Present Bias and Corporate Tax Policies

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Abstract

Two major forms of corporate tax policies are dividend and profits taxes. Based on conventional corporate theory, these tax policies distort the firm’s investment decisions and decrease firm value. However, this paper shows that under hyperbolically-discounted preferences, dividend taxation is capable of boosting firm investment in a value-enhancing way. The hyperbolically-discounted present value can be interpreted as reflecting irrational myopic preferences or, as we demonstrate, reduced-form implications of corporate agency issues. Both cases result in an underinvestment problem for the firm, but the firm valuation criteria differ. The optimal taxation issue is discussed under a Cobb-Douglas production function setting.

Keywords: Dividend tax; Corporate profits tax; Hyperbolic discounting; Agency problem; Corporate investment; Double taxation

JEL classification: D21; E22; G38; H21

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1. Introduction

The double taxation of corporate income has long been a controversial issue in corporate taxation. When the government imposes dividend tax in addition to corporate profits tax, the shareholders end up paying two types of taxes on the same corporate income source. To avoid the double taxation of corporate income, governments often face a choice of whether to reduce the dividend tax or profit tax. In the United States, tax reforms over the past two decades have attempted to reduce the double taxation issue through adjustments in both dividends and corporate profit tax rates. In 2003, the government has reduced the dividend tax to 15 percent, under the Jobs and Growth Tax Relief Reconciliation Act. On the other hand, the recently passed Tax Cuts and Jobs Act of 2017 reduced the corporate profits tax to an effective rate of 21 percent. These policies demonstrate the delicate choice faced by governments in reducing double taxation.

Conventional corporate theory does not yield a definitive answer to this choice, as either tax policy would distort firm investment and decrease firm value. From this standpoint, both taxes have similar effects. However, this paper shows that in the case where the firm makes investment decisions based on hyperbolic discounting, the choice of taxes can be relevant for mitigating issues associated with firms’ myopic decision-making, or short-termism. In particular, this paper shows that dividend taxation may have corporate welfare-enhancing benefits relative to corporate income taxes under certain circumstances.

The notion of short-termism behavior among corporations has been widely discussed. Practitioners of finance and policymakers often cite short-termism as a major constraint on value-enhancing corporate investment projects (e.g. Graham et al. 2005). Short-termism also features prominently in public policy debates on corporate taxation. However, despite the wide attention received, theoretical underpinnings for the linkage between short-termism and corporate investment remain sparse. This paper attempts to fill in the gap by constructing a theoretical model of corporate investment under short-termism and analyzing its associated policy implications under alternative forms of corporate taxation.

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2 More specifically, the law reduced the top individual tax rates on capital gains and dividends to 15 percent through 2008, accelerated the reduction in individual tax rates, and increased the amount of temporary bonus depreciation from 30 to 50 percent.

3 In some other countries, corporate taxes have integrated corporate and shareholder taxes, such as by allowing corporate tax deductions of dividends. This was also considered by the US Treasury Department in 1992. One of the logic of double taxation is that a firm should be considered as an independent enterprise from shareholders and profits tax should be considered as the tax imposed on the firm rather than shareholders, while the dividend tax should be separate income tax imposed on the shareholders.

4 For examples of these debates, see Barton and Wiseman (2014), Denning (2014), and Lazonick (2015). Policies to address corporate short-termism have also been discussed extensively in the most recent US presidential election debates.
We present a multi-period model under which the firm makes an investment decision in each period to maximize the present value of its dividend stream. The firm invests in one project that yields return in the final period. As shown in Phelps and Pollak (1968) and Laibson (1997), the decision makings based on discounting preferences result in an under-investment (undersavings) problem, i.e. there exists another feasible investment plan that improves all periods’ present values. The main structure of this paper is similar to Laibson (1996) and Amador, Werning, and Angeletos (2006)’s hyperbolic-discounted consumption-savings model in the sense that their models of savings and consumption are structurally similar to firm-level investment and dividend payout, respectively, in this paper. However, a main difference with the existing literature is that this paper applies hyperbolic preferences to corporate policies where the return function is not simply defined by one-period investment. To earn the project return, the firm needs to invest over multiple time periods, which are captured in our model in the spirit of Porter (2008) and Jacobs and Shivdasani (2012).

Also, the structure of our model enables us to investigate corporate taxation on dividends and profits, which could not be analyzed in a consumption-savings setting. Even though the literature on optimal tax policies under hyperbolic discounting is large, to the best of our knowledge, they are virtually all confined to consumer taxation rather than corporate taxation. Given the policy relevance of corporate taxation and abundant evidence showing myopic behaviors for corporations, modeling a time-inconsistent setting in corporate investment decisions is warranted.5

This paper contributes to analyses of short-termism in economics. Experimental and introspective evidence have long suggested that animal and human behavior are short-term oriented and that their discount functions are closer to hyperbolic than exponential (Ainslie 1992; Loewenstein and Prelec 1992). Decades ago, Strotz (1956), Phelps and Pollak (1968) and Laibson (1994) have begun to apply the theory of hyperbolic discounting to household’s consumption-saving decision problems.6 Laibson (1996, 1997) further shows that consumers with hyperbolic discounting preferences face undersaving problems, resulting in implications that explain US household saving patterns.

In parallel, the literature on corporate investment has also highlighted a prominent role for short-termism, and that such myopic decisions can result in suboptimal equilibrium (see Stein 1988, 1989; Porter 1992; Bebchuk and Stole 1993; Stein 2003). These theories on corporate short-termism have focused on agency conflicts between corporate managers and

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5This is not the first paper to apply hyperbolic discounting to firms’ (or entrepreneurs) investment decisions. Grenadier and Wang (2007) incorporated hyperbolic discounting into real options models and investigated how the time-inconsistent preferences affect entrepreneurs’ investment-timing decisions, in contrast to conventional time-consistent exponential discounting preference.

6Short-term discounting has also been linked to cognitive ability (Benjamin, Brown, and Shapiro 2013).
stockholders. Corporate managers may underinvest due to pressures from boosting earnings as reflected in stock values. The agency view to myopia, which maintains rationality, is distinct from the irrational managerial myopia view. The latter explains short-termism as a form of irrational intrinsic behavior arising from time inconsistency.

As will be shown in detail, this paper’s framework is able to capture both views. Hyperbolic discounting can be interpreted directly as the time-inconsistent preference of investors and managers. However, this paper also shows that firm value under hyperbolic discounting can be interpreted as the reduced-form version of the myopic manager’s preferences under Stein (1989)’s agency conflict setting. In Stein’s model, shareholders are not able to observe the manager’s decisions directly. Due to shareholders’ incomplete information on managerial decisions, they infer future earning based on current dividend payouts as a signal. When shareholders have higher expectations about future earnings, current equity price rises and subsequently the manager’s utility increases. Therefore, the manager has an incentive to increase dividend payouts to induce higher shareholders’ expectation of future earnings. We incorporate Stein’s structure to our multi-period production decision model and derive the manager’s reduced-form based on hyperbolic discounting factors.\textsuperscript{7}

Under this agency approach, the reduced-form hyperbolic preferences are neither the manager nor investors’ intrinsic preferences. Therefore, when evaluating firm value, time-consistent exponential preferences would be the relevant criteria. This paper shows that when exponential preferences are used to assess firm value, then the firm experiences a more severe underinvestment problem. This also implies that a policy that improves all hyperbolic present values is also an improvement based on exponential present value evaluation. Thus, an important feature of our model is that it could explain corporate myopia arising from agency problems, but yet shows that even under no agency conflicts, time inconsistency could in itself be a source of myopia that induces underinvestment. The underinvestment phenomenon resulting from our framework is consistent with both theories, with differing firm valuation criteria.\textsuperscript{8}

In terms of normative implications, this paper provides perspectives on the optimality of dividend taxation versus corporate profits tax, as discussed earlier. Under hyperbolic

\textsuperscript{7}This paper deals with agency problems between managers and shareholders under the hyperbolic framework. Our paper is not the first to incorporate the agency issue into hyperbolic discounting. In an analogous setting, Hwang and Möllerström (2017) have studied the agency issue between voters and political leaders under time-inconsistent hyperbolic discounting preferences, in which they show that time-inconsistent voters can choose more patient agents as a commitment device to control the voter’s impatience.

\textsuperscript{8}As mentioned in Grenadier and Wang (2007), in contrast to large firms that have more organized monitoring systems against managers’ myopic behavior, entrepreneurs might be more prone to hyperbolically-discounted time-inconsistent behavior. However, empirical evidence has also shown that as the size of the corporation becomes larger, agency problems tend to become more severe. Therefore, our theory is applicable for both small and large firms, each possibly facing different forms of myopia.
preferences, dividend taxes may increase investment and have the ability to address the underinvestment problem. Specifically, we consider dividend taxation that is revenue-neutral, in which the collected dividend taxes are returned to the firm with lump-sum subsidies. Even with this revenue-neutral policy, we show that such an intervention improves the firm’s present values in all periods. This type of Pareto-improving multi-period taxation is distinct from Pigouvian-style lump-sum transfers, in which taxation in the current period without taxation in other periods inevitably lowers the firm’s present value. Therefore, tax policies in all investment periods are necessary for Pareto-improving investment. In contrast to dividend taxation, we show that corporate profits tax under a revenue-neutral regime decreases firm value. These results suggest that if policymakers consider the reduction of double taxation, corporate profits tax reduction may be more effective than dividend tax reduction under some circumstances.

