DEPRECIATION OF DURABLE GOODS IN AN UNSTABLE ECONOMY: THE CASE OF ARGENTINA

A Hulten & Wycoff approach

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INDEX

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"The measurement of capital is one of the nastiest jobs that economists have set to statisticians"
(J. Hicks 1981), quoted by Ch. Hulten (1990)

"The fundamental problem of accounting is how to determine end of the accounting period prices for durable assets that are held by the business unit for multiple accounting periods" Diewert (2003)

Abstract

The main purpose of this paper is to identify the depreciation pattern in an unstable economy: the Argentina case, using vintage asset prices by means of Hulten and Wycoff (1981) approach.

The example of Argentina during 1998-2002 is very important because during that period, there was the biggest & longest economic depression of its modern economic history. As a consequence, the country abandoned the Convertibility Plan with currency mega devaluation (default & desdoralization) DDD which caused a high instability in relative prices that could challenge the measure of capital stock, gdp and productivity performance in so unstable economy.

The paper briefly discusses the depreciation concept, the importance in economic analyses and the information problems in the used durable goods markets according to SNA93, OECD Measuring Capital Manual and the most recent literature.

Applying the Hulten and Wykoff (1981) approach to Argentine case (farm tractors, aircrafts, cars, buses, trucks and light commercial vehicles), the econometric analysis would confirm the hypothesis of convex depreciation for almost every case under analyses, but overall, it would not confirm any geometric case.

We also found that there was a high instability of age price profile in the argentine economy and important distortions on price of durables goods capture by "representative official index".

This findings support the importance of valuation of the stock of durable goods taking into account the age price profile performance; instead of the use of standard depreciation without empirical support in the PIM context or the imputation of an age price profile of the reference year to the whole stock series supposing its stability.

[*] This paper is an extension of an annex of Coremberg-INDEC (2004): "Capital Stock in Argentina: Sources, Methods and Series". Comments from Daniel Heymann, Alberto Fracchia, Walter Sosa Escudero and Luis Suárez as well as the assistance of L.M. Camadro, L. Frank and A. Olgiatti on the gathering of the sources of information and the consistency of the database, are appreciated. The opinions expressed are solely the responsibility of the author.

Introduction

The purpose of this study is to analyze the possible functional form of durable goods depreciation in Argentina.

The identification of the functional form of durable goods depreciation is very important in economic analysis.

The measurement of the depreciation curve will have a direct impact in the value of durable consumption goods and therefore on the wellbeing of households. This occurs not only because the annual service of these goods represents an important part of households' consumption but also because durable goods represent a large share of households' wealth. In this last sense, changes in the age price profile through time generate important wealth effects on their owners.

At the same time, capital goods are an important subset of durable goods. Therefore it is important to consider the impact of the outcome of the depreciation curve of these goods on the value of capital stock and thus on the equity balance of firms, as well as its link with the stock annual services and the corresponding effect on firm's productivity.

The econometric finding of the depreciation rate and its functional form will have a direct impact on the estimates of the capital stock and other durable assets, verifying econometrically some of the most important assumptions (often not empirically tested) in the so called Perpetual Inventory Method (PIM), usually used for stock estimations.

Statistical international agencies such as the OECD Canberra Group II: "On the Measurement of Non-Financial Assets" and the 1993 National Accounts System (SNA93), recommend the consistent valuation of non financial assets taking into account their heterogeneity. They suggest valuating this type of assets by their market price or equivalent replacement cost, taking into account their features: model, age, etc.

In so doing, it is necessary to count with information of market prices of used durable goods. The empirical corroboration of the depreciation functional form, retirement pattern and age structure implied by the statistic of the analyzed good reduces the high level of uncertainty with respect to the level and performance of the durable goods stock originated in the quantity and magnitude of the PIM assumptions usually used, given the shortcomings of available data.

Given the instability and volatility of the relative prices of durable goods inherent to the argentine economy, it is important to check whether the depreciation curve estimated on the basis of market prices information is relatively stable. If the aim is to update the value of this type of goods, and if inflation is non neutral, it would be incorrect to apply price indexes, and even the extrapolation, to time series of the age price profile or relative price structure of the cohorts estimated for a certain base year.

Section 1 presents a summary of the definition and terminology related to depreciation. Section 2 briefly presents some examples of standard depreciation methods often used in the estimations of durable goods stock through the PIM method and a brief discussion of the possible distortions that their use may generate. Section 3 briefly analyzes the effect on depreciation estimations of possible information asymmetry problems in the used durable goods market. Section 4 displays the econometric results of a depreciation curve estimation for the sets of durable goods with available data for Argentina: cars, light commercial vehicles, trucks and buses, airplanes and farm tractors. Finally, conclusions are presented.

1. Depreciation: definitions and terminology[1]

The depreciation represents the loss of efficiency that is expected in the capital good, assuming a *normal use*, as a result of time passing. When basic data is not available, standard depreciation patterns are used: straight line, geometric, etc.

The definition of normal use is one of the methodological problems for the estimation of depreciation. Even assuming a typical economic cycle could be defined, this would necessarily be characteristic of the country, sector or even firm where the durable good is set up.

Note this definition refers exclusively to the foreseen obsolescence, not taking into account the notion of unforeseen obsolescence. The definition of depreciation stated before would be compatible with the notion of foreseen obsolescence as long as the user were able to define and anticipate clearly the technological cycle of the product and/or services generated by the durable good.

However, following an ample definition of depreciation, it should also include the retirements produced as a result of the breakdown and/or failures of the goods during *normal use*[2], leaving the retirements due to unforeseen obsolescence, war, natural disasters, etc. in the "other changes in the volume of assets" account, following the recommendations of the SNA (93).

Then again, both the restricted and the ample (including foreseen retirements) definition of depreciation exclude the unforeseen obsolescence as a consequence of the unexpected introduction in the market of newer more technologically advanced products (with a higher embedded productivity) generating a larger opportunity cost and a decline on the relative prices of durable goods already set up.

The notion of retirement pattern is important for the estimation of the value of the durable goods stock. This concept represents the retirements of durable goods from production or from household consumption as a result of foreseen obsolescence, failure or breakdown, etc. The estimation of the stock, when statistical data is not available, uses standard retirement patterns that indicate the average mortality rates of the corresponding type of capital good for the industry[3].

It is important to take into account the difference between the age efficiency profile and the age price profile.

The age efficiency profile is the productivity or efficiency profile of the capital good according to its age. On the other hand, the age price profile is the price profile of

[1] For a more comprehensive explanation see OECD (2001) and Suárez (2000a) (2000b).

[2] According to the Bureau of Economic Analysis (BEA) definition, see Fraumeni and Herman (2000)

[3] The latter, together with the assumptions on lifetime and standard depreciation methods necessary for the estimations by the PIM method, may not follow the reality of the user sector. See section 2.

the capital good according to its age[4]. While the price profile shows the relative price situation of durable goods in the used market, the age efficiency profile shows the physical productivity of capital goods by age according to their embedded engineering. Therefore, both profiles are not necessarily equivalent, although in practice both are assumed to be the same, in the understanding that there is certain correlation between relative productivities and relative prices by cohort[5].

2. Standard Depreciation Methods

Apart from the retirement pattern and lifetime of the equipment, the assumed depreciation standard is one of the main determinants of the level and performance of the durable goods' value while estimating the stock by the PIM method.

The PIM is the most widely used method for estimating the stock of durable goods, especially capital goods, given that census or records of capital goods included in the stock are not always available. The method consists basically in the estimation of the stock of durable good under study by accruing the past purchases or investment flows under certain assumptions regarding average lifetime, retirement pattern and depreciation pattern.

These assumptions are required given the inexistence of frequent and detailed information of the used goods relative prices' vector for certain categories of capital goods. The usual practice for retrieving the age price profile is the application of standard depreciation methods to the prices of new capital goods. Furthermore, some models of capital goods do not have a market and so their prices need to be assigned.

Generally, given the inexistence of detailed data about the retirement pattern, age efficiency profile and age price profile of durable goods, the PIM is reduced to estimating the capital stock at constant prices and at current prices using the *standard* depreciation methods and retirement patterns on the cohorts flows or *"harvests"* of investments as if they represented the true efficiency and age price profile; in other words, as the net result of combining the retirement pattern, age efficiency profile and the age price profile.

