamawaki, 1989). Some automobile market studies look at the impact of the POAs on market competition. In particular, Alley (1997) finds on the basis of a conjectural variation model, which takes into account POAs and foreign trade, that the degree of collusion due to the POAs in the American car market is even higher than that in the Japanese car market.

The automobile industry is characterized by extensive multimarket contact both within geographical and product market context, where different firms may have different "spheres of influence". In this paper the multimarket contact is defined on a product segment level in the light vehicles market within one geographical market, namely the US market. As it has been mentioned, the automobile industry is characterized not only by extensive multimarket contact but also by high degree of cross-ownership and different firm interrelationships. That is why, the attempt is also being made to differentiate the impact of these two factors on the firm behaviour. Testing the impact of the multimarket contact on the firm behaviour in the automobile market is complicated by the high concentration ratios and presence of the automotive manufacturers in almost all market segments, which necessitates looking for the variation in the multimarket contact and makes the construction of the multimarket contact measure to evaluate multimarket contacts effects rather inappropriate. The fact that to support collusion due to multimarket contact it is not enough only to be present in several markets, but it is important to have "spheres of influence" in individual markets (these are usually determined by market shares), is used for this purpose. Not only the diversification aspect matters but also the ability of the firms to use it in the creation of the transferrable slack should be taken into account. It is unlikely that the firms with a small market share will be able to generate the necesary slack to transfer to the other markets.

Preliminary results suggest some support that multimarket contact influences competition in the automobile market and increases the firms' strategic interdependence, although this effect is rather difficult to disentangle from the concentration effect on the firm behaviour. The model specification of multiproduct firm behaviour for automotive manufacturer groups has not been found among the most preferred supply-side specifications.

The given paper is organized in the following way. After an overview of the recent US automotive industry developments with a particular emphasis on the market segmentation and multimarket contact, I move to the description of the empirical oligopoly model, test methodology, and estimation procedure. The paper concludes with the presentation and discussion of the results.

2 Multi-market linkages in the US automobile market

As it has been mentioned above, the automobile market offers a nice possibility to study the multimarket contact effects on mutual forbearance across product lines and across geographical dimensions (i.e., the so-called geographic-product markets). The industry consolidation has resulted in a few major independent producers (see Table 1, Appendix C), which operate across a number of geographical markets (US, Western Europe, Japan, etc.). On the other hand, the development of the light trucks market has increased a number of product markets, in which the automotive firms interact.

The development of the light vehicles market is, in particular, a peculiar feature of the US automotive industry. At present, the light trucks sales make up about half of the total vehicles market sales in the US, increasing from about 32% in 1990. The mid-size segment share has significantly declined; in particular, it decreased from 27% in 2000 to 20% in 2003 of the total market sales, which may be to a certain degree attributed to the increased competition from the sports-utility vehicles (SUVs). During 2000-2003 there has been an especially vivid trend in the growth of luxury and SUVs market shares, and the market segments developments have been rather volatile recently (See Table 2, Appendix C). The SUVs market was the only growing market during 2000-2003, with the total light trucks showing positive growth rates. The shares of the mid-range, traditional, pickup, and van segments declined, while the share of the SUVs sales increased, and the shares of the small, upscale, and sporty market segments remained stable during 1999-2003.

The picture of the multimarket contact presence in the automobile market can be, to a certain degree, inferred from Table 3, Appendix C. As it can be seen, the car manufacturer groups are present in almost all market segments. The product lines of the automotive manufacturers have become rather similar and their product markets, therefore, overlap. The US traditional car market segment is especially concentrated and is characterized by the high presence of the US automotive producers, only Toyota having a 13.2% market share.

The "spheres of influence" in the automobile market can be found due to the difference in the production costs between the firms, or due to the presence of the economies of scale, ”home” brand loyalty, etc. Table 4, Appendix C gives an overview of the ”most important” and ”less important” markets for the automobile manufaturers. For example, for Honda the midrange market is the most important market, while BMW gets most of its profits from selling cars in the upscale market, and for both firms the SUV market is important. Ford has the highest market shares in the pickup and SUVs market segments and has been known for its competitive advantage in the SUV market. For GM the SUVs and midrange are the most important market segments. Chrysler has high market shares in the pickup and SUVs market segments and is known to have a competitive advantage in the van segment, where it has the highest share among all the firms. The presence of the "spheres of influence" can result in the respect by a firm of the "spheres of influence" of its rivals, when it expects that the rivals will also, in return, respect its own "spheres of influence"[7].

The industry is characterized not only by the high degree of multimarket contact but also a high degree of cross-ownership and various forms of firm co-operation (strategic alliances), which build up a very complex picture of inter-relationships and ownership structure in the global automotive industry, which certainly influence firm behaviour. There has been an increasing number of mergers-acquisitions and alliances between the three automotive poles (Europe, US and Japan). Table 5 in Appendix C gives an example of a product policy for VW. VW Group itself included VW, Skoda, Bentley, Bugatti, while Audi Group includes Audi, Seat, and Lamborghini. This illustrates the complex picture of multimarket contact presence and ownership structure in the automotive industry.

3 Empirical structural framework for the US automobile market

3.1 Demand

3.1.1 Utility (McFadden's (1978) utility specification)

Assume that consumer i, $i = 1, ..., n$ has utility $u_{ij} = u\left(x_j, \xi_j, p_j; \theta\right)$ from consuming product j, $j = 1, ..., J$, where $j = 0$ is an outside good, x_j and ξ_j are observed (e.g., horsepower, engine size) and unobserved (e.g., style, image) product characteristics, p_j is the price of product j, and $\theta = (\alpha, \beta)$ are the parameters to be estimated.

The linear version of the random indirect utility is given by:

$$u_{ij} = \delta_j + \epsilon_{ij}, i = 1, ..., n, j = 0, ..., J \tag{1}$$

where ϵ_{ij} is assumed to be identically and independently distributed across consumers and products.

The mean valuation for product j common to all consumers is:

$$\delta_j \equiv x_j\beta - \alpha p_j + \xi_j \tag{2}$$

It is assumed that a consumer purchases one unit of good that brings him the highest utility. Therefore, consumer i purchases one unit of product j if and only if

$$u_{ij} > u_{ik}, 0 \leq k \leq J, k \neq j \tag{3}$$

[7] Jayachandran et al (1999): "When the product lines of two firms evolve to become more similar and their product markets overlap, the greater MMC reduces the intensity of competition between firms in a specific market. Furthermore, if different firms dominate different product markets (segments), these markets (segments) may serve the function of the spheres of influence, thereby providing added motivation for the firms to reduce the intensity of competition".

Consequently, the probability s_{ij} that the consumer i purchases the product j is:

$$\begin{aligned} s_{ij} &= \Pr\left\{\delta_j + \epsilon_{ij} > \delta_k + \epsilon_{ik}, j \neq k\right\} = \\ &= \Pr\left\{\epsilon_{ik} < \epsilon_{ij} + \delta_j - \delta_k, j \neq k\right\} = \\ & \int_{-\infty}^{\infty} F_j\left(\epsilon_{ij} + \delta_j - \delta_0, ..., \epsilon_{ij}, ..., \epsilon_{ij} + \delta_j - \delta_J\right) \end{aligned} \quad (4)$$

where F_j are the partial derivatives of the joint cumulative distribution function F of $(\epsilon_{i0}, ..., \epsilon_{iJ})$ with respect to its jth argument.

Different specifications of the discrete choice models for the demand side are to be applied to find the model, which best describes the data, and at the same time offers flexible substitution patterns: nested multinominal logit with one and two nests, principles of differentiation generalized extreme value (PD GEV) and random coefficients models. In the present version of the paper, I am going to present the empirical framework and tests for the mutual forbearance hypothesis on the basis of the one-level nested multinominal logit, as the simplest reasonable way to start with.

3.1.2 Nested multinominal logit: one nest

Utility u_{ij} of household i for product j in group g is given by[8]:

$$u_{ij} = x_j\beta - \alpha p_j + \xi_j + \zeta_{ig} + (1-\delta)\,\epsilon_{ij}, j = 1, ..., I_g$$

where $\zeta_{ig} + (1-\sigma)\,\epsilon_{ij}$ is an extreme value random variable.

The I brands (products) are partitioned into G groups: $g = 0, 1, ..., G$, the outside group is group 0[9]. Let the set (number) of products in a group g be $I_g : I_0, ..., I_G$.

The market share of product j in the group g is given by:

$$\bar{s}_{j/g}(\delta, \sigma) = \left(\frac{e^{\delta_j/(1-\sigma)}}{D_g}\right) \quad (5)$$

where $D_g = \sum_{j \in I_g} e^{\delta_j/(1-\sigma)}$, $0 \leq \sigma < 1$.

The probability of choosing a group g among all groups is given by:

$$\bar{s}_g(\delta, \sigma) = \frac{D_g^{1-\sigma}}{\left[\sum_g D_g^{1-\sigma}\right]} \quad (6)$$

This gives a market share for product j that belongs to group g:

[8] In the exposition below, I follow Berry (1994).

[9] "Outside good" does not compete with other goods in the industry, its price or quantity is set exogenously. If there were not for the outside good, everyone would have been forced to purchase an "inside" good (Pakes lectures).

$$s_j(\delta,\sigma) = \bar{s}_{j/g}(\delta,\sigma)\,\bar{s}_g(\delta,\sigma) = \frac{e^{\delta_j/(1-\sigma)}}{D_g}\frac{D_g^{1-\sigma}}{\sum\limits_g D_g^{1-\sigma}} = \frac{e^{\delta_j/(1-\sigma)}}{D_g^{\sigma}\sum\limits_g D_g^{1-\sigma}} \tag{7}$$

where $\sigma \in [0,1]$ is a measure of the degree of substitution, or the within-group correlation of the utility levels. The lower σ means the lower correlation of preferences. $\sigma = 0$ implies no correlation of preferences, and consumers, thus, may switch to the products in another group, which means the standard logit model (Ivaldi and Verboven, 2002). $\sigma = 1$ implies perfect correlation of preferences for products within the same group, i.e., perfect substitutes. E.g., if a new compact car is introduced, the demand for the other subcompact cars will go down rather than the demand for the cars in the other segments.

