Housing Depreciation in the Canadian CPI

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Preface

Prices Division first started publishing the Analytical Series in December 1996 as a means to convey conceptual and applied research undertaken by its staff, and at times, by other persons from within or outside Statistics Canada on the subject of price indexes.

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The purpose of the series is to disseminate knowledge and stimulate discussion. Questions and comments on any aspect of the papers are welcome and can be forwarded to Louis Marc Ducharme, Director (Email: louismarc.ducharme@statcan.ca; Telephone: 613-951-0688) or to Robin Lowe, Chief, Quality Assurance (Email: robin.lowe@statcan.ca; Telephone: 613-951-9495), Prices Division, Statistics Canada, Ottawa, Ontario, K1A 0T6.

Abstract

The Canadian Consumer Price Index (CPI) applies a version of the user cost approach to measure the cost of home ownership. Because this approach specifically estimates the costs of using owned accommodation and not those faced by tenants, the measure includes a "replacement cost" (or depreciation) component. Depreciation is the only component in the CPI that is not an out-of-pocket expense. Consequently, economists face a unique set of methodological challenges when measuring depreciation.

Between 1949 and 1997, the annual housing depreciation rate used in the CPI was 2%. Statistics Canada adopted the rate from a study that analysed U.S. Federal Housing Administration field appraisal data from 1939.

This study argues that there is evidence that the 2% depreciation rate is too high to continue to use in the future. Consider that:

1) other Canadian studies show an upper bound of 1.7%, with a median estimate of 1.5%;

2) other statistical agencies use lower rates; and

3) every academic study over the past 40 years has arrived at a lower rate.

As a consequence of this study and the existing supporting evidence, the depreciation rate in the Canadian CPI was lowered to 1.5% effective January 1998.

Table of Contents

1.0 Introduction[1]

The *stock of housing* and the *flow of housing services* are two distinct concepts.[2] The combination of land, labour and residential building materials produces a house—an investment good. Collectively, houses make up the stock of housing. The overhead associated with owning and living in a house forms the consumer commodity "housing services". The cost of consuming housing services is reflected in the Consumer Price Index (CPI). More specifically, the CPI for Owned Accommodation contains six basic components that together define a *user cost approach* to measuring the changes in housing costs (see Table 1).[3] The replacement cost index measures the portion of the housing stock that is consumed, or used up, during a given period. In other words, the replacement cost index measures what is more commonly known as depreciation.

TABLE 1

Owned accommodation index,
1996 CPI basket shares at December 1997 prices

Components		Share in the owned accommodation index %	Share in the CPI %
1	Mortgage interest cost	33	4.9
2	Replacement cost (i.e. "net depreciation")	18	2.7
3	Property taxes	24	3.5
4	Homeowners' insurance premiums	7	1.1
5	Homeowners' maintenance and repairs	11	1.7
6	Other owned accommodation expenses (commissions, legal fees, etc.)	7	1.1
	TOTAL	100	15.0

[1] *This study greatly benefited from previous research and discussions with Marc Prud'Homme and Andy Baldwin, both of Prices Division at Statistics Canada.*

[2] *For the purpose of this study, "housing" will refer to owner-occupied housing.*

[3] *See Prud'Homme (1995).*

The CPI measures changes in the cost of purchasing a *fixed basket* of consumer goods and services over time. Each year, Statistics Canada carries out the Survey of Household Spending (formerly called the Family Expenditure Survey) to update the expenditure weights for many commodities in the basket. One exception is the housing depreciation rate used for measuring the replacement cost index. Because depreciation is not an out-of-pocket expense, its share in the basket must be imputed. The imputation procedure is described below.

THE METHODOLOGY

The replacement cost incurred by homeowners is derived using the following data:

❶ *Average price of residential properties*: These data are obtained from the Survey of Household Spending, and are based on the homeowners' own appraisals at the end of the survey year.

❷ *Average price of residential houses (exclusive of land)*: To obtain this value, multiply ❶ by the "house-to-property ratio" available from Statistics Canada.

❸ *Replacement cost*: Multiply ❷ by the depreciation rate of 2%.

❹ *Replacement cost at Canada level*: The national replacement cost index is a weighted aggregate of individual area indexes. The weights reflect relative shares of the total value of the national owner-occupied housing stock, which is compiled from the Survey of Household Spending.

