An Initial Look at Incentives and Prices for Motor Vehicles: What has been Happening in Recent Years?

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Abstract

We construct price indexes for motor vehicles for recent years using a unique dataset collected from a large national sample of motor vehicle dealerships. Given a wealth of information on both actual transaction prices and quantities in this dataset, we are able to estimate price measures within a matched-model framework. The resulting indexes illustrate an interesting pattern in which vehicle prices drop significantly as they near the end of their model-year life cycle, in large part through the use of marketing incentives. To examine why vehicle prices behave in this way, we also estimate constant-quality price changes using a hedonic regression. After controlling for the vehicle's fixed characteristics, we find that the value of a vehicle declines the longer it sits on the dealer's lot. We also test whether prices decline over the model year as the novelty of a newly introduced vehicle wears off, though we find little evidence that this has much of an effect.

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1. Introduction

Although motor vehicle manufacturers have used various types of incentives to boost consumer sales for some time, incentives in recent years appear to have become both more generous and more widespread. We construct monthly price indexes for motor vehicles from 1999 to 2003 using a unique dataset collected from a large national sample of motor vehicle dealerships that contains information on both actual transaction prices and quantities. Given such a wealth of data, we are able to estimate *monthly* price measures within a matched-model framework, and to the best of our knowledge, this is the first work to examine the within-year pattern of prices using such detailed information. The resulting indexes illustrate an interesting pattern in which vehicle prices drop significantly over the course of their model-year life cycle, in large part through the use of marketing incentives.

Vehicle prices may trend lower over the model year because of changes in dealers' costs. However, when we construct matched-model price indexes of dealer cost, we find that they are relatively stable over the four-year sample period, and they decline less than retail prices over the course of the model year do. We therefore conclude that it is movements in markups that account for most of the variation in prices.

Working on the assumption that the model-year price declines are demand driven, we then attempt to test two possible explanations for the observed pattern. In the first, motor vehicles prices behave like those of seasonal commodities, and prices are high initially because of the newness of the vehicles and the prestige associated with owning one. An alternative hypothesis is that as new vehicles sit on dealer lots they are subject to depreciation, in part because of the anticipated appearance of new and better vehicles each model year. Whether the model-year price declines are driven by seasonal or depreciation effects has implications for how these prices are measured. If seasonal, then chaining the month-to-month price changes is inappropriate, and we should look only at year-over-year changes in vehicle prices.

The remainder of this paper is organized as follows: In section 2 we provide an overview of the behavior of marketing incentives over the past four years and describe the data that we obtained from J.D. Power and Associates. In section 3 we present several matched-model price indexes and review their implications. Sections 4 and 5 contain the results of the hedonic price

regressions, and Section 6 includes a brief set of conclusions.

2. Incentives and Overview of the Database

Chart 1 shows two types of popular consumer incentives: cash rebates and reduced-rate financing. The top panel displays the average level of cash rebates calculated as the total nominal value of cash rebates in a period divided by the total number of sales in that particular period. The top panel also shows the average present discounted value of reduced-rate financing, which is referred to as interest rate subvention. The interest subvention plotted in chart 1 was constructed by J. D. Power and Associates. In constructing the measure, buyers are presumed to have received a subsidized interest rate if the interest rate on their purchase is below a set rate of 6 or 7 percent (depending on the time period).[1] These are assumed to be the rates that the individual would have received at a commercial bank or some other independent source of financing.

As seen in the chart, the two types of incentives have grown in value significantly in recent years. After changing little on balance from early 1998 through most of 2001, interest subvention shot up in October 2001. Following the attacks of September 11, General Motors announced a program that offered purchasers either zero percent financing for up to 60 months or a cash rebate. This proved to be immensely popular. In response, most other motor vehicle manufacturers also offered zero percent financing or boosted their incentive programs.

Over recent years, cash rebates have steadily moved higher, but they plummeted at the end of 2001 as interest subvention soared. Indeed, the two series often move inversely. For most vehicles, consumers may choose either the cash rebate or the special reduced-interest incentive but not both. However, it is possible for a consumer to take the rebate and still get a below-bank rate from an auto finance company, which would still be captured as interest subvention. In general, financing incentives have been more generous than cash rebates.

The bottom panel of chart 1 shows two measures of how widely used the incentives have

[1]We have observations on the interest rate of any purchase made through the dealership using either a dedicated lender or one of the captive finance companies such as GMAC, Ford Credit, or Chrysler Financial.

become. Recently, cash rebates are estimated to have been used in more than 50 percent of sales, and interest subvention occurred in more than 70 percent of purchases. The results in the chart 1 are rather startling. The data suggest that virtually all motor vehicle retail purchases since late 2001 received some type of sales incentive.[2]

As previously mentioned, the data shown in chart 1 are from a database constructed by J.D. Power and Associates called the Power Information Network Explorer (or PIN) database. This database contains daily information on motor vehicle transactions from dealerships around the country. The data are uploaded daily directly from the dealerships' F&I (finance and insurance) systems. The data are then checked for reporting or clerical errors before being made available to subscribers. The database is incredibly rich and includes a plethora of information on the type of vehicle sold, its cost, and price. Two demographic variables, consumer age and gender, are also collected.[3] The type of data collected in PIN are shown in table 1A. Categories that are in bold are used to generate our estimates and are explained a little later. According to J.D. Power, the PIN sample represents 70 percent of the geographical markets in the United States. Within those markets, J.D. Power collects data from roughly 1/3 of the dealerships and, all told, captures 15 to 20 percent of national retail transactions.[4]

To examine motor vehicle incentives and prices, we used monthly transactions data on both purchased and leased new motor vehicles by model and model year, e.g., 2001 Mercury Sable. The data used in estimating the price indexes run from March 1999 through March 2003

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[2]As mentioned previously, buyers may accept the cash rebate and still receive a below market finance rate, although not the special rate offered in the incentive program.

[3]Using the buyer's address recorded in the dealers' F&I system, J. D. Power has also linked observations in PIN with 1990 Census track data, which provides further information on education, ethnicity, income, family size, and profession.

[4]The geographic markets as of late 2002 were Boston, New York, Philadelphia, Pittsburgh, Baltimore, Washington DC, Charlotte, Atlanta, Orlando, Tampa, Miami, Houston, Dallas/Fort Worth, Tulsa/Oklahoma City, St. Louis, Indianapolis, Cleveland, Memphis/Nashville, Chicago, Detroit, Minneapolis/St. Paul, Denver, Phoenix, Los Angeles/San Diego, San Francisco/Sacramento, and Seattle/Tacoma/Portland.

for a total of 21,234 observations.[5] Table 1B provides examples of the model-level detail as well as our nomenclature. These data are incredibly rich. For example, although we generally refer to the various observations as model-level data, for many vehicles the observations are at a more detailed level, what is commonly referred to as "trim level." For example, we include in our sample the model, Buick LeSabre. The trim level appellation is Buick LeSabre Limited. However, for some models in our sample (for example, the Mercedes ML320 or the BMW 325XI in table 1B), no further level of detail is available. Thus, our sample includes these models at essentially the trim level. We believe that our unit of observation, vehicles by model and model year, is at a sufficiently detailed level to accurately estimate the matched-model price indexes.[6]

Table 2 shows the number of models by model year. All told, we have observations on 420 models. We also collected information on the number of vehicles that are completely new to the market as well as the number that have received a major redesigns. Since 1998, for each model year (with the exception of 2003), the number of models in our database has grown steadily. Our dataset is thus capturing an important development in vehicle markets during this period, when manufacturers were rapidly expanding the number models in an attempt to fill various "niches" in the market. This assumption is supported by data from Ward's Communications (chart 2 and table 2), which also shows the number of unique models rising over time.

Table 3 summarizes other variables in our dataset. The average vehicle price before incentives in the sample is $30,460. This is above the implied average price for automobiles and

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[5]This is the number of observations after editing the original data pulled from PIN. Some models were dropped because of an insufficient number of observations on sales, or the model was missing a significant number of observations in some other series that we used. In addition, days-to-turn was truncated for some models to avoid distorting estimates in our hedonic regressions. For several models, the days-to-turn series had a few observations appear following several months of no observations. Sometimes these dangling observations appeared 2-1/2 years after the model was introduced. This likely reflected dealer swaps wherein a dealer agrees to take a vehicle (usually a less desirable one) in exchange for obtaining a desired vehicle from another dealership.

[6] The PIN system classifies transactions at an even more detailed level, a level that PIN terms "trim-level." We have done some experimentation with these data, and have found that working at this level roughly doubles the size of the database while not materially changing results.

light trucks of about $22,000 used by the Bureau of Economic Analysis (BEA) in the NIPA accounts. However, the median vehicle price in our dataset is a little over $25,000, which is closer to the NIPA average.

Vehicle price less cash rebate (line 2) is a concept closest to what the Bureau of Labor Statistics (BLS) attempts to measure in the CPI for new motor vehicles. In general, customers are given a choice of either cash back or a reduced-rate financing when purchasing a vehicle. When this occurs, the BLS incorporates the value of the cash rebate into the price of the vehicle regardless of what the buyer actually chose.

Cash rebates (line 4) by model and model year were taken directly from the PIN database and the mean is the difference between the series in lines 1 and 2. However, we constructed model-level estimates of the value of discounted financing, commonly referred to as "subvention," so that we could develop price measures that capture the full effects of the discounts and incentives offered to consumers during our period of study. This was accomplished as follows: First, for each monthly observation by model and model year we calculated the present discounted value of loan payments using available data on the average amount financed, the average loan term, and the average interest rate paid. We then constructed the discounted value of what the loan payments would have been had consumers instead paid the average auto finance rate charged by commercial banks for a 48 month loan (a time series published by the Federal Reserve).[7] The value of subvention was then defined as the difference between these two estimates. Although the bank rate varies more over time than the fixed assumptions used by the J.D. Power series (chart 1), it does not vary by model. Thus, it assumes that all buyers in a given period carry the same risk.

As shown in table 3, the average value of interest subvention ($870) in recent years has exceeded the value of cash rebates ($520). If one believes that the value of all consumer incentives should be reflected in any measure of new vehicle prices, then the CPI as currently constructed has likely overstated consumer prices.[8] In contrast, the PPI, as a measure of the

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[7]This rate appears monthly in the Federal Reserve Board Consumer Credit release (G.19).

[8]The CPI no longer includes the line item, "automobile finance charges" that was separate from the index for new vehicles. One could argue that interest subvention should not affect new vehicle prices,

price received by the manufacturer net of any discounts, reflects the value of both cash rebates and interest subvention. Our series, price less cash rebates and subvention (line 3 of table 3) is the price series closest to the PPI concept.