The group 0 has only one outside good, with $\delta_0 \equiv 0$ (i.e., the utility from consuming the outside good is normalized to zero) and $D_0 = 1$ and with the market share of:

$$s_0(\delta,\sigma) = \frac{1}{\left[\sum\limits_g D_g^{1-\sigma}\right]} \tag{8}$$

Consequently, the following demand equation may be derived by inverting the market share equation:

$$\ln(s_j) = \ln(s_0) + x_j\beta - \alpha p_j + \sigma \ln\left(s_{j/g}\right) + \xi_j \tag{9}$$

where $\bar{s}_{j/g}$ is the share of product j in group g (within-group share), s_j is the share of product j in the total market, and s_0 is the proportion of the consumers who choose the outside good.

The own price elasticity E_{s_j/p_j} of the market share s_j of product j is:

$$E_{s_j/p_j} = \frac{\partial s_j}{\partial p_j}\frac{p_j}{s_j} \tag{10}$$

with

$$\frac{\partial s_j}{\partial p_j} = \frac{\partial s_j}{\partial \delta_j}\frac{\partial \delta_j}{\partial p_j} \tag{11}$$

$$\frac{\partial s_j}{\partial \delta_j} = s_j\frac{1}{1-\sigma}\left[1 - \sigma s_{j/g} - (1-\sigma)\,s_j\right] \tag{12}$$

Thus, the own-price elasticity can be written as:

$$E_{s_j/p_j} = -\alpha p_j\frac{1}{1-\sigma}\left[1 - \sigma s_{j/g} - (1-\sigma)\,s_j\right] \tag{13}$$

The cross-price elasticity E_{s_j/p_m} of the market share of product j with respect to the price of product m p_m is given by:

$$E_{s_j/p_m} = \frac{\partial s_j}{\partial p_m}\frac{p_m}{s_j} \tag{14}$$

with

$$\frac{\partial s_j}{\partial p_m} = \frac{\partial s_j}{\partial \delta_m}\frac{\partial \delta_m}{\partial p_m} \tag{15}$$

$$\frac{\partial s_j}{\partial \delta_m} = -s_j\left(\frac{\sigma}{1-\sigma}s_{m/g} + s_m\right) \tag{16}$$

Therefore, the cross-price elasticity is:

$$E_{s_j/p_m} = \alpha p_m\left(\frac{\sigma}{1-\sigma}s_{m/g} + s_m\right) \tag{17}$$

if j and m belong to the same market segment, and

$$E_{s_j/p_k} = \alpha p_k s_k \tag{18}$$

if j and k belong to different market segments.

3.2 Costs and firm behaviour

The log-linear marginal cost function is assumed:

$$\ln(c_j) = w_j\gamma + \omega_j + (\lambda \ln Q_j) \tag{19}$$

where w_j and ω_j are observed and unobserved product characteristics, respectively, Q_j are the total sales of product j, and γ and λ are the parameters to be estimated. The last term is included to allow for increasing/decreasing returns to scale.

Assume F sellers of a differentiated product[10].

Firm f produces J_f of F total differentiated products. The demand for product j is given by $q_j\left(p, X; \theta\right) = Ms_j\left(p, X; \theta\right)$, where M is the market size.

Let P_{J_f} be the set of prices that the player f sets. Product characteristics for any year are assumed to be exogenous.

Assume that the outside good is competitively supplied.

The firm f chooses P_{J_f} to maximize its profits, for given J and p_j with $j \in J_f$:

$$\max_{p_{J_f}} \pi_f = \sum_{j\in J_f}\left(p_j - c_j\right)Ms_j\left(p\right) - \sum_{j\in J_f} F_j \tag{20}$$

where c_j is the constant marginal cost of brand j, $s_j\left(p\right)$ is the market share of brand j, being a function of all brands' prices, and F_j is fixed cost.

[10] In the exposition below, I follow Berry, Levinsohn and Pakes (1995).

The first-order conditions for the manufacturer f's profit maximization problem are (assuming that a pure-strategy Nash equilibrium in prices exists and that prices are strictly positive):

$$s_j(p) + \sum_{r \in J_f} (p_r - c_r) \frac{\partial s_r(p)}{\partial p_j} = 0 \tag{21}$$

Let firm f have $k(f)$ products, which are indexed by $j = J_1^f, ..., J_{k(f)}^f$, with $J_1^1 = 1$ and $J_{k(F)}^F = J$.

Define matrix Ω_f as:

$$\Omega_f = \begin{pmatrix} \frac{\partial s\left(J_1^f\right)}{\partial p\left(J_1^f\right)} & ... & \frac{\partial s\left(J_{k(f)}^f\right)}{\partial p\left(J_1^f\right)} \\ ... & ... & ... \\ \frac{\partial s\left(J_1^f\right)}{\partial p\left(J_{k(f)}^f\right)} & ... & \frac{\partial s\left(J_{k(f)}^f\right)}{\partial p\left(J_{k(f)}^f\right)} \end{pmatrix} \tag{22}$$

In vector notation, the first-order conditions for J total products simultaneously can be written down as:

$$\underbrace{\begin{pmatrix} s_1 \\ ... \\ s_J \end{pmatrix}}_{\mathbf{s}} + \underbrace{\begin{pmatrix} \triangle^1 & & 0 \\ & ... & \\ 0 & & \triangle^F \end{pmatrix}}_{\mathbf{\Omega}} \underbrace{\begin{pmatrix} p_1 - c_1 \\ ... \\ p_j - c_j \end{pmatrix}}_{\mathbf{p-c}} = 0 \tag{23}$$

Assume that $\mathbf{\Omega}$ is a non-singular matrix. Therefore, the first-order conditions can be expressed as:

$$p = c + \Omega^{-1} s \tag{24}$$

with the marginal cost equation taking up the following form:

$$\ln(p - \Omega^{-1} s) = w\gamma + \omega + (\gamma \ln Q) \tag{25}$$

Within the last equation, the following scenarios can be tested: Bertrand behaviour with single-product firms, Bertrand behaviour with multi-product firms, perfectly collusive behaviour, and assumptions concerning multimarket contact firm behaviour. This can be done within the menu or conjectural variations parameters approaches.

The menu approach is discussed in Bresnahan (1987), Gasmi et al. (1990, 1992) and advocated, in particular, by Nevo (1998). Under this approach, different models of competition may be tested through setting different elements of the ownership matrix to one. The choice among the different models of conduct, which constitute a finite set (defined by a researcher based on his understanding), is done on the basis of "fit" of different models, formally by performing a test of nonnested hypothesis (e.g., Vuong, 1979).

Consequently, the matrix Ω^{-1} may be written as $\theta * \triangle^{-1}$, where $\triangle^{-1}$ is the matrix of own- and cross-price elasticities, and θ is an ownership matrix, with

$\theta_{ij} = 1$ if i and j are produced by the same firm, and 0 otherwise. This is an element-by-element multiplication of matrices of the same dimension.

The conjectural variations approach has been criticized for the problem of the interpretation of the conjectural variations parameters and the problem of identification[11]. The conjectural variations approach may allow to test the degree of collusiveness, or competitiveness of a particular market segment, or industry, or distinguishing between the more collusive and more competitive markets, not necessarily finding perfect market segment collusion as based on the menu approach.

3.3 Specification of the price equation and full system

Substituting the expressions for own- and cross-price elasticities into equation (25), it is possible to derive the explicit expressions for the pricing equations under different assumptions: single-product, multi-product and collusion, which is done below. This helps to avoid the computationally burdensome simulations as the error term ω enters the pricing equation non-linearly. These transformations were suggested by Berry (1994).

3.3.1 Single-product firm assumption

The first-order conditions under single-product assumption are:

$$p_j = c_j + \frac{s_j}{|\partial s_j / \partial p_j|} \tag{26}$$

where
$\frac{\partial s_j}{\partial p_j} = -\alpha \frac{1}{1-\sigma} s_j \left[1 - \sigma s_{j/g} - (1-\sigma) s_j\right]$

Assuming constant returns to scale, the following pricing equation is obtained:

$$p_j = w_j \gamma + \omega_j + \frac{1-\sigma}{\alpha \left[1 - \sigma s_{j/g} - (1-\sigma) s_j\right]} \tag{27}$$

Thus, for the nested logit model under single-product firm assumption, the following system of equations (9) and (27) is to be estimated:

$$\ln(s_j) = \ln(s_0) + x_j \beta - \alpha p_j + \sigma \ln\left(s_{j/g}\right) + \xi_j$$

$$p_j = w_j \gamma + \omega_j + \frac{1-\sigma}{\alpha \left[1 - \sigma s_{j/g} - (1-\sigma) s_j\right]}$$

where $\bar{s}_{j/g}$ is the share of product j in group g, s_j is the share of product j in the total market.

The product characteristics x_j and ω_j comprise the same variables.

[11] Conjectural variations for the automobile industry have been estimated by Sudhir (2001) for the market segments and calculated for market segments at the country level by Brenkers and Verboven (2004).

3.3.2 Multi-product firm assumption

For the multiproduct case, the following pricing equation, assuming that only cross-price elasticities among the products within a segment are taken into account, is to be estimated:

$$p_j = c_j + \frac{1-\sigma}{\alpha\left(1-\sigma s_{f/g}-(1-\sigma)\,s_f\right)} \tag{28}$$

where $s_{f/g}$ is the market share of firm f in group g, s_f is the market share of firm f in the total market.

