Do Sales Tax Credits Stimulate the Automobile Market?

Jiawei Chen*, Susanna Esteban†, Matthew Shum‡

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Abstract

In this paper, we quantitatively investigate the effectiveness of a sales tax reduction in stimulating sales and profits of durable goods manufacturers. Our question is motivated by policy makers' recent interest in helping ailing automobile manufacturers and in replacing a fleet of highly polluting vehicles. President Obama's economic stimulus plan, for instance, has directly targeted the primary market by including a sales tax credit on purchases of new cars and trucks. In this paper, we show that the benefit of reducing the sales tax, measured by its effect on firms' profits and sales, greatly decreases with the product's durability. The magnitude of our findings indicates that one must carefully account for durability and firms' behavior when evaluating such policies. Our findings are robust when we vary key parameters of the market.

Keywords: Sales Tax, Durable Goods, Oligopoly, Time Consistency, Secondary Markets, Automobile Industry

* *Department of Economics, University of California-Irvine, Irvine, CA 92697, USA*

† *Department of Economics, Universitat Autònoma de Barcelona, 08193 Bellaterra, Spain.* Esteban is also a member of the Barcelona Graduate School of Economics and acknowledges the support of the Spanish Ministry of Education, of the Excellence Project of the Bank of Spain, of the European Comission (EFIGE 225343), of the Barcelona GSE and of the government of Catalonia.

‡ *Division of Humanities and Social Sciences, California Institute of Technology, Pasadena, CA 91125, USA*

1 Introduction

In this paper, we quantitatively investigate the effectiveness of a sales tax reduction in stimulating sales and profits of durable goods manufacturers. Our question is motivated by policy makers' recent interest in helping ailing automobile manufacturers and in replacing a fleet of highly polluting vehicles. President Obama's economic stimulus plan, for instance, has directly targeted the primary market by including a sales tax credit on purchases of new cars and trucks.[1] The point of our paper is to show that the benefits of reducing the sales tax on new cars, measured by its effect on firms' profits and sales, must be qualified by the durability of the product since these benefits diminish significantly the more durable the product is.

Our result hinges on the product being durable and the firm facing a time consistency problem. Durability implies that consumers are purchasing an asset, with their willingness to pay depending on the anticipated future value. The firm can increase this future value by pre-announcing cutbacks in future output (or high future prices). These pre-announcements, however, are not credible. Consumers anticipate that the firm will lower its price once it has earned its current profit, deviating from its initial announcement. In other words, the firm is competing with its own future self, who does not conform with the current self's plans. In this environment, any mechanism that permits the firm to credibly commit to lowering future output (increasing future prices) has the indirect benefit of implementing a solution that is closer to the commitment (time inconsistent) one and thus, has a (partial) positive effect on the firm's profits.

In this paper, we analyze the effects of one such mechanism, a sales tax. With a dynamic

[1] This program is referred to as the American Recovery and Reinvestment Act Vehicle Tax Deduction, which is different from the popular Cash for Clunkers. Purchasers of new cars and trucks are allowed to deduct sales or excise taxes from their income taxes, without needing to itemize them. The new car purchased must be less than $49,500 and taxpayers must have an adjusted gross income of less than $125,000 if single or $250,000 if married.

equilibrium model of durable goods with secondary markets, which we simulate using parameter values calibrated to the U.S. automobile industry, we quantify the effect of permanently modifying sales taxes when the good is durable. We show that the benefit of reducing the sales tax, measured by the effect on firms' profits and sales, greatly decreases with the product's durability. Our finding that the effect of such policies greatly depends on the durability of the product is a direct implication of the time consistency problem of the firm. The good being less durable attenuates the competition of the firm with its own future self, because finite durability implies that high-willingness-to-pay consumers return to the primary market, which reduces the future self's incentives to lower prices. As a result, the commitment problem is less prevalent and the indirect benefit of taxation decreases. Our results confirm this intuition, showing that the benefits from cutting back sales taxes decrease with durability. These findings are robust when we vary key parameters.

An alternative policy we could have analyzed is a temporary cut in the primary market sales tax. This alternative policy would have the same qualitative effects: taxation confers commitment benefits to the firm and thus the positive effect of a sales tax reduction (both if offered temporarily and permanently) have to be measured against the loss of commitment benefits. In the long run, however, having had a temporary tax yields no effects.