The main result of this paper does not contradict the conventional economic view that any “one-time” corporate tax policy inefficiently distorts corporate investment decisions and decreases firm value. This view would always hold in a one or two period model where time-inconsistent preferences cannot be incorporated. In the two-period model, Chetty and Saez (2010) also theoretically investigate the impact of corporate versus dividend taxes on firm’s investment decisions. Under exponential discounting in their model, dividend taxation results in an overinvestment problem while corporate taxation helps the firm to achieve an efficient investment level by investing less in unproductive projects. In contrast, our model provides a different perspective by extending the model to three or more periods and showing how multi-period corporate tax policies affect the firm investment decisions. Under our framework, dividend taxation over multiple periods does not necessarily result in overinvestment problems, but instead could help the firm invest close to an optimal level by curbing the firm’s time-inconsistent decisions.

The rest of the paper proceeds as follows. In Section 2, we present the set-up of the theoretical framework. Section 3 shows that the firm faces an underinvestment problem in the Nash equilibrium. Sections 4 and 5 consider policy solutions to the underinvestment problem. In particular, we show that a revenue-neutral increase in dividend taxes can overcome the

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9The literature on dividend taxation has debated whether dividend tax cuts exert a significant effect on investment. Some argue that if corporations finance marginal investment through new stocks, dividend tax cuts would increase investment (Chetty and Saez 2005; Poterba and Summers 1995). On the other hand, if marginal investment is financed through retained earnings, then dividend taxes would not affect investment (Auerbach 1979; Bradford 1981).

10More specifically, Chetty and Saez (2010)’s model is a two-period corporate agency setting where the manager can invest in unproductive projects (i.e., “pet” project), which would increase the manager’s utility but not the shareholder’s utility. They show that the profit tax can help curb investment in “pet” projects, which increases shareholders’ wealth.
underinvestment problem, while profits taxes worsen the underinvestment problem. Section 6 shows how our results fit under both the irrationality and agency views of myopia. Section 7 derives the optimal dividend tax policies under Cobb-Douglas production functions. Section 8 concludes.

2. Three-period model

We first introduce a three-period model of corporate investment decisions under the hyperbolic discounting framework. The firm makes an investment decision in each period to maximize the present value of dividend streams. \(x_1\) and \(x_2\) denote exogenous cash flows in periods 1 and 2, respectively. The firm chooses to undertake investments of amounts \(i_1 \in (0, \infty)\) and \(i_2 \in (0, \infty)\) in periods 1 and 2. The return from investments is realized in period 3 and takes on the function \(f(i_1, i_2)\) on the domain of \((i_1, i_2) \in (0, \infty)^2\). The return function is continuously differentiable, strictly increasing, strictly concave, and \(f_{12}(i_1, i_2) > 0\). To ensure interior solutions, we have the following conditions: (1) \(f(i_1, 0) = 0\) and \(\lim_{i_2 \to 0} f_1(i_1, i_2) = \infty\) for any \(i_1 \in (0, \infty)\), (2) \(f(0, i_2) = 0\) and \(\lim_{i_1 \to 0} f_1(i_1, i_2) = \infty\) for any \(i_2 \in (0, \infty)\) and (3) there exists \(M \in \mathbb{R}_{++}\) such that for any \((i_1, i_2) \in \mathbb{R}_{++}^2\), \(f(i_1, i_2) < M\). Conditions (1) and (2) guarantee that the investment choice level is not zero. Condition (3) implies that the investment choice level is not infinite.

The firm’s dividends are denoted as \(d_1 = x_1 - i_1\) in period 1, \(d_2 = x_2 - i_2\) in period 2, and \(d_3 = f(i_1, i_2)\) in period 3. We assume that \(x_1\) and \(x_2\) are large enough to avoid negative dividends.

The present values in periods 1, 2 and 3 are given as

\[
PV_1 = d_1 + \beta_1 (\delta d_2 + \delta^2 d_3),
\]

\[
PV_2 = d_2 + \beta_2 \delta d_3,
\]

and

\[
PV_3 = d_3.
\]

where \(\beta_1\) and \(\beta_2\) are hyperbolic discounting factors in periods 1 and 2, respectively; and \(\delta\) is the long-term discounting factor. In the traditional hyperbolic discounting model, \(\beta_1\) and \(\beta_2\) are identical, which implies that the decision maker has the same incremental discounting rate between today and future periods. However, as will be shown in section 6, hyperbolic discounting preferences can be interpreted as the reduced-form of manager’s preferences under agency conflicts with asymmetric information. In this case, \(\beta_1\) and \(\beta_2\) would no longer
be interpreted as parameters reflecting intrinsic irrational myopia, but rather as market-driven myopia. In this paper, we consider both interpretations of hyperbolic discounting preferences.

With this $\beta, \delta$ functional form, $\beta_1 = \beta_2 = 1$ corresponds to exponential discounting, while $\beta_1, \beta_2 \in (0, 1)$ reflects present bias. In other word, $\beta_1$ and $\beta_2$ are excess discount factors between the current and the next period.

The use of extra discounting of present values to incorporate short-termism has been established by corporate finance research. This approach is grounded on vast empirical evidence that shows corporate discount rates are higher than those implied by efficient markets (King 1972; Poterba and Summers 1995; Miles 1993; Haldane and Davies 2011). Recently, Budish, Roin, and Williams (2015) defined a benchmark discount rate based on the real interest rate and risk factors. They defined short-termism as an exponential discount rate that is strictly greater than the benchmark discount rate. In our model, the extra discounting applies only to the current and the immediate future period, which deviates from the exponential discounting assumption.

We assume that the firm is sophisticated, as defined by knowing how its preferences change over time. The sophisticated firm in period 1 knows how the firm in period 2 makes decisions, given the period-1 decision. Therefore, the equilibrium can be derived in a recursive way. The firm in period 2 chooses $i_2$ to maximize $PV_2$, where $i_1$ is taken as given:

$$\max_{i_2} (x_2 - i_2) + \beta_2 \delta f(i_2, i_1).$$

From the maximization problem (1), we have an implicit function of $i_2$ in terms of $i_1$, denoted as $\tilde{i}_2(i_1)$. Even though in most cases, closed-form solutions for $\tilde{i}_2(i_1)$ do not exist, we know that $\tilde{i}_2(i_1)$ is a well-defined and strictly increasing function. Thus, with $\tilde{i}_2(i_1)$, the sophisticated firm chooses $i_1$ to maximize $PV_1$:

$$\max_{i_1} (x_1 - i_1) + \beta_1 \delta \left( x_2 - \tilde{i}_2(i_1) \right) + \beta_1 \delta^2 f \left( \tilde{i}_2(i_1), i_1 \right).$$

From the maximization problems in (1) and (2), we can define the subgame perfect Nash equilibrium of the multi-period investment decisions as follows:

**Definition 1** A subgame perfect Nash equilibrium $\left( i_1^*, \tilde{i}_2(i_1) \right)$ is such that $\tilde{i}_2(i_1)$ solves the period-2 maximization problem, conditional on $i_1$; and $i_1^*$ solves the period-1 maximization problem by substituting $i_2$ with $\tilde{i}_2(i_1)$.

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11 The behavior of present-biased agents can often be different depending on whether they are aware (sophisticated) or unaware (naive) of their self-control problems. O’Donoghue and Rabin (1999, 2015) carefully compare the decision and welfare differences between naive and sophisticated agents.
The following proposition shows that there exists a Nash equilibrium(s) from the firm’s maximization problem:

**Proposition 1** There exists a subgame perfect Nash equilibrium \((i_1^*, i_2(i_1))\) as in Definition 1.

**Proof.** See Appendix A. □

### 3. Underinvestment problem

Having presented the set-up of the model, we analyze how the myopic firm would make suboptimally low levels of investment in equilibrium. In other words, there exist other investment plans that induce higher firm values in all periods. The underinvestment problem occurs because the firm faces intertemporal conflicts across time. The firm’s present values are time inconsistent and it has a stronger preference towards current dividend payouts, which can be viewed as myopia. The intertemporal conflicts that occur in the firm’s decisions result in an inefficient investment equilibrium and lower present values.

To demonstrate the underinvestment problem, we will show the existence of an equilibrium that solves the two maximization problems defined in periods 1 and 2. Next, we show that marginal increases in both periods’ investments from the equilibrium investment level can improve the firm’s value in all three periods, which implies that the firm is facing an underinvestment problem. In the following section, we will show that there exist tax and subsidy policies that address this issue by inducing an increase in investment and thus a rise in the firm’s value in all periods.

