Consumer perception of US and Japanese automobiles: a statistical comparison via consumer reports and J.D. Power & Associates data

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Abstract: Consumer reports (CR) and J.D. Power & Associates (JDP) produce annual reports on cars made by US and Japanese auto-makers that are widely used by consumers in the US in making their purchase decisions. In the mainstream media, US and Japanese cars have been compared, but no systematic statistical analysis of this exists to the best of our knowledge. Further, the two sources, CR and JDP, have also not been compared for any potential correlation. In this paper, we carry out statistical tests to determine whether: i) strong correlation exists between these two sources; ii) whether US and Japanese cars have undergone any trends in the last 10 years. Our key findings are: i) CR and JDP are not strongly correlated;

ii) although Japanese cars still outrank US cars, the latter are fast closing the gap in perceived quality, while the former are fast losing ground on brand image.

Keywords: automotive surveys; consumer satisfaction; quality management; advertisements.

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1 Introduction

All over the world, many buyers of cars have typically considered information available on the internet before reaching out to their wallet, and this has been a trend for many years now (Klein and Ford, 2003; Ratchford et al., 2006). However, as is well-known, models of cars offered in the market change dramatically. It is well documented that a significant majority of car buyers in the US purchase cars from auto-makers associated to one of the two nations: USA and Japan.

Over the years, both US and Japanese cars have altered on various fronts. US cars have become more fuel-efficient, while Japanese cars have increased in size. Changes have also occurred in numerous other dimensions of the car, including the engine and the brakes etc. Japanese cars, which enjoyed a very high standing for many years, have recently partially lost that special status of safety they enjoyed with customers – with Toyota's massive recall owing to defective brakes. Similarly, General Motors has seen a huge recall of their vehicles recently because of failure of their ignition systems. Further, the auto-industry has changed dramatically, and the customer's reactions are being paid close attention in the market. These changes – some cosmetic, but mostly non-cosmetic – have led to a new automobile market; these changes have naturally produced a significant impact on the consumers' perceptions of these cars. It is also well-known that US and Japanese cars have been the subject of comparison and numerous debates over the media for many years now, and have undergone certain trends in the last 10 years. However, no systematic study of these trends or comparisons is available in the academic literature.

Another aspect to the information available out there has to do with the veracity of the claims made in advertisements. Recent reports suggest that many advertisements from auto-makers and their dealers are known to be misleading (Burns et al., 2005; Weinmann and Bhasin, 2011; Malik, 2013; Kendall, 2014). The phenomenon of misleading advertisements is certainly not limited to automobiles, or to the US, and has been recognised as a common problem worldwide (Kossman, 2013; Dalal, 2013). Nonetheless, car manufacturing and car buying are very significant economic activities that have consequences for the economic health of a nation. Hence, it is essential that the value of information out there be studied in depth in an objective manner, via statistics, so that the prevalence of confusion and misinformation is minimised. Because of misleading advertisements, many consumers often read reports from consumer reports (CR) and J.D. Power & Associates (JDP) before making critical purchasing decisions. CR and JDP generate significant amounts of data of consumer perception of cars, and a large number of consumers, as well as marketing strategists/forecasts, rely on these data to make important decisions.

Overall, this paper, hence, aims to study data from two angles:

- study the consistency of the data from the two major sources, namely JDP and CR
- find whether any trends exist in terms of the perception of cars from the US and Japanese auto-makers.

From the results, it is possible to make recommendations to consumers and marketing strategists. We now provide a motivation for a close examination of the two angles:

Consistency of surveys: It is mainly because of problems with advertisements discussed above that potential car buyers often turn to surveys, which they perceive to be repositories of data from neutral observers. Establishing consistency of ratings/ rankings/scores from different sources seeking to measure the *same* metric is usually desirable in order for the customer to trust each of the sources. Thus, a statistical comparison of CR and JDP, to determine whether the two sources provide *consistent* information for a given vehicle, can be very useful. In case strong correlation/consistency is lacking, it becomes necessary to dig deeper into reasons for the lack and provide recommendations to the users based on the reasons found.

The need for discovering trends: Finding trends of improving or worsening consumer perception of an automaker is crucial – both for managerial strategy and consumers. From the perspective of marketing managers, such trends are necessary to help understand which features of reliability are appreciated by customers and which features cause their products to fare poorly. Discovering such trends also help marketing managers understand where the market is going in terms of consumer feedback. From the perspective of the consumer, these surveys can often become confusing – largely because of the numerous attributes used in defining reliability/dependability. This makes it necessary to combine the information provided in these surveys in a 'micro' sense into attributes that convey the information in a compact, 'macro' sense more meaningful to the layperson. To this end, we successfully consolidated the data obtained from CR and JDP into two macro-attributes: the 'perceived quality' and the 'brand image' of the automobile. These, as we will discuss later, are accepted attributes for marketing strategists.

Contributions of this paper: This paper, to the best of our knowledge, for the first time studies any potential correlation between CR and JDP. Further, cars from Japanese and US automakers have been compared in the mainstream media for years, but to the best of our knowledge, no systematic statistical analysis has been conducted in the academic literature in recent years. This paper seeks to fill these two critical gaps in the literature. Our main findings were as follows:

- scores of CR and JDP are not strongly correlated, implying that consumers and marketing strategists should consider both sources before making decisions
- both CR and JDP surveys indicate that Japanese cars continue to outrank US cars in terms of perceived quality and brand image
- trends from CR indicate that the perceived quality of both US and Japanese cars is climbing, but the slope of US cars is steeper
- the brand image of Japanese cars is falling rapidly.