This section presents a summary of main Standard depreciation methods[6].

Usual standard depreciation methods are lineal, geometric and hyperbolic. The former and the second generate convex age efficiency profiles; with constant depreciation sums that cancel the residual value at the end of its lifetime for the *lineal* and with a constant depreciation rate with positive residual value at the end of its lifetime for the *geometric*:

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[4] The age price profile reflects the decline of the value of the asset not only by age efficiency profile but also because the older models with the same productivity of newer ones reflect a lower survival probability (the useful life of the asset becomes shorter as time passes).

[5] In fact, this assumes that distortions on the used durable goods market have a lower impact on the depreciation estimated from the age price profile. See section 4.

[6] For a more comprehensive discussion of depreciation methods see OECD (2001), Coremberg (2002) Suárez (2000b) and Coremberg-INDEC (2004)

Lineal: $$D_t = \frac{V_0}{T}$$

Geometric: $$V_t = V_0 \left[1 - (1/T)\right]^t$$

t: years 1,2,...T (lifetime)
D: depreciation
V: value of the capital good

Less used than the formers, although recommended in OECD (2001), the *sum of digits* depreciation method implies a convex age efficiency profile with depreciation sums declining with the age of the capital good and a null residual value at the end of its lifetime:

Sum of digits: $$D_t = V_0 \left[T - t + 1\right] / \left[T(T+1)/2\right]$$

The US Bureau of Economic Analysis (BEA), agency in charge of the National Accounts official estimations, uses the geometric depreciation method for the capital stock estimation, although correcting it according to econometric studies that allow retrieving the depreciation curve implied by market prices of used capital goods and also affected by the true retirement pattern[7]. The geometric depreciation pattern is corrected accelerating or retarding the fall in the value of the asset according to information provided by econometric regressions:

Adjusted Geometric: $$V_t = V_0 \left[1 - (R/T)\right]^t$$

being R the coefficient that allows accelerating or diminishing the efficiency profile according to the used market information by type of capital good. Note that the case of R=2 coincides with the double depreciation method.

Used by the US Bureau of Labor Statistics (BLS) for the capital services estimation and by the Australian Bureau of Statistics (ABS) that also uses it for estimating the stock and fixed capital consumption, the *hyperbolic* depreciation method generates a concave efficiency profile, meaning that the capital good's productivity reduction at the beginning of its lifetime takes place at a decreasing rate:

Hyperbolic: $$V_t = V_0 \left[T - (t-1)\right] / \left[T - \beta(t-1)\right]$$

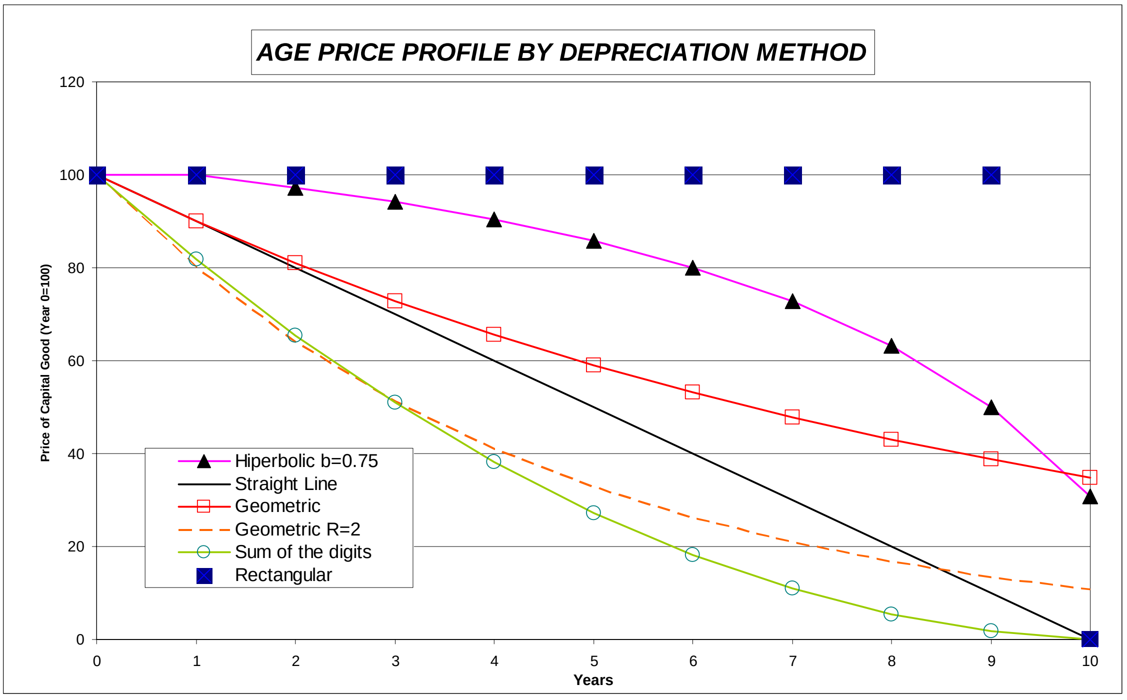
β : coefficient that adjusts the curve of the efficiency profile according to the type of capital good.

[7] See Fraumeni (1997), Katz and Herman (1997), BEA (1999) and Fraumeni and Herman (2000).

Another depreciation method is the *rectangular*. It consists in maintaining constant the productivity of the capital good along its lifetime, going through a single sudden depreciation, amounting the whole initial value, at the end of its lifetime; in other words, it displays the type of retirement pattern of a "light bulb". In practice, the stock estimated by this method coincides with its gross level.

The following graph shows the different efficiency profiles of the value of a capital good according to its age, by each of the depreciation methods:

Gráfico 1



The geometric depreciation assumption has the analytical advantage that the *productive* definition of the stock coincides with its *net* definition[8], given that only under this case the age efficiency profile matches exactly the age price profile. It also has the advantage that the depreciation level is independent of the age structure of the stock (crucial assumption of the PIM)[9].

It is important to note that under the usual practice on PIM, both the estimation at current prices and at constant prices do not contemplate the changes in the age price profile of the used capital goods market. In other words, the age price profile of the base year (or the year of reference) implied in the assumption of standard depreciation and retirement pattern is assigned assuming it is constant or stable along the whole series.

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[8] In the estimations of the durable goods stock under the PIM, the *productive* definition corresponds to the estimation based on the age efficiency profile assumed. The latter should reflect the reduction in physical productivity or services of the good as a result of the time passing. On the contrary, the *net* definition consists on the valuation of the goods at their asset value through the market age price profile, which represent the present value of the services the durable good is expected to provide according to its lifetime and the age cohort to which it belongs.

[9] See Hulten (1990) (1999).

For practical reasons, many countries assume the standard of other developed countries' retirement patterns, efficiency profiles and lifetime vectors. However, given that the reliability of the PIM regarding the level and change of the capital stock depends crucially on these three assumptions, their supposition should correspond to the reality of the user sector in the country under analysis[10]; otherwise, both the level and change of the durable goods stock would be biased, specially that of the capital stock with its corresponding effect on the analysis of the wellbeing, productivity and wealth of the economy[11].

As pointed out by Hulten (1990) (1999), before adopting assumptions on the type of age price profile, the depreciation pattern should be verified empirically in order to check whether the use of the geometric pattern matches the reality of the durable good's market under analysis.

In this sense, the SNA93 and the OECD Canberra Group II recommend that, when estimating the stock under the PIM, if continuous statistics of stock and market prices of the used goods market are unavailable, then the functional form of the depreciation should be empirically verified at least for a base or reference year, updating the parameters on the grounds of new information.

In order to econometrically estimate the depreciation curve on the basis of the age efficiency profile, it would be necessary to count with statistical samples of productivity and/or physical efficiency data of the goods according to their age (industrial engineering studies). However, given the lack of such studies, an econometrical test of the functional forms of the depreciation based on price statistics of the used goods market is carried out. *Therefore its use as a depreciation curve implies the assumption that the age price profile is equal to the age efficiency profile or at least that there is a positive correlation between them.*

Before the introduction of the econometric results it is necessary to take into account the information problems in the used durable goods market that may distort the significance of the age price profile as equivalent to the efficiency profile and proxy variable of the depreciation.