The identification of commitment mechanisms that, despite the induced distortion, may be preferable for a durable goods manufacturer is not new in the literature. Kahn (1986) analyzes the durable goods monopolist's problem with a convex cost function. The shape of the cost function can aid the firm by making cutbacks in future output credible, yielding indirect commitment benefits as well. An implication of the model is that the firm may have an incentive to choose an inefficient technology. Goering and Boyce (1996) analyze the effects of excise taxation with a stylized two-period lived durable goods monopolist model. They find that not only the commitment benefit is present, but that excise taxation can also have an overall positive effect on profits, which is a result we do not obtain in our more empirical framework. Their framework, and also ours, may be nested within Kahn's (1986) setup, because excise taxes are increases in the marginal cost of production. Liang (1999) studies a different mechanism, which is the tradeability in the secondary market, showing that it can give indirect commitment benefits and facilitate the return of high-willingness-to-pay consumers to the primary market, making high future prices credible.

There are other papers analyzing government intervention in the automobile market, but focusing on other effects or policies. Smith (2009) relates to our paper in that it analyzes the effects of taxation, although it focuses instead on how changes to the primary market filter down to the secondary market. Adda and Cooper (2000), Esteban (2007), Schiraldi (2009), Licandro and Sampayo (2004) and Alberini, Harrington, and McConnell (1995) focus on scrappage programs, which have recently been implemented in the U.S. but have been popular for years in the European Union. Fullerton and West (2000), Hahn (1995) and West (2004) analyze various alternative policies that aim to stimulate the retirement of highly polluting vehicles.

Our findings highlight the importance of accounting for durability and time consistency in the problem of the firm when evaluating alternative public policies. Accounting for such an environment implies solving dynamic equilibrium models of demand and supply, which is a complex computational task and which requires simplifying other relevant and interesting aspects of the automobile market. In particular, our model restricts the type of consumer and product heterogeneity, making them both unidimensional, but allows consumers to be forward-looking, anticipating future prices, and firms to be an oligopoly simultaneously solving dynamic problems.

The current paper is part of our research agenda analyzing the dynamic implications of durability and secondary markets, both theoretical and empirical, when the primary market is imperfectly competitive. The model we use here is a simplification of the environment in Chen, Esteban, and Shum (2008), where we quantify the bias in estimating the structural parameters for the model if we do not account for the durability of the product. The models differ in that here we eliminate stochastic costs yet we add primary market taxation. Also related are Esteban and Shum (2007), which derives a dynamic time-consistent oligopoly model but focuses on a linear-quadratic specification, and thus requires a more restrictive environment than the one considered here, and Chen, Esteban, and Shum (2007), where we build a dynamic equilibrium model of durable goods oligopoly in which consumers face lumpy costs of transacting in the secondary markets to quantify the competition that secondary markets represent for durable goods manufacturers.

Also incorporating the supply-side problem with market power are Nair (2004), which estimates an equilibrium dynamic durable goods monopoly model for the console-video game market, and Goettler and Gordon (2008) which estimates a model of dynamic oligopoly with durable goods and endogenous innovation for the PC microprocessors industry. In these two models, as in our present model, both consumers and firms are forward-looking, and solve dynamic programming problems, but there is no secondary market for used goods. Other papers have added a supply side problem but made different assumptions on market power and time consistency. For example, Gavazza and Lizzeri (2008) assume the primary market is perfectly competitive, while Porter and Sattler (1999) solve for the time inconsistent solution to the monopolist's problem.

The next section presents the model. Section 3 describes the parameterization of the model. Section 4 presents the effects of primary market sales taxation. Section 5 concludes.

2 Model

We specify a durable goods oligopolistic model with primary market taxation and a competitive secondary market. The model simplifies the environment in Chen, Esteban, and Shum (2008) by eliminating cost uncertainty and reducing the heterogeneity of the product but retaining the key dynamic properties of the model.