The derivation of the last equation can be found in Appendix A.

3.3.3 Market segment collusion assumption

Assume: coalitions consist of segments.

To test whether a firm maximizes its joint profits, i.e., colludes with other competitors in its market segment, rather than considers only profits from its own products in the segment, the following price equation is estimated:

$$p_j = c_j + \frac{1-\sigma}{\alpha\left(1-(1-\phi)\,\sigma s_{f/g}-\phi\delta s_g-(1-\phi)\,(1-\sigma)\,s_f-\phi\,(1-\sigma)\,s_{g/M}\right)} \tag{29}$$

where $s_{f/g}$ is the sum of shares of own products of firm f in market g, s_g is the sum of shares of products of colluding firms in segment g, s_f is the share of the firm f in the total market M, and $s_{g/M}$ is the share of colluding firms in the total market M.

If $\phi = 0$, the firm considers only its own profits in the given market segment. If $\phi = 1$, the firm colludes with the other products in the market segment.

Thus, basically if one assumes collusion in a particular market segment, the following pricing equation is to be estimated:

$$p_j = c_j + \frac{1-\sigma}{\alpha\left(1-\delta s_g-(1-\sigma)\,s_{g/M}\right)} \tag{30}$$

The derivation of this pricing equation is similar to the derivation of the pricing equation under the multiproduct assumption, described in Appendix A.

4 Test for the multimarket contact effects

The idea of this approach is to test different assumptions/hypotheses concerning the firm behaviour through adjusting in an appropriate way the ownership matrix in order to derive the competition pattern in the industry and across market segments, including the possibility of the mutual forbearance hypothesis. The test under this approach can be done in two steps:

Step 1. Derive the pricing equation under the multimarket contact assumption using the menu approach, i.e., by specifying a particular ownership matrix.

The multimarket firm will maximize the following profits:

$$\pi_f = \sum_{i \in J_{MMC}} (p_i - c_i) M s_i(p) \tag{31}$$

where J_{MMC} stands for the own products of the firm and the products of the firms, with which it meets in the other market segments.

The following pricing equation is to be estimated:

$$p_j = c_j + \frac{1-\sigma}{\alpha\left(1 - \sigma s_{MMC/g} - (1-\sigma) s_{MMC}\right)} \tag{32}$$

where s_{MMC} will be the sum of the shares of the multimarket contact firms, $s_{MMC/g}$ is the share of the multimarket contact firms in the market segment g, s_{MMC} is the share of the multimarket contact firms in the total market M.

In addition to the multimarket contact specification, the multi-product price specification can be written not only for car manufacturers (brand level) but also for manufacturer groups, which may allow to test the impact of cross-ownership on the firm behaviour.

Step 2. Test different assumptions about the equilibrium interactions of firms (i.e., single-product, multi-product, collusion, collusion due to the multimarket contact), and choose the best model among the competing models on the basis of the goodness-of-fit of the model (most often R-squared, adjusted R-squared, some information, or prediction criterion, or the test of nonnested hypothesis (e.g., Vuong, 1989). In the absence of publicly available information on marginal costs and price-cost margins[12], this has been a way that has been pursued in a number of empirical studies as well (Verboven, 2002).

The goodness-of-fit of the model as measured by R-squared may be not the best criterion for selecting the model, especially when the model specifications appear similarly good (in terms of estimated coefficients and standard errors). As it has been mentioned, models are often selected on the basis of some information criterion (e.g., Akaike (1973, 1974) information criterion, Schwarz (1978) information criterion, Hannan and Quinn (1979), Bayesian information criterion). Under this approach, the model with the smallest information criterion is preferred. However, the selection procedures that these tests are based upon are not completely satisfactory (Rivers and Vuong, 1999). The actual values of the model selection criteria can be subject to statistical variations as they are determined by sample information. The models may not, thus, outperform each other significantly. Akaike's information criterion, based on minimizing the loss of information, is calculated on the basis of the mean squared prediction error when it is applied in case of the OLS estimation. In case of linear regression models, the criteria that are based on the calculation of the in-sample MSEP are widespread.

[12] There exist only a few studies that select the best model on the basis of some calculated marginal costs or some publicly available information on price-cost margins. For example, Nevo (2001) compares estimated and observed markups to select the best model.

There seems to be several tests for nested/non-nested regression models around: e.g., Cox (1961) for testing separate families of hypothesis, Pesaran (1974) for testing non-nested linear regressions; J-test and P-test suggested by Davidson and Mackinnon (1981), which allow testing against several alternative models simultaneously; test for nested/non-nested/overlapping specifications by Vuong (1989). Rivers and Vuong (2002) develop the generalization of the Vuong (1989) tests to the broader class of estimations. MacKinnon, Davidson, and White (1983) extend the results of Davidson and MacKinnon (1981) paper, in particular to the cases when there are lagged dependent variables, or when the dependent variables in the non-nested models are different transformations of each other. Within this approach, the two non-nested models are embedded into a more general artificial model (see Appendix B for more detail).

As there appears to be no single most reliable test to choose the best model, the results from the test for non-nested hypothesis (MacKinnon, Davidson, and White, 1983), the Akaike information criterion and sum of squared residulas (SSR) will be compared to get some meaningful and reliable results.

5 Data and estimation

5.1 Data

The major source of the automotive data for this research is the Automotive News Market Data Book for 2001-2003[13]. The available data for the US automotive market include:

1. Car and light truck sales by market class for models. In the dataset those models with the yearly sales of less than 200 models have been excluded.

2. Prices of cars, pickups, minivans, vans and SUVs.

Prices for the given year are shown as of April/May of the corresponding year. The base prices include the retail price as suggested by the manufacturer and the destination charge. The prices of imported vehicles cover ocean freight and the U.S. import duty. State, or local taxes, or optional equipment are not included into the prices. The list prices are converted into real terms by using the US Consumer Price Index (CPI).

3. Vehicles characteristics: auto transmission, air conditioning, antilock brakes, sunroof/moonroof; information on dimensions, engines, capacities, safety, miscellaneous. The physical characteristics of the base specification have been used in the estimations.

4. Automotive advertising spending in the US (measured US ad spending per vehicle).

The data on miles per gallon, engine volume, cylinders are available from the Fuel Economy Guide by US Environmental Protection Agency (EPA)). The log of the total sales volume, or global production by model, which is available

[13] I have tried to do some cross-sectional estimations, but it is difficult to fit the model. This result is similar to the one by BLP (1995), who have chosen to use the panel data, and Nevo (2001), who have used the data for several geographical markets.

from Global Insight, can be used to account for the economies of scale. GDP data are taken from the Bureau of Economic Analysis (BEA)).

The number of potential customers is approximated by the total number of households in the economy, following BLP (1995). That is, each household is treated to be a potential buyer of a new car. The other measures of the potential market should be thought of. The information on the number of households is taken from the US Census Bureau.

The automotive market classification by the Automotive News, which I use in this study, is determined by vehicle size, price and market intent. The cars are segmented into the following classes: small, midrange, traditional, upscale, sporty, alternative power. The alternative power market is not analyzed because it is a thin market. The light trucks are segmented into the following classes: pickups, vans, and SUVs. The summary statistics across the market segments is presented in Tables 6 and 7, Appendix C. The prices, size and horsepower increase as one moves from the smaller car segments to the larger ones, also to those with the higher presence of premium products. For the sensitivity analysis (for my estimations, the definition of a relevant market is very important), alternative market segmentations could be tried, in particular, the one by Ward's (Ward's Automotive Yearbook). According to this classification, which is based upon price, body style and size, the light vehicles are segmented into the following classes: small, middle, large, luxury, cross-utility vehicles, SUVs, vans and pickups.

In my estimations I do not include all the available technical characteristics in order to minimize the problem of multicollinearity. The variables have been chosen into the specification on the basis of the p-value correlation analysis. The summary of the variables used in the estimations is given in Table 8, Appendix C. The following variables have been used in the specifications: horsepower (to measure car performance), width and length (vehicle dimensions), air conditioning and antilock brakes (safety), automatic transmission (convenience), miles per gallon (MPG) (fuel efficiency).

5.2 Estimation strategies for the demand equation and full system

In general, the demand and pricing equations can be estimated either separately, or jointly. Under the separate, or step-by-step, estimation, the demand equation is estimated first, after which the matrix of own- and cross-price elasticities is constructed on the basis of the estimated demand parameters, and the pricing equation is estimated after having substituted into it the matrix of the elasticities. The standard errors of the pricing equation parameters have to be corrected. There are several advantages of this two-step procedure, e.g., reduction in the computational burden due to the separate estimation of the demand and pricing equations, possibility to experiment with different supply specifications without re-estimating the demand function, the possible supply model misspecification will not impact the results from the demand side (Goldberg and Verboven, 2001)[14]. The major drawback of this procedure is the loss in the efficiency of the estimated parameters.

5.3 Instruments

Prices and market shares are endogenous, correlated with the error term ξ_j and ω_j, and, consequently, have to be instrumented. Prices will be collinear with product characteristics that are not observed. The introduction of product fixed effects to control for unobserved characteristics can lead to an identification problem due to the correlation between fixed effects and product characteristics. If there is some positive correlation between prices and omitted characteristics, the price coefficient will tend towards zero.

The detailed discussion of the choice of the efficient instruments for differentiated products models can be found in Berry, Levinsohn and Pakes (1995). In general several groups of instruments can be pointed out that have been used in the studies on the differentiated products demand and structural model estimation: cost shifters and quasi-cost shifters, product characteristics, prices in other markets (following Hausman et al. (1994) and Hausman (1996)), etc. I use product characteristics as instruments in my estimations, so I will discuss them in more detail now.

