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Quality Change in Brazilian Automobiles

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ABSTRACT

In this paper I investigate the quality evolution of Brazilian autos. To measure the quality evolution of Brazilian autos, I have assembled a data set for Brazilian passenger cars for the period 1960/94, to which I have applied the hedonic pricing methodology. To the best of my knowledge, this is the first time an index of quality change has been constructed for the Brazilian automobile industry.

The results presented here have two major implications. They allow a better understanding of product innovation in Brazil's auto industry, and they provide a clearer explanation of the behavior of auto prices.

1 - INTRODUCTION

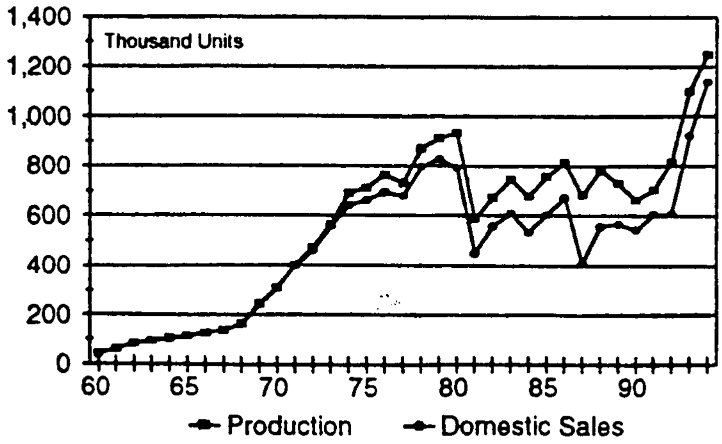
The automobile has had an enormous impact in modern industrial society. It has affected not only the industrial production process, but the lifestyle of the society as well. The industry was the scene of two profound evolutions in the production process: mass production and lean production [see Womack, Jones and Ross (1990, Ch. 1)]. It, should be no surprise that the industry has been a constant object of study by a variety of disciplines.

In 1994, world automobile production reached 50 million units. The Brazilian automobile industry contributed 3.1% of this total, making it the ninth largest world producer of vehicles [see Anfavea (1995b, p.21)]. The industry has played a vital role in Brazil's economic history. The industry, about to celebrate its 40th anniversary, was the symbol of the industrialization policy implemented in the 1950s. It accounted for more than 10% of Brazil's gross industrial product during the 1970s, peaking at 15% in 1975. During the 1980s, its share of industrial output fell somewhat, to an average of 9.5%, and them returning to 15% in the 1990s. Nevertheless, the industry was the second largest source of tax revenues, and generated more than a US$ 1 billion trade surplus, representing, on average, 8% of Brazilian exports. Moreover, about 95% of passenger transportation and 55% of cargo transportation in Brazil is by road [see Anfavea (1995b, p.29-30)].

Automobile production grew steadily from 1957 (its birth year) until 1980. The 1980s, however, are considered a disaster. The Brazilian economy entered recession and automobiles sales stagnated (see Figure 1). By the end of the decade, production was still 13% below its 1980 level and labor productivity was about the same.

Figure 1

Annual Production and Domestic Sales
Brazilian Passenger Car Market
1960 - 1994



Source: Anfavea (1995a, p.59 and 78) and Ferro (1994, p.15).

In 1990, Brazil started to open its economy to foreign competition. The automobile industry was one again at center stage. Because of very low productivity, the industry was under fire and the quality of Brazilian-made cars was being heavily criticized. However, despite such criticism, there have been very few attempts to quantify the evolution of quality in Brazilian autos.

To fill this gap, I have built what, to the best of my knowledge, is the first quality change index for Brazilian automobiles. The methodology is described in the next section. Construction of the data set is discussed in Section 3, the results are shown in Section 4, and are followed by conclusions.

2 - METHODOLOGY

Innovation is verifiable but is quite difficult to quantify. For example, most would agree that a car with electronic fuel injection is superior to one equipped with a carburetor, but few can define *how* superior it is. Moreover, changes in product's quality generally occur in multiple dimensions. That is, several characteristics of the product may change simultaneously, making it harder to quantify the quality. One way to approach this question is to construct a quality index based on the hedonic pricing methodology.

The hedonic pricing methodology was developed by Court (1939) and revived by Griliches (1961).[1] Since then, the approach has been used frequently to estimate quality change in automobiles. Among the important contributions are Triplett (1969), Ohta and Griliches (1976 and 1980), Feenstra (1987 and 1988), Gordon (1990), and Raffand Trajtenberg (1995).

The main assumption behind hedonic pricing is the "characteristics approach" to demand theory [see, for example, Lancaster (1971)]. According to this approach, goods are defined as bundles of characteristics (qualities), and consumers have preferences over those characteristics. Thus, a consumer will decide not only whether to buy an automobile, for example, but which automobile best matches her preferences over the available characteristics.

The real world is full of examples of goods being sold with different added-on components, attributes, sizes and colors, that is, with different characteristics (qualities), in different varieties. Moreover, the reason that different varieties of a commodity sell at different prices must be due to differences in their sets of characteristics. Therefore it is reasonable to assume that, in equibrium, there is a well-defined relationship between the price of a commodity and its characteristics.

Based on the assumptions above, it is possible to write the price of variety i of a specific commodity at time t as a function of a set of qualities X and some disturbance u. That is:

[1] For more details on the development of the hedonic methodology see, for example, Berndt (1990).

$$p_{it} = f_t(x_{1t}, x_{2t}, \ldots, x_{kit}, u_{it}) \qquad (1)$$

Additionally, the hedonic approach is based on the assumption that the multitude of models and varieties of a particular commodity can be analyzed in terms of a few characteristics or basic attributes of a commodity. Given the high correlation among some characteristcs, this assumption is not as strong as it may seem.

The next problem to be addressed is the definition of the functional form of the relationship represented in (Results 1). Here, I will follow previous work and assume a semilogarithmic form, relating the logarithm of the price to the absolute values of the qualities. One advantage of this form is that the coefficients on the Xs will represent percentage changes in price due to changes in the related characteristic. In other words, I assume:

$$\log p_{it} = a_0 + a_1 x_{1it} + a_2 x_{2it} + \ldots + u_{it} \qquad (2)$$

Equation (2) can be computed for each period for which there are enough observations. An index of quality change can be defined from the estimated equations as follows:

$$q_{1i}^{0} = \frac{\widehat{P}_{i1}}{\widehat{P}_{i0}} \quad where \quad \begin{array}{l} \widehat{P}_{i0} = f_0(X_{1i0}, \ldots), \\ \widehat{P}_{i1} = f_0(X_{1i1}, \ldots) \end{array} \qquad (3)$$

That is, the measure of quality change for variety *i* is a ratio between the price predicted, using estimated equation f_0, for the combination of attributes this variety had in period 0 and the price predicted for the combination of characteristics it had in period 1. In other words, the measure gives us the percentage change in price due to changes in characteristics, as predicted by the function f_0. To calculate a quality change measure for the “commodity” (the group of varieties), one can aggregate these q’s using each variety’s market share, for example, as a weight.

Considering that the estimated coefficients will differ among different periods, the general index number problem of changing weights will arise. So, the quality change index will depend on the period chosen as reference. Rewriting equation (3) using the estimated equation f_1 instead of f_0 should produce a different quality change index.

However, for periods not too far apart, characteristics’ coefficients may not differ significantly among periods. Here, one may pool the cross section data from the different periods. To account for this, I rewrite equation (2) in the following way:

$$\log\ p_{it} = \alpha_0 + \sum_{i=1}^{n} \alpha_j x_{jit} + \sum_{s=1}^{S} \beta_s D_s + u_{it} \qquad (4)$$

In specification (4), *i* denotes the commodity's variety, *t* denotes periods (years), *s* denotes years for which there is a specific "time"variable *D*, and X_{ji} represents the set of characteristics of variety *i*. This functional form allows for changes in the intercept over time, but assumes that slopes are constant.

That is, the effect of each characteristic on the commodity's price is assumed constant over the selected years. However, the introduction of time dummies allows the price to change among periods, even when the characteristics remain the same. The time dummies take the value one in their reference period and the value zero in all other periods. Also, the number of such variables in the regression is equal to the number of periods being pooled minus one.

The hedonic pricing methodology has its weaknesses. Many authors have criticized hedonic estimates because of the impossibility of recovering the underlying utility function.[2] However, as Griliches (1990) points out, the aim is not to estimate utility or cost functions **per se.** Hedonic pricing estimates the intersection of demand and supply curves. It allows us to estimate the implicit, or "missing", prices of characteristics using observed prices of differentiated products and their sets of characteristics.

It is also true that we may not be able to recognize the true extent of quality improvement using the hedonic approach. For example, no hedonic measure will detect quality changes that are introduced simultaneously in all goods.[3] But, as Griliches has reminded us, "half a loaf is better than no bread at all."

Oht and Griliches (1976, p.326-327) summarize the issue as follows:

> (...) What the hedonic approach attempted was to provide a tool for estimating 'missing' prices, prices of particular bundles not observed in the original or later periods. It did not pretend to dispose of the question of whether various observed differentials are demand or supply determined, how the observed variety of models in the market is generated, and whether the resulting indexes have an unambiguous welfare interpretation. Its goals were modest. It offered the tool of econometrics, with all of its attendant problems, as a help to the solution of the first two issues, the detection of the relevant characteristics of a commodity and the estimation of their marginal market valuation (...).
>
> To accomplish even such limited goals, one requires much prior information on the commodity in question (econometrics is not a very good tool when wielded blindly), lots of good data, and a

[2] Trajtenberg (1990) has proposed an approach based on discrete choice models [McFadden (1981) and Train (1986)] that allows one to estimate the parameters of the underlying utility function. Thus, the magnitude of innovation change between two periods can be measured by the increments in consumer surplus. However, this approach requires detailed data on individual consumers, which are not available.

[3] For a more expansive treatment of these matters, see Triplett (1969), Rosen (1974) and Trajtenberg (1990, Ch. 1).

> detailed analysis of the robustness of one's conclusions relative to the many possible alternative specifications of the model."

3 - THE SAMPLE AND THE VARIABLES

The hedonic analysis reported in Section 4 is based on data for Brazilian passenger cars (excluding station wagons and convertible models) for the period 1960/94. For each year of this period an attempt was made to collect price, specification, performance, and market share data for all models for which such data were available. Ultimately, I have built a data set, disaggregated down to the submodel level, with 1,717 observations.[4] Each observation is related to about 70 characteristics, representing technical specifications and performance.

Domestic sales data, by submodel, were provided by the National Association of Motor Vehicle Manufacturers (Anfavea) and the Association of Manufacturers of Parts and Components to Motor Vehicles (SindPeças). The market share variable was then computed as the radio between sales of a specific submodel and the total sales of passengers cars (excluding station wagons) during the year in consideration.

Prices and characteristics were collected from the magazine Quatro Rodas, a Brazilian automotive monthly. The magazine publishes prices and technical information, and carries out its own performance tests. The data set has been constructed based on all issues from August 1960 through December 1995.

Prices are list prices, including taxes. I acknowledge that it would be more appropriate to use transaction prices. However, given the unavailability of transaction prices, I had no choice but to use list prices. The data contain three kinds of price series: current prices, constant prices and prices denominated in U.S. dollars.

Due to high inflation during most of the years considered in this study, prices changed considerably from one month to the next. Thus, to reduce the effect of high inflation on relative prices, I use a four-month average price. One should expect that prices listed for the end of the model's first anniversary are closer to the equilibrium price. As new models are usually launched in the last quarter of the calendar year, I choose the months of May, June, July and August to construct the average price.