❺ *The replacement cost index*: This index is updated every month by applying the movements of the New Housing Price Index (NHPI) exclusive of land.

Example

Replacement cost across all households for September 1996 =

$$\left[(\text{Property Value})_{1992} \times \left(\frac{\text{House Value}}{\text{Property Value}}\right) \times (2\%\ \text{Depreciation Rate})\right] \times \text{NHPI Houses Only}\left(\frac{\text{September 1996}}{1992}\right)$$

2.0 Sources of housing depreciation

Statistics Canada defines housing depreciation as "the hypothetical amount of money that would be necessary to replace the used-up portion of the stock of dwellings owned and occupied by the target population at the end of a year".[4] It is useful to distinguish among three sources of depreciation:

[4] *See Statistics Canada (1995).*

1) *Physical depreciation* occurs due to corrosion, and the normal wear and tear that results from use. Some types of physical depreciation are reversible, while others are not. Reversible depreciation covers items that homeowners periodically replace or repair, for instance roof shingles and mechanical equipment such as a gas furnace. By contrast, long-lived items that usually last the lifetime of the house depreciate more slowly. Floor structures, foundations, and exterior walls fall into this category.

2) *Functional depreciation* (sometimes called *obsolescence*) occurs when older houses become relatively less desirable, simply because they do not incorporate recent construction methods, standards, and materials. Examples are houses with antiquated electrical wiring and old-fashioned floor plans.

3) *External depreciation* occurs as a result of natural disasters.

For the replacement cost component, only physical and functional depreciation should be included (sometimes called *micro-depreciation*). While external depreciation is a potential user cost, the CPI includes insurance premiums to cover such disasters as a separate commodity (see Table 1). By contrast, a measure of depreciation that is meant to adjust Gross Capital Stock in the National Accounts to derive Net Capital Stock estimates should consist of the total of physical, functional and external depreciation (sometimes called *macro-depreciation*).

Economic theory states that the price of a house is equal to the present value of the flow of net housing services it provides. Since the price of a house obviously reflects the state of its upkeep, it follows that economic depreciation is equivalent to net depreciation. By definition,

Net Depreciation = Gross Depreciation – Repair & Maintenance Expenditures

where gross depreciation is equal to the portion of the house that the owner consumed. Net depreciation refers to the portion of gross consumption that owners did not replace through repair and maintenance. In every period,

$$\textit{Net Depreciation}_t = \textit{Value of House}_{t-1} - \textit{Value of House}_t$$[5]

In contrast, total cumulative depreciation is the difference between the reproduction cost of a structure and its market value.

[5] *This formula is valid if the purchasing power of a dollar remains constant over time. In the case of general price inflation, the "purchase price" must first be inflated by a measure such as the "New Housing Price Index – Houses Only". Chinloy (1980, pp. 87–92) presents a formal model of the time path of net depreciation of a house.*

Apart from irreversible depreciation, the state of maintenance of a house depends on the owners' choice of care. The depreciation rate should reflect the actual level of care that homeowners apply, and should not simply be a theoretical maximum.

3.0 Origin of the 2% housing depreciation rate

Statistics Canada has used a declining-balance depreciation method in the Consumer Price Index and the System of National Accounts (SNA) at an annual rate of 2% for 40 years. According to *The Consumer Price Index Reference Paper* (Catalogue No. 62-553, p. 55), the rate is consistent with the System of National Accounts, which has used it to calculate Net Residential Capital Formation.[6] The reason why the CPI and the SNA adopted the same rate remains unclear. Since the SNA includes rental accommodation, which depreciates faster, it should assume a higher rate.

A 1968 report, entitled "Estimates of Residential Capital Stock and Flows", documents the origin of the deflator. It explains that Statistics Canada adopted the rate from Grebler *et al*. (1956), who analysed U.S. Federal Housing Administration (FHA) field appraisal data from 1939. Using a sample of 1500 owner-occupied single family houses, on average 20 years old, the authors estimated an average depreciation rate for a number of dwelling vintages (see Table 2).

