ACCLERATED DEPRECIATION: ESTABLISHING A HISTORICAL AND CONTEXTUAL PERSPECTIVE[1]

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1. Introduction

Carbon-constrained and post-carbon economies potentially necessitate economic and financial instruments to facilitate the uptake of new technologies designed to limit environmental impacts and reduce cost intensity. One of the proposed methods to achieve this is the introduction of accelerated depreciation schedules. Yet there has been considerable debate regarding whether such schemes are really effective tools with respect to promoting technological investment. There is thus a need to ascertain whether accelerated depreciation has had a historical application in industries where there was also need to acquire new technologies rapidly, as there now is in the case of carbon-emitting/carbon-constrained sectors such as transportation, stationary energy, etc. Very little cohesive work has been attempted on this theme from a historical perspective, with most critiques of accelerated depreciation having taken a firmly theoretical viewpoint.

Accelerated depreciation regimes have been implemented in various historical, industrial and economic contexts (such as regulated and deregulated markets) during the past century. Factors that have caused governments to implement accelerated depreciation schedules are varied. Different types and accompanying instruments/policies have been used, while varying methods of accelerating the depreciation have been applied. Furthermore, various sectors have been targeted, with the impact of accelerated depreciation on economic activity emerging as highly variable depending on the economic, institutional and other contextual circumstances. Indeed, the value of such schemes has also been criticized from several quarters since not only does accelerated depreciation bring about benefits, but also incurs significant financial and social costs that might not be sufficiently counterbalanced by the scheme's positive attributes (Forte, 1966; Furstenberg and Malkiel, 1977). In many instances, accelerated depreciation schemes were discontinued, and alternative mechanisms were implemented.

This paper provides a historical overview of issues pertaining to accelerated depreciation. It analyses stated rationales for accelerated depreciation and the broader contexts in which such schemes were implemented. The paper describes the major goals, types, and accompanying instruments/policies of individual schemes, and then considers evidence of the scheme's impact on economic activity and how this evidence squares with initial predictions. It thus presents an overall evaluation of the respective schemes under investigation. The paper concludes by extrapolating whether there are any clear lessons to be learned for future application of accelerated depreciation schedules, or whether other tools that could have the same effect, or better outcomes, should be used in cognate contextual circumstances.

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2. A need for accelerated depreciation?

Although accelerated depreciation schedules have been in use in various contexts for the best part of a century, it is the increased attention being paid to what is widely regarded as anthropogenic climate change that has resulted in increased interest in accelerated depreciation. Governments throughout the world have either introduced emissions trading schemes, such as the European Union, or intend to introduce them in the near future, such as Australia. Under an emissions trading scheme, assets heavily reliant on carbon-based fuels sources such as coal, natural gas or petroleum will be penalized, with the rate of penalty increasing with time so as to encourage an overall reduction in carbon emissions (Garnaut Climate Change Review, 2008). In view of these constraints, firms relying on fossil fuels will either have to purchase increasingly expense carbon credits, or invest in less carbon-intensive technologies, or preferably ones that do not emit carbon dioxide at all (HM Treasury, 2006).

The scenario described above represents a considerable challenge to the stationary energy and transport sector in particular. These sectors involve huge sunk costs, and infrastructure and equipment designed to operate over several decades (Betz, 1998). To take the example of the rail industry, locomotives represent a considerable up-front investment on the part of rail companies. Furthermore, locomotives can be extremely long lived. In Australia, the average age of a locomotive is reportedly over 30 years (Australasian Railways Association, 2008). Most of these locomotives are fully depreciated and do not, in the absence of emissions trading, incur any costs aside from maintenance and fuel. Some are also impaired since revenue from assets does not justify current valuation of the asset. Yet older locomotives are not especially energy efficient and will thus incur penalties to their owners in a carbon-constrained environment. As peak oil draws near, fuel costs will also rise and make older locomotives increasingly uneconomical.

To meet emissions targets, there is a clear need to incentivize the introduction of cleaner and less environmentally intrusive technologies (Bookchin and Foreman, 1991). It is not likely, however, that transport and stationary energy firms, with their considerable sunk costs, will have the financial resources to carry out the much-needed investment in new technology. Thus the introduction of accelerated depreciation schedules has been mooted as an instrument to shift industry away from carbon-intensive technologies, including older generation diesel-electric locomotives, and coal-fired power stations, which could be replaced by newer, cleaner locomotives or hydroelectric, geothermal, photovoltaic, wind or even nuclear power generation respectively.

Accelerated depreciation, as an extension, will presumably increase demand in more energy-efficient technologies. It is generally agreed that cleaner and thus more environmentally sustainable technologies are feasible, or have even been developed (Ryan and Charles, 2007), yet insufficient market incentive currently exists for accelerating the introduction and maturation of these technologies, especially given the significant research and development (R&D) costs involved.

3. Accelerated Depreciation

Before we turn our attention to historical examples, it is important to provide a description of accelerated depreciation and the rationale behind it.

Depreciation is a term used in accounting, economics and finance, with reference to the fact that finite lived assets lose their value (i.e., depreciate) over time, and must be replaced. There are at least two factors causing depreciation: deterioration and obsolescence (Nelson and Caputo, 1997). Deterioration represents the combined

effects of the reduction in the useful life of the asset, input decay (an increase in the input requirements necessary to maintain a given level of output), and output decay (a reduction in the output produced by a given asset, holding other inputs constant). Obsolescence represents the decline in the value of used assets resulting from technological improvements embodied in new assets.

Accelerated depreciation allows deductions for declines in the value of an asset to occur at a rate above what is expected in practice (Review of Business Taxation, 1999). The total amount of depreciation allowed over an asset's life is the same under both the nominal and accelerated depreciation regimes. Accelerated depreciation only allows the amount of depreciation taken each year to be higher during the earlier years of the life of an asset (Goode, 1955). The benefit of accelerated depreciation is confined to tax deferral. Companies generally pay taxes on profits: revenues minus expenses. There are various types of expenses, and depreciation is one of them. As a result, accelerated depreciation defers a company's taxes during the earlier years of an asset's life and increases them in later years. In many respects, this tax deferral property of accelerated depreciation will increase a firm's demand for depreciable facilities and expand its financial capabilities for acquiring them (Ture, 1967).

Accelerated depreciation increases the present value of the depreciation deductions and thereby increases the after-tax present value of the net returns from investing in depreciable facilities.[2] The increase in the present value of the depreciation deductions also represents a once-and-for-all reduction in the cost of the depreciable facilities involved (Ture, 1967). *Ceteris paribus*, the taxpayer will find such facilities more attractive to use in combination with other inputs in the production process, thereby increasing the desirability to invest.[3]

The use of accelerated depreciation results in a greater flow of internal funds generated with respect to any given amount of depreciable facilities. This cash-flow benefit is not particularly meaningful for businesses acquiring assets in any one year, since the increase in cash flows in the asset's earlier years will be exactly offset by the reduction in cash flows in the later years of the asset's life. However, for firms acquiring assets in more than one year, it will result in an increase in cumulated cash flows until these firms completely liquidate their depreciable asset account. For businesses whose purchases of depreciable assets are increasing, accelerated depreciation will continue to yield a larger cash flow than that resulting from the use of a non-accelerated method. The more rapid the growth in the stock of depreciable facilities, the greater will be the excess of the cash flow under an accelerated depreciation regime (as compared with the ordinary method).

