ISSN 1648-2603 (print)
ISSN 2029-2872 (online)

VIEŠOJI POLITIKA IR ADMINISTRAVIMAS
PUBLIC POLICY AND ADMINISTRATION
2020, T. 19, Nr. 4 / 2020, Vol. 19, No 4, p. 142–154.

PROBLEMS OF AMORTIZATION METHODOLOGY IN ACCOUNTING POLICY (ON THE EXAMPLE OF INSTITUTIONAL SECTORS OF THE UKRAINIAN ECONOMY)

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DOI: 10.13165/VPA-20-19-4-10

Abstract. *The aim of this study is the substantiation of the need to synchronize the depreciation methodology in accordance with the rate of change of technology in different industries. When studying the compliance of the depreciation methodology with the pace of scientific and technological progress, the statistical data of the World Bank from the period of 2014 to 2019 were analyzed. To study the opinion of economists, accountants, and* *engineers on the adaptation of the Hulten-Wykoff method with Nomura's improvements to the practice of depreciation in Ukraine from 2017 to 2019, a survey of the employees of the technical and accounting services of 2500 enterprises across the industries of agriculture (32% of enterprises), transport (34% of enterprises), industry (27% of enterprises), and trade (7% of enterprises) was conducted. To adapt the model for determining the life cycle of fixed assets in Ukraine, the method of dynamic programming using the Bellman optimality criterion was used. The modeling of the duration of the asset life cycle was carried out, which revealed discrepancies with the normative value in accordance with the Tax Code of Ukraine not only based on the types of assets but also depending on the field of their application. A dynamic approach to determining the life cycle of an asset with adjustments to the probability coefficient of technological change in a particular industry is proposed. The use of a sectoral approach allows for the objective assessment of the financial result of the use of fixed assets and the comprehensive assessment of the need for their renewal.*

Keywords: *depreciation, amortization, asset life cycle, accounting policy, pace of technological change, fixed assets, survey.*

Reikšminiai žodžiai: *nusidėvėjimas, amortizacija, turto gyvavimo ciklas, apskaitos politika, technologinių pokyčių tempas, ilgalaikis turtas, tyrimas.*

Introduction

Economic studies on the issues and state of the accounting policy of Ukrainian enterprises have drawn our attention to the process of accounting, the concept of accumulation, and the use of depreciation. In the vast majority of enterprises, depreciation is a nominal component of costs. Support for the integration of the investment component into the use of depreciation requires a significant change in accounting. The increased flexibility of the methodology for calculating depreciation manifests itself in the development of mechanisms for responding to the pace of technological change, taking into account the industry component and asset type. Reducing the life cycle of assets is an economic lever for accelerating the modernization of fixed assets. At the same time, to stimulate the modernization of fixed assets at the state level the government uses a system of tax rebates and state subsidies, along with control over the formation of the investment-focused enterprise depreciation fund.

The purposes of this research are: the substantiation of the need to synchronize the depreciation method in accordance with the pace of technological change; the isolation of the asset life-cycle indicator as the most influential element of the depreciation technique; and the determination of the feasibility of sectoral and object-based differentiation of assets.

Literature Review

Obsolescence indirectly depends on depreciation estimates due to an asset's early retirement or shorter periods of use—an idea that is confirmed by the calculation of depreciation for the modified Winfrey pattern. When developing the methodology of Hulten and Wykoff (1981), the authors did not focus on which depreciation model was used. Instead, they estimated the age-price profiles of the assets of several businesses, which they call Type A assets, using the Box-Cox model.[1] There is a direct correlation between fixed asset efficiency modelling and depreciation modelling. Present and future decreases in asset efficiency result in the impairment or decreasing of the asset's value as it ages. Depreciation modelling could reduce the pace of this process, and thus provide a more effective outcome in view of external economic processes (inflation, for example).