The best candidates for the instruments in the differentiated product markets are the model characteristics, which are usually treated to be exogenous, based on the assumption that in the short run they cannot be quickly adjusted by a firm. Thus, the matrix Z of instruments includes the product's own characteristics (which decreases the number of necessary additional instruments) and other exogenous variables used in the estimations. Product characteristics are used as instruments for a set of unobserved supply shifters in the pricing, or marginal cost equation. Furthermore, the functions of the exogenous characteristics of the competing products can be used as instruments.

The car's own price and demand will be correlated with the physical characteristics of the other products, and depend on the degree and closeness of competition that the firms face with other competitors. The distance from the nearest neighbouring product will determine the markup of each brand.

The major difficulty with using nonprice characteristics as instruments is that these variables are usually used both in the demand and cost side, so that there may "not a sufficient number of instruments for the number of parameters to be estimated" (Verboven, 2002). This problem has been discussed by Berry (1994) and Berry, Levinsohn and Pakes (1995) and it has been suggested to use the characteristics of competitors and their functions as additional instruments. The functions of the exogenous physical characteristics (own and competitors') can be used as instruments (sums and averages).

Bresnahan et al (1997) suggest the following groups of instruments: principles of differentiation (defined on a group-specific basis), ownership (defined on a firm-specific basis, making use of the economics of the multiproduct pricing)

[14] Step-by-step estimations are also used by Nevo (2001).

and ownership with principles of differentiation (combination of a group-specific and a firm-specific basis).

Therefore, the following instruments could be used for the estimation of the one-level nested logit: 1) number of other products in a group; 2) sum/average of characteristics of other products in a group (interacted with a group dummy variable); 3) number of other products the firm sells in the group; 4) sum/average of characteristics of other products the firm sells in the group (interacted with a group dummy variable); 5) number of products the other firms sell in the group; 6) sum/average of characteristics of products the other firms sell in the group (interacted with a group dummy variable).

5.4 Estimation results (one-level nested logit)[15]

5.4.1 Step-by-step estimation

The results of the step-by-step demand estimation for the one-level nested logit[16] can be found in Table 9, Appendix D. The demand equation can be estimated by the 2SLS, or GMM. The null hypothesis of homoscedasticity has been tested by performing the test of heterogeneity by Pagan and Hall (1983) for instrumental variables estimation. The tests results have not rejected the homoscedasticity hypothesis, thus, the IV estimation should be rather used (GMM estimation results are presented for comparison in Table 9).

Horsepower has been found statistically significant in all specifications and has an expected positive sign. Width and length have got a negative sign. Air conditioning, brakes and automatic transmission have got an expected positive sign. The miles per gallon has got a negative sign on the contrary to the a priori expectations: the higher miles per gallon value, the more efficient the vehicle is. The negative sign was also found in some other studies (e.g., BLP, 1995, Sudhir, 2001). Time fixed effects might capture macro-economic fluctuations that influence a person's decision to buy a car.

The marginal costs equation under different assumptions is estimated using OLS with robust standard errors (Huber/White sandwich estimator of the variance) (see Table 10 and 11 in Appendix D). Horsepower is found to be positive in all specifications. The signs and magnitudes of some coefficients have been changing across different specifications. At the first sight, Toyota appears to be not the most efficient producer. These results may be in line with some of the results of the previous studies. In particular, Petrin (2002) finds the marginal costs to be slightly higher for Japanese producers as compared to those of

[15] I have done estimations for the nested logit with two nests (market segment and country of origin, i.e., domestic vs. foreign producer) and have encountered similar problems as under the estimation of the nested logit with one nest, described in this section.

[16] The estimations with different correlation parameters for different market segments (not reported) produced rather implausible magnitudes (higher correlation for more luxury segments), and some coefficients turned out to be greater than 1, although the Wald test has not rejected the hypothesis that they could be equal to or less than one. The latter problem could be explained by the choice of instruments. It should be also mentioned that in some cases the coefficients greater than 1 could be consistent with the utility-maximizing behaviour. These estimations could be more looked at in the future work.

American producers. Higher marginal costs for Japanese producers have been also found by Sudhir (2001). It should be noted that the interpretation of the brand dummies coefficients is not so straightforward because they may contain information about both technology (costs of production) and preferences, or valuations by consumers (demand).

5.5 Results of the test for the multimarket contact effects

The application of thE test for multimarket contact effects for the automotive industry is complicated by the fact that the automotive firms are present in almost every market segment. Thus, one needs to find some variation in the multimarket contact among the automotive firms. There could be different criteria for that, e.g., how long the firm has been present in the market, difference due to the geographical market presence, technology difference (e.g., diesel technology), etc.

In the US, the firms that are present in all automotive product markets are Toyota, GM, Ford and DaimlerChrysler. Renault-Nissan group is present in all the markets, except for the traditional market segment.

The criteria that I use at present for the differentiation of the multimarket contact are: 1) the presence of the firm in all or almost all market segments, 2) multimarket firms with shares with more than 10% in each market segment[17], and 3) the combination of the above two criteria. Under the first criterion the collusion possibility between GM, Ford, DaimlerChrysler, Toyota and Renault-Nissan groups is tested. Under the second criterion, the collusion is between GM, Ford, DaimlerChrysler, Toyota, Honda, Hyundai and BMW. Under the third criterion, the collusion is between GM, Ford, DaimlerChrysler and Toyota. In addition, the collusive behaviour between GM, Ford, and DaimlerChrysler is tested as these firms have tended to dominate the US automotive market in general and across separate market segments. For the other firms, I have tested different assumptions: competitive, single-product, and multi-product. The choice of the above criteria has been based on the following arguments. Not only the diversification aspect matters but also the ability of the firms to use it in the creation of the transferrable slack should be taken into account. It is unlikely that the firms with a small market share will be able to generate the necessary slack to transfer to the other markets.

The results of the estimated marginal costs equations under multimarket contact assumptions can be found in Table 11 in Appendix D.For the model selection, the best way would be, of course, to get the real estimates of the marginal costs of the automotive firms, and to compare the obtained estimates with those ones, but this is again difficult to realize in practice. Not surprisingly, there is not so much publicly available information on the profit margins of the OEMs in the US market.

[17] D'Avon (2002): "If the number of overlapping markets is impractically large, it is often useful to eliminate trivial market overlaps using a decision rule such as including only overlaps in markets that are at least 1% of the focal firm's total sales".

Relying on the "goodness-of-fit" of the model may be not the best criterion for selecting a model in these circumstances. As it can be already seen from the estimation results, the R-squared is rather similar for all model specifications. In this version of the paper I further apply the information criteria, RSS and test for non-nested hypotheses to choose the model that best fits the data.

The results of the comparison of the information criteria and SSR as a way to differentiate between the models can be found in Table 12, Appendix D. The specifications of the single-product, multi-product (brand) and multi-product (group) price competition have got the lowest AIC and BIC values. However, these values are not so much different from the values for three multimarket contact assumptions, namely collusive behaviour for Ford, GM and Daimler-Chrysler and competitive or single-product or multiproduct price competition for the other automotive players. That is why, one should be rather careful in making conclusions on the basis of these information criteria results. The comparison of the SSR values shows a similar picture. It should be noted that the SSR in any case could not be treated as a sufficient condition for rejecting all the other null hypotheses.

The results of the test for nonnested hypothesis after MacKinnon, White and Davidson (1983) can be found in Table 13, Appendix D. At the top of each row there are several alternative modes of market conduct. Each of the columns represents one of the alternative market conduct scenarios. The results of the test can be best seen by evaluating the columns. It could be seen that when the alternative is MMC4 assumption, i.e., collusive assumption for the American Big Three GM, Ford and DaimlerChrysler, all other null hypothesis are rejected. That is, MMC4 is our most preferred supply-side specification. The interpretation of this result is not so straightforward. Ford, GM and DaimlerChrysler have extensive multimarket contact with each other, at the same time they have the highest market shares in almost all market segments, so that the found collusive behaviour could be attributed to the highly concentrated nature of the US light vehicles market. It should be noted that the multi-product (group) specification, which captures the effect of the cross-ownership on firm behaviour has not been found to be the most preferred supply-side specification. However, these results should be rather interpreted with caution and some research is needed to make the final conclusions.

6 Concluding remarks

To the best of my knowledge, this is the first study on the automotive industry, which concentrates on studying various sources of the market power in an extensive way: fewness (a few competitors and large concentration), differentiation (products have unique features), market-specific collusion, and collusion due to the multimarket contact presence, both at industry and market segment level.

Preliminary results suggest some support that multimarket contact influences competition in the automobile market and increases the firms' strategic interdependence. This effect is, however, difficult to disentangle from the effect of the market concentration and the specific structure of the US automobile market on the firm behaviour. The model specification of multiproduct firm behaviour for automotive manufacturer groups has been found among the most preferred supply-side model specifications on the basis of the information criteria and SSR, but not on the basis of the test for non-nested hypotheses.

These results should be rather interpreted with caution at present as they could be improved in several ways which is my current on-going work. First of all, more flexible and reasonable substitution patterns can be estimated (e.g., random coefficients), which will lead to the more plausible mark-ups and more reliable marginal costs estimates. Second, I would like also to apply some other test for non-nested hypothesis (e.g., Rivers and Vuong, 2002). Third, I simulate some shocks to the market segments in order to separate out own-market and cross-markets effects on the firm behaviour and, thus, make inferences about the interdependence of the firm behaviour across the markets.