The rest of this paper is organised as follows. Section 2 provides a literature review. In Section 3, we investigate existence of correlation between JDP and CR. Section 4 contains the main results related to analysing US and Japanese cars. Managerial implications are discussed in Section 5. Conclusions, along with a discussion on potential future research, are presented in Section 6.

2 Background literature

Consumer surveys have historically produced a significant impact on design and manufacturing of automobiles (Hauser and Clausing, 1988). Hence, it is no surprise that CR and JDP have acquired importance; they provide voluminous amounts of consumer survey data that manufacturers can use to improve their vehicles. Brand names often convey signals of product quality to the consumer (Rao and Ruekert, 1994), and consumer surveys can perform reality checks for potential buyers when a given brand name performs poorly. As a result, consumer surveys and product reviews have become very important instruments in the business world (Belsky, 2012). Unfortunately, product quality is often unobservable (Kirmani and Rao, 2000), and therefore a consumer survey can play a key role in the purchasing process. Chen and Xie (2008) argue that while new word-of-mouth information is gathering popularity, online consumer reviews are playing an increasingly important role in consumers' purchase decisions. Of course, we must note that purchase decisions are also influenced by a variety of other factors, e.g., self-image congruence (Heath and Scott, 1998; Hosany and Martin, 2012), which may be potentially influenced by consumer surveys. Peterson and Wilson (1992) also argue that automotive purchase decisions are complicated and are often affected by issues unrelated to customer satisfaction, e.g., personal characteristics. Oliver (1993) also suggests that measuring customer satisfaction is a complex process in which 'joy' and 'interest' in using a product are treated as separate attributes. Thus, it is clear that there is work in the literature that cautions against reading too much into consumer satisfaction responses, as they appear to be affected by extraneous factors not directly related to customer satisfaction.

Nonetheless, it is important to point out that the consumer survey reports produced by JDP and CR, *which are quantitative in nature*, are used extensively in the real world for decision-making and have also been employed in the academic literature (e.g., Shiv et al. (1997) and Rangaswamy and van Bruggen (2005) to cite a subset of journal articles). While there are numerous works that use data from JDP and CR, there is no literature on examining the relationship between the data provided by these sources. In particular, no systematic study exists that compares and contrasts features of cars examined by these sources. As stated earlier, despite a great deal of information available on the internet from automakers and car dealers, the customer is interested in unbiased information from third party sources such as JDP and CR. It is natural to expect some sort of consistency from the two sources, given that both survey reliability/dependability, although they use different scales in their ranking systems.

Reliability and safety information has been generated by CR and JDP since 1936 and 1968 respectively, which has been used for purchasing new as well as used cars. CR is well-respected in marketing and economics circles (Sowell, 2007; Murray, 2007). It is published by the independent nonprofit organisation, *Consumers Union*, which does not accept outside advertising. JDP provides the information it collects from opinion surveys of a sample of consumers in the so-called *Power Circle Ratings* (Website 1, 2012). The Consumer Reports National Research Center sends out *The Annual Auto Surveys* (Website 2, 2012) to a random sample of the several million readers who subscribe to CR (*consumerreports.org*). These surveys yield detailed information on approximately 300 models annually on vehicles in the preceding 12 months in 17 trouble areas. CR develops a forecast about the upcoming year's model on the basis of the survey information gathered in the last 10 years.

It is important to note that questions have been raised about the impartiality and generality of data provided by CR and JDP (Flint, 2005; Dodge, 2007). According to Korsch (2007), CR's reviewers are concentrated more on the coasts than in the heartland or the Deep South. He also questions the impartiality of ratings because of the fact that the responses come from self-selected individuals. Noah (1999) highlights the differences in the incentives of JDP and CR in generating the rankings they publish. According to him, CR does not allow its ratings to be publicised by advertisers nor does it advertise them itself, while JDP uses advertisements from its clients to 'improve their own profile'. Thus it appears that there may be a symbiotic relationship between JDP and its clients, which may hamper objectivity; it also appears that JDP has stopped releasing *very* unfavourable rankings to the public. While JDP is a private organisation that must make revenues from its own business, their impartiality is being increasing questioned (Morran, 2010).

3 Investigating correlation between CR and JDP

A key aspect of evaluating these cars is the methodology adopted by the rating agency. CR and JDP adopt different methodologies in performing their evaluations in terms of the specific features used and their rating scales. It is unclear whether this is intentional, but this leads to some unique issues in comparing results for a given automobile from the two agencies. CR's evaluations, called 'reliability ratings', are based on opinions of users from the previous 12 months, while JDP's 'dependability ratings' for any given year are an average of feedback from three-year old vehicles, where the feedback is for the preceding 12 months. Thus, although there are differences in the ratings from the two agencies, it is a fact that market forecasts are prepared on the basis of consumer perceptions, among other factors. Equally importantly, many consumers look at ratings from *both* agencies before buying vehicles. Hence it is natural to test if the two agencies provide similar results. Generally, when there are correlations, the user can substitute one by the other, i.e., consider only one of the two.