TABLE 2

U.S. Federal Housing Administration (FHA) appraisal data, September–December 1939

Year built	Avg. age in years	FHA property valuation $	FHA house valuation $	Replacement cost in 1939 $	Ratio of current value to replacement cost %	Average annual decline in value %
1938	1	5851	4703	4935	95.3	4.7
1937	2	5543	4505	4766	94.5	2.7
1936	3	6440	4989	5640	88.5	4.0
1935	4	6452	5089	6187	82.3	4.8
1930–1934	7	5518	4368	5506	79.3	3.3
1925–1929	12	5024	3864	5321	72.6	2.6
1920–1924	17	4846	3596	5492	65.5	2.5
1915–1919	22	4608	3427	5992	57.2	2.5
1910–1914	27	4698	3393	6002	56.5	2.1
1900–1909	34	4212	3127	5978	52.3	1.9
< 1900	52	4033	2788	7766	35.9	2.0

[6] *In statistical practice, macro-depreciation equals micro-depreciation plus the value of housing demolitions.*

The second last column in Table 2 suggests that depreciation followed an approximate declining-balance profile. Houses lost an average of 18% of their initial value over the first four years of their construction. Depreciation slowed sharply after that period. The authors of the FHA study did not explicitly show or explain how they arrived at a constant 2% depreciation rate, or why they chose it, but the rate does correspond well to a housing stock that is on average more than 27 years old. The modern housing stock is on average 28–29 years old, which would validate a depreciation rate of 2% using this study.[7]

The study was seminal for its time, and applying the results to the Canadian CPI certainly made sense. The most important limitation of the study today is its age. Obviously, the composition of the current Canadian housing stock is different from that of the United States in 1939. Construction machinery and equipment, building materials, weatherproofing techniques, roofing materials and heating systems have all changed. Consequently, Statistics Canada reviewed the depreciation formula in 1996.

4.0 Modern approaches to depreciation analysis

Applying housing data to simple depreciation methodology such as “straight-line” and “declining-balance” may be adequate for estimating the depreciation profile of a group of houses with similar construction and vintage. These traditional methods are reviewed in Appendix II. They are not reliable, however, for an aggregate of houses that are heterogeneous in terms of characteristics and construction date. For example, *vintage effects* are an important factor. If older houses were of inferior quality to today’s houses, they would depreciate faster, independent of other effects. The modern way to control the complexities of a heterogeneous housing stock is to apply “hedonic methods”. Hedonic methods have been specifically designed to estimate depreciation rates and pure price changes for heterogeneous durable goods such as houses and vehicles.

To begin, consider that a house is the sum of its physical parts such as the building materials used, the method of heating, and the type of floor covering. Similarly, the value of a house is the sum of the value of its “basic attributes” such as the size, age, type of roofing, and so on. These assertions have some weaknesses. For example, a house with a popular floor plan will sell at a premium compared to one that has a less desirable layout. Limitations aside, applying the hedonic approach to housing goes a long way in managing the heterogeneity problem. In practice, the task is to: a) identify the basic attributes; b) specify the regression equation that relates the price of houses to the basic attributes; and c) estimate the parameters. Frequently, the regression is specified in a semi-logarithmic form; that is the effect of each basic attribute on the house value is expressed as a percentage mark-up rather than in dollar terms. Thus, the presence of a sunroom will have a greater impact on the price of an expensive house than on one of lower

[7] *The average age of the Canadian housing stock can be calculated from Statistics Canada’s* ***Homeowner Repair and Renovation Expenditure****, Catalogue No. 62-201-XPB, and from census data. As a note, the median age of Canadian houses is 20 years. However, the median is not the appropriate measure here because the median is insensitive to how data are distributed around it. Of course, if depreciation were straight-line or truly “constant” declining-balance, then the age of the housing stock would not matter.*

value. This is a reasonable assumption because the more expensive house is expected to have a larger, more expensive sunroom.

The interpretation of hedonic regressions is as follows. Assume that a sample includes a house constructed in 1981 and another in 1982. The price of the two houses differs because a) the 1981 house is one year older than the 1982 house, and b) the 1982 house may have different attributes. Since hedonic regressions statistically control differences in basic attributes, the coefficient corresponding to "age of the house" will give the implied premium of a 1982 house over a 1981 house.[8] The rate of change of observed house prices with respect to age is interpreted as the net depreciation rate.[9] Most modern estimates are based on hedonic methods.