Both firms and consumers are forward-looking. The model is cast in discrete time and has an infinite horizon. The only characteristics of a car are its quality and age. All new cars—cars in their first period of life—are homogenous in quality and after one period of use, all depreciate into used cars also of homogenous quality (albeit possibly different from the one of new cars). Once used, cars face stochastic death and thus their expected lifetime can be more than two periods. These last two assumptions are useful as they allow us to match the average age of cars in the U.S. and the relative size of the primary and secondary markets while retaining the computational tractability of having a limited state space.

The timing of events is as follows. At the beginning of each period, consumers inherit either a used car or the outside good from their decisions in the previous period. Then firms and consumers simultaneously make production and purchase/sale decisions, whereby firms obtain per-period profits and consumers enjoy per-period utility from consumption. At the end of each period, goods depreciate and a new period arrives. We restrict our attention to Markov strategies, where firms' production choices are only a function of the stock of used cars, which is also the supply in the secondary market.

We index cars by $j = 0, 1, 2$, which are, in that order, outside good, new car, and used car. We denote by $\delta \in [0, 1]$ the probability characterizing the process of stochastic death.

In what follows, we describe the model and derive the equilibrium. We consider consumers' and firms' problem in partial equilibrium and then require full equilibrium by clearing all markets and formulating correct expectations on both sides of the market. For consumers' problem, this implies that, for now, consumers take the sequence of prices as given.

2.1 Consumers' Problem and Demand Function

There is a continuum of consumers of size M, with a generic consumer being denoted by i. Consumers are heterogeneous in their valuations of goods, which perturb their choices of goods in every period. Let $\vec{\epsilon}_{it} \equiv (\epsilon_{i0t}, \epsilon_{i1t}, \epsilon_{i2t})$ be the vector of idiosyncratic shocks of consumer i for period t, with the shock being i.i.d. across consumers, car types and time. That is, ex-ante, consumers are identical up to their car endowment.[2] We let r_{it} denote the index of the car owned by the consumer i at the beginning of period t and let K_t denote the fraction of consumers in the population who own a used car at the beginning of t (these consumers either bought a new car in the previous period or owned a used car that did not die). By construction, r_{it} can only equal 0 or 2 (not own a car or be endowed with a used one).

We define consumer i's state at time t to be his endowment, the vector of shocks, and the vector of prices for periods t and $t+1$. Then, consumer i's period-t utility if she chooses $s_{it} = 0, 1, 2$ for consumption can be expressed as

$$u(s_{it}, r_{it}, \vec{\epsilon}_{it}, \vec{p}_t) = \alpha_{s_{it}} + \gamma \left(p_{r_{it}t} - (1 + \mathbf{1}(s_{it} = 1)\tau) p_{s_{it}t} \right) + \epsilon_{is_{it}t}, \tag{1}$$

where γ is her marginal utility of money, α is the quality of the good, which we normalize to 0 for the outside good, $\vec{p}_t = (p_{0t}, p_{1t}, p_{2t})$ is the price vector in period t, with the convention that $p_{0t} = 0$ for all t, and $\tau \in [0, 1]$ is the tax rate on the new good.

[2] Our assumptions on preference heterogeneity are in-line with the literature. An alternative, for example, would have been the demand-side model in Gandal, Kende, and Rob (2000) in which consumers are heterogeneous in their eagerness to purchase.

Because in the model there are no transaction costs that depend on the consumer's particular car endowment, the assumption of quasi-linearity in income of the consumer's per-period utility makes the decision of the consumer in any given period state independent. As a result, the consumer's decision is simplified to be the comparison of the one-period utilities with the price being the implicit rental price, which is the price paid minus the expected resale price at $t+1$. This dependence on the expected resale price is what generates forward-looking behavior on both consumers and firms. Thus, the decision problem of the consumer at t can be written as

$$\max_{s_{it}\in\{0,1,2\}} [\alpha_{s_{it}} - \gamma(1+\mathbf{1}(s_{it}=1)\tau)p_{s_{it}t} + \epsilon_{is_{it}t} + (\mathbf{1}(s_{it}=1)+\mathbf{1}(s_{it}=2)(1-\delta))\beta_2\gamma p_{2t+1},] \tag{2}$$

where β_2 is the consumers' discount factor. We reserve β_1 to denote the firms' discount factor.