In this section, we will show that the firm’s decision is suboptimal and the firm experiences the underinvestment problem. We define the underinvestment problem as follows:

**Definition 2** At the Nash equilibrium investment levels \((i_1^*, i_2^*)\), the firm faces the underinvestment problem if there exists \((i_1', i_2')\) such that

\[
i_1' > i_1^*, \quad i_2' > i_2^*,
\]

\[
\mathcal{PV}_1 (i_1', i_2') > \mathcal{PV}_1 (i_1^*, i_2^*),
\]

\[
\mathcal{PV}_2 (i_1', i_2') > \mathcal{PV}_2 (i_1^*, i_2^*),
\]

and

\[
\mathcal{PV}_3 (i_1', i_2') > \mathcal{PV}_3 (i_1^*, i_2^*),
\]

7
where
\[ \mathcal{PV}_1(i_1, i_2) = (x_1 - i_1) + \beta_1 \delta (x_2 - i_2) + \beta_1 \delta^2 f(i_1, i_2), \]
\[ \mathcal{PV}_2(i_1, i_2) = (x_2 - i_2) + \beta_2 \delta f(i_1, i_2), \]
and
\[ \mathcal{PV}_3(i_1, i_2) = f(i_1, i_2). \]

Definition 2 states that the firm has the underinvestment problem if there exists another investment plan \((i_1', i_2')\) such that (a) it is strictly higher than the Nash equilibrium investment level \((i_1^*, i_2^*)\), and (b) its associated present values are strictly higher than those of the investment decisions. The following proposition shows that based on Definition 2, the firm has an underinvestment problem at the Nash equilibrium:

**Proposition 2** The firm faces an underinvestment problem (as in Definition 2) for any hyperbolic discounting parameters \(\beta_1, \beta_2 < 1.\)

**Proof:** The proof of Proposition 2 will be based on the following two lemmas. Lemmas 1 and 2 investigate whether the present value functions \(\mathcal{PV}_1(i_1, i_2)\) and \(\mathcal{PV}_2(i_1, i_2)\), respectively, increase or decrease in small variations in \((i_1, i_2)\) at the Nash equilibrium. The present value in period 3, \(\mathcal{PV}_3(i_1, i_2)\), trivially increases in \((i_1, i_2)\).

**Lemma 1** At the Nash equilibrium investment plan \((i_1^*, i_2^*)\), we have
\[ \frac{\partial \mathcal{PV}_1}{\partial i_1} < 0 \quad \text{and} \quad \frac{\partial \mathcal{PV}_1}{\partial i_2} > 0. \]

**Proof.** See Appendix B.

Lemma 1 indicates that an increase in period-2 investment beyond the Nash equilibrium investment level can improve period-1 firm value, i.e., \(\partial \mathcal{PV}_1/\partial i_2 > 0\). This implies that from the perspective of the period-1 firm decision maker, the period-2 investment is inefficiently low. With no short-termism \((\beta = 1)\), an increase in period-2 investment cannot improve period-1 firm value, i.e., \(\partial \mathcal{PV}_1/\partial i_2 = 0\).

**Lemma 2** At the Nash equilibrium investment plan \((i_1^*, i_2^*)\), we have
\[ \frac{\partial \mathcal{PV}_2}{\partial i_1} > 0 \quad \text{and} \quad \frac{\partial \mathcal{PV}_2}{\partial i_2} = 0. \]

**Proof.** See Appendix C.
Lemma 2 indicates that an increase in period-1 investment can improve period-2 firm value, i.e., $\frac{\partial \overline{PV}_2}{\partial i_1} > 0$. From Lemmas 1 and 2, in a small open set around the investment decision $(i_1^*, i_2^*)$, there are four different regions, as depicted in Figure 1. Region I is the area where all three present values are higher than those associated with the investment decision. Furthermore, in none of the regions is there an overinvestment situation, in which there would exist a lower investment level that leads to Pareto-improving present values in all periods.

**End of Proof of Proposition 2.**

From Lemma 2, we know that period-2 investment must be increasing in order to raise $\overline{PV}_2$ at the Nash equilibrium. From Lemma 1, we know that an increase in period-1 investment decreases $\overline{PV}_1$ but increases $\overline{PV}_2$. Therefore, period-2 investment must be increasing sufficiently relative to the increase in **period-1 investment** for $\overline{PV}_1$ to be higher. From equations (64) and (66) in the Appendix, we have the following:

$$\frac{\partial \overline{PV}_1}{\partial i_1} \Delta i_1 + \frac{\partial \overline{PV}_1}{\partial i_2} \Delta i_2 = d_i_1 \left( (\beta_2 - 1) \beta_1 \delta^2 \tilde{i}_2(i_1) f_2 \right) + d_i_2 \beta_2 \delta^2 (1 - \beta_1) f_2$$

In order for (3) to be strictly positive, $\frac{\Delta i_2}{\Delta i_1} > \tilde{i}_2(i_1)$ needs to satisfy the following inequality:

$$\frac{\Delta i_2}{\Delta i_1} > \tilde{i}_2(i_1) > 0$$
Inequality (4) will be used in showing the existence of Pareto-improving tax-policies in the following sections.

As an example in which $f(i_1, i_2) = 20i_1^{1/4}i_2^{1/6}$, $\beta_1 = \beta_2 = 0.6$ and $\delta = 0.9$, the indifference curves of $\mathbf{PV}_1(i_1, i_2)$ and $\mathbf{PV}_2(i_1, i_2)$ are plotted in Figure 2.\textsuperscript{12} The surrounding region enclosed by the two indifference curves is the Pareto-superior region (Region I). The main goal of policies to be introduced in the following two sections is to move the Nash equilibrium investment plan into region I in Figure 2.

4. Dividend taxation

In the previous section, we have shown that myopic corporate decisions result in an under-investment problem. Now, we move on to policy experiments and examine whether outside authorities’ intervention can improve the firm’s value. For this normative question, we assume that the authority has no exogenous expenditures so that the tax policy is balanced. The collected amount of dividend taxes would be returned to the firm in the form of lump-sum subsidies. We show that even with a revenue-neutral tax policy, the firm’s value can be improved.

We examine the effects of proportional dividend taxes on the firm’s dividend/investment decisions and present values. Let there be a proportional dividend tax rate $\tau_t$ and a lump-

\textsuperscript{12}With a Cobb-Douglas return function, there exists a closed form solution for the equilibrium investment (See section 7). In this example, we have $(i_1^*, i_2^*) = (4.69, 3.22)$. 

Figure 2: Equilibrium and Pareto-superior region
sum transfer $s_t$ in period $t$. The firm’s budget sets are

$$(1 + \tau_1) d_1 + i_1 = x_1 + s_1,$$

$$(1 + \tau_2) d_2 + i_2 = x_2 + s_2,$$

and

$$d_3 = f(i_1, i_2).$$

Since the government has no exogenous expenditure to finance, its budget constraints satisfy $s_t = \tau_t d_t^*$, where $d_t^*$ is the dividend payout decision in period $t$. The tax policies $\tau_1$ and $\tau_2$ are fully anticipated and affect both period-1 and period-2 decisions.

For the proof of the existence of Pareto-improving policies, we consider infinitesimal changes in two periods’ tax policies at $(\tau_1, \tau_2) = 0$ in order to guarantee the existence of a Nash equilibrium. In Proposition 1, we have shown that without tax policies, there exists an Nash equilibrium in which the first and second order conditions are satisfied. The result in Proposition 1 also implies the existence of a Nash equilibrium with $(\tau_1, \tau_2) = 0$. However, for any strictly positive tax policy $(\tau_1, \tau_2) > 0$, the existence of a Nash equilibrium is not guaranteed, and therefore we need to focus on local analysis in which small changes in tax-policies are considered.

Imposing dividend taxes decreases the marginal cost of investment relative to that of dividends. Because the collected tax is returned as a lump-sum subsidy, an increase in taxes has a substitution effect but not an income effect.\(^{13}\) The substitution effect, in general, decreases the level of dividend and increases the level of investment. The following lemma shows that an increase in $\tau_1$ increases both $i_1^*$ and $i_2^*$.