Vehicle cost (line 6) measures the cost of the vehicle at the time of sale. It includes transportation charges and the cost of dealer add-ons such as roof racks and paint sealants. Ideally, vehicle cost would only include the cost of manufacturing and transporting the vehicle to the dealership. However, our cost measure also includes the value of factory-to-dealer cash incentives and dealer advertising allowances.

Days-to-turn (line 7) captures the number of days that a vehicle is on a dealer's lot. For example, if the dealer obtained a new vehicle on September 1 and sold it on September 15, days-to-turn would equal 15. Days-to-turn can be affected by overall vehicle demand. In addition, it also tends to lengthen as a vehicle comes to the end of the its model life and new model-year vehicles appear on dealers lots. The median number of days-to-turn in the sample is 53; however, for 438 observations, or 2 percent of the sample, days-to-turn is greater than a year. Days-to-turn is less than 5 days for one percent of the sample (225 observations); this seems plausible given that vehicles are often ordered by consumers who want a particular color or trim combination.

3. Matched-Model Indexes

The J.D. Power monthly model-level data contain a nontrivial set of "matched" observations from one period to the next (table 4). As a result, an aggregate price index can be compiled by successively applying a superlative index number formula to those items for which prices are observed in adjacent periods. The result is a form of matched-model index. We calculate matched-model price indexes using three formulations, the Tornqvist, the Fisher, and a geometric mean.

The matched-model Tornqvist price index, for example, is a weighted geometric mean of price ratios in two periods using an average of each item's revenue share in the two periods as

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but should reduce overall consumer prices (Lebow, 2001). However, currently the overall CPI does not reflect the value of new motor vehicle interest subvention.

weights. In logs the aggregate price, P^{MT}, from t-1 to t is expressed as

(1) $$\ln P^{MT}_{t} - \ln P^{MT}_{t-1} = \Sigma_{m\in Mt/t-1}\, s_{m,t}\, (\ln P_{m,t} - \ln P_{m,t-1}) ,$$

where $$s_{m,t} = ½\, [PQ_{m,t} / \Sigma_{m\in Mt/t-1} PQ_{m,t} + PQ_{m,t-1} / \Sigma_{m\in Mt/t-1} PQ_{m,t-1}] .$$

Summation over matched models is denoted as $\Sigma_{m\in Mt/t-1}$, where the number of homogeneous varieties produced or sold in each period is given by M_t, and the number produced or sold in adjacent periods is $M_{t/t-1}$, (that is, $M_t \cap M_{t-1}$). When the results of (1), as well as results using the closely related Fisher formula, are chained together over T periods, the price index will be exact for periods before and after changes in the composition of $M_{t/t-1}$ (Diewert 1987).

The geometric mean indexes we calculate use (1) with $s_{m,t}$ replaced by $1/M_{t/t-1}$. Of course, if prices of all items being aggregated move in pretty much the same proportions, as one might expect if the items are close substitutes (different brands of essentially the same sport utility vehicles, for example), then this aggregation formula will produce pretty much the same result as a weighted, or superlative, formulation (Abraham, Greenlees, and Moulton 1998).

Chart 3 shows matched-model Fisher price indexes for the three price concepts discussed earlier. As may be seen, the inclusion and treatment of incentives in the underlying price data has noticeable effects on the aggregate results. The broadest measure (the blue line) posts a cumulative decline of more than 20 percent for the period shown, an annual average drop of about 5-1/2 percent. By contrast, the index calculated using prices before customer cash rebates (the black line) falls just more than 10 percent, a 2-3/4 percent average decline per year over the period shown. The effect of the sharp increase in the value and incidence of interest subvention alone shows through in the difference between the broadest measure and the measure that just excludes customer cash rebates (the red lines). Note that these price indexes diverge noticeably only for the very recent period, that is, beginning in 2001.

The underlying quantity data used for weighting all indexes in chart 3 are the actual quantities sold per period, and the post-2000 results suggest that these magnitudes have also been affected by the average size, prevalence, and type of incentive on each vehicle. When General Motors offered zero interest finance rates on their makes in the wake of 9/11, consumer expenditure patterns shifted toward these models. When these expenditure patterns are applied

to price measures that do not include interest subvention, the aggregate matched-model price indexes post a temporary increase.

Table 5 provides a summary comparison of the matched-model price indexes using the Fisher (the indexes charted), Tornqvist, and geometric mean formulas. For the indexes of prices before cash rebates and of prices after cash rebates, the weighted formulas fall noticeably more slowly than the indexes that use the geometric mean formulation. However, the results for index formulations for prices after cash rebates *and* interest subvention are not materially different from one another, suggesting that price movements for vehicles that are close substitutes to one another are highly similar once interest subvention is taken into account.

Returning to chart 3, note that all matched-models measures fall appreciably faster than BLS's official measure, which raises a number of questions. It's obviously difficult for us to answer specific questions about BLS's prices, but we do know that, in addition to having very detailed information on cash and financing incentives, the J.D. Power PIN dataset that we are using differs from that of the BLS in that our data include monthly observations on *quantities* and well as prices. As suggested by table 4, we often simultaneously observe selling prices for a given model vehicle in a given model year with those for the same vehicle in an adjacent model year. As a result, we are able to include the price change for each model-year vehicle, where the change for each year is included in the index with the appropriate quantity weights.

Rather than comparing our results with official data, therefore, what we would like to stress is that the dataset we are using differs from those that have been used in earlier studies of motor vehicle prices in that we have *monthly* data; for example, Court (1939), Griliches (1971), Berry, Levinson and Pakes (1995), and Raff and Trajtenberg (1997) all used annual or model-year data. We are thus able to look at the intra-year pattern of vehicle price change, which raises a number of interesting questions about the determinants of prices for durable goods that undergo frequent and/or recurring upgrades, changes, and redesigns.

Chart 4 illustrates what's going on by model year in our matched-model superlative price indexes. The top panel graphs monthly expenditure shares by model year. As may be seen, the transition to a new model year is largely over by the end of each calendar year, and the changes in shares are most dramatic during the summer months. Nonetheless, what is striking is that,

contrary to popular wisdom, the expenditure shares by model year do not change abruptly at one point in a given year, and the total length of time a given model-year vehicle is *marketed* (not produced) substantially exceeds one year.

The bottom panel of chart 4 stacks *two-year* plots of matched-model price indexes calculated *for each model year* (the price measure used is the price after customer cash rebate, and each two year period begins in January). As suggested by the expenditure shares in the upper panel, the period from September of one calendar year, T, to September of the next model year, T+1, is the core selling period for vehicles in model year T+1, but the selling period can begin as early as January in year T and continue for two years after that. The pattern of these price indexes by model year clearly illustrates what is happening in the aggregate matched-model indexes: Vehicle prices by model year fall over the course of each model year. These price-by-model-year measures, when aggregated by the shares shown in the top panel, yield the aggregate matched-model price measures shown in chart 3. Thus, the cumulative drop in our overall indexes would appear to result, at least in part, from the month-to-month chaining of these recurring within-year price declines.

The downward trend in light vehicle prices over the model year could be driven by producer costs, or it could be a demand-driven phenomenon. Because the J.D. Power data contain information on the dealers' vehicle cost, we can also examine the within-year pattern of costs. Aggregate matched-model indexes of vehicle cost and vehicle cost after incentives are shown in chart 5, and two-year stacks of these cost indexes by model year are shown in chart 6. As may be seen, the drops in the overall cost indexes are much less than the comparable consumer price measures (e.g., compare the results in chart 2 with those in chart 5). Note also that the dealers' basic costs over the model year change little (the upper panel of chart 6), even when cash rebates are subtracted from vehicle cost (the lower panel of chart 6). The average decline in vehicle cost less cash rebates over the core model year selling period (September to September) is about 2 percent, which is 2 percentage points less than the drop in the comparable retail price.

All told, these results suggest that only a very small portion of the drop in consumer vehicle prices over the model year stems from underlying producer costs. With regard to the

price measure that excludes cash rebates, about one-half of the downward trend in consumer prices stems from the incentives, and, by implication, the remainder of the intra-year variation is accounted for by dealer markups.

The accuracy of the price measures shown in chart 3 and table 5 is predicated on assumptions that deserve further scrutiny, however. Although the basic physical characteristics of a vehicle do not change over the period in which a given model year vehicle is produced and sold, the matched-model indexes we have calculated will not be accurate measures of price change if, all else equal, consumers would not purchase the same car, defined in terms of these basic physical characteristics, at the same price over the course of the model year.

The vehicle attributes, or characteristics, that are being held constant from one month to the next in our matched-model indexes include, at a minimum, those that have been found to be important determinants of vehicle prices in earlier studies. But, as noted earlier, this literature has not addressed the determinants of within-year pricing, and we still may be missing important characteristics that vary over the course of model year. For instance, new vehicles may be subject to price depreciation as they sit on dealer lots waiting to be sold, and thus their "age" in inventory may be an important demand characteristic.

Alternatively, consumers' valuation of a vehicle's (fixed) attributes may simply change in a systematic, recurring, manner each year, year in and year out. If so, consumer vehicles should be treated as "weakly seasonal" commodities (Dard 1998, 2003). The chaining of month-to-month price changes using a conventional index number formula is inappropriate for seasonal commodities; only year-over-year changes yield like-with-like comparisons.[9] Indeed, if the model year price indexes shown in chart 3 were linked together a year-over-year fashion, they would post only a small decline over the period shown.

These alternative explanations of the observed within-year pattern of vehicle prices are explored in the next section using price hedonic.

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[9] By "conventional" index number formula, we (following Diewert) are referring to a superlative index number that treats models at the close of one season and models at the beginning of another as separate items in (1).

4. Hedonic Regressions

The typical hedonic regression expresses the prices of varieties of a good in terms of the quantities of characteristics contained in each variety in the period and dummy variables in time. When there are nontrivial sets of overlapping varieties from one period to the next, and the data are organized so that each model represents a homogeneous variety, and the coefficients on each characteristic are allowed to vary by model, the hedonic regression can be expressed as a fixed-effects model (Aizcorbe, Corrado, and Doms 2000). Each unique model (m = 1, ... N) can be assigned a dummy variable that captures the average value of its unique characteristics on its price.

Our data conform to these demands of the fixed-effects model, and as a proxy for measurements on the (fixed) physical characteristics of each vehicle, we define and use a dummy variable for each model-year vehicle in the sample, i.e., "2001 Honda Accord." Over the four-year sample period there are 1,650 such combinations of models and model years and a total of 21,234 observations.[10] Because the characteristics of a vehicle are fixed over its selling cycle, and because each model of vehicle has many observations, these dummy variables account for much of the cross-sectional variation in prices while allowing for the "brand effects," or model-specific values for coefficients on characteristics, that many researchers have found important in empirical work using the hedonic technique.