Assume ϵ_{ijt} is distributed type 1 extreme value, independent across consumers, goods, and time. Then the demand for new cars, used cars and outside good in period t are given, respectively, by

$$D_1(\vec{p}_t, p_{2t+1}) = M\frac{\exp(\alpha_1 - \gamma(1+\tau)p_{1t} + \beta_2\gamma p_{2t+1})}{1+\exp(\alpha_1 - \gamma(1+\tau)p_{1t} + \beta_2\gamma p_{2t+1}) + \exp(\alpha_2 - \gamma p_{2t} + (1-\delta)\beta_2\gamma p_{2t+1})}, \tag{3}$$

$$D_2(\vec{p}_t, p_{2t+1}) = M\frac{\exp(\alpha_2 - \gamma p_{2t} + (1-\delta)\beta_2\gamma p_{2t+1})}{1+\exp(\alpha_1 - \gamma(1+\tau)p_{1t} + \beta_2\gamma p_{2t+1}) + \exp(\alpha_2 - \gamma p_{2t} + (1-\delta)\beta_2\gamma p_{2t+1})}, \tag{4}$$

and

$$D_0(\vec{p}_t, p_{2t+1}) = M\frac{1}{1+\exp(\alpha_1 - \gamma(1+\tau)p_{1t} + \beta_2\gamma p_{2t+1}) + \exp(\alpha_2 - \gamma p_{2t} + (1-\delta)\beta_2\gamma p_{2t+1})}. \tag{5}$$

We now turn to the supply side problem. As in this section, we first consider partial equilibrium and exogenously set the inverse demand function.

2.2 Firms' Problem

There is an oligopoly of N identical firms, producing a homogenous product, with each firm choosing simultaneously in every period its level of production to maximize its discounted sum of profits. As we restrict attention to Markov strategies, chosen production is only a function of past output, K_t, which we write as $q^*(K_t)$.

Let n be a representative firm and denote the primary market's inverse demand function by $P(Q_t, K_t)$, where Q_t is the total new car production. The inverse demand function derived from the durable goods demand problem must depend on future behavior of the firm. In a Markov perfect equilibrium, future behavior of the firm can be written recursively as a function of the current control and state. Therefore, the assumed inverse demand function $P(Q_t, K_t)$ will later be consistent, when written recursively, with the demand equations that yield the forward-looking dependance. Thus the Bellman equation that characterizes firm n's value function is given by

$$W(K_t) = \max_{q_{nt}} \left[\left(P(q_{nt} + (N-1)q_{-nt}, K_t) - c \right) q_{nt} + \beta_1 W(K_{t+1}) \right], \tag{6}$$

where

$$K_{t+1} = (1-\delta)K_t + q_{nt} + (N-1)q_{-nt},$$

β_1 is the firms' discount factor, and c is the marginal cost of production. Then, in a symmetric MPE, $q_{nt} = q^*(K_t)$ solves the maximization problem in (6) given that all remaining firms produce $q^*(K_t)$ and the value function $W(\cdot)$ satisfies (6).

2.3 Equilibrium

To close down the definition of the Markov perfect equilibrium, we require that all markets clear and that the inverse demand function is consistent across consumers and firms.

First note that the distributional assumptions on preference heterogeneity ensure that the secondary market price is positive since this market is never in excess supply. As a result, the demand for used cars equals the stock. Then market clearance implies $D_1(\vec{p}_t, p_{2t+1}) = Nq^*(K_t)$ and $D_2(\vec{p}_t, p_{2t+1}) = K_t = (1-\delta)K_{t-1} + Nq^*(K_{t-1})$, with the last equality being the law-of-motion of the state.

On the other hand, consistency of the inverse demand functions implies that $P(\cdot)$ solves the demand equations in (3) given $q^*(K_t)$, market clearance and the law-of-motion. To see this, note that the system of the demand equations in (3)—(5) reduces to a system with two equations with 3 unknowns, p_{1t}, p_{2t} and p_{2t+1}. From the supply side problem, let $p_{1t} = P(Q_t, K_t)$ in (3) and solve for p_{2t+1} as a function of Q_t and K_t. Updating to $t+1$ using $q^*(K_{t+1})$ and the law-of-motion, this must be, in equilibrium, consistent with the used car equation in (4). Finally, given the derived functional form for the used car price, p_{1t} obtained in (3) must be consistent with $P(\cdot, \cdot)$.