Accelerated depreciation thus reduces the risk of investment in depreciable facilities and effectively transfers cash flows from later years to earlier years (Goode, 1955). Greater early cash flows mean that a greater proportion of the asset's cost will be recovered within a short period, thereby benefiting firms relying on a short payoff period approach to allow for the risk of investment in depreciable assets. For firms relying on a discounting approach, cash flows received in the earlier years are subject to relatively slight discounting to cash flows received in the later years. Accelerated

[2] The amount of this increase depends on at least four factors: i) the discount rate used to calculate the present value of future receipts; ii) the asset's expected life; iii) the marginal tax rate; and iv) the method of accelerated depreciation used.

[3] The amount of the increase in the desired stock of depreciable facilities depends on the possibilities of substituting such facilities for other agencies of production. It follows that, the greater the elasticity of substitution, the greater the increase in the desired capital stock.

depreciation, in sum, reduces the average effective discount for risk and justifies earlier replacement of existing facilities (Ture, 1997) and has the potential to reduce the optimum replacement cycle for depreciable facilities (Friedrich and Lutz, 1951; Edwards, 1961). In practice, firms comparing expected cash flows from existing facilities and that from replacements are likely to find that the more rapid reduction in existing facilities' cash flows under accelerated depreciation will make earlier replacement more feasible.

Of course, there is a revenue cost to the government from the tax deferral aspect of accelerated depreciation. Accelerated depreciation is equivalent to the government providing an interest-free loan to the taxpayer, since it allows a deferral of tax payments to later years, with no increase in the amount due (Auerbach, 1982). Thus, the cost to the government is the interest on this loan less any extra income earned by the taxpayer as result of this loan (Review of Business Taxation, 1997). The impact on the government's revenue flow will be significantly negative in the earlier years of the asset's life (when the loan is first granted). If the stock of investment subject to accelerated depreciation is constant over time (in case the loan is not effective at boosting economic growth or, in our case, encouraging investment in cleaner technologies), the on-going cost to the government's revenue from granting the scheme would be no more than the cost of the interest-free loan. If the stock of capital subject to accelerated depreciation grows (in case the loan is effective at achieving the desired outcomes), loan outlays would always exceed loan repayments and, as a result, the on-going cost of the scheme could be significant. This cost needs to be weighed against the benefit from higher economic growth, which yields high tax revenues.

4. Forms of accelerated depreciation

Accelerated depreciation takes many different forms and is also known by other names. For the sake of cohesion and simplicity, we characterize the term 'accelerated' as any depreciation method allowing the taxpayer to charge off more of the depreciable cost of an asset in the early years than under an ordinary method, i.e., *straight-line depreciation*, which calculates an asset's annual depreciation by dividing the difference between the purchase price and the salvage value of the asset[4] by the estimated useful life of the asset (Margalioth, 2008). Remember that accelerated depreciation only allows the amount of depreciation taken each year to be higher during the earlier years of the life of an asset (Goode, 1955)—it makes no change on the overall deduction.

A widely-accepted way to accelerate the depreciation deductions is to alter the pattern of the depreciation deductions so that a larger part of the depreciable amount is charged against income in the earlier years of the asset's service life, while a smaller part is charged in the later years. Two popular methods that change the pattern of the depreciation deductions are the *declining-balance method* and *sum-of-the-years-digits* methods. Under the former method, the taxpayer could start deductions at usually 1.5 times or 2 times the amount allowed under the straight-line method (Hanchett, 1996). Each year thereafter, the taxable value of the asset is computed by subtracting the amount already deducted from the initial value. This procedure dramatically curves the depreciation line. Under the latter method, a continually decreasing ratio is applied to the difference between the asset's original cost and the

[4] The salvage value is the value of the asset at the end of its useful life. It is usually assumed to be zero.

asset's estimated salvage value (Barritt, 1959). The numerator of the ratio in any year is the number of years of service life remaining (including the present year), whereas the denominator is the sum of the numbers representing the successive years in the estimated life of the asset. Suppose that the remaining life of the asset is 5 years. In the first year, the numerator would be 5 and the denominator would be the sum of 1 + 2 + 3 + 4 + 5, which would provide the ratio of 5/15. This ratio is the first year's depreciation charge per dollar of the asset cost less savage. The annual *sum-of-the-years-digits* depreciation per dollar of the asset cost less savage is 4/15 in the second year, 3/15 in the third year, etc.

Another common form of accelerated depreciation, called the *American system* by Domar (1953), is to maintain the straight-line depreciation system, but shorten the period of depreciation below the actual economic life of the asset. Suppose that the period of depreciation is reduced from the normal service life of 10 years to 5 years. Under this *shortened service life* method, a firm may claim 1/5 in depreciation per dollar of the asset cost less savage each year for the first 5 years, and nothing for the last 5 years.

The literature also describes another (less-common) form of accelerated depreciation, called *initial allowance*. Here, a company is permitted to claim a specified extra proportion of the asset's cost during the earlier years of the asset's service life (Baritt, 1959). This supplementary allowance is deducted from the written-down value for tax purposes, and so reduces the sum on which subsequent depreciation allowances are calculated. The initial allowance method, however, makes no change in the overall deduction. If there is an initial depreciation allowance of 10% of cost at the time of purchase, subsequent depreciation allowances are then based on 90% of the purchase price. A derivative of the initial allowance is *free depreciation*, under which corporate taxpayers are permitted to write off the full cost of assets in the first year after the acquisition (Ture, 1967). Thus, free depreciation is equivalent to 100% initial allowance.

There are three other popular methods of liberalizing the rules governing the determination of depreciation charges. One of these methods is to substitute replacement cost for original cost as the basis for the depreciation deduction. With the replacement cost method, it is thus possible to claim depreciation deductions a sum greater than the original cost of the asset (Goode, 1955). Another depreciation liberalization method is known as the investment allowance. Like initial allowance, the investment allowance method also permits a firm to claim a specified extra proportion of the cost of the assets during the earlier years of the asset life (Goode, 1955). However, this supplementary allowance is not taken into account in the calculation of subsequent depreciation allowances. Like replacement cost method, it is possible with investment allowances to claim depreciation deductions of a sum greater than the original cost of the asset. Another liberalization method is the price-index adjustment of depreciable basis. This method is actually the replacement cost approach, with inflation taken into account (Barritt, 1959). In particular, the depreciation allowance is calculated from the actual inflated replacement cost rather than the original cost. We do not consider the three methods discussed here as accelerated methods since they may increase the overall deduction above what is allowed under ordinary depreciation practice.

5. History of Accelerated Depreciation

To understand the impact of accelerated depreciation, and whether it could prove useful in encouraging investment in more environmentally friendly technologies, it is

important to look first at the background of depreciation law in several countries. This section provides the historical usage of accelerated depreciation in selected countries where accelerated depreciation has, at various times, been an integral part of taxation and economic policy.