5.0 Review of academic studies on housing depreciation

There is a body of literature spanning five decades that specifically addresses the question of housing depreciation. Table 3 summarizes the most important ones. Many of these studies were reviewed by S. Malpezzi, *et al* (1987).[10]

TABLE 3

Summary of selected housing depreciation studies

Study	Model	Data	Dependant variable	Results
Wenzlick (1953)	$d = \frac{2}{(\text{avg. life})}$	Survey of the average life of houses in St. Louis	Average life	2.2%
Grebler, Blank and Winnik (1956)	Declining-balance	FHA data, 1939	Selling price	2%
Kain and Quigley (1970)	Hedonic	Household survey, St. Louis, 1967	Monthly rent; house value	Renters: 0.4% Owners: 0.7%
Weston (1972)	Declining-balance	--	--	Owners: 1.6%
Couillard (1977)	Census benchmarks	Canadian census data (1941, 1961, 1971)	--	1.3% – 1.7%

[8] *This variable can also be interpreted as measuring a vintage effect. The two interpretations are observationally equivalent.*

[9] *For an introduction to the mathematical development of hedonic depreciation rates, refer to Zvi Griliches, "Introduction: Hedonic Price Indexes Revisited", p. 9, 1971.*

[10] *Another unsurprising result is that tenant-occupied homes depreciate faster. Tenants face different incentives than owner-occupants with respect to care for property.*

Follain and Malpezzi (1979)	Hedonic (double-log)	Annual housing survey, 39 SMSAs, 1974–1976	Gross rents; house value	Renters: 0.8% Owners: 0.6% (of 10 yr. old houses)
Chinloy (1979, 1980)	Hedonic (semi-log)	Survey of housing units, 2 Canadian cities in Ontario, 1974	Expected selling price	London: 0.7% – 0.9% St. Catharines: 1% – 1.2%
Leigh (1979, 1980)	Stock adjustment model	Annual macro data from census and other sources, 1950–1970	Derived from housing starts and capital stock estimates	Renters: 1.3% Owners: 0.6% Both: 1%
Cannaday and Sunderman (1986)	Hedonic (semi-log)	Single family home sales, Champaign (Illinois), 1976–1984	House value	0.4% for new houses, 0.75% for dwellings 44 yrs. and older
Malpezzi, Ozanne and Thibodeau (1987)	Hedonic (semi-log)	Annual housing survey, 59 SMSAs, 1976–1978	House value	0.3% – 0.9% (varies with age of house)
Randolph (1988)	Hedonic (semi-log)	CPI rent survey and housing census data	Contract rent	0.3% – 0.4%
Shilling, Sirmans and Dombrow (1991)	Hedonic (double-log)	Real estate transactions in Louisiana	House value	Varies: 1.2% – 1.9% for owner-occupied and 1.65% – 3.5% for tenants
Marshall & Swift (1995)	Effective age method	Canadian and U.S. appraisal data	Confirmed selling price	Varies with age of house from 0.25% – 2%

Except for the research done by Couillard (1977) and Chinloy (1979, 1980), the studies use U.S. data. It is unclear how applicable U.S.-based studies are to Canada. Characteristics of the U.S. and Canadian housing stocks differ in some ways. Although approximately one third of the U.S. population lives in a similar climatic zone as Canada's, many live in climates where houses do not need to withstand the wear and tear caused by freeze and thaw cycles. Furthermore, the housing stock in the Southern United States is of much lighter construction, and bungalows are common.[11] Bungalows depreciate faster as they allow for very light construction and the roof, which depreciates faster than the rest of a dwelling, is more important to the value of a bungalow than it is to other types of houses. For our purposes, it is best to rely on studies using Canadian data.

[11] *In many instances, "lighter" construction does not imply "less sturdy" construction, but a movement along the learning curve towards efficient construction, or the application of new technology.*

5.1 Couillard (1977) ➤ 1.5% – 1.7%

Couillard estimated a depreciation profile for the Canadian housing stock by using census "benchmark estimates" for 1941, 1961 and 1971. The benchmarks reflected the market value of properties and had to be lowered to exclude the land value. The author estimated the land values for 1941, while information from the National Housing Administration (NHA) provided the basis to calculate the 1971 land ratios. The author adjusted the land ratios from the NHA for the following reasons: a) the NHA only finances new houses, therefore, land ratios will be higher on existing properties due to accumulated depreciation; b) older properties tend to be closer to the urban core where land is more valuable; and c) houses financed under the NHA Act tend to be less expensive than average. Therefore, the use of NHA information tended to underestimate the ratio for the first two reasons and overestimate it for the third. Couillard's analysis suggested that the net effect would be to underestimate the ratio. He calculated the final depreciation estimates using NHA lower bound and upper bound land ratios of 17% and 36% in 1961, and 21% and 38% in 1971.