While estimating the nested multinominal logit, I have had to rely on the market segmentation criteria often used in other empirical and analytical studies. The changes in the market segmentation may lead to changes in the demand estimates. The question is how distinctive, or relevant, the market segments are. Whether they are perceived in the same way by the automotive manufacturers poses another important issue. The market definition is particularly critical in the context of the mutual forbearance hypothesis. On the demand side, this problem can be solved by estimating the random coefficients model. However, the problem still remains when the interdependence of the firm behaviour across the market segments is being tested. Sensitivity analysis due to the changes in the market segmentation will be helpful to shed some light on this problem.

List prices of light vehicles may be not the best alternative in my estimations due to the numerous price incentives in the US automotive market, and, thus, be a point of potential critique. Transaction prices should be rather used, which are difficult to get. A possible way out is to collect information on the customer incentives for cars offered, which are often cited in the automotive news media, and then calculate the "transaction" prices. On the other hand, the problem of the list prices may be not so severe as the use of list prices instead of transaction prices can be treated as a measurement error in the explanatory variable, and the prices are instrumented in any way.

Some policy implications may be derived for conducting competition policy. The possible anticompetitive effects of the multimarket contact will have to be taken into account while setting up the antitrust policy (e.g., there may be implications for the entry of new firms), and assessing the effects of the conglomerate mergers. If the markets are found to be strategically linked, then policy makers should take into account both direct effects of their regulatory actions in one particular market, and indirect effects in the other markets. The sole market assumption by the regulators may, thus, be irrelevant. The measurement of the competitive pressure in an industry can be more complicated than it could be inferred from the concentration ratio, or Herfindahl index, accounting for the multimarket contact effects.

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8 Appendix A

Derivation of the pricing equation under multiproduct assumption, taking into account only own-price elasticities

The profits of the multiproduct firm are:

$$\pi_f = \sum_{i \in J_f} (p_i - c_i) M s_i (p) \tag{33}$$

The first-order conditions are:

$$s_i(p) + \sum_{r \in J_f} (p_r - c_r) \frac{\partial s_r (p)}{\partial p_i} = 0 \tag{34}$$

The own-price and cross-price demand elasticities are substituted into (35) to get:

$$s_i + (p_i - c_i)(-\alpha) s_i \frac{1}{1-\sigma} \left[1 - \sigma \bar{s}_{i/g} - (1-\sigma) s_i \right] = - \sum_{r \in J_{fg}} (p_r - c_r) \alpha s_r \left[\frac{\sigma}{1-\sigma} \bar{s}_{r/g} + s_r \right] \tag{35}$$

where J_{fg} are the products of firm f in group g.

$$-s_i + (p_i - c_i) \alpha s_i \frac{1}{1-\sigma} = \sum_{r \in J_{fg}} (p_r - c_r) \alpha s_r \left[\frac{\sigma}{1-\sigma} \bar{s}_{r/g} + s_r \right] \tag{36}$$

Divide by s_i to get the below equation:

$$-1 + (p_i - c_i)\,\alpha\frac{1}{1-\sigma} = \sum_{r\in J_{fg}} (p_r - c_r)\,\alpha\left[\frac{\sigma}{1-\sigma}\bar{s}_{r/g} + s_r\right] \tag{37}$$

The right-hand side is the same for any product sold by the same firm, therefore:

$$(p_i - c_i)\,\alpha\frac{1}{1-\sigma} - 1 = (p_r - c_r)\,\alpha\frac{1}{1-\sigma} \tag{38}$$

for any product sold by the same firm, so that:

$$(p_i - c_i) = (p_r - c_r) \tag{39}$$

Substitute this equation into the equation (33) to get rid of c_r, so that only c_i remain:

$$(p_i - c_i)\,\alpha\frac{1}{1-\sigma} - 1 = \sum_{r\in J_{fg}} (p_i - c_i)\,\alpha\left[\frac{\sigma}{1-\sigma}\bar{s}_{i/g} + s_i\right] \tag{40}$$

$$(p_i - c_i) = \frac{1-\sigma}{\alpha(1 - \sum_{r\in J_{fg}} \sigma\bar{s}_{i/g} - \sum_{r\in J_{fg}} (1-\sigma)\,s_i)} \tag{41}$$

The following price equation for the multiproduct case under the nested logit model with one nest is to be estimated:

$$p_j = c_j + \frac{1-\sigma}{\alpha\left(1 - \sigma s_{f/g} - (1-\sigma)\,s_f\right)} \tag{42}$$

where $s_{f/g}$ is the market share of firm f in group g, s_f is the market share of firm f in the total market.

9 Appendix B

MacKinnon, White and Davidson (1983) test for non-nested hypothesis[18]

These tests fall under the category of "artificial testing". Two non-nested models are embedded into a more general artificial model. MacKinnon, White and Davidson (1983) derive the test for the linear case (J-test), the non-linear case (P-test), with transformed dependent variables and in case of the IV estimation.

The given test can be applied in case of the different transformation of the dependent variables (e.g., $w_t y_t$, where w_t is some exogenous variable).

The null hypothesis is given by:

[18] This test has been in particular applied by Feenstra and Levinsohn (1995) and Verboven (2002).

$$H_0 : y_t = f_t(X_t, \beta) + \varepsilon_{0t} \tag{43}$$

The alternative hypothesis is given by:

$$H_1 : h_t(y_t) = g_t(Z_t, \gamma) + \varepsilon_{1t} \tag{44}$$

y_t can be replaced by $\widehat{f}_t$.
The artificial regression will be as follows:

$$y_t - \widehat{f}_t = \alpha(\widehat{g}_t - h_t(\widehat{f}_t)) + \widehat{F}_t b + \varepsilon_t \tag{45}$$

where b is a vector of regression coefficients, $\widehat{F}_t$is a row vector of derivatives of f_t with respect to β evaluated at $\widehat{\beta}$.

Pairs of models are compared. The test statistic has a standard normal distribution. The t-statistic should be calculated.

As applied to my situation, I can re-write the below pricing equation, which is derived from the first-order conditions:

$$p = c + \Omega^{-1} s \tag{46}$$

in the following way

$$p = w\gamma + D\lambda + \omega + b \tag{47}$$

where w are product characteristics, D are firm dummies, ω are unobserved product characteristics, and $b = \Omega^{-1}s$ is the product markup. The quality-adjusted prices will then be:

$$\pi = p - w\gamma - \omega = D\lambda + \Omega^{-1}s \tag{48}$$

The null hypothesis will be as follows:

$$H_0 : p = w\gamma_0 + \pi_0 + \varepsilon_0 \tag{49}$$

The alternative hypothesis can be written down as:

$$H_1 : p = w\gamma_1 + \pi_1 + \varepsilon_1 \tag{50}$$

If the model under H_0 is a true model, then there should be no correlation between its residuals and the difference between the fitted values of H_0 and H_1. w, i.e., product characteristics will be the same in case of both models, thus, the quality-adjusted prices π_0 and π_1 will be the fitted values of interest.

The idea of the P-test is to evaluate whether $p - \widehat{\pi}_0$ is orthogonal to $\widehat{\pi}_1 - \widehat{\pi}_0$. For that purpose, the artificial regression should be run:

$$(p - \widehat{\pi}_0) = wa + (\widehat{\pi}_1 - \widehat{\pi}_0)b + u$$

a and b are the parameters to be estimated within the regression.

APPENDIX C. DATA DESCRIPTION

Table 1. Interdependence of automotive manufacturers

Manufacturer group	*Companies and share*	*Further ownerships*
GM Group	Opel/Vauxhall (100%)	
	Saab (100%)	
	Isuzu (12%)	
	Suzuki (20%)	Maruti (54%)
	Fuji Heavy (20%)	
	Daewoo (42%)	
	Fiat (10%)	
Ford Group	Aston Martin (100%)	
	Jaguar (100%)	
	Mazda (33%)	
	Volvo (100%)	
	Land Rover (100%)	
DaimlerChrysler Group	Mercedes-Benz (100%)	
	Chrysler (100%)	
	Smart (100%)	
	Maybach (100%)	
	Mitsubishi (?)	
Fiat	Fiat Auto (90%)	Alfa (100%)
		Lancia (100%)
	Ferrari (90%)	Maserati (100%)
Renault/Nissan Group	Dacia (100%)	
	Nissan (44%)	
	Samsung (70.1%)	
VW Group	Audi (100%)	Lamborghini (100%)
	Seat (100%)	
	Skoda (100%)	
	Bugatti (100%)	
	Bentley (100%)	
Toyota	Daihatsu (52%)	
BMW	Rolls Royce (100%)	
	Mini (100%)	
PSA	Peugeot (100%)	
	Citroen (100%)	
Hyundai	Kia (60%)	
	Asia (100%)	
Honda		
Porsche		
Rover	MG	
	Triumph, etc.	