As the value of used fixed assets relates only to those assets that are currently being used, Hulten and Wykoff (1981) employed the weighted average prices of fixed assets that were used, taking into account the degree of impairment of their depreciation, to assess the structure and dynamics of depreciation. It was assumed that average service life expectancy is the basis for estimating the probability of a fixed asset being disposed of and their model was built to be as close as possible to actual values. Hulten and Wykoff assumed that the net worth of disposable assets averaged zero. As a consequence, the depreciation amounts derived from the Box-Cox model corresponded to both the efficiency of an asset's decline and the decrease in its price.

The methodology of evaluating an asset's life cycle produced by Statistics Canada is based on the Hulten and Wykoff (1981) methodology. The difference in this methodology is that it is formed not only based on accounting data, but also on survey data from economic specialists and the technical services of enterprises. Because of the Capital and Repair Expenditures Survey, a unique database of the fixed prices and life cycles of assets (based on projected and actual indicators) has been generated. The database has accumulated information for almost 40 years, and is used by researchers worldwide.

Research by the Japanese scientist Nomura and other scientists from Canada and Japan (Nomura and Momose 2008; Nomura and Suga 2018; Drew and Dollery 2015; Sato and Yano 2013; Liao 2016; Dou, Hu, and Wu 2013; Wielhouwer, 2017) substantiates the feasibility of using an asset's recoverable amount, which is the basis for calculating the cost of capital. The methodology for obtaining this cost is based on the statistical depreciation profiles of different types of assets. These contain the results of modelling the sale price and the terms of the asset's use, which are transformed into the categories of "updated cost" and "life cycle" of the fixed asset. Selected categories allow researchers to correlate the benefit of holding and using an asset, as well as calculate the cost of replacing it (taking into account the cost of selling the disposable asset). However, modelling such as this requires not only accounting information that can be collected through traditional statistical observations, but also technical and general economic information that is more predictive rather than retrospective. Based on the accumulated array of data, scientists have modelled the life cycle of each type of asset using a dynamic programming method that uses the calculations of the Weibull function (1951).

This method is based on the Bellman optimality principle, and makes it possible to compare the extremal values of the objective function in such tasks for which the differ-

1 https://www.statisticshowto.datasciencecentral.com/box-cox-transformation/

ent duration of the processes studied is typical. In this case, the decisions made at each step of the simulation affect the results obtained in the following steps. The justification for using this method in determining the life cycle of an asset is provided in the book *Measuring Capital*, published on the basis of joint research by the Organization for Economic Cooperation and Development.[2]

In one study (Nomura and Sugab, 2018), to test the effectiveness of changes to the value of fixed assets, the results of the statistical study of depreciation rates from 1985 to 2001 are compared with the data for the period from 2002 to 2018. On average, the amount of depreciation for buildings does not differ significantly. Total depreciation for machinery and equipment increased, although this is mainly because the total value of fixed assets with higher depreciation rates (such as computers and communication equipment) is increasing. The cost of individual assets over the two periods is often indistinguishable. The next stage of the study was to combine the data from the two periods and to obtain the average cost of fixed assets on the basis thereof. The growth rates of fixed capital, estimated using new depreciation rates, are similar to those obtained using the depreciation rates supplied by Gellatly, Tanguay, and Yan (2002). Using the above method, estimates of service life were compared with the expected estimates of service life obtained on the basis of surveys, and both types of estimates proved to be almost identical (Nomura and Suga 2018). This method is called the "permanent inventory method,", and is implemented in the accumulation of information about both the cost of past investments and actual depreciation, which is calculated to obtain a summary of the net cost of the fixed assets used in the production process and the cost of future upgrades to them.