**Lemma 3** At the Nash equilibrium of $(\tau_1, \tau_2) = 0$, a (finite) increase in $\tau_1$ increases the equilibrium investments in both periods, that is

$$0 \leq \frac{di_1^*}{d\tau_1} < \infty \text{ and } 0 \leq \frac{di_2^*}{d\tau_1} < \infty.$$  \hspace{1cm} (5)

We also have

$$\frac{di_2^*}{d\tau_1} \bigg/ \frac{di_1^*}{d\tau_1} = \gamma_2(i_1).$$  \hspace{1cm} (6)

\(^{13}\)It may seem trivial that an increase in the dividend tax in period $t$ causes a decrease in dividend and increase in investment in the same period. However, our context also accounts for the ability of the tax policy in one period to affect the firm’s decision in another period. Because of this intertemporal effect, investment is not necessarily increasing in dividend taxes in the same period. This will be shown for the case of period-2 dividend taxation in this section.
**Proof.** The present value in period 1 is

\[
P V_1 = \frac{x_1 - i_1 + s_1}{1 + \tau_1} + \beta_1\delta \left( \frac{x_2 - \tilde{i}_2(i_1) + s_2}{1 + \tau_2} \right) + \beta_1\delta^2 f \left( i_1, \tilde{i}_2(i_1) \right). \tag{7}
\]

The first order condition from (7) is

\[
-\frac{1}{1 + \tau_1} - \beta_1\delta \frac{\tilde{i}_2'(i_1)}{1 + \tau_2} + \beta_1\delta^2 f_1 + \beta_1\delta^2 f_2\tilde{i}_2'(i_1) = 0. \tag{8}
\]

Where \((\tau_1, \tau_2) = (0, 0)\), the first-order condition in (8) is equivalent to (60) in the proof of Proposition 1. Since we show that \(\tilde{i}_2(i_1)\) and \(\tilde{i}_2'(i_1)\) are continuously-differentiable functions in \(i_1 \in (0, \infty)\) in Proposition 1, we know that the Nash equilibrium \(i_1^*\) is also a continuously-differentiable function in \((\tau_1, \tau_2) = (0, 0)\). The second order condition from (8) is

\[
-\beta_1\delta \frac{\tilde{i}_2''(i_1)}{1 + \tau_2} + \beta_1\delta^2 f_{11} + 2\beta_1\delta^2 f_{12}\tilde{i}_2'(i_1) + \beta_1\delta^2 f_{22} \left( \tilde{i}_2'(i_1) \right)^2 + \beta_1\delta^2 f_2\tilde{i}_2''(i_1) \leq 0. \tag{9}
\]

Where \((\tau_1, \tau_2) = (0, 0)\), the second-order condition in (9) is equivalent to (61) in the proof of Proposition 1. Implicitly differentiating (8) with respect to \(\tau_1\), we have

\[
\frac{1}{(1 + \tau_1)^2} d\tau_1 - \beta_1\delta \frac{\tilde{i}_2''(i_1)}{1 + \tau_2} di_1 + \beta_1\delta^2 f_{11} di_1 + 2\beta_1\delta^2 f_{12}\tilde{i}_2'(i_1) di_1 + \beta_1\delta^2 f_{22} \left( \tilde{i}_2'(i_1) \right)^2 di_1 + \beta_1\delta^2 f_2\tilde{i}_2''(i_1) di = 0. \tag{10}
\]

By equation (10) and the second order condition (9), we have

\[
0 \leq \frac{di_1^*}{d\tau_1} < \infty. \tag{11}
\]

By (11) and that \(\tilde{i}_2'(i_1) > 0\), we have

\[
0 \leq \frac{di_2^*}{d\tau_1} < \infty, \tag{12}
\]

12
Lemma 3 shows that period-1 dividend taxation increases investment levels in both periods, and the ratio of the marginal increases of the two periods’ investments is equal to \( \frac{\delta \tau_1}{\tau_1} \cdot \frac{\delta i_1^*}{\delta \tau_1} = \hat{\iota}_2(i_1) \). The increasing rate \( \hat{\iota}_2(i_1) \) implies that if only period-1 dividend taxation is imposed, the Pareto-superior investment plan cannot be achieved (see inequality (4)). Therefore, we also need period-2 dividend taxation. The substitution effect from higher period-2 dividend taxes can increase the choice function \( \hat{\iota}_2(i_1) \), but does not directly increase the period-2 investment, \( i_2^* \). The change of the choice function \( \hat{\iota}_2(i_1) \) affects the period-1 investment choice, and the period-1 investment choice will affect the period-2 investment, \( i_2^* \), through the choice function \( \hat{\iota}_2(i_1) \). Therefore, whether the two periods’ investments increase or decrease from period-2 taxation is not a trivial question. Nevertheless, we can derive the possible range of investment changes by period-2 taxation, which is sufficient to show the existence of Pareto-improving tax policies.\(^{14} \)

**Lemma 4**  At the Nash equilibrium of \( (\tau_1, \tau_2) = 0 \), the following inequality is satisfied:

\[
\hat{\iota}_2(i_1) \frac{di_1}{d\tau_2} < \frac{di_2}{d\tau_2}.
\]

**Proof.** The present value in period 2 is

\[
P V_2 = \frac{x_2 - i_2 + s_2}{1 + \tau_2} + \beta_2 \delta f(i_1, i_2).
\]

The first order condition from (15) is

\[
\frac{-1}{1 + \tau_2} + \beta_2 \delta f_2(i_1, i_2) = 0.
\]

Implicitly differentiating (16) with respect to \( \tau_2 \), we have

\[
\frac{d\tau_2}{(1 + \tau_2)^2} + \beta_2 \delta f_{22}(i_1, i_2) di_2 = 0,
\]

\(^{14}\)We conjecture that depending on the elasticity of substitution between the two periods’ investments, period-1 investment can increase or decrease from period-2 taxation. For higher values of the elasticity of substitution, increases in period-2 taxation might decrease the period-1 investment because the increased period-1 investment (by period-2 taxation) can substitute for period-1 investment. If the elasticity is small, the reverse result would be expected. Further studies on this issue are necessary.
and, equivalently,
\begin{equation}
\frac{d\tau_2}{d\tau_2} = -\frac{1}{(1 + \tau_2)^2 \beta_2 \delta f_{22}} > 0.
\end{equation}

The maximization problem of period-1 present value can be expressed as
\begin{equation}
\max_{i_1, i_2} PV_1(i_1, i_2),
\end{equation}
subject to
\begin{equation}
\tau_2(i_1) = i_1.
\end{equation}

Taking a total derivative of equation (18) with respect to \( \tau_2 \), we have
\begin{equation}
\frac{d\tau_2}{d\tau_2} + \frac{\gamma_2(i_1) d_1}{d\tau_2} = \frac{d_2}{d\tau_2}.
\end{equation}

Since \( \frac{d\tau_2}{d\tau_2} > 0 \) from (17), we have
\begin{equation}
\frac{\gamma_2(i_1) d_1}{d\tau_2} < \frac{d_2}{d\tau_2}.
\end{equation}

Lemma 4 indicates that period-2 taxation induces the equilibrium investment to move above the \( \tau_2(i_1) \) curve (i.e., \( \tau_2(i_1) \frac{d_1}{d\tau_2} < \frac{d_2}{d\tau_2} \)). Inequality (14) does not imply whether period-1 and 2 investments increase or decrease.

From Lemmas 3 and 4, the existence of Pareto-improving dividends taxation policies is shown in the following proposition:

**Proposition 3** For any hyperbolic discounting parameters \( \beta_1, \beta_2 < 1 \), there exist positive Pareto-improving proportional dividend taxes \( \tau_1, \tau_2 \gg 0 \).

**Proof:** In the proof, we consider small changes in dividend taxes at \( (\tau_1, \tau_2) = 0 \). Lemmas 3 and 4 show that the Nash equilibrium investment is a continuously-differentiable function of dividend tax policies at \( (\tau_1, \tau_2) = 0 \). Since there exists an equilibrium at \( (\tau_1, \tau_2) = 0 \), as shown in Lemmas 3 and 4, there is also an open set \( T \subset \mathbb{R}^2 \) such that \( T \) includes \( (0, 0) \) and such that an equilibrium exists for any \( (\tau_1, \tau_2) \in T \). Therefore, if the equilibrium at \( (\tau_1, \tau_2) = 0 \) is locally unique, there still exists a locally unique equilibrium with small variations in \( (\tau_1, \tau_2) \). Lemma 3 indicates that period-1 taxation induces both periods’ investment to move along the \( \tau_2(i_1) \)-line in Figure 3 (see (6) in Lemma 3). Inequality (14) in Lemma 4 implies that period-2 taxation induces the investments in both periods to move above the \( \tau_2(i_1) \)-line in Figure 3. Therefore, by combining dividend taxations in both periods, the
equilibrium investment can move into the Pareto-superior region (region I). Mathematically, this means that at the equilibrium \((\tau_1, \tau_2) = (0, 0)\), there exists a positive constant \(a\) such that

\[
\frac{\partial^2 \hat{i}_2}{\partial \tau_2^2} + a \frac{\partial^2 \hat{i}_2}{\partial \tau_2 \partial \tau_1} < \infty.
\]

The end of Proof of Proposition 3.