Source: Deutsche Bank (2004)

Table 2. US light vehicles market: shares of segment sales in total light vehicles sales, and % change to the previous year

	1999	*2000*	*2001*	*2002*	*2003*
Small					
share	10.4	10.8	10.9	10.3	10.3
% change		7.3	-1.0	-7.3	-1.0
Mid-range					
share	28.3	27.6	27.1	27.0	24.7
% change		0.1	-3.2	-2.1	-9.4
Traditional					
share	3.6	3.5	3.1	2.6	2.3
% change		-0.6	-13.1	-17.3	-11.5
Upscale					
share	6.4	6.6	6.1	6.2	6.3
% change		5.8	-9.4	-0.8	1.7
Sporty					
share	2.9	3.1	3.2	3.2	3.0
% change		11.0	-0.3	-2.3	-5.1
Total cars					
share	51.6	51.7	50.4	49.4	46.8
% change		2.9	-3.9	-3.9	-6.1
Pickup					
share	19.3	18.7	18.6	17.6	18.1
% change		-0.7	-1.6	-7.5	1.7
Van					
share	10.4	10.2	8.9	8.7	8.4
% change		1.4	-14.0	-4.2	-4.9
SUV					
share	18.7	19.3	22.0	24.3	26.7
% change		6.1	12.6	8.3	8.7
Total light trucks					
share	48.4	48.3	49.6	50.6	53.2
% change		2.4	1.4	0.1	3.9
Total light vehicles					
% change		2.7	-1.3	-1.9	-1.0

Source: Automotive News Market Data Book, own calculations

Table 3. US light vehicles market: shares in segments, %, 2003

Manufacturer group	*Small*	*Midrange*	*Traditional*	*Upscale*	*Sporty*	*Pickup*	*Van*	*SUV*
Honda	0.0	17.2	0.0	6.6	6.4	0.0	11.0	8.4
GM	26.9	32.5	36.3	18.4	6.1	35.2	24.3	32.0
DaimlerChrysler	7.2	9.2	7.4	16.1	9.6	18.6	28.4	14.3
Hyundai/Kia	16.8	3.3	0.0	0.0	4.2	0.0	3.6	3.3
Volkswagen	0.0	8.0	0.0	2.7	1.7	0.0	0.3	0.4
Ford	19.4	10.8	43.0	21.3	36.7	35.5	23.2	22.2
Toyota	21.2	9.9	13.2	11.0	5.5	8.5	7.5	11.6
Renault/Nissan	5.6	7.3	0.0	6.8	7.3	2.2	1.7	4.5
Mitsubishi	2.9	1.8	0.0	0.0	7.7	0.0	0.0	2.1
BMW	0.0	0.0	0.0	17.0	11.3	0.0	0.0	0.9
Fiat	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0
Porsche	0.0	0.0	0.0	0.0	3.1	0.0	0.0	0.3
# firms	7	9	4	9	12	5	8	11
C-1 ratio	26.9	28.0	36.3	21.3	36.7	35.5	28.4	32.0
C-4 ratio	84.3	66.0	100	72.8	65.4	97.8	86.8	80.1

Source: Automotive News Market Data Book, own calculations

Table 4. US light vehicles market: shares in a firm's total sales, %, 2003

	Small	*Midrange*	*Traditional*	*Upscale*	*Sporty*	*Pickup*	*Van*	*SUV*	*Share in total US sales*
Honda	0.0	53.1	0.0	5.2	2.4	0.0	11.4	27.9	8.1
GM	9.4	28.2	2.9	4.0	0.6	22.1	7.1	29.6	30.0
DaimlerChrysler	5.1	16.4	1.2	7.2	2.1	23.9	16.9	27.2	14.1
Hyundai	44.2	21.4	0.0	0.0	3.3	0.0	7.9	23.2	3.8
Volkswagen	0.0	85.2	0.0	7.2	2.1	0.0	1.2	4.2	2.3
Ford	8.7	12.0	4.4	6.0	5.0	28.6	8.7	26.5	22.4
Toyota	19.3	22.4	2.8	6.3	1.5	13.9	5.7	28.0	11.1
Renault/Nissan	11.9	38.0	0.0	9.1	4.6	8.5	2.9	25.0	4.8
Mitsubishi	18.8	28.9	0.0	0.0	15.1	0.0	0.0	37.1	1.5
BMW	0.0	0.0	0.0	64.8	20.5	0.0	0.0	14.7	1.7
Fiat	0.0	0.0	0.0	41.6	58.4	0.0	0.0	0.0	0.0
Porsche	0.0	0.0	0.0	0.0	54.5	0.0	0.0	45.5	0.2
Shares of segment sales in total sales	10.1	25.0	2.3	6.3	3.0	18.1	8.4	26.8	

Source: Automotive News Market Data Book, own calculations

Table 5. Product policy of an independent automotive producer: example of Volkswagen product policy

	Hatch	*Notch*	*Station*	*MPV*	*Pickup/Del. Van*	*SUV*	*Sport Coupe*	*Lim. Coupe*	*Conv.*	*Roadster*
Luxury		Bentley					Lamborghini Bugatti			Lamborghini
Upper		VW Audi					Bentley Lamborghini	Bentley		
Upper middle		Audi	Audi	VW		VW				
Middle		VW Skoda Audi	VW Audi	VW Seat			Audi		Audi	Audi
Compact	Audi VW Seat	Skoda Seat	VW Audi Skoda	VW Seat Audi	VW				VW	
Small	VW Skoda Seat	VW Seat Skoda	Skoda							
Mini	VW Seat									

Source: Volkswagen AG

Table 6. US light vehicles market: summary statistics across market segments

Market segment	*Best-selling models, 2003*	*# obs. (min-max)*	*Share of segment in total market, % (2003)*	*Asian share, %, 2003*	*European share, %, 2003*
Small	Toyota Corolla, Chevrolet Cavalier, Ford Focus	20-22	10.3	52.0	0.0
Midrange	Toyota Camry, Honda Accord, Ford Taurus	29-31	24.7	45.7	9.2
Traditional	Buick LeSabre, Mercury Grand Marquis, Ford Crown Victoria	6-7	2.3	13.2	0.0
Upscale	BMW 325, Merc. C class, Cadillac DeVille, Lexus ES 300	30-32	6.3	24.5	39.3
Sporty	Ford Mustang, Mitsubishi Eclipse, Nissan 350Z	20-25	3.0	35.8	22.1
Pickup	Ford F series, Chevrolet Silverado, Dodge Ram	11	18.1	11.2	0.0
Van	Dodge Caravan, Honda Odyssey, Ford Econoline	20-21	8.4	26.0	0.0
SUV	Ford Explorer, Chevrolet TrailBlazer, Jeep Grand Cherokee	36-39	26.7	32.5	3.3

Source: Automotive News Market Data Book, own calculations

Table 7. US light vehicles market: descriptive statistics across market segments

Variable	Mean	St. deviation			Mean	St. deviation		
		Overall	**Between**	**Within**		**Overall**	**Between**	**Within**
	Small				**Midrange**			
Horsepower	122	14.9	14.1	5.3	159	25.9	25.5	5.3
Price	12968	1608.5	1620.4	231.8	18949	2703.0	2673.3	402.1
Size	11795	622.7	595.4	166.0	13262	1038.6	1007.3	264.5
	Traditional				**Upscale**			
Horsepower	215	15.4	18.1	1.1	227	38.1	37.8	6.1
Price	25064	1810.0	2050.2	351.1	38009	10951.9	11009.7	845.8
Size	15366.7	980.2	1006.9	27.3	13917	1186.3	1165.6	251.7
	Sporty				**Pickup**			
Horsepower	199	61.7	61.8	3.9	164	35.8	35.0	11.6
Price	29822.1	15889.1	15591.9	390.0	15570	2368.2	2369.1	588.6
Size	11956	1245	1235.7	169.4	14527	1648.4	1686.2	227.2
	Van				**SUV**			
Horsepower	188	19.3	17.5	8.2	202	54.0	52.7	10.3
Price	22668	2109.9	2015.7	544.3	25386.9	7012.2	6910.2	1020.8
Size	15135	1180.0	1153.8	153.4	13543	1794.7	1808.4	24.9

Source: Automotive News Market Data Book, own calculations

Table 8. US light vehicles market: variables description

Variables	*Variable name*	*Notes*
Horsepower	horse	Net horsepower
Width	width	Overall width (in.)
Length	length	Overall length (in.)
Air conditioning	air-cond	Dummy: 1 if air conditioning is standard equipment
Antilock brakes	brakes	Dummy: 1 if antilock brakes is standard equipment
Transmission	transm	Dummy: 1 if automatic transmission is standard equipment
Miles-per-gallon	mpgcity	City miles per gallon: for urban driving
Disposable income	income	Disposable personal income in chained 2000 dollars (bn)

Source: Automotive News Market Data Book, own calculations

APPENDIX D. ESTIMATION RESULTS FOR ONE-LEVEL NESTED LOGIT

Table 9. Demand estimation

Dependent variable: log of the ratio of the own model share to the share of the outside good

	IV		*GMM*	
	Specification IV.A	Specification IV.B	Specification GMM.A	Specification GMM.B
price	-0.00015*	-3.996*	-0.00017*	-4.465*
	(0.000)	(0.799)	(0.000)	(0.788)
ln (segmentshare)	0.866**	0.702**	0.796**	0.691**
	(0.437)	(0.370)	(0.371)	(0.351)
horse	0.020*	0.015*	0.022*	0.017*
	(0.007)	(0.004)	(0.007)	(0.005)
width	-0.055*	-0.028	-0.051*	-0.032***
	(0.024)	(0.020)	(0.022)	(0.018)
length	-0.005	-0.002	-0.003	-0.005
	(0.009)	(0.008)	(0.009)	(0.009)
air_cond	0.083	0.487*	0.184***	0.551*
	(0.166)	(0.182)	(0.109)	(0.162)
brakes	0.167	0.295**	0.212***	0.362*
	(0.160)	(0.144)	(0.143)	(0.144)
transm	0.390**	0.345*	0.383**	0.431*
	(0.172)	(0.138)	(0.176)	(0.175)
mpgcity	-0.038***	-0.074*	-0.030***	-0.079*
	(0.023)	(0.017)	(0.018)	(0.015)
income	-0.0005	-0.0006***	-0.0006***	-0.0006**
	(0.103)	(0.000)	(0.000)	(0.000)
const	4.647	39.675*	4.192	44.968
	(3.279)	(7.885)	(3.197)	(8.449)
Adj. R2	0.36	0.56	0.26	0.51
Root MSE	1.06	0.87	1.14	0.93
Pagan&Hall (all, p-value)	1.00	0.99	-	-
Overidentification test	4.05	2.61	4.95	3.13

Note: Specifications IV.A and GMM.A are with p, while Specifications IV.B and GMM.B are with ln(p).
***, **, * - indicate significance at 10%, 5% and 1%, respectively.
Standard errors are given in parenthesis.
Time dummies have been included but are not reported.