5.1. The Introductory Period (Pre-Second World War)

The first application of accelerated depreciation occurred during the First World War. Schemes of 100% initial allowances were adopted in Britain (in 1915) and the United States (in 1916) and were applied to war-related plant and machinery (Barritt, 1959). The first use of accelerated depreciation was not aimed to be a progressive method of stimulating investment. Britain's first provision of accelerated depreciation was adopted as an offset against the loss in the value of war-related plant and machinery arising from the postponement of renewals, or from repairs caused by exceptional depreciation or premature obsolescence owing to the war (Barritt, 1959). In the United States, the major reason leading Congress to introduce the scheme was that munitions makers' profits were determined almost entirely from their performance of contracts with foreign governments. Accelerated depreciation was viewed as a method of securing a more equitable definition of taxable income for these munitions makers (Brown and Patterson, 1943).

With the United States' entry into the war in 1917 came a need for expanded munitions capacity. A new accelerated depreciation scheme, called 'reasonable deduction', was incorporated in the Revenue Acts of 1918 and 1921 and aimed to give incentive to manufacturers of war goods to expand their plants (Brown and Patterson, 1943). Under the reasonable deduction provision, the loss in value of facilities used to produce articles contributing to the war effort was recognized in excess of ordinary wear and tear. Brown and Patterson (1943) contended that the reasonable deduction provision offered little investment incentive, especially in view of the delay in permitting the scheme—the law was not passed until three months after the hostilities had ceased. Uncertainties surrounding the length of time that the emergency demand was expected to last, in addition to uncertainties surrounding the amount that would be allowed to depreciate, further problematized the scheme. The total amount of costs that could be depreciated and the spreading of costs through time were determined by the Bureau of Internal Revenue (Brown and Patterson, 1943). The Bureau of Internal Revenue's determination was based on its estimation of the post-war value of these facilities. As a result, firms did not know in advance what their depreciation allowance would be if they expanded their plants for war production.

Accelerated depreciation reappeared just before the Second World War. The free depreciation system was adopted by the Swedish government in 1938, and applied to equipment and machinery in general industry. The government hoped that the system would eliminate conflicts between taxpayers and tax administrators over correct depreciation rates (Muten and Faxen, 1966). The possible stimulus that the scheme might give to the consolidation of business firms was a secondary motive. Although the system was not adopted primarily as an investment-stimulating measure, it achieved a significant expansionary effect. Muten and Faxen (1966) contended that free depreciation increased corporate liquidity, or the availability of funds for new investment. Free depreciation had made self-financed investment in boom periods too easy for too many firms. As a result, the expansionary effects of free depreciation became too strong. Ultimately, the inflationary pressure that followed the excessive

investment forced the Swedish government to restrict the system in 1951, and completely repeal it in 1955.

Muten and Faxen (1966) criticized Sweden's use of free depreciation for several reasons. First, free depreciation was selective in nature and made self-financing easier for some firms, and for certain types of investments. In particular, free depreciation tended to favour long-term over short-term investment, in addition to investment in machinery and equipment over that in buildings. Moreover, free depreciation gave more investment stimulus to firms already showing profits than it did to new ones. Second, free depreciation encouraged overinvestment by misleading firms into undertaking bad investment projects for the sake of acquiring assets on which they could take free depreciation.

5.2. The Period of Recognition (Second World War)

Accelerated write-offs were used by a number of governments during the Second World War, when increased investment in defence and defence-related facilities became a matter of overwhelming importance. In Great Britain, for example, the special allowance of depreciation deductions introduced during the First World War was used again during the second global conflict. This time, however, only a 10% interim allowance was given forthwith (Barritt, 1959). In the United States, a scheme of five-year amortization allowance was introduced in 1940 (Goode, 1955). The scheme allowed the asset to be written off in five years at 20% each year and was applied to defence and defence-related facilities, for which certificates of necessity were issued (Barritt, 1959).[5] In Canada, certificates were issued from 1940 by the Ministry of Defence Production for special initial allowances for projects involving the production of war materials (Sharp, 1952). The specified extra proportion of the asset's cost that would be allowed to depreciate during the earlier years of the asset's service life was based on the asset's post-war residual value (Morgan, 1942).

Even though the United States' five-year amortization allowance offered significant incentive for private manufacturers to invest more in defence and defence-related facilities, there was still restricted private investment in emergencies during the Second World War. Three causes that contributed to the scheme's failure were i) complications of obtaining the necessity certificates from the authorities before accelerated depreciation could commence; ii) the general fear of a post-emergency depression; and iii) the great increase in possibly competitive plants being built with government funds (Brown and Patterson, 1943). The situation was reversed in Canada, where accelerated depreciation successfully encouraged expansion in production of war-related materials, in addition to other products (Morgan 1942; Sharp 1952).[6]

5.3 The Expansionary Period (The Post-war Years)

The provision of special depreciation allowances during the wars introduced the idea of accelerated depreciation as a means of stimulating investment (Barritt, 1959). In most cases, however, the application of accelerated depreciation was restricted to war industries. It was not until the post-war period that this measure was expanded to

[5] The full cost of these facilities can be written off in five years by a straight-line method, even when the normal useful life exceeded five years.

[6] Up to 1951 in Canada, accelerated depreciation related to $109 million out of $158 million of expenditure being made by the taxpayers for 45 projects, mainly concerning the production of aircraft, steel, aluminium, and sulphur.

other industries. The rationale behind this was that, after the Second World War, stimulating economic growth was an important agenda of tax policy in many countries (National Bureau of Economic Research, 1966). There was a general belief that accelerated depreciation would facilitate investment financing and thus promote economic growth (Margalioth, 2008).

As a result, an increased recourse to accelerated depreciation occurred in the post-war period, with the objective, at least in part, of speeding reconstruction or spurring capital formation so as to promote economic growth (Barritt, 1959). There was, however, no explicitly stated objective to encourage technological investment, although it would appear a concomitant of the overall objectives since raising long-run economic growth is closely related to increasing the rate of technological change (Boskin, 1988). Nonetheless, the rate of investment may positively feed back on the rate of technical change since in the process of investment, people learn new production processes and discover new products (Landau and Rosenberg, 1986). This might explain why encouraging investment in general was the first priority.

A wide variety of accelerated depreciation arrangements, including initial allowances and shortened service lives, were evident (Ture, 1967). The declining-balance method of depreciation was widely adopted as an alternative method to the straight-line approach. Moreover, other liberal forms of depreciation arrangements such as investment allowances and priceindex adjustments of depreciable basis also featured in many nations' tax policy for the purpose of increasing investment (Ture, 1967). The post-war development of these measures in selected countries and their efficacy in promoting investment (on a country-by-country basis) are summarized below.

5.3.1. United States

In the first major change of the United States tax law, viz., the Revenue Act of 1954, sum-of-the-years-digits and double declining-balance formulas were introduced as alternatives to the ordinary straight-line approach. In 1962, guidelines for useful lives of assets for tax purposes were promulgated by Treasury (Margalioth, 2008). Theses guidelines allowed investors to write assets off over a shorter period than what had been previously allowed (Auerbach, 1982). In 1971, another major change in depreciation practice occurred. Treasury created the Asset Depreciation Range (ADR) system, which allowed firms to write off their assets over a period that was, in most cases, 20% shorter than the 1962 guidelines allowed (Bischoff, Bosworth and Hall, 1971).