Figure 4 also describes how dividend taxation policies can Pareto-improve the firm’s values. As an example in which \(f(i_1, i_2) = 20i_1^{1/4}i_2^{1/6}\), \(\beta_1 = \beta_2 = 0.6\) and \(\delta = 0.9\), the investment decision with \((\tau_1, \tau_2) = (10\%, 40\%)\) is indicated in Figure 4. An increase in period-1 tax can move the Nash equilibrium point along the \(\hat{i}_2(i_1)\) curve. Without period-2 taxation, the period-1 taxation cannot improve the period-1 present value (the period-1 present value becomes even lower along the \(\hat{i}_2(i_1)\) curve). Together with period 1 and 2’s tax policies, the Nash equilibrium can move into the Pareto-superior region.

5. Corporate profits tax

In this section, we show that the corporate profit tax intensifies firm’s myopia and thus decreases firm value. As in the previous section, we assume that the authority adopts revenue-neutral policies. Therefore, lump-sum subsidies in the same amount as profits taxes will be imposed in the same period. The firm’s budget constraints under profits taxes are

\[
d_1 + i_1 = x_1,
\]
Figure 4: Pareto-improving dividend taxation

\[ d_2 + i_2 = x_2, \]

and

\[ d_3 = (1 - \theta) f(i_1, i_2) + \eta, \]

where \( \theta \) and \( \eta \) are the proportional tax rate and the lump sum subsidy, respectively, in period 3. Since the outside authority has no exogenous expenditure to finance, its budget constraints satisfy \( \eta = \theta f(i_1^*, i_2^*) \), where \( i_t^* \) is the equilibrium investment level in period \( t \).

Following the same but reverse logic as the dividend-taxation case in Section 4, an increase in \( \theta \) raises the cost of investment relative to the cost of dividends. By the substitution effect, an increase in \( \theta \) induces lower equilibrium investment, and therefore, lower present value.

**Proposition 4** As the profit tax \( \theta \) increases, firm value is Pareto-disimproving for any hyperbolic discounting parameters \( \beta_1, \beta_2 < 1 \).

**Proof.** It is a straightforward proof that as \( \theta \) increases, investments in both periods decrease because an increase in \( \theta \) lowers the marginal return of investments. We only need to show \( \frac{\partial f}{\partial i_1} > \frac{\partial f}{\partial i_2} \) to show that an increase in \( \theta \) moves the investment into region III rather than region I. The following is the proof:

\[ \frac{\partial f}{\partial i_1} > \frac{\partial f}{\partial i_2} \]

15In the previous section, we did not specify whether \( f(i_1, i_2) \) represents net or gross return of the project, because under dividend taxation it does not affect the main results of this paper. Considering that the corporate profit tax is imposed on net return, \( f(i_1, i_2) \) should represent net return as well in this section. If \( f(i_1, i_2) \) is the net return, the gross return should be \( f(i_1, i_2) + i_1 (1 + r_1) (1 + r_2) + i_2 (1 + r_2) \), where \( r_1 \) and \( r_2 \) are the real interest rates in periods 1 and 2, respectively.
The present value in period 2 is

\[
P V_2 = x_2 - i_2 + \beta_2 \delta \{ (1 - \theta) f(i_1, i_2) + \eta \}.
\]  

(20)

The first order condition from (20) is

\[-1 + \beta_2 \delta (1 - \theta) f_2(i_1, i_2) = 0.\]

(21)

Implicitly differentiating (21) with respect to \( \theta \), we have

\[-\beta_2 \delta f_2(i_1, i_2) + \beta_2 \delta (1 - \theta) f_{22}(i_1, i_2) \frac{d\hat{i}_2(i_1; \theta)}{d\theta} = 0,\]

and, equivalently,

\[
\frac{d\hat{i}_2(i_1; \theta)}{d\theta} = \frac{\beta_2 \delta f_2(i_1, i_2)}{(1 - \tau_2)^2 \beta_2 \delta f_{22}} < 0. \tag{22}
\]

The maximization problem of period-1 present value can be expressed as

\[
\max_{i_1, i_2} PV_1(i_1, i_2),
\]

subject to

\[
\hat{i}_2(i_1) = i_2. \tag{23}
\]

Taking a total derivative of equation (23) with respect to \( \theta \), we have

\[
\frac{d\hat{i}_2(i_1)}{d\theta} + \hat{i}_2(i_1) \frac{d\hat{i}_1}{d\theta} = \frac{di_2}{d\theta}. \tag{24}
\]

Because \( \frac{di_2(i_1)}{d\theta} < 0 \) from (22), we have

\[
\hat{i}_2(i_1) \frac{di_1}{d\theta} > \frac{di_2}{d\theta}.
\]

Even though the dividend tax and profit tax are structurally different in this setting, to prove the negative firm-value impact of the profits tax in Proposition 3, the same but reverse logic as the proof of Proposition 3 is applied. The increase in profits tax decreases the cost of dividend payout and raises the cost of investment, which is mathematically equivalent to the case of a decrease in dividend taxation. As profits tax increases, the investment level moves to Region III, where the value of the firm for all periods is lower than the Nash equilibrium.
value without tax policy. This also implies that profits subsidies necessarily Pareto-improve firm value.

6. Agency problems and hyperbolic discounting

One of the most popular approaches in explaining managerial myopia is agency problems resulting from information asymmetry, under which investors and shareholders have incomplete information about the manager’s internal decisions. Based on Stein (1988, 1989)’s work, under efficient and rational stock markets, investors naturally infer future stock prices based on previous dividend payouts. The manager’s preferences are assumed to be dependent on both the firm’s current stock price as well as on its long-term value. This provides the manager an incentive to boost current stock prices in order to increase her utility. Grounded on Stein’s theory, Asker, Farre-Mensa, and Ljungqvist (2015) empirically compare investment levels of publicly-listed firms with that of private firms. Holding firm size, industry characteristics, and investment opportunities constant, they show that on average, public firms invest 45% less than private firms over the period 2001–2011.

This section incorporates Stein’s (1989) agency-problem model to the multi-period investment model and shows that even when the investors and managers exhibit the typical exponential discounted time preferences, asymmetric information would lead to an investment plan that is the same as that under hyperbolic discounted preferences. The main premise of Stein’s theory is that investors are not able to observe the manager’s actions and earnings directly. Since investors have incomplete information on cash flow, they infer future cash flows (future earning) based on current dividend payouts. To induce higher investors’ expectation of future earnings, the manager has an incentive to increase dividend payouts by decreasing investment. When investors have higher expectations about future earnings, current stock price rises and subsequently the manager’s utility increases.

To incorporate Stein’s agency-problem framework to our paper, we need to define cash flows as a random variable. Specifically, we assume that the cash flow $x_t$ (the earning from the previous project) is incomplete information to the manager and the market. For $t \geq 2$, we have

$$x_t = z_t + \varepsilon_t,$$

where $z_t$ and $\varepsilon_t$ represent permanent and transitory components of earnings, respectively. The $\varepsilon_t$’s are independent across periods with mean zero and variance $\sigma_{\varepsilon}^2 (= 1/h_\varepsilon)$. $z_t$ follows a random walk: $z_t = z_{t-1} + u_t$, where $u_t$ are a sequence of independent mean zero normal variates with variance $\sigma_u^2 (= 1/h_u)$. The manager and the market share prior beliefs about
That prior is normally distributed with mean $m_1$ and variance $\delta_1^2(=1/h_1)$.

The assumptions about dividend payouts in each period are the following: $d_1 = x_1 - i_1$, $d_2 = x_2 - i_2$, and $d_3 = x_3 + R(i_1, i_2)$. Assuming that investors are risk neutral, we can define their wealth based on exponential discounting time preferences as

$$V_1 = d_1 + \delta E_1 [d_2 + \delta d_3],$$

$$V_2 = d_2 + \delta E_2 [d_3], \text{ and } V_3 = d_3$$

where $E_1$ and $E_2$ represent the expectations of future earnings in periods 1 and 2, respectively.

The market price of the firm’s stock is the investor’s expected valuation. We define the stock price in period $t$ as the discounted sum of all dividend payouts since period $t + 1$. Therefore, we have $P_1 = E_1^t [\delta d_2 + \delta^2 d_3]$ and $P_2 = E_2^t [\delta d_3]$, where $E_1^t$ and $E_2^t$ represent the investors’ expectations in periods 1 and 2, respectively.

We also define the manager’s preferences in the same way as in Stein (1989).

$$V_{1M}^t = E_1 [d_1 + \pi P_1 + (1 - \pi) (\delta d_2 + \delta^2 d_3)]$$

$$V_{2M}^t = E_2 [d_2 + \pi P_2 + (1 - \pi) \delta d_3]$$

$$V_{3M}^t = d_3$$

where $P_t$ is the estimated stock price by investors at period $t$ and $(1 - \pi)$ represents the fraction of the manager’s stock ownership at market value. Stein (1989, p.659) proposes several interpretations of the positive value of $\pi$. Even though managers want to hold the stock for the longer term, they face a probability $\pi$ of takeover in each period (see also Stein 1988). Another possibility is that funding requirements might force the manager to go to the stock market and issue new stocks. Where the exogenous cash flow is deterministic, the dividend payouts are perfectly estimated and therefore the managers’ preferences become the same as those of the investors following exponential discounting. In other words, without information uncertainty, there is no difference across managers’ preferences, stock prices, and investors’ preferences.

