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NOT SO FAST: HOW SLOWER UTILITIES REGULATION CAN REDUCE PRICES AND INCREASE PROFITS

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SUMMARY

Energy consumers are facing cost pressures from multiple directions. Wholesale natural gas prices have been climbing substantially from their record lows. Oil prices have only recently cooled slightly after reaching nearly $100 a barrel (WTI) earlier this year. That makes it that much more important to minimize costs to wholesale consumers of energy, and ultimately, retail buyers, wherever possible. There is little room in the energy network for unnecessary costs. But in a regulated system, profits for utilities must remain healthy, too, if we expect them to stay active in the market.

But the way that government agencies regulate oil and gas pipelines in Canada, and elsewhere, appears to be increasing costs beyond where they need to be in order to fairly serve both utilities and customers. By relying on traditional rate-of-return regulation models — which calculate price-rates based on the regulated firm's cost of capital (that is, how much it costs the company to finance its operations) — regulators, including the National Energy Board and the Alberta Utilities Commission, reward firms for over-investing in their operations, rather than reducing costs.

Utilities are motivated to prolong the period in which they can earn a return on their capital, since it is one of the few opportunities they have to increase profits under the widely used rate-of-return regulatory model. That results in utilities keeping assets on the books — and paying for them — longer than they might otherwise need to be. The end result is a distortion of the decisions made by regulated firms and higher prices for consumers than might occur under a different regulatory model.

Regulators that take a more passive role in setting the rate of return for their client industries, however, are likely to see their idleness pay off. Firms with a freer hand to do so will seek to accelerate the depreciation of capital assets, reducing costs more quickly. The result may see end-consumers pay more in the short term, but substantially less over the long term.

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ÉLOGE DE LA LENTEUR DANS L'APPLICATION DE LA RÉGLEMENTATION DANS LES SERVICES PUBLICS

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RÉSUMÉ

Les consommateurs d'énergie sont confrontés de toutes parts à une hausse des coûts. Les prix de gros du gaz naturel ont augmenté substantiellement par rapport aux plus bas niveaux jamais atteints. Ceux du pétrole n'ont légèrement fléchi que tout récemment après avoir frôlé les 100 $ le baril de WTI plus tôt cette année. Ainsi, il est de toute première importance de réduire autant que possible les coûts pour les consommateurs d'énergie en gros et ultimement, pour les acheteurs au détail dans la mesure du possible. Il y a peu de place dans le réseau d'énergie pour des dépenses inutiles. Mais dans un système assujetti à une réglementation, les profits des services publics doivent demeurer suffisants si nous souhaitons que ceux-ci demeurent actifs sur le marché.

Toutefois, la réglementation par les organismes gouvernementaux des pipelines de pétrole et de gaz au Canada et ailleurs semble faire augmenter les coûts au-delà de la limite qui permettrait de répondre équitablement aux besoins des services publics aussi bien que des consommateurs. En tablant sur les modèles traditionnels de réglementation fondés sur les taux de rendement — à l'aide desquels les prix sont calculés en fonction des coûts en capital des entreprises réglementées (c'est-à-dire ce qu'il en coûte à une entreprise pour financer ses activités) — les organismes de réglementation dont l'Office national de l'énergie et la Alberta Utilities Commission, récompensent les entreprises qui investissent à outrance dans leurs opérations au lieu de réduire leurs coûts.

Les services publics sont motivés à prolonger la période durant laquelle ils peuvent obtenir un rendement de leur capital, car c'est l'une des seules occasions qui se présentent de pouvoir augmenter leurs profits dans le cadre du modèle réglementaire largement utilisé, axé sur le rendement. C'est ainsi que les services publics maintiennent leur actif dans les livres — et qu'ils en assument le coût — plus longtemps que nécessaire. En fin de compte, ce modèle réglementaire incite les entreprises qui y sont assujetties à prendre des décisions faussées se traduisant par des prix plus élevés pour les consommateurs.

Les organismes de réglementation qui optent pour un rôle plus passif dans l'établissement du taux de rendement de leurs industries pourraient bien y trouver leur compte. Ainsi, les entreprises qui n'auraient plus les mains liées pourraient accélérer la dépréciation de leurs immobilisations et réduire plus rapidement leurs coûts. Le prix pour le consommateur s'en trouverait accru à court terme, mais diminuerait sensiblement à long terme.

† L'auteur souhaite remercier des lecteurs anonymes pour leurs commentaires utiles.

1 INTRODUCTION

Improper economic regulation of public utilities can increase the costs faced by consumers, taxpayers and regulated firms. Exact measures of the increased costs resulting from regulatory inefficiencies are difficult to present objectively since appropriate benchmarks are often unobservable. But existing literature has shown that regulatory reform can lead to significant financial gains for regulated firms and consumers.[1]

Economic regulation in North America generally follows the rate-of-return model.[2] Given that the use of this model is deeply entrenched in both legislation and institutional practice, an important policy question is how best to implement the existing regulatory model. Even without changing the underlying structure (which would prove difficult given its entrenchment), adjustments can be made to increase the market efficiency and the financial security of regulated firms.

Specifically, I argue that in healthy regulated markets, the regulator should encourage accelerated depreciation whenever possible. This will reduce the average cost of capital faced by a regulated firm and allow for lower regulated prices. I show that an effective method to encourage accelerated depreciation is for the regulator to be less active in its application of the rate-of-return model. A passive regulator can encourage the regulated firm to reduce its own costs, increasing the size of the financial pie shared by the regulated firm and its consumers, while simultaneously making sure everyone gets a bigger slice.

In declining markets (where the demand for a utility's services is expected to disappear in the near future), the identification of a general policy prescription is somewhat elusive; however, I also suggest more specific advice to regulators and firms operating in such a market.

This paper is organized as follows: Section 2 provides a brief overview of the generally accepted rationale and goal of economic regulation. Section 3 provides an overview of the common and entrenched rate-of-return model of regulation. Section 4 discusses the undesirable effects influencing a regulated firm's input decisions utilizing graphical methods and simple analysis. Section 5 includes hypothetical cost and profit calculations to exemplify the discussion and more directly motivate policy implications. Finally Section 6 concludes with a policy overview.

2 THE RATIONALE AND GOALS OF ECONOMIC REGULATION

While there are some academics with dissenting opinions (specifically those following Stigler's development of capture theory)[3] most regulators believe they regulate "in the public interest." The public interest in this case refers to the regulator's ability to influence the actions of a regulated firm in order to make society as a whole better off.

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[1] Joseph Doucet and Stephen Littlechild, "Negotiated settlements and the National Energy Board in Canada," Energy Policy 37, 11 (2009); Stephen Littlechild, "The Bird in Hand: stipulated settlements and electricity regulation in Florida," *Utilities Policy* 17, 3–4 (2009).

[2] In conventional usage the term "rate of return" refers to the ratio of revenue or income generated by an investment and the total value of that asset. The rate-of-return model of economic regulation is explained in detail in Section 3 of this paper.

[3] George J. Stigler, "The Theory of Economic Regulation," *The Bell Journal of Economics And Management Science* 2, 1 (1971): 3-21.

In competitive markets, we leave it to the existence of multiple firms to constrain each other's actions. Think of a mall food court with two restaurants: Jen's Burgers and Michael's Hot Dogs. If Jen's Burgers substantially raises its prices, this would hurt consumers if there were no close substitute. However, the existence of Michael's Hot Dogs acts as a constraint on the price that Jen's Burgers can charge before too many consumers substitute burgers with hot dogs. Most retailers operate in a market with some degree of competition and directly respond to changes in a competitor's price. Perfect examples are found in the actions of retail gas stations that will almost immediately lower their own posted price in response to a price change by a rival. In general, more firms mean more substitutes and lower prices for consumers.

Now think of the pipeline-services market between Edmonton and Vancouver. If Trans-Mountain pipeline is the only large oil pipeline joining these two cities, it can raise its price and any company that wants to ship oil from Edmonton to Vancouver will be forced to pay more and/or ship less.

If such a price increase leads to a lower demand for the good or service, some consumers who would have benefited from consumption (where their value of the good or service exceeds its cost of production) will forgo consumption and the economic benefit of the transaction is lost. This "dead-weight loss" represents a lost economic opportunity; neither the producer nor the consumer benefits from a transaction that would have produced positive economic values. Other ethical and moral considerations also increase the regulator's incentive to intervene, since regulators often feel they have a duty to protect consumers from excessive prices.[4]

We might think that an effective policy to counter this monopoly problem would be to encourage competitors to enter the market (as in the food-court example). However, most public utilities and large-scale pipelines can be defined as "natural monopolies." A natural-monopoly industry is one in which a single firm is able to supply the entire market at a lower total cost than multiple firms can. The introduction of a competing firm in a natural monopoly industry would needlessly duplicate costs and would increase the average cost, and potentially the market price, of the service being provided.

