MOODY'S ANALYTICS

ANALYSIS
29 MAY, 2020

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Introducing the Datium Insights – Moody's Analytics Used Vehicle Price and Retention Index

INTRODUCTION

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Introducing the Datium Insights - Moody's Analytics Used Vehicle Price and Retention Index

BY TONY HUGHES, MICHAEL BRISSON AND LOC QUACH

In the typical household balance sheet, two assets immediately stand out. While housing has been an obsession for many Australians for decades, the valuation of vehicles—the next biggest asset for most families—has been largely overlooked. The purpose of this article is to introduce some new data and analytics into Australian economic commentary that pertain to the health of the auto industry and the value of the nation's vehicle fleet.

Specifically, we introduce the Datium Insights - Moody's Analytics Used Vehicle Price Index and Retention Index. Our work draws on data sourced from Datium Insights, the analytics division of Pickles, the largest remarketer of vehicles in Australia. Datium Insights aggregates large amounts of vehicle information from across Australia to create an extensive and accurate database. Both Datium Insights and Moody's Analytics are focused on providing businesses the tools and analysis needed to quantify risk. The Datium Insights - Moody's Analytics price indexes are an example of the tools and expertise able to be provided.

The monthly updates of these indexes should be of considerable interest both within and beyond the auto industry. Indicators like these have a long history in the United States, where they provide a useful portmanteau economic indicator at the intersection of consumer demand and industrial activity. Vehicle prices, after all, are driven by the importation, production and marketing decisions made by auto manufacturers, as well as the evolving tastes and demands of local consumers. In combination with other measures of consumer and producer health, vehicle valuation data can provide useful signals of turning points in the broader economic trajectory.

The Australian economics community tends to focus heavily on real estate dynamics—examples include the CoreLogic - Moody's Analytics Australian Forecast Home Value Index—but plenty of room remains for other indicators of local economic health.

For those whose livelihoods depend on vehicles, be they dealers, financiers, insurers, rental agencies or fleet managers, these new data should be especially valuable. These companies often hold a financial interest, either direct or indirect, in many thousands of vehicles. If the market value of these assets ebbs or flows, it can have a profound impact on the profitability of the companies in question.

For example, suppose that a recession increases the default rate on car loans. If secondary markets for vehicles remain robust, the bank holding the loans should be able to cushion the impact of the recession and recover most of its exposed funds following repossession of defaulted vehicles. Likewise, if a rental agency managing a large fleet of small, compact cars sees consumer demand shift in favour of larger cars or SUVs, it will recoup a smaller percentage of its initial investment, eroding its ability to fund the next round of vehicle acquisitions.

These residual risks are, for many in the auto and finance sectors, an existential threat to the operation of their businesses.

To analyse these risks, forecasts of vehicle values play an important role. Moreover, it is critical for these companies to also address the range of outcomes possible so contingencies can be considered and potential disasters averted. In the banking sector in recent decades, stress-testing has formed the backbone of this style of analysis, with banks considering the impact of a range of recession scenarios on the performance of their portfolios. Though such analysis is not as commonplace for others in the auto industry, such as fleet managers, we feel they too can benefit from access to these projections in formulating their strategies.

The purpose of this paper is to describe our indexes, which are based on hedonic pricing models. This methodology allows us to control for the mix of vehicles being sold and thus uncover the underlying price dynamics driving the industry.

Controlling for mix is critical, mainly because of the worldwide trend in favour of larger vehicles. A similarly appointed ute will typically sell for a higher price than a large sedan, simply because it contains more raw materials. Average sales prices may therefore be observed to increase simply because a greater proportion of utes are transacting. The indexes we will introduce will consider overall prices, overall price retention (how much of the initial valuation the vehicles retain as they age), and separate car- and ute-based indicators. Our methodology is flexible and can be used to address other issues of interest such as manufacturer price behavior, indexes specific to certain ages of vehicles, or more detailed vehicle category classifications.

The next sections will detail the motivation, data and methodology. We will follow this with a description of the historical behavior of the indexes.

Motivation

When building a price index, treating heterogeneity is a critical task. If the products under consideration are homogenous in nature, like gold for example, we can easily measure how price changes from one period to the next.