Even though market investors do not observe the manager’s actions, they are able to infer them through the following observations,

$$o_1 \equiv x_1 = d_1 + i_1^* \text{ and } o_2 \equiv x_2 = d_1 + i_2^*,$$

where $i_1^*$ and $i_2^*$ are the investment decisions in periods 1 and 2, respectively. As will be shown in Proposition 5, $i_1^*$ and $i_2^*$, are not affected by these observations. This is because
the expectation of future cash flows by the Bayesian learning process is linearly related to current and past cash flows (see equations (32) and (33)). This further implies that in the first order conditions of the manager’s investment decisions, the observations \{o_1, o_2\} would be cancelled out. Therefore, both the manager and the stock market know the investment plan \(i_1^*, i_2^*\) such that the manager cannot fool the market. Nevertheless, the manager and investors are trapped into behaving myopically because the manager’s decision to increase investment beyond the Nash equilibrium is recognized as a decrease in cash flow by investors. Stein (1989) described this situation as analogous to the prisoner’s dilemma, in the sense that the efficient equilibrium is not sustained as a Nash equilibrium.\(^{16}\)

Through the observation of \{o_1, o_2\}, the market learns about earnings, \(z_t\). Then, the posterior distribution of \(z_t\) will remain normal and we have the following expectations:

\[
E_1[x_2 | o_1] = E_1[x_3 | o_1] = E_1[z_2 | o_1] = (1 - \mu_1) m_1 + \mu_1 o_1, \tag{32}
\]

and

\[
E_2[x_3 | o_1, o_2] = E_1[z_3 | o_1, o_2] = (1 - \mu_2) m_2 + \mu_2 o_2, \tag{33}
\]

where

\[
m_2 = (1 - \mu_1) m_1 + \mu_1 o_1, \\
\mu_1 = \frac{h_e}{h_1 + h_e} < 1 \text{ and } \mu_2 = \frac{(h_e/h_u) + \mu_1}{1 + (h_e/h_u) + \mu_1} < 1. \tag{34}
\]

Equations (32-34) indicate that if the variance of the transitory noise is low (i.e., the precision of \(h_e\) is high), expectation of future earnings would be sensitive to the observations. In this case, the stock price is more dependent on past dividend payouts such that the manager will behave more myopically.

We now show that under Stein’s setting with asymmetric information, the corresponding manager’s investment decisions are equivalent to that under the hyperbolic discounted firm value, expressed in the following proposition:

**Proposition 5** The reduced form of the manager’s maximization problem under information asymmetry leads to equivalent investment plans as that under hyperbolic discounting time preferences.

**Proof.** In period 2, the manager maximizes the following problem and solves for the optimal
\( i_2 \), where \( i_1 \) is taken as given:

\[
\max_{i_2} (x_2 - i_2) + \pi P_2 + (1 - \pi) \delta (x_3 + R(i_1, i_2)). 
\] (35)

From the maximization problem of (35), we have the choice function \( \hat{i}_2(i_1) \). The choice function is known to both the manager and the stock market (investors). In the maximization problem, the choice function is not affected by previous and future cash flows.

The first-order condition of the maximization problem in (35) is

\[
-1 + \pi \frac{dP_2}{di_2} + (1 - \pi) \delta R_2(i_1, i_2) = 0. 
\] (36)

where we have

\[
\frac{dP_2}{di_2} = -\delta \mu_2 + \delta R_2(i_1, i_2), 
\] (37)

because an increase in investment results in a decrease in dividend, which consequently results in a decrease in observation \( o_2 \) (see equation (31)).

From the first order condition (36), we have

\[
\frac{\delta}{1 + \pi \delta \mu_2} R(i_1, i_2) = 1. 
\] (38)

Defining

\[
\beta_2 = \frac{1}{1 + \pi \delta \mu_2} < 1, 
\] (39)

the maximization problem in (35) and the first-order condition (36) are equivalent to those under hyperbolic discounted time preferences.

In period 1, given the choice function \( \hat{i}_2(i_1) \), the manager has the following maximization problem

\[
\max_{i_1} \left[ (x_1 - i_1) + \pi P_1 + (1 - \pi) \delta \left( x_2 - \hat{i}_2(i_1) \right) \right. 
\]
\[
+ \left. (1 - \pi) \delta^2 \left( x_3 + R(i_1, \hat{i}_2(i_1)) \right) \right] 
\] (40)

Since we have

\[
\frac{dP_1}{di_1} = -\delta \mu_1 - \delta^2 \mu_1 + \delta^2 R_1 + \delta^2 R_2 \hat{i}_2'(i_1), 
\] (41)

the first-order condition of (40) is

\[
-1 - \pi (\delta + \delta^2) \mu_1 - \delta \hat{i}_2'(i_1) + \delta^2 R_1 + \delta^2 R_2 \hat{i}_2'(i_1) = 0. 
\]
Defining $\beta_2$ as

$$\beta_2 = \frac{1}{1 + \pi (\delta + \delta^2) \mu_1} < 1,$$

we have the following first-order condition,

$$-1 - \beta_2 \delta \hat{d}_2(i_1) + \beta_2 \delta^2 f_1 + \beta_2 \delta^2 \hat{f}_2(i_1) = 0,$$  \hspace{1cm} (42)

which is equivalent to that of hyperbolic discounting time preferences. \hfill \blacksquare

Proposition 5 indicates that in the presence of the agency problem with asymmetric information, the manager’s investment decision can be derived from hyperbolic discounting time preferences. Specifically, defining the hyperbolic discount factors

$$\beta_1 = (1 + \pi \delta (1 + \delta) \mu_1)^{-1}$$

and $\beta_2 = (1 + \pi \delta \mu_2)^{-1}$, the corresponding hyperbolic discounting preferences are also able to explain the manager’s myopic behavior under the agency problem.\(^{17}\)

Under agency problems, the firm’s value must be evaluated by exponential discounting, rather than the manager’s hyperbolic reduced-form utilities. Therefore, a natural question that arises is whether investment decisions based on hyperbolic discounting also imply underinvestment in term of exponential discounting preferences.\(^{18}\) The following lemma shows that the investment plan derived from hyperbolic preferences also results in underinvestment problems based on the original exponential preferences.

**Lemma 5** Assume that there are two dividend payout plans, $(d_1^*, d_2^*, d_3^*)$ and $(d_1', d_2', d_3')$. If the hyperbolic discounted present values in all three periods based on $(d_1', d_2', d_3')$ are strictly higher than those based on $(d_1^*, d_2^*, d_3^*)$, then the exponential discounted present values under the former plan are strictly higher than those under the latter plan, that is,

$$d_1' + \delta d_2' + \delta^2 d_3' > d_1^* + \delta d_2^* + \delta^2 d_3^*,$$  \hspace{1cm} (43)

\(^{17}\)In this finite period model, the hyperbolic discounting factors $\beta_1$ and $\beta_2$ are not identical. However, in the steady-state of an infinite-period model described in Stein (1989) and Holmström (1999), the derived hyperbolic discounting factors could be identical across all periods. Specifically, in the infinite period model, the steady state $\beta^*$ is given by

$$\beta^* = \left(1 + \frac{\pi \delta \mu^*}{1 - \delta}\right)^{-1} \text{ where } \mu^* = \frac{1}{2} \left(\sqrt{h^2/h_u^2 + 4h_{\varepsilon}/h_u} - h_{\varepsilon}/h_u\right).$$

See equation (19) in Holmström (1999) for deriving $\mu^*$.

\(^{18}\)O’Donoghue and Rabin (1999) have argued that policy effectiveness should be evaluated with unbiased discounted values. They proposed a long-run value function from a prior perspective, in which the agent weighs all future periods based on unbiased exponential discounting. This long-term perspective criterion is widely used in the literature for analyzing policy implications. For policy evaluations based on the long-run criterion, see O’Donoghue and Rabin (1999, 2003, 2006), Krusell and Smith (2002), Diamond and Koszegi (2003) and Guo and Krause (2015). In the corporate finance context, unbiased present value has been interpreted as shareholders’ present value, whereas biased present value refers to that of corporate managers.
Lemma 5 implies that if there is an underinvestment problem based on the welfare function of hyperbolic preferences, there would also be an underinvestment problem based on the original exponential preferences.\textsuperscript{19} Specifically, Lemma 5 indicates that at any investment plan, the Pareto-superior region (Region I) defined under the hyperbolic firm value is smaller than and strictly included by the Pareto-superior region defined under the exponential (i.e., unbiased) firm value. Figure 5 shows this in an example of \( f(i_1, i_2) = 12i_1^{1/4}i_2^{1/6}, \beta_1 = \beta_2 = 0.75 \) and \( \delta = 0.95 \). The dashed curves in Figure 5 represent the indifference curves of unbiased (i.e., \( \beta = 1 \)) present values in periods 1 and 2. Therefore, with agency problems, the firm suffers from two underinvestment problems: one is the internal decisions conflict due to hyperbolic discounting time preferences (i.e., reduced form of manager’s preferences) and the other is from the preference difference between hyperbolic and exponential.