Jen's Burgers and Michael's Hot Dogs act as constraints on each other's pricing behaviour, but natural monopolies are free from competitive constraints and will generally find it profit-maximizing to charge high prices, thus reducing the number of consumers who are willing to purchase the good or service and damaging the remaining consumers that do make a purchase.

Economic regulation is a means to impose external constraints on the prices charged by natural-monopoly firms. A regulator steps in to limit a firm's price in an effort to mimic the efficiency of a more competitive market. The regulated firm needs to receive enough revenue to cover its costs, but the regulator also has a duty to ensure that prices are kept low.

Jurisdictions where the rate-of-return model is employed include the National Energy Board, for Canadian inter-provincial pipelines; the Alberta Utilities Commission, for Alberta intra-provincial pipelines; the Federal Energy Regulatory Commission, for U.S. inter-state pipelines; and the Florida Public Service Commission, for Florida's electricity generators (just to name a few).

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[4] Article 62 of the National Energy Board Act calls for regulation to produce "Just and Reasonable Tolls."

All of these utilities are regulated in order to constrain the monopoly behaviour of firms, but the practice is especially important in Canada, as this country is the sixth-largest oil-producing country in the world and the third-largest natural-gas producer. Almost all of the oil and gas produced in Canada flows through the regulated pipeline system before it is consumed domestically or exported. Thus, effective regulatory strategies are important not only at the local and provincial levels in Canada, but also at the national and international levels for firms all down the energy-production supply chain, as well as for Canada's export partners.

3 THE RATE-OF-RETURN MODEL OF ECONOMIC REGULATION

As stated above, the most common regulatory mechanism used to control prices in North American utilities industries is the rate-of-return model. The application of the rate-of-return model is carried out in a number of stages:

First, the regulator aggregates the firm's assets into an account called the "rate base" (the rate base is equivalent to the book value of the firm's capital stock). The regulator calculates a "fair" rate of return to be applied to this rate base. This rate of return is intended to compensate the firm for the cost of its capital, as well as providing a small profit. The rate-of-return calculation is generally based on the firm's weighted average cost of capital (WACC).[5]

Next, the product of the rate base and the fair rate of return are added to the firm's calculated variable costs. (Variable costs include labour costs, office supplies and fuel for generation or pumping facilities — essentially any cost unrelated to capital assets). A depreciation allowance is also calculated and added to the total, thus producing a revenue requirement deemed adequate to compensate the firm for its costs.

$$\text{Revenue Requirement} = (\text{Rate Base}) \times (\text{Fair Rate of Return}) + \text{Variable Costs} + \text{Depreciation Allowance}$$

In the last step, prices are set consistent with demand expectations to provide the regulated firm with revenue equal to this calculated revenue requirement.

$$\text{Prices} = \frac{\text{Revenue Requirement}}{\text{Total Quantity}}$$

The standard mandate of ensuring a "fair" return implies that a regulated firm is adequately compensated for the costs it has incurred. This policy is adopted to ensure that regulated firms maintain non-negative profits and, by extension, have incentives to continue serving the market. If the regulated firm were to sustain negative economic profits (losses), on average, in the long run, that firm would exit the market.

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5 The weighted average cost of capital is the rate at which a firm is expected to pay its security holders in order to finance its assets. The WACC is the minimum payment that must be made to the firm's creditors for continued access to the financial capital used to finance the purchase and ownership of the firm's assets. If the payment made to creditors is too low, they will find more attractive investment opportunities and the firm in question will no longer have sufficient financial capital to finance its asset holdings.

The basic theory is straightforward, but the practical determination of the revenue requirement is much more complex. Both in theory and in practice the most appropriate method for identifying the fair return on investment is contentious. Currently, most jurisdictions lump all of a firm's assets into a single rate base and calculate the regulated rate of return based on the firm's WACC.[6]

The rate-of-return methodology has the notable handicap that it ties a regulated firm's profits directly to its input decisions. The firm's actual productivity becomes almost irrelevant to its earnings; if a regulated firm can reduce its variable costs by a dollar, its regulated revenues will also drop by a dollar, leaving no net gain. However, if a regulated firm can increase its total invested capital by a dollar, it can earn the "fair" return on this capital (net of accumulated depreciation) every year. Through these channels, the current regulatory policy rewards over-investment but does not reward cost reductions. Actual production becomes less relevant than the firm's input decisions. The only two ways a regulated firm can earn an economic profit are: 1) inducing the regulator to increase the "fair" return (to widen the margin between the "fair" return and the firm's actual capital costs); and 2) inflating the capital stock (also called the rate base) onto which this return is applied.

The analysis below is based on the proposition that a sluggish regulator can improve outcomes for regulated firms and consumers (higher profits and lower prices) relative to a more involved regulator. The policy prescription is for a regulator to set an educated rate of return that is not tied directly to an estimate of a firm's actual average cost of capital. This allows the firm to benefit from cost reductions related to the duration of its capital investments and the depreciation expense and capital costs implied by this duration. In many cases, a light-handed approach to setting the rate of return provides an incentive for regulated firms to reduce their capital costs in exchange for a higher depreciation rate, an action that benefits all parties: revenues and costs will both fall, but costs will fall by a larger proportion, providing a net benefit to the firm (a larger gap between revenue and cost, implying higher profits) and to the consumers (lower firm revenues, implying lower prices).

A regulated firm's total revenue requirement is sensitive to its aggregate capital stock and, by extension, its depreciation rate. A lower capital stock implies a lower revenue requirement, since a substantial element of the revenue requirement is the product of the "fair" return and the capital stock. Higher depreciation rates draw down the outstanding capital stock at a more rapid pace, reducing its average over a fixed period.

Several modifications and alternatives to the traditional rate-of-return model have been suggested and some have been implemented with varying degrees of success. Negotiated settlements, where the regulator has only limited participation in determining the cost elements discussed above, has become popular in Canadian and U.S. jurisdictions.[7] However negotiated settlements, like other modifications to the rate-of-return model, keep the price-setting formula outlined above essentially intact.

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[6] Jurisdictions where the rate-of-return model is employed using the firm's assessed WACC as a basis for the regulated return include: the National Energy Board for Canadian (for inter-provincial pipelines); the Alberta Utilities Commission (for Alberta's intra-provincial pipelines); the Federal Energy Regulatory Commission for (U.S. inter-state pipelines); and the Florida Public Service Commission (for Florida's electricity generators).

[7] The U.S. Federal Energy Regulatory Commission, The Canadian National Energy Board, The Alberta Utilities Commission and the Florida Public Service Commission have all facilitated the use of negotiated settlements.

Other potential replacements for the rate-of-return model have been suggested but have not been implemented. Practical considerations and legislative entrenchment have made application of the rate-of-return model very resilient to major changes in regulatory structure. Performance-based rate-making is often suggested as an alternative to the more traditional rate-of-return mechanism in an effort to introduce cost-reducing incentives. Performance-based regulation is a form of incentive regulation that attempts to build regulatory methods to create incentives for firms to reduce costs or enhance characteristics of the products they produce. In effect the idea is to flip the incentives, rewarding outputs rather than inputs.

While some regulators have introduced elements of performance-based rate-making into their application of the rate-of-return model, here again the pricing formula outlined above remains the basis for regulation. Putting a large emphasis on performance in the determination of regulated firms is somewhat problematic for utilities in particular, as there are some fundamental issues with identifying a good measure of performance on which to build a rate-making mechanism. The discussion in Mansell and Church summarizes the conditions required for a good measure of performance as follows:

> "....it is very important that the performance measure chosen be sensitive to the actions of the firm which are unobserved by the regulator but which the regulator is attempting to influence in order to achieve quality of service objectives."[8]

Mansell and Church go on to consider the use of service outages as a performance measure for pipeline and electricity-generation regulation. They observe that, since outages occur randomly, the rewards and penalties would have a significant random element. This increases the risk faced by the firm which would increase its cost of capital (investors would demand a higher risk premium) and, therefore, costs in general.[9]

Despite the existence and discussion surrounding performance-based rate-making and other alternatives or modifications, the core formula behind the rate-of-return model is well entrenched in practical application. Thus, the inefficiencies resulting from the application of rate-of-return regulation, besides already being important practical considerations, are made more so by the lack of a feasible alternative to the rate-of-return model.

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8 Robert L. Mansell and Jeffrey R. Church, *Traditional and Incentive Regulation: Applications to Natural Gas Pipelines in Canada*, The Van Horne Institute for International Transportation and Regulatory Affairs, 1995: 90.

9 Readers interested in performance-based regulation or incentive regulation in general are directed to Doucet and Littlechild (2009) and Mansell and Church (1995).