The presence and significance of within-year effects is explored by using measurements (Z) that vary by month and by model. The hedonic regressions we estimate thus use the following semi-logarithmic form:

$$(2) \qquad \ln P_{m,t} = \Sigma_m \underset{\sim}{\Phi}_m MD_m + \Sigma_m \Sigma_k \underset{\sim}{\beta}_k Z_{k,m,t} + \Sigma_t \underset{\sim}{\delta}_t TD_{m,t} + \underset{\sim}{\varepsilon}_{m,t}$$

where $MD_{m,t}$ = 1 if the price is for model m, and
= 0 otherwise.

$Z_{k,m,t}$ = the value of within-year measurement k for model m at time t.

$TD_{m,t}$ = 1 if a price for model m is observed at time t, and
= 0 otherwise.

[10] The sample for price after cash rebates and interest subvention is slightly smaller, because for some of the observations we did not have the variables needed to construct an estimate of the value of subvented financing.

and where Φ_{m}, β_k, δ_t, and $\varepsilon_{m,t}$ denote econometric estimates. Changes over time are identified by the coefficients on the time dummies for each time period in the sample.

We estimated separate regressions for each of the three available price measures. Chart 6 illustrates the results of these baseline regressions. As can be seen in the chart, similar to the results for the matched-model price indexes, the indexes based on hedonic regressions of prices both before and after incentives drop noticeably over the March 1999 to March 2003 sample period. Table 6 reports the cumulative price declines as well as the average annual price change. In the baseline regression, the price before incentives drops 17.5 percent, while the indexes of prices after incentives drop between 20 and 22 percent. In all three cases, the estimated declines are comparable to the results of the geometric mean matched-model index.

Given these baseline results, we then examined the importance of several additional vehicle characteristics to see if they would significantly alter the results of the price regression. Specifically, we tested two hypotheses: The first is based on a stylized fact reported by many observers that newly introduced models or newly redesigned models seem to fetch higher prices than comparable models that existed in previous model years. This could be because consumers value the "newness" of a vehicle, or they associate some sort of prestige with being the first one on the block to own a new type of vehicle. If so, we might expect all new cars to be valued higher at the beginning of the model year.

Our model does not allow us to test for the significance of this type of a "seasonal effect" explicitly. However, if such an effect is present, it should be especially evident for models that have been through a major redesign, like the 2002 Toyota Camry and the 2003 Honda Accord, or models that are completely new, such as GM's Hummer H2, which was introduced in the 2003 model year, and the BMW Mini Cooper, which was introduced in the 2002 model year. We therefore defined a dummy variable that was set to equal one in the first six months in which each of these new or redesigned models was sold. A positive coefficient on this dummy variable would indicate that, ceteris paribus, new or redesigned models are sold at a premium in the first few months after they are released.

The results of adding these variables to the baseline regression are shown in table 6. As can be seen in the table, the indexes based on a regression with the newness dummy added to

the right-hand side are little different from the baseline regressions. The coefficient on the newness dummy variable was not significant in two out of the three regressions. For the regression of prices after cash rebates and incentives, the coefficient was positive and significant at the 95 percent confidence level; however, with an average annual price decline of 5.4 percent, as compared with the 5.6 percent decrease in the baseline index, quantitatively the newness variable had only a very small effect on the overall pattern of prices. All told, these results do not provide much support for the seasonal argument based on the "newness" of a vehicle.

A second hypotheses we tested is the idea that as vehicles sit on dealer lots they are subject to depreciation during the period of time before the vehicle is actually purchased. Although these are still new vehicles (based on their mileage), they become less valuable to consumers because they are closer to being considered used vehicles. Moreover, as the end of a model year approaches, consumers know that the next model-year vehicles will soon be available, so they are likely to place a lower value on the existing models.[11] Another reason consumers might pay less for older "new" vehicles is that there may be a perception that vehicles that have been sitting on dealer lots for some time are lemons.

In order to examine the importance of this "depreciation effect," we included the days-to-turn variable, which as we said is a measure of a vehicle's age in inventory. The results in table 6 affirm that the days-to-turn measure does indeed have a significant effect on the vehicle's transaction price. In all three price regressions, the estimated coefficients on days-to-turn are significant with t statistics of at least 7.0.[12] As expected, the signs on the coefficients are negative, ranging between -0.01 and -0.02 percent per day; this implies that, all else equal, a car that has been on the lot for 100 days will sell at a price 1 to 2 percent lower than one that has just arrived at the dealership.[13]

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[11]For example, a popular car-shopping website lists instructions on how to determine the date a vehicle was produced from its vehicle identification number (VIN). Any consumer can therefore look at the VIN to figure out the age of a given vehicle.

[12]We also included days-to-turn squared in the set of independent variables; its coefficient was statistically significant but small.

[13]We also tried adding a measure of "model age" to the regression, where model age is defined as the time that has elapsed (in months) since the first sale of a model-year vehicle (2001 Honda Accord). However, the results were totally implausible; we believe this reflects a problem of collinearity. By construction, the model age variable implicitly assumes that all vehicles of a particular model and year were produced at the same time, i.e., in the first month they were sold. But since firms tend to cluster the

Chart 8 illustrates that the price indexes implied by the regression with days-to-turn are quite a bit different than the baseline indexes. The price after cash rebate falls by a total of 13.6 percent over the four-year sample period, much less than the 22.1 percent drop in the baseline index. The decline in the price after cash rebates and interest subvention is also not as steep (18.1 percent vs. 20.4 percent) when days-to-turn is included. In other words, days-to-turn is an important vehicle characteristic that affects the transaction price, and aggregate price indexes that do not control for this characteristic imply a steeper drop in prices.

The pattern of days-to-turn over each model year and its demonstrated importance as a demand characteristic provide evidence that the sharp price declines occurring over each model year are at least partially the result of a "depreciation effect." After controlling for a vehicle's physical characteristics, we find that the value of a vehicle declines the longer it sits on the dealer's lot. To illustrate this point, chart 9 graphs the average days-to-turn for all vehicles by model year. As can be seen in the chart, the average days-to-turn increases noticeably throughout the life cycle of a given model year, even before the end of a vehicle's production cycle (which takes place between the vertical bars).

5. Quality Adjustment Using Vehicle Cost

In an alternative set of regressions, we estimated hedonic price indexes using a reduced set of dummy variables that control for unique models, rather than model/years. This allowed us to include an explicit adjustment for quality using vehicle cost. Of course, vehicle cost is an imperfect measure of quality changes in that it also reflects any shocks that affect production costs. However, over the time period from 1999 to 2002, such supply-side shocks were arguably infrequent and relatively unimportant. Hence, the vehicle cost variable will capture changes in a vehicle's features from one model year to the next. For example, if a firm adds air bags or power windows to a given model's list of standard equipment, its vehicle cost will increase.

introduction of new model-year vehicles in the third quarter, all vehicles of a given model year have a similar age. Hence, there is too little variation in model age, and the variable is (nearly) perfectly correlated with the time and model-year dummy variables. By contrast, the days-to-turn measure captures the fact that there is cross-sectional variation in the age of vehicles for a given model year; in addition, days-to-turn provides additional information because it is measured in days, not just months.

We should point out that, compared to the results presented above, the variables included in this regression correspond more closely to the information used by the BLS in constructing the CPI. Reportedly, the BLS samples new vehicle dealerships and tracks prices for the same models across model years; substitutions between model years are made when the new model-year vehicle's dollar volume sales exceed those of the old model year (this is determined separately for each vehicle at each dealer). Adjustments for quality change in the model-year changeover month are then made using information on changes in production costs from the PPI (plus some markup to retail).

Among the 21,234 observations in the sample, there were 420 unique models. In addition to the dummy variables for each model, we added dummy variables for the 58 models that had been redesigned, so that they were essentially treated as different models from the model years before the redesign. The resulting indexes for the three price measures (before and after incentives) are shown in chart 10, along with the CPI for new vehicles. Although the index of price before incentives declines at a rate similar to the change in the CPI, the indexes of prices after incentives drop somewhat more steeply than the CPI; nonetheless, all of these indexes decrease much less sharply than the indexes based on model-year fixed effects and days-to-turn.

6. Conclusions

In recent years, and particularly since September 2001, marketing incentives have become an integral component to understanding movements in transaction prices for motor vehicles. The average value of cash rebates and interest subvention has increased dramatically, as has the share of transactions that included some form of incentive. In order to better understand the effects of these incentives on aggregate prices, we constructed several matched-model price indexes using a unique dataset that contains highly detailed price and quantity information. To our knowledge, this is the first work to examine the *monthly* pattern of prices using such detailed information.

We find that prices for vehicles of a given model year drop markedly, in large part through the use of incentives. By contrast, indexes of vehicle cost by model year remain relatively flat. We therefore test whether the drop in prices over the model year reflects

differences in demand characteristics that change over time. In a hedonic price regression, we find that, after controlling for the fixed characteristics of each vehicle, days-to-turn is an important determinant of the transaction price. We interpret this result as evidence that new vehicles are subject to depreciation in the period of time between their arrival on dealer lots and when they are finally purchased.

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Table 1A. Information available in the PIN database on new retail motor vehicles

Model	Engine	AH insurance premium	Trade in amount
Model year	Transmission	Life insurance premium	Trade in over/under allowance
Vehicle price	Fuel	Lease/finance or cash purchase	Trade in equity
Vehicle price less customer cash rebate	Aspiration (turbo)	monthly payment	Vehicle gross
Vehicle cost	Doors	amount financed	Vehicle profit margin
Days-to-turn	Cylinders	Down payment	Vehicle profit markup
Cash rebate	Displacement	term	Buy rate APR/IRR
Interest rate	Drive type	Money factor, lease	Finance reserve
Origin	Exterior color	Residual, lease	Service contract costs
Make	Fuel type	Cap reduction, lease	Service contract income
Nameplate	Segment (compact car)	Lender/lessor name	AH insurance cost
Trim/series	Subsegment (premium compact car)	Captive flag	AH insurance income
Body type	Service contract premium	trade in cash value	Buyer age and gender

Source: J. D. Power and Associates, 2002. Includes purchased and leased vehicles.

Table 1B. Examples of Nomenclature Authors' database

Manufacturer	Nameplate	Model	Trim level	Model year
General Motors	Buick	LeSabre	LeSabre Limited	2001
BMW Group	BMW	325XI	n.a.	2003
Ford	Mercury	Sable	Sable GS	2000
DaimlerChrysler	Mercedes-Benz	ML 320	n.a.	2003

Source: Extracted from J. D. Power and Associates' PIN database.