Propositions 3 and 4 show that outside authority’s policies can result in Pareto-improvement of hyperbolic discounted values in all periods. Lemma 5 shows that the Pareto-superior region based on exponentially discounted values includes the region based on hyperbolic discounted present values. Therefore, we can conclude that if a policy improves biased present values in all three periods, it also improves the exponential present values. This is shown in the following corollary:

\[ d'_2 + \delta d'_3 > d''_2 + \delta d''_3, \quad (44) \]

**Proof.** See Appendix D. \[ \blacksquare \]

However, the reverse is not true. See Kang (2015).
Corollary 1 There exist positive dividend taxes \((\tau_1, \tau_2)\) that improve the firm’s unbiased values.

Proof. Directly from Propositions 3 and 4, and Lemma 5. ■

7. Optimal dividend tax under Cobb-Douglas production

Under hyperbolic discounting, the preference parameters are changing over time. In other words, the preference in one period is not consistent with those in other periods, and thus one preference relation is not a subset of another one. Consequently, it is not trivial to define optimal tax policy with hyperbolic discounting preferences. In particular, one tax policy can be optimal for period-t preference but suboptimal for other periods’ preferences. However, in the agency model introduced in the previous section, there exists a welfare function, which is defined under exponential discounting (see Eqs. (26-27)). In this section, we study optimal dividend taxation with the Cobb-Douglas production function.20

The Cobb-Douglas production function is defined as

\[
f(i_1, i_2) = z_i^{a_1} i_2^{a_2},
\]

where \(z > 0, a_1 > 0, a_2 > 0,\) and \(a_1 + a_2 < 1.\) The choice function \(\hat{i}_2(i_1)\) under the dividend tax policy can be derived from the following period-2 maximization problem:

\[
\max_{i_2| i_1} E_2 \left[ \frac{(x_2 - i_2 + s_2)}{1 + \tau_2} + \beta_2 \delta z_i^{a_1} i_2^{a_2} \right],
\]

where \(s_2 = \tau_2 d^*_1.\) From Eq. (45), we have the following choice function

\[
\hat{i}_2(i_1) = \left( (1 + \tau_2) \beta_2 \delta z a_2 i_1^{a_1} \right)^{1/a_2} = k \times i_1^{a_1/a_2},
\]

where \(k = \left\{ (1 + \tau_2) \beta_2 \delta z a_2 \right\}^{1/(1-a_2)}.\) From Eq. (46), we have the following period-1 maximization problem:

\[
\max_{i_1} E_1 \left[ \frac{(x_1 - i_1 + s_1)}{1 + \tau_1} + E \beta \delta \left( \frac{x_2 - \hat{i}_2(i_1) + s_2}{1 + \tau_2} + \beta_1 \delta^2 z i_1^{a_1} \left( \hat{i}_2(i_1) \right)^{a_2} \right) \right]
\]

20 The optimal tax policy under information asymmetry is an important topic in public finance research. However, unlike this paper, most papers on this topic have focused on consumer taxation, (See Brett and Weymark 2018) rather than corporate taxation.
The first order condition from Eq. (47) is
\[ -\frac{1}{1+\tau_1} - \beta_1 \delta \frac{a_1 k}{1-a_2} i_1^{a_1-1} - \beta_1 \delta^2 \frac{a_1 k a_2}{1-a_2} i_1^{a_1-1} = 0, \]
and the first-period investment decision is
\[ i_1^* = \left\{ \frac{a_1}{1-a_2} \beta_1 \delta (1+\tau_1) \left( \delta z k^{a_2} - \frac{1}{1+\tau_2} k \right) \right\}^{1-a_2} \] (48)

The shareholder’s value function is defined with exponential discounting, as shown in Eqs. (26-27). Therefore, we can derive the optimal investment level that maximizes the shareholder’s value by substituting \( \delta \) and \( \tau \) into Eqs. (46) and (48), because the manager’s preferences with \( \delta \) and \( \tau \) is equivalent to the shareholder’s preferences. Specifically, let \( i_1^* \) and \( i_2^* \) be functions of \((\beta_1, \beta_2, \tau_1, \tau_2)\) from Eqs. (46) and (48), in the forms of \( i_1^* (\beta_1, \beta_2, \tau_1, \tau_2) \) and \( i_2^* (\beta_1, \beta_2, \tau_1, \tau_2) \). Then, the optimal tax level \((\tau_1, \tau_2)\) should satisfy both
\[ i_1^*(1,1,0,0) = i_1^* (\beta_1, \beta_2, \tau_1, \tau_2) \] (49)
and
\[ i_2^*(1,1,0,0) = i_2^* (\beta_1, \beta_2, \tau_1, \tau_2). \] (50)

In Eqs. (49) and (50), \( i_1^*(1,1,0,0) \) and \( i_2^*(1,1,0,0) \) represent the optimal investment levels that maximize the shareholder’s utility, while \( i_1^* (\beta_1, \beta_2, \tau_1, \tau_2) \) and \( i_2^* (\beta_1, \beta_2, \tau_1, \tau_2) \) represent the manager’s investment decision under myopia \((\beta_1, \beta_2)\) and the tax policy \((\tau_1, \tau_2)\). From Eqs. (49) and (50), there is a unique tax plan \((\tau_1, \tau_2)\) such that
\[ \tau_1 = \frac{[\delta z k^{a_2} - k]}{\beta_1 \left[ \delta z k^{a_2} - \frac{1}{1+\tau_2} k \right]} - 1 \] (51)
and
\[ \tau_2 = \frac{1}{\beta_2} - 1. \] (52)

The optimal tax plan is follows. In the second (i.e., last) period, the optimal tax rate directly depends on the degree of myopia, \((1-\beta_2)/\beta_2\), as shown in Eq. (52). For higher levels of myopia (i.e., lower values of \( \beta_2 \)), the optimal tax rate \((\tau_2)\) will be increasing. Eq. (51) also indicates that the optimal tax rate in period 1 \((\tau_1)\) is increasing in the degree of myopia \((1-\beta_1)/\beta_1\). However, the optimal period-1 tax rate \((\tau_1)\) is smaller than the degree of myopia, \((1-\beta_1)/\beta_1\). This is because the period-2 tax policy \((\tau_2)\) affects not only
the choice function but also the period-1 investment decision, as indicated in Lemma 4. Specifically, the period-2 tax rate \( \tau_2 \) effectively increases the marginal investment in period 2, which also increases the marginal period-1 investment through the choice function.

8. Conclusion

We construct a theoretical framework that incorporates hyperbolic discounting preferences into corporate investment decisions. In doing so, we rigorously establish the linkage between short-termism and underinvestment. In our three-period framework, the firm with present bias makes investment decisions that result in suboptimally low levels of investment, as defined by the existence of a higher-level investment plan that improves all periods’ present value of dividends.

We then conduct two policy experiments that might overcome or deteriorate this underinvestment problem: dividend and corporate profit taxation. We show that revenue-neutral dividend taxes can mitigate the market distortions imposed by present bias. On the other hand, profit tax worsens the underinvestment problem and thus decreases firm value. We then demonstrate a concrete example of these two types of taxation policies under the Cobb-Douglas production setting. The analysis in this paper provides a theoretical angle to debates in the policy arena that advocate dividend taxation, as opposed to corporate profits taxation, as a means of addressing corporate short-termism.

Theories of myopia have been separately developed in two strands: 1) agency problems in the corporate finance literature, and 2) irrational decision-making behavior. Our paper is able to bridge these two theories in a unified framework. This paper indicates that the two main approaches can be modeled by the same mathematical framework – hyperbolic discounted time preferences, and that both of these theories lead to underinvestment problems. Therefore, the same types of policies can improve firm value regardless of whether managerial myopia is attributed to intrinsic nature or agency conflict.

More recently, empirical and survey evidence have demonstrated that short-termism is a prominent feature of corporations (Asker, Farre-Mensa and Ljungqvist 2015; Budish, Roin and Williams 2015; Poterba and Summers 1995). In particular, Asker, Farre-Mensa and Ljungqvist (2015) have directly investigated the effect of short-termism on corporate investment. They argue that public firms would invest substantially less than private firms, because the former are subject to short-termism arising from pressure on current share prices. The more consolidated nature of ownership in private firms, on the contrary, allows more effective monitoring of management to pursue long-term values. Despite these empirical evidence and the prevalent view that short-termism features importantly in manager’s behavior,
the theory of hyperbolic discounting has not been formally applied to corporate decisions. This stands in contrast to the large volume of literature that applied hyperbolic discounting preferences to consumers’ decision. This paper contributes to theories of corporate short-termism by introducing the hyperbolic discounting framework to corporate investments, and shows that this framework can be meaningfully related to both existing empirical evidence and theoretical approaches.