3. Information Problems in the Durable Goods Market: effect on depreciation

According to Diewert (2003), "the main problem for accounting is determining the value of the capital goods that are used by the firm for more than one fiscal year". This author highlights a series of problems for determining the value of a capital good (relevant for the whole set of durable goods) apart from the information problems: joint costs, inexistence of markets, reproducibility, objectivity, etc.

This section briefly presents a summary of the problems that are directly associated to the estimation of the depreciation of durable goods from market prices information.

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[10] For example, among the most widely used retirement patterns are the mortality functions (18 types of curves) of R. Winfrey who provided these estimations based in statistical data for the US user industry for the 1920's and 1930's!, or the normal or lognormal or bell-shaped mortality functions which have not been empirically verified.

[11] For a comprehensive criticism of the PIM see Miller (1983) (1990).

Following Hulten and Wykoff (1981), Fraumeni (1997) and Fraumeni and Herman (2000), the value of the durable goods could be distorted by a series of information problems in the used durable goods market:

3.1 Asymmetric information (lemons problem)

Pointed out for the first time by Akerlof (1970) in the framework of the used durable goods market, the sales price of durable goods could be distorted in terms of their hedonic significance as a consequence of the belief of buyers that most of the used durable goods sold in the market are of lower quality than the real, this phenomena could overstate the depreciation and understate the capital stock value.

3.2 Censored data

The valuation of the durable goods stock can be biased unless it is taken into account that, in general, the prices sample of used durable goods may be censored by reflecting only the price profile of the capital goods marketed in the used market, excluding information of prices of models that have been withdrawn from the market but still in stock. Contrary to the former case, this would understate the depreciation and overstate the value of the stock. In order to correct these distortions, Hulten and Wykoff (1981) suggest weighting the used capital goods prices by their survival probability implied in the age structure of the existent stock.

3.3 Alternative uses

The alternative use of a same durable good may generate a change or structural break in the depreciation curve. For example, a truck used by a transport firm that makes use of it for moving heavy merchandises throughout the country is sold to a commercial transport firm that moves light weights within the city. The depreciation pace of the latter user will be less than the former even though both make use of the same vehicle[12].

This problem is particularly important in the case of transport equipment, though not necessarily for the rest of the durable goods. Following Hulten and Wykoff (1981), market price statistics will reflect the average depreciation and not necessarily the differences in the age profile among alternative uses. It is possible for an econometric study to distort the depreciation's functional form towards the geometric type when, actually, it happens as a result of the transfer of an asset from one use to another, being in general, the first use the most productive[13].

3.4 Stability of the Depreciation Curve

The macroeconomic instability or idiosyncratic shocks on the user sector may generate changes in relative prices not only among goods but also among age cohorts for a same model of a durable good. In other words, the age price profile may not be

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[12] Alberto Fracchia is thanked for this comment.

[13] See Hulten and Wykoff (1981) fig.3 p.381

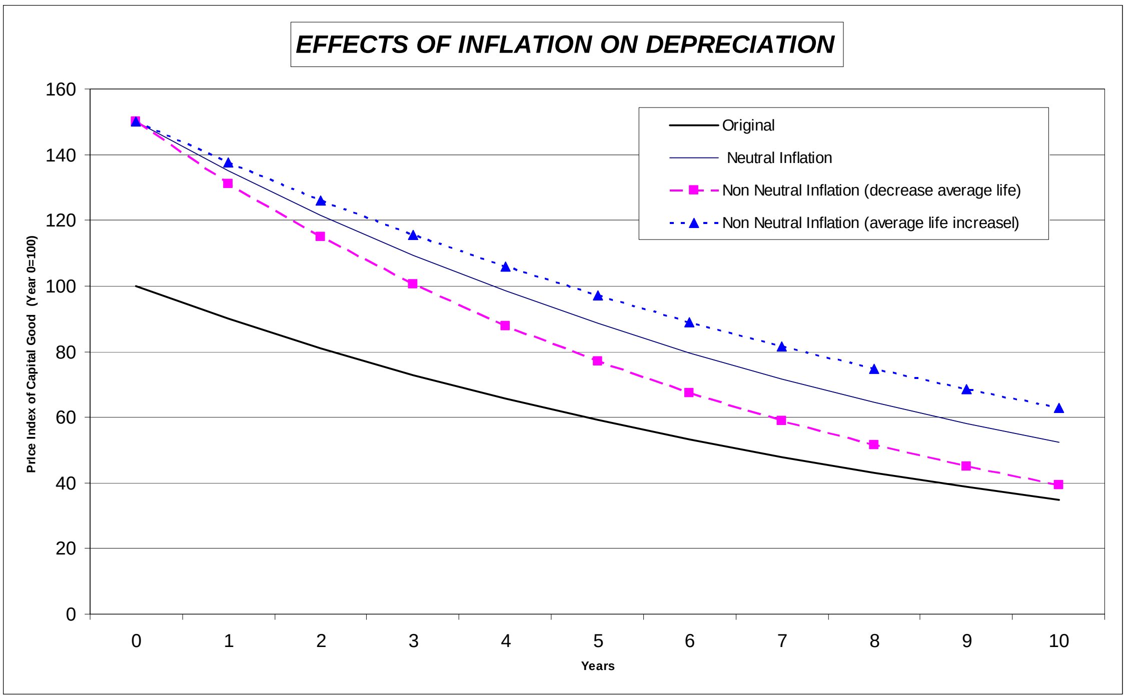
constant in the face of changes in the asset's relative prices due to changes in the overall price index or due to particular changes in the relative demand and supply of the good.

A theoretical neutral inflation process generates an adjustment of the prices of the used goods market cohorts by the same rate as the new model, shifting the depreciation curve to the right without changing its slope. However, if relative price changes at a micro or macroeconomic level are of different magnitude, for instance given an unforeseen inflation shock, these changes could encourage the user to change the goods' lifetime by altering the retirement pattern or the intensity of use, generating a change in the life span of the asset and consequently the depreciation curve's slope.

This issue is relevant when considering the use of standard depreciation methods or the extrapolation of age price profiles estimated for a base or reference year for calculating the durable goods stock (and capital goods stock) by the PIM, which might result in a distortion of the level and change of the stock, as seen in the previous section.

The following graph shows the effect of neutral and non neutral inflation on the age price profile:

Gráfico 2



As can be noted, neutral inflation induces a parallel shift of the curve, in other words, the prices of every vintage change at the same rate. On the other hand, non neutral inflation presents two cases: (i) when the user reacts by reducing the lifetime, the prices' rate of change decreases with age and (ii) when the user augments the lifetime, the prices' rate of change increases with age.

The following table summarizes the previous discussion about the information problems in durable goods market that could distort the measurement on depreciation and value of these types of assets:

TABLE 1 Information Problems in the Used Durable Goods Market		
	Depreciation	**Value**
"Lemons Problem"	+Bias	-Bias
Censored Data	-Bias	+Bias
Alternative Uses	(+ or -) Bias	(+ or -) Bias
Age Price Profile Stability	(+ or -) Bias	(+ or -) Bias

Taking into account these issues regarding market prices data, the following section presents an econometric study of durable goods depreciation through vintage asset prices for the categories with reliable data in Argentina.

4. The Durable Goods Depreciation Curve in Argentina: Econometric Analysis of its Functional Form

The purpose of this section is to present briefly the main econometric results of the functional form test of the depreciation curve. The study was carried out for those durable goods categories whose statistics present reliable data about vintage assets prices for Argentina: airplanes, farm tractors and transport equipment (cars, light commercial vehicles, trucks and buses).

The functional form test of the depreciation curve is done on the basis of statistics of used goods market prices. As pointed out before, its use as a depreciation curve implies the assumption that the age price profile is equivalent and/or correlated with the age efficiency profile[14].

The methodology for the estimation is based in the main antecedent on this topic: Hulten and Wykoff (1981), applying the so called Box Cox test that allows testing a series of functional forms, apart from estimating the optimal functional form according to the test.