Fixed asset lifecycle modelling (Nomura and Momose 2008) in Ukraine confirmed global trends in the reduction of this indicator for several types of fixed assets, and identified an issue in the lack of relevant data for state-level calculations. This requires the expansion of the existing forms of statistical observation in Ukraine, and an increase in the speed of their submission and processing. At the same time, the methodology for estimating the future cost of replacement requires adjustments for each country's economic environment. The greatest risk in modelling the replacement cost and the life cycle of an asset is the likelihood of a significant change in technology that will result in the sharp impairment of the asset and possibly even the need for its retirement. In our study, we sought to adjust the existing Hulten and Wykoff (1981) technique, extended by Nomura, to produce an indicator that would determine the likelihood of innovation in a particular sector of the economy and, accordingly, change the likelihood of a fixed asset's obsolescence and thereby adjust its life cycle. In this context, the life cycle of an asset is recognized as an economic, rather than a physical or engineering-based, category. This is important because it means that the asset life cycle can change over time simply through economic events, even if the asset is still physically unchanged. In fact, the asset life cycle is one way to identify aging and to make decisions on liquidation when there is the prospect or opportunity to replace an asset with a new, possibly more productive and / or cheaper asset which renders an existing model outdated.

2 https://www.oecd.org/sdd/na/1876369.pdf

Binding the life cycle of an asset to the probability of technological change will bring the process of depreciation closer to real economic indicators, and at the same time will minimize government interference in the process of depreciation in enterprises. Previous studies of the components of the depreciation methodology and the experience of their practical application have allowed for the involvement of definitions of technologically favourablefavorable terms of use-life for assets in the practice of accounting for depreciation. At the same time, the pace of technological change and the fact that there are "technological leaps" in development require a differentiated, sectoral approach to each type of asset. This is due to the economic conditions that surround the use of the depreciation methodology for each country, and the status of the country's economic development.

The reform of accounting for depreciation must begin with a change in relation to statistical observations and the beginning of the formation of a database for the calculation and adjustment of the life cycles of assets. At the same time, the statistical observation information database can be expanded with the data needed to calculate the likelihood of technological change. At present, the empirical classification first introduced by the OECD is widely used, which is based mainly on the intensity of R&D measured by R&D expenditure in relation to the total amount of sales revenue.

Methodology

This study sanalyzed the number of scientists and technicians per 1 million people (using the World Bank's indicators in terms of 148 countries[3]). Austria, Slovenia, Switzerland, and Iceland lead the way, and the largest country with a high level of this indicator was Canada.[4] In order to determine the effectiveness of fixed capital investment, the growth of fixed assets in every country of the world,[5] and in particular in those countries that were among the leaders in terms of the previously mentioned indicators, was seanalyzed to determine the effectiveness of fixed capital investment. The forerunner, in terms of research of new technologies, was Canada. To specify the characteristics of each industry, the level of investment by type of equipment was studied based on statistical data provided by the US Economic Agency and Statistics Canada.

The bulk of investments were made in the communications industry, and in the industries of transport and trade. To adapt the method of depreciation for application in Ukraine, these industries were also sanalyzed.

To test the scientific hypothesis of the depreciation methodology and transformations in accounting, a survey of enterprises from different industries was conducted with the help of the Federation of Accountants and Auditors of the agro-industrial complex of Ukraine and the public organization "Innovations and Ssocio-Eeconomic iInitiatives" p.

An asset which is used in four industries and has the same technical characteristics—a truck—was selected for the purpose of demonstrating the specificity of its use in each industry. The task was then to prepare a schedule for the replacement of the asset that

3 http://wdi.worldbank.org/table/5.13#
4 https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS?view=map
5 https://data.worldbank.org/indicator/NE.GDI.TOTL.ZS?view=map

enabled its cost-effective use, taking into account the cost of its replacement and the price at which the used asset could be sold. For example, according to the results of the survey, the industry average cost of a new truck was determined to be 115,000 UAH. It should also be noted that for this study, a model with technical characteristics that, as much as possible, satisfied the needs of enterprises of all the industries studied was chosen. Other indicators—the economic effect (cost savings compared to the cost of hiring that equipment) of the use of a given truck and the price at which it could be attained both depending on the age of the asset and the industry—provide the data set on which the modelling was conducted. The maximum period of use of the vehicles was 15 years in the enterprises surveyed, hence this period was applied to the sectors identified in the study.