The constant price series was built as follow: for each year in our sample, the current price for the months of May through August was deflated by the wholesale price index (IPA-DI) of their respective month, and then averaged. Similar process

[4] A model is in general, offered in different submodels. Submodels differ from each other in quality and price. For example, in 1992, the VWGol (model) was sold in five different submodels (CL 1.6, CL 1.8, GL 1.8, GTS, and GTI).

was employed in the construction of the U.S. dollars series. Only that in this case, the conversion was based on the official (commercial) exchange rate.
Quatro Rodas has been testing Brazilian-made automobiles since August 1961. However, as the number of models and submodels increase, some submodels are tested less frequently. That is, some models or submodels have not been tested every year. In such cases, when the model's technical and physical characteristics have not changed significantly over the years, I have used the performance and technical variables from an earlier or later test to fill the gap. On the other hand, some models and/or submodels have been tested more than once in a year. In these cases, laveraged the results of the tests.[5]

The sample is highly representative, although its ratio to total sales falls to 60% in 1992 (see Table 1). The lower ratio between sample sales and total sales during the 1990s is due to (1) increased sales of gasoline-based cars relative to ethanol-based cars, (2) the beginning of the emission control program in 1992, and (3) imported cars.

Table 1
Ratio of Sample Sales to Total Sales

Year	Share (%)	Year	Share (%)	Year	Share (%)	Year	Share (%)
1960	100	1970	100	1980	99	1990	89
1961	100	1971	100	1981	100	1991	73
1962	92	1972	100	1982	99	1992	60
1963	96	1973	100	1983	98	1993	70
1964	96	1974	99	1984	97	1994	75
1965	96	1975	100	1985	96		
1966	97	1976	100	1986	92		
1967	100	1977	96	1987	89		
1968	96	1978	99	1988	95		
1969	98	1979	97	1989	96		

During the 1980s, following the trend in total sales, most of the cars tested by *Quatro Rodas* used ethanol as fuel. In the 1990s, most used gasoline. Thus, the majority of observations in the data set were gathered in 1990 or later, as there were no previous tests of gas-fuelled models that one could use to fill the gaps.

The emission control legislation had the same effect, but with greater consequences. Starting in 1992, the mandatory use of a catalytic converter affected some of the main characteristics of all models, horse power and speed in particular. Thereby pratically invalidating the use of any prior test in the construction of the data for 1992 on. So all submodels included in the year of 1992, have been tested either in that year or in the following years. The task was made still harder by the introduction of imported cars in the domestic market, as

[5] Note that when I refer to tests performed in the same year I am considering those tests performed on submodels of the same vintage.

the number of domestic cars tested per year descreased significantly due to "competition" with imports for magazine space.

However, most of the submodels left out of our sample are the ones using ethanol as fuel. Table 2 shows the share of ethanol-based cars in the sample and in total sales. The sample covers most gasoline-based submodels. As almost all ethanol-based models have a gasoline-powered counterpart, we can still argue that the sample is highly representative.

Table 2
Share of Ethanol-Based Cars in Sample and Total Sales

Year	1988 (%)	1989 (%)	1990 (%)	1991 (%)	1992 (%)	1993 (%)	1994 (%)
Sample	93	63	13	9	7	4	0.5
Total	88	61	13	22	29	27	12

The data set has a large number of characteristics per submodel (see Table 3). The data are composed of numerical and dummy variables. The numerical variables represent performance and technical (physical) characteristics. Dummy variables take the value of one if the particular submodel possesses the characteristic (as standard equipment) and zero if it does not. The dummies variables are mostly related to technical/physical characteristics, though some dummies have been created to control the sample.

As stated earlier, most models come in different submodels. Some submodels differ by engine size, horsepower, or other components already included among the regressors. Other submodels, however, differ in minor aspects not accounted for anywhere in the regression model. Therefore, I have introduced "luxury" dummy variables to separate these submodels. These variables (L1, L2 and L3) allow me to account for to up to four similar submodels of a model. Without these variables, some submodels in our sample would differ only by price and market share.

Table 3
Sample Variables
Technical Dummy Variables

Variable Name	Technical Specification
ENGF	front engine
TRANS	transverse engine
V16	16-valve engine
CARB2	double carburetion
TCARB	two carburetors
INJE	electronic fuel injection
ALTER	alternator
TRACF	front drive
SINCR	total synchronized transmission
GEAR4	4-speed drive
GEAR5	5-speed drive
PSTE	power steering
BOOST	vacuum assisted brake system
DISCF	front disc brake
VENTF	front vented disc brake
DISCR	rear disc brake
VENTR	rear vented disc brake
ABS	antilock brake system
DHE	helicoidal front suspension
DIMHE	independent, MacPherson, and helicoidal front suspension
THE	helicoidal rear suspension
THELI	semi-and independent helicoidal rear suspension

Performance Variables Numerical

Variable Name	Technical Specification	Unit
SPEED	top speed	Km/h
ACCE	time to speed: 0-100 Km/h	sec
DIST	stopping distance: 80-0 Km/h	meter
CONS	average fuel consumption	Km/l
C080	fuel consumption at constant speed (80 Km/h)	Km/l

Technical Variables Numerical

CILIN	number of cylinders	unit
DISP	displacement	cc
HPS	horsepower	hp (SAE)
HPA	horsepower	hp (ABNT)
LENG	length	centimeter
WBAS	wheelbase	centimeter
WEIG	weight	Kg
TANK	fuel capacity	liter
TRUNK	trunk capacity	liter

Dummy Control Variables

ALCO	fuel: ethanol
GAS	fuel: gasoline
POPU	“popular” model
L1, L2, L3	luxury levels 1, 2, and 3
DOOR4	four doors
HATCH	hatchback model

Other control variables are DOOR4 to identify four-door models, POPU to distinguish "popular" cars from the others, and ALCO and GAS to identify cars using ethanol and gasoline, respectively, as fuel. "Popular" and cars with engine sizes under 1,000 cc carry significantly lower taxes. Thus, their prices are lower for reasons not accounted for by their characteristics.[6] Similarly, ethanol-fueled vehicles have a lower price than their gasoline-fueled counterparts (also due to tax incentives), higher fuel consumption, and, in general, higher horsepower.

4 - THE REGRESSION RESULTS

In spite of the theoretical questions about using the hedonic technique to estimate quality change, discussed in Section 2, some econometric specification problems must also be addressed by the researcher [see Gordon (1990, Ch. 3) and Berndt (1990)].

A common problem one faces when estimating hedonic regressions is the identification of the relevant set of characteristics. In the case of automobiles, for example, the first dilemma is the choice between performance and physical characteristics. When a consumer decides to buy an automobile she is interested in the performance of the vehicle and not in its physical characteristics, **per se.** That is, she will be interested in the speed, handling, steering, driving position, comfort, etc. In such case, the hedonic estimation should be based on performance variables because they enter the utility function directly.

However, most previous studies have been based on physical rather than performance data. Two reasons for this are that physical information is more readily available and that most performance data is based on subjective conditions that may introduce a serious measurement error.

The use of physical characteristics is justified by the assumption that performance characteristics are functions of physical characteristics. As long as this relationship does not change significantly, the use of physical characteristics as proxies for performance characteristics causes no problem. This assumption may be true for the short run. However, most of the innovation occurring in the car industry has resulted in increased performance with little or no change in physical characteristics. For example, a new design may result in higher speed and acceleration rate. Using horsepower to proxy for speed, without including "design" in the equation, would bias our results.

Ohta and Griliches (1976) address this question and conclude that substituting physical characteristics for performance variables does not significantly affect the fit, at least not for the short period from 1963 to 1966. In any case, I have combined both kinds of characteristics. To avoid the bias introduced by subjective

[6] The tax incentives on vehicles of 1,000 cc or less were introduced in 1990. In 1993, the tax exemption was extended to a few models with displacements above 1,000 cc, and the term "popular"was born. For more details, see Fonseca (1996, Ch. 4, Section 4).

evaluations I include just a few of the many performance variables available, the ones least vulnerable to subjective analysis and to changes in the measurement methodology.

Another difficulty inherent in hedonic estimation is the omission of relevant variables , which results in biased estimators [see Greene (1993, p.245-247)]. For this study, an effort was made to build as complete a data set as possible. However, many pieces of information available in one period of time are not available in others. Additionally, information on some variables are not available for all submodels. Throughout I have faced a trade-off between the range of characteristics and sample size.

Multicollinearity is bound to be an issue in this kind of study. Luxury models are higher quality, and so possess most of the quality characteristics. Thus, one should expect a high correlation among the variables in the sample. Two points should be made here. First, of course it would be nice if the explanatory variables of a regression model were linearly independent. However, to exclude variables with this goal in mind is to negate the model's fundamentals. As stated earlier, excluding variables may create especification problems, since one may be omitting a relevant variable. Additionally, it is worth recalling that the least squares estimator will remain the best unbiased estimator of the parameters. As Greene (1993, p.270) points out, the problem with multicollinearity is that "best" is not very good.

Second, a consequence of multicollinearity is that the individual shadow (implicit) price of a particular characteristic will not be well-identified. Although multicollinearity affects the estimates of an individual variable's coefficient, it does not affect their combined effect on prices. In this study, I am not particularly interested in the implicit price of a specific characteristic. The goal is to estimate the fitted path, that is, the effect of the whole set of characteristics (quality variables) on price. Thus, with respect to the main purpose of this study, multicollinearity is not a problem at all.

A novelty presented in this analysis is the use of normalized variables. This procedure has been introduced to compensate for the bias created when comparing big cars with small ones. For example, as heavier cars need a longer distance to stop, I divided DIST by WEIG (DISWEI). A similar rationale applies to horsepower: Cars with big engines tend to have more horsepower than cars with small engines. To normalize the horsepower variable, I divided HPS (or HPA) by DISP (HPSCC or HPACC).[7] Note that this procedure also takes care of the bias created by the V6 and V8 engines during the first two decades. Moreover, technically, HPS(A)CC is a better measure for engine quality, namely, the power per unit of displacement, that is horsepower per cubic centimeter.

[7] Initially, horsepower was measured according to SAE standards (HPS). By the first half of the 1980s, however, it started to be measured according to the Brazilian Association of Technical Norms (ABNT) methodology (HPA).

WELENG (WEIG divided by LENG) is another normalized variable. The use of the weight variable has been justified as a proxy for more features, since a heavier car tends to incorporate more features than a lighter one. On the other hand, its use has been criticized because, overtime the industry has reduce car weights (and lengths) without reducing their quality. Smaller, lighter cars with no significant loss in comfort (internal room) or performance have been introduced. Thus, the use of weight as an explanatory variable should be pursued with caution.

Employing WELENG reduces the bias toward large cars. However, the problem of innovations that, other things equal, reduce car's weight remains. In summary, I have replaced the usual set of physical characteristics: weight, length and horsepower by WELENG and HPS(A)CC.

At last, it is worth to note that some variables may account for more than one desired attribute. For example, the variable TRANS, as well as being a proxy for a modern engine, also accounts for internal space and modern design, because a transverse rather than a longitudinal engine allows for more internal room in a given car. The same is true for DISWEI, which may account for both the quality of the brake system and for the vehicle's stability.

In an attempt to improve the results of this study, I have decided to weight the data. The rationale for this is that sometimes a manufacturer may set the "wrong price", given the quality of its vehicle. Not accounting for such deviations from the "right price" may bias our conclusions. To minimize the bias from mistakes and idiosyncrasies in manufacturers' pricing policies, I have weighted the data by the market share of each submodel.[8]

Thus, the procedure used to estimate the hedonic equations was weighted least squares, with market share as the weight. Wheighted data were computed by multiplying the original data by the square root of the weights. The estimated coefficients are nothing more than ordinary least squares coefficients for the regression with weights. However, the constant is no longer a constant, but is instead the square root of the weights.

Two groups of equations have been estimated, one based on the variables SPEED and WELENG, and the other based on HPS(A)CC and WELENG. The data were aggregated in three year intervals, with the exception of the 1960s. Given the small number of observation during the 1960s, I opted for a four-year pooling (1960/63 and 1964/67).