The estimated depreciation range was 1.5% to 1.7%, with the true rate more likely at the lower end. The narrow band suggests that the depreciation rate may not be very sensitive to changes in land ratios.

The conclusion of the study is weakened by a methodology that ignored vintage effects. Older and newer houses are not perfect substitutes. For one, older houses tended to be larger. Although a modern design could compensate for the difference in size, the true depreciation rate could be slightly below 1.5%.

5.2 Chinloy (1980) ➤ 1.4% – 1.5%

Using the 1974 Survey of Housing Units conducted by Statistics Canada and the Central Mortgage and Housing Corporation (now the Canada Mortgage and Housing Corporation), Chinloy estimated depreciation rates for about 1200 properties each in the St. Catharines and London areas.[12] Although the data rejected an identical net depreciation rate, Chinloy concluded that differences between the two cities were not substantial. On this basis, he estimated the depreciation rate for property values (house plus land) to be 0.96%.

One way to arrive at a rate excluding land is to adjust Chinloy's estimate by applying a land-property ratio for new houses. Using data from the New Housing Price Index, the mean land-property ratio during 1975 was about 29% in St. Catharines and London. Using this ratio, the depreciation for houses becomes 1.35%.

[12] *See Chinloy (1980).*

NHPI data, though representative of the average property value of new housing constructions, tend to underestimate the land ratio of existing properties for the same three reasons cited in 5.1. A somewhat arbitrary upward adjustment of the land ratio from 29% to 36% would raise the depreciation rate to 1.5%.

5.3 Marshall & Swift depreciation tables

Marshall & Swift is a property appraisal company that developed replacement cost and depreciation tables for residential and industrial structures.[13] Using a sample that includes Canadian data, Marshall & Swift's estimates show that depreciation is low during a structure's early life, accelerates thereafter, and stabilizes in later years. For a house of average age (28-29 years) with a life expectancy of at least 70 years at the time of construction, the annual depreciation rate is 0.7%. The depreciation cycle has some support in the selected literature. For example, S. Malpezzi *et al*. (1987) found depreciation rates equal to 0.9% in the first year, declining to 0.45% after ten years, and to 0.28% after twenty years. After twenty years, the house is past its "prime" and the depreciation rate accelerates to 0.6% annually by the time the house is 30 years old.[14]

Statistics Canada does not know the characteristics of the sample or the statistical procedures used by Marshall & Swift to derive their estimates.

6.0 Depreciation estimates of other statistical agencies

The method used in the treatment of home ownership costs varies among statistical agencies. Conceptual ambiguities and formidable measurement issues explain these diverse treatments. A number of statistical agencies exclude the price of owner-occupied accommodation from the consumer price index altogether. Countries that use a *cash outlay approach* differ from those that employ a user cost approach only in their exclusion of the imputed replacement cost component.

[13] *The Canada Mortgage and Housing Corporation has provided the Marshall & Swift depreciation tables as a courtesy. However, the Marshall Valuation Service is copyrighted. For a more elaborate use of the data base, contact Marshall Valuation Service, 911 Wilshire Boulevard, 16th floor, Los Angeles CA 90017–3409, Fax: (213) 683-9010.*

[14] *Malpezzi et al. (1987), p. 382. Other studies exist that find non-constant depreciation rates. Depending on the age of the house, Diewert's 1974 study finds gross depreciation rates ranging between 1% and 2%.*

TABLE 4

Treatment of owned accommodation in various CPIs[15]

