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Should short-term speculators be taxed, or subsidised?*

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Summary. This paper explores the welfare implications of a securities transaction tax when long-term information contained in stock prices can improve resource allocation but speculators have short horizon objectives. Speculators can trade on information of differing time horizons and profit maximizing firms can use long-term information contained in stock prices to improve their investment decisions. The model takes full account of the effect of a tax on market liquidity and welfare for all market participants. Surprisingly, a *subsidy* on short-term speculation can increase the amount of equilibrium trade on long-horizon information. This is because short-term informed trade exerts a positive externality over long-term informed trade when speculators have a short planning horizon. The cost of paying the subsidy may be smaller than the gain in firm value, while no trader is made worse off.

Keywords and Phrases: Investment efficiency, Short-termism, Securities transaction tax, Liquidity, Welfare.

JEL Classification Numbers: G14, G18, D60, D82.

1 Introduction

This paper addresses the question of how economic welfare is affected by short horizon trading objectives of potentially informed speculators, and how a securities transaction tax may mitigate possible inefficiencies arising from such short objectives. There is a widespread belief that institutional traders, such as pension and mutual fund managers, operate according to short-term objectives due to

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performance pressure by investors (see Marsh [22], and Demirag [6] for an overview of the debate on short-termism).[1] Such short-term objectives are typically seen as detrimental to economic welfare, as they may be responsible for the mispricing of long-term assets, leading to inefficient investment decisions by firm managers (Shleifer and Vishny [25]).

Little work has been done that attempts to formalize the interdependence of speculators' trading horizons, investment efficiency and economic welfare (see, however, the discussion below). Existing work on trading horizons typically focuses on the impact of short-term trading objectives on the informational efficiency of prices in a financial market (see Froot, Scharfstein, and Stein [13], Dow and Gorton [8], Vives [33], Allen, Morris and Shin [2]). However, these treatments do not model financial markets as being socially beneficial, which makes it impossible to assess the welfare implications of speculators' exogenous short horizons. Moreover, it remains an open question what the policy implications are, if it is indeed the case that traders' short-term objectives reduce investment efficiency.[2] Can economic welfare be improved by taxing traders? If so, which trades should be taxed and how?

In this paper I consider an economy with a sequence of (potentially) informed speculators who have short-term objectives, but who can produce information regarding the long-term prospects of a company. Short-lived speculators then may have an incentive to produce and trade on long-term information, if a subsequent generation of speculators trades on the same information. This allows the original speculators to unwind their positions at a profit, before their private information becomes publicly known. Long-term information is thus telescoped into the present by a sequence of short horizon speculators.[3] As Summers and Summers [30] put it:

> "Even if it is granted that portfolio managers care only about returns over a short horizon, they nonetheless necessarily must care about the price at which they can unload the stock. This will depend on tomorrow's demand for that stock, which will in turn depend upon tomorrow's expectations about corporate performance thereafter. It should be clear that a holder of corporate stock today who anticipates quickly selling to a sequence of future short-term holders should nonetheless be concerned about his company's profitability over the long term..."

Each generation of speculators does not take into account the externality it exercises over another generation. There is therefore scope for welfare improving

[1] Short-term objectives may also arise without agency problems, for example due to risk aversion (Holden and Subrahmanyam [18]) or consumption smoothing over time (see Allen, Morris and Shin [2]).

[2] Securities transaction taxes exist in many countries in the form of a stamp duty (e.g., in the UK (0.5%) and France (0.3%)). Other countries, such as Germany, levy a tax on speculative gains that accrue from positions held for less than one year. The time limitation is intended to curb short-term speculation. Related to a securities transaction tax is the Tobin tax (Tobin [31]) on international capital flows. While this paper does not focus on international capital flows as such, much of the underlying economic mechanisms do apply to this setting.

[3] See also Dow and Gorton [8] and Hirshleifer, Subrahmanyam and Titman [17] who explore related interactions between early and late informed traders. Both papers are discussed in more detail in Section 3.

taxation of trading activities. In order to conduct a full welfare analysis I introduce an allocational role for prices, and endogenize uninformed trading as originating from a hedging motive. Non-information driven trade derives from risk averse agents who trade for insurance reasons. They are thus (rationally) willing to pay a premium in the form of trading losses to the informed speculators, in exchange for insuring against income risk that is correlated with the value of a stock. Market liquidity and uninformed traders' welfare is therefore endogenous and depends on the magnitude of the tax.

I consider a set-up in which short-term information is socially wasteful, while long-term information can improve resource allocation.[4] I assume that informational efficiency of (long-term) share prices increases firms' investment efficiency, because firms use the information contained in prices to learn about their optimal investment level (Dow and Rahi [11] use a similar formalization, but without a distinction between the long and the short-term). This is the case, because firms need to take a 'long-term' investment decision. Therefore, only information that is reflected in prices a sufficiently long time before an investment pays off can be useful in guiding a firm's decision. Short-term information cannot directly change investment and is therefore socially wasteful.

