Utilities Policy 40 (2016) 88–103

Contents lists available at ScienceDirect

Utilities Policy

journal homepage: www.elsevier.com/locate/jup

Which asset valuation and depreciation method should be used for regulated utilities? An analytical and simulation-based comparison

Hans-Ulrich Küpper [a], Burkhard Pedell [b, *]

[a] Institute for Accounting and Control, Ludwig-Maximilians-Universität Munich, Germany
[b] Department of Management Accounting and Control, University of Stuttgart, Germany

ARTICLE INFO

Article history:
Received 3 December 2013
Received in revised form
9 May 2016
Accepted 9 May 2016
Available online 30 May 2016

Keywords:
Asset valuation
Depreciation method
Rate regulation
Monte Carlo simulation

ABSTRACT

Capital charges constitute the major share of costs in regulated network industries; in regulatory practice, however, no universally accepted method of depreciation exists. This paper compares the most commonly used asset valuation and depreciation methods according to their provision of adequate investment incentives, their compatibility with market developments, and their consistency with financial accounting principles. Current replacement-cost and annuity depreciation are found to be the most advantageous methods. The structural differences between these two methods are presented in detail. A simulation analysis indicates that the differences among the depreciation methods are less pronounced for sets of multiple assets but remain very large for certain parameter constellations, particularly those with substantial asset price changes and long asset lives.

1. Introduction

Regulated network industries, such as those providing telecommunications, energy, water, and rail services, require high levels of capital investment. Accordingly, capital charges constitute the major share of those industries' total costs; the determination of those charges is one of the most important problems when justifying cost-oriented regulated prices. We focus on comparing the asset valuation and depreciation methods used for the purposes of rate regulation. To calculate the cost of infrastructure, one must consider all of the costs associated with an asset. Using a building-block approach (see Johnstone, 2003, pp. 2f.), all of these costs (that is, operating expenditures such as maintenance and repair, depreciation costs, and opportunity costs) must be considered together because they are interrelated. We restrict our analysis to depreciation and interest, as they are the fundamental cost factors in network industries.[1] The depreciation method not only determines depreciation cost but also drives the remaining book value and interest cost. Consequently, the choice of depreciation method determines the time path of regulated prices to a substantial extent, and depreciation methods may be chosen to pursue policy and regulatory objectives related to that time path. Despite their central role in rate regulation, depreciation methods have earned less attention than the assessment of the adequate rate of return (Brennan, 1991).

The academic literature on regulatory depreciation methods is relatively fragmented. The topic is addressed in an ongoing debate by regulatory economics researchers and accounting researchers, who do not always take sufficient notice of each other's perspectives. On the one hand, the extant literature delivers no clear recommendation for a particular asset valuation and depreciation method, and the results partly appear to be contradictory. For example, some authors argue in favour of frontloaded capital recovery compared with the timing of capital recovery that would be induced by straight-line depreciation (e.g., Crew and Kleindorfer, 1992; Knieps et al., 2001), whereas others argue in the opposite direction for backloading (e.g., Burness and Patrick, 1992). The various conditions and criteria that drive these variations are not always sufficiently clear. On the other hand, different approaches yield partially congruent results. For example, annuity depreciation is found to be optimal based on different argumentations (e.g., Brennan, 1991; Nezlobin et al., 2012). Therefore, our analysis of

* Corresponding author.
E-mail addresses: kuepper@bwl.lmu.de (H.-U. Küpper), burkhard.pedell@bwi.uni-stuttgart.de (B. Pedell).

[1] Küpper (2009a) analyses the interdependencies of investment with maintenance and repair.

http://dx.doi.org/10.1016/j.jup.2016.05.001
0957-1787/

asset valuation and depreciation methods begins with a clear presentation of the criteria for comparison and a systematisation of the extant literature according to these criteria.[2]

We also emphasize no uniform standards for depreciation methods have emerged in regulatory practice. A global overview of implemented depreciation methods would be far beyond the scope of our paper, but the following evidence underscores that there is no universally accepted standard for regulatory depreciation methods. An overview of the regulation of electricity and gas distribution and transmission networks in large European countries, for example, can be found in EY (2013). More countries in Eastern Europe and Asia as well as Australia are covered by the overview in ERRA (2009), which focuses on the determination of the regulatory asset base. The two basic approaches underlying regulatory depreciation are historical-cost accounting and current-cost accounting. The former uses historical acquisition cost for the depreciable regulatory asset base, while the latter can be implemented by applying indexation to the regulatory asset base. Both approaches are widely used and, in most cases, depreciation is calculated according to the straight-line method. However, other depreciation methods can also be found, in particular, methods that accelerate depreciation or that result in an annuity pattern for the sum of depreciation and interest.