Concept	Description	Justification/Advantages	Selected countries[a]
1. User cost	Measures changes in the cost of owning and using a given dwelling stock. Includes actual and imputed costs.	This is a robust measure that brings the CPI closer in line with a cost-of-living index.	Canada, United Kingdom, Sweden, Finland, South Africa
2. User cost: rental equivalence version	Estimates equivalent market rents for homeowners.	This measure is consistent with the treatment of owner-occupied housing in the System of National Accounts.	Germany, The Netherlands, Denmark, Spain, Portugal, Japan, Switzerland, United States (since 1983)
3. Money outlay	Measures cash outlays related to home ownership.	Reflects only actual costs, not imputed ones.	Australia, Belgium, Iceland, Norway, Ireland, New Zealand
4. Net purchase	Measures changes in market prices for houses (with or without mortgage cost).	This measure is most suitable for monitoring the current rate of inflation.	New Zealand[b], United States (prior to 1983)
5. Excludes owned accommodation from the CPI		Houses are considered an investment rather than a consumer good.	Austria, France[c], Greece, Italy, Luxembourg

[a] Based on *Main Economic Indicators: Consumer Price Indices, Sources and Methods*, OECD, Paris, 1994, and *Statistical Sources and Methods, Volume 1: Consumer Price Indices*, ILO, 2nd ed., Geneva, 1987.

[b] The mortgage interest component of the New Zealand index is calculated in a way that is more compatible with a money outlay or user cost approach than with a net purchase approach.

[c] France provides an equivalent rent estimate for international comparisons.

Canada, the United Kingdom, Sweden, Finland and South Africa all use the same methodology in the treatment of owned accommodation in their CPIs. Some details are provided below for the U.K., Sweden and Finland. The depreciation rate currently used in South Africa was unavailable in the OECD documentation.

[15] *See Prud'Homme (1995).*

6.1 United Kingdom ➤ 1.4%

The U.K. Retail Price Index has included housing depreciation since 1995. Using hedonics, the straight-line depreciation rate was estimated at 1.4%. Statistics Canada is not privy to the manner in which the Central Statistical Office (CSO) applies straight-line depreciation in its calculations.

6.2 Sweden ➤ 1.4%

Statistics Sweden has been using a depreciation rate of 1.4% since the mid-1980s.

6.3 Finland ➤ 2.0% – 2.5%

Many years ago, a Finnish engineering company estimated a 2.0% depreciation rate for brick structures and a 2.5% rate for structures with wooden frames. Correspondence revealed that the statistical agency will soon review the rates.

7.0 Summary findings and recommendations

1) Reputable estimates for the annual depreciation rate range from less than 1% to almost 2%. These differing findings are due to the specific models and the data employed, tenure status, and the conditions of the real estate market.

2) Evidence suggesting that a depreciation rate of 2% is too high is: a) Statistics Canada's internal study has estimated a lower rate; b) other statistical agencies are using lower rates; and c) every academic study over the past 40 years has arrived at a lower rate.

3) Studies using Canadian data have narrowed the range of plausible estimates considerably. The results from Statistics Canada's study (1.5% – 1.6%) and those implied in Chinloy's work (1.4% – 1.5%) are very similar. It is this author's belief that the true depreciation rate lies between 1.4% and 1.6%, which is supported by the British and Swedish estimates (1.4%). Any estimate between 1.4% and 1.6% is reasonable. Unfortunately, there is not enough information to narrow the band of estimates further.

4) To settle the question of the true depreciation rate, Statistics Canada would need to collect a large sample of house appraisal values and data on physical characteristics. This survey is currently not planned.

Given the present set of constraints and circumstances, a median estimate between 1.4% and 1.6% is the best estimator. Therefore, it is this author's recommendation that a net depreciation rate of 1.5% be adopted in Statistics Canada's CPI programs. Further, the average age of the housing stock should be reviewed periodically as the depreciation rate is sensitive to it.

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Appendix I

Impact of a lower depreciation rate on the CPI

Statistics Canada undertook a sensitivity study to estimate the extent to which a revised depreciation rate would affect the owned accommodation index and the All-items CPI.[16] The simulation (using data from January 1992 – June 1995) compares the results of the current 2% rate with those of a 1.5% rate.