Short-term information, however, has an indirect effect on the amount of long-term information production precisely when all speculators have short-term objectives. I show that providing a subsidy for short-term informed trade leads to an increased amount of production and trade on long-term information. The subsidy has two positive effects on the amount of short-term information production. Firstly, the subsidy makes it easier for speculators to recover the cost of information acquisition. Secondly, the subsidy increases market liquidity by increasing the amount of hedge-driven trades.

Because of the positive externality on long-term informed trade, the subsidy on short-term trades increases the amount of long-term information acquisition. This is beneficial to the investment efficiency of firms. Moreover, under some parameter values, the cost of paying the subsidy is lower than the resultant increase in ex ante firm value, without making any trader worse off. The payment of a subsidy to short-term traders can increase welfare. Moreover, it is shown that there is a stronger case for payment of a subsidy when firms' investment decisions are particularly sensitive to stock price movements. The financial system of a country may therefore have an impact on the desirability of such a subsidy (or the cost of a tax to the real economy). Countries with a market based financial system may be expected to suffer more from a securities transaction tax than do bank based economies.

This result stands in contrast to a number of arguments in favor of securities transaction taxes. Stiglitz [28] argues for a securities transaction tax (STT), because traders spend a socially wasteful amount of resources on research in financial markets. Information production by one speculator exerts a negative externality over

[4] Diamond [7] and Hirshleifer [16] were among the first to show how stock prices in secondary markets can improve resource allocation through improved investment decisions. In Leland [21] information based trading affects the firm's cost of capital. Fishman and Hagerty [12] and Holmstrom and Tirole [19] showed that stock prices also matter by affecting managerial incentives. Dow and Gorton [9] show that the relationship between informational and economic efficiency may be tenuous.

the profitability of other speculators' trades. Therefore, too much effort is spent on producing information in equilibrium compared to the social optimum. This can be corrected by taxing trades. Dow and Rahi [10], however, show that a tax can make speculators better off, because it leads them to scale back their trades. This makes aggregate order flow less revealing and increases speculative profits. They also show that the effect is ambiguous for hedgers, depending on their risk sharing requirements.

According to Stiglitz [28] and Summers and Summers [30] short-termism in financial markets constitutes another inefficiency that a tax can help to mitigate. They argue that a transactions tax affects speculators who trade frequently more than those who hold their positions for longer periods. The introduction of a tax may therefore increase holding periods and thus mitigate firm managers' bias for inefficient short-term investment. Subrahmanyam [29] formalizes this intuition in a setting where speculators have infinite planning horizons, but engage in a socially wasteful race to uncover information before others do.

This argument hinges on the assumption that planning horizons can be affected relatively easily by increasing the cost of short holding periods. This may not be the case, particularly when horizons are short due to agency problems. In that case a fund manager's job prospects may be very sensitive to short-term performance, and their willingness to switch to long-term performance goals may be limited. Note also that the above argument implicitly assumes that short planning horizons and short holding periods have to coincide. That is not the case. A fund manager's short-term performance can easily be inferred from the market value of his portfolio. The manager may then be subject to short-term objectives, even though he holds his positions for long time periods. This paper is concerned with the case where the elasticity of substitution between planning horizons is low and a tax on short holding periods therefore cannot effectively correct for short-termism.

Interestingly, in this case Stiglitz' argument about excessive information gathering activity by speculators is turned on its head: information production by one trader is now no longer always detrimental to another speculator's trading profits. On the contrary, production of and trade on (socially wasteful) short-term information is necessary to enable some myopic speculators to trade profitably on long-term information.

A number of other arguments have been put forward in favor of a securities transaction tax. Those include (i) a revenue motive,[5] and (ii) the reduction of price volatility. In this paper the revenue effect of a tax/subsidy is fully taken into account, and it is shown that ex ante firm value increases may outweigh the cost of paying a subsidy. The cost of paying the subsidy could therefore be raised by a lump sum tax on the firms. Note that changes in trading behavior that result from taxation are fully taken into account. In fact they constitute part of the gains: Subsidising short-term trades increases market liquidity, which increases the amount of information production.

[5] Summers and Summers [30] argue that a STT would yield an estimated US$10 billion for a 0.5% tax on transactions carried out on US financial markets. Campbell and Froot [5] maintain that revenue figures are typically overstated, as estimates fail to take into account the behavioral changes that a STT would cause.

Tobin [31] and Summers and Summers [30] also argue that a tax may be an effective way to curb excessive speculation and noise trade, responsible for excess volatility in financial markets. In general, however, it is unclear whether a STT alone would reduce volatility, since not only destabilizing noise traders would be driven out of the market, but also price stabilizing informed traders (Schwert and Seguin [24]).[6] In this paper I ignore irrational noise traders and therefore the issue of 'excess' volatility. I do so, because of the ambiguities that arise when trying to measure welfare for this set of traders.[7] And without a well defined welfare measure 'excess' volatility cannot be studied (see also Ross [23]).