If we consider a heterogeneous product such as a vehicle, comparison becomes much more difficult. If people are buying a different set of products now than they did in the past, we need to make adjustments to observed average prices to account for the fact that more utility, or a different kind of utility, is now being derived from the product, warranting a different price.

Two types of heterogeneity are most pressing—technological advances and changes in product mix.

Controlling for changes in vehicle technology is especially difficult. For instance, when airbags became mandated for new vehicles, cars with airbags installed would, all else being equal, sell for a higher price than a vehicle that did not have the airbag. Some indexes go to great lengths to quantify the changes in technology for vehicles. However, this takes on a level of speculation that falls outside of our purpose of providing a transparent, empirically based price index for industry participants.

The utility of vehicles is largely driven by their ability to reliably and safely transport passengers to a desired location. Comfort and fuel economy are also factors. Comparing a 2000 base model Toyota Camry and a 2019 version, there is no doubt that the 2019 is better in all of these dimensions. It has more airbags, more advanced braking and steering, new safety features such as lane assist, better fuel economy, and more creature comforts such as Bluetooth and a touchscreen.

The 2000 Camry was viewed as a solid, dependable, safe car, as is the 2019 version. The vehicle continues to reliably serve its primary purpose, providing a similar level of utility. While we recognize that the 2019 Camry is better than the 2000 version, we view their place in the consumer landscape and the utility they provide to their owners as fundamentally identical.

What we can say about technological change is it trends higher in a fairly smooth pattern. However, the trend tends to decelerate because of diminishing marginal returns for each advancement as the low-hanging fruit gradually gets eaten. Take, for example, seat belts versus lane assist technology. The introduction of effective seat belts had an enormous impact on vehicle safety, cutting the road toll dramatically as their use rapidly became universal. Lane assist technology—no doubt a huge technological advance—will nonetheless have a more marginal impact on the safety of vehicles.

At this point it is important to mention the possibility of a transportation system that is overhauled to a point it begins to approach zero fatalities. Such an experience has been discussed at length because of current research into the field of self-driving vehicles. However, if the network of self-driving vehicles comes to fruition, the transportation industry will have far greater concerns than the potential impact of technology on used-car prices. Until then we expect the rate of technological progress to gradually slow.

One final reason to not adjust for quality/technological progress is that a key user of our index is likely to be financiers. When a loan is made on a vehicle, what matters to the lender is the value of the collateral should the loan not be repaid. To a bank, recovering its losses on a 2001 car in 2003 should be similar to recovering on a 2017 model in 2019. The lender is unlikely to consider whether the 2017 model is intrinsically better because it has Bluetooth and lane assist while the 2000 version is lacking these features.

To summarise, we view adjustments for technological change to be difficult to implement and doing so will cause the usefulness of our index to decline. For these reasons, our focus when treating heterogeneity is very much geared to controlling the effect of changes in the mix of vehicles sold.

As mentioned, buyers' preferences have gradually changed over time from traditional sedans and hatchbacks to crossovers and SUVs. At the same time, smaller cars have enjoyed cyclical upturns, especially during periods of high petrol prices or when the economy faces recession. Still, when looking at the mix of cars and utes sold in our data, a clear change in consumer preferences is immediately noticeable (see Chart 1).

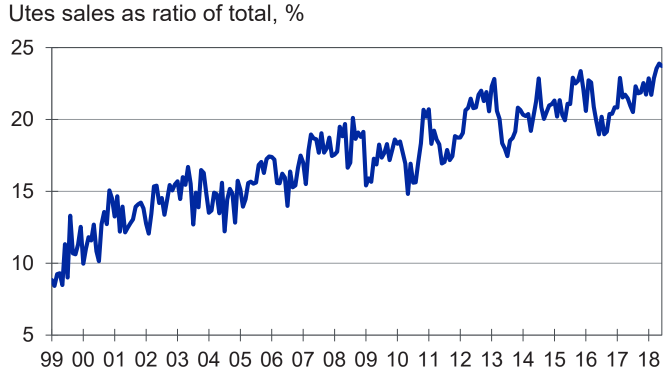
As shown, starting in 2000 around 12% of used vehicles sold in Australia were defined as utes. However, more recently that number has risen to nearly 25%. The duration of the trend indicates the increase is not only a factor of lower petrol prices but also a broad-based increase in Australian demand for larger vehicles.