Table 2. Number of models by model year.

Model Year	Total	New	Major Redesigned	**Memo: Wards Communications[1]**
1998	229	–	–	237
1999	256	10	n.a.	245
2000	262	17	16	248
2001	292	59	9	252
2002	309	39	17	270
2003	301	41	16	266
Total, all years[2]	420	166	n.a.	n.a.

Source: Authors' database constructed from J.D. Power and Associates' PIN Explorer Database; information provided by Rod Tadross, Banc Securities; and Edmunds.com.

1. Number of models as of December in the year indicated. Data for 2003 are through June.

2. The figures for all years are net from the beginning of the 1999 model year.

Table 3. Summary Statistics on Vehicle Database[1]

	Variable	Mean	Median	Standard deviation	Minimum	Maximum
1.	Vehicle price	$30,460	$25,560	$16,115	$7,690	$152,175
2.	Vehicle price less cash rebate	$29,940	$24,840	$16,280	$5,610	$152,175
3.	Vehicle price after cash rebate and mean subvention	$29,070	$23,970	$16,285	$4,740	$152,175
4.	Cash rebate	$520	$170	$710	0	$6,160
5.	Interest subvention	$870	$335	$1,200	0	$6,000
6.	Vehicle cost	$28,330	$24,500	$14,810	$7,350	$130,670
7.	Days to turn (days)	90	53	95	0	633
	Memo:					
	Number of observations	21,234				

1. Values are calculated over all models and model years. Current dollars. Data were extracted from J. D. Power and Associates PIN database.

Table 4. Number of continuing models by model year, average monthly rate per quarter, 1999Q2 to 2003Q1

Model Year	1999			2000				2001				2002				2003
	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
1998	60	17	2	1												
1999	249	239	202	153	75	18										
2000	11	64	220	250	258	248	212	166	100	43	12					
2001				4	20	88	253	279	285	273	249	172	97	35	7	2
2002								1	13	81	272	299	302	288	246	176
2003												4	18	85	261	299
Total continuing	320	320	423	408	352	355	465	446	398	396	534	476	417	407	515	477
Memos: Entering models	5	58	17	9	7	64	18	6	7	70	21	6	8	67	21	1
Exiting models	24	18	17	17	30	19	20	15	34	34	19	31	26	25	22	25
Total marketed	325	378	440	417	359	419	483	452	405	466	555	482	426	474	536	479

Note: Components may not sum to totals due to independent rounding. Exiting models are counted in month t+1, i.e., the period in which a match cannot be made. Total marketed is the sum of continuing plus entering models.

Source: Authors' database constructed from monthly data in J.D. Power and Associates' PIN Explorer Database. In the author's database, PIN transactions for a model in a month that preceded or trailed the primary selling period for the model by more than 3 months were not included.

Table 5. Matched-model price indexes for consumer light vehicles

percent change, March 1999 to March 2003

Price measure and type of index	Cumulative	Average annual rate
Price before incentives		
Fisher	-10.2	-2.7
Tornqvist	-9.4	-2.5
Geomean	-17.6	-4.7
Price after cash rebate		
Fisher	-15.6	-4.1
Tornqvist	-16.4	-4.3
Geomean	-21.6	-5.8
Price after cash rebate and interest subvention		
Fisher	-19.8	-5.4
Tornqvist	-19.7	-5.3
Geomean	-21.2	-5.9

Source: Authors calculations using data from J.D. Power & Associates.

Table 6. OLS Estimates of the Hedonic Price Equation, March 1999-March 2003

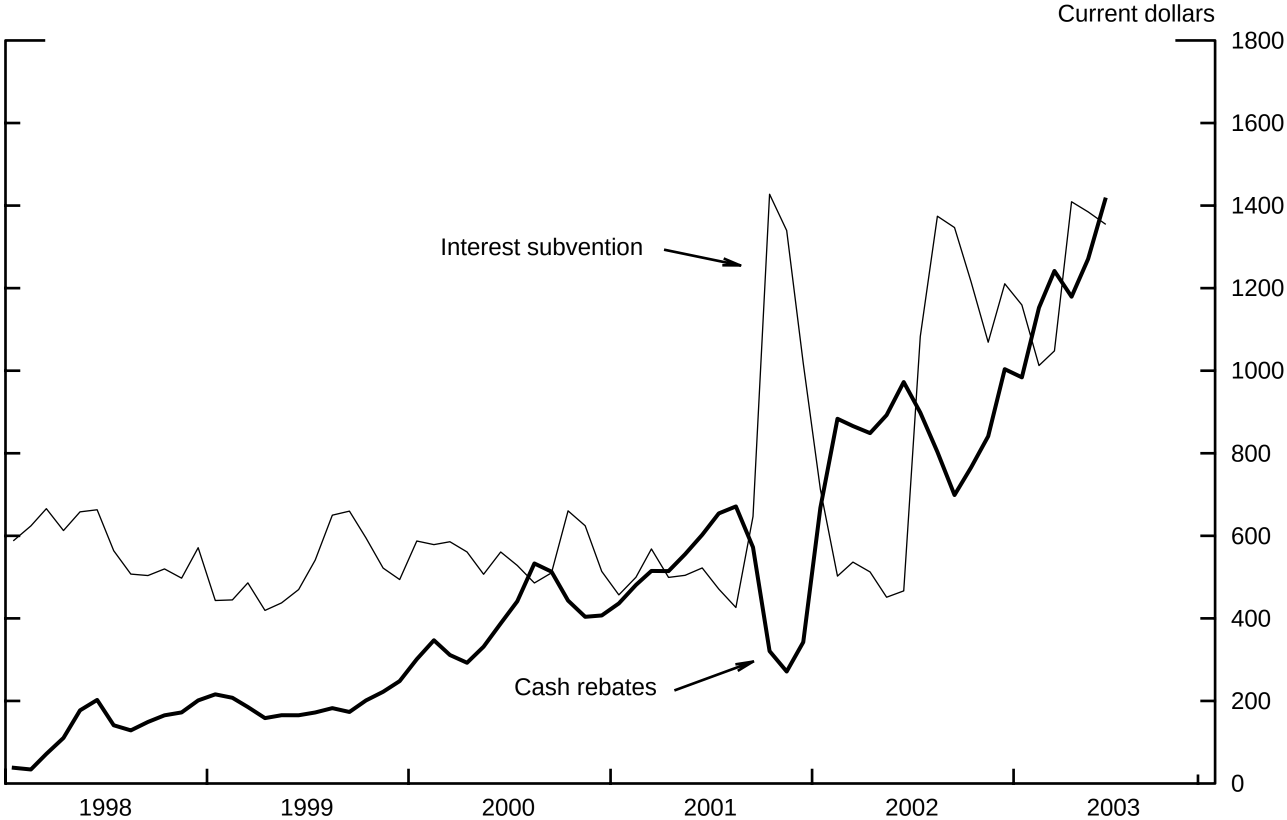
Row	Price Index	No. of obs	Adjusted R-square	Cum. price decline Mar 99-Mar 03 (percent)	Avg. annual price decline Mar 99-Mar 03 (percent)
	Price before incentives				
1	Baseline	21,234	0.993	-17.5%	-4.7%
2	With newness	21,234	0.993	-17.5%	-4.7%
3	With days to turn	21,234	0.994	-7.1%	-1.8%
	Price after cash rebate				
4	Baseline	21,234	0.994	-22.1%	-6.0%
5	With newness	21,234	0.994	-22.1%	-6.1%
6	With days to turn	21,234	0.994	-13.6%	-3.6%
	Price after cash rebate and interest subvention				
7	Baseline	21,084	0.993	-20.4%	-5.6%
8	With newness	21,084	0.993	-20.0%	-5.4%
9	With days to turn	21,084	0.993	-18.1%	-4.9%

Source: Authors' database constructed from monthly data in J.D. Power and Associates' PIN Explorer Database.
Note. The baseline regression includes dummy variables for each of the 1,650 model-year vehicles in the sample as well as a dummy variable for each time period.