The features (attributes) used by CR and JDP for evaluation purposes have some similarities, but a simple comparison between the ratings from the two agencies is not feasible. Using these attributes from each agency, we sought to compare a select group of US and Japanese cars over 10 years. The comparison was performed to determine whether there are performance gaps in US and Japanese cars, and if there are any statistical trends. To make a meaningful comparison between the results from CR and JDP, five categories of representative models were selected, where each automaker had a representative model for comparison. These models were family sedans, large sedans, sports vehicles, large SUVs and small SUVs. Further, four representative attributes were chosen for our overall study, which were: powertrain dependability (PT), body and interior dependability (BI), feature and accessory dependability (FA) and overall dependability.

Assigning numerical values to each rating on the scales was an obvious choice. However, the two sources used different scales; hence, a conversion to a consistent numerical scale had to be conducted –to obtain readings that could be compared. CR has a rating system that is represented by symbols, which correspond to a different evaluation level by the consumer. With 'excellent' being the best rating, the score ranges through 'very good', 'good', 'fair' to 'poor'. These qualitative values were assigned numbers from 1 to 5 with 1 representing 'poor' and 5 representing 'excellent'. Similarly, JDP's ratings range from 'among the best' to 'the rest' with four different ratings. We assigned 4 to the best rating and 1 to the lowest rating, with numbers in between for those between 'the best' and 'the rest'. See Figure 1 for a pictorial representation of the JDP scheme. Figure 2 shows how we aligned the scales. We mapped the CR score from a five-point scale to a four-point scale. The rationale behind mapping the scores for CR from five to four is based on the fact that on a four-point scale, 'excellent' would be assigned 4, 'very good' would be assigned 3 and 'good' would be assigned 2; this suggests that 'fair' and 'poor' could be combined to form a group that can be assigned 1. Further, this is a logical assignment if we consider 'excellent' to mean 'among the best' and 'very good' to mean 'better than most'. Another possibility would have been to assign CR ratings of 'excellent' and 'very good' to the JDP rating of 'among the best'. Since a main theme of this study is to study the perception of high quality, we decided to leave the top ratings as they are and do the combining of scales at the lower end.

Figure 1 JDP rating scale (see online version for colours)

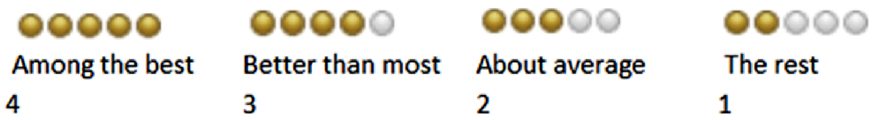
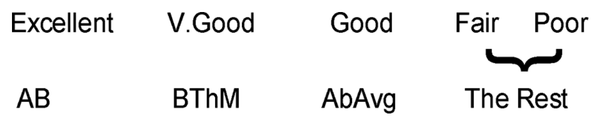


Figure 2 Aligning the CR and JDP scale: The 5-point scale on the top is that of CR where V. Good denotes very good. The 4-point scale on the bottom is that of JDP, where AB denotes Among the Best, BThM denotes better than most, and AbAvg denotes above average



Mathematically, our 'aggregation' mapping can be defined via the following notation: X_{CR} and X_{JDP} will denote actual readings for CR and JDP respectively, while Z_{JDP} and Z_{CR} will denote the unified readings for JDP and CR respectively.

$$Z_{JDP} = X_{JDP}$$
$$Z_{CR} = X_{CR} - 1 \quad \text{when } X_{CR} \geq 2,$$
$$Z_{CR} = 1 \quad \text{otherwise.}$$

Another approach often pursued in comparing two indices is to 'normalise' each score (see Mishra (2009) and references therein). In this context, normalisation, if designed for a four-point scale, will work as follows: The JDP scale will remain unaltered, but the CR score will be transformed to a four-point-scale as follows:

$$Z_{JDP} = X_{JDP}$$
$$Z_{CR} = 1 + X_{CR}\frac{3}{4}.$$

This will cause half of the cars ranked between 'average' and 'better than average' by CR to acquire the scores close to 'better than most' of JDP. E.g., consider a car scored 3.1 by CR, which is slightly above 'good' in the CR scoring system, would get a score of 2.575

in the new scale, which would be considered closer to 'better than most' than 'about average' in JDP; however, such a car in an aligned scale should be considered 'about average'. Hence, we did not use normalisation, and instead, as described above, chose to merge the 'worse than average' and 'much worse than average' of CR into one category, making it equivalent to the 'rest' of JDP.

Stated formally, our first hypothesis is as follows:

H1: The ratings produced by JDP and CR are strongly correlated.

To test his hypothesis, we conducted a number of studies. We now describe each study in detail. The goal of these studies was to investigate if the two sources are strongly correlated.