While the Mansell and Church text is almost two decades old, their discussion of performance-based rate-making is no less relevant now than at the time of publication.

4 THE EFFECT OF A RATE-OF-RETURN CONSTRAINT ON ASSET LIFE AND DEPRECIATION

As hinted at in the introduction, the depreciation methodology employed in a regulated setting can have a large potential impact on the regulated firm's capital stock and, by extension, its revenue requirement, costs and profits. In theory, the depreciation allowance that goes into the revenue requirement is intended to represent the reduction in productive value of the firm's underlying assets (similar to a capital cost allowance used in calculating corporate tax rates). Previous studies have shown that the application of a regulated rate of return introduces an important relationship between depreciation and the value of the revenue requirement across time. It has been repeatedly illustrated that accelerated depreciation reduces the total revenue requirement over the firm's lifespan.[10] This reduction in the revenue requirement will reduce the firm's total costs and the regulated price, generating substantial gains for consumers.

Given this relationship between depreciation and the revenue requirement, it is likely that depreciation considerations will have a strong effect on the input decisions of a regulated firm.

In this section, I present a general discussion of two effects that distort a regulated firm's investment decisions. The first effect, which I dub the "depreciation-duration effect," is related directly to the relationship between depreciation and the total rate base or capital stock. The second effect, dubbed the "yield-curve effect," relates the regulated firm's choice of capital inputs with different depreciation rates, to the difference (or margin) between the regulated rate of return and the firm's true weighted average cost of capital.

In a regulated context, where we are concerned with costs through time, it is the book value of the firm's capital assets, and not market values that determine the firm's regulated revenue requirement, financing costs and ultimately the regulated price. The total aggregate investment in capital may, in fact, be much less important than the choice of how to allocate and finance this investment. I investigate these relationships presently.

4.1 The Depreciation-Duration Effect

To construct an example showing the relationship between firm investment, depreciation and profits, assume that a regulated firm can finance the purchase of an asset choosing between a one- or two-year depreciation rate without altering its weighted average cost of capital (WACC). Consider the firm's choice between two different scenarios for purchasing photocopiers.

In the first case, the firm purchases a single $5,000 photocopier with a deemed depreciation rate of 100 per cent per year, under straight-line depreciation.[11] The firm makes the same purchase at the beginning of every year.

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[10] Shimon Awerbuch, "Accounting Rates of Return: Comment," *The American Economic Review* 78, 3 (1988); Shimon Awerbuch, "Depreciation and Profitability Under Rate of Return Regulation," *Journal of Regulatory Economics* 4, 1 (1992); Shimon Awerbuch, "Depreciation for regulated firms given technological progress and a multi-asset setting," *Utilities Policy* 2, 3 (1992); Shimon Awerbuch, "Market-based IRP: It's easy!!!" *The Electricity Journal* 8, 3 (1995).

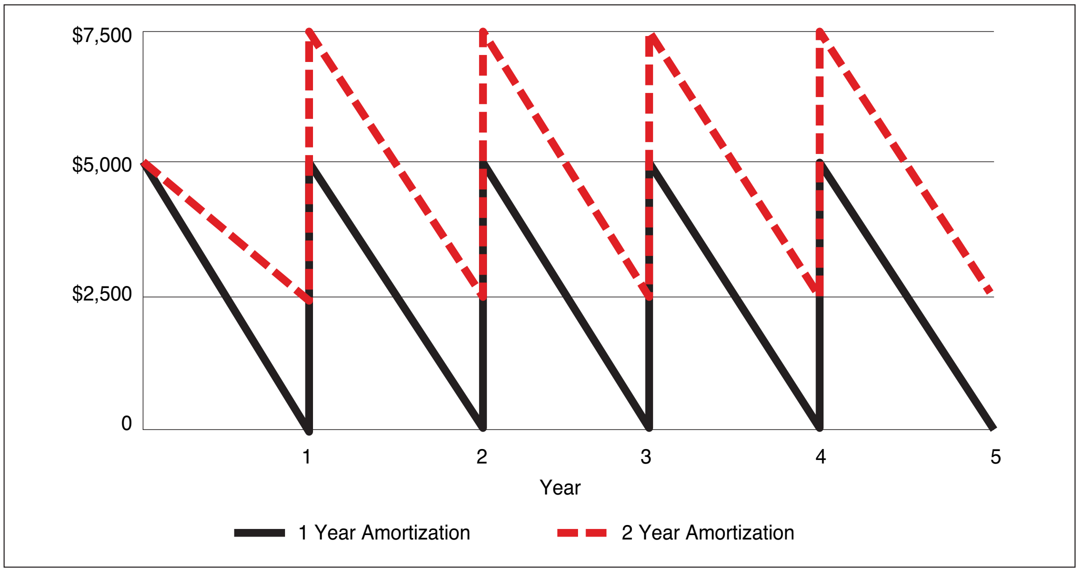
[11] Under straight-line depreciation, the depreciation expense (the annual amount by which the book value of the firm's capital stock falls over time) is fixed annually. That is, the depreciation expense is equal to the book value of capital stock divided by the number of years over which it is being depreciated.

In this first case (with a short-lived photocopier), the initial capital stock at the beginning of each year is $5,000. By extension, the firm makes a $5,000 depreciation payment each year (paying down the entire capital stock). This leaves the firm with a capital stock of $0 at the end of each year.

In the second case, the firm purchases a single $5,000 asset with a deemed depreciation rate of 50 per cent per year, under straight-line depreciation. The firm makes the same purchase at the beginning of every year.

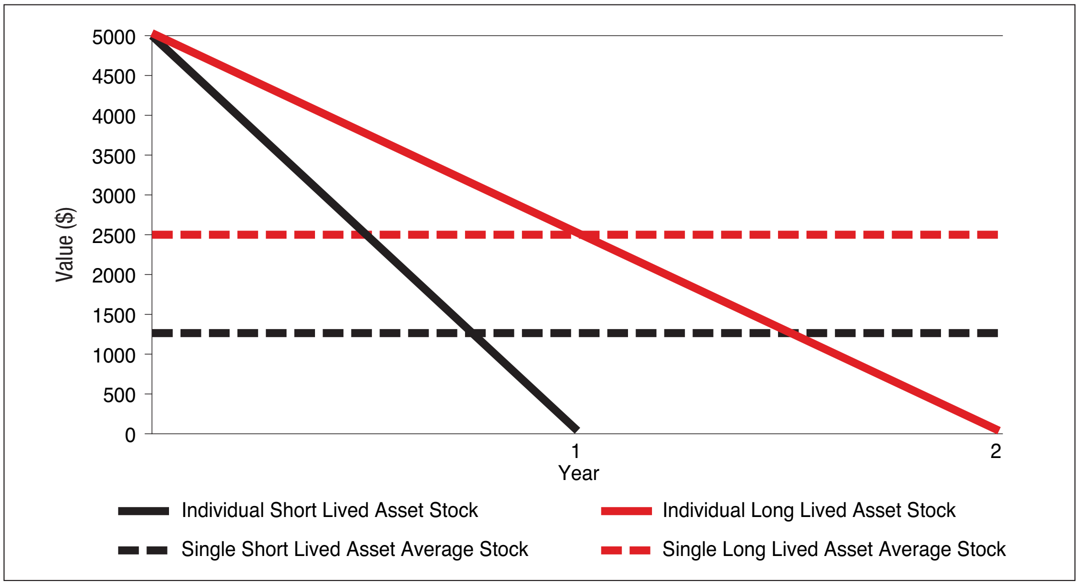
In this second (long-lived photocopier) case, the initial capital stock is $5,000 at the beginning of Year One and $2,500 at the end of Year One (=$5,000 – ($5,000/2 years)). The firm will have $7,500 in capital at the beginning of Year Two (=$2,500 in existing unamortized capital + $5,000 in new investment capital). At the end of Year Two, the firm will be left with the same $2,500 in unamortized capital (=$7,500 – (($5,000/2 years) x (2 assets))). This pattern will then continue in each subsequent year. In this case, only $2,500 is depreciated in Year One, but the same $5,000 is depreciated out in each subsequent year with the firm investing another $5,000 in new capital.

FIGURE 1: ASSET STOCK UNDER ONE- AND TWO-YEAR DURATION SCHEMES



In nominal terms, the firm will spend the same dollar amount on purchasing the photocopiers in either case. However, because the firm is regulated, the two-year depreciation term is more attractive. The return on capital remains the same, but the firm is able to earn that return on an average capital stock of $5,000 instead of $2,500. If the difference between the regulated rate of return and the true capital cost is even two per cent, the firm can earn $50 of pure profit simply by purchasing the second copier early. Figure 2 illustrates the difference in the capital stock for a single $5,000 asset under one- and two-year durations. The red line is the contribution to the firm's total asset stock made by a single $5,000 photocopier depreciated out over two years. The black line is the contribution to the firm's total asset stock made by a single $5,000 photocopier depreciated out over one year. This decomposition shows that the yearly average book value for any new investment is higher if it is depreciated at a slower rate.