For details on how this equilibrium is computed, see Chen, Esteban, and Shum (2008).

3 Parameterization

Here we present the parameter values that are used in our baseline model. We assume that the life of a car consists of 2 stages, new and used, and that used cars die stochastically. We choose the depreciation parameter δ to match the average age of cars in the U.S. data. The 2001 National Household Travel Survey (NHTS) reports that the average automobile age in the United States was about 9 years. In our model, this translates into a depreciate rate of $\delta = 0.1$, approximately.

On the supply side, we consider a duopoly so $N = 2$. We choose c, the constant marginal cost of production, to equal the estimate of marginal cost (after deflating it) in Copeland, Dunn, and Hall (2005) (page 28). There a marginal cost of \$17,693 (in 2000 dollars) is reported, which corresponds to \$18,905 in 2003 dollars, so we set $c = 1.9$, the unit being $\$10,000$.[3] We assume the interest rate to be 4%, which is common for consumers and firms. This gives discount factors $\beta_1 = \beta_2 = 1/1.04 \approx 0.96$.

We normalize the population of consumers M to 1. We follow Chen, Esteban, and Shum (2007) in choosing α_1 (the new car utility), α_2 (the used car utility), and γ (the consumers' marginal utility of money). The calibration exercise in that paper, which is based on the American automobile industry over the 1994–2003 period, finds that $\alpha_1 = 2.07$ and $\alpha_2 = 1.40$. In that paper there are two types of consumers in equal proportions, with marginal utilities of money calibrated to be 1.86 and 2.75, respectively. Here we set γ to be 2.31, which is the average of those two numbers.

4 Effects of Primary Market Tax Reduction

Using the model developed above, we investigate the effects of a primary market tax reduction when goods are durable, by varying the tax rate on new goods. For each parameterization, we solve the model for the steady state prices, quantities, markup, and profit. Our focus is on how the tax reduction affects firms' profits and sales. The hypothesis is that a reduction in taxes is less beneficial to the firms if the good is more durable because sales taxes confer indirect commitment benefits to durable goods manufacturers. We vary δ in

[3] An alternative would be to use the marginal cost estimates in Berry, Levinsohn, and Pakes (1995) (pg 882), but recent estimates are significantly lower reflecting the reduction in marginal costs of production in the industry over more recent years.

our model (the probability of stochastic death) to evaluate our hypothesis and β_2 (the consumers' discount factor) to validate the role of commitment. We also vary γ (the consumers' marginal utility of money) to establish robustness patterns.

4.1 Results from the Baseline Model

The top panel in Table 1 presents the results from our baseline model, with the tax rate on new cars being τ = 30%, 20%, 10%, and 0%. The results, so far, are as expected. When the tax rate is decreased, production increases and is transacted at a lower after-tax price. Firms' markup, measured as $\frac{p_1 - c}{p_1}$, increases, reflecting an increase in the before-tax price, and firms' profits increase as well. For example, when the tax rate on new cars drops from 20% to 0%, new car production increases by 3%, firms' markup increases by 17%, and firms' profits increase by 27%. The reduction in the tax rate on new cars also affects the secondary market. In particular, the price of used cars decreases, paralleling the behavior of prices in the primary market.

4.2 Durability

The surprising finding surfaces when we vary durability and modify the expected lifetime of cars. As previously argued, taxation brings forth indirect commitment benefits by making cutbacks in future output credible. A cut back in future output increases the expected resale price of used cars and this feeds back into the valuation of consumers who now capitalize a higher resale value, yielding higher profits for the firms.

Shortening the lifetime of a car attenuates the commitment problem. Because of the shorter durability, high-willingness-to-pay consumers return to the primary, which works by reducing the firms' incentives to lower future prices (increase output). As a result, the commitment problem is less prevalent when the good is less durable and the indirect benefit of taxation decreases.