First study: For our first study, our regression model was defined as:

$$Z_{\mathrm{JDP}} = \beta_0 + \beta_1 Z_{\mathrm{CR}} + \beta_2 t + \beta_3 Z_{\mathrm{CR}} t + \varepsilon, \tag{1}$$

where t denotes the year. Regressions were run separately for each of the following five classes: the family sedans, the large sedans, the sports vehicles, the small SUVs, and the midsize SUVs; in each regression data from years 2001 through 2010 was used. It must be noted that in each of these regressions, the tth data point for $t = 1, 2, \ldots, 10$ can be denoted by the 3-tuple, $(Z_{\mathrm{CR}}(t), t, Z_{\mathrm{JDP}}(t))$, where $Z_{\mathrm{CR}}(t)$ denotes the arithmetic average of the CR scores of all the vehicles in that class for year t and $Z_{\mathrm{JDP}}(t)$ denotes the same for JDP. In addition, data from all vehicles from the years 2001 through 2010 was combined to run a sixth regression using equation (1). In other words, for the sixth regression, $Z_{\mathrm{CR}}(t)$ will denote the arithmetic average of the CR scores of all the vehicles *for all the five classes* for year t and $Z_{\mathrm{JDP}}(t)$ *will* denote the same for JDP. It must be noted that each value provided by JDP or CR is itself an average of several hundred samples. Thus, for instance, JDP provides an average score, over hundreds of samples, for a given year and for a given vehicle, e.g., Ford Escape (V6) for 2005. In our analysis, $Z_{\mathrm{JDP}}(t)$ represents an average of these average JDP scores of all vehicles in the class under consideration for the year t. The R^2 values for each of these six regressions are presented in Table 1, and the p-values for testing whether the coefficients, β_1, β_2 and β_3, in the respective regression models are non-zero are provided in Table 2. As is clear from the p-values in Table 2, only Z_{CR} turns out to be significant. This leads us to our next study.

Table 1 R^2 values from the regression model with year as an independent variable

Vehicle class	R^2
Family sedans	0.489956
Large sedans	0.140323
Sports vehicles	0.245093
Small SUVs	0.428750
Midsize SUVs	0.491109
All classes	0.300312

Table 2 The table shows *p*-values for testing whether coefficients in the regression model are non-zero

Regression variables	*Family sedans*	*Large sedans*	*Sports vehicles*	*Small SUVs*	*Midsize SUVs*	*All classes*
Z_{CR}	<0.0001	0.0070	0.0136	<0.0001	<0.0001	<0.0001
t	0.6197	0.6061	0.6961	0.6095	0.7386	0.2688
$Z_{CR}\,t$	0.5944	0.6693	0.9436	0.7102	0.8143	0.6905

Second study: Since the *p*-values for only Z_{CR} indicated significance (see Table 2), i.e., the year t and the interaction term $Z_{CR}t$ are both insignificant across all models, time (t) was dropped from the model in equation (1), and hence for the second study, we used the following model:

$$Z_{JDP} = \beta_0 + \beta_1 Z_{CR} + \varepsilon. \tag{2}$$

The above is a linear model with one dependent and one independent variable. Hence, a strong correlation is indicated when the absolute value of r, the *Pearson product moment correlation coefficient,* is greater than 0.8. This implies that for a linear model with one dependent and one independent variable, the coefficient of determination, R^2, must exceed 0.64. We performed regressions separately for each of the five classes, which were described in the first study, and a sixth regression combining all the data for the five classes. The resulting R^2 values are shown in Table 3. As is clear, in none of the cases does R^2 exceed 0.64, indicating that our hypothesis, H1, cannot be true. In other words, any correlation between JDP and CR is not strong.

Table 3 R^2 values from regression analysis for equation (2), which was used for the second study

Vehicle class	R^2
Family sedans	0.4480
Large sedans	0.0472
Sports vehicles	0.0701
Small SUVs	0.3744
Midsize SUVs	0.4508
All classes	0.2751

Third study: Since the previous study did not show strong correlation, we performed separate regressions, using equation (2), for each auto-maker-class combination. There are five auto-makers in our study, namely, GM, Chrysler, Ford, Toyota, and Honda, and five classes (described above). For some combinations, data were not available. In all, we ran 21 regressions for the combinations for which data was available, and the resulting R^2 values are shown in Table 4. Finally, data from all the classes for each automaker were combined to run regressions separately for each of the five automakers; the R^2 values for these are shown via the last row of Table 4. As is clear from the table, in none of the cases does the R^2 value exceed 0.64.

Table 4 R^2 values from regression analysis for equation (2), which was used for the third study: N/A indicates data not available

Auto-maker	*GM*	*Ford*	*Chrysler*	*Toyota*	*Honda*
Family sedans	0.0020	N/A	0.0159	0.2105	0.2297
Large sedans	0.0006	0.0684	0.0050	0.3790	0.0815
Sports vehicles	0.0384	N/A	N/A	0.3995	0.0228
Small SUVs	0.2916	0.0005	0.1653	0.2927	0.2071
Midsize SUVs	N/A	0.0878	0.0172	0.2034	0.2580
All classes	0.0287	0.0492	0.0617	0.3147	0.1554

Implications: Taken together, our three studies indicate the correlation is not strong enough statistically to suggest that the ratings from JDP and CR strongly agree. This has significant implications for the consumers as well as marketing strategists. Forecasts of numerous manufacturers that supply products to auto-makers depend in turn on forecasts of different automobiles. Indeed, the actual sales also depend critically on consumer perceptions of the previous year(s). Thus, a clear implication for consumers here is that they should consider *both* CR and JDP before making purchase decisions. For marketing strategies, in addition to looking at both sources, it is also important to discover the reasons for the differences and identifying the source that may be more reliable for a given brand. As stated above, the fact that JDP does not disclose data on very unfavourable rankings from consumers should be taken very seriously by marketing strategists and other forecasting agencies, as selective deletion of data, related to consumer perceptions, may lead to misleading forecasts.