Without some way to control for the changing mix of vehicles, the shift in vehicle mix would indicate an unreasonable rate of price increase. The unwarranted price inflation would take place because for a similar level of trim, a large ute costs more to buy than a smaller sedan or station wagon.

The Datium Insights - Moody's Analytics price indexes control for mix by using a he-

Chart 1: Demand for Utes Increases

Utes sales as ratio of total, %



Sources: Datium Insights, Moody's Analytics donic modelling methodology. This approach will be detailed in a later section.

Data

The data used for the creation of our price indexes are sourced from Datium Insights and are updated monthly. Datium Insights is the analytics division of Pickles, Australia's largest volume auto auction house with 23 nationwide locations. The database covers approximately 60% of the wholesale Australian used-vehicle market. Transaction-level data cover approximately 1.7 million transactions from 1999 through current. Some of the key variables provided include mileage at time of sale, sale price, Manufacturer Suggested Retail Price, and vehicle characteristics. For the purposes of constructing our price indexes, we exclude commercial vehicles such as commercial trucks and utility vans, and focus solely on passenger cars, utes and SUVs. Additionally, our indexes measure prices for vehicles from 1 to 20 years of age at the time of sale.

We included older cars in the data sample because prices for older used cars can help us home in on the prices of newer vehicles. At any time, all else being equal, a newer car will transact at a higher price than an equivalent older vehicle. If we have data concerning the prices of 8-year-old Ford Rangers and data for 3-year-old Ford Rangers, we will likely do a better job of discerning price dynamics for 5-year-old Ford Rangers, relative to the case where such information is excluded from the analysis.

Method

Using the available data, we have been able to build two related and broad used-vehicle price indexes. The first index measures the movements in wholesale prices. In this sale price index, we statistically isolate pure price movements after controlling for observed shifts in the mix of vehicles in the database. The second index measures wholesale prices deflated by the vehicle's MSRP. This vehicle value retention index is able to control for jumps in MSRP that are not controlled for in the hedonic regression components, whereas the sale price index includes any inflation observed in the price of new vehicles over time.

In constructing our indexes, we seek to use the most robust methodology available to us. To this end, in both instances, we employ a weighted hedonic regression. This involves specifying a model of prices (or of price-to-MSRP ratio) where key vehicle characteristics are controlled. We include three main types of characteristics that influence vehicle price. First, obsolescence is modelled as a function of time measured by vehicle age while the effects of physical depreciation are controlled by including a kilometres-per-year variable. Other vehicle features that are time invariant are also included, such as make, segment, fuel type, body type and drive type, etc.

The final set of included variables that forms the basis of our index is a full set of monthly time dummies. Our index is determined by the values of these coefficients, scaled appropriately.

The principle at play here is the time dummies convey the average price level after accounting for the influence of each feature in our vector of control characteristics. A simple way to understand this is by way of example: Suppose that two cars were sold at adjacent times, 2015 and 2016, for $10,000 and $11,000, respectively. The cars involved were identical except that the car sold in 2015 had 30,000 kilometres on the odometer and the car sold in 2016 had 25,000. If our regression model estimates the extra 5,000 kilometres should depress prices by $1,000, then our time dummies will measure no change in intrinsic prices. Our complete model statistically performs this calculation across all time periods to create a measure of prices robust to the influence of the most pertinent characteristics of different vehicles sold at auction.

The hedonic price regression is specified as a linear regression model with a log-linear functional form. The dependent variable is either price or price-to-MSRP depending on the index type. The regressions use a vector of indicator and continuous variables as independent variables. The coefficients are estimated via ordinary least squares.

Price movements

Given this described methodology, it remains important to answer what, exactly, are the price and retention indexes measuring?

The price index is measuring used-vehicle sale price inflation. Inflation for a particular type of used car, say a 3-year-old Holden Commodore, occurs for three main reasons. First, broad price and income inflation throughout the economy will reflect itself in rising prices for the Commodore; second, supply and demand for a 3-year-old Commodore (and for competitor brands, including newer and older Commodores) tend to shift over time. Finally, prices of Commodores tend to shift because Holden gradually adds safety features and new technology when redesigning the car, while also finding ways to cut the costs of production and pass these savings on to consumers. A measure of nominal Holden Commodore inflation would thus track price changes of vehicles with similar age, mileage and type over time relative to their prices in some base period.