Chart 1

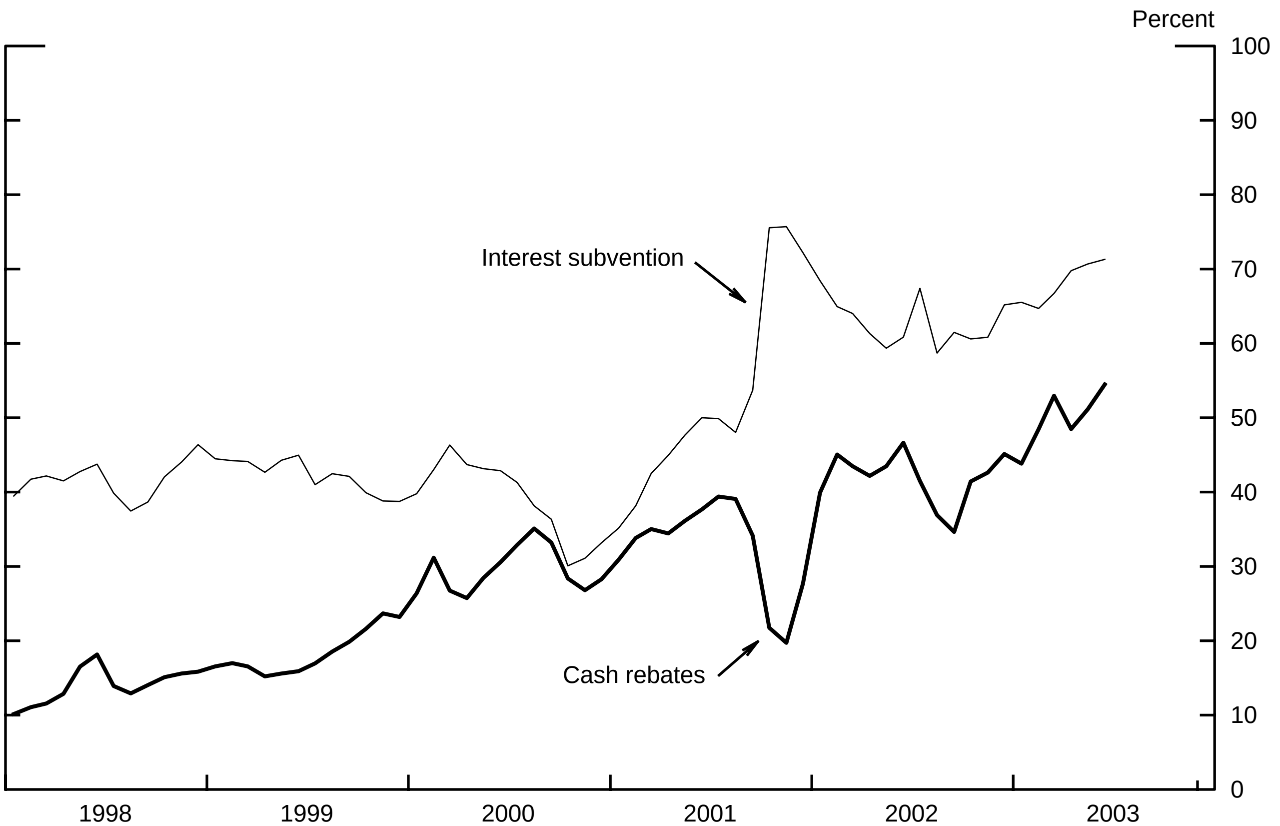
MOTOR VEHICLE INCENTIVES

Average Value of Cash Rebates and Interest Subvention



Source: J.D. Power and Associates

Sales Penetration of Incentives



Source: J.D. Power and Associates

Chart 2. Ward's Count of Models Sold by Month, 1995-2003

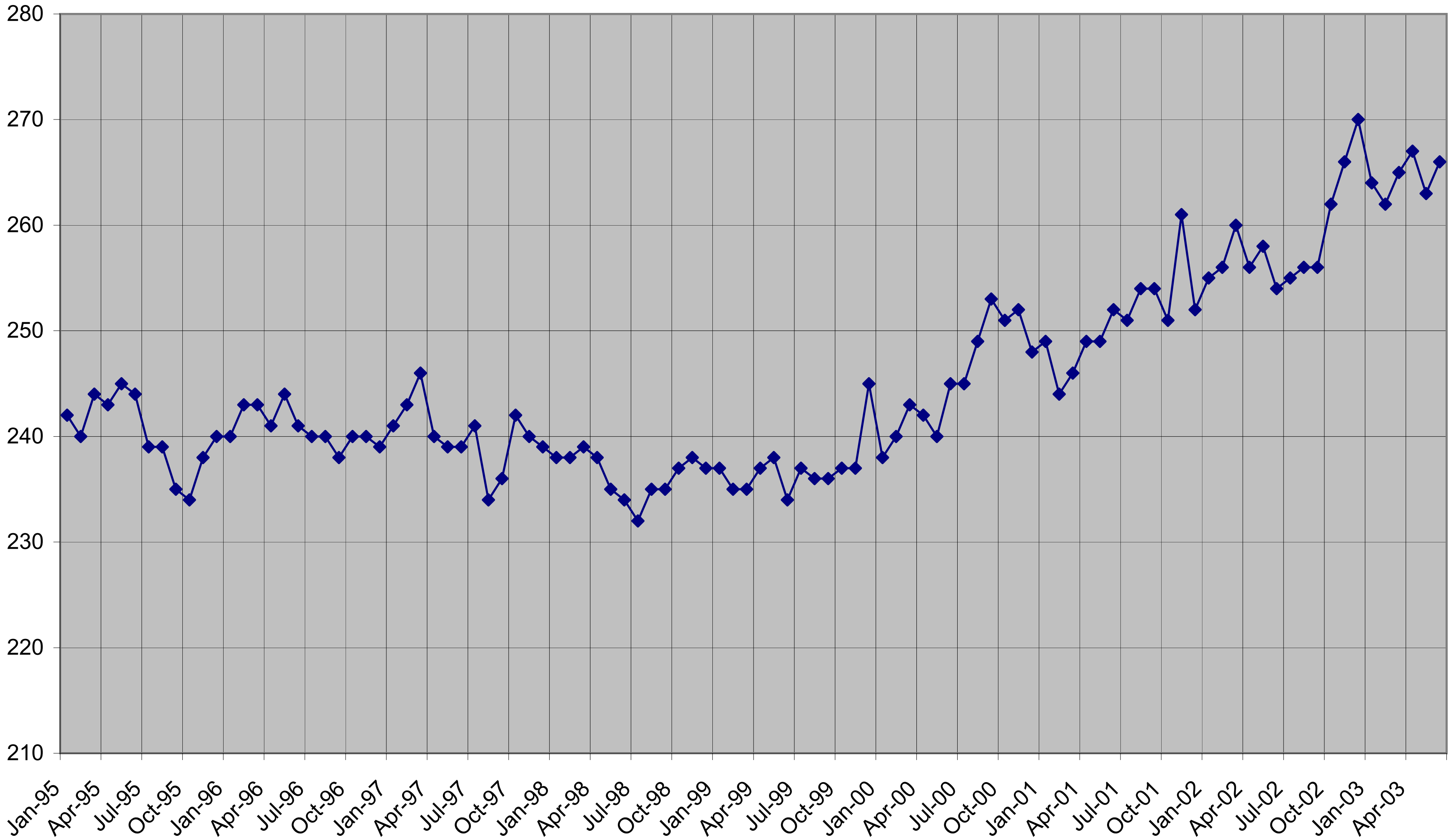


Chart 3
Matched-model Fisher Price Indexes for New Motor Vehicles
(Authors' calculations using J.D. Power and Associates PIN data)

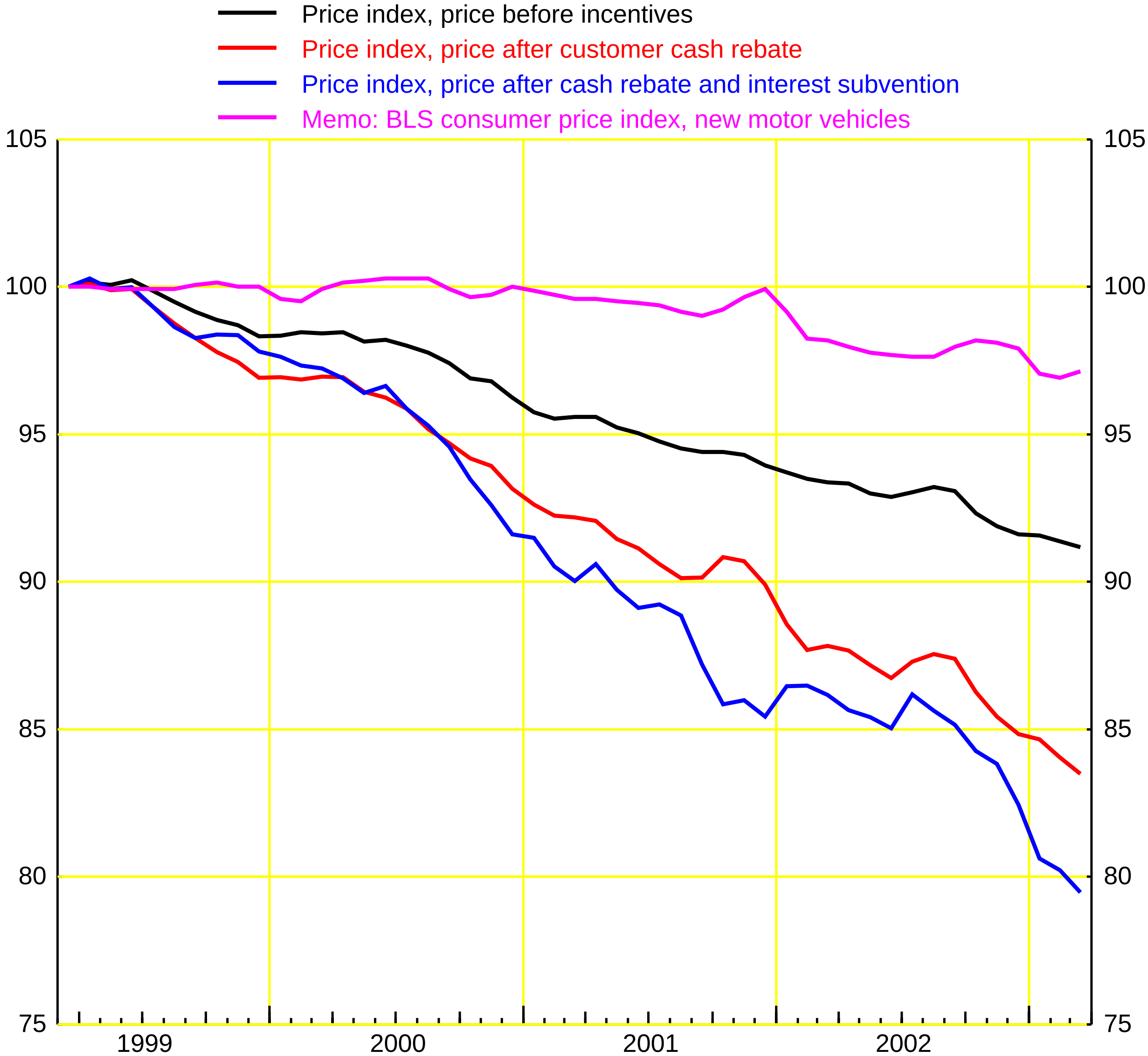
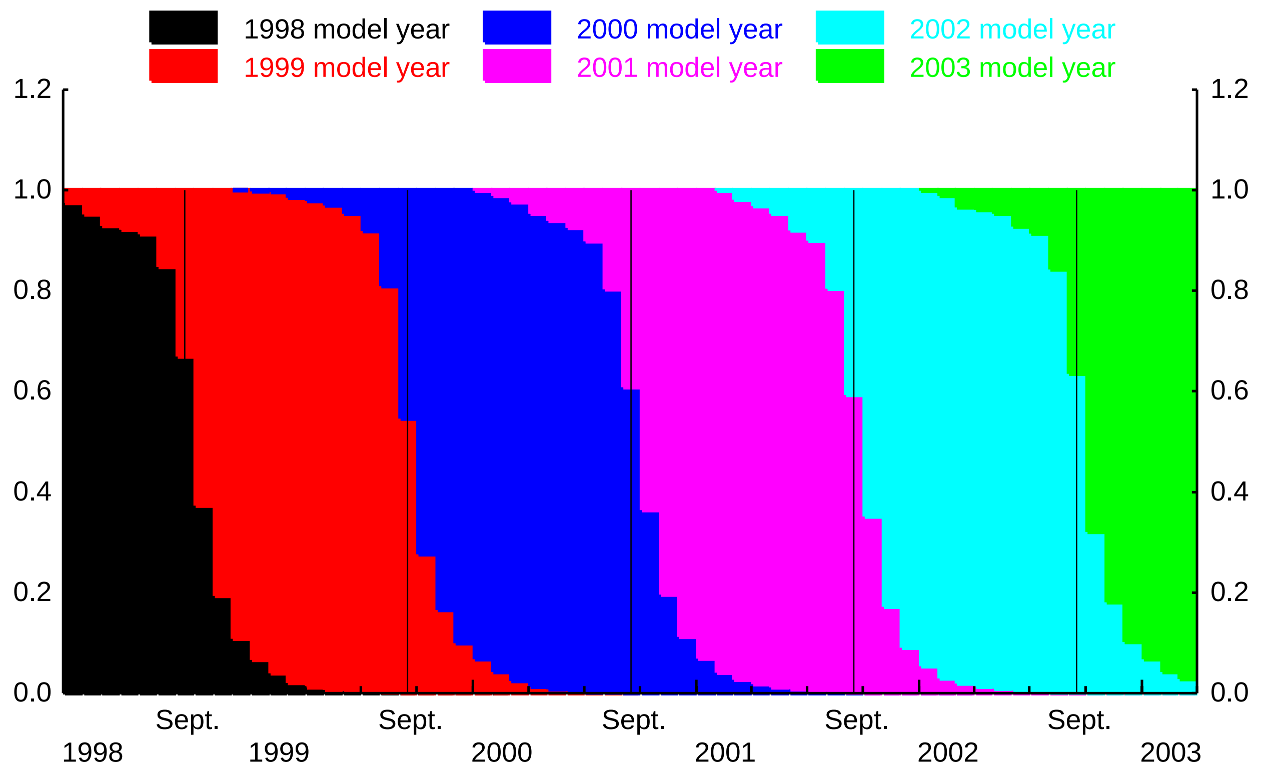