On the basis of the obtained data, the life cycle modelling of a certain asset was performed using the dynamic programming method, utilisingutilizing the calculations of the Weibull function (1951). The justification for using this method in determining the life cycle of an asset is provided in the book *Measuring Capital*,[6] published as a research output of the Organization for Economic Cooperation and Development.

For the modelling, the following notation has been used:

t – the age of the fixed asset, which determines the state of the system;

$r(t)$ – the enterprise's income from the use of one fixed asset, the age of which is t years;

$l(t)$ – the annual maintenance costs of the fixed asset;

$\varphi(t)$ – the profit (effect) derived from the exploitation of the fixed asset, the age of which is t years, over one year;

$s(t)$ – depreciated value (the price at which the available fixed asset could be obtained);

p – the price of a new fixed asset.

Developing a dynamic model for choosing the optimum useful life of a fixed asset (optimal update strategy) involves the identification of some key steps. The years from k to N are selected as a step in optimizing the replacement plan. The economic effect of the use of the fixed asset over this period depends on its age at the beginning of the current step (k – year). Since in this type of optimization task the process begins from the previous step ($k = N$), at the second step it is not known in which year from the first to the year (k–1) the fixed asset should be replaced and, accordingly, the age of the fixed asset at the beginning of the year k is also unknown. The age of the fixed asset, which determines the state of the system, is denoted as t, and its value is subject to the following limitations:

$$1 \leq t \leq t_0 + k - 1. \qquad (1)$$

Expression (1) indicates that t cannot exceed the age of the fixed asset for the year (k – 1) of its operation, taking into account its age at the beginning of the first year, which is t_0 years. This value cannot be less than one (i.e. in cases concerning the age of a fixed asset at the beginning of the year k if replacement occurred before the beginning of the previous (k – 1) year).

The control variable in the k step is a binary variable that can take one of two values: save (0) or replace (1) the asset at the beginning of the year k.

6 https://www.oecd.org/sdd/na/1876369.pdf

The description of dynamic programming as a mathematical optimization method is based on the Bellman optimality principle. The Bellman function $f_k(t)$ is defined as the maximum possible income (profit) from the exploitation of a fixed asset in the years from k to N if the age of the fixed asset was t years before the beginning of the k year. After applying a particular equation, the system enters a new state (Abdelkader, Sofiane and Zaineb, 2018). That is, if the fixed asset is retained at the beginning of the k year, then by the beginning of the $(k - 1)$ year its age will have increased by one (the system state will be $(t + 1)$, whereas in case of the replacement of the old fixed asset the new one will reach the age of $t_1 = 1$ year at the beginning of the $(k - 1)$ year.

On this basis, an equation was determined that allowed us to recurrently calculate the Bellman function based on the results of the previous step. For this purpose, a correlation was found between the indicators characterizing the problem at two adjacent stages. If we retain the fixed asset which has an age of t years, then the income of the enterprise from its use will consist of the income at the N step, which will be equal to $\varphi(t) = r(t) - l(t)$, and is received for $N + 1$ steps of work on the equipment of age $t + 1$ years:

$$f_N(t) = r(t) - l(t) + f_{N+1}(t + 1) = \varphi(t) + f_{N+1}(t + 1). \quad (2)$$

If at the N step the fixed asset, which has an age of t years, is replaced by a new one, then the income from such a replacement consists of the income calculated as the difference in the total cost $s(t) - p + r(0) - l(0)$, where $r(0)$ represents the cost of production using the equipment, which is 0 years old, and $l(0)$ represents the operating costs deducted from the revenue received from the remaining $N + 1$ steps of work on the equipment, the age of which is 0 + 1 year:

$$f_N(t) = s(t) - p + r(0) - l(0) + f_{N+1}(1) = s(t) - p + \varphi(0) + f_{N+1}(1). \quad (3)$$