CHART 1
Impact of a lower depreciation rate on the owned accommodation index for Canada

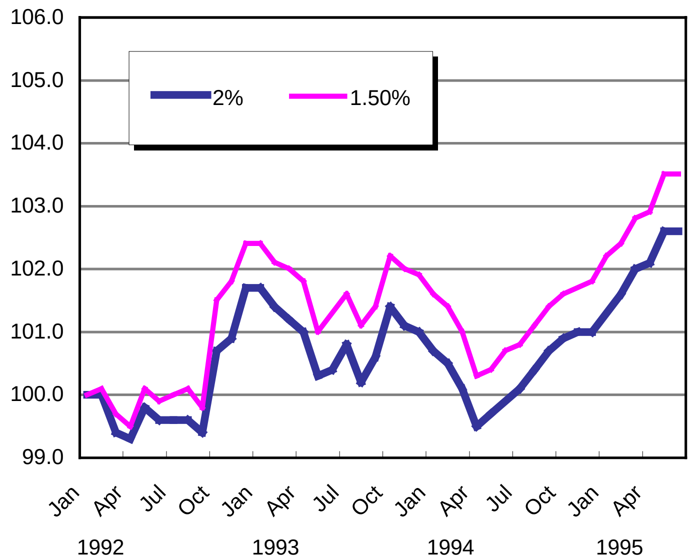


CHART 2
Impact of a lower depreciation rate on the All-items CPI for Canada

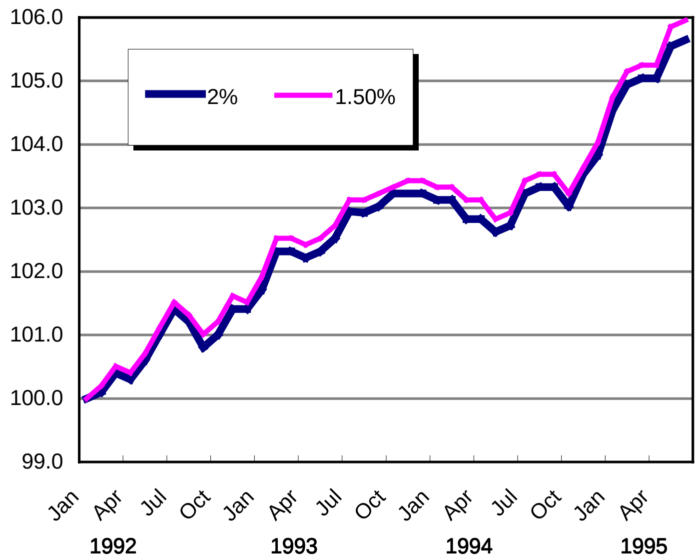


Chart 1 shows that lowering the depreciation rate from 2% to 1.5% raises the rate of increase for the owned accommodation index from 2.6% to 3.1% over the 42-month period. On the other hand, the impact of the lower depreciation rate on the All-items CPI would be smaller, raising the index movement from 5.6% to 5.8%.

Despite appearances, a lower depreciation rate would not systematically raise or lower the indexes. The replacement cost index of the CPI is roughly equal to the New Housing Price Index (Houses Only) with a one-month lag, and its share in the CPI basket depends on the depreciation rate. During the sample period, the NHPI increased at a slower rate than the owned accommodation CPI components. Therefore, if the depreciation rate were lowered, the All-items index would rise more rapidly. If the NHPI had increased at a faster rate than the CPI components (as it did during the late 1980s), then, a lower depreciation rate would cause the CPI to rise less rapidly.

[16] *The sensitivity study was conducted by Marc Prud'Homme of Prices Division at Statistics Canada.*

Appendix II

Classic depreciation methods

Land, in contrast to buildings, does not depreciate. Consequently, property values have to be split into "house" and "land" components in order to compute depreciation. Furthermore, all methods of depreciation make assumptions about the life expectancy of houses.

Let V_{t-j} denote the portion of a house, built at time j, that has been consumed at time t. Further, let D_{t-j} denote the depreciation rate (percentage) of a house at time t, built at time j, and expressed in terms of initial cost.

Straight-line depreciation of a house with a useful life of n years:

$$V_{t-j} = \frac{t-j}{n} \qquad\qquad D_{t-j} = \frac{1}{n}$$

The straight-line method assumes that dwellings depreciate by a constant dollar amount every year. The life expectancy of a house is estimated and the constant annual depreciation rate is applied to the initial cost in each period, so that at the end of the house's life, the depreciation equals 100% of the initial cost. An important practical drawback is that the historic cost of houses must be known to apply the straight-line method.