The price index, as shown in Chart 2, demonstrates vehicle prices generally decreased until the middle of this decade. More recently, prices have increased at a more consistent pace of 2.6% a year since 2014. The price movements of the last two decades make intuitive sense. Used-vehicle prices increased as the Australian economy had a relatively stable ride from 2014 through December 2018. Additionally, during periods of economic uncertainty there is an expected decrease in prices for used vehicles as demand wanes and people are less inclined to spend.

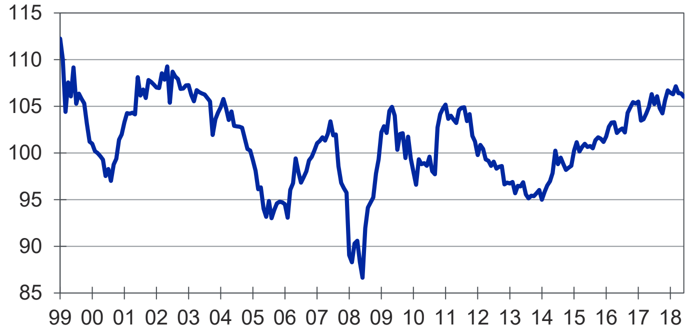
To validate this trend, it is helpful to look at average sale prices in the data—a naïve index that does not control for mix. In Chart 3 we see the average sale price of all vehicles stayed relatively stable at around $17,000 from 1999 through 2014 and increased noticeably from 2015 to 2018. Also in Chart 3, we look at two segments of vehicles, large SUVs and large passenger cars. During the period of 2000-2014 both sub-segments experienced a fall in average sale price, but the naïve index remains largely stable. If we were to use the naïve average sales price index we would believe that prices have remained unchanged, while, in fact, mix-adjusted prices were actually falling.

This misdirection in the naïve index is because raw price levels do not account for the change in vehicle mix that was shown in Chart 1. As mentioned, during the sample period consumer tastes shifted from less costly sedans to more expensive utes and SUVs. In short, Australians, on average, were paying more for vehicles but were also receiving a lot more vehicle for their dollars.

Chart 3 provides strong evidence that our methodology is working as intended. It

Chart 2: Used-Vehicle Price Index

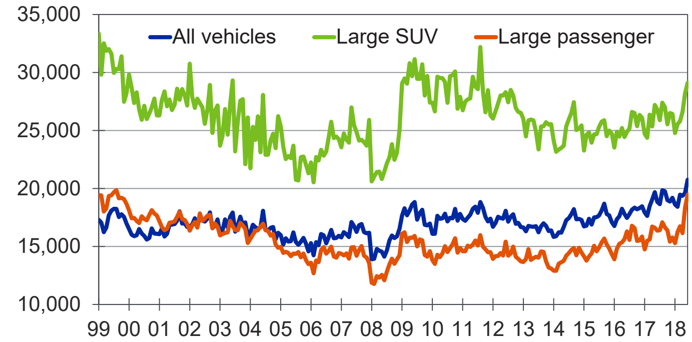
Jan 2010=100, SA



Sources: Datium Insights, Moody's Analytics

Chart 3: Naïve Price Levels

Avg sale price, A$



Sources: Datium Insights, Moody's Analytics

still leaves unanswered the question as to why the sale price index is lower at the end of 2018 than in mid-1999, where our index starts. The actual average inflation rate in Australia has been 3.4% from 1999 through 2018 (see Chart 4). Obviously used-auto prices have taken a very different path.

There are two main reasons the auto industry has experienced long-term sale price decreases. The first is the reduction of tariffs on new-vehicle imports since 2000. When our series began there was a 15% duty on all auto imports, but this has since been reduced to only 5%. Additionally, tariffs on new vehicles were removed entirely for Japanese imports following the Japan-Australia Economic Partnership Agreement. Japan is the largest exporter of vehicles into Australia. Given that new cars are almost perfect substitutes for used cars, the prices for new vehicles establish a ceiling that used-vehicle prices will not go above.