The sample has been split according to the different phases in the industry's development. This is an important issue: pooling different years is to assume that no significant changes in consumers' taste or production costs occurred during the chosen interval (refer to Section 3 of this chapter).

[8] Graphing the squared residuals (of a non-weighted regression) against market share showed evidence that observations with smaller market share tend to produce estimates with a higher deviation from the true price.

Thus, the first two periods are the industry's maturation phase. The "Miracle" phase is split into two periods: 1968/70 and 1971/73. Intervals 1974/76 and 1977/79, represent the "Retrenchment" phase. The 1980s were the era of the ethanol car and economic stagnation. Three intervals account for this phase: 1980/82, 1983/85, and 1986/88. The last phase, marked by trade liberalization, is represented by the periods 1989/91 and 1992/94 [see Fonseca (1996, Ch. 1)].

I estimate equations for current prices, constant prices and U. S. dollar prices. As should be expected, the estimated coefficients have not been affected by changes on price measurement. The use of different price series affects the "constant" term, year-dummy coefficients, and the goodness of the fit, or more specifically, the R-squared statistic.

Given high inflaction, especially during the last two decades, the use of current prices produces R-squared statistics very close to 1 (see Table 4). The annual change in prices is captured by the year-dummies, and those changes were above 100% during the 1980s, and exceeded 2,000 in the 1990s. As I am interested in changes on price due the characteristics (quality) variables, it makes no difference which price series is used.

Table 4 presents the results for group 1 (SPEED), using current prices. The fit of these regressions is very good.[9] The coefficients on SPEED and WELENG are quite stable and significantly different from zero from one equation to another. The notable exception is the WELENG coefficient for the period 1983/85 that is well above the values for the other periods. This behavior may reflect the fast growth rate in vehicles average weight during the period (see Tables A.1 and A.2). As will be discussed later, this probably marks a shift in demand from small models to higher quality medium and medium-large models.

[9] As mentioned above, the R-squared statistic approaches one during the 1980s and, especially, the 1990s, due to extremely high inflation. Accounting for the inflation by using constant prices results in lower R-squareds, but the regressions are still able to explain 90 or more of the variance in the logarithm of car prices in most cases.

Table 4

Regression: 1960/94

Period	60/63	64/67	68/70	71/73
Dep. Variable	LPRICBR	LPRICBR	LPRICBR	LPRICBR
Number of Obs.	31	42	48	81
Adj. R-squared	0.981	0.955	0.968	0.954
SSR	0.112	0.250	0.112	246
Explanatory Variables	Coefficients (t-stat.)	Coefficients (t-stat.)	Coefficients (t-stat.)	Coefficients (t-stat.)
C	-2.10**	-0.566*	0.968**	1.11**
	(-3.33)	(-2.11)	(5.85)	(9.16)
L1	0.210**	0.093	0.135**	0.065*
	(5.85)	(1.24)	(5.06)	(2.00)
L2	-	-0.020	-	0.190*
		(-0.41)		(2.64)
DOOR4	-	-	-0.020	0.024
			(-0.49)	(0.73)
SPEED	0.0082	0.0096**	0.0061**	0.0072**
	(1.22)	(2.85)	(4.06)	(5.43)
WELENG	0.342**	0.405**	0.319**	0.345**
	(4.14)	(4.35)	(10.8)	(3.93)
CARB2	0.139	0.089	0.011	0.023
	(0.97)	(1.56)	(0.27)	(0.46)
PSTE	-	0.111	0.267**	0.196**
		(1.62)	(6.20)	(3.98)
DHE	0.0003	-0.195*	0.051	0.082**
	(0.006)	(-2.23)	(1.71)	(2.86)
DISCF	-	-	0.099	0.087**
			(1.73)	(3.06)
BOOST	-	-	-	0.054
				(1.90)
Y61			-	-
	0,205**	-	-	-
Y62	(4.32)			
	0.426**	-	-	-
Y63	(9.10)			
	1.12**	-	-	-
Y65	(26.4)		-	
	-	0.383**	-	-
Y66		(5.24)		
	-	0.567**	-	-
Y67		(7.59)		
	-	0.746**	-	-
Y69		(9.06)		
	-	-	0.153**	-
Y70			(6.14)	
	-	-	0.255**	-
Y72			(8.26)	
	-	-	-	0.107**
Y73				(3.79)
	-	-	-	0.171**
				(6.16)

(continue)

Table 4

Regression Results: 1960/94

Period	74/76	77/79	80/82
Dep. Variable	LPRICBR	LPRICBR	LPRICBR
Number of Obs.	132	154	263
Adj. R-squared	0.973	0.971	0.981
SSR	0.363	0.629	2.71
Explanatory Variables	Coefficients (t-stat.)	Coefficients (t-stat.)	Coefficients (t-stat.)
C	2.00**	2.48**	3.54**
	(15.)	(17.6)	(22.0)
L1	.0.65**	0.063**	0.089**
	(3.71)	(2.80)	(5.01)
L2	0.014	0.103**	0.131**
	(0.78)	(3.00)	(2.81)
L3	-	-	0.260**
			(7.32)
DOOR4	0.055*	0.049	0.064
	(2.22)	(1.37)	(1.55)
HATCH	0.0010	-0.039	-0.073*
	(0.04)	(-0.17)	(-2.32)
ALCO	-	-	- 0.033
			(-1.72)
SPEED	0.0045**	0.0031	0.0025*
	(3.08)	(1.59)	(2.55)
WELENG	0.234**	0.503**	0.659**
	(4.66)	(4.55)	(6.10)
CARB2	0.071*	0.147**	0.084**
PSTE	(2.00)	(4.31)	(2.87)
	0.369**	0.139	0.199**
DHE	(9.02)	(1.45)	(2.87)
	0.123**	0.072	-
DIMHE	(4.96)	(1.97)	
	-	-	0.111**
DISCF			(4.15)
	0.071**	-	-
BOOST	(3.22)		
	0.074**	0.153**	0.170**
VENTF	(3.37)	(4.95)	(6.51)
	-	-	0.014
Y75			(0.41)
	0.327**	-	-
Y76	(16.4)		
	0.539**	-	-
Y78	(30.2)		
	-	0.317**	-
Y79		(12.2)	
	-	0.732**	-
Y81		(27.6)	
	-	-	0.816**
Y82			(50.2)
	-	-	1.64**
	-	-	(87.1)

(continue)

Table 4

Regression Results: 1960/94

Period	83/85	86/88	89/91
Dep. Variable	LPRICBR	LPRICBR	LPRICBR
Number of Obs.	286	227	254
Adj. R-squared	0.959	0.989	0.997
SSR	11.12	4.90	3.32
Explanatory Variables	Coefficients (t-stat.)	Coefficients (t-stat.)	Coefficients (t-stat.)
C	5.42**	9.03**	12.8**
	(22.8)	(24.6)	(31.0)
L1	0.048	0.023	0.088**
	(0.85)	(0.79)	(3.70)
L2	0.213**	0.123**	0.129**
	(2.97)	(2.46)	(2.51)
L3	0.427**	0.262**	0.177*
	(8.19)	(5.85)	(2.35)
DOOR4	0.074	0.042	0.0051
	(1.43)	(1.43)	(0.16)
HATCH	-0.144**	-0.129**	-
	(-4.26)	(-3.47)	
ALCO	-	-	-0.075**
			(-3.34)
GAS	0.040	0.104	-
	(0.94)	(1.77)	
POPU	-	-	-0.062
			(-1.26)
SPEED	0.0041	0.0049*	0.0157**
	(1.44)	(2.04)	(7.21)
WELENG	0.843**	0.448**	0.376**
	(4.61)	(4.32)	(3.33)
CARB2	0.050	0.048	-
	(0.69)	(0.96)	
INJE	-	-	0.357**
			(4.07)
PSTE	0.012	0.215**	0.322**
	(0.75)	(3.53)	(5.9)
DIMHE	0.168*	0.211**	0.091**
	(2.41)	(4.79)	(4.31)
VENTF	0.309**	0.233**	0.105**
	(4.43)	(6.52)	(3.81)
TRUNK	-	0.0006*	0.0011**
Y84		(2.26)	(8.08)
Y85	1.02**	-	-
	(19.1)		
Y97	2.16**	-	-
	(52.7)		
Y98	-	1.46**	-
		(42.6)	
Y90	-	3.32**	-
		(97.0)	
Y91	-	-	3.84**
			(185)
	-	-	5.22**
			(173)

(continue)

Table 4
Regression Results: 1960/94

Period	92/94
Dep. Variable	LPRICBR
Number of Obs.	185
Adj. R-squared	0.999
SSR	1.57
Explanatory Variables	Coefficients (t-stat.)
C	22.9** (64.3)
L1	0.061 (1.68)
L2	0.256** (7.32)
DOOR4	0.025 (0.65)
ALCO	-0.0002 (-0.007)
POPU	-0.323** (-6.79)
SPEED	0.0025 (1.40)
WELENG	0.372** (3.29)
INJE	0.093** (2.83)
PSTE	0.314** (5.95)
VENTF	0.153** (2.71)
ABS	0.228** (3.95)
TRUNK	0.0007** (3.17)
Y87	-
Y88	-
Y90	-
Y91	-
Y93	2.90** (76.7)
Y94	6.56** (147)

* Significant at 95%.
** Significant at 99% t-statistics are in the parentheses.

You may note that SPEED and WELENG are the only variables that appears in all estimations. The set of the remained variables changes over time according to their quality relevance. For example, double carburetion was a major innovation until 1989, when it was replaced by electronic fuel injection. Thus, starting in 1989, the relevant variable becomes INJE instead of CARB2. Other variables, as *front disc brake* (DISCF) and vaccum-assisted brake system (BOOST), for example, become standard during the period, losing its relevance to the analysis (see Tables A.1 and A.2).

The estimated coefficients give us the percentage change in price associated with a change on the relevant characteristic. For example, in 1980/82, a one Km/h increase in the average top speed of Brazilian-made passenger cars would result in an increase of 0.25% in the average price. The same estimation suggests that the introduction of vacuum-assisted brake system would increase the average price by 17%.[10]

The quality change index was built by multiplying the characteristics'change in the period by their estimated coefficients, and adding them up. The result gives us the percentage change in price attributable to quality changes. Thus, assuming 1980 as the base year (1980=100), the weighted index value for 1981 was constructed as follows: The quality change from 1980 to 1981 is (0.0025 x 3) + (0.659 x -0.002) +(0.084 x 0.025) + (0.199 x 0.001) + (0.111 x 0.048) + (0.17 x 0.194) + (0.014 x 0.0) = 0.046. Thus, the index for 1981 is 104.6.[11]

Figures 2a and 2b depict the quality change index for specification 1 (SPEED) and 2 (HPCC), based on the non-weighted sample (left graph) and the weighted one (right graph). Note that changing specification barely affects our results, except when comparing a series over a brief period of time.

Figure 2a
Quality Change Indexes
Brazilian Automobile Industry
Non-Weighted Sample
1960 - 1994

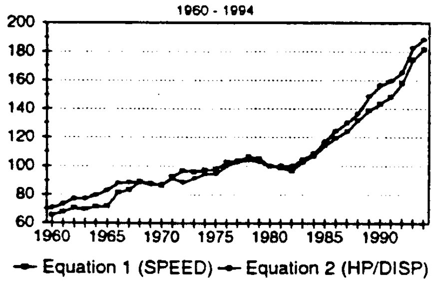
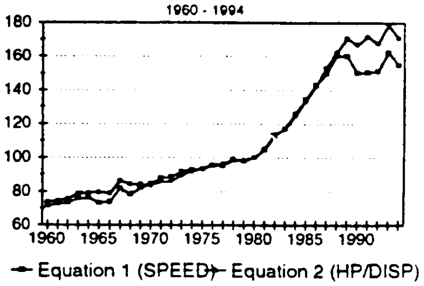


Figure 2b
Quality Change Indexes
Brazilian Automobile Industry
Weighted Sample
1960 - 1994



[10] As stated earlier, because of multicollinearity, this interpretation should be taken with caution.
[11] The formula refers to the coefficients on an the changes in the following set of characteristics: SPEED, WELENG, CARB2, PSTE, DIMHE, BOOST, and VENTF.