Chart 4
Expenditure shares by model year



Matched-model price indexes by model year (price after cash rebate)

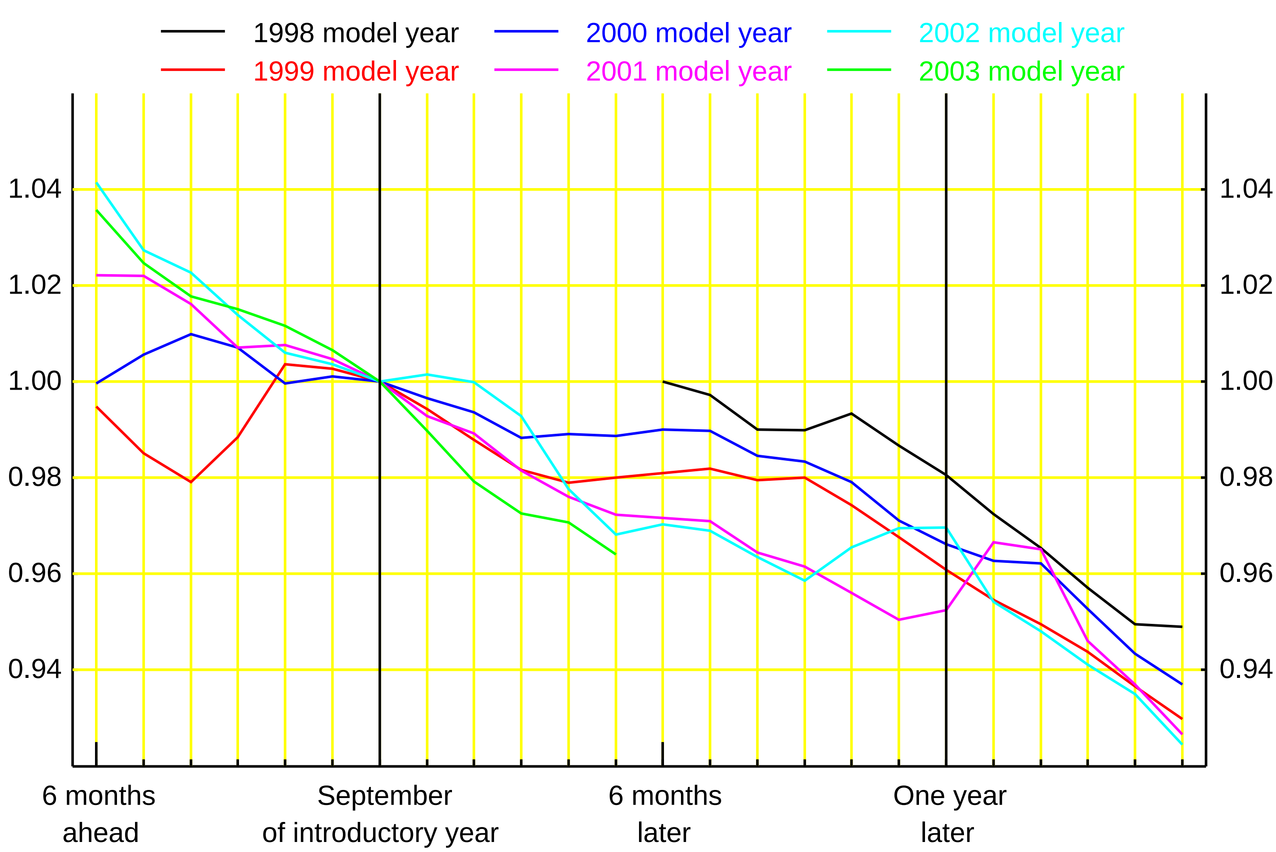


Chart 5

Matched-model Fisher Price Indexes for Vehicle Cost

(Authors' calculations using J.D. Power and Associates PIN data)

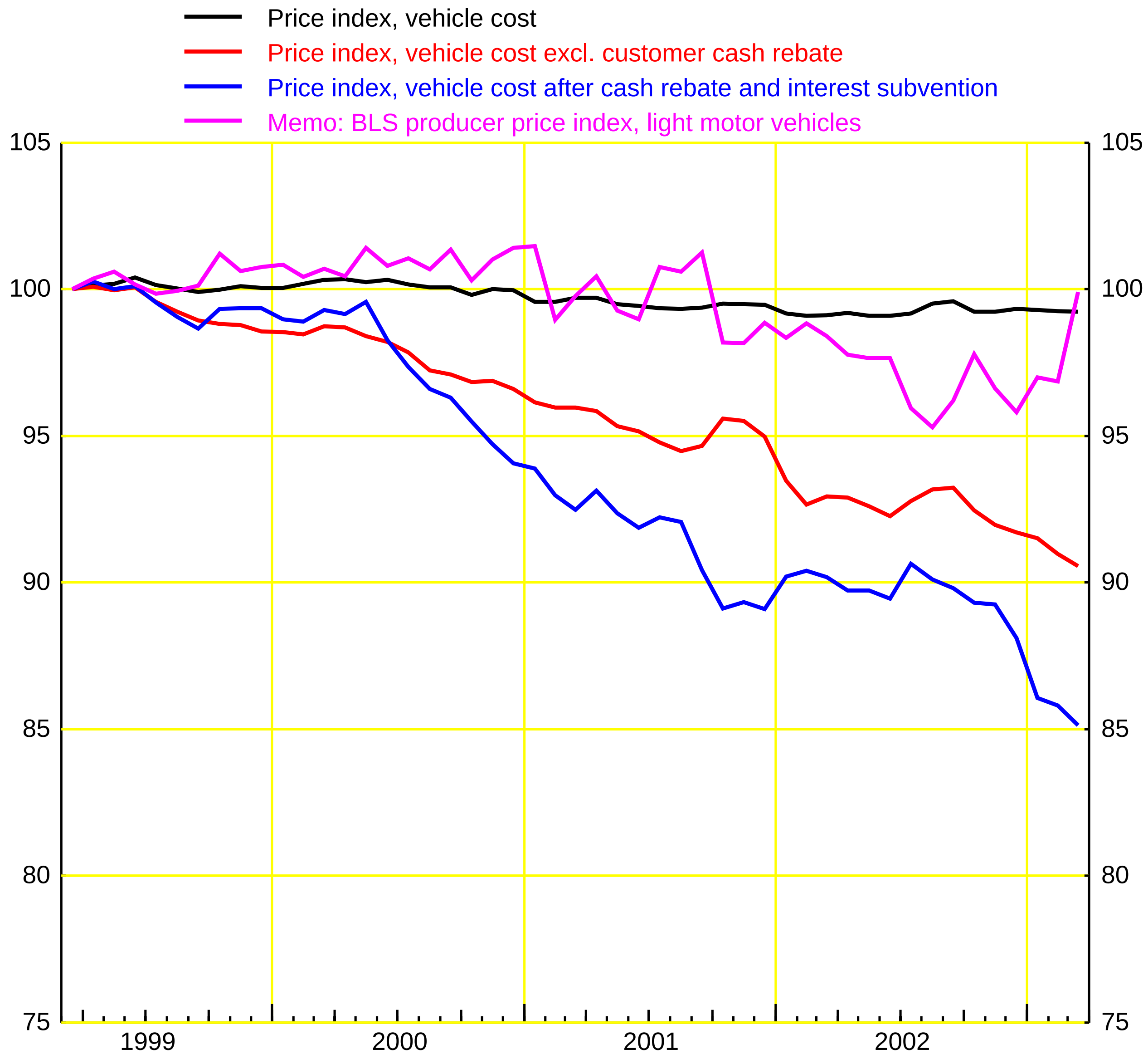
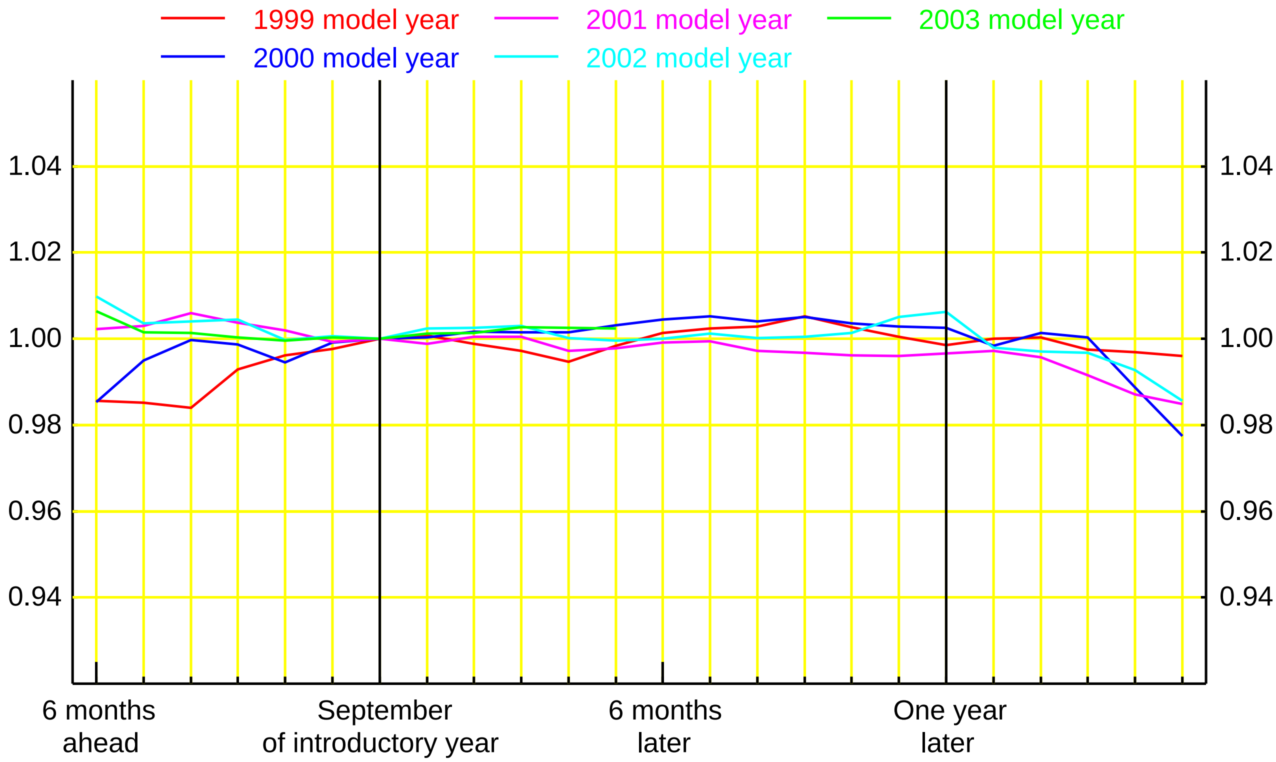
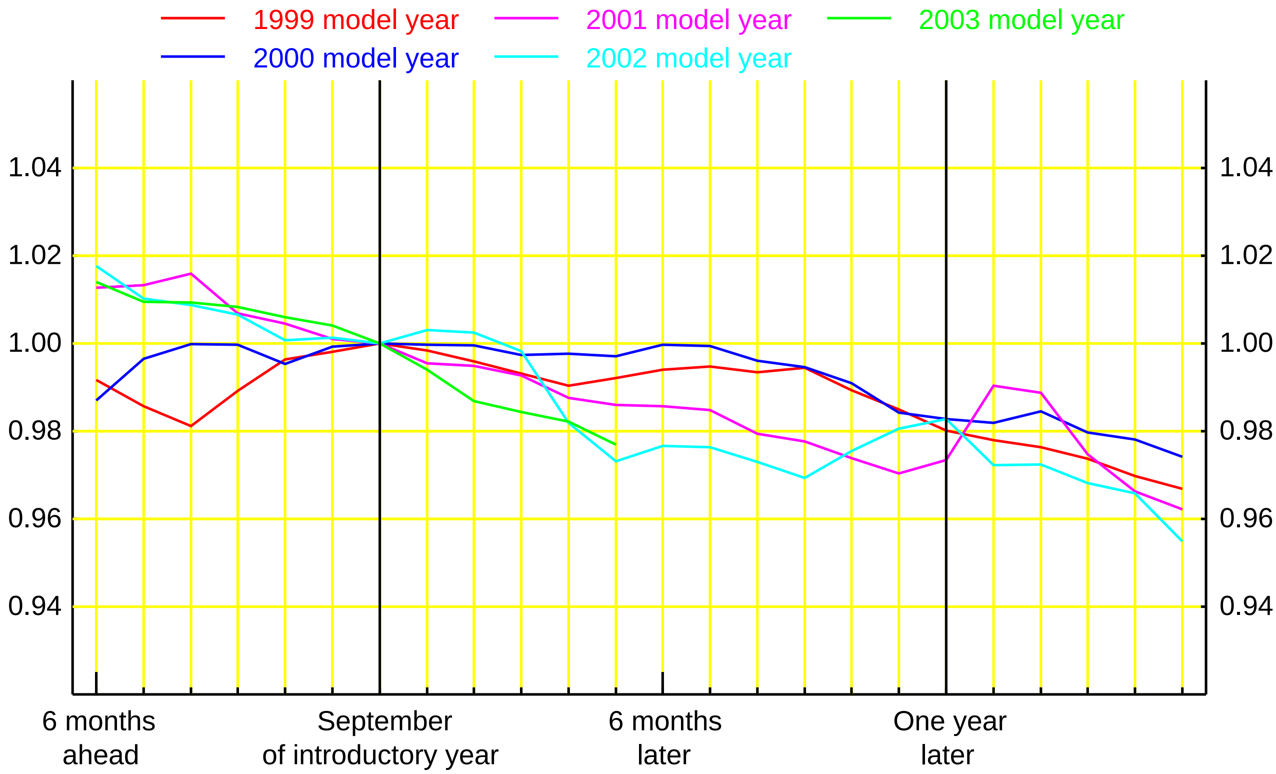