Table 10. Marginal cost equations under different assumptions

Dependent variable: log(marginal cost)

	Single-product	*Multi-product*	*Multimarket collusion*	*Hedonic pricing*
	Coefficient	Coefficient	Coefficient	Coefficient
horse	0.998*	1.011*	1.256*	0.952*
	(0.047)	(0.047)	(0.055)	(0.045)
width	-0.051*	-0.054	0.162	-0.053
	(0.186)	(0.185)	(0.227)	(0.177)
length	-0.501*	-0.496*	-0.739*	-0.457*
	(0.142)	(0.142)	(0.174)	(0.137)
air_cond	0.161*	0.164*	0.279*	0.144*
	(0.019)	(0.019)	(0.025)	(0.018)
brakes	0.066*	0.065*	0.080*	0.062*
	(0.019)	(0.019)	(0.024)	(0.018)
transm	0.140*	0.139*	0.164*	0.131*
	(0.019)	(0.019)	(0.024)	(0.017)
mpgcity	0.004	0.009	-0.091	0.022
	(0.060)	(0.061)	(0.075)	(0.057)
year01	0.031**	0.032**	0.041**	0.030*
	(0.016)	(0.016)	(0.019)	(0.015)
year02	0.021	0.021	0.025	0.020
	(0.015)	(0.015)	(0.019)	(0.014)
Hyundai	-0.370*	-0.378*	-0.595*	-0.337*
	(0.048)	(0.048)	(0.066)	(0.044)
Kia	-0.361*	-0.369*	-0.597*	-0.328*
	(0.046)	(0.046)	(0.068)	(0.043)
Toyota	-0.209*	-0.221*	-0.325*	-0.190*
	(0.042)	(0.041)	(0.053)	(0.039)
GM	-0.319*	-0.343*	-0.470*	-0.295*
	(0.037)	(0.037)	(0.046)	(0.035)
Ford	-0.270*	-0.287*	-0.402*	-0.245*
	(0.039)	(0.039)	(0.048)	(0.036)
Chrysler	-0.299*	-0.313*	-0.432*	-0.277*
	(0.038)	(0.038)	(0.048)	(0.036)
Nissan	-0.404*	-0.412*	-0.567*	-0.378*
	(0.043)	(0.043)	(0.055)	(0.041)
Mazda	-0.167*	-0.172*	-0.259*	-0.153*
	(0.054)	(0.054)	(0.068)	(0.051)
Mitsubishi	-0.211*	-0.216*	-0.326*	-0.192*
	(0.047)	(0.047)	(0.058)	(0.044)
Suzuki	-0.403*	-0.409*	-0.591*	-0.374*
	(0.043)	(0.042)	(0.054)	(0.040)
Honda	-0.244*	-0.256*	-0.352*	-0.226*
	(0.047)	(0.046)	(0.057)	(0.044)
VW	-0.121*	-0.127*	-0.210*	-0.109*
	(0.045)	(0.045)	(0.058)	(0.042)
Subaru	-0.270*	-0.278*	-0.398*	-0.252*
	(0.038)	(0.038)	(0.048)	(0.036)
Audi	-0.047	-0.056	-0.119**	-0.040
	(0.049)	(0.049)	(0.062)	(0.046)
BMW	0.036	0.024	-0.026	0.043
	(0.053)	(0.052)	(0.063)	(0.050)
Mercedes	0.219*	0.208*	0.166*	0.224*
	(0.053)	(0.053)	(0.060)	(0.052)
Volvo	0.065***	0.055	0.033	0.067***
	(0.042)	(0.041)	(0.051)	(0.039)
Jaguar	0.081***	0.070	0.002	0.089**
	(0.048)	(0.047)	(0.055)	(0.046)
Saab	0.196*	0.187*	0.200*	0.190*
	(0.041)	(0.041)	(0.052)	(0.039)
const	7.582*	7.487*	6.575	7.607*
	(0.931)	(0.934)	(1.177)	(0.881)
R-squared	0.89	0.89	0.90	0.89
Root MSE	0.14	0.14	0.18	0.13

Note: ***, **, * - indicate significance at 10%, 5% and 1%, respectively.
Robust standard errors are given in parenthesis.
Based on GMM.A specification.
Isuzu is used as a reference group.
Horsepower, width, length and mpgcity are in logarithmic form.

Table 11. Marginal costs equations under multimarket contact assumptions

Dependent variable: log(marginal cost)

	Specification MMC.1.	*Specification MMC.2.*	*Specification MMC.3.*	*Specification MMC.4.*
	Coefficient	Coefficient	Coefficient	Coefficient
horse	1.182*	1.199*	1.126*	1.073*
	(0.055)	(0.055)	(0.055)	(0.047)
width	0.140	0.006	0.015	-0.131
	(0.238)	(0.225)	(0.230)	(0.193)
length	-0.939*	-0.638*	-0.789*	-0.521*
	(0.184)	(0.172)	(0.172)	(0.141)
air_cond	0.236*	0.244*	0.215*	0.166*
	(0.029)	(0.025)	(0.026)	(0.020)
brakes	0.045***	0.060*	0.052**	0.040**
	(0.027)	(0.025)	(0.026)	(0.020)
transm	0.197*	0.148*	0.182*	0.158*
	(0.024)	(0.023)	(0.023)	(0.020)
mpgcity	0.191*	0.121***	0.156**	0.100***
	(0.078)	(0.076)	(0.076)	(0.061)
year01	0.033***	0.039**	0.032***	0.029***
	(0.019)	(0.019)	(0.019)	(0.016)
year02	0.024	0.027	0.022	0.021
	(0.019)	(0.019)	(0.018)	(0.016)
Hyundai	-0.218*	-0.502*	0.214*	-0.228*
	(0.060)	(0.063)	(0.056)	(0.049)
Kia	-0.156*	-0.519*	-0.165*	-0.204*
	(0.059)	(0.057)	(0.054)	(0.048)
Toyota	-0.328*	-0.307*	-0.295*	-0.103*
	(0.058)	(0.051)	(0.056)	(0.041)
GM	-0.414*	-0.412*	-0.383*	-0.342*
	(0.050)	(0.043)	(0.047)	(0.039)
Ford	-0.359*	-0.358*	-0.332*	-0.292*
	(0.053)	(0.046)	(0.050)	(0.042)
Chrysler	-0.404*	-0.392*	-0.375*	-0.338*
	(0.050)	(0.043)	(0.047)	(0.039)
Nissan	-0.516*	-0.220*	-0.270*	-0.280*
	(0.064)	(0.054)	(0.054)	(0.046)
Mazda	-0.246*	-0.242*	-0.221*	-0.194*
	(0.067)	(0.067)	(0.065)	(0.057)
Mitsubishi	-0.076	0.016	-0.074	-0.090***
	(0.067)	(0.065)	(0.061)	(0.052)
Suzuki	-0.553*	-0.565*	-0.506*	-0.439*
	(0.058)	(0.053)	(0.055)	(0.044)
Honda	-0.169*	-0.305*	-0.152*	-0.144*
	(0.059)	(0.056)	(0.056)	(0.047)
VW	0.019	0.089***	0.018	0.023
	(0.056)	(0.052)	(0.053)	(0.046)
Subaru	-0.142*	-0.099*	-0.138*	-0.137*
	(0.050)	(0.044)	(0.047)	(0.040)
Audi	-0.004	0.065	0.021	0.051
	(0.061)	(0.057)	(0.059)	(0.051)
BMW	0.091	0.002	0.052)	
	(0.063)	(0.059)		
Mercedes	0.177*	0.202	0.206*	0.243*
	(0.063)	(0.058)	(0.061)	(0.054)
Volvo	0.049	0.023	0.066	0.091**
	(0.053)	(0.050)	(0.051)	(0.043)
Jaguar	0.043	0.031	0.074	0.108**
	(0.059)	(0.055)	(0.057)	(0.048)
Saab	0.202*	0.163*	0.211*	0.223*
	(0.054)	(0.049)	(0.051)	(0.043)
const	7.420*	6.472*	7.572*	7.300
	(1.188)	(1.143)	(1.140)	(0.983)
R-squared	0.87	0.88	0.87	0.89
Root MSE	0.18	0.17	0.17	0.15

Note: ***, **, * - indicate significance at 10%, 5% and 1%, respectively.
Robust standard errors are given in parenthesis.
Specification MMC.1: collusive assumption for GM, Ford, DaimlerChrysler, Toyota and Renault-Nissan and competitive assumption for the others
Specification MMC.2: collusive assumption for GM, Ford, DaimlerChrysler, Toyota, Honda, Hyundai and BMW and competitive assumption for the others
Specification MMC.3: collusive assumption for GM, Ford, DaimlerChrysler and Toyota and competitive assumption for the others
Specification MMC.4: collusive assumption for GM, Ford, DaimlerChrysler and competitive assumption for the others
Horsepower, width, length and mpgcity are in logarithmic form.