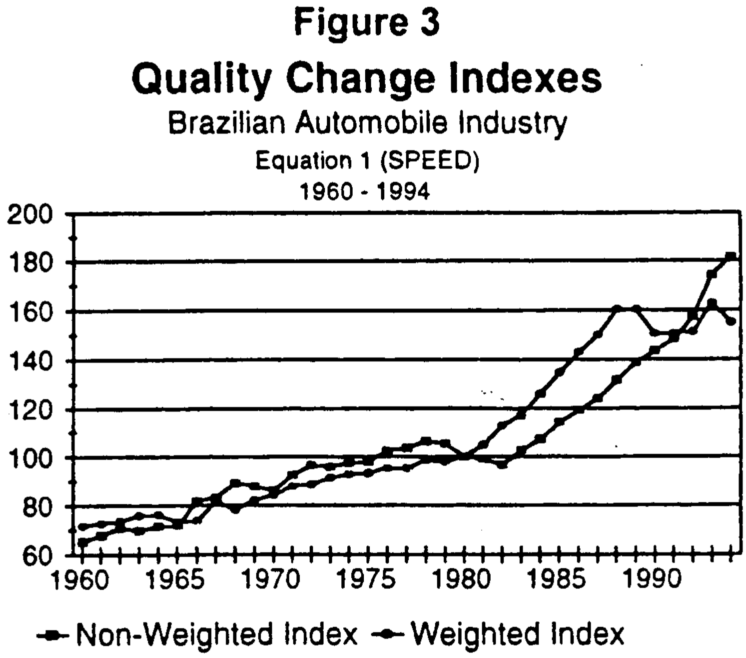
A summary of the quality change in Brazilian automobile is presented in the following table. Table 5 shows the change in automobile quality (equations 1) for selected periods. The whole series are presented in Tables A.3 and A.4, in the Appendix.

Table 5
Quality Change in Brazilian Automobiles — 1960/94

	Equations 1 (SPEED)			
Period	Whole Period (%)		Annual Average (%)	
	NW	W	NW	W
1960/70	32.3	16.7	2.8	1.6
1970/80	16.3	19.0	1.5	1.8
1980/90	44.0	51.0	3.7	4.2
1990/94	26.4	2.6	6.0	0.7
1960/65	10.8	1.4	2.1	0.3
1965/70	19.4	15.1	3.6	2.8
1970/75	14.0	10.7	2.6	2.1
1975/80	2.0	7.5	0.4	1.5
1980/85	14.0	35.0	2.7	6.2
1985/90	26.3	11.9	4.8	2.3
1990/94	26.4	2.6	6.0	0.7
1960/65	36.9	8.3	4.0	1.0
1968/74	10.1	19.2	1.6	3.0
1974/80	2.0	7.5	0.3	1.2
1980/90	44.0	51.0	3.7	4.2
1990/94	26.4	2.6	6.0	0.7

NW = Non-Weighted; W = Weighted.

Figure 3 compares the quality change index for the non-weighted and weighted samples, specification 1 (SPEED). Note that the index based on the-weighted sample illustrates quality change in the automobile supply, while the index based on the weighted sample yields the quality evolution of the average domestically-produced car sold in the Brazilian market. The distinction is important. It allows us to identify quality change driven by changes in demand **versus** those driven by supply-side factors. For example, a significantly higher rate of change in the weighted index suggests a shift in demand towards higher quality vehicles.



As can be see on Figures 2 and 3, and Table 5, the quality of Brazilian-made passenger cars grew steadily for almost all of the first two decades of the industry's existence. It is interesting that the enormous rate of growth of output during 1968/74 (see Figure 1), apparently had little effect on the rate of quality change.

After 1980, the numbers change dramatically. While the Brazilian economy, and consequently, the automobile industry faced a big recession, the quality of automobiles increased at a rate without precedent. Comparing the non-weighted series with the weighted one reveals two major changes. During the first half of the 1980s, the weighted index rose by 35%, compared to a rise of 14% in the non-weighted index. This reflects a shift in demand toward cars of higher quality. The opposite happened in the 1990s. From 1990 to 1994, the non-weighted index grew by 26.4% while the weighted index rose by only 2.6%, reflecting as hift in demand for domestic automobiles toward lower quality models [see Fonseca (1996)].

A comparison of these results with similar estimates for the U. S. automobile market shows that, from 1960 to 1985, the quality of the average Brazilian-made car has improved proportionally more than the quality of the average car sold in America (see Table 6).

Table 6 presents estimates of quality change for U.S. automobiles. However, these quality change indexes are of no use if we want to compare the quality of an average 3 Brazilian car with an average American car. The only comparison possible is of the quality evolution in the two markets, that is, the proportional change in car quality. The index says nothing about absolute quality. Moreover, the reduction in vehicle size during the 1970s and 1980s, was much more marked in the U. S. than in Brazil. Historically, the average size of cars sold in the U. S. was much bigger than that of cars sold in Brazil. As length and weight are primary characteristics used in these regressions, we should expect a smaller rate of change in the U. S. during this period.

Also, one should acknowledge that most product innovation in Brazil's auto industry has consisted of adopting new technology already used in other countries. Thus higher rate of change, instead of indicating better quality cars, may be a signal of change, instead of indicating better quality cars, may be a signal of lower quality at the beginning of the period. The lower the initial quality, the bigger will be the proportional change needed to bring quality closer to the state-of-the-art.

Table 6
Quality Change in U.S. Automobiles

Period	Rate of Change (%)		Source
	Total	Average	
Domestic Cars			
1906/14	87.4	17.0	Raff and Trajtenberg (1995)
1914/24	-4.9	-1.0	
1924/32	57.4	12.0	
1930/40	-44.2	-11.00	
1937/50	22.7	1.6	Griliches (1961)[a]
1950/54	2.2	0.5	
1954/60	20.0	3.1	
1954/60	16.1	2.5	
1960/68	-8.0	-1.2	Triplett (1969)
1947/50	-7.4	-2.5	Gordon (1990)[b]
1950/55	14.1	2.7	
1955/60	11.6	2.2	
1960/65	-10.1	-2.1	
1965/70	5.4	1.1	
1970/75	5.1	1.0	
1975/80	-8.1	-1.7	
1980/83	-1.6	-0.5	
1979/84	5.6	1.1	Feenstra (1987)[c]
Japanese Imported Cars			
1979/85	27.1	3.5	Feenstra (1988)[c]

[a] Row 1 and 3: adjacent years; row 2 and 4: pooling 1954/60.
[b] Values calculated deducting the change in the average stripped price (Tb. 8.3) from the change in the hedonic index (Tb. 8.8).
[c] Small cars.

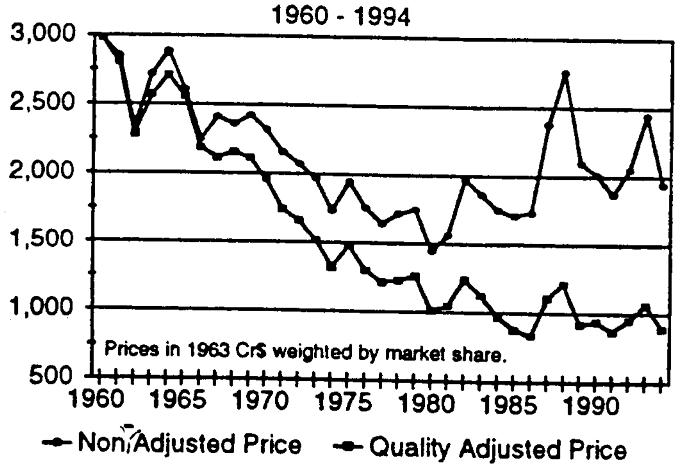
Despite all these considerations, the speed of quality change in Brazilian automobiles after 1980, is still impressive. The U. S. industry only achieved higher rates during early years, a period, as Raff and Trajtenberg remind us, when new goods make their largest contributions to society [Raff and Trajtenberg (1995, p.1)]. This shows that it is not difficult for an industry consisting of transnational firms to bring its product to the state-of-the-art level. It just needs the right incentives.

The hedonic technique can also be used to estimate the process innovation effect. One may decompose a price change into two components: product and process innovation related. The quality change index estimated here identifies the change in prices due to product innovation. The residual change, that is, the change in the quality-adjusted price, may be considered an effect of process innovation. However, as Raff and Trajtenberg (1995) warn, this decomposition should be undertaken cautiously. Prices can change due to many other factors, such as, changes in input price or in the degree of competition in the market. Moreover, some productivity gains may not be passed along to prices, and so will not be captured by price movements.

Figure 4 presents the real weighted average price of passenger cars, excluding station wagons. The prices have been deflated by the wholesale price index (IPA-DI) and are measured in **cruzeiros** of November-December of 1963. The figure depicts two series of real prices, one not adjusted for and the other adjusted for quality.

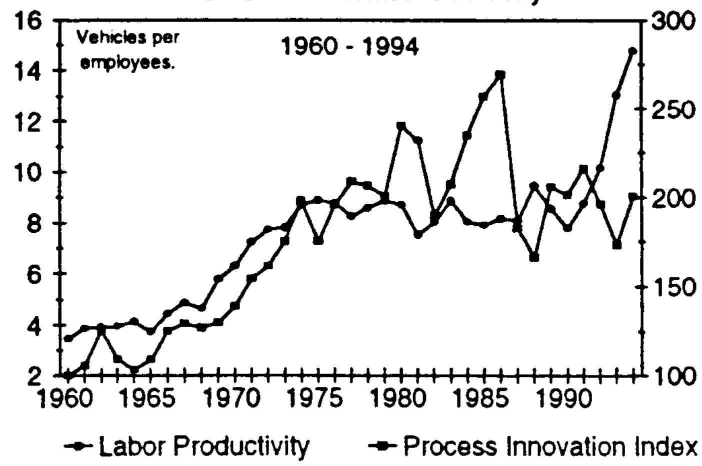
The unadjusted real weighted average price fell from **2,980** to **1,445 cruzeiros** between 1960 and 1980. During the 1980s, it increased by more than 90 percent, reaching its peak value of **2,758** in 1988. The unadjusted real weighted average price then fell again and practically stabilized a little above **2,000 cruzeiros**. On the other hand, the quality-adjusted price kept falling, though no without interruption, until 1986. After reaching a low of **840 cruzeiros**, the adjusted average price became quite stable at the **950 cruzeiros** level (see Table A.5).

Figure 4
Weighted Average Real Price
Brazilian Passenger Cars
1960 - 1994



If we assume that a price change, holding product quality constant, is a result of process innovation, we can build and index of process innovation passed on to consumers. Figure 5 compares such an index with labor productivity in the automotive industry.[12] It is clear that the two series follow a very similar path during the first two decades. The correlation coefficient for the 1960/79 period is .955, but falls to .672 when calculated for the whole period (1960/94).

Figure 5
Process Innovation Index and Labor Productivity
Brazilian Automotive Industry



By the end of the 1970s, as labor productivity stopped rising, the process innovation index starts to fluctuate wildly. As this index is calculated as a residual, the higher variance for the 1980s and 1990s is probably a result of very high inflation. In this case, quality-adjusted prices would be changing for reasons other than changes in productivity, such as unfulfilled inflation expections.

The comparison between the process innovation index and labor productivity is evidence that, during periods of lower inflation (or at least not extremely high inflation), changes in quality-adjusted real price was driven mostly by changes in productivity.