4 Comparison of US and Japanese cars

Now that we have established that the correlation between CR and JDP is not very strong, we now move on to the next step in our analysis, which is to *compare* the perception of US and Japanese cars and detect any potential trends. As stated above, lack of academic literature on a statistical comparison of consumer perception of cars from the US and Japan motivated us to find ways to detect any comparative trends. If a strong correlation between two or more sources is discovered, it is customary to use the source that has the greatest volumes of data; however, our analysis in the previous section, which shows lack of strong correlation, makes it imperative that we consider *both* sources, JDP and CR, before drawing any conclusions. Hence, in the remainder of this paper, we will analyse data from CR and JDP separately.

The plan we have for our analysis is sequential. First, we will analyse each model separately to see if we can find any trends. For this, we will use the score given by the source (JDP or CR). If no useful trend is discovered, we will then seek to combine the information in the scores for the different features to form attributes to determine if we can find a trend for a given automaker. Finally, if we do not find a useful trend, then we will combine data from all automakers of a given country to discover potential trends. We now present details of this study.

Our overall goal here is to perform a time-series analysis using the following regression model:

$$Z = \beta_0 + \beta_1 t + \varepsilon, \tag{3}$$

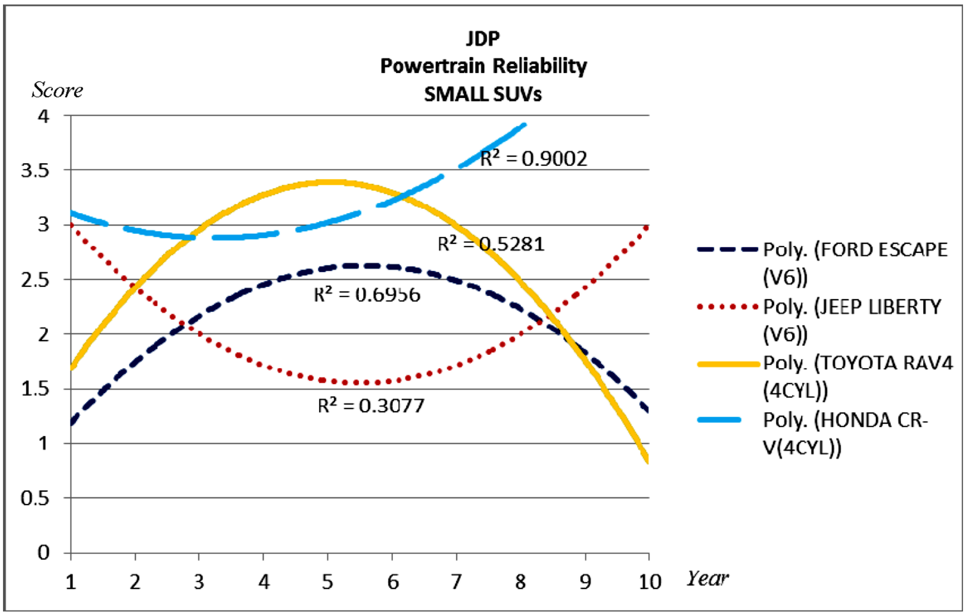
where Z denotes the score obtained from a given source (CR or JDP) for a given feature (e.g., powertrain reliability) and for a given auto-maker, while t denotes the year. Here, to be more specific, our tth data point can be denoted by $(t, Z(t))$, where $Z(t)$ denotes the score for a feature from a given auto-maker in the year t for $t = 1, 2, \ldots, 10$. Table 5 shows the R^2 values for linear trends for the attribute of powertrain reliability of Small SUVs, namely, Ford Escape, Jeep Liberty, Toyota RAV-4, and Honda CRV, using JDP data. Unfortunately, some car models showed clear trends while others did not. Hence, we subsequently used polynomial trends, which are shown in Figure 3. Although the polynomial trends improved the R^2 values, as is clear from Figure 3, the shape of the polynomial fit for some models is the reverse of that for some of the other models – implying that there is no uniform trend. This turned out to be true of all other attributes.

Since trends were not visible from analysing models separately, data for *all* models for a single automaker were aggregated, via a unique combined attribute, to determine if a uniform trend becomes visible. This required a systematic comparison of the attributes used by the two systems, JDP and CR. We now describe the analysis needed to perform this comparison.

Table 5 R^2 for a linear model

Car model	R^2
Ford escape	0.3767
Jeep liberty	0.0769
Toyota RAV-4	0.1202
Honda CRV	0.5545

Figure 3 Polynomial trend lines for JDP powertrain reliability (see online version for colours)



Grouping of data via attributes: To make a meaningful comparison, the nature of the attributes that were scored by the consumers had to be analysed. Both CR and JDP take into account similar items for dependability; however, how they group those items for scoring is different. JDP has four dependability categories that it provides ratings on: powertrain (PT), body-interior (BI), feature-accessory (FA), and the overall average. On the other hand, CR's reliability ratings are grouped under numerous 'problem areas', e.g., characteristics of the engine, transmission system, cooling system, audio system etc. The attributes of CR as well as those of JDP are presented in Table 6. Table 6 also maps the attributes of CR that fall under the four broad categories of JDP that were named above. Thus, for 'powertrain dependability', CR lists five areas that are related to powertrain: engine, transmission, brakes, drive system, and suspension. For the 'body and interior dependability' rating, CR provides ratings for body integrity and paint/trim/rust. Finally, for the 'feature and accessory dependability' area, CR has the ratings for the climate system, power system and accessories, body hardware, and audio system.