Chart 6

Matched model indexes for vehicle cost by model year



Matched model indexes for vehicle cost excl. cash rebates by model year



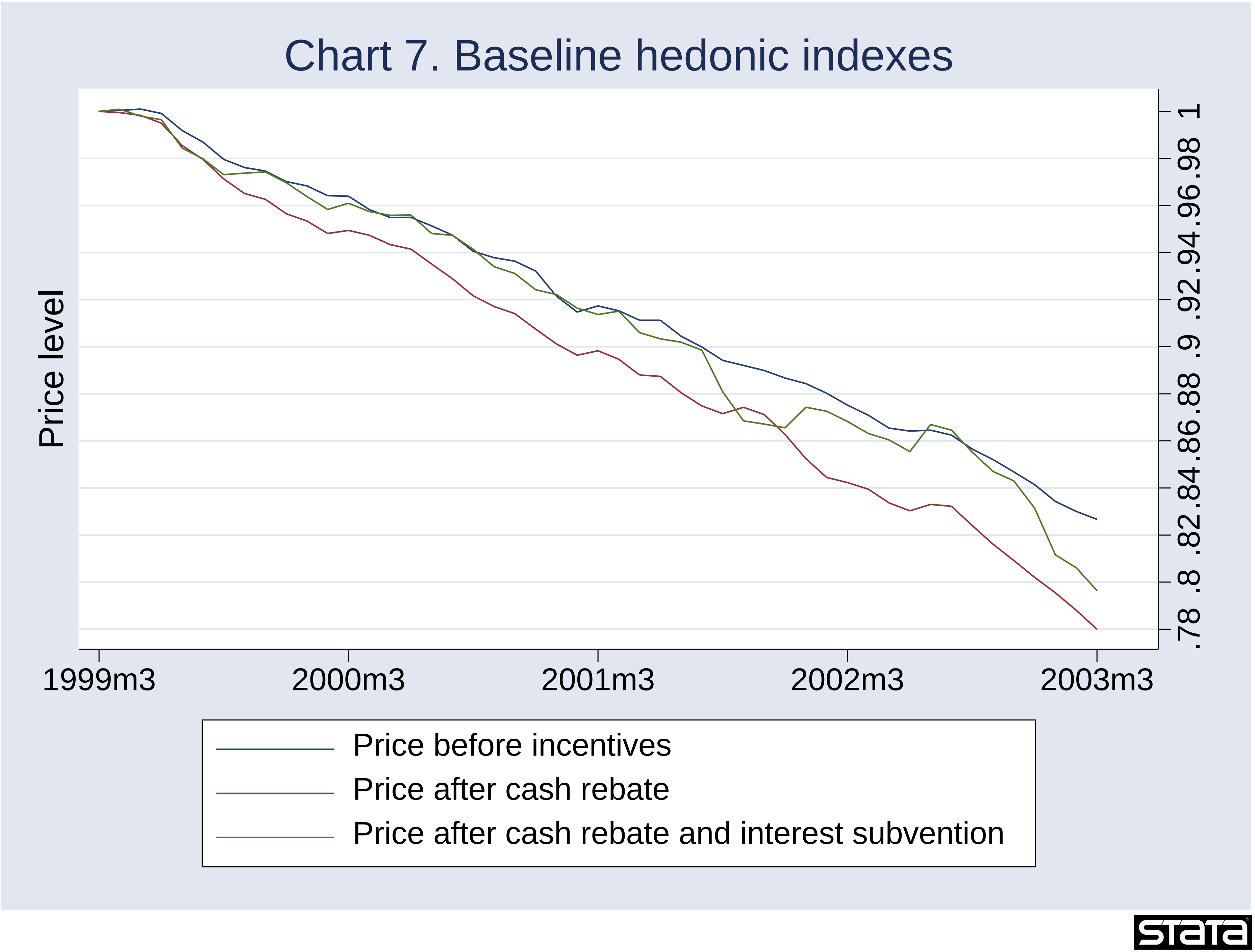


Chart 7. Baseline hedonic indexes
Price level
.78
.8
.82
.84
.86
.88
.9
.92
.94
.96
.98
1
1999m3
2000m3
2001m3
2002m3
2003m3
Price before incentives
Price after cash rebate
Price after cash rebate and interest subvention
stata