FIGURE 2: ASSET STOCKS FOR INDIVIDUAL ONE- AND TWO-YEAR ASSETS



This photocopier story is a simple example, but it serves to illustrate an important effect. Regulated firms have a direct incentive to extend the book value of their assets through lower financial depreciation rates in order to inflate the book value of their capital stock.[12]

The ability of a firm to inflate its capital stock simply by moving to a lower depreciation rate will hereafter be referred to as the "depreciation-duration effect." Unfortunately, in deriving useful policy implications, the depreciation-duration effect is only part of the story.

Different capital investments are associated with different capital costs. Specifically, lenders (either shareholders or commercial banks) require a higher return on their investment for longer borrowing periods. In the case of debt financing (corporate or government bonds), we observe this relationship as the bond yield curve. The shape of the yield curve, in conjunction with the use of a single regulated rate of return, introduces an additional distortion to the firm's choice of investments across different depreciation rates.

4.2 The Yield-Curve Effect

Proper understanding of the relationship between capital investment and lending rates requires an examination of the shape of the bond yield curve.[13] A bond yield curve can almost always be characterized by a positive relationship between the duration of a bond and its yield, up to the 20-year duration. Thus, even for regulated firms, it is reasonable to assume that the financing of longer-lived assets will be associated with a higher cost of capital paid by the firm.

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[12] The identified effect is similar to the Averch-Johnson effect, in that it occurs due to the firm's ability to earn a positive net return on capital investment (and only capital investment). See: Harvey Averch and Leland L. Johnson, "Behaviour of the Firm Under Regulatory Constraint," *American Economic Review* 52, 5 (1962).

For a further insight into this inflation of book values through deferred depreciation, see my recent paper (specifically figures 1 and 2): G. Kent Fellows, "Negotiated Settlements: Long-term Profits and Costs," *SPP Research Papers* 5, 15, University of Calgary (May 2012).

[13] The bond yield curve is a graphical depiction of the relationship between the interest rate/required return or "yield" on a bond, and the duration of repayment of principle on that bond.

Under rate-of-return regulation, the firm earns a *single* rate of return on all assets. In practice, a regulator like the National Energy Board in Canada will attempt to match the regulated rate to some measure of the firm's weighted average cost of capital (borrowing costs averaged over all of the firm's assets).[14] This follows from the aforementioned goal of the regulator to keep prices low in order to protect the consumer.[15]

The use of a single regulated rate of return implies that the regulated firm will be able to earn a higher margin on shorter-lived assets than on longer-lived ones regardless of the methodology used to set the "fair" return. An overly simplified equation of profits under rate-of-return regulation can be given as:

$$\text{Profits} = (S - r) \times K$$

Where S is the regulated rate of return, r is the cost of capital and K is the capital stock. Assume that the regulator chooses to set the regulated rate of return at some fixed value above the firm's cost of capital; $S = r + 0.05\%$. Then, the firm cannot change its profitability by seeking out less-expensive capital (reducing the WACC):

$$\text{Profits} = ([r + 0.05] - r) \times K = 0.05 \times K$$

However, if the regulator sets a fixed regulated rate of return (e.g., $S = 12\%$) the firm can increase profits by seeking lower-cost capital (reducing the WACC).

$$\text{Profits} = (12 - r) \times K$$

$$\downarrow r \text{ implies } \uparrow \text{profits}$$

The standard positive relationship between the life of an asset and the return on debt (bonds) can be interpreted as an inverse relationship between the depreciation rate on an asset and its cost of capital. Given the inverse relationship between depreciation and cost of capital, the effect just described will drive regulated firms towards shorter-lived assets. Figure 4 shows this relationship graphically.

The black curve in Figure 3 is a stylized representation of the yield curve, while the horizontal red line is a hypothetical regulated rate of return. Comparing the two schedules, the figure illustrates that the firm will receive a larger excess return on a shorter-lived asset (6.1% - 3.5% = 2.6%) than it will on a longer-lived asset (6.1% - 5.5% = 0.6%) given a single regulated rate of return for all assets.

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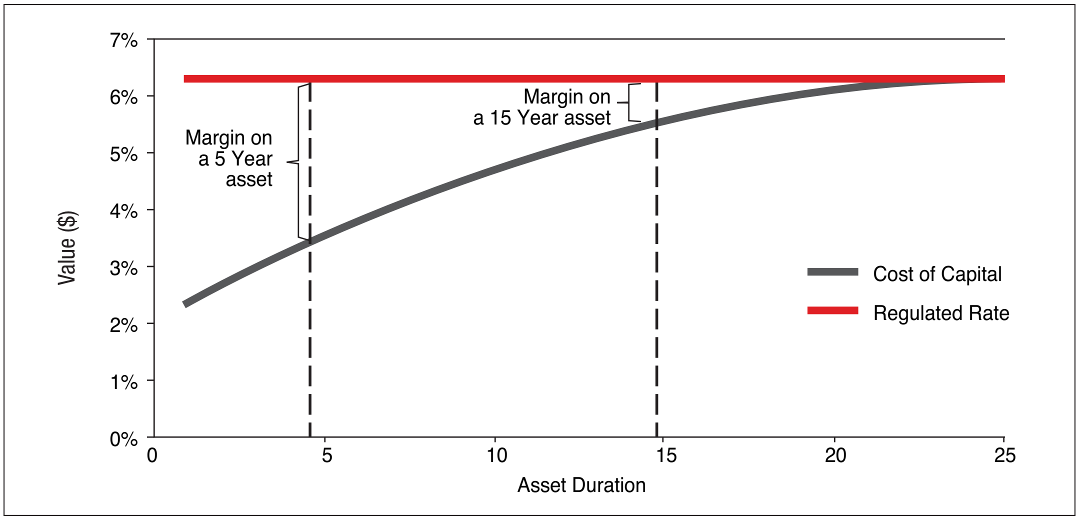
[14] In the case of the Canadian National Energy Board, a fairly simple formula has historically been employed to calculate the return for the pipelines it regulates. The formula added a simple risk premium (a benchmark of 300 basis points in 1994) to the long-term rate on government bonds (9.25 per cent in 1994). While this specific formula was abandoned in 2009, the use of a single average regulated rate of return, set by adding a risk adjustment (usually specific to each firm) to a measure of the risk-free rate of return, is typical of rate-of-return regulation in practice.

[15] As the regulated rate of return falls, the revenue requirement falls, as do prices. However, the regulator must be careful not to reduce the rate of return below the regulated firm's borrowing costs since this would leave the firm with costs exceeding its revenues and eventually drive the regulated firm out of the market.

FIGURE 3: PROFIT MARGINS ON CAPITAL INVESTMENTS BY DURATION



Since the yield-curve effect and the depreciation-duration effect introduce offsetting incentives, an appropriate policy prescription cannot be made without additional assumptions. In the next section, I impose different sets of assumptions in order to derive useful policy prescriptions, and to show that a light-handed approach to setting the regulated rate of return outperforms more active regulation in many cases.

The existence of these two effects have been empirically validated in accompanying work using the U.S. electricity-generation sector and the Canadian inter-provincial pipeline sector as case studies. The results of this econometric estimation are available in a current working paper.[16]

5 DISCUSSION OF EFFECTIVE REGULATORY POLICIES

Specific assumptions can yield useful policy directions, despite the difficulty associated with decomposing the offsetting yield-curve and depreciation-duration effects. Of special interest is the firm's ability to increase its own profits by adjusting its asset holdings. We are interested in identifying a policy where the regulator's actions induce the firm to adjust its capital stock to reduce the total revenue requirement and, by extension, the market price. Since firms are motivated primarily by profits, the best outcome is one where higher firm-profits correspond to a lower revenue requirement. The regulated firm will not care what its revenues are, as long as its profits are increasing.

A set of example balance sheets for a regulated firm (located in the Appendix) are used here to illustrate the changes in the total cost to consumers (the revenue requirement) and firm profits resulting from a shift to shorter- or longer-lived assets. The goal is to identify a policy that rewards cost-saving trade-offs between short- and long-lived assets (trade-offs that lower the revenue requirement) with higher firm-profits.

[16] G. K. Fellows, "Strategic Input Decisions Under Rate-of-return regulation," Working Paper, University of Calgary, 2013.