Valuing the depreciable asset base at historical acquisition costs and calculating depreciation according to the straight-line method offer the advantages of transparency and simplicity. Current-cost accounting can be advocated for with the argument that it better reflects current market conditions with respect to input prices, demand and technology; it is therefore consistent with forward-looking cost models and, in particular, aims at providing incentives for efficient investment. Accelerated depreciation is used to reflect high losses in asset value in early periods of the asset's life and tends to decrease investment risk when it induces a frontloading of revenues. The annuity method can be used to provide an equal distribution of costs over time, for example, to provide intergenerational equity or to make several utilities comparable in the context of benchmarking capital expenditures.

It is not unusual for applied depreciation methods to change significantly over time and, in some cases, different methods can be applied in combination. For example, Ofgem (2013) recently raised regulatory asset lives for new but not for existing electricity distribution assets in the UK from 20 years to 45 years, thereby restricting accelerated depreciation. Also, in the German energy sector, different rules are applied in parallel according to the timing of investments.[3] Assets entered onto balance sheets after January 1, 2006, are depreciated according to the straight-line method based on historical acquisition values. With respect to assets that entered the balance sheet before that cut-off date, the equity-financed amount is depreciated based on full replacement value, whereas the debt-financed balance is depreciated using historical acquisition value.

The choice of depreciation method is interdependent with the adequate interest rate. In an analysis of the German water sector, for example, four competing approaches are compared: (1) depreciation of historical acquisition value combined with the nominal interest rate; (2) indexing of asset value using a consumer price index combined with the real interest rate; and (3) depreciation of the replacement value of assets combined with the real interest rate calculated using a consumer price index or (4) the specific price-change rate of the assets.[4]

In some cases, determining the depreciable regulatory asset base is combined with an optimisation approach. In the US, for example, it has long been common to apply used-and-useful tests or prudence reviews to the asset base (see Kolbe et al., 1993). The former approach excludes all assets acquired in the past that are not used and useful from a current perspective. In a prudence review, the regulator disallows from the rate base investments improperly made considering the information available at the time of investment. In Australia, the concept of depreciated optimised replacement cost (DORC), which combines a current-cost approach with an optimisation element, has been intensely debated (see Johnstone, 2003). These are but a few examples of currently applied depreciation methods, which demonstrate that a systematic comparison of depreciation methods is highly relevant for substantiating regulatory practice.

The contributions of our paper are threefold. First, we compare the depreciation methods most commonly used in regulation according to three criteria that are related to the level of capital charges, their allocation over time, and the division between interest and depreciation, respectively: net present value neutrality, market compatibility, and consistency with financial accounting standards and practices. Net present value neutrality is relevant to stimulating investments on the one hand and to preventing excess profits on the other. Market compatibility encompasses alignment with developments in market prices, demand, and technology. The consistency of regulatory accounting with financial accounting practice is of practical importance as it tends to increase the credibility of regulatory accounting and thus to reduce the risks for the parties involved in a rate-setting process.

A comparison between historical straight-line depreciation, full and current replacement-cost depreciation, and the annuity scheme based on applying these criteria returns three results: (1) all of these methods fulfil the criterion of net present value neutrality, assuming that in the full replacement-cost method, interest is based on real instead of nominal interest rates; (2) the periodic costs (as the sum of depreciation and interest cost) of both replacement-cost methods are equal; and (3) because only the current replacement-cost and annuity schemes fulfil all three criteria, these methods appear to be the most advantageous. We also analytically elaborate the structural differences between these two methods. Furthermore, we can show which theoretical arguments favour the annuity method; however, whether market

[2] The discussion of the conditions under which the accounting rate of return (ARR) coincides with the internal rate of return (IRR) (see, among others, Solomon, 1966; Vatter, 1966; Livingstone and Salamon, 1970; Stauffer, 1971; Gordon, 1974; Kay, 1976; Leech, 1976; as well as Peasnell, 1982; for an overview see Luckett, 1984; and Stark, 2004) is somewhat structurally analogous to our research. However, although this discussion arises out of given cash flows and elaborates the conditions of, inter alia, the depreciation method under which ARR equals IRR and focuses on an ex post evaluation of (periodic) performance, our starting point is considering regulatory objectives. Discussing which depreciation method best fulfils these objectives, we thus focus on reconciliation over the entire period ex ante. The cash flows of the regulated firm result from the depreciation method chosen by the regulator for rate-setting purposes. More specifically, annuity depreciation is a specific limiting condition in the ARR versus IRR research, whereas we find arguments for using it for rate setting. However, because the formal structure of the discussions exhibits some analogies, our results might be a useful catalyst for the discussion of specific limiting conditions in the ARR versus IRR research.

[3] See the German ordinance on rate regulation for the gas sector (GasNEV) and for the electricity sector (StromNEV) from 25.7.2005, according to which LRIC must be taken for equipment investments in the years before 2005 and historical costs taken for new equipment.

[4] See BDEW/VKU (2012), p. 21ff. and Hern et al. (2012), p. 19ff. Using a consumer price index does not reflect the development of market prices for assets. Furthermore, the combination of depreciation of the replacement value of assets and a real interest rate calculated using a consumer price index is inconsistent, as will become clear in Section 3.