4.1 Box-Cox Simple Form Test

The purpose of the Box-Cox test, in its simpler version, is to test the following transformation of the endogenous variable:

$$p^{(\lambda)} = \alpha + \beta_1 a + \varepsilon$$

[14] In order to econometrically estimate the depreciation curve on the basis of the age efficiency profile, it would be necessary to count with statistical samples of productivity and/or physical efficiency data for the goods according to their age (industrial engineering studies).

Where *p*: price; a: age; ε: standard error, being $p^{(\lambda)}$ a non lineal transformation of p of the general family:

$$p^{(\lambda)} = \frac{\left(p^{\lambda} - 1\right)}{\lambda}$$

The test verifies the semilog hypothesis against the reciprocal and lineal functional forms:

Functional Form	λ
(I) Semilog	0
(II) Lineal	1
(III) Reciprocal	-1

When a panel data sample is available (as in the case of transport equipment), the equation to be estimated is the following:

$$p^{(\lambda)} = \alpha + \beta_1 a + \beta_2 t + \varepsilon$$

t: time, indicates the year of the observation

It is important to test whether the optimal functional form is approximately semilog given that it would correspond to a geometric age price profile. This result would allow verifying the hypothesis that the age price profile is not only convex but also exactly geometric; assumption generally used in the empirical literature on durable goods and capital stock estimation by the PIM given that only under this case the depreciation amount is independent of the stock's age structure[15].

The durable goods categories with reliable statistics of market prices of durable goods by vintage in Argentina are:

TABLE 2
Information Sources on the Age Price Profile of Durable Goods

	Sources	**Period of Reference**
Airplanes[16]	Aircraft Bluebook Price Digest	2002
Cars	DGI based on Market Prices	1998-2002
Light commercial vehicles	DGI based on Market Prices	1998-2002
Buses	DGI based on Market Prices	1998-2002
Trucks	DGI based on Market Prices	1998-2002
Farm Tractors	Private Surveys on Market Prices	1997

DGI: Tax Agency board
INDEC: National Statistics Institute

[15] See section 2

[16] This case implies the adoption of the international price methodology. The age price profile is implicitly assumed to be correlated with the characteristics of the models independently of its geographic location (the weak hedonic hypothesis is not validated). See Pakes (2001) and Moch and Triplett (2002).

The following table presents the main results for the simple form:

TABLE 3 Simple Form Box-Cox Test						
	λ	α	β_1	β_2	**Log-likelihood**	**n. obs.**
Airplanes	-0,17	5,34	-0,01		-36935	2.783
Cars	-0,17	-11,45	-0,03	0,01	-222518	20.675
LCV	-0,03	-37,21	-0,10	0,02	-47642 Semilog	4.636
Buses	-0,15	-19,71	-0,04	0,01	-12601	1.148
Trucks	0,39	-1244,31*	-3,88*	0,71	-38351	3.293
Farm Tractors	-0,06*	7,56	-0,03		-6200 semilog	571

Parameters present a significance level, except in the case of*. Tests use cross-section data for airplanes and farm tractors; and panel data for cars, light commercial vehicles, buses and trucks.

In all cases, convex functional forms are detected although the null hypothesis of identification of the proposed functional forms (geometric, reciprocal and lineal) is rejected, except for light commercial vehicles and farm tractors. Only in the latter case, the exact geometric form (λ=0) is accepted.

The following graphs present the average age price profiles for each case.