Declining-balance depreciation: This procedure assumes that dwellings depreciate rapidly following construction, but depreciate more slowly afterward. Such a profile makes sense when buyers prefer a modern house with a recent construction date. In practice, a constant declining-balance depreciation rate is commonly used. *Ceteris paribus*, a constant declining-balance depreciation rate, D, is twice as high as the equivalent straight-line rate.[17] Therefore,

$$D = \frac{2}{n}$$

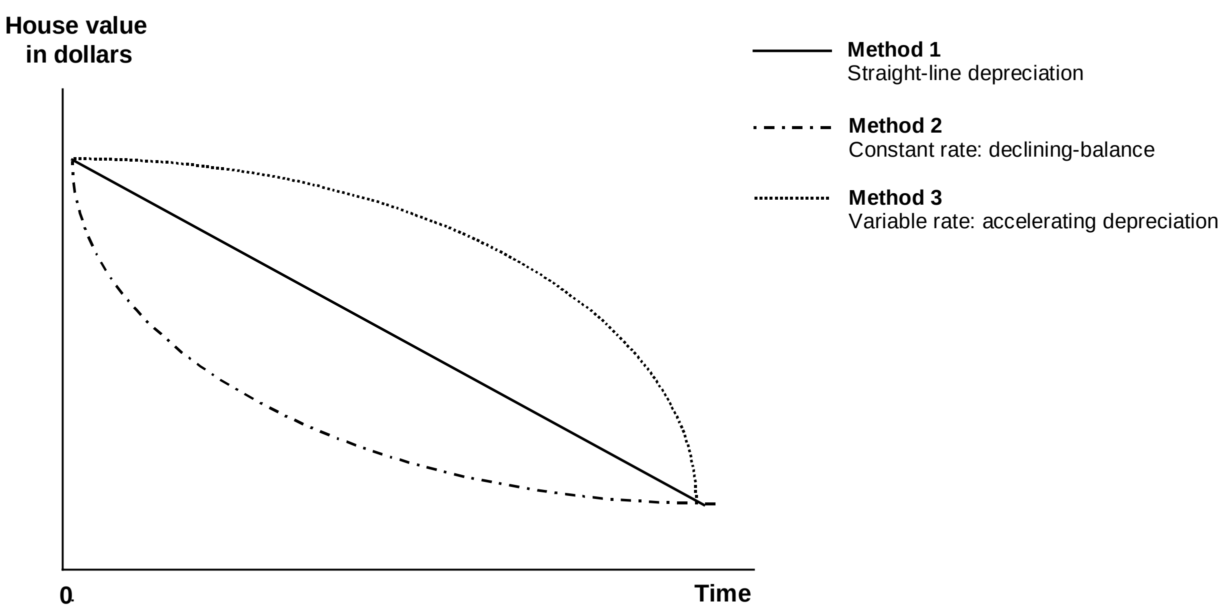
As long as homeowners maintain a standard of repair and upkeep on their houses, the true depreciation can be approximated by deducting a constant proportion of the remaining value of the housing stock each year:

$$V_{t-j} = \left(1-\frac{2}{n}\right)^{t-j} \qquad\qquad D_{t-j} = \frac{2}{n}\left(1-\frac{2}{n}\right)^{t-j-1}$$

[17] *A derivation of this result can be found in R. Winfrey's "Statistical Analysis of Industrial Property Retirement", Iowa Engineering Experiment Station, Bulletin 125, 1935.*

Accelerating depreciation: According to this method, houses depreciate little in early life. In later years, the dwelling depreciates faster, as reflected by rising maintenance bills. Some pioneers of this method have invoked the concept of the "effective age" of a house, which says that houses age like people. The overall life expectancy increases the higher the actual age is.[18] Excellent repair and maintenance slows depreciation and raises life expectancy. Substandard care increases the effective age above the real age. When this model is applied statistically, the effective age is treated as a sliding scale. This is in contrast to considering a continually lengthening life expectancy as the dwelling ages chronologically. The Marshall & Swift tables show depreciation rates for every age on a sliding scale by housing type.

Time profiles of housing depreciation



[18] *Marshall & Swift (1995), in particular, developed the "effective age" concept.*