In 1981, Congress adopted the Accelerated Recovery System (ACRS), under which the depreciation system became even more generous than the pre-1981 system. The key aspect of ACRS was the shortening and simplification of depreciation schedules applicable to general industry equipment and structures (Margalioth, 2008). With the enactment of the Tax Reform Act in 1986, ACRS was replaced by the Modified Accelerated Recovery System (MACRS). Significant modifications, generally less favourable to taxpayers, were made to ACRS. The most important alteration was the lengthening of depreciation schedules for certain assets (Givoly and Hayn, 1991). Even though MACRS offered less-generous depreciation rules compared to ACRS, some accelerated depreciation aspects were still apparent. First, MACRS assigned the salvage value to zero (Kranz and Worrel, 2001). Second, the application of the half-year convention allowed taxpayers to take one-half of the total depreciation allowance for the year of purchase, even if the depreciable asset was purchased late in the year (Margalioth, 2008). Third, the 200% declining balance

method with switchover to straight-line was applied to assets with short useful lives, while the 150% declining balance methods was applied to assets with longer useful lives (Kranz and Worrel, 2001). MACRS is still in effect.

The stimulus that post-war accelerated depreciation provisions gave was evident in a number of sectors. These provisions fundamentally altered the economics of real estate development in the United States. Since accelerated depreciation mostly affected newly-erected business buildings, compared with alternatives such as renovation of existing structures, there was an explosion in the number and the size of shopping centres and other new commercial constructions, beginning the late 1950s and gathering momentum throughout the 1960s (Hanchett, 1997). The same conclusion could be drawn with regard to the steel industry. By the mid 1960s, it had replaced many of its open-heart furnaces with the much more efficient basic oxygen furnace, and was able to produce improved steel (Prechel, 1990). According to Prechel (1990), this resulted from the incentive provided by the accelerated depreciation provision incorporated in the Revenue Act of 1962. Accelerated depreciation allowances also contributed to a significant increase in the steel industry's rate of reinvestment during the late 1980s.

Changes in tax policy, including the introduction of shortened tax lives and accelerated depreciation, had a positive impact on the investment of equipment and structures in the agricultural sector, during the period from 1955 through 1978 (Halvorsen, 1991). The stimulus that post-war accelerated depreciation measures gave to the rate of technological advance was also notable, especially in the 1981 tax reform with the R&D tax credit and accelerated depreciation incorporated (Boskin, 1988). Unfortunately, these R&D incentives were severely restricted by the 1986 tax reform (Boskin, 1988).

The situation for rate-regulated firms was different. In more than one case, the regulatory authority insisted that any reduction in current tax payments (from the use of accelerated depreciation deductions) should be treated as an increase in earnings, thereby making it possible to reduce permitted rates, and thus transferring some of the benefits of accelerated depreciation to present customers (Connecticut Public Utilities Commission Docket, 1969). As a result, there was a conflict between regulatory bodies and certain utilities (e.g., AT&T) that would have liked to use accelerated depreciation as a source of working capital (Linhart, 1970).

Furstenberg and Malkiel (1977) argue that the post-war accelerated depreciation provisions were biased in nature, thereby leading to tax inequity. The 1950s and 1960s provisions discriminated against investment in maintenance and repairs relative to investment in new facilities (Broadway, 1978). This discriminatory feature resulted in the reduction in the market value of old capital (Kotlikoff, 1983; Auerbach and Kotlikoff, 1987). The 1981 ACRS discriminated against owner housing and favoured rental housing, thereby increasing rental housing relative to owner housing (Berkovc and Fullerton, 1992). The opposite result occurred when the MACRS was enacted in 1986, since it discouraged rental housing investment relative to owner-occupied housing (Poterba, 1992).

Another criticism was aimed towards the ADR system, which was believed to make tax accounting more complicated for the investor (there were over hundred distinct depreciation classes under ADR) (Auerbach, 1982). Added complexity could explain why many smaller businesses failed to adopt ADR, even several years after its introduction, and also continued to use straight-line depreciation. Although ACRS fixed the problem pertained to the ADR, its revenue losses were large by historical standards (Auerbach, 1982). Indeed, Congress passed significant tax increases in both

1982 and 1984, largely in reaction to the revenue losses from the 1981 tax reform (Aurbach and Slemrod, 1997).

Hall and Jorgenson (1967), Sinai and Eckstein (1983), Makin (1984), Sahling and Akhtar (1984), and Boskin (1988) concluded that accelerated depreciation was quite effective in stimulating additional investment in the United States in the post-war years. However, contrasting opinions were expressed by Eisner (1969), Coen (1969, 1972), and Auerbach and Hassett (1992). There are several possible explanations for these contrasting findings. First, these empirically-derived results were based on different assumptions made regarding the value of the elasticity of capital stock with respect to the cost of capital (Boskin, 1988; Margalioth, 2008). Second, standard econometric policy evaluation may be misleading (Lucas, 1976). Third, many factors other than taxes influence investment, including the firm's liquidity, the price of investment goods, interest rates, tax rates, the nature and course of a recovery, and expectations about future economic activity (Boskin, 1988; Margalioth, 2008).

5.3.2. United Kingdom

The British Income Tax Act of 1945 introduced the initial allowance for plant, machinery, shipbuilding, buildings, and mining work (Barrit, 1959). In addition, an investment allowance was introduced in 1954 (Williams, 1966). Rates at which initial and investment allowances were granted and the classes of assets affected were altered several times during the period 1945-1970 (Williams, 1966; Boatwright and Eaton, 1972). Both schemes were rescinded and reinstated several times during the same period (Rozen 1963; Boatwright and Eaton, 1972). The United Kingdom also used a traditional depreciation method called 'writing down allowance' (Barritt, 1959), which was granted on a declining-balance basis. In other words, a constant percentage of the consecutive written-down value of the asset could be written off against tax. The absolute value of the allowance would therefore fall year by year. Surprisingly, the ordinary straight-line method of depreciation was permitted after the traditional writing-balance system.[7] In 1970, a new system of accelerated depreciation payments was developed (Boatwright and Eaton, 1972). Under this, firms were granted initial allowances of 35%, and annual writing-down allowances of 25%. These rates were larger than those of the previous system.

Based on a number of independent surveys, Williams (1966) held that investment decisions were materially affected by favourable changes in investment and initial allowances. He noted, however, that the impact of these provisions was much greater on large firms than on small ones, and also much greater on growing firms. Williams's view was supported by a subsequent empirical study of Fieldstein and Flemming (1971), who used a generalized neoclassical investment function (originally developed by Jorgenson in 1963 and 1965) to assess the effects of tax policy on investment in Britain during the period from 1954 to 1967 and found significantly positive result.[8]

[7] The situation was often reversed outside Great Britain.

[8] Fieldstein and Flemming's model (1971) showed that both the accelerated depreciation allowances and the use of differential taxation to induce the retention of corporate profits had substantial and significant impacts on investment behaviour. Simulations with their investment equation showed that the increases in depreciation allowances accounted for approximately 45% of net capital accumulation in the period after 1954.