The hypothetical firm represented through these balance sheets is assumed to hold its assets in three classes: one-year duration, five-year duration and 10-year duration.[17] The cost of capital applied in each of the examples below are: 4.72 per cent for a one-year asset, 5.74 per cent for a five-year asset and 6.14 per cent for a 10-year asset. These rates are the actual Canadian bond yield averages for the period 1993-2009. The depreciation rates used are the standard rates associated with straight-line depreciation (100 per cent, 20 per cent and 10 per cent for one-, five- and 10-year assets respectively).[18]

In Section 5.1 the firm is assumed to be operating in a declining market where the market is forecast to disappear in the near future and the firm's assets are reaching the end of their economic lives. That is, following their full depreciation (when the book value drops to zero), assets will not be replaced. The analysis where capital assets are continually replaced as they are depreciated will be discussed using a second set of balance-sheet examples in Section 5.2. It is important for policy-makers to consider both of these examples as the policy implications become more difficult to identify in a healthy market.

5.1 Effective Policies in a Declining Market

If an asset is not replaced once its book value hits zero (that is, if the capital stock is allowed to fall), the resulting trade-off for a regulated firm making an asset-portfolio decision is a trade-off between earning a small margin on capital for a longer period of time (by deferring depreciation; the depreciation-duration effect) or earning a larger margin on capital for a shorter period of time (by shifting to shorter-duration assets; the yield-curve effect).

Table 1 indicates the cost to consumers and profits received by the firm for two hypothetical asset portfolios (A and B) under active and passive regulation over a 10-year period.

Portfolio A is the long-lived-assets case, wherein the firm invests $20,000 in a relatively long-lived (10-year duration) asset and $0 in a relatively short-lived (five-year) asset. Portfolio B is the short-lived-assets case, wherein the firm invests $10,000 in each of the five- and 10-year assets. In both cases the firm also invests $1,000 a year on a one-year asset.[19]

The dollar values in Table 1 are derived from a more complex spreadsheet analysis. For the full calculations, see Tables 3 and 4 in the Appendix.

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17 All trade-offs are made between five- and 10-year assets. The one-year asset is included to more accurately represent changes in the average cost of debt faced by the firm.

18 While the hypothetical examples share bond yield averages with the real world data, there is no other relationship between the two. In fact, the necessity of using hypothetical examples to illustrate changes in total cost, etc., is a result of data limitations. The financial data available for regulated firms do not include details of specific asset durations. A proper investigation requires an analysis of depreciation expense by asset class. Available data include only an aggregate measure of the total depreciation expense and is therefore insufficient for this purpose. Hypothetical examples also allow for simple and direct control over the assumptions and conditions a regulator may be operating under.

19 To provide an example of a reasonable comparison between these two asset portfolios, assume a hypothetical natural gas pipeline company: The pipeline has a single trunk-line with a book value of $20,000 (add a few zeros if the magnitude makes you uncomfortable) serving multiple markets in a number of regions. Suppose that, due to shifts in the demand and supply for natural gas, the company realizes that the market for the eastern-half of its trunk-line will disappear in five years, while the western-half of the line is expected to have a market for twice as long. The firm can depreciate the whole line at 10 per cent per year, which is the status quo (panel A). Alternatively the firm can refinance the shorter-lived half and depreciate it at 20 per cent per year while continuing to depreciate the western leg at 10 per cent, reflecting the actual forecast economic life of each leg (panel B).

TABLE 1: ASSET PORTFOLIO COMPARISONS UNDER ACTIVE AND PASSIVE REGULATION (DECLINING MARKET)

Rate-of-Return Methodology	Active S=r+0.05%		Passive S=6.10%	
Portfolio	**A** (long life)	**B** (short life)	**A** (long life)	**B** (short life)
Total Cost to Consumers (Revenue Requirement)	$37,286	**$35,619**	$37,320	**$35,795**
Total Nominal Profits	**$60**	$48	$94	**$224**

The active regulator is assumed to recalculate the regulated rate of return every period to reflect the firm's changing average cost of capital. The active regulator sets the regulated rate in each period at five basis points (0.05 per cent) above the firm's average cost of capital.[20] Since the firm is always holding assets of different durations, the relative rates at which the book value of these assets are drawn down will change the average cost of capital over time (even holding the individual bond rates constant).

Comparing total nominal profit across portfolio A and B under active regulation it is clear that, given the option, the firm will choose the longer asset duration. By holding capital for longer, the firm earns $60 rather than the $48 it would earn by redistributing assets to shorter book durations. Unfortunately for the regulator, the firm's incentive is directly opposite of the regulator's assumed objectives. The cost to consumers (equivalent to the revenue requirement) is higher under portfolio A than portfolio B indicating that consumers are worse off.[21]

The passive regulator is assumed to set the regulated rate of return at 6.07 per cent, regardless of the firm's actual average cost of capital. Under passive regulation the regulated firm earns $224 under portfolio B versus just $94 under portfolio A. Conversely, the revenue requirement (representing the aggregate cost to consumers) is higher under portfolio A then it is under portfolio B ($37,320 in panel A versus $35,795 in panel B). Thus, both the regulator and the firm prefer the outcome in portfolio B under passive regulation, even though the firm is earning more.

From Table 1, the best outcome for consumers would be for the regulator to take an active role in setting the rate of return, and for the firm to choose portfolio B. However, this outcome is unattainable since the firm is free to make its own input decisions and will elect to choose portfolio A under active regulation.

The best *attainable* outcome is for the regulator to take a passive role in setting the rate of return, so that the firm will choose to reduce its costs by accelerating its depreciation.

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[20] This rate-of-return methodology may seem unrealistic or arbitrary, however, it is plausible that the regulator may have some signal of the firm's average cost of capital (perhaps expressed through evidence at a rate hearing) without observing detailed information regarding the firm's asset holdings or the rental rates it faces. (Recall, that the bond yields are only one component of the rental rates faced by the firm.)

[21] Only nominal values are discussed here, however, referring to Table 3, discounting the financial flows using any positive discount rate would not change the results in any meaningful way, since the regulatory profits are the same or higher in each period in panel A compared to panel B. Additionally, while the margin here is very small (only five basis points), this relationship holds for any constant positive margin between the regulated rate of return and the average cost of capital.

By re-weighting towards shorter-lived assets, the firm's actions will reduce the overall capital stock in years two through 10 by enough to save consumers $1,525 (= $37,320 - $35,795) over the 10 years, while still earning a higher nominal profit.

Based on these examples, it is reasonable to suggest that regulators, when they are regulating firms in declining markets, should encourage accelerated depreciation. If the asset being depreciated will not be replaced, then faster depreciation will lower the firm's overall costs and the total revenue requirement.

The downside of this shift is that consumers will necessarily pay higher costs (measured in either current or constant dollars)[22] in the early years, as the burden is shifted away from the future and towards the present. In Table 4, consumers will pay more in years one through five, and substantially less in years six through 10. In a sense, this is actually a more equitable outcome as well. (Based on our hypothetical pipeline story presented in footnote 19, after year five, the number of consumers served by the firm's remaining assets will drop.)

The policy prescription, and indeed the logic here, is consistent with concerns regarding stranded assets (where the market for the asset's output disappears before the asset is fully depreciated). Taking stranded assets into account, depreciating the capital stock at a higher rate has the added bonus of reducing the risk of stranding an asset.

5.2 Identifying Policy Prescriptions in a Healthy Market.

In the declining-market case, the reduction in future prices can be identified as a result of the falling capital stock and the corresponding falling debt-service costs. If the capital stock is continually renewed by periodic investment, a shift to shorter-lived assets may or may not reduce the capital stock, but it will not cause the capital stock to fall any faster through time.

In this case, a shift to short-lived assets can potentially increase the total cost faced by consumers rather than decrease it, even though this shift reduces the firm's average cost of capital.

Since these are healthy-market cases, new investment is assumed to be equal to depreciation expense. Assets are replaced as they wear out, and the capital stock under any asset portfolio is the same in every period. However, the capital stock and investment/depreciation flows may be very different under different asset portfolios. In sections 5.2.1 and 5.2.2, I examine two extreme cases.

First, in Section 5.2.1, I examine the outcomes of regulatory policies in which the capital stock is held constant over three different asset-portfolio choices. The firm is given a fixed capital stock and allowed to allocate it over assets of different durations. The capital stock is fixed, but the depreciation expense (and the cost of capital) change. This case is realistic if we assume that the firm is able to change its depreciation methodology without changing the actual physical makeup of its capital stock.

[22] Since the comparison is between two cost streams, the distinction between current and constant is irrelevant as long as the same index is applied to both the original cost stream and the cost stream under the accelerated-depreciation scheme.

In Section 5.2.2, the firm's depreciation expense is fixed across three asset portfolios and the total capital stock is allowed to change. This keeps the depreciation-expense portion of the revenue requirement fixed, but the capital stock and the weighted average cost of capital change. This case is perhaps less realistic than that described for Section 5.2.1, but it is still an important case to consider.