In our subsequent analysis, the average value of the attributes of CR that were classified under each group of JDP was determined, and thus a single score was obtained for each JDP category. Further, both CR and JDP provide the so-called *overall average* separately. This metric reflects the overall value of the vehicle to the consumer and is typically the result of a separate question to the consumer related to what the overall impression of the consumer for that brand is. There, we compute a separate average of the first three categories, namely powertrain, body interior and feature accessory, and refer to that average as the *combined average* or Avg. PT, BI, FA. Our combined average, hence, is different than the *overall average*. These three descriptors, it must be noted, are unlikely to be correlated, because they measure different aspects of the vehicle, and hence it is appropriate to average them. We gave equal weight to each descriptor in our averaging.

Table 6 Scheme used to bring CR and JDP ratings to equivalency

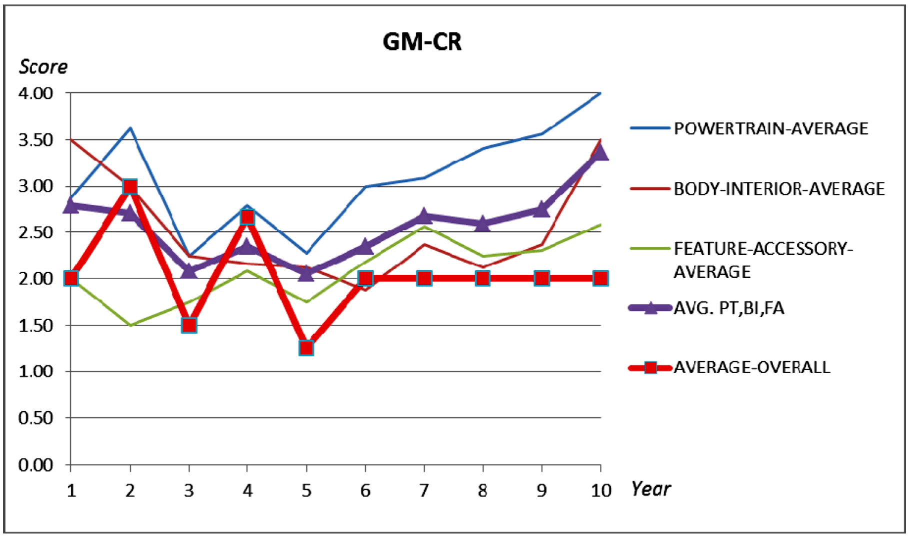
CR	*JDP*
Engine major Engine minor Engine cooling Transmission major Transmission minor Drive system Suspension Brakes	Powertrain dependability
Paint/trim Squeaks and rattles	Body and interior dependability
Climate system Body hardware Power equipment Audio system	Feature and accessory dependability
Used car verdict	Overall dependability

The *overall average* is likely to be more aligned with the image of the brand-model combination, while the sum total of the actual impressions for each individual feature may be more aligned with the perceived quality of the product. The literature indicates (Homer, 2008) that a difference is often made between the brand image and the perceived quality, and the brand image may in fact be more critical in marketing than the perceived quality. One could also argue that both the combined and overall averages could be treated as metrics of perceived quality, but the fact that the two revealed strikingly different average values *consistently* in our studies (that we describe later) reinforce our belief that the overall average appears to capture a version of the 'brand image', which we do not see in the aggregate average computed via the combined average. We will use the following symbols to denote these averages:

- *A1*: combined average or perceived quality
- *A2*: overall average or brand image.

When we looked at the individual attributes for each automaker separately, i.e., Toyota, Honda, Ford, etc., and performed regressions with equation (3), we did not discover any uniform trends. We present one sample of such a regression in Figure 4, which shows the trends for GM with CR data. Fortunately, when all models of all makers for a given country were pooled together and the combined and the overall averages were computed, we discovered useful trends. Of course, this analysis had to be done separately for each rating agency, because as stated above our results in the previous section indicate that JDP and CR are not strongly correlated.

Figure 4 GM-CR: the legend AVG. PT, BI, FA denotes A1 while the AVERAGE OVERALL denotes A2 with JDP data (see online version for colours)



A regression analysis was employed to determine any linear trends and the amount of gap over time between Japanese and US manufacturers. The linear regression model used for the analysis was as follows:

$$Y = \beta_0 + \beta_1 t + \varepsilon, \tag{4}$$

where Y equals the value of A1 or A2 and t denotes the year. The model was run separately for each country and each source (i.e., JDP and CR). Thus, here the tth data point in the regression analysis can be denoted by $(t, Z(t))$ where $Z(t)$ denotes the averaged score of all cars from a given country for a given attribute and year t, where $t = 1, 2, \ldots, 10$.

The resulting trends are presented in Figures 5–8. The figures show values of the regression coefficients as well as their R^2 values. One immediate conclusion that can be drawn is that *Japanese cars appear to be outranking US cars over all the 10 years surveyed by both JDP and CR for both A1 and A2*. The confidence intervals for slopes in the models that resulted in satisfactory R^2 values are shown in Table 7; the confidence intervals indicated either an upward or downward slope with 95% confidence. We present our findings separately for CR and JDP.