5.3.3. France

Accelerated depreciation provisions were first used in the early 1950s. A double depreciation allowance was permitted in the first year, together with a 10% special initial allowance, was applied to machinery and certain types of equipment (Barritt, 1959). Beginning in 1953, steelmaking and mining concerns were allowed to add a supplementary depreciation allowance, based on their rate of turnover, to the regular rate of depreciation. During 1957-1959, recognized export firms were allowed to take additional depreciation allowances varying with the importance of their export business. In 1959, the use of the declining-balance method of depreciation in lieu of the straight-line approach was introduced. The declining-balance rates varied with assets' estimated service lives (Tabatoni, 1967). There was also a special 50% initial allowance in the first year for the purchase of buildings, materials, and equipment devoted to research. This was regarded as advantageous to companies setting up research facilities whose equipment had a high rate of obsolescence (Tabatoni, 1967), though this provision was eliminated when the declining-balance method was introduced. A special initial allowance was also given to firms that had research undertaken by a specialized company. These firms were permitted a special depreciation allowance of 50% in the first year for the purchase of shares in an approved research concern. This remained valid for shares purchased since 1960. In addition to accelerated depreciation provisions, an optional system allowed the historic cost and the depreciation allowances to be multiplied by an index factor to bring the cost and allowances into terms of current value (Barritt, 1959). This optional system, instituted in 1955, was applied to capital investment made before 1955.

Although business investment in France rose at a very striking rate during the post-war period, Tabatoni (1966) argued that it was due to the value-added taxation system developed in 1954, not provisions permitting accelerated depreciation. Tabatoni found that a large number of firms did not elect to take advantage of various accelerated depreciation provisions. Many firms were afraid of tax increases during the deceleration phase, or a drop in bank credit, or any other factor likely to create financial difficulties in the future. Some firms chose to postpone depreciation in order to offset against their present inadequate gross income. When their stock is traded on an exchange, firms might have to show a sizeable net income and therefore elect not to claim all their depreciation allowances. Some firms also preferred to have substantial depreciation in advance of large borrowing. A similar conclusion was drawn regarding the effectiveness of the provision that permitted the revaluation of depreciable assets. Among larger firms, the failure to take advantage of this privilege was attributable to the fact that the increase in reserves from revaluation made the firm more vulnerable to the demands of shareholders, associates, and even employees. The limited use of this provision among small businesses was due to ignorance, the complexity of the system and the expense it entailed, and the fact that the tax on revaluation reserves might constitute a financial burden.[9]

5.3.4. The Netherlands

Accelerated depreciation in the Netherlands took the form of the initial allowance (Goedhart, 1966). In 1949, special accelerated depreciation arrangements were given to buildings, motor cars, and office equipment (Barritt, 1959). The precise amount of the initial allowance was changed repeatedly. Taxpayers were originally allowed to

[9] Under the revaluation provision, as a rule, revaluation profits were exempted from profits taxes but a tax of 3% was imposed on the reserve.

write off one-third of the cost in the first 5 years; in 1960, the figure ranged from 0% on passenger cars to 6% on new factories, and 8.33% on certain other means of production (Goedhart, 1966). Investment allowance was added in 1953, which permitted firms to write off 4% of the cost of new durable production facilities for 5 successive years (Barritt, 1959). In addition, the Dutch government, in 1950, instituted a revaluation system to certain types of assets purchased before the war and still in use, so as to take account of inflation. Depreciation allowances were then calculated from the inflated cost, rather than the original cost.

In his analysis of the role that tax policy played in promoting post-war economic growth, Goedhart (1966) concluded that the increase in investment activity in the Netherlands since the war was positively influenced by various tax regulations favouring the use of retained profits for investment purposes, one of which was accelerated depreciation.[10] Tempel (1966) supported Goedhard and maintained that these tax incentives solved the previous uncertainty problem about future possibilities and hesitancy to venture large investments and, as a result, resulted in the general increase in the level of investment. Hoorn Jr. (1966), however, was not as optimistic and claimed that the scheme only encouraged investment in existing businesses. He also wondered whether a generally lower level of taxation could accomplish the same task and give private investors freedom to make their own investment choices.

Barritt (1959) has pointed out that excessive investment activity during the 1950s contributed to the nation's rapid growing inflation during that period. During the mid-1950s, the Dutch government became concerned about growing inflation. This was why several generous accelerated depreciation provisions were subsequently restricted or withdrawn (Barritt, 1959). In 1955, the initial allowance for plant was reduced, and in 1956, investment allowance was withdrawn (Barritt, 1959).

5.3.5. Sweden

As previously stated, the free depreciation system was repealed in 1955 owing to inflationary pressure. The system was replaced by a new accelerated depreciation scheme called 'book depreciation' (Muten and Faxen, 1966). This was considered less generous in many ways, e.g., there were restrictions placed on the maximum depreciation allowance for machines with a useful life of more than three years. The system was designed to furnish the Swedish government with a better tool against the inflation that followed from the excessive level of investment caused by the free depreciation system (Muten and Faxen, 1966). Book depreciation allowed all business firms to choose between a 20% straight-line depreciation and a 30% declining-balance formula, which enabled them to write off slightly more than half of the cost of a machine during the first two years of its life (Muten and Faxen, 1966). The right was also given to switch from 30% declining-balance rate to a 20% straight-line method, if the former system's written down value had been used from the outset. The right to change the method became advantageous in the fourth year (Barritt, 1959).

Even though the taxpayer had to raise more money in the first year of investment under book depreciation than he was required under free depreciation, Muxen and Faxen (1966) contended that there was no significantly difference between the two systems regarding the degree of investment incentive that they gave. The new system still implied substantial amount of tax deferral because normal useful lives of assets were generally very long (usually 25 years). Sandels (1966), however, noted that tax

[10] Figures provided by the Central Bureau of Statistics indicate that the volume of gross private investment increased every year during the period that these tax regulations were effective.

deferral from accelerated depreciation might impair the free flow in the market of businesses as going concerns. This led Sandels doubt whether liberalizing deferral rules was more advantageous than lowering the corporate tax rate with respect to encouraging investment.

5.3.6. Italy

Here, accelerated depreciation took two forms: shortened service life and initial allowance (Forte, 1966). The shortened service life, introduced in 1951, reduced the period of depreciation by not more than two-fifths in the case of new facilities, or where existing facilities were transformed, reconstructed, or improved. This was the first liberalization of the depreciation provisions in the Italian law that, up to that time, had been quite restrictive and only permitted the straight-line method. The initial allowance, adopted in 1956, granted initial allowances of 10%, which might be spread over 3 years, in addition to the accelerated depreciation allowances under the former system (Forte, 1966). In 1963, the initial allowance was increased to 15% (Forte, 1966). In addition to accelerated depreciation provisions, a revaluation system was adopted before 1953 to revalue assets purchased before 1947 (Barritt, 1959). The re-valued cost of the asset was then used as the depreciable base.

Forte (1966) criticized the initial allowance system (adopted during 1950s) as inequitable; in particular, the rule limiting the allowance to a stated percentage of reported income discriminated against growing enterprises and favoured very large ones. Forte did not attempt to assess accelerated depreciation's effectiveness in spurring investment. He suspected, however, that the rule's limitation diminished the system's impact. His argument is supported by a fact that increases in the level of investment during the 1950s were greatest in the heavily industrialized sections of northern Italy, but investment in agriculture was lagged. This could have been due to the selective nature of the provision.

One might argue that Italian accelerated depreciation provisions, even though inequitable, still did their job of spurring investment in targeted industries. However, the high level of investment in these industries might have been caused by other stimulating measures, e.g., tax exemptions and tax reductions were also provided during the same period.