Table 12. Information criteria and sum of squared residuals (SSR) for different supply side specifications

	AIC	*BIC*	*SSR*
Single-product	-539.63	-415.83	9.97
Multi-product (group)	-535.29	-411.49	10.05
Multi-product (independent)	-534.40	-410.59	10.07
Market segment collusion	-306.90	-183.10	15.49
MMC1	-306.30	-182.50	15.51
MMC2	-324.57	-200.76	14.98
MMC3	-345.43	-221.63	14.40
MMC4	-497.40	-373.60	10.80
MMC5	-306.56	-182.76	15.50
MMC6	-306.77	-182.96	15.49
MMC7	-331.26	-207.45	14.79
MMC8	-331.34	-207.54	14.79
MMC9	-347.72	-223.91	14.34
MMC10	-347.81	-224.00	14.33
MMC11	-480.08	-356.28	11.16
MMC12	-478.98	-355.18	11.18

Specification MMC.1: collusive assumption for GM, Ford, DaimlerChrysler, Toyota and Renault-Nissan and competitive assumption for the others
Specification MMC.2: collusive assumption for GM, Ford, DaimlerChrysler, Toyota, Honda, Hyundai and BMW and competitive assumption for the others
Specification MMC.3: collusive assumption for GM, Ford, DaimlerChrysler and Toyota and competitive assumption for the others
Specification MMC.4: collusive assumption for GM, Ford, DaimlerChrysler and competitive assumption for the others
Specification MMC.5: collusive assumption for GM, Ford, DaimlerChrysler, Toyota and Renault-Nissan and single-product assumption for the others
Specification MMC.6: collusive assumption for GM, Ford, DaimlerChrysler, Toyota and Renault-Nissan and multi-product assumption for the others
Specification MMC.7: collusive assumption for GM, Ford, DaimlerChrysler, Toyota, Honda, Hyundai and BMW and single-product assumption for the others
Specification MMC.8: collusive assumption for GM, Ford, DaimlerChrysler, Toyota, Honda, Hyundai and BMW and multi-product assumption for the others
Specification MMC.9: collusive assumption for GM, Ford, DaimlerChrysler and Toyota and single-product assumption for the others
Specification MMC.10: collusive assumption for GM, Ford, DaimlerChrysler and Toyota and multi-product assumption for the others
Specification MMC.11: collusive assumption for GM, Ford, DaimlerChrysler and single-product assumption for the others
Specification MMC.12: collusive assumption for GM, Ford, DaimlerChrysler and multi-product assumption for the others

Table 13. Results of the test for non-nested hypotheses (MacKinnon, White and Davidson, 1983)

	H1															
H0	A1: Single	A2: Multi (brand)	A3: Multi (group)	A4: Segm. Coll	A5: MMC1	A6: MMC2	A7: MMC3	A8: MMC4	A9: MMC5	A10: MMC6	A11: MMC7	A12: MMC8	A13: MMC9	A14: MMC10	A15: MMC 11	A16: MMC12
A1: Single		- 0.00000 (-0.03)	.00004 (0.56)	.0001 (1.65)	- .000045 (-6.04)	- 0.00000 (-0.45)	-.00004 (-5.31)	- .000037 (-2.6)	- .000045 (-6.1)	- .000045 (-6.07)	0.00000 (-0.45)	-0.0000 (-0.45)	-.00004 (-5.36)	-.00004 (-5.32)	-.00004 (-2.80)	-.000038 (-2.68)
A2: Multi (brand)	0.00006 (0.71)		0.0002 (1.39)	0.0001 (1.83)	- 0.00005 (-6.37)	-0.0000 (-0.53)	- 0.00005 (-5.61)	- 0.00005 (-2.99)	- 0.00005 (-6.43)	- 0.00005 (-6.40)	- 0.00000 (-0.53)	- 0.00000 (-0.53)	- 0.00004 (-5.67)	- 0.00005 (-5.64)	-0.00005 (-3.21)	-0.00005 (-3.10)
A3: Multi (group)	0.00001 (0.14)	-0.0002 (-1.14)		0.00008 (1.42)	- 0.00005 (-6.35)	0.00000 (-0.60)	- 0.00005 (-5.60)	0.00005 (-3.02)	- 0.00005 (-6.41)	- 0.00005 (-6.39)	- 0.00000 (-0.60)	- 0.00000 (-0.60)	- 0.00005 (-5.66)	- 0.00005 (-5.63)	-0.00005 (-3.23)	-0.00005 (-3.13)
A4: Segm. Coll	-0.0001 (-0.96)	-0.0001 (-1.27)	-0.0001 (-1.02)		-0.0001 (-5.98)	- 0.00000 (-0.70)	- 0.00005 (-4.84)	- 0.00004 (-2.61)	-0.0001 (-6.03)	-0.0001 (-6.02)	-0.0000 (-0.69)	-0.0000 (-0.69)	0.00005 (-4.88)	0.00005 (-4.86)	-0.00005 (-2.76)	-0.00005 (-2.71)
A5: MMC1	0.0001 (14.82)	0.0001 (14.94)	0.0001 (14.99)	0.0001 (14.70)		0.0001 (11.15)	0.0002 (6.21)	0.0002 (14.35)	-0.0005 (-0.87)	0.0003 (0.78)	0.0001 (11.13)	0.0001 (11.14)	0.0001 (1.79)	0.0001 (1.83)	0.000118 (8.86)	0.000117 (8.86)
A6: MMC2	0.0001 (5.83)	0.0001 (5.71)	0.0001 (5.77)	0.0001 (6.02)	-0.0001 (-5.23)		-0.0001 (-4.94)	0.00003 (1.98)	-0.0001 (-5.29)	-0.0001 (-5.27)	0.0000 (0.01)	- 0.00003 (-0.04)	-0.0001 (-5.00)	-0.0001 (-4.97)	0.00003 (1.82)	0.00003 (1.87)
A7: MMC3	0.0001 (12.96)	0.0001 (13.02)	0.0001 (13.09)	0.0001 (12.80)	-0.0001 (-2.27)	0.0001 (9.52)		0.0002 (12.20)	- 0.00006 (-2.33)	- 0.00006 (-2.23)	0.0001 (9.52)	0.0001 (9.51)	-0.0006 (-1.06)	-0.0002 (0.49)	0.0002 (12.07)	0.0002 (12.11)
A8: MMC4	0.0001 (7.22)	0.0001 (7.28)	0.0001 (7.43)	0.0001 (7.28)	-0.0001 (-7.97)	0.00002 (1.99)	-0.0001 (-7.52)		-0.0001 (-8.04)	-0.0001 (-7.99)	0.00002 (1.99)	0.00002 (1.99)	-0.0001 (-7.60)	-0.0001 (-7.54)	-0.001 (- 3.68)	-0.0003 (-1.27)
A9: MMC5	0.0001 (14.85)	0.0001 (14.96)	0.0001 (15.00)	0.0001 (14.71)	0.0007 (1.28)	0.0001 (11.34)	0.0001 (6.22)	0.0002 (14.37)		0.0007 (1.45)	0.0001 (11.33)	0.0001 (11.33)	0.0002 (6.12)	0.0002 (6.21)	0.0002 (14.21)	0.0002 (14.26)
A10: MMC6	0.0001 (14.79)	0.0001 (14.91)	0.0001 (14.95)	0.0001 (14.66)	-0.0001 (-0.21)	0.0001 (11.30)	0.0002 (6.11)	0.0002 (14.30)	-0.0006 (-1.34)		0.0001 (11.29)	0.0001 (11.29)	0.0002 (6.01)	0.0002 (6.12)	0.0002 (14.14)	0.0002 (14.21)
A11: MMC7	0.0001 (5.89)	0.0001 (5.78)	0.0001 (5.84)	0.0001 (6.08)	-0.0001 (-5.24)	0.0001 (0.07)	-0.0001 (-4.87)	0.00002 (2.04)	-0.0001 (-5.31)	-0.0001 (-5.28)		-0.0001 (-0.05)	-0.0001 (-4.94)	-0.0001 (-4.91)	0.00002 (1.89)	0.00003 (1.94)
A12: MMC8	0.0001 (5.89)	0.0001 (5.78)	0.0001 (5.84)	0.0001 (6.08)	-0.0001 (-5.23)	0.0001 (0.10)	-0.0001 (-4.87)	0.00003 (2.05)	-0.0001 (-5.30)	-0.0001 (-5.27)	0.0001 (0.09)		-0.0001 (-4.94)	-0.0001 (-4.91)	0.0003 (1.89)	0.00003 (1.94)
A13: MMC9	0.0001 (12.99)	0.0001 (13.05)	0.0001 (13.10)	0.0001 (12.82)	-0.0001 (-2.29)	0.0001 (9.72)	0.0008 (1.49)	0.0002 (12.23)	-0.0001 (-2.38)	-0.0001 (-2.30)	0.0001 (9.72)	0.0001 (9.72)		0.0006 (1.32)	0.0002 (12.09)	0.0002 (12.13)
A14: MMC10	0.0001 (12.93)	0.0001 (13.00)	0.0001 (13.05)	0.0001 (12.77)	-0.0001 (-2.34)	0.0001 (9.68)	0.00001 (0.04)	0.0002 (12.17)	-0.0001 (-2.43)	-0.0001 (-2.36)	0.0001 (9.68)	0.0001 (9.68)	-0.0005 (-1.20)		0.0002 (12.03)	0.0002 (12.07)
A15: MMC11	0.0001 (7.37)	0.0001 (7.43)	0.0001 (7.54)	0.0001 (7.39)	-0.0001 (-7.91)	0.00002 (2.16)	-0.0001 (-7.39)	0.001 (4.10)	-0.0001 (-8.00)	-0.0001 (-7.96)	0.00002 (2.16)	0.00002 (2.16)	-0.0001 (-7.48)	-0.0001 (-7.43)		0.0004 (1.59)
A16: MMC12	0.0001 (7.25)	0.0001 (7.32)	0.0001 (7.43)	0.0001 (7.28)	-0.0001 (-7.90)	0.00003 (2.10)	-0.0001 (-7.37)	0.0005 (1.84)	-0.0001 (-7.98)	-0.0001 (-7.96)	0.00003 (2.10)	0.00003 (2.10)	-0.0001 (-7.46)	-0.0001 (-7.43)	-0.0004 (-1.38)	

Note: t-statistics are given in parentheses