CR data: The regression models with CR's data yield satisfactory R^2 values except for US cars for A2 (overall average or brand image); for this latter case, even non-linear models did not yield a satisfactory R^2 value. For the combined average, i.e., perceived quality (A1), there appears to be an increasing trend for both US and Japanese cars, but the slope for the US cars is steeper, indicating that US cars are catching up quickly in terms of their perceived quality. For the brand image, there appears to be a decreasing trend for Japanese car makers; for US cars, the model is not satisfactory and cannot be used to make predictions regarding trends. It is clear however that the brand image of Japanese cars is still superior to that of US cars, indicating that US cars have room for improvement.

Table 7 Regression models, where *L* (*slope*) denotes the lower limit of the confidence interval on the slope in the regression model while *U* (*slope*) denotes the upper limit of the same

Country	*Source*	*Attribute*	*p-value* (*slope*)	*L* (*slope*)	*U* (*slope*)
Japan	CR	A1	0.0484	0.000176	0.03146
Japan	CR	A2	0.009882	–0.10277	–0.01917
USA	CR	A1	0.001168	0.055807	0.154375

Figure 5 Scatter plot and regression model for A1 with CR data (see online version for colours)

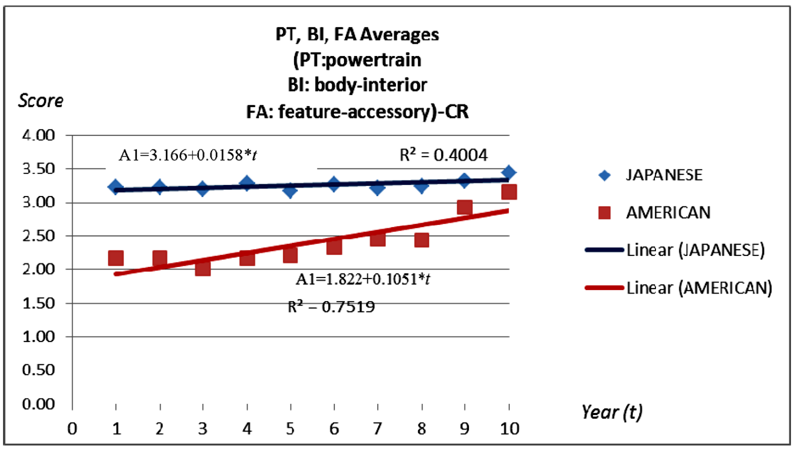


Figure 6 Scatter plot and regression model for A2 using CR data (see online version for colours)

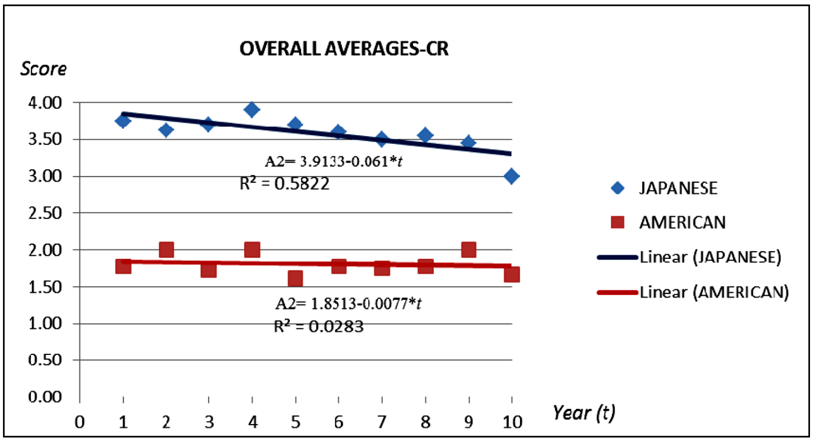


Figure 7 Scatter plot and regression models for A1 via JDP data (see online version for colours)

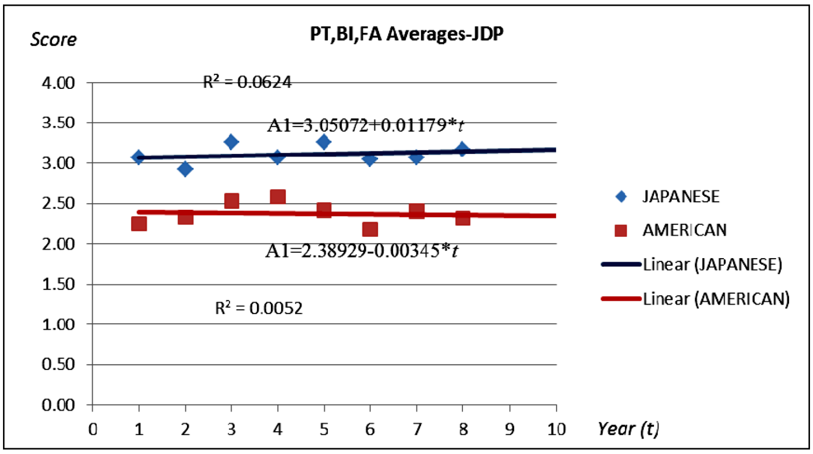
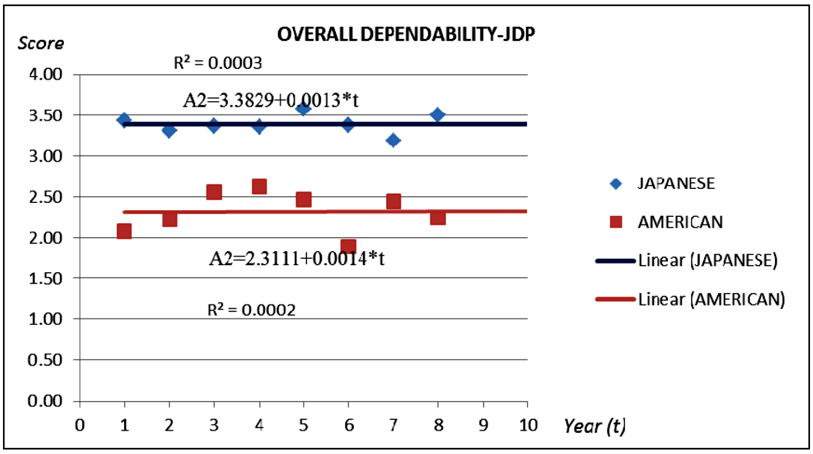