5.3.7. Germany

The then West Germany introduced a wide variety of accelerated write-off measures and specific provisions that permitted the retention of a major portion or of all profits before taxes. The most important was the Asset Revaluation Law of 1949, which permitted revaluation of all assets to the 1948 cost level and reactivation of written-off items, even though still in use, or assets lost by war action at one-third of their 1948 replacement cost (Wertheimer, 1958; Barritt, 1959). The Income Tax Laws of 1948 and 1949 permitted the fast write-off for replacement of assets lost during the war (Wertheimer, 1958). In 1950, rapid write-off provisions for defence plants were permitted in case of emergency (Wertheimer, 1958) while, in 1951, substantial accelerated depreciation allowances were provided in certain basic goods industries (e.g., coal, iron, steel, electricity, gas, etc., and essential foods) where prices were still controlled (Hauser, 1966). This involved permitting one-half of an investment in machinery and one-third of that in a plant to be written off in three years. For other sectors, a shift from the straight-line depreciation to the declining balance method of depreciation at 2.8 times the straight-line rate was permitted in 1952 (Wertheimer, 1958). In 1971, special depreciation allowances were permitted on ships ordered in or

after 1971 (Ademuni-Odeke, 1984). The cumulative amount of special depreciation was originally up to 30% of the ship's acquisition costs.

Hauser (1966) pointed out that accelerated depreciation provisions played an important role in recovering the country's economic collapse after the Second World War. He noted that accelerated depreciation provisions of the late 1940s and early 1950s were successful in overcoming bottleneck industries and stimulating capital goods industries. Furthermore, he estimated that nearly 3 billion DM were invested as a direct result of the benefits provided. This accomplishment reinforced the boom and spurred growth, but also resulted in overcapacity in some industrial sectors (which contributed to a slowing down of growth by 1958). Hauser's positive view was shared by Wertheimer (1958), who estimated that tax incentives for investment, including accelerated depreciation, provided 93.5% of all business expenditures on fixed assets and inventory changes from 1950 to1955. Senf (1966), however, contended that a more rigorous analytical and empirical way was required in order to draw a valid conclusion regarding the impact of special investment-stimulating measures. Neumark (1966) also expressed his agreement with Hauser's view. Nevertheless, he called particular attention to the inequalities to the complexities in the nation's growth-promoting tax policies. In particular, they were extremely complicated and therefore only the wealthy who could afford highly specialised tax consultants could take full advantage of the system.

5.3.8. Japan

Many special provisions for accelerated depreciation were introduced after the enactment of the Shoup Mission of 1949-1950, which proposed a radical reform of Japan's taxation system (Kaizuka, 1992). In 1950, a revaluation system similar to those permitted in Western European countries was provided in view of war and post-war inflation (Komiya, 1966). The list of useful lives for each type of fixed asset was reviewed in 1951 and in 1962. Accelerated depreciation for important industrial equipment was permitted in 1951, with additional initial depreciation for important industries introduced in 1952 (Kaizuka, 1992). Initial allowances for equipment embodying new technology were given in 1958, while accelerated depreciation for equipment for SMEs was given in 1963(Kaizuka, 1992).

Accelerated depreciation was also apparent in Japanese export industries. From 1961 to 1972, firms were allowed accelerated write-offs for equipment if they raised the proportion of their businesses from exports above the previous year's level (Kaizuka, 1992). In 1967, the initial depreciation on machinery and equipment used for the prevention of environmental pollution was increased in 1967 (Ishi, 2001). During the 1970s, the trend towards expanding accelerated depreciation provisions began to slow down. Accelerated depreciation for export industries was abolished, while the increased initial depreciation for important industries was reduced (Ishi, 2001).

Komiya (1966) questioned the selective nature of the accelerated depreciation system of the 1950s; in particular, that the particular industry or type of machinery and equipment eligible for accelerated depreciation was left to the discretion of the Minister of Finance. He argued that i) only large firms could cope with such complicated administrative procedures and ii) that, as a consequence, the stimulus effect was undermined. In addition, even though some of the desired effects were achieved, they were gained at the expense of tax equity (Komiya, 1966). A different view was expressed by Hara (1966) and Yasui (1966), who argued that the largest part of the new investment in Japan was achieved by the application of accelerated

depreciation. They believed that the selective nature of accelerated depreciation was appropriate because industries eligible for the provisions were to contribute to the modernization of Japanese industries and the advancement of new technologies and contended that accelerated depreciation is less inequitable than other tax laws in stimulating investment. Komiya's view, however, was supported by the subsequent studies of Hayashi (1985) and Homma et al. (1989), who used an econometric model called Tobin's q to provide evidence that, during 1956-1970, the contribution of tax incentives (accelerated depreciation included) in promoting investment were limited. Hayashi and Homma et al. argued that a high level of investment was caused by a high expected rate of return, and not necessarily a lower cost of capital as a result of tax incentive schemes.

5.3.9. Australia

The most notable form of accelerated depreciation in Australia during the post-war period was the '5/3' depreciation system (Reinhardt and Steel, 2006). This system permitted eligible assets, which could otherwise be depreciated at a rate in excess of 20% using a straight line method, to be written off at a rate of 33.33 % (three-year write-off). It also permitted eligible plants, which could otherwise be depreciated at a rate of 20% less, to be written off at a rate of 20% (five-year write-off). It was believed that 5/3 depreciation provided a significant incentive to invest in the modernisation of Australian industry (Network Economics Consulting Group, 2002). 5/3 depreciation arrangement was gradually wound back in the 1980s (Reinhardt and Steel, 2006).

In the Australian shipping industry, an accelerated depreciation allowance of 20% per annum was introduced in 1984 (Gillies and Cleworth, 2008). This rate was an increase from the previous rate of 6.25%. Ships qualifying for the provision could be written off over 5 years—significantly shorter than their actual economic life. The provision even allowed ship owners to begin claiming depreciation in the year *before* the commissioning of the ship. In practice, the vessels were usually depreciated over four years, 40% in the first year and 20% in each of the following three years. In the late 1980s, this scheme was extended for an additional five years, as a result of recommendations by the Shipping Reform Task Force (Bureau of Transport and Communications Economics, 1997). This scheme was argued to make Australian coastal shipping more cost-competitive vis-à-vis foreign ship and land transport operators (Gillies and Cleworth, 2008).

Accelerated depreciation was also evident in the Australian natural resource sector. Some capital expenditure in the mining and petroleum sector, including natural gas pipelines, was allowed to be written off over ten years, even though actual life might exceed fifty (Department of Minerals and Energy, 1999). The scheme is regarded as positively affecting international competitiveness and investment attraction of these capital-intensive parties, since most other countries provide tax benefits for certain capital expenditures (Queensland Government, 1999). Arguments could be made that there are possible externalities associated with the investment made from these industries such as technology spin-offs and the importance of high quality infrastructure in attracting further industry (Review of Business Taxation, 1999).

Following a review, the Commonwealth Government decided to abolish various accelerated depreciation arrangements in return for a revenue neutral reduction in the company tax rate. Depreciation rates have then been aligned to the effective life of the asset (Department of Minerals and Energy, 1999). This change was aimed at

removing tax-induced distortions to investment decisions and substantially funding a reduction in the corporate tax rate (Reinhardt and Steel, 2006).