In reality, it is likely that substitutions between capital asset portfolios with assets of different durations would cause changes in both the depreciation/investment flows and the overall capital stock. Considering both of these extremes (fixed depreciation/investment flows and fixed capital stock) provides important insight into the desirability of accelerated depreciation caused by passive regulation, depending on whether a change in the regulated firm's asset portfolio causes a significant reduction in the firm's capital stock (rate base). As the next two sections show, a move to accelerated depreciation that is not accompanied by a reduction in the overall capital stock leads to an increase, rather than a decrease, in the costs faced by consumers.

5.2.1 ALLOCATING A FIXED CAPITAL STOCK IN A HEALTHY MARKET: AN EXAMPLE

If we assume that the regulated firm is essentially redistributing portions of an existing capital stock across assets of different durations, then the total capital stock is invariant to portfolio decisions and the depreciation-duration effect will not come into play. In this case, a shift to longer-lived assets will not (and, by definition of the constraint, cannot) lead to an inflation in the book value of the capital stock.

Table 2 shows the total annual cost to consumers (revenue requirement) and the total annual profits for three asset portfolios for a hypothetical firm under active and passive regulation. Under portfolio A (short-lived assets) the firm maintains:

- a $1,000 stock of a one-year asset ($1,000 invested and depreciated every year);
- a $20,000 stock of a five-year asset, ($2,000 invested and depreciated every year);
- and a $0 stock of a 10-year asset.

Under portfolio B (medium-lived assets), the firm maintains:

- a $1,000 stock of a one-year asset ($1,000 invested and depreciated every year);
- a $10,000 stock of a five-year asset, ($2,000 invested and depreciated every year);
- and a $10,000 stock of a 10-year asset. ($1,000 invested and depreciated every year).

Under portfolio C (long-lived assets) the firm maintains:

- a $1,000 stock of a one-year asset ($1,000 invested and depreciated every year);
- a $0 stock of a five-year asset;
- and a $20,000 stock of a 10-year asset ($2,000 invested and depreciated every year).

The dollar values in Table 2 are again derived from a more complex spreadsheet analysis. For the full calculations, see Table 6 in the Appendix.

TABLE 2: ASSET PORTFOLIO COMPARISONS UNDER ACTIVE AND PASSIVE REGULATION (HEALTHY MARKET, FIXED STOCK)

Rate-of-Return Methodology	Active S=r+0.22%			Passive S=6.10%		
Portfolio	**A** (short life)	**B** (medium life)	**C** (long life)	**A** (short life)	**B** (medium life)	**C** (long life)
Total Cost to Consumers (Revenue Requirement)	$6,241	$5,281	**$4,321**	$6,281	$5,281	**$4,281**
Total Profits	$46	$46	$46	**$86**	$46	$6

The active regulator is assumed to recalculate the regulated rate of return every period to reflect the firm's changing average cost of capital. The active regulator sets the regulated rate in each period at 22 basis points (0.22 per cent) above the firm's average cost of capital. Since the firm is always holding assets of different durations, the relative rates at which the book value of these assets are drawn down will change the average cost of capital over time (even holding the individual bond rates constant).

Comparing total nominal profit across portfolios A, B and C under active regulation, it is clear that the firm is indifferent to this choice. It earns $46 a year under any of the three portfolio choices. The regulator and consumers would prefer the firm choose C (long asset duration) in this case, since portfolio C leads to a lower cost for consumers ($4,321 versus $5,281(B) or $6,241(C)). However, under active regulation, the regulated firm has no incentive to choose the portfolio providing the lowest cost to consumers.

The passive regulator is assumed to set a fixed regulated rate of return at 6.10 per cent. Comparing total nominal profit across portfolios A, B and C under passive regulation, the firm now has an incentive to move to shorter-duration assets. It earns $86 per year under portfolio A, but only $42 per year under B and $6 per year under C.

The regulator and consumers would still prefer the firm choose C (long asset duration) since portfolio C leads to a lower cost for consumers under passive regulation as well ($4,281 versus $5,281(B) or $6,281(A)).

As in the declining-market case, passive regulation introduces an incentive to accelerated depreciation in this setting. However, given a fixed capital stock and a healthy market (where new investments are continually being made to offset depreciation), accelerated depreciation inflates, rather than reduces, the firm's revenue requirement and the costs faced by consumers.

As stated above, the assumption of a fixed capital stock (and associated rate base) is an extreme case and is likely somewhat unrealistic. Fixing the capital stock implies that only the flows into and out of the capital stock (that is, investment and depreciation) change, while the stock itself does not. The opposite extreme is to hold the flows (investment and depreciation) constant while varying the capital stock instead. This exercise is conducted presently.

5.2.2 ISOLATING THE DEPRECIATION-DURATION EFFECT WITH PERIODIC ASSET REPLACEMENT: AN EXAMPLE

If the firm is periodically replacing assets, it may be more appropriate to focus on an example where total new investment, and not the capital stock, is held constant as substitutions are made. Returning briefly to Figure 1, the hypothetical example in that case (whether to buy and fully depreciate a single photocopier every year, or whether to purchase two photocopiers and hold them for two years) essentially keeps the depreciation expense constant. In that case, the depreciation expense remained constant at $5,000 per year (either 1 x $5,000 or 0.5 x $10,000) while the capital stock grew from $5,000 to $10,000 as the firm shifted from one photocopier to two.

Table 3 shows the total annual cost to consumers (revenue requirement) and the total annual profits for three asset portfolios for a hypothetical firm under active and passive regulation. Under portfolio A (short-lived assets) the firm maintains:

- a $1,000 stock of a one-year asset ($1,000 invested and depreciated every year);
- a $15,000 stock of a five-year asset ($3,000 invested and depreciated every year);
- and a $0 stock of a 10-year asset.

Under portfolio B (medium-lived assets) the firm maintains:

- a $1,000 stock of a one-year asset ($1,000 invested and depreciated every year);
- a $10,000 stock of a five-year asset ($2,000 invested and depreciated every year);
- and a $10,000 stock of a 10-year asset ($1,000 invested and depreciated every year).

Under portfolio C (long-lived assets) the firm maintains:

- a $1,000 stock of a one-year asset ($1,000 invested and depreciated every year);
- a $0 stock of a five-year asset;
- and a $30,000 stock of a 10-year asset ($3,000 invested and depreciated every year).

Note that under each portfolio choice, the firm depreciates out and invests $4,000 per year.

TABLE 3: ASSET PORTFOLIO COMPARISONS UNDER ACTIVE AND PASSIVE RATE OF RETURN (HEALTHY MARKET, FIXED FLOWS)

Rate-of-Return Methodology	Active S=r+0.22%			Passive S=6.10%		
Portfolio	**A** (short life)	**B** (medium life)	**C** (long life)	**A** (short life)	**B** (medium life)	**C** (long life)
Total Cost to Consumers (Revenue Requirement)	**$4,943**	$5,281	$5,957	**$4,976**	$5,281	$5,891
Total Nominal Profits	$35	$46	**$68**	**$68**	$46	$2

The dollar values in Table 3 are again derived from a more complex spreadsheet analysis. For the full calculations, see Table 7 in the Appendix.

The active and passive regulators are assumed to regulate using the same formulas is in Section 5.2.1 above (the active regulator sets the regulated rate at 22 basis points, or 0.22 per cent, above the firm's average cost of capital; the passive regulator sets the regulated rate at 6.10 per cent).

Comparing total nominal profit across portfolios A, B and C under active regulation, the firm's best choice is portfolio C. Under portfolio C, the regulated firm can earn $68 (versus $46 under B and $35 under A). The regulator and consumers would prefer the firm choose A (short asset duration) in this case since portfolio A leads to a lower cost for consumers ($4,943 versus $5,281(B) or $5,957(C)). Thus we see a similar perversion of incentives as identified in the declining-markets case above. And here again, passive regulation can be employed to realign the incentives of the firm and consumers/regulator.

Comparing total nominal profit across portfolios A, B and C under passive regulation, the firm now has an incentive to move to shorter-duration assets. It earns $68 per year under portfolio A, but only $42 per year under B and $2 per year under C.

Consumers are still paying more under portfolio A with passive regulation than they would under portfolio A with active regulation. However, the portfolio A/active regulation outcome is likely unattainable as the firm will choose longer, not shorter, asset durations under active regulation. As in the declining-market case, passive regulation introduces a beneficial incentive to accelerate depreciation in this setting.

Obviously these examples are overly simplistic relative to the actual balance sheets and operations of regulated firms. In the examples here, if assets of different durations are not perfect substitutes (which they almost certainly would not be), and if there are accounting regulations prohibiting firms from financing assets over a drastically different book-duration compared to their physical duration (which there almost certainly are in each duration), then the substitution patterns between the portfolio choices outlined would not be feasible. The firm may not be able to shift to shorter- or longer-lived assets without varying its aggregate depreciation expense/investment in each year. It is likely that these substitutions would also change the aggregate capital stock.