Figure 8 Scatter plots and regression models for A2 via JDP data (see online version for colours)



JDP data: The data from JDP did not yield satisfactory R^2 values for any of the cases. This was somewhat disappointing, but there is literature pointing to the fact that JDP is influenced by advertising (Noah, 1999), which can potentially lead to less clear trends in the data they publish. However, even from JDP data, it is clear that for both brand image and perceived quality, Japanese cars seem to be outranking US cars. Nonetheless, since statistically significant trends are useful in marketing, CR appears to have more predictive power than JDP.

Implications for practitioners and engineering managers: Our research has numerous implications for practitioners and engineering managers. The first outcome of this study is the finding that correlation between the surveys of CR and JDP is not strong, which implies that marketing strategists should look at *both* before developing forecasts for the next year.

A second important finding is that Japanese cars still outrank US cars in both their perceived quality and brand image. Hence, an important lesson that can perhaps be drawn is that even today, dependability/reliability work may not work as a very viable measure of competitiveness for US makers against the Japanese in the car market. Measures of competitiveness often serve as ‘core competencies’ for firms, and are hence critical for senior management in drawing their strategic plans. On the other hand, our study provides a lot of good news for US car makers. First, their perceived quality is improving sharply and steadily, which implies that they must continue to work on improving features used in measuring attribute A1, i.e., the powertrain, the body interior, and feature accessory. Further, in general it is true that brand image lags behind perceived quality in time; in other words, it takes a while for brand image to improve even after the perceived quality improves consistently for a few years. Hence, it is expected that brand image will also rise as long as the perceived quality keeps improving steadily. Japanese cars have seen a decline in their brand image in the years we studied, but US car makers should not get complacent: for instance, Toyota has taken numerous corrective steps after its recent brake failures and is likely to claw its way back to its high standing for brand image. It is thus clear that the auto market will continue to remain competitive, and automakers must keep improving their quality to keep customers satisfied.

The third implication is that a manager looking for trends may find surveys from CR to be more useful. Surveys from JDP lack clear trends, and this could perhaps be attributed to the symbiotic relationship between JDP and CR discussed widely in the mainstream media (Noah, 1999; Morran, 2010).

5 Conclusions

The US automobile market is currently flooded with cars from Asia and Europe in addition, of course, to those from US automakers. Naturally, a comparison of automobiles on the basis of the country of origin and maker is a regular topic for discussion in the mainstream media (see e.g., Website 3 (2013) for a recent example). What the academic literature lacks is a systematic scientific comparison of these automobiles and a methodology for performing this comparison via statistical tools. The research presented in this paper was motivated by this gap in the literature. In what follows, we summarise our main findings and present some directions for future research.

Summary of findings: First, somewhat surprisingly, our statistical analysis did not reveal a strong correlation between CR and JDP data for the same vehicles surveyed in the same timeframe of 10 years. What also became evident from this analysis is that a consistent ranking scheme, which would use a fixed numeric scale of measurement and could be treated as an industry standard, is lacking but will be of immense help to the consumer. Second, we found that JDP's data did not reveal clear trends, although CR's data exhibited clear trends for much of the analysis. In particular, CR's data showed that the perceived quality of both Japanese and US cars was improving with time over a 10-year period, and although US cars were lagging behind their Japanese counterparts, they were closing the gap very fast. For the brand image, CR's data showed that Japanese cars appear to have a declining trend.

Scope for future work: To keep the analysis tractable, we chose only a few representative models for which data was available for all 10 years in our timeframe. A study with a larger database may reveal other insights. Further, our study was limited to US and Japanese cars, but European and Korean cars also have a significant market share in the USA and should be analysed in future studies. Additionally, it is important to note that statistical studies of the kind we carried out here need to be performed after regular intervals of time, e.g., every 5–10 years, because automobiles change almost every year. It is also important to take a critical look at the features investigated by the rating agency and how they contribute to brand image and perceived quality. Finally, the lack of correlation between ratings of the same automobile from different agencies perhaps indicates that very low evaluations should not be discarded and that this issue needs further investigation.

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