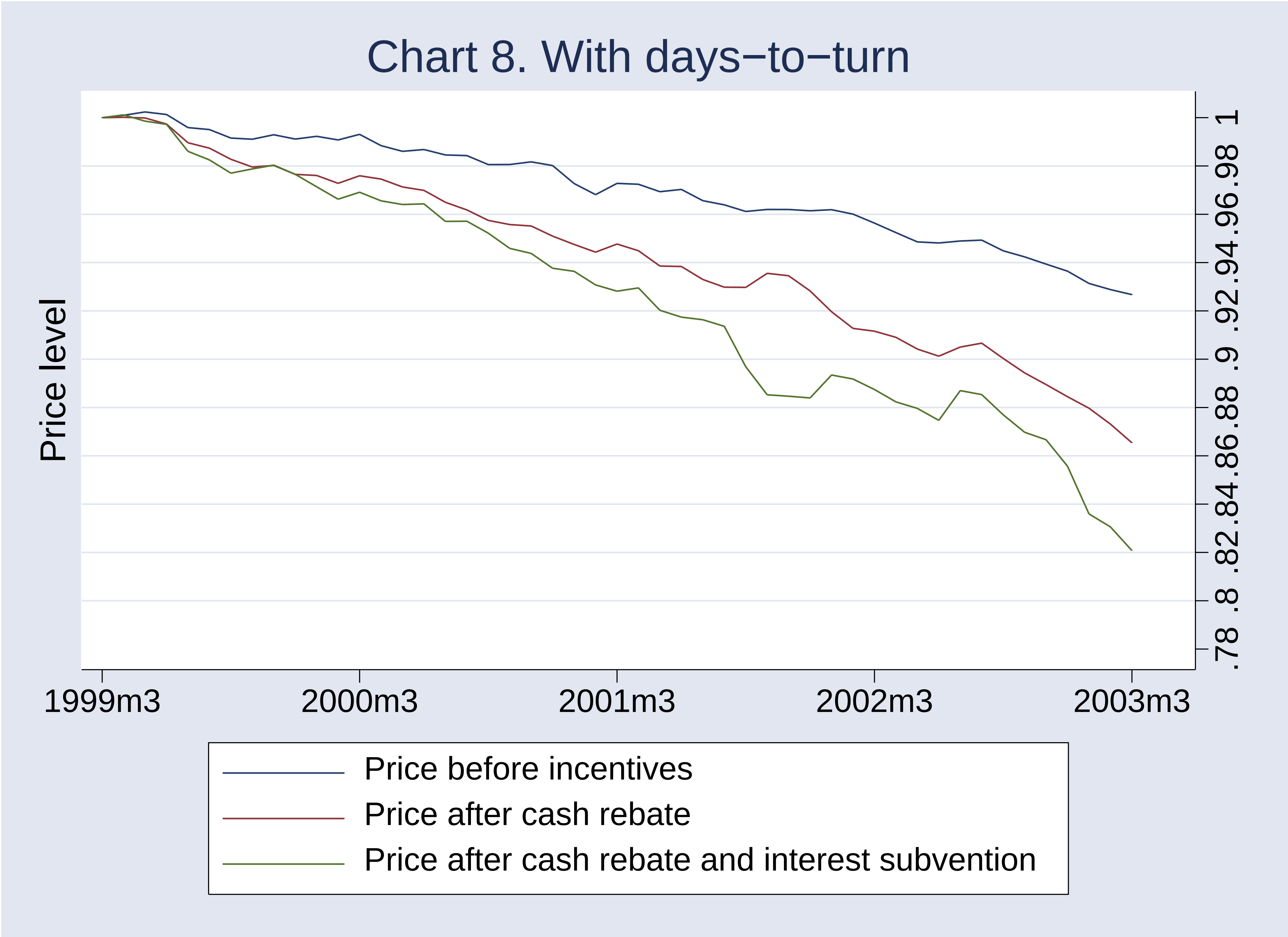
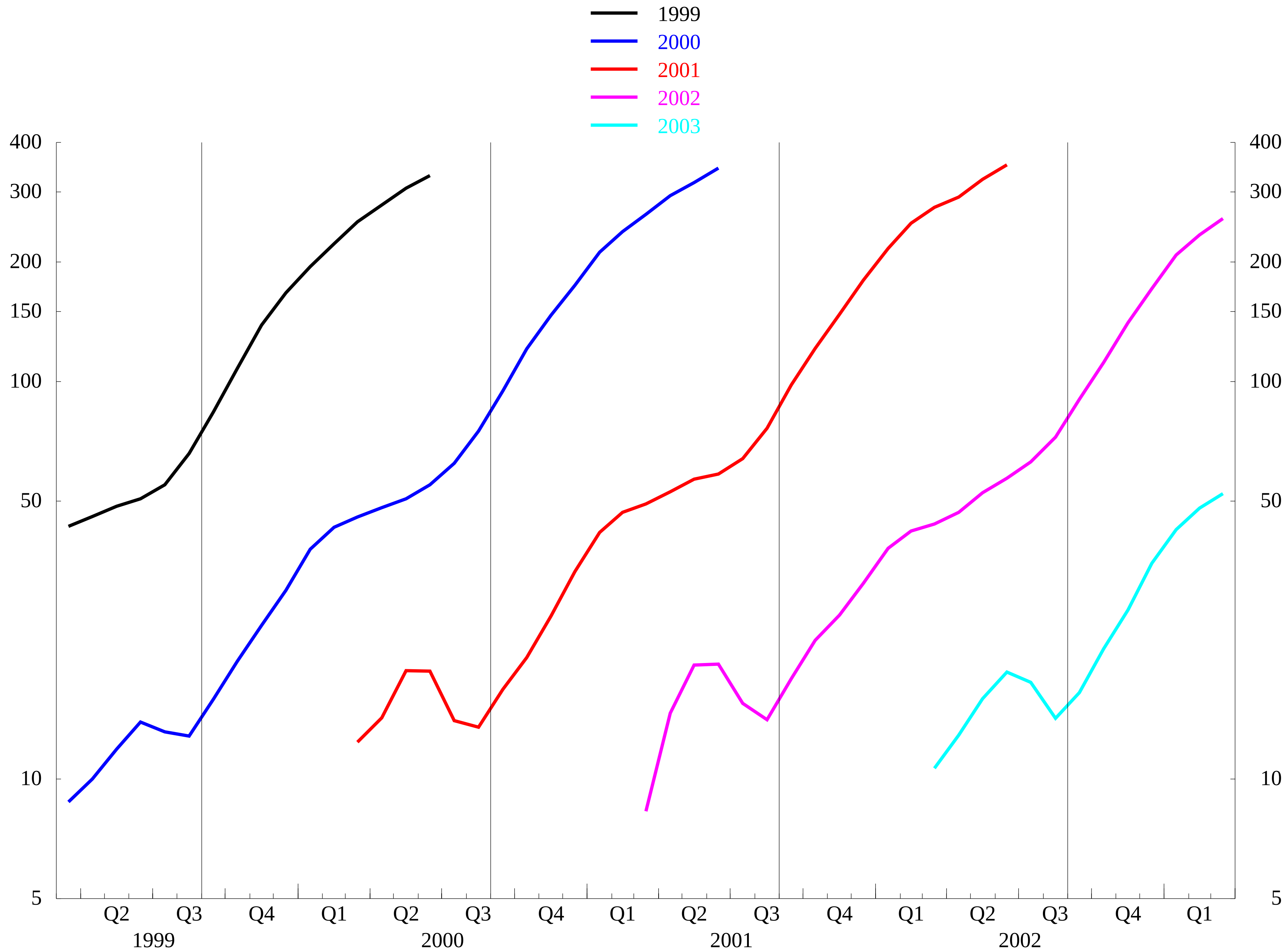


Chart 8. With days−to−turn
Price level
.78 .8 .82 .84 .86 .88 .9 .92 .94 .96 .98 1
1999m3
2000m3
2001m3
2002m3
2003m3
Price before incentives
Price after cash rebate
Price after cash rebate and interest subvention

Chart 9. Days-to-turn by model year



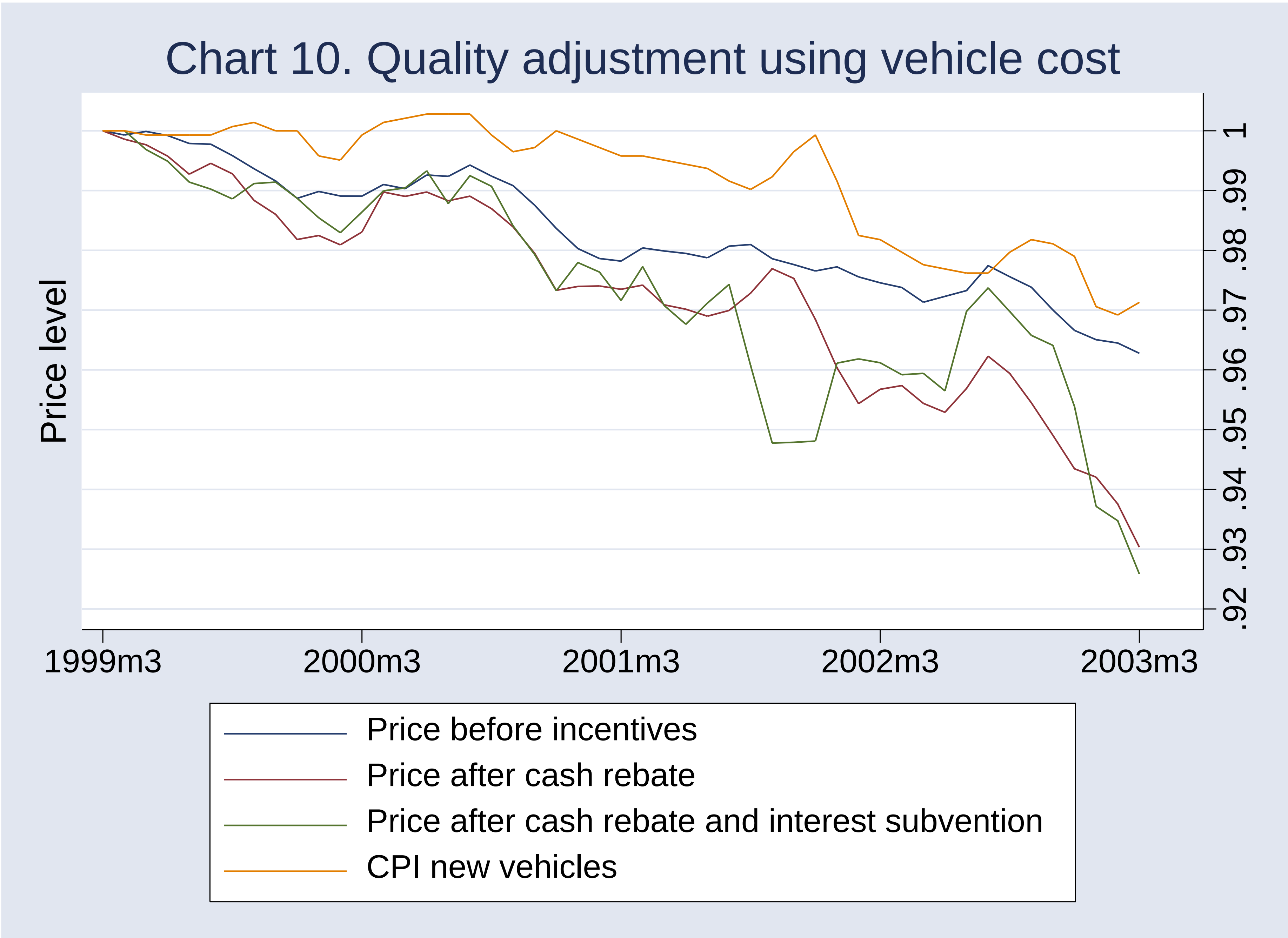


Chart 10. Quality adjustment using vehicle cost
Price level
1
.99
.98
.97
.96
.95
.94
.93
.92
1999m3
2000m3
2001m3
2002m3
2003m3
Price before incentives
Price after cash rebate
Price after cash rebate and interest subvention
CPI new vehicles