The example portfolio choices in this section (Section 5) are specifically lacking, in that the book-value asset durations are in no way tied to the physical characteristics of the asset. This is less of an issue in the declining-market case (Section 5.1), where we can assume that assets of different durations are serving different markets.[23] Unfortunately, since the substitution patterns illustrated are somewhat arbitrary, it is not possible to conclude that the use of a constant rate of return will in all cases incentivize regulated firms to reduce their costs and, by extension, the revenue requirement. Thus, passive regulation can be said to be preferable in most cases, unless the associated capital-asset-portfolio-choice changes by the firm lead to large changes in the investment/depreciation flows and small changes in the total size of the capital stock.

[23] In the example provided, the markets are differentiated regionally. More generally, any market differentiation is acceptable in the declining-markets case so long as one market is declining faster (or will truncate at an earlier date).

6 POLICY IMPLICATIONS AND CONCLUSION

The discussion above has introduced and characterized two potential biases in investment decisions resulting from the application of rate-of-return regulation. The depreciation-duration effect pushes regulated firms to over-invest in long-lived capital, or to lower their depreciation rate, in order to keep capital investments on the books for a longer period of time. By doing so, these firms can prolong the period over which they earn a return on this capital. As a result of regulation, this is one of only two avenues available to regulated firms in trying to increase profits.

The yield-curve effect pushes regulated firms to over-invest in short-lived capital (offsetting the depreciation-duration effect). By doing so, these firms can reduce their average cost of capital and earn a larger excess return ($S–r$) on the book value of their capital — the second potential avenue of increasing their profits.

Since these two effects are offsetting, a regulator cannot be sure if the firm is choosing an asset portfolio with overly long- or short-lived capital (relative to the portfolio that minimizes the costs to consumers) without more information. However by realizing that these two effects exist, a regulator can adopt policies to take advantage of a firm's profit-maximizing behaviour to induce outcomes that benefit everyone.

Section 5.1 above shows that, when regulated firms are operating in a declining market, the regulator should encourage accelerated depreciation whenever possible. Given the yield-curve effect, this will reduce the average cost of capital faced by a regulated firm and lead to a faster reduction in the capital stock to which this cost of capital is applied. Regulators should be aware that an incentive (in the form of a higher regulated rate of return, or a guarantee that the regulator will not reduce the regulated rate of return) is likely required to encourage accelerated depreciation. If there is a strong link between the firm's average cost of capital and the regulated rate of return, the firm may not have any clear reason to adjust its depreciation.

Increasing current costs to reduce future costs and aggregate costs overall will most likely be unpopular with current consumers. They may be unconvinced that costs will fall over time. Nevertheless, a responsible regulator needs to represent all consumers in the market, not just current consumers. Thus, accelerated depreciation should be encouraged for any regulated firm operating in a declining market.

In a healthy market, with periodic replacement of assets, it is impossible to prescribe a wide, generalized policy without some detailed information on a regulated firm's characteristics. Based on the evidence and analysis above, regulators would be wise to put significant effort into scrutinizing all new investment made by the firms they regulate.

Regulators should be certain that any shift towards short-lived assets is absolutely necessary, if these assets will require periodic replacement. If a shift does not lead to a significant reduction in the firm's capital stock (rate base) then it should be discouraged. If there is no reduction in the capital stock, any shift towards shorter-lived assets will lead to an increase in the depreciation expense in each period, with only a very small drop in the average cost of capital. Such a shift will likely increase both the firm's costs, prices and regulated profits. That is not to say that all investment in short-lived assets should be discouraged when assets are to be periodically replaced. If the firm is able to modestly reduce its capital stock by shifting to short-lived assets, the shift should be encouraged, as the higher depreciation expense will be accompanied by a substantially reduced debt-service payment.

In any of the above cases, a reduction in the accuracy with which the regulated rate of return approximates the firm's actual average cost of capital is advised. This is contrary to the current conventional practice, which is based on the argument that a better approximation of the average cost of capital will lead to a lower revenue requirement by reducing the gap between revenues and costs.

While regulators are generally careful to maintain a positive margin between the regulated rate of return and the average cost of capital (so that the firm can cover its costs and remain in the market), this is not enough. As established above, any link between the firm's average cost of capital and the regulated rate of return reduces the firm's incentive to shift to a lower average duration of its assets, even if this shift is cost reducing.

APPENDIX: HYPOTHETICAL BALANCE SHEETS

A.1 TWO PORTFOLIOS IN A DECLINING MARKET

TABLE 4: ACTIVE REGULATION: REGULATED RATE OF RETURN = AVERAGE COST OF CAPITAL + 0.05%

(a) High Average Asset Life

Year	1	2	3	4	5	6	7	8	9	10
Stock of 1-Year Asset	**1000**	1000	1000	1000	1000	1000	1000	1000	1000	1000
Stock of 5-Year Asset	**0**	0	0	0	0	0	0	0	0	0
Stock of 10-Year Asset	**20000**	18000	16000	14000	12000	10000	8000	6000	4000	2000
Capital stock (Start of Year)	21000	19000	17000	15000	13000	11000	9000	7000	5000	3000
Investment in 1-Year Asset	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Total Investment	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Depreciation on 1-Year Asset	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Depreciation on 5-Year Asset	0	0	0	0	0	0	0	0	0	0
Depreciation on 10-Year Asset	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Depreciation	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Accumulated Depreciation	3000	6000	9000	12000	15000	18000	21000	24000	27000	30000
Average Cost of Capital (%)	6.07	6.07	6.06	6.05	6.03	6.01	5.98	5.94	5.86	5.67
Regulated Rate of Return (%)	**6.12**	**6.12**	**6.11**	**6.10**	**6.08**	**6.06**	**6.03**	**5.99**	**5.91**	**5.72**
Debt Service	1275.20	1152.40	1029.60	906.80	784.00	661.20	538.40	415.60	292.80	170.00
Total Cost of Service	4275.20	4152.40	4029.60	3906.80	3784.00	3661.20	3538.40	3415.60	3292.80	3170.00
Revenue Requirement	4285.70	4161.90	4038.10	3914.30	3790.50	3666.70	3542.90	3419.10	3295.30	3171.50
Regulatory Profits	**10.50**	**9.50**	**8.50**	**7.50**	**6.50**	**5.50**	**4.50**	**3.50**	**2.50**	**1.50**

Summary Results	
Total Cost of Service	**37226.00**
Total Revenue Requirement	**37286.00**
Total Nominal Profits	**60.00**
Margin on Rate of Return (%)	**0.05**

(b) Low Average Asset Life

Year	1	2	3	4	5	6	7	8	9	10
Stock of 1-Year Asset	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Stock of 5-Year Asset	10000	8000	6000	4000	2000	0	0	0	0	0
Stock of 10-Year Asset	10000	9000	8000	7000	6000	5000	4000	3000	2000	1000
Capital stock (Start of Year)	21000	18000	15000	12000	9000	6000	5000	4000	3000	2000
Investment in 1-Year Asset	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Total Investment	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Depreciation on 1-Year Asset	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Depreciation on 5-Year Asset	2000	2000	2000	2000	2000	0	0	0	0	0
Depreciation on 10-Year Asset	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Total Depreciation	4000	4000	4000	4000	4000	2000	2000	2000	2000	2000
Accumulated Depreciation	4000	8000	12000	16000	20000	22000	24000	26000	28000	30000
Average Cost of Capital (%)	5.88	5.88	5.89	5.89	5.89	5.90	5.86	5.79	5.67	5.43
Regulated Rate of Return (%)	**5.93**	**5.93**	**5.94**	**5.94**	**5.94**	**5.95**	**5.91**	**5.84**	**5.72**	**5.48**
Debt Service	1235.20	1059.00	882.80	706.60	530.40	354.20	292.80	231.40	170.00	108.60
Total Cost of Service	5235.20	5059.00	4882.80	4706.60	4530.40	2354.20	2292.80	2231.40	2170.00	2108.60
Revenue Requirement	5245.70	5068.00	4890.30	4712.60	4534.90	2357.20	2295.30	2233.40	2171.50	2109.60
Regulatory Profits	**10.50**	**9.00**	**7.50**	**6.00**	**4.50**	**3.00**	**2.50**	**2.00**	**1.50**	**1.00**

Summary Results	
Total Cost of Service	**35571.00**
Total Revenue Requirement	**35618.50**
Total Nominal Profits	**47.50**
Margin on Rate of Return (%)	**0.05**