5 - CONCLUSION

The main target of this work was to build a quality change index for the Brazilian automobile industry. To the best of my knowledge, this is the first time such index has been constructed. Moreover, as important as the estimation of the index was the construction of the data set for the Brazilian passenger cars. The data set

[12] Labor productivity is measured as the number of vehicles produced divided by the number of employees. Source: Table A.6.

comprise information on attributes, prices, and volume of sales for the period 1960/94.
The estimation of a quality change index for the Brazil's auto industry has two major significance. They allow a better understanding of product innovation in Brasil's auto industry, as well as a better understanding of the behavior of auto prices.

For example, it has been shown that the real average price, when adjusted for changes in quality, has fallen more than commonly supposed. Moreover, during the 1980s and 1990s, most of the real price increase was due to an increase in vehicle quality. The quality-adjusted real average price, practically remained constant. Interesting too, is the suggestion that trade liberalization had no apparent effect on prices.

In the matter of product innovation, the index shows us that the "lost decade", as the 1980s have been known, was, in fact, a period of significant evolution in the quality of the Brazilian-made automobiles. Additionally, the index constructed here allows us to study the effects of trade liberalization on product innovation. These themes are analyzed in Fonseca (1996).

APPENDIX

Table A.1
Characteristics of Brazilian Passenger Cars (excl. S. W.)
Non-Weighted Sample: 1960/94

Year	Average							
	LENG Cm	WBAS Cm	WEIG Kg	TANK liter	TRUNK liter	DISP cc	HPS hp (SAE)	HPA hp (ABNT)
1960	442	255	1,044	n.a.	n.a	1,664	69	n.a.
1961	446	257	1,071	n.a.	n.a	1,762	72	n.a.
1962	450	258	1,110	n.a.	n.a	1,835	78	n.a.
1963	448	256	1,092	n.a.	n.a	1,794	79	n.a.
1964	445	255	1,126	n.a.	n.a	1,756	78	n.a.
1965	445	255	1,126	n.a.	n.a	1,756	79	n.a.
1966	450	258	1,172	n.a.	n.a	1,888	90	n.a.
1967	451	258	1,155	n.a.	n.a	1,981	93	n.a.
1968	458	263	1,223	n.a.	n.a	2,282	103	n.a.
1969	459	263	1,173	n.a.	n.a	2,439	103	n.a.
1970	454	260	1,120	n.a.	n.a	2,453	101	n.a.
1971	459	262	1,158	n.a.	n.a	2,807	112	n.a.
1972	456	260	1,133	n.a.	n.a	2,858	113	n.a.
1973	453	259	1,142	n.a.	n.a	2,862	114	n.a.
1974	452	260	1,143	n.a.	n.a	2,826	114	n.a.
1975	451	259	1,128	n.a.	n.a	2,654	109	n.a.
1976	449	259	1,114	n.a.	n.a	2,562	110	n.a.
1977	450	259	1,129	n.a.	n.a	2,480	107	n.a.
1978	446	258	1,123	n.a.	n.a	2,392	105	n.a.
1979	447	257	1,132	61	n.a	2,480	108	n.a.
1980	438	252	1,066	59	n.a	2,194	96	n.a.
1981	435	251	1,047	59	n.a	2,072	94	n.a.
1982	430	247	1,002	56	n.a	1,733	85	71
1983	423	245	966	59	n.a	1,669	86	72
1984	422	246	974	60	n.a	1,700	n.a.	76
1985	426	247	1,008	62	n.a	1,851	n.a.	83
1986	427	248	1,032	63	360	1,887	n.a.	87
1987	429	249	1,038	62	370	1,925	n.a.	90
1988	432	249	1,041	66	363	1,901	n.a.	89
1989	426	249	1,036	63	343	1,913	n.a.	92
1990	426	250	1,036	62	336	1,901	n.a.	93
1991	426	250	1,033	60	337	1,923	n.a.	94
1992	418	246	1,029	59	325	1,779	n.a.	92
1993	422	250	1,073	60	335	1,801	n.a.	96
1994	419	251	1,067	61	329	1,771	n.a.	98
Excluding "Popular" Models								
1990	426	250	1,038	62	338	1,910	n.a.	93
1991	427	250	1,036	60	338	1,936	n.a.	95
1992	421	247	1,041	59	332	1,835	n.a.	95
1993	425	251	1,094	61	345	1,868	n.a.	100
1994	424	252	1,096	63	344	1,859	n.a.	104
"Popular" Models								
1990	364	236	820	55	224	994	n.a.	48
1991	364	236	820	50	224	994	n.a.	48
1992	382	237	852	51	215	996	n.a.	49
1993	383	237	855	51	229	1,096	n.a.	55
1994	380	238	842	48	213	1,080	n.a.	54

Table A.1
Characteristics of Brazilian Passenger Cars (excl. S. W.)
Non-Weighted Sample: 1960/94

Year	Average				
	WBLENG	WELENG Kg/Cm	HPSCC hp/cc	HPACC hp/cc	DISWEI meter/Kg
1960	0.5763	2.330	0.0414	n.a.	0.0274
1961	0.5748	2.368	0.0410	n.a.	0.0269
1962	0.5738	2.437	0.0422	n.a.	0.0263
1963	0.5722	2.411	0.0438	n.a.	0.0270
1964	0.5729	2.495	0.0442	n.a.	0.0257
1965	0.5729	2.495	0.0454	n.a.	0.0257
1966	0.5723	2.567	0.0473	n.a.	0.0251
1967	0.5714	2.517	0.0478	n.a.	0.0274
1968	0.5749	2.626	0.0453	n.a.	0.0264
1969	0.5729	2.526	0.0434	n.a.	0.0285
1970	0.5719	2.430	0.0433	n.a.	0.0262
1971	0.5716	2.493	0.0420	n.a.	0.0256
1972	0.5717	2.459	0.0417	n.a.	0.0263
1973	0.5733	2.497	0.0420	n.a.	0.0259
1974	0.5757	2.501	0.0425	n.a.	0.0270
1975	0.5763	2.478	0.0431	n.a.	0.0280
1976	0.5770	2.452	0.0453	n.a.	0.0291
1977	0.5770	2.480	0.0457	n.a.	0.0277
1978	0.5794	2.490	0.0462	n.a.	0.0290
1979	0.5777	2.499	0.0458	n.a.	0.0303
1980	0.5783	2.404	0.0454	n.a.	0.0336
1981	0.5773	2.377	0.0469	n.a.	0.0338
1982	0.5765	2.314	0.0500	0.0421	0.0345
1983	0.5789	2.275	0.0521	0.0438	0.0354
1984	0.5850	2.301	n.a.	0.0455	0.0345
1985	0.5823	2.354	n.a.	0.0463	0.0331
1986	0.5825	2.404	n.a.	0.0478	0.0320
1987	0.5818	2.411	n.a.	0.0488	0.0310
1988	0.5784	2.403	n.a.	0.0482	0.0308
1989	0.5864	2.427	n.a.	0.0497	0.0301
1990	0.5889	2.427	n.a.	0.0499	0.0299
1991	0.5884	2.418	n.a.	0.0501	0.0300
1992	0.5912	2.453	n.a.	0.0514	0.0313
1993	0.5953	2.537	n.a.	0.0530	0.0291
1994	0.6009	2.538	n.a.	0.0548	0.0291
Excluding “Popular” Models					
1990	0.5883	2.4293	n.a.	0.0500	0.0298
1991	0.5875	2.4201	n.a.	0.0502	0.0299
1992	0.5889	2.4692	n.a.	0.0515	0.0308
1993	0.5928	2.5651	n.a.	0.0533	0.0283
1994	0.5973	2.5781	n.a.	0.0553	0.0280
“Popular”Models					
1990	0.6484	2.2527	n.a.	0.0483	0.0380
1991	0.6484	2.2527	n.a.	0.0483	0.0380
1992	0.6222	2.2330	n.a.	0.0487	0.0383
1993	0.6214	2.2373	n.a.	0.0508	0.0379
1994	0.6289	2.2240	n.a.	0.0509	0.0374

Table A.1
Characteristics of Brazilian Passenger Cars (excl. S. W.)
Non-Weighted Sample: 1960/94

		Average			Proportion of new cars with		
Year	SPEED Km/h	ACCE sec	DIST meter	DOOR4 (%)	ENGF (%)	TRACF (%)	TRANS (%)
1960	126	30.3	26.2	83.3	66.7	16.7	0.0
1961	127	29.5	26.7	85.7	71.4	14.3	0.0
1962	128	29.2	27.1	87.5	75.0	12.5	0.0
1963	127	29.2	27.9	90.0	70.0	10.0	0.0
1964	127	27.0	26.7	88.9	66.7	11.1	0.0
1965	128	25.2	26.9	88.9	66.7	11.1	0.0
1966	137	23.7	27.4	90.9	72.7	9.1	0.0
1967	138	23.7	29.4	84.6	69.2	15.4	0.0
1968	142	22.0	29.9	77.8	66.7	0.0	0.0
1969	144	20.1	31.7	78.9	84.2	21.1	0.0
1970	144	19.8	27.6	65.0	75.0	25.0	0.0
1971	150	17.6	27.9	60.0	80.0	20.0	0.0
1972	152	17.6	28.3	41.7	75.0	20.8	0.0
1973	150	18.4	28.2	31.3	78.1	15.6	0.0
1974	150	17.3	29.4	33.3	82.1	17.9	0.0
1975	149	17.8	29.9	35.4	81.3	18.8	0.0
1976	151	17.5	30.6	35.6	88.9	28.9	0.0
1977	147	17.3	29.5	38.0	92.0	28.0	2.0
1978	150	17.6	30.7	32.0	92.0	30.0	6.0
1979	148	18.2	32.0	35.2	88.9	25.9	7.4
1980	145	19.1	34.0	30.7	88.6	40.9	8.0
1981	145	18.8	33.8	33.3	89.6	47.9	7.3
1982	145	18.8	33.4	27.8	92.4	60.8	13.9
1983	149	17.0	33.6	35.0	98.1	76.7	27.2
1984	152	15.8	33.0	35.6	99.0	77.2	39.6
1985	154	15.3	32.6	30.1	98.8	78.3	37.3
1986	157	14.5	32.2	29.7	98.6	75.7	33.8
1987	155	13.9	31.7	29.2	100.0	80.6	43.1
1988	157	13.7	31.6	35.7	100.0	77.4	36.9
1989	159	13.0	30.7	34.9	100.0	84.9	50.0
1990	160	12.5	30.5	29.9	100.0	87.6	51.5
1991	160	12.6	30.5	30.7	100.0	88.0	58.7
1992	164	13.5	31.6	25.0	100.0	95.0	68.3
1993	169	13.3	30.4	29.0	100.0	98.6	63.8
1994	173	12.9	30.2	32.3	98.4	98.4	66.1
Excluding “Popular” Models							
1990	160	12.4	30.5	30.2	100.0	87.5	51.0
1991	160	12.5	30.5	31.1	100.0	87.8	58.1
1992	166	12.8	31.5	26.8	100.0	96.4	69.6
1993	171	12.7	30.2	30.2	100.0	100.0	63.5
1994	177	12.4	30.0	32.7	100.0	100.0	65.5
“Popular” Models							
1990	136	20.0	31.2	0.0	100.0	100.0	100.0
1991	136	20.0	31.2	0.0	100.0	100.0	100.0
1992	133	23.5	32.5	0.0	100.0	75.0	50.0
1993	140	20.1	32.4	16.7	100.0	83.3	66.7
1994	145	17.2	31.4	28.6	85.7	85.7	71.4

Table A.1
Characteristics of Brazilian Passenger Cars (excl. S. W.)
Non-Weighted Sample: 1960/94