The second reason for long-term used-vehicle price deflation is the exchange rate. During the observed period, the Australian auto industry shuttered its last manufacturing plant, and vehicles became exclusively an import product. When looking at price levels for such products the impact of exchange rates in a floating currency environment becomes crucially important.

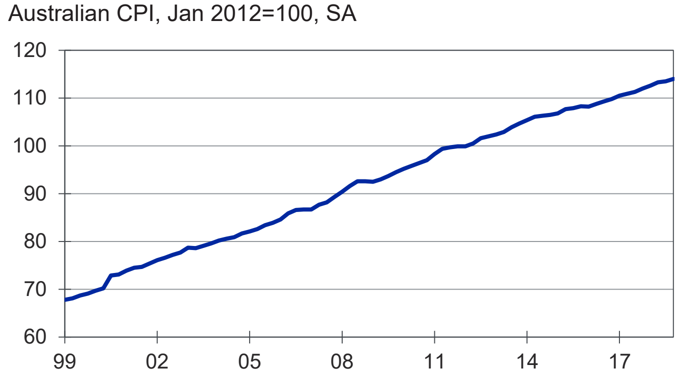
Chart 5 shows nominal AUD-USD and AUD-JPY exchange rates during the sample period. Japan is the major exporter of vehicles to Australia and we can use the U.S. dollar as a proxy for many other locales. The relative value of the Australian dollar increased, in trend terms, from 2000 through 2014 before declining to its current value of around $0.70. This pattern is almost an exact inversion of the behavior observed in our vehicle sale price index. This makes sense because a stronger Australian dollar will allow imported products to be sold at a lower price in AUD terms.

A second lens through which one can view used-vehicle prices, particularly in the leasing domain, is the behavior of retention values over time, defined as the sale price as a percentage of Manufacturer Suggested Retail Price when new. For a given type of vehicle sold at a given age, the average used-car sale price will increase over time because starting MSRP values rise with the addition of new technology, redesigns, and changes in original equipment manufacturer pricing strategy.

It is conceivable, however, that the value retention stays constant if new- and used-car prices witness a similar trajectory. In concrete terms, both a 2013 and 2017 Toyota Camry may be worth 48% of MSRP when sold after three years of existence, even though the 2017 Camry had a higher starting MSRP. In this way, measuring value retention dynamics can remove some, but not all, of the inflation effect caused by changing quality and initial