Gráfico 3

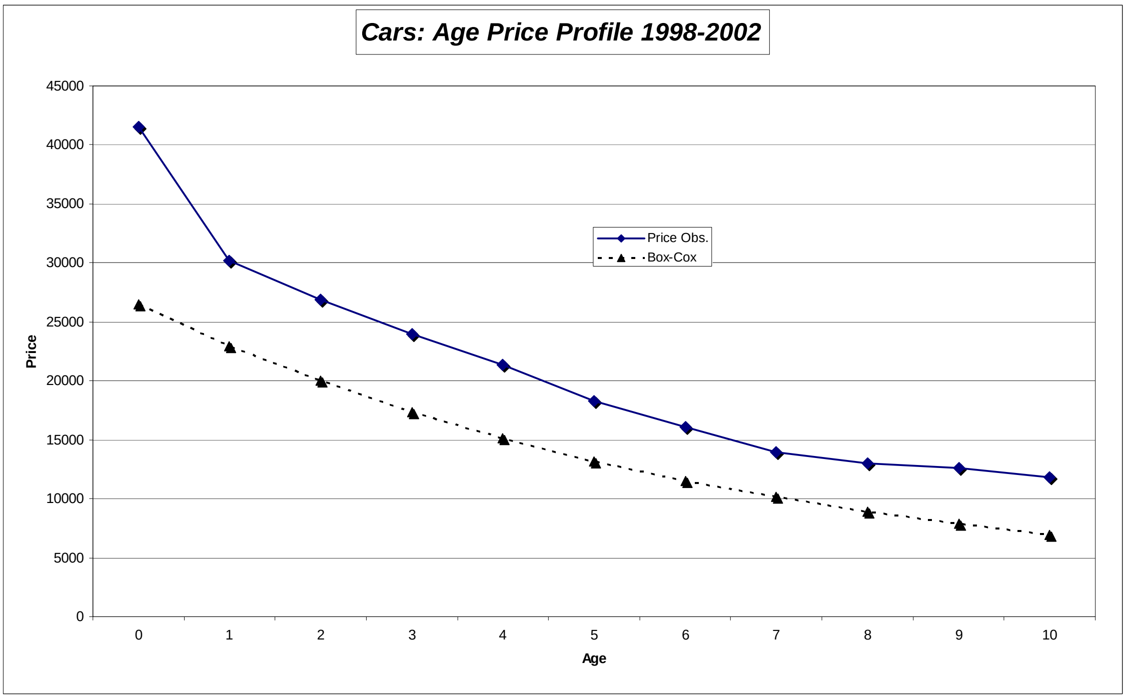


Gráfico 4

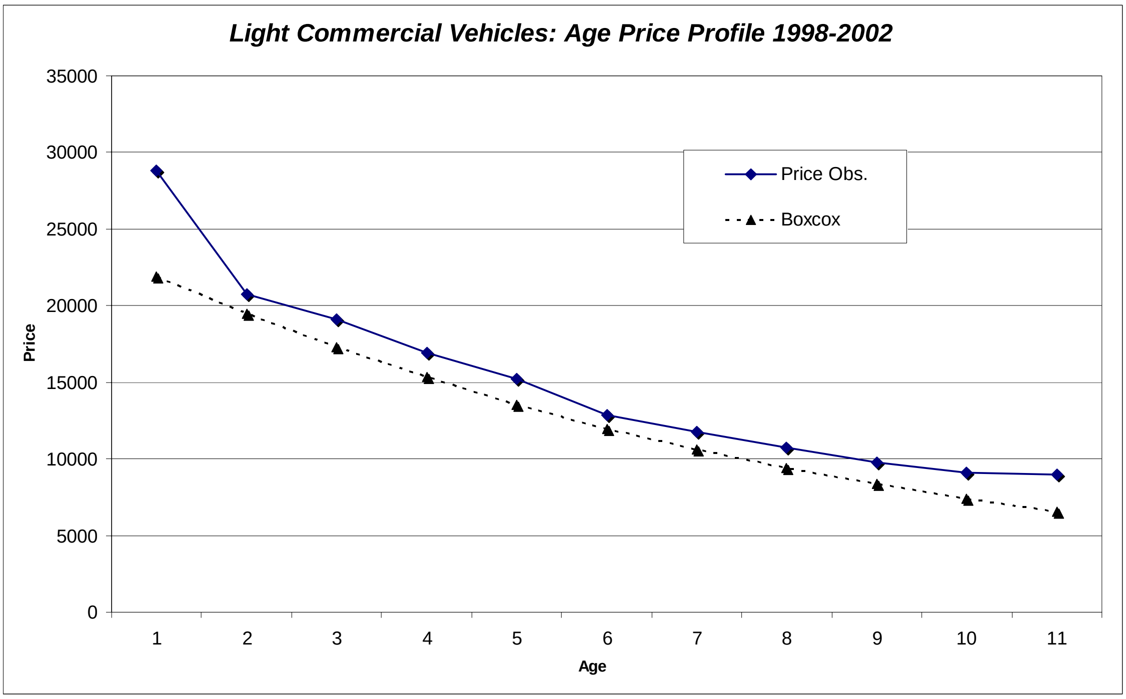


Gráfico 5

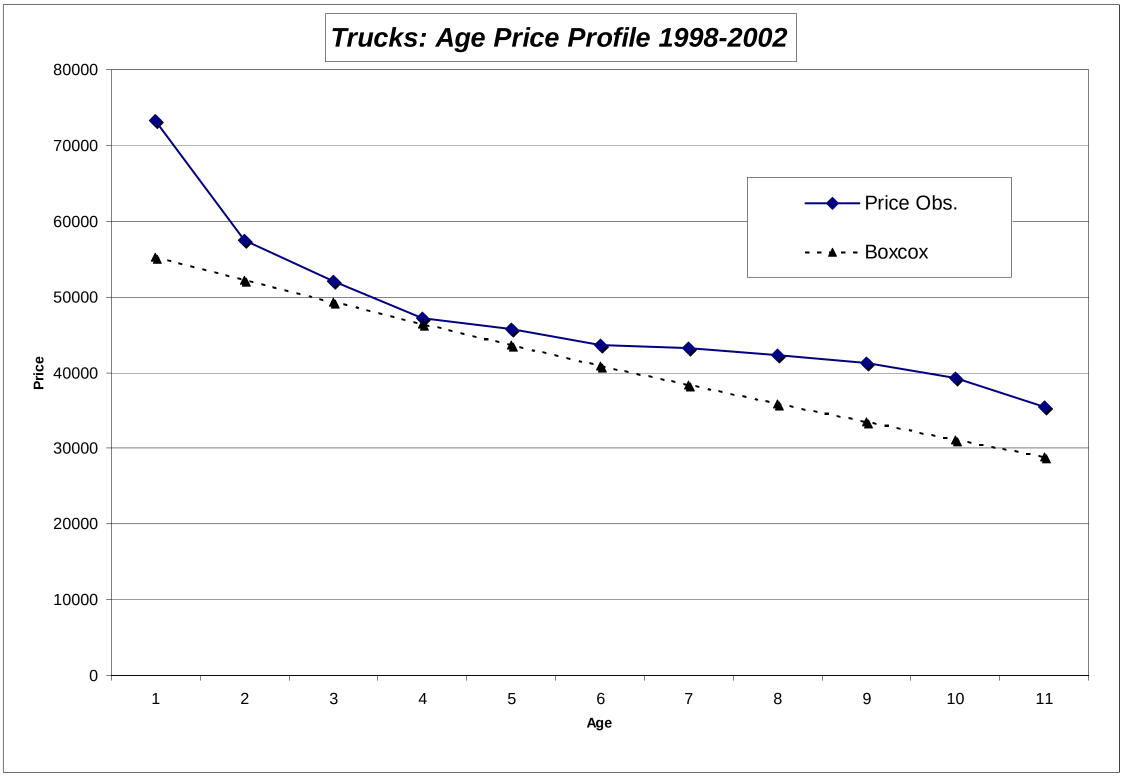


Gráfico 6

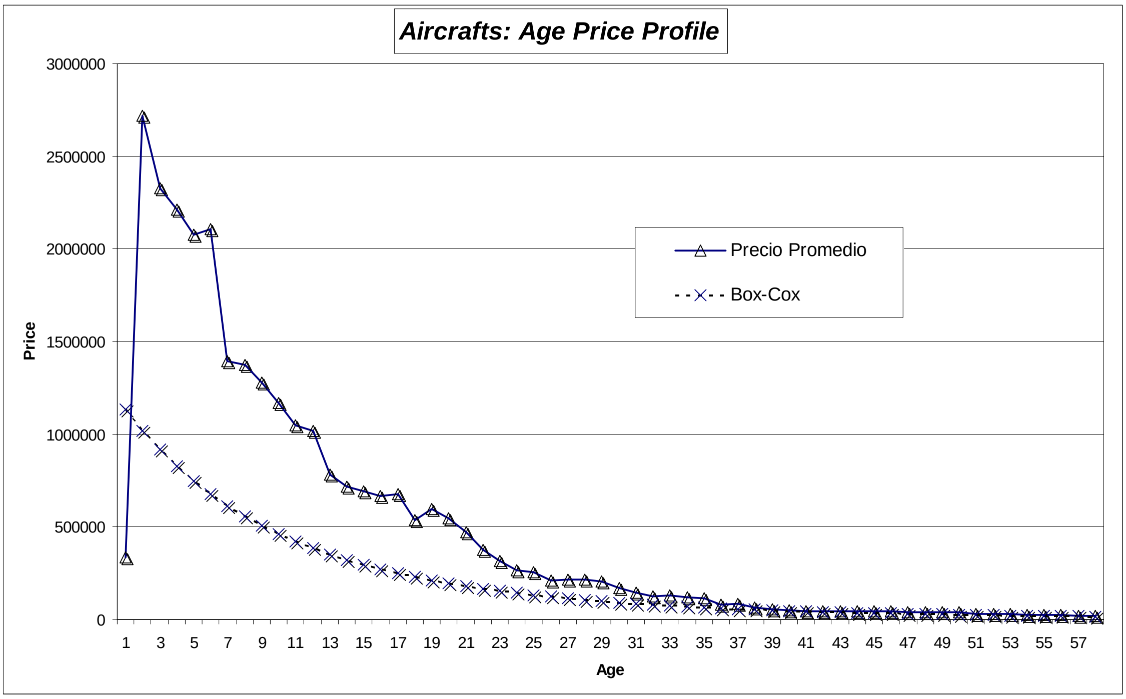
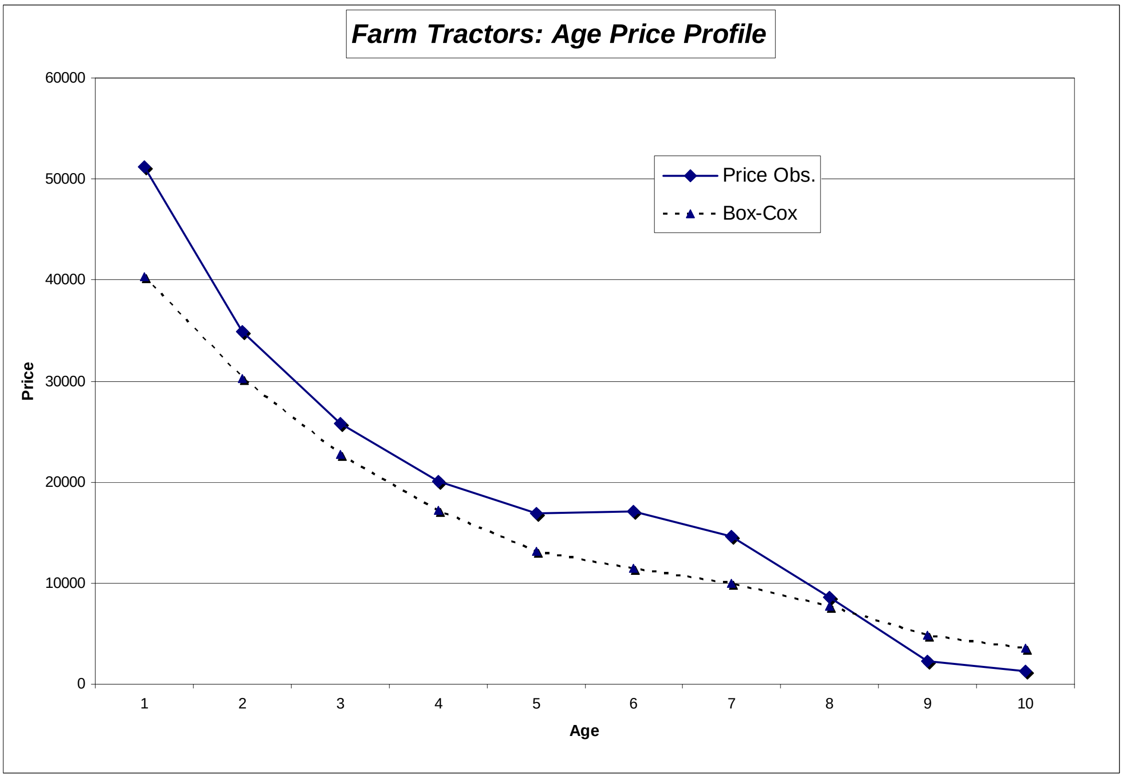