Year	Proportion of new cars with							
	CARB2 (%)	TCARB (%)	INJE (%)	ALTE (%)	SINCR (%)	PSTE (%)	BOOST (%)	DISCF (%)
1960	33.3	0.0	0.0	0.0	33.3	0.0	0.0	0.0
1961	42.9	0.0	0.0	0.0	42.9	0.0	0.0	0.0
1962	50.0	0.0	0.0	0.0	37.5	0.0	0.0	0.0
1963	50.0	10.0	0.0	0.0	70.0	0.0	0.0	0.0
1964	33.3	22.2	0.0	0.0	66.7	0.0	0.0	0.0
1965	33.3	22.2	0.0	0.0	77.8	0.0	0.0	0.0
1966	45.5	18.2	0.0	63.6	81.8	0.0	0.0	0.0
1967	46.2	7.7	0.0	76.9	84.6	7.7	0.0	0.0
1968	55.6	11.1	0.0	66.7	88.9	11.1	0.0	0.0
1969	36.8	5.3	0.0	84.2	100.0	10.5	0.0	5.3
1970	30.0	15.0	0.0	100.0	100.0	10.0	10.0	20.0
1971	32.0	16.0	0.0	100.0	100.0	12.0	12.0	24.0
1972	29.2	16.7	0.0	100.0	100.0	12.5	20.8	70.8
1973	28.1	12.5	0.0	100.0	100.0	9.4	21.9	68.8
1974	28.2	10.3	0.0	100.0	100.0	7.7	30.8	82.1
1975	41.7	10.4	0.0	100.0	100.0	6.3	33.3	85.4
1976	48.9	4.4	0.0	100.0	100.0	8.9	53.3	95.6
1977	54.0	6.0	0.0	100.0	100.0	8.0	54.0	96.0
1978	54.0	6.0	0.0	100.0	100.0	8.0	60.0	96.0
1979	59.3	7.4	0.0	100.0	100.0	11.1	50.0	96.3
1980	47.7	11.4	0.0	100.0	100.0	15.9	58.0	95.5
1981	46.9	12.5	0.0	100.0	100.0	15.6	64.6	95.8
1982	46.8	11.4	0.0	100.0	100.0	10.1	78.5	94.9
1983	61.2	5.8	0.0	100.0	100.0	5.8	89.3	98.1
1984	63.4	5.0	0.0	100.0	100.0	5.9	89.1	100.0
1985	60.2	3.6	0.0	100.0	100.0	7.2	91.6	100.0
1986	71.6	4.1	0.0	100.0	100.0	10.8	90.5	100.0
1987	81.9	0.0	0.0	100.0	100.0	11.1	94.4	100.0
1988	78.6	0.0	0.0	100.0	100.0	19.0	100.0	100.0
1989	86.0	0.0	1.2	100.0	100.0	19.8	100.0	100.0
1990	83.5	0.0	4.1	100.0	100.0	22.7	100.0	100.0
1991	80.0	0.0	5.3	100.0	100.0	24.0	100.0	100.0
1992	48.3	0.0	41.7	100.0	100.0	28.3	100.0	100.0
1993	43.5	0.0	53.6	100.0	100.0	39.1	100.0	100.0
1994	30.6	1.6	67.7	100.0	100.0	43.5	98.4	100.0
Excluding “Popular” Models								
1990	0.0	4.2	100.0	100.0	100.0	22.9	100.0	100.0
1991	0.0	5.4	100.0	100.0	100.0	24.3	100.0	100.0
1992	0.0	44.6	100.0	100.0	100.0	30.4	100.0	100.0
1993	0.0	58.7	100.0	100.0	100.0	42.9	100.0	100.0
1994	0.0	74.5	100.0	100.0	100.0	49.1	100.0	100.0
“Popular” Models								
1990	0.0	0.0	0.0	100.0	100.0	0.0	100.0	100.0
1991	0.0	0.0	0.0	100.0	100.0	0.0	100.0	100.0
1992	25.0	0.0	0.0	100.0	100.0	0.0	100.0	100.0
1993	83.3	0.0	0.0	100.0	100.0	0.0	100.0	100.0
1994	71.4	14.3	14.3	100.0	100.0	0.0	85.7	100.0

Table A.1
Characteristics of Brazilian Passenger Cars (excl. S. W.)
Non-Weighted Sample: 1960/94

Year	Proportion of new cars with							
	VENTF (%)	DISCR (%)	VENTR (%)	ABS (%)	DHE (%)	(DIMHE) (%)	THE (%)	THELI (%)
1960	0.0	0.0	0.0	0.0	33.3	0.0	16.7	16.7
1961	0.0	0.0	0.0	0.0	42.9	0.0	14.3	14.3
1962	0.0	0.0	0.0	0.0	75.0	0.0	12.5	12.5
1963	0.0	0.0	0.0	0.0	80.0	0.0	20.0	20.0
1964	0.0	0.0	0.0	0.0	77.8	0.0	22.2	22.2
1965	0.0	0.0	0.0	0.0	77.8	0.0	22.2	22.2
1966	0.0	0.0	0.0	0.0	72.7	0.0	18.2	18.2
1967	0.0	0.0	0.0	0.0	61.5	15.4	23.1	15.4
1968	0.0	0.0	0.0	0.0	66.7	22.2	22.2	11.1
1969	0.0	0.0	0.0	0.0	78.9	15.8	31.6	0.0
1970	0.0	0.0	0.0	0.0	65.0	0.0	55.0	0.0
1971	4.0	0.0	0.0	0.0	68.0	0.0	60.0	0.0
1972	4.2	0.0	0.0	0.0	62.5	0.0	62.5	0.0
1973	3.1	0.0	0.0	0.0	65.6	6.3	56.3	0.0
1974	2.6	2.6	0.0	0.0	69.2	12.8	56.4	0.0
1975	12.5	2.1	0.0	0.0	70.8	16.7	54.2	0.0
1976	13.3	2.2	0.0	0.0	80.0	22.2	68.9	0.0
1977	16.0	4.0	0.0	0.0	84.0	22.0	68.0	0.0
1978	16.0	4.0	0.0	0.0	86.0	26.0	66.00	0.0
1979	14.8	3.7	0.0	0.0	79.6	22.2	59.3	0.0
1980	1.1	2.3	0.0	0.0	83.0	29.5	75.0	4.5
1981	0.0	3.1	0.0	0.0	85.4	29.2	78.1	7.3
1982	2.5	2.5	0.0	0.0	92.4	34.2	83.5	12.7
1983	11.7	1.9	0.0	0.0	98.1	57.3	89.3	38.8
1984	8.9	2.0	0.0	0.0	99.0	67.3	88.1	48.5
1985	16.9	2.4	0.0	0.0	98.8	62.7	85.5	44.6
1986	18.9	2.7	0.0	0.0	98.6	58.1	86.5	43.2
1987	26.4	0.0	0.0	0.0	100.0	65.3	86.1	50.0
1988	46.4	0.0	0.0	0.0	100.0	65.5	83.3	47.6
1989	57.0	0.0	0.0	0.0	100.0	82.6	83.7	66.3
1990	61.9	2.1	0.0	0.0	100.0	85.6	88.7	74.2
1991	74.7	2.7	0.0	0.0	100.0	98.7	82.7	70.7
1992	75.0	0.0	0.0	0.0	100.0	96.7	80.0	75.0
1993	79.7	13.0	0.0	1.4	100.0	98.6	75.4	73.9
1994	79.0	25.8	1.6	4.8	98,4	98.4	74.2	74.2
Excluding “Popular” Models								
1990	62.5	2.1	0.0	0.0	100.0	98.6	83.8	71.6
1991	75.7	2.7	0.0	0.0	100.0	98.2	82.1	78.6
1992	80.4	0.0	0.0	0.0	100.0	100.0	77.8	77.8
1993	85.7	14.3	0.0	1.6	100.0	100.0	78.2	78.2
1994	87.3	29.1	1.8	5.5	100.0	100.0	79.7	79.7
“Popular” Models								
1990	0.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0
1991	0.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	100.0	75.0	50.0	25.0
1993	16.7	0.0	0.0	0.0	100.0	83.3	50.0	33.3
1994	14.3	0.0	0.0	0.0	85.7	85.7	42.9	42.9

Table A.1
Characteristics of Brazilian Passenger Cars (excl. S. W.)
Non-Weighted Sample: 1960/94

LEGEND	
LENG	length
WBAS	wheelbase
WEIG	weight
TANK	fuel capacity
TRUNK	trunk capacity
DISP	displacement
HPS	horsepower (SAE)
HPA	horsepower (ABNT)
WBLENG	WBAS/LENG
WELENG	WEIG/LENG
HPSCC	HPS/DISP
HPACC	HPA/DISP
DISWEI	DIST/WEIG
SPEED	top speed
ACCE	time to speed (0-100 Km/h)
DIST	stopping distance (80-0 Km/h)
DOOR4	four doors
ENGF	front engine
TRACF	front drive
TRANS	transverse engine
CARB2	double carburetion
TCARB	two carburetors
INJE	electronic fuel injection
ALTE	alternator
SINCR	total synchronized transmission
PSTE	power steering
BOOST	vacuum assisted brake system
DISCF	front disc brake
VENTF	front vented disc brake
DISCR	rear disc brake
VENTR	rear vented disc brake
ABS	antilock brake system
DHE	helicoidal front suspension
DIMHE	independent, MacPherson, and helicoidal front supension
THE	helicoidal rear suspension
THELI	semi-and independent helicoidal rear suspension

Source: Author’s calculation based on data from **Quatro Rodas**, various issues.

Table A.2
Characteristics of Brazilian Passenger Cars (excl. S. W.)
Weighted Sample: 1960/94

Year	Average							
	LENG Cm	WBAS Cm	WEIG Kg	TANK liter	TRUNK liter	DISP cc	HPS hp (SAE)	HPA hp (ABNT)
1960	424	246	870	n.a.	n.a.	1,451	51	n.a.
1961	424	247	883	n.a.	n.a.	1,484	51	n.a.
1962	423	247	898	n.a.	n.a.	1,445	50	n.a.
1963	425	248	931	n.a.	n.a.	1,495	56	n.a.
1964	425	247	932	n.a.	n.a.	1,503	56	n.a.
1965	421	246	896	n.a.	n.a.	1,430	53	n.a.
1966	420	245	880	n.a.	n.a.	1,409	51	n.a.
1967	426	249	931	n.a.	n.a.	1,663	65	n.a.
1968	421	246	884	n.a.	n.a.	1,580	61	n.a.
1969	425	247	893	n.a.	n.a.	1,691	65	n.a.
1970	427	248	901	n.a.	n.a.	1,817	68	n.a.
1971	427	248	915	n.a.	n.a.	1,861	70	n.a.
1972	426	248	916	n.a.	n.a.	1,825	68	n.a.
1973	424	247	929	n.a.	n.a.	1,832	72	n.a.
1974	422	246	921	n.a.	n.a.	1,754	71	n.a.
1975	420	245	902	n.a.	n.a.	1,634	68	n.a.
1976	419	245	907	n.a.	n.a.	1,609	68	n.a.
1977	410	242	887	n.a.	n.a.	1,505	66	n.a.
1978	411	241	894	n.a.	n.a.	1,492	66	n.a.
1979	410	241	887	46	n.a.	1,505	69	n.a.
1980	410	241	891	47	n.a.	1,480	67	n.a.
1981	413	241	895	50	n.a.	1,494	70	n.a.
1982	414	241	905	51	n.a.	1,510	74	62
1983	412	240	907	55	n.a.	1,548	77	66
1984	412	242	921	56	n.a.	1,610	n.a.	74
1985	413	243	937	57	n.a.	1,629	n.a.	76
1986	415	244	960	58	345	1,636	n.a.	81
1987	412	243	959	58	344	1,665	n.a.	84
1988	411	243	971	60	337	1,693	n.a.	86
1989	409	244	973	60	300	1,720	n.a.	87
1990	403	243	950	57	280	1,671	n.a.	83
1991	404	244	947	56	287	1,640	n.a.	82
1992	400	242	951	54	272	1,528	n.a.	77
1993	401	245	980	55	275	1,498	n.a.	79
1994	392	243	941	53	258	1,324	n.a.	71
Excluding “Popular” Models								
1990	406	243	958	57	283	1,712	n.a.	85
1991	412	245	975	57	300	1,779	n.a.	89
1992	409	245	999	55	292	1,756	n.a.	89
1993	418	251	1,066	59	327	1,828	n.a.	97
1994	421	252	1,077	60	333	1,848	n.a.	100
“Popular” Models								
1990	364	236	820	55	224	994	n.a.	48
1991	364	236	820	50	224	994	n.a.	48
1992	377	237	839	51	225	995	n.a.	48
1993	376	236	861	50	203	1,043	n.a.	55
1994	374	237	856	49	211	997	n.a.	53