The results presented in Table 1 confirm this intuition. From top to bottom, the five panels in Table 1 report the steady state results with $\delta = 0.1$ (the baseline), 0.05, 0.15, 0.2, and 1, respectively. We find that as used cars become less durable, the increase in firms' profits due to the tax reduction becomes more significant. For example, consider a tax rate decrease from 20% to 0%. With $\delta = 0.1$, firms' profits increase by 27%. When used cars are more durable with $\delta = 0.05$, firms' profits increase by a smaller percentage, 24%. As we increase δ, the percentage increase in profits goes up to 31% when $\delta = 0.15$, 33% when $\delta = 0.2$, and 70% when $\delta = 1$ (which corresponds to used cars living for only one period and then dying with probability 1). The evolution of new car sales and its magnitude mimics the one of profits: an increase in 3% of production for the baseline value of durability, contrasting with a much larger 33% increase when $\delta = 1$.

Thus, the benefit of reducing the sales tax, measured by its effect on firms' profits and sales, greatly decreases with the product's durability. The magnitude of our findings highlights the importance of accounting for durability and firms' behavior when evaluating such policies.

We next show that these findings are robust when we vary key parameters.

4.3 Robustness Checks

Our first robustness check is to vary the consumers' discount factor, β_2. Varying this discount factor also allows us to validate the role of commitment in our discussion.

The consumers' discount factor, and not the firms', is the key to the firms' commitment problem. Suppose the firm only values the present, with $\beta_1 = 0$, but consumers value the future at some positive discount rate $\beta_2 > 0$. Because consumers value the future in their decision problem, they value the discounted expected resale price, which the firm can, as before, affect by pre-announcing cutbacks in future output. These pre-announcements, however, are not credible unless there is a mechanism that implements them. Notice that this time consistency argument does not rely on the firms' discount factor, instead, it fully depends on the consumers being patient. An increase in the consumers' discount factor exacerbates the firms' commitment problem as the consumer gives more weight to the lower expected resale price, which, in turn, lowers her willingness to pay. Therefore, intuitively, we expect that lowering taxation will have greater benefits when consumers are less patient since, for these cases, the indirect benefit of taxation is less prevalent.

Tables 2 and 3, which report the results for the parameterizations with $(\beta_2, \gamma) = (0.9, 2.31)$ and $(0.8, 2.31)$, confirm our intuition. For example, for the baseline case of $\delta = 1$, profits increase by 37%, 30% and 27% with β_2 being equal to 0.80, 0.9 and 0.96 respectively. As before, the % increases are computed for a tax rate drop from 20% to 0%.

We conduct additional robustness checks varying the consumers' marginal utility of money, γ. For the sake of brevity, we do not report the results here, as they are qualitatively identical.

5 Conclusion

In this paper, we have quantitatively investigated the effects of sales tax reductions in stimulating sales and profits of automobile manufacturers. We have shown that the benefit of reducing the sales tax, measured by its effect on firms' profits and sales, significantly decreases with the product's durability. Our findings hinge on taxation providing an indirect commitment benefit to durable goods manufacturers, which limits the benefits of tax reduction policies when goods are durable.

The quantitative magnitude of our findings stresses the importance of accounting for durability and time consistency in the problem of the firms when evaluating alternative public policies. Accounting for such an environment implies solving dynamic equilibrium models of demand and supply, which is a complex computational task and which requires simplifying other relevant and interesting aspects of the automobile market. In this paper, we approach this problem with a simplified model. Nonetheless, given the popularity and diversity of government intervention policies in the primary market, and the importance of this market, we believe more work needs to be done in analyzing and comparing alternative policies while accounting for the durability of the product and the resulting dynamic problems of demand and supply. As shown in this paper, the benefits of such policies may need to be qualified if the goods are durable.

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Table 1. Effects of primary market tax incentives: more vs. less durability; beta2 = 0.96, gamma = 2.31

Baseline: delta = 0.1

Tax rate (%) on new cars	30	20	10	0
New car production per firm	0.033	0.033	0.034	0.034 (+3%)
New car price (including tax)	3.151	2.974	2.794	2.614
Used car transaction	0.226	0.223	0.220	0.217
Used car price	1.702	1.540	1.376	1.211
Firm markup: (p1-c)/p1	0.216	0.233	0.252	0.273 (+17%)
Profit per firm	0.017	0.019	0.022	0.024 (+27%)

The number in parentheses is the percentage change in the variable when tax rate drops from 20% to 0%.