Appendices

A. Proof of Proposition 1

The first-order condition from maximization problem (1) is

$$-1 + \beta_2 \delta f_2(i_1, i_2) = 0. \quad (53)$$

The second-order condition from maximization problem (1) is

$$\beta_2 \delta f_{22}(i_1, i_2) < 0. \quad (54)$$

By the first and second-order conditions, we know that for any value of $i_1 > 0$, there exists a unique $i_2 > 0$ that solves Eq. (53). We define $\hat{i}_2(i_1)$, which solves the first order condition in (53), such that

$$-1 + \beta_2 \delta f_2\left(i_1, \hat{i}_2(i_1)\right) = 0. \quad (55)$$

Since $f_2(i_1, i_2)$ is continuous, $\hat{i}_2(i_1)$ is also a continuous function in $i_1 \in (0, \infty)$. Implicitly differentiating Eq. (55) with respect to $i_1$, we have

$$\beta_2 \delta f_{12}\left(i_1, \hat{i}_2(i_1)\right) + \beta_2 \delta f_{22}\left(i_1, \hat{i}_2(i_1)\right) \hat{i}_2'(i_1) = 0.$$

which in turn equivalently is

$$\hat{i}_2'(i_1) = -\frac{f_{12}\left(i_1, \hat{i}_2(i_1)\right)}{f_{22}\left(i_1, \hat{i}_2(i_1)\right)} > 0. \quad (56)$$

Since $\hat{i}_2(i_1)$ is a continuous function in $i_1 \in (0, \infty)$, Eq. (56) implies that $\hat{i}_2'(i_1)$ is strictly positive for all domain of $i_1$, that is, $(0, \infty)$. 

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Figure 6: The period-1 investment decision $i^*_1$ with the mean value theorem

The firm maximizes the following in period 1:

$$PV_1(i_1) = (x_1 - i_1) + \beta_1 \delta \left( x_2 - \hat{i}_2(i_1) \right) + \beta_1 \delta^2 f \left( i_1, \hat{i}_2(i_1) \right).$$  \hspace{1cm} (57)

For the proof of existence of a Nash equilibrium, we will apply the mean value theorem. To use the mean value theorem, we need to show that neither zero nor infinite investment can be the optimal solution. First, where $i_1 = 0$, $PV_1$ in Eq. (57) is

$$PV_1(0) = x_1 + \beta_1 \delta x_2,$$  \hspace{1cm} (58)

By conditions (1) and (2), which are $f(i_1, 0) = 0$ and $\lim_{i_2 \to 0} f_1(i_1, i_2) = \infty$ for any $i_1 \in (0, \infty)$, (2) $f(0, i_2) = 0$ and $\lim_{i_1 \to 0} f_1(i_1, i_2) = \infty$ for any $i_2 \in (0, \infty)$, we know that $PV_1$ is strictly increasing in $i_1$ at $i_1 = 0$. This implies that $i_1 = 0$ cannot be the Nash equilibrium investment level.

Because the production function $f(i_1, i_2)$ is bounded above by condition (3), we know that as the investment level $i_1$ is diverging to infinity, $PV_1$ is also diverging to a negative value. This implies that there exists a $\bar{i}_1 > 0$ such that

$$PV_1(\bar{i}_1) = x_1 + \beta_1 \delta x_2,$$  \hspace{1cm} (59)

which has the same value as that of $PV_1(0)$. From Eqs. (58) and (59), we can apply the mean value theorem (as shown in Figure 6) such that there is an interior solution $i^*_1$ in which
the first-order condition is zero and the second-order condition is negative. The first-order condition is
\[-1 - \beta_1 \hat{i}_2'(i_1) + \beta_1 \delta^2 \left( f_1 + f_2 \hat{i}_2'(i_1) \right) = 0. \tag{60}\]
The second-order condition is
\[\beta_1 \hat{i}_2''(i_1) + \beta_1 \delta^2 \left( f_{11} + 2 f_{12} \hat{i}_2'(i_1) + f_{22} \left( \hat{i}_2'(i_1) \right)^2 \right) + \beta_1 \delta^2 f_2 \hat{i}_2''(i_1) \leq 0. \tag{61}\]

By the mean value theorem, we can only prove the existence of Nash equilibrium but we cannot prove its uniqueness. In addition, the second-order condition in Eq. (61) is not necessarily strictly negative in the hyperbolic discounting model. In the case where the second-order condition is not strictly negative but zero, there exist multiple equilibria.

\[\text{B. Proof of Lemma 1}\]

Taking the partial derivative $PV_1$ with respect to $i_1$ at the Nash equilibrium $(i_1^*, i_2^*)$, we have
\[\frac{\partial PV_1}{\partial i_1}\big|_{(i_1, i_2) = (i_1^*, i_2^*)} = -1 + \beta_1 \delta^2 f_1. \tag{62}\]

From (60) and (62), we have
\[\frac{\partial PV_1}{\partial i_1}\big|_{(i_1, i_2) = (i_1^*, i_2^*)} = -1 + \beta_1 \delta^2 f_1 = \beta_1 \delta \hat{i}_2'(i_1) \left( 1 - \delta f_2 \right). \tag{63}\]

From (53) and (63), we have
\[\frac{\partial PV_1}{\partial i_1}\big|_{(i_1, i_2) = (i_1^*, i_2^*)} = (\beta_2 - 1) \beta_1 \delta \hat{i}_2'(i_1) f_2 < 0. \tag{64}\]

Taking the derivative of $PV_1$ with respect to $i_2$ at the Nash equilibrium $(i_1^*, i_2^*)$, we have
\[\frac{\partial PV_1}{\partial i_2}\big|_{(i_1, i_2) = (i_1^*, i_2^*)} = -\beta_1 \delta + \beta_1 \delta^2 f_2 = \beta_1 \delta \left( -1 + \delta f_2 \right). \tag{65}\]

21 If $\hat{i}_2'(i_1)$ is linear, the second derivative of $PV_1 \left( i_1, \hat{i}_2(i_1) \right)$ with respect to $i_1$ is strictly negative globally and, therefore, a unique solution is guaranteed. However, in general, $\hat{i}_2'(i_1)$ is not linear and in a special case, there can be multiple equilibria. Even though multiple maximum equilibria exist, at the equilibrium the first and second order conditions are well-defined by the mean value theorem.
From (53) and (65), we have
\[
\frac{\partial PV_1}{\partial i_2}\big|_{(i_1^*,i_2^*)} = \beta_1 \delta (\beta - \beta_2) f_2 + \delta f_2) = \beta_1 \delta^2 (1 - \beta_2) f_2 > 0. \tag{66}
\]

C. Proof of Lemma 2

Taking the partial derivative of $PV_2$ with respect to $i_2$ at the Nash equilibrium $(i_1^*, i_2^*)$, we have
\[
\frac{\partial PV_2}{\partial i_1}\big|_{(i_1,i_2)=(i_1^*,i_2^*)} = \beta_2 \delta f_1 > 0. \tag{67}
\]

The partial derivative of $PV_2$ with respect to $i_2$ is the first order condition (53). Therefore, we have
\[
\frac{\partial PV_2}{\partial i_2}\big|_{(i_1,i_2)=(i_1^*,i_2^*)} = 0. \tag{68}
\]

D. Proof of Lemma 5

We have
\[
d_1' + \beta_1 \delta d_2' + \beta_1 \delta^2 d_3' > d_1^* + \beta_1 \delta d_2^* + \beta_1 \delta^2 d_3^*, \tag{69}
\]
\[
d_2' + \beta_2 \delta d_3' > d_2^* + \beta_2 \delta d_3^*, \tag{70}
\]
and
\[
d_3^* > d_3^*. \tag{71}
\]

Inequality (70) can be expressed as
\[
d_2' + \delta d_3' - (1 - \beta_2) \delta d_3' > d_2^* + \delta d_3^* - (1 - \beta_2) \delta d_3^*. \tag{72}
\]

Multiplying $(1 - \beta_2)$ in inequality (71) and adding it to inequality (72), we have
\[
d_2' + \delta d_3' > d_2^* + \delta d_3^*. \tag{73}
\]

Inequality (69) can be expressed as
\[
d_1' + \delta d_2' + \delta^2 d_3' - (1 - \beta_1) \delta (d_2' + \delta d_3') \tag{74}
\]
\[
> d_1^* + \delta d_2^* + \delta^2 d_3^* - (1 - \beta_1) \delta (d_2^* + \delta d_3^*). \]
Multiplying \((1 - \beta_1) \delta\) in inequality (73) and adding it to inequality (74), we have

\[
d_1' + \delta d_2' + \delta^2 d_3' > d_1^* + \delta d_2^* + \delta^2 d_3^*.
\]