Table A.2
Characteristics of Brazilian Passenger Cars (excl. S. W.)
Weighted Sample: 1960/94

	Average				
Year	WBLENG	WELENG Kg/Cm	HPSCC hp/cc	HPACC hp/cc	DISWEI meter/Kg
1960	0.5815	2.026	0.0348	n.a.	0.0306
1961	0.5832	2.056	0.0341	n.a.	0.0296
1962	0.5829	2.092	0.0345	n.a.	0.0297
1963	0.5820	2.158	0.0371	n.a.	0.0294
1964	0.5822	2.160	0.0367	n.a.	0.0289
1965	0.5831	2.099	0.0362	n.a.	0.0297
1966	0.5837	2.066	0.0354	n.a.	0.0298
1967	0.5840	2.143	0.0385	n.a.	0.0328
1968	0.5865	2.069	0.0375	n.a.	0.0340
1969	0.5809	2.080	0.0388	n.a.	0.0344
1970	0.5817	2.091	0.0381	n.a.	0.0330
1971	0.5807	2.125	0.0383	n.a.	0.0319
1972	0.5823	2.133	0.0381	n.a.	0.0323
1973	0.5832	2.172	0.0397	n.a.	0.0321
1974	0.5845	2.169	0.0411	n.a.	0.0321
1975	0.5847	2.136	0.0421	n.a.	0.0349
1976	0.5850	2.153	0.0426	n.a.	0.0349
1977	0.5904	2.158	0.0443	n.a.	0.0353
1978	0.5886	2.169	0.0451	n.a.	0.0363
1979	0.5888	2.154	0.0463	n.a.	0.0386
1980	0.5893	2.165	0.0454	n.a.	0.0389
1981	0.5855	2.163	0.0469	n.a.	0.0388
1982	0.5843	2.183	0.0490	0.0415	0.0380
1983	0.5853	2.198	0.0496	0.0424	0.0381
1984	0.5887	2.229	n.a.	0.0457	0.0361
1985	0.5897	2.262	n.a.	0.0472	0.0351
1986	0.5894	2.308	n.a.	0.0494	0.0339
1987	0.5929	2.323	n.a.	0.0510	0.0331
1988	0.5928	2.359	n.a.	0.0515	0.0325
1989	0.5981	2.378	n.a.	0.0511	0.0319
1990	0.6040	2.354	n.a.	0.0495	0.0329
1991	0.6058	2.343	n.a.	0.0501	0.0330
1992	0.6085	2.356	n.a.	0.0496	0.0346
1993	0.6135	2.435	n.a.	0.0527	0.0329
1994	0.6216	2.388	n.a.	0.0534	0.0332
Excluding “Popular”Models					
1990	0.5883	2.4293	n.a.	0.0500	0.0298
1991	0.5875	2.4201	n.a.	0.0502	0.0299
1992	0.5889	2.4692	n.a.	0.0515	0.0308
1993	0.5928	2.5651	n.a.	0.0533	0.0283
1994	0.5973	2.5781	n.a.	0.0553	0.0280
“Popular”Models					
1990	0.6014	2.3603	n.a.	0.0496	0.0326
1991	0.5966	2.3623	n.a.	0.0505	0.0319
1992	0.5996	2.4334	n.a.	0.0502	0.0328
1993	0.6014	2.5390	n.a.	0.0527	0.0297
1994	0.6005	2.5491	n.a.	0.0538	0.0287

Table A.2
Characteristics of Brazilian Passenger Cars (excl. S. W.)
Weighted Sample: 1960/94

Year	Average			Proportion of new cars with			
	SPEED Km/h	ACCE sec	DIST meter	DOOR4 (%)	ENGF (%)	TRACF (%)	TRANS (%)
1960	115	35.7	25.0	54.1	34.2	8.0	0.0
1961	116	34.9	24.9	43.6	33.9	7.7	0.0
1962	116	35.2	25.0	44.4	34.0	10.3	0.0
1963	117	33.4	26.0	49.5	36.2	8.7	0.0
1964	117	32.9	25.4	45.1	33.9	7.0	0.0
1965	115	37.1	25.1	40.4	27.1	5.5	0.0
1966	116	39.1	24.8	33.1	24.6	6.0	0.0
1967	121	28.7	28.2	28.3	25.4	4.9	0.0
1968	120	29.0	28.3	17.3	16.8	0.0	0.0
1969	125	27.5	30.0	34.8	36.9	18.7	0.0
1970	129	25.2	28.5	30.2	36.5	12.8	0.0
1971	133	22.9	28.2	23.7	36.4	14.2	0.0
1972	132	23.9	28.4	10.2	36.9	15.2	0.0
1973	134	23.7	28.8	5.6	42.6	12.4	0.0
1974	133	22.3	28.8	5.2	48.1	14.6	0.0
1975	131	23.6	30.7	5.4	46.5	20.4	0.0
1976	133	23.2	30.9	4.3	46.8	20.6	0.0
1977	133	23.2	30.8	3.1	49.8	28.8	10.4
1978	136	23.3	31.8	2.9	55.7	34.6	12.6
1979	133	23.7	33.5	3.9	57.4	39.7	13.8
1980	133	24.8	34.1	4.0	66.4	46.4	13.3
1981	136	22.7	34.2	5.9	77.1	58.6	10.2
1982	141	20.4	33.9	4.1	85.3	69.9	16.6
1983	143	19.8	34.1	5.3	87.8	78.6	21.6
1984	150	15.7	32.8	5.6	89.7	86.6	38.1
1985	152	15.4	32.4	6.6	92.4	89.0	40.8
1986	155	14.6	32.1	8.0	95.9	92.7	42.1
1987	154	14.0	31.4	9.2	100.0	96.5	47.7
1988	157	13.1	31.3	11.4	100.0	93.6	40.4
1989	158	12.8	30.7	14.1	100.0	92.6	49.0
1990	156	13.4	30.9	11.6	100.0	92.0	54.3
1991	155	14.1	30.8	12.2	100.0	93.1	66.0
1992	153	16.4	32.3	15.4	100.0	91.4	63.3
1993	157	16.0	31.3	25.5	100.0	96.7	61.3
1994	156	15.9	30.6	28.3	99.9	99.9	72.2
Excluding "Popular" Models							
1990	158	13.0	30.8	12.3	100.0	91.5	51.6
1991	159	12.8	30.7	14.8	100.0	91.6	58.7
1992	161	13.3	32.1	22.1	100.0	97.0	61.0
1993	170	12.8	30.8	32.0	100.0	100.0	63.8
1994	174	12.5	30.2	38.5	100.0	100.0	72.9
"Popular" Models							
1990	136	20.0	31.2	0.0	100.0	100.0	100.0
1991	136	20.0	31.2	0.0	100.0	100.0	100.0
1992	133	23.8	32.7	0.0	100.0	78.6	68.6
1993	139	20.4	32.1	16.5	100.0	92.1	57.7
1994	145	18.0	30.8	21.9	99.8	99.8	71.8

Table A.2
Characteristics of Brazilian Passenger Cars (excl. S. W.)
Weighted Sample: 1960/94

Year	Proportion of new cars with							
	CARB2 (%)	TCARB (%)	INJE (%)	ALTE (%)	SINCR (%)	PSTE (%)	BOOST (%)	DISCF (%)
1960	10.3	0.0	0.0	0.0	9.2	0.0	0.0	0.0
1961	11.9	0.0	0.0	0.0	64.7	0.0	0.0	0.0
1962	10.2	0.0	0.0	0.0	66.4	0.0	0.0	0.0
1963	9.9	17.6	0.0	0.0	69.1	0.0	0.0	0.0
1964	9.8	17.1	0.0	0.0	73.0	0.0	0.0	0.0
1965	6.3	15.3	0.0	0.0	86.7	0.0	0.0	0.0
1966	4.5	14.2	0.0	25.0	91.6	0.0	0.0	0.0
1967	13.8	6.7	0.0	27.8	97.1	6.6	0.0	0.0
1968	12.0	4.8	0.0	16.6	99.4	4.0	0.0	0.0
1969	5.8	1.5	0.0	36.9	100.0	2.4	0.0	7.3
1970	6.5	7.2	0.0	100.0	100.0	1.6	1.3	9.7
1971	7.0	13.7	0.0	100.0	100.0	2.2	1.2	15.5
1972	6.4	7.3	0.0	100.0	100.0	1.9	1.7	26.5
1973	5.9	5.5	0.0	100.0	100.0	1.8	2.3	31.0
1974	5.0	1.7	0.0	100.0	100.0	1.4	4.4	45.4
1975	7.5	3.4	0.0	100.0	100.0	1.0	10.6	67.6
1976	9.2	12.8	0.0	100.0	100.0	1.4	18.1	70.2
1977	6.6	25.6	0.0	100.0	100.0	0.7	17.8	75.1
1978	5.6	22.5	0.0	100.0	100.0	0.8	28.9	78.0
1979	19.2	20.7	0.0	100.0	100.0	0.9	20.5	78.5
1980	18.2	22.3	0.0	100.0	100.0	1.3	25.7	79.2
1981	20.8	18.2	0.0	100.0	100.0	1.3	45.2	82.2
1982	23.1	17.7	0.0	100.0	100.0	0.9	67.7	85.6
1983	29.4	23.2	0.0	100.0	100.0	0.6	82.2	87.8
1984	38.4	21.2	0.0	100.0	100.0	0.5	84.9	100.0
1985	48.1	12.4	0.0	100.0	100.0	1.4	81.5	100.0
1986	68.9	7.9	0.0	100.0	100.0	2.7	84.3	100.0
1987	76.0	0.0	0.0	100.0	100.0	6.1	88.7	100.0
1988	81.8	0.0	0.0	100.0	100.0	7.0	100.0	100.0
1989	85.1	0.0	0.4	100.0	100.0	9.7	100.0	100.0
1990	82.0	0.0	1.1	100.0	100.0	7.9	100.0	100.0
1991	72.7	0.0	1.5	100.0	100.0	9.6	100.0	100.0
1992	42.8	0.0	26.6	100.0	100.0	11.3	100.0	100.0
1993	64.6	0.0	34.3	100.0	100.0	16.2	100.0	100.0
1994	63.8	0.1	36.0	100.0	100.0	14.7	99.9	100.0
Excluding "Popular" Models								
1990	87.1	0.0	1.1	100.0	100.0	8.4	100.0	100.0
1991	88.4	0.0	1.9	100.0	100.0	11.7	100.0	100.0
1992	56.8	0.0	38.0	100.0	100.0	16.1	100.0	100.0
1993	40.6	0.0	59.2	100.0	100.0	27.9	100.0	100.0
1994	26.8	0.0	73.2	100.0	100.0	38.1	100.0	100.0
"Popular" Models								
1990	0.0	0.0	0.0	100.0	100.0	0.0	100.0	100.0
1991	0.0	0.0	0.0	100.0	100.0	0.0	100.0	100.0
1992	10.0	0.0	0.0	100.0	100.0	0.0	100.0	100.0
1993	97.6	0.0	0.0	100.0	100.0	0.0	100.0	100.0
1994	87.0	0.2	12.8	100.0	100.0	0.0	99.8	100.0