Gráfico 7



4.2 Stability of the Age Price Profile: the case of transport equipment

For transport equipment, previous panel data regressions assume the slope of the depreciation curves do not change over time or, in other words, inflation is neutral with respect to relative prices of used goods. The following graphs show the effect of inflation on the annual age price profile by category of vehicle has not necessarily been neutral:

Gráfico 8

Gráfico 9

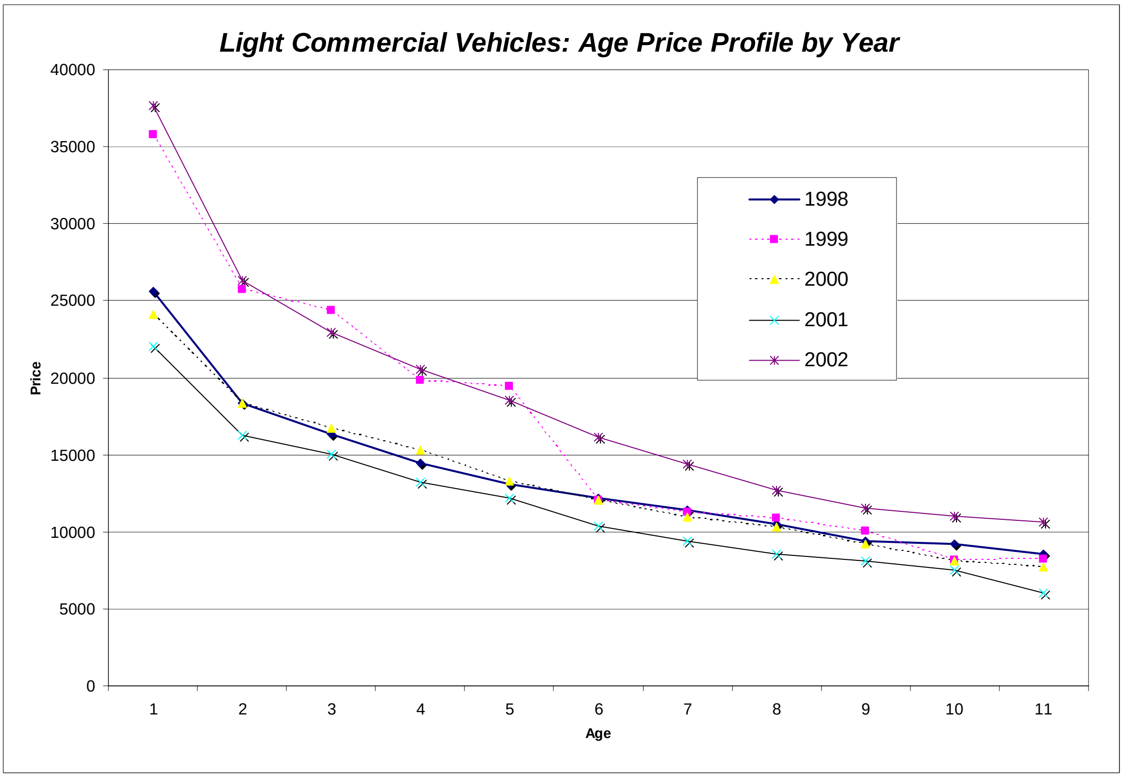


Gráfico 10

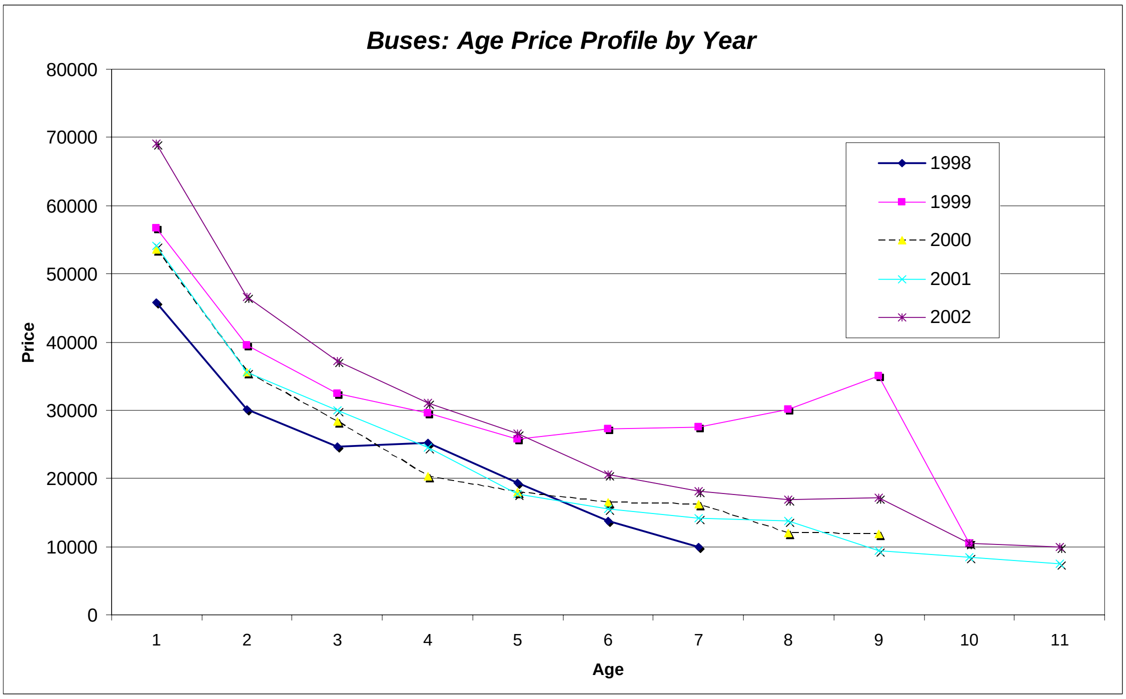
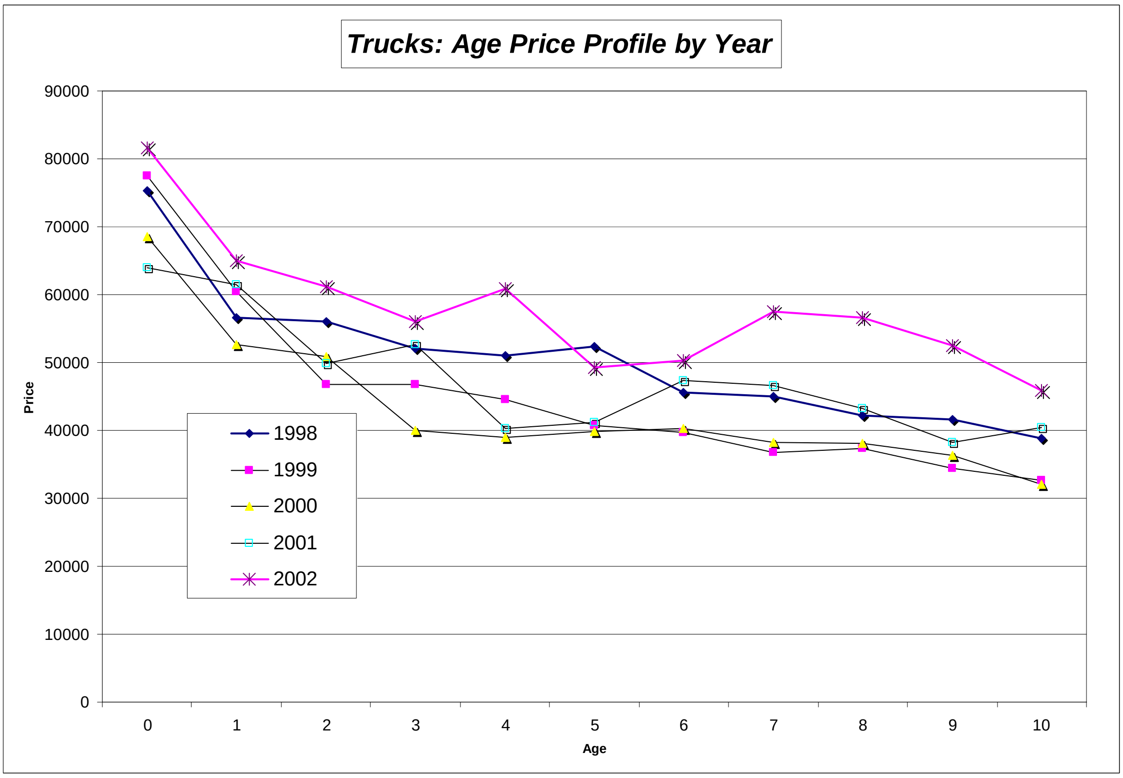