The Queensland Government submitted that the decision to scale back accelerated depreciation provisions would adversely affect the incentive to invest in mining, manufacturing and some infrastructure provision industries which were principal beneficiaries of existing accelerated depreciation provisions. The decision would shift the allocation of investment from major long-term resource projects, particularly in mining, to projects with a shorter life (Queensland Government, 1999), thus posing a serious threat to regional development and employment. More recently, the shipping industry blamed the changes for contributing to the underutilization of coastal shipping in Australia, and for preventing the industry from re-equipping with more advanced (and cleaner) vessels (Maritime Union of Australia, 2008; Gillies and Cleworth, 2008).[11]

Despite the changes, accelerated depreciation provisions remain in force for assets constructed or acquired before September 1999 (Network Economics Consulting Group, 2002). However, its benefit arising from tax deferral has been somewhat reduced by the new approach to taxation in tariffs for rate-regulated firms. These firms are usually the owners of infrastructure assets. The most obvious examples include assets pertaining to electricity, natural gas, rail, telecommunications, and water networks. In exchange for access to their networks, infrastructure owners are paid transmission tariffs in amounts mandated by independent regulatory agencies, such as the ACCC in Australia (Johnstone, 2003). The new taxation approach (proposed by the ACCC in 2000) involves adjusting the permitted tariff for regulated natural gas pipelines downward that have the effect of transferring to pipeline customers the full benefits of accelerated taxation depreciation (ACCC, 2000). This system thus cancels out the investment incentives intended through accelerated depreciation (Network Economics Consulting Group, 2002).

5.4. The Green Taxation Era

Recently, accelerated depreciation provisions were proposed in many parts of the world as part of environmental-based tax programs. These aimed to control carbon emissions resulting from industrial production and were supposed to encourage businesses to replace carbon-intensive equipment with environmentally friendly equipment that would reduce emissions. Accelerated depreciation schemes are found in a number of countries.

In the United States, the Emergency Economic Stabilization Act of 2008 contains a number of depreciation incentives for increasing energy efficiency (Cudd and Jewett, 2008). The Act permits accelerated depreciation for smart electric meters and smart electric grid systems. Taxpayers are allowed to recover the cost of this property over 10 years, unless the property already qualifies under a shorter recovery schedule. The Act also permits accelerated depreciation for purchase of equipment used to collect, distribute, or recycle a variety of commodities (Cudd and Jewett, 2008). In Canada, an accelerated depreciation provision has been put in place to allow taxpayers an accelerated write-off (at a rate of 30%) for specified energy efficiency and renewable energy equipment. Such equipment can be depreciated at annual rates of between 4% and 20% (Department of Finance Canada, 2004). The program also allow the costs of pre-feasibility and feasibility studies, negotiation costs, site

[11] The average age of Australian flagged ships is significantly older than the world fleet average (Gillies and Cleworth, 2008).

approval costs, etc., to be subject to accelerated depreciation (Government of Canada, 1998).

A similar scheme was introduced by the Dutch government in 1991 (Green Tax Commission, 2001). This scheme has provided companies the freedom to choose how to write off the costs of investing in such equipment, although it is only applicable for equipment specified on an environmental list updated by the Ministry of Environment. The list includes equipment pertaining to mitigating water pollution, soil pollution, waste, and noise, etc. that has not yet been widely accepted, has no negative side effects, and has the potential for a substantial market. Costs associated with obtaining advice on the purchased machinery are also subject to accelerated depreciation (McKane et al. 2007). In Singapore, companies investing in energy-efficient equipment are permitted to write-off the capital expenditure in one year (McKane et al., 2007). However, unlike the Netherlands and Canada, expenses related to acquiring information or consultant fees for identifying and analysing the equipment purchase are not subject to accelerated depreciation. An environmental rationale has also been put forward in Japan. Since 1993, an accelerated depreciation allowance equal to 30% of the acquisition cost has been available for investments in specified environmentally friendly equipment (Anderson, 2002). From 2005, Mexican investors were allowed to deduct up to 100% of the investment in the first year for approved renewable energy technology projects (defined under the General Law for Ecological Equilibrium and Environmental Protection). According to the regulation's guidelines, equipment shall remain in operation at least five years following the tax deduction (Econsense, 2008).

Given the recent nature of these schemes, it is difficult to assess their overall impact on environmentally friendly investment. There are, however, a few theoretical studies indicating their effectiveness in promoting investment in clean technologies. For example, the case study of a Brazilian chemical plant by Soares et al. (2005) illustrates that an accelerated depreciation scheme could increase the expansion of Combined Heat and Power (CHP) plants in Brazil by 24%. The authors conclude that the scheme is costly to government, yet induces technological advancement and improves the feasibility of ventures that would not otherwise have taken place. A similar result is found in Kranz and Worrell's study (2001), which investigates and compares several depreciation methods to assess the effectiveness of possible policy measures with respect to the depreciation schedules for investments in CHP plants in the United States.

6. Discussion: Moving Towards Carbon-Constrained Economies

The general conclusion from the theoretical literature is that accelerated depreciation positively influences the investment decisions of firms by lowering a tax obstacle. However, empirical results have been mixed across different contexts. Studies of the effect of accelerated depreciation provisions in the same place and approximately at the same time have led to conflicting results, e.g., the debate between Hall and Jorgenson (1967) and Coen (1969). This suggests that it is very difficult to estimate, with confidence, the part played by accelerated depreciation in influencing new investment or replacement decisions. In reality, re-equipment or expansion plans may be guided by non-tax factors. Nonetheless, it is not unreasonable to assume that accelerated depreciation does create an expansionist atmosphere. In many cases, this expansionist atmosphere has spurred investment in eligible sectors. There is some historical evidence suggesting that the expansionist atmosphere associated with accelerated depreciation led to an increase in technological investment, e.g., the steel

industry in the United States, and the fast growth in technological advancement in Japan post-war (see Section 5.3). Nevertheless, an in-depth analysis of the extent to which accelerated depreciation influences technological investment is still required to prevent ill-conceived decisions relating to taxation.

Investment can be stimulated by other measures such as a reduction in taxes or interest rates. Accelerated depreciation, of course, has the advantage of being more selective since the benefits are restricted to those who acquire eligible assets. This was the case in Japan, where accelerated depreciation was permitted for certain types of investment necessary for modernizing Japanese industries (Komiya, 1966). This discriminatory feature was reasonably effective in bringing about the conspicuous modernizing of Japanese industrial equipment (Hara, 1966; Yasui, 1966). In the current situation, where increased attention is being paid to an overall reduction in carbon emissions, the selective aspect of the scheme can be used to encourage firms to invest in cleaner and less environmentally intrusive technologies. As discussed in the previous section, this has already started to take place in various nations.

Despite this, the biased nature of accelerated depreciation has an important drawback. In general, accelerated depreciation tends to favour firms that normally make long-term investment over those that usually undertake short-term investment, since the latter can be written off quickly even without changes in the depreciation rule (Cary Brown, 1962). It thus tends to discriminate in favour of well-established firms. New firms, whose income is likely to be negative, will most likely *not* find tax benefits from accelerated depreciation all that attractive (Williams, 1966). This has been the case in Japan and several European countries (see Section 5.3). The United States' use of accelerated depreciation, which favoured new capital by lowering the present value of taxes, left old capital at a tax disadvantage, which caused the market value of the old capital to fall (Kotlikoff, 1983; Auerbach and Kotlikoff, 1987). This naturally means little for growing firms; but for static firms possessing a lot of old capital, accelerated depreciation devalues their equipment. Its selective nature may thus result in political pressure from opponents, especially those who cannot access the scheme's benefits, and those who will lose from it.