TABLE 5: PASSIVE REGULATOR: CONSTANT REGULATED RATE OF RETURN = 6.10%

(a) High Average Asset Life

Year	1	2	3	4	5	6	7	8	9	10
Stock of 1-Year Asset	**1000**	1000	1000	1000	1000	1000	1000	1000	1000	1000
Stock of 5-Year Asset	**0**	0	0	0	0	0	0	0	0	0
Stock of 10-Year Asset	**20000**	18000	16000	14000	12000	10000	8000	6000	4000	2000
Capital stock (Start of Year)	21000	19000	17000	15000	13000	11000	9000	7000	5000	3000
Investment in 1-Year Asset	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Total Investment	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Depreciation on 1-Year Asset	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Depreciation on 5-Year Asset	0	0	0	0	0	0	0	0	0	0
Depreciation on 10-Year Asset	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Total Depreciation	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
Accumulated Depreciation	3000	6000	9000	12000	15000	18000	21000	24000	27000	30000
Average Cost of Capital (%)	6.07	6.07	6.06	6.05	6.03	6.01	5.98	5.94	5.86	5.67
Regulated Rate of Return (%)	**6.10**	**6.10**	**6.10**	**6.10**	**6.10**	**6.10**	**6.10**	**6.10**	**6.10**	**6.10**
Debt Service	1275.20	1152.40	1029.60	906.80	784.00	661.20	538.40	415.60	292.80	170.00
Total Cost of Service	4275.20	4152.40	4029.60	3906.80	3784.00	3661.20	3538.40	3415.60	3292.80	3170.00
Revenue Requirement	4281.00	4159.00	4037.00	3915.00	3793.00	3671.00	3549.00	3427.00	3305.00	3183.00
Regulatory Profits	**5.80**	**6.60**	**7.40**	**8.20**	**9.00**	**9.80**	**10.60**	**11.40**	**12.20**	**13.00**

Summary Results	
Total Cost of Service	**37226.00**
Total Revenue Requirement	**37320.00**
Total Nominal Profits	**94.00**
Regulated Rate of Return (%)	**6.10**

(b) Low Average Asset Life

Year	1	2	3	4	5	6	7	8	9	10
Stock of 1-Year Asset	**1000**	1000	1000	1000	1000	1000	1000	1000	1000	1000
Stock of 5-Year Asset	**10000**	8000	6000	4000	2000	0	0	0	0	0
Stock of 10-Year Asset	**10000**	9000	8000	7000	6000	5000	4000	3000	2000	1000
Capital stock (Start of Year)	21000	18000	15000	12000	9000	6000	5000	4000	3000	2000
Investment in 1-Year Asset	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Total Investment	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Depreciation on 1-Year Asset	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Depreciation on 5-Year Asset	2000	2000	2000	2000	2000	0	0	0	0	0
Depreciation on 10-Year Asset	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Total Depreciation	4000	4000	4000	4000	4000	2000	2000	2000	2000	2000
Accumulated Depreciation	4000	8000	12000	16000	20000	22000	24000	26000	28000	30000
Average Cost of Capital (%)	5.88	5.88	5.89	5.89	5.89	5.90	5.86	5.79	5.67	5.43
Regulated Rate of Return (%)	**6.10**	**6.10**	**6.10**	**6.10**	**6.10**	**6.10**	**6.10**	**6.10**	**6.10**	**6.10**
Debt Service	1235.20	1059.00	882.80	706.60	530.40	354.20	292.80	231.40	170.00	108.60
Total Cost of Service	5235.20	5059.00	4882.80	4706.60	4530.40	2354.20	2292.80	2231.40	2170.00	2108.60
Revenue Requirement	5281.00	5098.00	4915.00	4732.00	4549.00	2366.00	2305.00	2244.00	2183.00	2122.00
Regulatory Profits	**45.80**	**39.00**	**32.20**	**25.40**	**18.60**	**11.80**	**12.20**	**12.60**	**13.00**	**13.40**

Summary Results	
Total Cost of Service	**35571.00**
Total Revenue Requirement	**35795.00**
Total Nominal Profits	**224.00**
Regulated Rate of Return (%)	**6.10**

A.2 TWO CASES IN THE STEADY STATE

TABLE 6: ASSET-DURATION SHIFTS IN THE STEADY STATE — FIXED CAPITAL STOCK (DEPRECIATION-DURATION EFFECT ABSENT)

(a): Active Regulation: Endogenous Regulated Rate of Return (No Yield-Curve Effect)

(Rate of return = Average Cost of Capital +0.22%)	Portfolio		
	A	B	C
Stock of 1-Year Asset	**1000**	**1000**	**1000**
Stock of 5-Year Asset	**20000**	**10000**	**0**
Stock of 10-Year Asset	**0**	**10000**	**20000**
Capital stock (Start of Year)	21000	21000	21000
Depreciation on 1-Year Asset	1000	1000	1000
Depreciation on 5-Year Asset	4000	2000	0
Depreciation on 10-Year Asset	0	1000	2000
Total Depreciation	5000	4000	3000
Composite Depreciation Rate (%)	24	19	14
Average Cost of Capital (%)	5.69	5.88	6.07
Regulated Rate of Return (%)	**5.91**	**6.10**	**6.29**
Debt Service	1195	1235	1275
Total Cost of Service	6195	5235	4275
Revenue Requirement	6241	5281	4321
Regulatory Profits	**46**	**46**	**46**

(b) Passive Regulation: Constant Regulated Rate of Return

(Rate of return = Constant 6.10%)	Portfolio		
	A	B	C
Stock of 1-Year Asset	**1000**	**1000**	**1000**
Stock of 5-Year Asset	**20000**	**10000**	**0**
Stock of 10-Year Asset	**0**	**10000**	**20000**
Capital stock (Start of Year)	21000	21000	21000
Depreciation on 1-Year Asset	1000	1000	1000
Depreciation on 5-Year Asset	4000	2000	0
Depreciation on 10-Year Asset	0	1000	2000
Total Depreciation	5000	4000	3000
Composite Depreciation Rate (%)	24	19	14
Average Cost of Capital (%)	5.69	5.88	6.07
Debt Service	1195	1235	1275
Total Cost of Service	6195	5235	4275
Revenue Requirement	6281	5281	4281
Regulatory Profits	**86**	**46**	**6**

TABLE 7: ASSET-DURATION SHIFTS IN THE STEADY STATE — FIXED DEPRECIATION EXPENSE (DEPRECIATION-DURATION EFFECT PRESENT)

(a) Active Regulation: Endogenous Regulated Rate of Return (No Yield-Curve Effect)

(Rate of return = Average Cost of Capital +0.22%)	Portfolio		
	A	B	C
Stock of 1-Year Asset	**1000**	**1000**	**1000**
Stock of 5-Year Asset	**15000**	**10000**	**0**
Stock of 10-Year Asset	**0**	**10000**	**30000**
Capital stock (Start of Year)	16000	21000	31000
Depreciation on 1-Year Asset	1000	1000	1000
Depreciation on 5-Year Asset	3000	2000	0
Depreciation on 10-Year Asset	0	1000	3000
Total Depreciation	4000	4000	4000
Composite Depreciation Rate (%)	25	19	13
Average Cost of Capital (%)	5.68	5.88	6.09
Regulated Rate of Return (%)	**5.90**	**6.10**	**6.31**
Debt Service	908	1235	1889
Total Cost of Service	4908	5235	5889
Revenue Requirement	4943	5281	5957
Regulatory Profits	**35**	**46**	**68**

(b) Passive Regulation: Constant Regulated Rate of Return

(Rate of return = Constant 6.10%)	Portfolio		
	A	B	C
Stock of 1-Year Asset	**1000**	**1000**	**1000**
Stock of 5-Year Asset	**15000**	**10000**	**0**
Stock of 10-Year Asset	**0**	**10000**	**30000**
Capital stock (Start of Year)	16000	21000	31000
Depreciation on 1-Year Asset	1000	1000	1000
Depreciation on 5-Year Asset	3000	2000	0
Depreciation on 10-Year Asset	0	1000	3000
Total Depreciation	4000	4000	4000
Composite Depreciation Rate (%)	25	19	13
Average Cost of Capital (%)	5.68	5.88	6.09
Debt Service	908	1235	1889
Total Cost of Service	4908	5235	5889
Revenue Requirement	4976	5281	5891
Regulatory Profits	**68**	**46**	**2**

About the Author

G. Kent Fellows received his B.A. (Honours) and M.A. in economics from the University of Calgary in 2008 and 2010 respectively. Between his undergraduate and graduate studies Mr. Fellows worked as a summer student at the Canadian National Energy Board which has formed the basis for much of his research agenda to this point. He is currently pursuing a PhD in economics at the University of Calgary, specializing in regulation with a strong focus on the Rate-of-Return model.

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