Gráfico 11



The following table also presents the rate of change of prices by age cohort, year and category:

TABLE 4
Price Change by Cohort and Vehicle Category

Cars	1999	2000	2001	2002	LCV	1999	2000	2001	2002
0	-13,7%	13,1%	3,0%	56,6%	0	39,6%	-32,6%	-8,7%	71,2%
1	-8,2%	2,6%	-0,2%	57,7%	1	39,9%	-28,7%	-11,3%	62,0%
2	-2,6%	5,6%	-8,1%	49,8%	2	49,1%	-31,5%	-9,9%	52,4%
3	-1,7%	1,7%	0,6%	43,2%	3	37,5%	-23,0%	-13,3%	55,1%
4	-0,4%	-6,0%	3,4%	60,4%	4	48,7%	-31,7%	-8,3%	51,9%
5	-2,2%	-13,5%	7,4%	60,1%	5	-1,2%	-0,1%	-13,8%	55,2%
6	-3,7%	-21,8%	7,3%	58,4%	6	-1,1%	-2,6%	-14,5%	53,4%
7	-10,4%	-20,7%	-6,5%	58,1%	7	3,4%	-5,4%	-17,2%	49,1%
8	-5,9%	-25,6%	-6,0%	47,9%	8	6,9%	-8,4%	-12,1%	42,6%
9	-2,6%	-25,5%	-5,9%	43,6%	9	-10,8%	-0,9%	-7,5%	46,3%
10	15,4%	-23,1%	3,2%	40,2%	10	-4,1%	-6,6%	-21,7%	76,4%
Buses	1999	2000	2001	2002	Trucks	1999	2000	2001	2002
0	23,9%	-5,6%	1,0%	27,8%	0	3,0%	-11,6%	-6,7%	27,7%
1	30,9%	-9,8%	-0,1%	31,1%	1	6,8%	-12,9%	16,5%	5,9%
2	31,7%	-12,4%	5,7%	24,1%	2	-16,6%	8,9%	-2,1%	22,8%
3	17,5%	-31,3%	20,5%	26,9%	3	-10,0%	-14,5%	31,6%	6,4%
4	33,5%	-30,5%	-1,0%	49,6%	4	-12,7%	-12,5%	3,3%	51,1%
5	97,8%	-39,8%	-5,3%	32,0%	5	-22,4%	-2,0%	3,4%	19,5%
6	175,0%	-41,1%	-12,9%	28,1%	6	-12,8%	1,4%	17,5%	6,4%
7		-60,3%	15,2%	22,6%	7	-18,4%	4,0%	22,2%	23,3%
8		-66,2%	-20,4%	81,8%	8	-11,5%	2,0%	13,3%	31,0%
9		-100,0%		23,6%	9	-17,4%	5,5%	5,6%	37,2%
10				32,9%	10	-15,8%	-2,1%	26,3%	13,5%

Shifts in the depreciation curve generated by inflation would not be neutral with respect to the age price profile. The change in relative prices induced by the 2002 devaluation, and even by the deepening of the recession from the last quarter of 1999 onwards, appears to have altered the age price profile in the analysed markets.

Shifts in the age price profile curve due to inflation were not neutral, according with our previous analyses in section 3.4. Inflation could still have different effects on the age price profile according to which institutional sector use the asset:

1. Consumer Durable Goods: cars & Light C.V.: Life Span Decreases

2. Capital Goods: Buses and Trucks: Average Life Increases

These different effects could belong to different causes. In the case of firms: the effect could compensate the reduction of investment during recession. In the case of households: the increase in the slope of depreciation could be the indirect effect of the increases in sales of old consumer durable assets in the market in order to increase the liquidity preference of households during recession & uncertainty times.

These results have important effects on the value of capital stock estimation, and it seems consistent with economic theory. In the following slide, you could find the main macroeconomic figures of capital stock estimation

But there is another important result of this analysis. Taking into account an exhaustive list of prices of vehicles by model and vintage, inflation capture by this source is very different respect to the official price index from INDEC (National Statistics Institute) which captures the performance of the prices for "representative" models, according to table 5.

Table 5 Price of New Vehicles-annual rate of change (%)-								
	Cars		**LCV.**		**Trucks**		**Buses**	
	DGI	**INDEC**	**DGI**	**INDEC**	**DGI**	**INDEC**	**DGI**	**INDEC**
1999	-1,30	-13,70	-2,30	39,60	0,50	3,00	0,20	23,90
2000	1,90	13,10	0,70	-32,60	0,00	-11,60	19,40	-5,60
2001	-7,00	3,00	-11,00	-8,70	-8,00	-6,70	-4,20	1,00
2002	78,30	56,60	86,10	71,20	64,70	27,70	193,00	27,80

The use of standard price index (with representative models) may not only distort the analysis of the age price profile performance but also the price of new durables goods, biasing the value of capital stock and also the analysis of wealth and productivity of an economy.

A simple representative index would not amply reflect the degree of heterogeneity that exists in the stock or in the sales market (in Argentina, there are more than 7000 models by more than 40 different vintage in the vehicles stock)

In order to update the value of these types of goods, when inflation is non neutral, it would be inappropriate to use fixed base price representative indexes. Even the extrapolation to the whole time series of the age price profile estimated for a base or reference year could biased the measurement of the depreciation and the value of durable goods, given the fact that relative price changes among vintage of the same asset year by year[17].

If the aim were to detect price changes of flows sold in the used goods market or the stock valuation, it would be necessary to build an index that took into account not only the age structure but also the rest of the characteristics of the goods weighted by model. Given the diversity of the models sold or the censored data problem pointed out in section 3.3., it is important to determine a hedonic price index that allows understanding the true price change ceteris paribus changes in quality and/or models.

Taking into account the non neutrality of inflation, it is important to analyse the functional form of the depreciation carrying out a cross section study.

The following table presents the main results:

[17] In Coremberg-INDEC (2004), the National Accounts Office (DNCN) presents capital stock estimation by means of a direct valuation of census data of the stock's most important categories using an exhaustive price list, trying to avoid the price indexes problems and PIM assumptions mentioned throughout this paper.

TABLE 6 Box-Cox Test Simple Form of Cars by Category with Annual Frequency					
Cars	**1998**	**1999**	**2000**	**2001**	**2002**
λ	-0,21	-0,17	-0,05	-0,27	-0,28
β_1	-0,02	-0,03	-0,10	-0,01	-0,01
α	4,14	4,82	8,14	3,42	3,37
Log-likelihood	(33.456.498)	(39.501.799)	(45.261.191)	(49.357.153)	-54690.15
n. obs.	3.098	3.673	4.243	4.682	4.998
LCV	**1998**	**1999**	**2000**	**2001**	**2002**
λ	0,16	-0,30	0,39	0,30	0,07
β_1	-0,58	-0,01	-4,85	-0,20	-0,16
α	25,29	3,21	120,58	62,59	14,69
Log-likelihood	(62.671.616)	(79.786.978)	(97.504.504)	(10.810)	(12.615.189)
n. obs.	623	763	972	1.093	1.197
Buses	**1998**	**1999**	**2000**	**2001**	**2002**
λ	-0,78	0,06*	-0,26	-0,41	-0,13
β_1	0,00	-0,29	-0,01	0,00	-0,05
α	1,29	14,93	3,64	2,40	5,77
Log-likelihood	(135.843) recíproco	(217.627) semilog	(25.888)	(31.478)	(3.260)
n. obs.	127	191	242	293	308
Trucks	**1998**	**1999**	**2000**	**2001**	**2002**
λ	0,31	-4,85	0,27	0,37	0,61
β_1	-1,63	0,00	-1,15	-2,12	-30,24
α	98,99	0,21	65,47	151,05	1475,52
Log-likelihood	-8.059*	-21.887*	-1.225*	-4.576	-5.071
n. obs.	692	743	1065	392	429

Parameters present a significance level, except in the case of*.