More durability: delta = 0.05

Tax rate (%) on new cars	30	20	10	0
New car production per firm	0.018	0.018	0.018	0.018 (+2%)
New car price (including tax)	3.101	2.908	2.722	2.535
Used car transaction	0.203	0.200	0.197	0.194
Used car price	1.445	1.261	1.084	0.906
Firm markup: (p1-c)/p1	0.203	0.216	0.232	0.251 (+16%)
Profit per firm	0.009	0.009	0.010	0.012 (+24%)

The number in parentheses is the percentage change in the variable when tax rate drops from 20% to 0%.

Less durability: delta = 0.15

Tax rate (%) on new cars	30	20	10	0
New car production per firm	0.045	0.046	0.047	0.047 (+4%)
New car price (including tax)	3.148	2.973	2.800	2.627
Used car transaction	0.241	0.238	0.236	0.233
Used car price	1.780	1.627	1.476	1.325
Firm markup: (p1-c)/p1	0.215	0.233	0.254	0.277 (+19%)
Profit per firm	0.023	0.026	0.030	0.034 (+31%)

The number in parentheses is the percentage change in the variable when tax rate drops from 20% to 0%.

Less durability: delta = 0.2

Tax rate (%) on new cars	30	20	10	0
New car production per firm	0.054	0.056	0.057	0.058 (+5%)
New car price (including tax)	3.128	2.956	2.785	2.616
Used car transaction	0.248	0.247	0.245	0.243
Used car price	1.796	1.652	1.508	1.366
Firm markup: (p1-c)/p1	0.210	0.229	0.250	0.274 (+20%)
Profit per firm	0.028	0.031	0.036	0.042 (+33%)

The number in parentheses is the percentage change in the variable when tax rate drops from 20% to 0%.

Less durability: delta = 1

Tax rate (%) on new cars	30	20	10	0
New car production per firm	0.062	0.073	0.085	0.097 (+33%)
New car price (including tax)	2.983	2.788	2.607	2.443
Used car transaction	0.108	0.125	0.141	0.156
Used car price	1.388	1.287	1.191	1.103
Firm markup: (p1-c)/p1	0.172	0.182	0.198	0.222 (+22%)
Profit per firm	0.024	0.031	0.040	0.053 (+70%)

The number in parentheses is the percentage change in the variable when tax rate drops from 20% to 0%.

Table 2. Effects of primary market tax incentives: more vs. less durability; beta2 = 0.9, gamma = 2.31

delta = 0.1

Tax rate (%) on new cars	30	20	10	0
New car production per firm	0.031	0.032	0.032	0.033 (+4%)
New car price (including tax)	3.086	2.911	2.733	2.558
Used car transaction	0.236	0.233	0.229	0.225
Used car price	1.652	1.491	1.328	1.167
Firm markup: (p1-c)/p1	0.200	0.217	0.235	0.257 (+19%)
Profit per firm	0.015	0.017	0.019	0.022 (+30%)

The number in parentheses is the percentage change in the variable when tax rate drops from 20% to 0%.

More durability: delta = 0.05

Tax rate (%) on new cars	30	20	10	0
New car production per firm	0.017	0.017	0.018	0.018 (+3%)
New car price (including tax)	3.051	2.867	2.676	2.499
Used car transaction	0.216	0.212	0.207	0.203
Used car price	1.402	1.226	1.042	0.874
Firm markup: (p1-c)/p1	0.190	0.205	0.219	0.240 (+17%)
Profit per firm	0.008	0.008	0.009	0.011 (+26%)

The number in parentheses is the percentage change in the variable when tax rate drops from 20% to 0%.

Less durability: delta = 0.15

Tax rate (%) on new cars	30	20	10	0
New car production per firm	0.042	0.043	0.044	0.046 (+5%)
New car price (including tax)	3.078	2.905	2.734	2.563
Used car transaction	0.246	0.244	0.241	0.238
Used car price	1.733	1.580	1.429	1.279
Firm markup: (p1-c)/p1	0.198	0.215	0.235	0.259 (+20%)
Profit per firm	0.020	0.023	0.026	0.030 (+34%)

The number in parentheses is the percentage change in the variable when tax rate drops from 20% to 0%.