Table A.2
Characteristics of Brazilian Passenger Cars (excl. S. W.)
Weighted Sample: 1960/94

Year	Proportion of new cars with							
	VENTF (%)	DISCR (%)	VENTR (%)	ABS (%)	DHE (%)	DIMHE (%)	THE (%)	THELI (%)
1960	0.0	0.0	0.0	0.0	29.0	0.0	19.9	19.9
1961	0.0	0.0	0.0	0.0	20.9	0.0	9.8	9.8
1962	0.0	0.0	0.0	0.0	34.1	0.0	10.4	10.4
1963	0.0	0.0	0.0	0.0	40.8	0.0	13.3	13.3
1964	0.0	0.0	0.0	0.0	38.1	0.0	11.2	11.2
1965	0.0	0.0	0.0	0.0	35.0	0.0	13.3	13.3
1966	0.0	0.0	0.0	0.0	26.9	0.0	8.4	8.4
1967	0.0	0.0	0.0	0.0	22.8	2.6	9.5	2.9
1968	0.0	0.0	0.0	0.0	16.6	5.2	4.6	0.6
1969	0.0	0.0	0.0	0.0	36.7	2.5	21.1	0.0
1970	0.0	0.0	0.0	0.0	32.1	0.0	31.2	0.0
1971	0.9	0.0	0.0	0.0	32.0	0.0	31.6	0.0
1972	0.6	0.0	0.0	0.0	32.9	0.0	32.9	0.0
1973	0.6	0.0	0.0	0.0	38.9	3.1	35.1	0.0
1974	0.4	0.6	0.0	0.0	46.2	5.7	40.2	0.0
1975	3.0	0.8	0.0	0.0	45.5	9.7	42.4	0.0
1976	3.5	0.8	0.0	0.0	46.1	10.4	42.9	0.0
1977	1.4	0.8	0.0	0.0	49.5	23.5	37.9	0.0
1978	0.8	0.5	0.0	0.0	55.5	24.3	42.2	0.0
1979	0.2	0.3	0.0	0.0	57.0	28.9	43.1	0.0
1980	0.0	0.3	0.0	0.0	66.4	34.6	53.1	6.7
1981	0.0	0.2	0.0	0.0	77.0	39.4	66.8	15.7
1982	1.8	0.2	0.0	0.0	85.3	52.0	75.7	29.0
1983	4.4	0.1	0.0	0.0	87.8	54.4	77.7	38.5
1984	2.4	0.0	0.0	0.0	89.7	67.5	78.9	53.5
1985	10.5	0.1	0.0	0.0	92.4	69.6	77.7	53.5
1986	11.3	0.0	0.0	0.0	95.9	74.7	81.6	55.3
1987	24.7	0.0	0.0	0.0	100.0	78.9	83.5	61.3
1988	39.6	0.0	0.0	0.0	100.0	78.9	87.4	66.0
1989	45.9	0.0	0.0	0.0	100.0	87.9	87.0	74.9
1990	43.9	0.9	0.0	0.0	100.0	91.0	80.8	71.9
1991	50.8	1.5	0.0	0.0	100.0	95.9	71.4	64.5
1992	42.6	0.0	0.0	0.0	100.0	91.5	66.6	58.0
1993	47.3	10.4	0.0	1.3	100.0	96.7	66.4	63.1
1994	37.8	9.5	1.1	2.1	99.9	99.9	62.4	62.4
Excluding “Popular” Models								
1990	46.6	1.0	0.0	0.0	100.0	90.5	85.8	76.3
1991	61.8	1.8	0.0	0.0	100.0	95.0	86.7	78.4
1992	60.9	0.0	0.0	0.0	100.0	97.1	81.7	78.7
1993	78.6	17.9	0.0	2.2	100.0	100.0	81.0	81.0
1994	81.3	24.7	2.8	5.4	100.0	100.0	79.7	79.7
“Popular” Models0.0								
1990	0.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0
1991	0.0	0.0	0.0	0.0	100.0	100.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	100.0	78.6	31.4	10.0
1993	4.1	0.0	0.0	0.0	100.0	92.1	46.4	38.4
1994	10.7	0.0	0.0	0.0	99.8	99.8	51.5	51.5

Table A.2
Characteristics of Brazilian Passenger Cars (excl. S. W.)
Non-Weighted Sample: 1960/94

LEGEND	
LENG	length
WBAS	wheelbase
WEIG	weight
TANK	fuel capacity
TRUNK	trunk capacity
DISP	displacement
HPS	horsepower (SAE)
HPA	horsepower (ABNT)
WBLENG	WBAS/LENG
WELENG	WEIG/LENG
HPSCC	HPS/DISP
HPACC	HPA/DISP
DISWEI	DIST/WEIG
SPEED	top speed
ACCE	time to speed (0-100 Km/h)
DIST	stopping distance (80-0 Km/h)
DOOR4	four doors
ENGF	front engine
TRACF	front drive
TRANS	transverse engine
CARB2	double carburetion
TCARB	two carburetors
INJE	electronic fuel injection
ALTE	alternator
SINCR	total synchronized transmission
PSTE	power steering
BOOST	vacuum assisted brake system
DISCF	front disc brake
VENTF	front vented disc brake
DISCR	rear disc brake
VENTR	rear vented disc brake
ABS	antilock brake system
DHE	helicoidal front suspension
DIMHE	independent, MacPherson, and helicoidal front supension
THE	helicoidal rear suspension
THELI	semi-and independent helicoidal rear suspension

Source: Author’s calculation based on data from **Quatro Rodas**, various issues.

Table A.3
Quality Change Index
Brazilian Automobile Industry

Year	Equation 1 [SPEED]			
	Non-Weighted Sample		Weighted Sample	
	Index (1980=100)	Change (%)	Index (1980=100)	Change (%)
1960	65		72	
1961	68	3.7	73	1.6
1962	71	4.2	73	0.8
1963	70	-1.4	76	3.4
1964	72	2.5	76	0.5
1965	72	0.5	73	-3.9
1966	82	13.5	74	0.7
1967	83	2.3	82	10.6
1968	89	6.9	78	-4.2
1969	88	-1.3	82	4.9
1970	86	-1.9	84	2.6
1971	92	7.1	88	4.3
1972	97	4.5	89	0.7
1973	96	-0.8	92	3.3
1974	98	1.7	93	1.4
1975	98	0.3	93	0.5
1976	102	4.8	95	2.3
1977	104	1.2	95	-0.1
1978	106	2.6	99	3.4
1979	105	-0.9	98	-0.7
1980	100	-5.1	100	2.2
1981	99	-0.9	105	4.8
1982	97	-2.3	113	7.8
1983	103	5.9	117	3.7
1984	107	4.4	126	7.5
1985	114	6.7	135	6.8
1986	119	4.3	143	6.3
1987	124	4.0	150	4.9
1988	132	6.2	161	7.0
1989	139	5.3	160	-0.1
1990	144	3.6	151	-6.2
1991	148	3.4	151	0.1
1992	158	6.2	151	0.5
1993	174	10.6	163	7.5
1994	182	4.2	155	-4.7

Source: Author’s calculation.

Table A.4
Quality Change Index
Brazilian Automobile Industry

Year	Equation 2 [HP (.)CC]			
	Non-Weighted Sample		Weighted Sample	
	Index (1980=100)	Change (%)	Index (1980=100)	Change (%)
1960	71		74	
1961	73	3.7	75	1.2
1962	77	5.4	76	1.3
1963	77	-0.3	79	4.0
1964	80	3.3	79	0.8
1965	83	4.0	80	0.4
1966	88	6.1	79	-0.9
1967	89	1.0	87	9.7
1968	89	0.2	84	-2.5
1969	87	-1.8	84	0.0
1970	87	-0.4	84	-1.1
1971	91	4.8	86	2.9
1972	89	-2.6	86	0.4
1973	91	2.8	89	3.6
1974	94	3.4	92	2.7
1975	94	0.1	93	1.7
1976	100	6.0	96	2.5
1977	103	2.4	96	0.5
1978	104	1.5	99	3.1
1979	103	-1.1	98	-1.2
1980	100	-2.9	100	2.0
1981	100	0.4	105	5.3
1982	100	-0.7	114	7.9
1983	104	4.6	117	3.3
1984	109	4.3	125	6.5
1985	117	7.2	134	7.0
1986	124	6.6	142	6.6
1987	130	4.3	153	7.6
1988	136	5.1	163	6.1
1989	149	9.1	171	5.1
1990	156	5.0	167	-2.3
1991	159	2.1	172	2.8
1992	165	3.7	168	-2.3
1993	183	10.4	179	6.5
1994	188	3.2	171	-4.4

Source: Author's calculation.

Table A.5
Quality Adjusted Price
Brazilian Automobile Industry
Weighted Average: 1960/94

Year	Real Weighted Avg. Price		Quality Adjusted Real Weighted Avg. Price	
	Prices in Cr$ of 1963	(%)	Prices in Cr$ of 1963	(%)
1960	2,980		2,980	
1961	2,853	-4.2	2,805	-5.9
1962	2,341	-17.9	2,278	-18.8
1963	2,719	16.2	2,569	12.8
1964	2,885	6.1	2,712	5.6
1965	2,610	-9.5	2,560	-5.6
1966	2,245	-14.0	2,184	-14.7
1967	2,410	7.4	2,113	-3.2
1968	2,356	-2.3	2,153	1.9
1969	2,422	2.8	2,107	-2.1
1970	2,315	-4.4	1,959	-7.0
1971	2,157	-6.8	1,741	-11.2
1972	2,073	-3.9	1,660	-4.6
1973	1,967	-5.1	1,521	-8.3
1974	1,736	-11.8	1,321	-13.2
1975	1,945	12.1	1,474	11.6
1976	1,759	-9.6	1,299	-11.8
1977	1,642	-6.6	1,214	-6.6
1978	1,718	4.6	1,228	1.2
1979	1,750	1.9	1,260	2.6
1980	1,445	-17.5	1,013	-19.6
1981	1,564	8.3	1,048	3.4
1982	1,972	26.1	1,240	18.3
1983	1,864	-5.5	1,126	-9.2
1984	1,753	-5.9	975	-13.4
1985	1,707	-2.6	882	-9.5
1986	1,733	1.5	840	-4.8
1987	2,375	37.0	1,110	32.1
1988	2,758	16.1	1,211	9.1
1989	2,098	-23.9	923	-23.8
1990	2,013	-4.0	942	2.1
1991	1,868	-7.2	873	-7.4
1992	2,049	9.7	954	9.3
1993	2,443	19.2	1,066	11.7
1994	1,941	-20.6	896	-15.9

Source: Author’s calculation.

Table A.6
Process Innovation Index and Labor Productivity
Brazilian Automobile Industry

Year	Process Innovation Index (1960=100) a	Labor Productivity Veh./Empl. b
1960	100	3.46
1961	106	3.89
1962	126	3.94
1963	110	3.96
1964	104	4.14
1965	109	3.74
1966	125	4.43
1967	130	4.86
1968	127	4.63
1969	130	5.79
1970	139	6.31
1971	154	7.24
1972	162	7.74
1973	175	7.81
1974	198	8.70
1975	175	8.90
1976	196	8.78
1977	209	8.26
1978	206	8.58
1979	201	8.88
1980	240	8.72
1981	232	7.51
1982	190	8.02
1983	207	8.87
1984	235	8.05
1985	257	7.91
1986	269	8.17
1987	183	8.11
1988	166	9.46
1989	206	8.56
1990	201	7.79
1991	216	8.77
1992	196	10.16
1993	173	13.04
1994	201	14.76

Source: a Author’s calculation.
b Author’s calculation based on Anfavea (1995, p. 45 and 57).

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