Chart 4: Consumer Prices

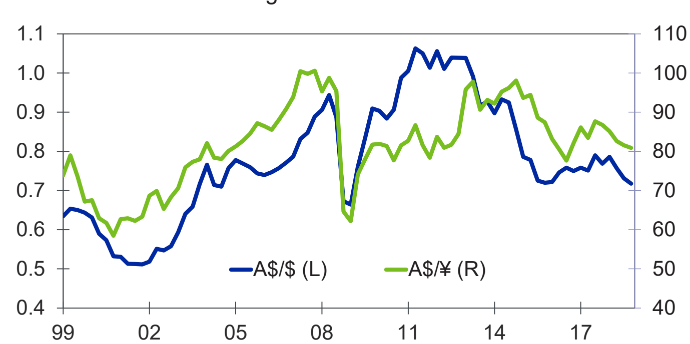
Australian CPI, Jan 2012=100, SA



Sources: Australian Bureau of Statistics, Moody's Analytics

Chart 5: Australian Dollar Gains Value

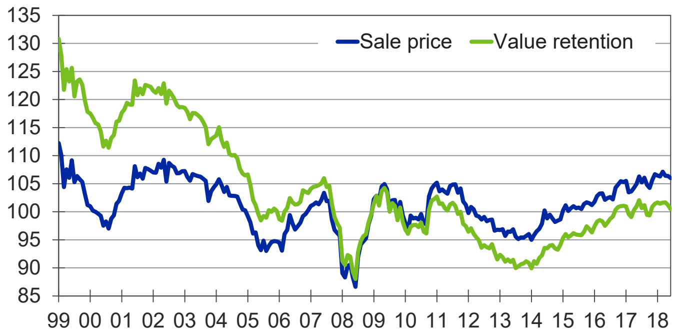
Nominal bilateral exchange rate



Sources: IMF, Federal Reserve, Moody's Analytics

Chart 6: Price and Retention Indexes

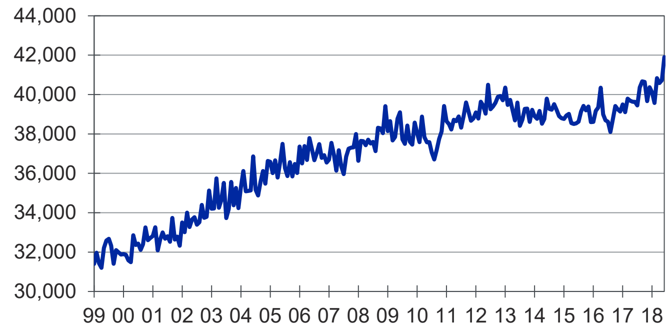
Jan 2010=100, SA



Sources: Pickles, Moody's Analytics

Chart 7: MSRPs Rise Over Time

Avg Manufacturer Suggested Retail Price, A$, NSA



Sources: Pickles, Moody's Analytics

pricing. Because retention values vary by vehicle age and segment, the application of the hedonic price index methodology, for the same reasons previously mentioned, is apt to most accurately measure value retention dynamics in wholesale markets.

Value retention trends can be quite different compared with overall used-car prices, as observed by comparing the Datium Insights - Moody's Analytics Price Index with the Datium Insights - Moody's Analytics Retention Index in Chart 6. Particularly noticeable is the large divergence in the beginning of the series through 2005. During this period the loss in value retention was much larger than the decrease in sale prices. Following this period, movements in the price and retention indexes track each other quite closely.

The divergence early in the data series shows the retention index to have decreased more rapidly than the price index. This is only possible if the MSRP, in the denominator, rises at a faster rate than used-vehicle prices over this period. In Chart 7 we confirmed that MSRPs were rising during this period, but it remains an open question as to why sale prices did not follow a similar pattern. Some possibilities include a change to a more aggressive incentive scheme to attract buyers into new-car showrooms. This would increase the MSRP but keep sale prices relatively stable. Bear in mind that the MSRP reflects the price the manufacturer wants to get for the vehicle, not necessarily the price that the consumer is prepared to pay.

Another possibility is demand for new cars increased quickly over this period as the tastes of the auto market shifted away from used cars because of a change in consumer preferences. This would allow manufacturers to charge a premium for new cars that would not be recovered in the used-vehicle sale price numbers.

Possibilities

Datium Insights and Moody's Analytics joined forces to help provide better analytical tools for the Australian auto finance and auto remarketing communities. In addition to the indexes described in this paper, we have also introduced a new vehicle-level price forecasting tool for use by anyone exposed to large numbers of vehicles. The two offerings are complementary: The indexes provide a useful summary statistic that allows industry-level trends to be tracked while the vehicle-level model allows disparate and heterogeneous portfolios to be effectively modelled and tracked under different economic scenarios.

In terms of the indexes themselves, we have created forecasts and stress scenario models that will allow the data to be included in forecasting models for loss given default and probability of default, lease residual projection models, lease return probability models, and so on. The availability of scenarios means stress tests can be run easily and effectively.

Our methodology can also be applied, quickly and flexibly, for clients interested in specific customized indexes on smaller portions of the used-car market. For example, a rental agency may be concerned only with 2-year-old compact cars. A fleet manager may be exposed only to the values of 3-year-old Holden Commodores. An investor may be concerned only with the performance of late-model VWs and require an index aimed directly at this target. With our index methodology, these needs can be rapidly fulfilled without the user needing to master a new methodology.