Tax inequity can have serious political repercussions. For example, fairness was part of the reason why the United States' ACRS was restricted in 1986 (Auerbach and Slemrod, 1997). At the time, it was argued that tax fairness would be improved by the combination of rate reduction, base-broadening and the elimination of special preferences, e.g., those tied to accelerated depreciation (Auerbach and Slemroad, 1997). This would suggest that proponents of the scheme must find ways to rationalize its enactment so as to reduce the political strain and engender bipartisan support. In the environmental field, assuming that no ETS is operating, firms relying on older equipment may request justification for why they are at a tax disadvantage if accelerated depreciation laws were passed. The biased aspect of accelerated depreciation thus leads to an interesting future research question: what is a fair way of implementing the scheme in order to promote investment in environmentally friendly technologies?

Despite political pressure, it could still be concluded that the adoption of accelerated depreciation to encourage investment in innovative 'green' technologies would be difficult to argue against since benefits would be distributable to almost everyone in the community. With the increasing enactment of emissions trading schemes, accelerated depreciation would make it easier for firms using cleaner technology to compete in a carbon-constrained business environment, thus leading to a competitive advantage for nations introducing accelerated depreciation.

Accelerated depreciation, of course, does not always work as intended. There are clearly some lessons to learn in order to guarantee the effectiveness of these provisions as they pertain to encouraging technological investment. For example, Sweden provides historical evidence that it is possible for firms to abuse the provision, i.e., by undertaking bad investment projects for the sake of acquiring assets on which they could make use of accelerated depreciation for tax benefits. In the context of innovative technology, there is the danger that firms will acquire 'environmentally-okay' equipment for the sake of taking the privilege, rather than equipment (presumably more expensive) with class-leading credentials. This suggests a need for firm guidelines about what equipment's depreciation can be accelerated and what should not.

The historical examples make it clear that the extent to which accelerated depreciation provisions can have a positive effect depends largely on the extent of their use. However, this study indicates a number of constraints that may militate against firms' shifting from normal depreciation practice to accelerated methods. Depreciation accounting under accelerated depreciation methods is more complex than under the straight-line approach and involves greater administrative costs. For small companies or those with relatively small amounts of assets eligible for accelerated depreciation, the increase in compliance costs might outweigh the expected benefits. Administrative complexity was part of the reason why the United States' five-year amortisation allowance and ADR were not very successful (Brown and Patterson, 1943). This has also been the case in Japan, France and Germany, where only large firms could cope with the complicated administrative procedure of using the scheme (Komiya, 1966; Tabatoni, 1966). This has an important implication: make the scheme simple or not all firms will use it, thus negating its potential benefits.

The firm's accounting conventions may make it difficult to report income and costs to shareholders on a different basis from that used for tax purposes. The reported increase in depreciation deductions resulting from using an accelerated instead of straight line depreciation can lead to a reduction in profits before tax. This might reflect adversely, albeit inaccurately, on the firm's management. Accounting conventions were part of the reason why many French firms did not elect to adopt accelerated depreciation during the post-war years (Tabatoni, 1966), which suggests that the future adaptation of accelerated depreciation aimed at promoting environmentally technological investment requires clear government communication regarding the scheme's financial advantages.

Another factor preventing a firm adopting accelerated depreciation is the expectation of a change in marginal rates of tax. Accelerated depreciation yields less benefit if marginal tax rates are expected to be lowered (Ture, 1967). The inducement to adopt accelerated methods would thus be relatively weak for smaller firms if they expect marginal tax rates to decrease. Adopting accelerated depreciation can also prove problematic if marginal tax rates are expected to rise, as occurred in post-war France (Tabatoni, 1966). The impact is especially significant during the decelerated phase of the scheme, i.e., when depreciation deductions reduce and taxable income from the depreciable facilities rises. Smaller firms expecting an increase in income, and hence in marginal tax rates, might therefore wish to defer adoption of accelerated depreciation. To guarantee its efficacy in promoting investment in innovative technologies, the firms' expectation for a change in marginal tax rates demands consideration. The historical evidence suggests that it is best for the government to keep marginal tax rates unchanged.

Uncertainties surrounding the amount that would be allowed to depreciate and uncertainties surrounding when and how long the scheme would be implemented can also potentially deter the accelerated depreciation scheme's intended objective. This was the case in the United States, where uncertainties associated with accelerated depreciation were the most conspicuous factors contributing to the failure of the scheme during the introductory period (Brown and Patterson, 1943). Guidelines regarding the amount of allowance and the length of time of the allowance thus need to be given to potential investors in innovative environmental technologies. It would also be better, as Barritt (1959) contends, to create a greater atmosphere of confidence by introducing accelerated depreciation provisions with a reasonable guarantee of continuity, thus allowing forward planning.

Furthermore, accelerated depreciation may not offer significant investment incentive to rate-regulated firms, e.g., owners of electricity, gas, rail, telecommunications, and water networks. Some regulatory authorities have advocated that any reduction in current tax payments (from the use of accelerated depreciation deductions) should be treated as an increase in earnings, thereby making it possible to reduce permitted rates, and thus transferring the benefits of accelerated depreciation to present customers. As a result, the investment incentives intended through accelerated depreciation will be entirely negated. This occurred in the United States, where there was conflict between regulatory bodies using this transfer and utilities that would have liked to use the scheme as a source of working capital (Linhart, 1970). This has also been the case in Australia, where the ACCC proposed a new approach to taxation in tariffs for regulated pipelines involving adjusting the permitted revenue downward so as to transfer in full taxation benefits to consumers (Network Economics Consulting Group, 2002). If accelerated depreciation provisions were to be introduced to taxation law to encourage investments in innovative environmental technologies, the transfer of the benefit of accelerated deprecation to consumers sends an unfortunate signal to rate-regulated firms, which are also potential investors in these assets.

Considerations also need to be made regarding the costs that accelerated depreciation might produce. The scheme is obviously expensive to implement (e.g., the large revenue losses from the ACRS in the United States), and perhaps the government might be better off spending its tax revenue in other areas. A number of countries (e.g., Sweden, the Netherlands, and Canada) experienced rapid growing inflation from excessive investment activity, which was a consequence of permitting depreciation schemes that were too generous. Moreover, when substantial investments made under the accelerated depreciation begin to make their full contribution to the output of eligible sectors, overcapacity may occur and slow down the nation's economic growth. This was the case in Germany during the late 1950s (see Section 5.3). A review session thus needs to take place occasionally to evaluate the scheme's outcome and guard against unintended consequences.

Finally, it is important to note that taxation is only one of many factors that may restrain investment. This implies that accelerated depreciation alone may not be sufficient to assure a desired level of investment in cleaner technologies. This was always the case in every country surveyed. Indeed, accelerated depreciation is often *part* of the program to stimulate investment, not the primary mechanism. To encourage investment in clean technologies, there is a need to adopt other measures to support its use. Schemes involving a carbon emissions penalty obviously loom as important in this context.

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