Thus, if the profit margin (2) is greater than or equal to the profit margin (3), then the available fixed asset must be used, otherwise it must be changed. By combining (2) and (3), we get the functional equation:

$$f_N(t) = \max\begin{Bmatrix} \varphi(t) + f_{N+1}(t+1) \\ s(t) - p + \varphi(0) + f_{N+1}(1) \end{Bmatrix} \quad (4)$$

where the top row determines the profit that can be obtained from using an old fixed asset, and the bottom line from replacing it. It is assumed that the transition to working with a new fixed asset occurs in one step.

Equation (3) allows one to determine the value of $f_N(t)$ depending on $f_{N+1}(t + 1)$, where the transition from one step to another increases the age of the vehicle from t to $t + 1$, and the number of remaining steps decreases from N to $N - 1$.

At each subsequent step, the calculation is continued until the condition is fulfilled:

$$s(t) - p + \varphi(0) + f_{N+1}(1) \leq \varphi(t) + f_{N+1}(1)$$

At this moment, the fixed asset must be replaced because the profit resulting from the replacement of the equipment is greater than it would be if the old one were to continue being used.

These calculations were performed in order to determine the optimal replacement scheme for the fixed asset—the truck—so that the total income for all N years of its use was the maximum that could be achieved, taking into account that at the beginning of operation the age of the vehicle was t_0 years.

Results

According to the survey results, the modelling of the fixed asset life cycle was performed with the dynamic programming method, using the Weibull function and the Bellman optimality criterion in these calculations. It should be noted that both the retrospective cost of the fixed asset's replacement and its current value were used to develop the model, which would allow for the formation of an appropriate reserve for personal investments.

To test the model, calculations were made which allowed the authors to determine the life cycle of the truck. The results of the asset life cycle calculations were as follows: 10 years for agriculture; 6 for trade; 7 for transport; and 8 for manufacture. At the same time, the duration of this period was, on average, 15 years for the enterprises surveyed. We assume that, based on the national data set, the results of this modelling will be different in practice from those obtained in this paper, but the general tendency towards reducing use-lives, using replacement cost rather than cost of asset recovery, and the deepening of industry specificity are precisely the indicators that this methodology of accounting should focus on. Alongside the study of the indicators of the economic effectiveness of the use of fixed assets, a questionnaire on the professional estimation of the possible terms of use of the asset and the effectiveness of the adopted depreciation method was prepared, taking into account the pace of technological change. The results of both the simulation and the survey are shown in Table 1.

Table 1. **Variants of the useful life of the asset depending on the source of information, years**

Industry	Truck	
	professional judgment of enterprises specialists (according to the results of the survey)	**forecast (the results of lmodeling)**
Agriculture	10	**10**
Transport	4	**7**
Trade	7	**6**
Manufacture	8	**8**
Actual enterprises indicator (according to the results of Ukrstat)	**15**	

Source: systematized by the authors based on questionnaires of 2.5 enterprises of Ukraine, modeling results and Ukrstat

The survey that was conducted confirmed the effectiveness of the professional judgment and the possibility (or necessity) of applying such indicators in the reporting for the period of own statistical database formation.

The modern method of depreciation must take into account the possibility for a dramatic change in technology, and accordingly the need to upgrade fixed assets. This is a new manner of the aging of fixed assets, and it can be predicted by considering the level of intensity of an industry, which can be determined with the integration of the following indicators:

Indicator 1 is based on the intensity of scientific and technical development, which is measured as the percentage of total expenditure that R&D costs amount to (calculated in the statistical report according to the form of the INN "Enterprise Innovation Survey for the Period");

Indicator 2 is based on the performance of scientific and technical developments, which is measured as the percentage of total sales revenue that R&D costs amount to;

The third indicator—the pace of technological innovation—represents the share of enterprises that make technical innovations in a particular industry (Table 2).