In all cases, convex functional forms are detected. In almost every case, the proposed standard functional forms are rejected[18].

As it is shown in the table 6, the rate and functional form of depreciation for every type of vehicle show very different figures for every year. This fact confirms the instability of depreciation for the whole period under analyses.

4.3 Box-Cox Double FormTest

However, the regressions presented assume the exogenous variable functional form is a straight line. A variation of the Box-Cox test allows testing the functional form of the endogenous and of the exogenous variable independently:

$$p^{(\lambda_1)} = \alpha + \beta_1 a^{(\lambda_2)} + \varepsilon$$

[18] Except in the case of buses: reciprocal functional form for the year 1998 and of the semilog form for the year 1999.

Carrying out this analysis allows testing the robustness of the previous test's conclusions.

Results for the cases of airplanes and farm tractors are presented in TABLE 7, while for transport equipment by category, results are displayed with an annual frequency in table 8.

TABLE 7
Box-Cox Test Double Form for Airplanes and Farm Tractors

	λ_1	λ_2	α	β_1	Log-likelihood	n. obs.
Aircraft	-2,58	3,83	0,39	0,00	(31.057)	2.783
Farm Tractors	-0,05	0,87	8,18	-0,05	(6.198)	571

Parameters present a significance level, except in the case of*.

TABLE 8
Double Form Box-Cox Test for Transport Equipment by Category with Annual frequency

Cars	**1998**	**1999**	**2000**	**2001**	**2002**
λ_1	-0,20	-0,16	-2079,05	-0,27	-0,28
λ_2	0,40	0,51	0,02*	0,76	0,80
β_1	-0,05	-0,06	-1317,15	-0,02	-0,01
α	4,40	5,03	9,27	3,49	3,41
Log-likelihood	-33.439	-39.489	-45.689	-49.353	-54.688
n. obs.	3.098	3.673	4.243	4.682	4.998
LCV	**1998**	**1999**	**2000**	**2001**	**2002**
λ_1	0,22	-2,10	0,45	0,34	0,09
λ_2	0,14*	18707,78	0,17*	0,35	0,26
β_1	-3,12	0,00	-27,29	-7,55	-0,89
α	37,39	0,48	204,88	83,71	17,06
Log-likelihood	-6.250	-7.508	-9.729	-10.797	-12.523
n. obs.	623	763	972	1093	1197
Buses	**1998**	**1999**	**2000**	**2001**	**2002**
λ_1	-0,79	0,10	-0,21	-0,37	-0,09*
λ_2	1,13*	-2.156.209*	0,22*	0,66	0,59
β_1	0,00	-395,11	-0,06	-0,01	-0,13
α	1,26	19,74	4,27	2,68	6,92
Log-likelihood	-1358	-2178	-2584	-3146	-3258
n. obs.	127	191	242	293	308
Trucks	**1998**	**1999**	**2000**	**2001**	**2002**
λ_1	0,06*	-2,31	0,53	0,53	0,77
λ_2	-1091,41	775,30	-9,39	19,79	-10,19
β_1	-2143,14	0,00	-8,78E+07	0,00	-5,20E+13
α	15,31	0,43	9351476,00	500,82	5,10E+12
Log-likelihood	-8.083	-8.090	-12.321	-4.461	-4.868
n. obs.	692	743	1065	392	429

Parameters present a significance level, except in the case of*.

In almost every case, convex functional forms were detected, $\lambda_1 < 1$ and $\lambda_2 < 1$; except for the case of light commercial vehicles (1999), buses (1999) and trucks (1999 and 2001) which presented atypical depreciation functional forms similar to the backward S type, accelerated depreciation or in two stages[19]. It is important to mention that in the case of light commercial vehicles, the simple form test with panel data apparently validated the geometric functional form (see table 3)[20], but its test with an annual frequency both under the simple and double form, not only rejected the geometric form but also showed high instability for the depreciation functional form.

The joint analysis of the econometric results weakly confirms the convex functional form hypothesis for the depreciation of the analyzed durable goods categories.

The cross section results would allow asserting the non neutrality of inflation on the depreciation curves of the transport equipment categories in Argentina. In other terms, there seems to be an annual instability of the age price profile according to the changes in the rate and functional form of the depreciation, particularly since the deepening of the economic depression of end 1999 and the devaluation of year 2002[21].

Like every econometric study, these results are preliminary for the following reasons, although intuitively we believe that they would not reject firmly the conclusions described:

i) There has not been any adjustment for censored data problem. However, Hulten and Wykoff (1981) present an adjustment of vintage asset prices profile taking into account their survival probability. The authors find this adjustment neutral with respect to the functional form test[22].

ii) The functional form and the correlation between price and age in the Box-Cox test may be affected not only by the rise of the price level of the analyzed good but also by other exogenous variables; especially other hedonic attributes may be correlated with age. It would be important to enclose the functional form study in a framework of hedonic prices econometric analysis, pinpointing the functional parameter for each variable[23].

iii) This study should be of the panel data and cross section type, carrying out a stability econometric test of the age price profile, isolating the effect of the rest of the exogenous variables.

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[19] Note these functional forms could result from the *lemons problem*, especially in the real estate market, where the buyer does not doubt about the quality of the good just built but uncertainty about its condition or quality increases as time passes. See Hulten and Wykoff (1981) footnote 13

[20] Although the individual significance test of the functional parameter of the endogenous variable indicated it was significantly different from zero.

[21] Hulten and Wykoff (1981) find stable age price profiles for different categories of Real Estate in United States for the 1956-1971 period. This result would correspond to Real Estate with relative prices by cohort that are more stable than durable equipment, a much more stable economy than Argentina and a period of relatively stable prices prior to the oil crisis.

[22] The retirement pattern adopted by the authors for the study of the Real Estate does not belong to the same statistical source of the study. This correction will be included in a forthcoming extension of this paper.

[23] See Hulten (1990), Jorgenson (1999) and Hill (2000) for a discussion and recent literature review regarding the hedonic valuation of capital goods.

5. Conclusions

This study presents a brief analysis of the depreciation of durable goods in an unstable economy: Argentina during 1998-2002 when there was the biggest & longest economic depression of its modern economic history.

The topic is relevant given its importance for valuating durable goods consumed by households and given the effect of this subset of capital good used as means of production by the firms in the analysis of economic wellbeing, productivity performance and wealth of an economy.

A brief summary of the importance of the economic depreciation profile detection for the estimation of the durable goods stock, and particularly capital stock, was carried out. The econometric study of depreciation allows validating empirically the use of assumptions on the depreciation functional form; assumptions needed for the process of estimating the stock by the PIM which are not necessarily correlated with the reality of the firm, sector or country and which generally distort the level and change of the estimated stock.

Given that the estimation of depreciation is based on age price profile data for the durable goods market, the consequences on the depreciation estimation of the distortions that may result from the age market price profile are briefly analyzed: asymmetric information, censored data, alternative uses and annual instability of relative prices among cohorts.

Applying the Hulten and Wykoff (1981) methodology for Argentina, the econometric analysis seems to confirm, although weakly, the hypothesis of convex functional form of depreciation in Argentina for the analyzed durable goods categories.

The geometric form is very important in economic analyses because only in that case the depreciation is exogenous (independent of the age structure of the stock), an attractive and necessary property for measuring the value of durable stock by the PIM method.

But the econometric test in its simple form only verifies an exact geometric shape in the case of farm tractors (1997) and buses (1999), although any exact functional form has been detected with the Box-Cox test double form.

Besides, we found a relative instability of the age price profile for the transport equipment. This fact would not allow extrapolating a stable functional form for the whole stock series in case of using these results in the estimations of the durable goods stock by the PIM method.

The lack of a geometric form for almost every case and the instability of the age profile in Argentina emphasize the importance of the valuation of the durable goods stock taking into account the change on the age structure and its age price profile with annual frequency, in order to avoid assigning depreciation curves not empirically verified and/or extrapolating the age price profile of a reference year to the whole series assuming its stability.

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