Less durability: delta = 0.2

Tax rate (%) on new cars	30	20	10	0
New car production per firm	0.051	0.053	0.054	0.056 (+7%)
New car price (including tax)	3.073	2.898	2.726	2.556
Used car transaction	0.250	0.249	0.248	0.246
Used car price	1.768	1.620	1.473	1.330
Firm markup: (p1-c)/p1	0.196	0.213	0.233	0.257 (+20%)
Profit per firm	0.023	0.027	0.031	0.037 (+36%)

The number in parentheses is the percentage change in the variable when tax rate drops from 20% to 0%.

Less durability: delta = 1

Tax rate (%) on new cars	30	20	10	0
New car production per firm	0.058	0.069	0.081	0.094 (+35%)
New car price (including tax)	2.971	2.773	2.588	2.420
Used car transaction	0.102	0.119	0.136	0.152
Used car price	1.425	1.321	1.221	1.127
Firm markup: (p1-c)/p1	0.169	0.178	0.193	0.215 (+21%)
Profit per firm	0.022	0.028	0.037	0.049 (+71%)

The number in parentheses is the percentage change in the variable when tax rate drops from 20% to 0%.

Table 3. Effects of primary market tax incentives: more vs. less durability; beta2 = 0.8, gamma = 2.31

delta = 0.1

Tax rate (%) on new cars	30	20	10	0
New car production per firm	0.028	0.029	0.030	0.031 (+7%)
New car price (including tax)	2.994	2.818	2.643	2.475
Used car transaction	0.246	0.243	0.239	0.235
Used car price	1.580	1.418	1.256	1.100
Firm markup: (p1-c)/p1	0.175	0.191	0.209	0.232 (+22%)
Profit per firm	0.011	0.013	0.015	0.018 (+37%)

The number in parentheses is the percentage change in the variable when tax rate drops from 20% to 0%.

More durability: delta = 0.05

Tax rate (%) on new cars	30	20	10	0
New car production per firm	0.016	0.016	0.017	0.017 (+6%)
New car price (including tax)	2.975	2.797	2.613	2.437
Used car transaction	0.232	0.227	0.220	0.214
Used car price	1.335	1.164	0.987	0.819
Firm markup: (p1-c)/p1	0.170	0.185	0.200	0.221 (+19%)
Profit per firm	0.006	0.007	0.008	0.009 (+32%)

The number in parentheses is the percentage change in the variable when tax rate drops from 20% to 0%.

Less durability: delta = 0.15

Tax rate (%) on new cars	30	20	10	0
New car production per firm	0.037	0.039	0.041	0.043 (+9%)
New car price (including tax)	2.997	2.821	2.647	2.477
Used car transaction	0.250	0.249	0.248	0.245
Used car price	1.684	1.526	1.371	1.220
Firm markup: (p1-c)/p1	0.176	0.192	0.210	0.233 (+22%)
Profit per firm	0.015	0.018	0.021	0.025 (+39%)

The number in parentheses is the percentage change in the variable when tax rate drops from 20% to 0%.

Less durability: delta = 0.2

Tax rate (%) on new cars	30	20	10	0
New car production per firm	0.044	0.047	0.050	0.052 (+11%)
New car price (including tax)	3.003	2.825	2.650	2.478
Used car transaction	0.247	0.249	0.250	0.250
Used car price	1.739	1.585	1.434	1.286
Firm markup: (p1-c)/p1	0.178	0.193	0.211	0.233 (+21%)
Profit per firm	0.018	0.021	0.025	0.030 (+41%)

The number in parentheses is the percentage change in the variable when tax rate drops from 20% to 0%.

Less durability: delta = 1

Tax rate (%) on new cars	30	20	10	0
New car production per firm	0.052	0.063	0.075	0.088 (+40%)
New car price (including tax)	2.951	2.752	2.560	2.384
Used car transaction	0.093	0.109	0.127	0.145
Used car price	1.488	1.381	1.274	1.171
Firm markup: (p1-c)/p1	0.163	0.171	0.184	0.203 (+18%)
Profit per firm	0.019	0.025	0.032	0.042 (+73%)

The number in parentheses is the percentage change in the variable when tax rate drops from 20% to 0%.