Table 2. **Integration of income and cost indicators of innovation performance in determining the coefficient of technological change**[7]

Years	% of total cost spent on R&D	% of total sales spent on R&D	The share of enterprises that make technical innovations	The coefficient of technological change
2014	0.45	0.22	18.3	1.859264856
2015	0.52	0.25	17.8	2.326518606
2016	0.49	0.23	18	1.989582018
2017	0.45	0.21	15.9	1.532924481
2018	0.42	0.18	19.2	1.482857617
2019	0.38	0.17	16.8	1.106765824

The rate of technological change is obtained by multiplying the percentages of R&D expenditure by total costs, revenues from sales, and the share of enterprises that implement such innovations, since the first two indicators are obtained from the statistics of enterprises that innovate. According to the indicators of the efficiency of economic activity of enterprises (in the form of state statistical observations), all enterprises engaged in innovation activity have stable indicators of excess income over costs close to 100%. However, this is an overall result in all areas, and the percentage of it that is due to innovation (not an increase in production for other reasons, or an increase in the price of sales) does not determine statistical observations.

7 Built according to state statistical observations http://www.ukrstat.gov.ua/

Conclusions

1. The critical evaluation of the individual elements of the depreciation method allowed the authors to determine that the life cycle of an asset is its key component in times of rapid technological progress and abrupt changes in technology.
2. Strengthening their understanding of the specifics of an industry when calculating depreciation will allow organizations to make optimal use of existing assets and avoid unjustified disposal.
3. Determining the life cycle of an asset at the enterprise level can be based on the professional judgment of technical services. At the state level, it is possible to determine a unified indicator of the life cycle of an asset, taking into account the industry coefficient of probability of change in technology.
4. The proposed asset life cycle model for Ukraine can be adapted to the regulatory framework at the state level. This will make the process of depreciation accounting clear and understandable to business entities, which will then facilitate the transition to the new methodology and at the same time simplify control over the implementation of the depreciation policy of the state and the enterprise.

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Amortizacijos metodikos problemos apskaitos politikoje (Ukrainos ekonomikos institucinių sektorių pavyzdys)

Anotacija

Šio tyrimo tikslas yra pagrįsti poreikį sinchronizuoti nusidėvėjimo metodiką atsižvelgiant į skirtingų pramonės šakų technologijų kaitos greitį. Tiriant nusidėvėjimo metodikos atitiktį mokslo ir technologijų pažangos tempą, buvo analizuojami 2014–2019 metų Pasaulio banko statistiniai duomenys. Ištirta ekonomistų, buhalterių ir inžinierių nuomonė apie Hulteno–Wykoffo metodo „Nomura" pritaikymą su patobulinimais prie Ukrainos nuvertėjimo praktikos 2017–2019 m. Atlikta 2,5 tūkst. įvairių pramonės šakų įmonių techninių ir apskaitos paslaugų darbuotojų apklausa (žemės ūkio įmonių – 32 %, transporto – 34 %, *pramonės – 27 %, prekybos – 7 %). Pritaikant modelį Ukrainos ilgalaikio turto gyvavimo ciklui nustatyti, buvo taikomas dinaminio programavimo metodas, pasitelkiant Bellmano optimalumo kriterijų. Buvo atliktas turto gyvavimo ciklo trukmės modeliavimas, kuris atskleidė norminės vertės neatitikimus pagal Ukrainos mokesčių kodeksą ne tik pagal turto rūšis, bet ir pagal taikymo sritį. Siūlomas dinamiškas būdas nustatyti turto gyvavimo ciklą, pritaikant jį tam tikrų pramonės šakų technologinių pokyčių tikimybės koeficientui. Tai yra sektorinis požiūris, leidžiantis objektyviai įvertinti ilgalaikio turto naudojimo finansinį rezultatą ir iš tikrųjų įvertinti jo atnaujinimo poreikį.*

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