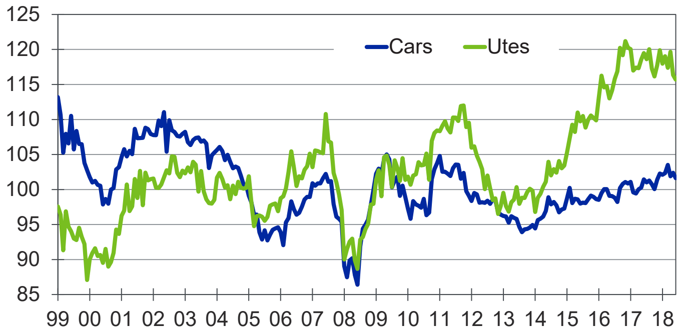
The approach we employed is easily generalizable to measure price changes for any segment, make or age group of the used-car market. Subset-restricted indexes are useful to measure accurately unique price trends in sections of the market that are washed out when included in an aggregate market index.

Certain differences in pricing trends are revealed, for instance, when the sale price index methodology is applied to the cars versus utes segments as shown in Chart 8. Here we see the price of cars decreasing 10% over the sample and the price of utes increasing by nearly 20% over the sample. Just like the market-level indexes, the segment-level variants are robust to shifting vehicle sales mix within each segment over time. The segment indexes therefore measure inflation caused by supply, demand and quality changes particular to each segment.

Having a transparent, theoretically sound and flexible methodology to create price indexes yields endless possibilities tailored to different use cases. Lessors can use an index focused on retention values for 3-year-old vehicles and subprime lenders can home in on entry-level sedans. Moreover, when combined with Moody's Analytics macroeconomic models, the indexes can be properly projected across a range of economic scenarios to understand the complex trends and risks in every corner of the market.

Chart 8: Car and Ute Price Index

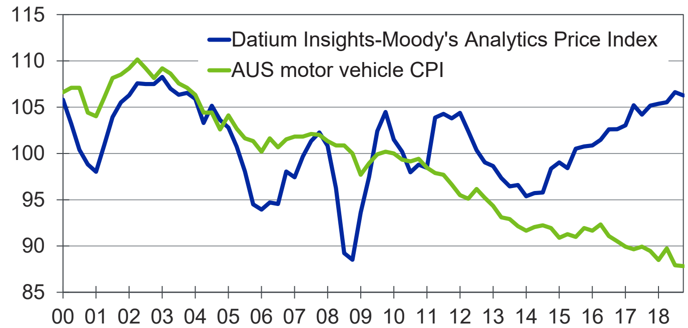
Jan 2010=100, SA



Sources: Datium Insights, Moody's Analytics

Chart 9: Price Indexes Diverge

2010Q1=100, quarterly, SA



Sources: Australian Bureau of Statistics, Datium Insights, Moody's Analytics

Conclusion

Recent availability of the Datium Insights data has allowed for the development of a new set of indexes that provide a useful addition to Australian macroeconomic commentary. Australia has relatively few consumer series that are closely followed by markets and even fewer that relate to the health of business. The auto price indexes introduced here are of use in this space because they relate to both sectors—weak prices in the context of healthy consumer demand indicate high levels of activity in new-vehicle markets.

These new indexes measure something rather distinct from other available indexes such as the motor vehicle CPI (see Chart 9). This index, released quarterly by the Australian Bureau of Statistics, takes quality and technological changes very seriously and carefully expunges the effect of these phenomena from the calculated data. This has recently caused the index to decrease during a period when the industry has experienced rising prices. Thus, if you were to use this index to track recoveries from bad loans you would severely underestimate your expected returns. Additionally, the CPI is looking at both new and used vehicles rather than focusing squarely on the wholesale market for used cars.

Both lenders and lessors are able to use the Datium Insights - Moody's Analytics price indexes to accurately gauge market conditions. Additionally, the forecasts that are available allow market participants to plan for future movements, stress-test their portfolios, and thus devise strategies to maximize profitability.

The technique is fully flexible and transparent. It can be put to use to help enhance internal loss models, as well as to track a wide variety of industry trends and volatility.

About the Authors

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Loc Quach is an economist with the economic research group at Moody's Analytics. He covers state and regional economies. Loc also contributes to the U.S. macroeconomic forecast model. He holds an MS in quantitative economics from California Lutheran University and a BA in economics from California State University, Long Beach.

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Moody's Analytics added the economic forecasting firm Economy.com to its portfolio in 2005. This unit is based in West Chester PA, a suburb of Philadelphia, with offices in London, Prague and Sydney. More information is available at www.economy.com.

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