The remainder of the paper proceeds as follows. In Section 2 the model is presented. Equilibrium order flows by all types of traders are derived in Section 3, while Section 4 states basic results concerning the equilibrium price setting rule by the market maker and investment rules by firms. Section 5 describes the equilibrium with myopic speculators and general tax rates. In Section 6 it is shown under which conditions a subsidy on short-term speculators may be desirable. Section 7 concludes.

2 The model

2.1 The firm

Consider an economy with four dates $t \in \{0, 1, 2, 3\}$. There is a firm in possession of a production technology which requires an investment I at $t = 1$. The final (date 3) value V of the firm is distributed to the shareholders, i.e. the firm is liquidated. The firm is all equity financed and its shares are traded on a stock market at dates $t = 1$ and $t = 2$. The relation between investment I and final value V is given by

$$V = yI - \frac{c}{2}I^2 + \varepsilon + \eta, \tag{1}$$

where $y \in \{a, b\}$ denotes a random variable that determines the optimal investment level. One could think of y as for example the future demand for a firm's output or as its productivity level (see Dow and Rahi [11]). Assume y can take the values a or b ($a < b$) with equal probability. The random variables ε and η denote other random components of firm value. As will become apparent later, it is analytically convenient (but not necessary) to allow ε and η to take the values $-B$ or B with equal probability, where $B \equiv \frac{b^2 - a^2}{4c}$,

Moreover, assume that ε becomes publicly known at $t = 2$ (i.e. the date preceding liquidation), while η is only revealed at the date of liquidation $t = 3$. This provides a convenient way of modeling endogenous liquidity trade at both dates.

[6] Umlauf [32] presents evidence from Sweden, which suggests that the introduction of a tax not only reduced trading volume sharply, but also increased volatility. This may have been the result of trade migration to other markets.

[7] Gümbel and Sussman [15] show that a Tobin tax can help reduce FX volatility in the absence of irrational traders, because it makes it easier for a central bank to implement a smoothing policy for its exchange rate.

2.2 Informed speculation

There are two speculators in the economy: an early born (at date $t=0$) speculator and a late born ($t=1$) speculator. Speculators are risk neutral and able to acquire information regarding the firm's productivity parameter y. Acquiring information incurs cost $\kappa > 0$. At date zero of her life, a speculator can decide whether or not to incur the cost of information acquisition. For mixed strategies denote by $\nu_l(\nu_s)$ the probability with which the date-1 (date-2) speculator acquires information. During the subsequent period she receives a perfectly informative signal with probability q, if she acquires information. Otherwise she never receives a signal. At the following date (date 1 of a speculator's life) she can trade. Assume that the speculator born at date $t=1$, has to take the information acquisition decision before she can observe prices. Hence, at the time of information acquisition she does not yet know, whether prices will reveal this information. Traders die two periods after they were born.

In this set-up both speculators are short-term traders in the sense that they unwind their positions after a short period.[8] The reasons for short-termism are not modeled here, but could arise because the trader is subject to short-term performance pressure from investors (Shleifer and Vishny [26]). The early born trader can produce long-horizon information (receives a signal two periods before the event date), while the late born speculator produces information that has a short horizon (signal received one period before the event date). The subsequent analysis is mainly concerned with the incentives for such short-term speculators to produce long-horizon information. In what follows I shall call the early-born (late born) speculator, the date-1 (date-2) speculator, indicating the date at which they can first trade.

Note that in this specification, a speculator knows whether the information is long-term or short-term when she acquires it. This contrasts with some of the literature on short-term trading, e.g, Froot, Scharfstein and Stein [13], and Hirshleifer, Subrahmanyam and Titman [17] who assume that traders first acquire information, and then learn whether they will have the opportunity to trade early or late. Their assumption is important for the herding result derived in these papers, because it increases all traders' ex ante incentives to acquire information when more traders do the same. This complementarity is absent from my model, because speculators know their identity, and more long-term information acquisition reduces incentives to acquire short-term information. Equilibrium profits (net of the cost of information production) from either information horizon are zero and multiple 'herding' equilibria do not arise.

2.3 Liquidity trade

Finally, there are two types of liquidity traders who are risk averse agents wishing to hedge income risk. They serve to add 'noise' to prices, which allows informed speculators to earn profits from trade. Bhattacharya and Spiegel [4] and Spiegel

[8] Alternatively, one could model short-term objectives due to performance evaluation, without requiring that traders unwind their positions (see Gümbel [14]).

and Subrahmanyam [27] first endogenized noise trade in this way. Due to the well known Hirshleifer effect informed trade is typically harmful to these types of traders: more informative prices destroy insurance opportunities. This, however, depends on the risk sharing requirements and sometimes more informed trade can improve insurance (see Dow and Rahi [10]). More recently, Bhattacharya and Nicodano [3] endogenized liquidity trade as driven by shocks to intertemporal consumption preferences. In such a setting informed trading can improve risk sharing between early and late consumers. This might provide a further argument for the usefulness of a subsidy to short-term informed speculators.

Hedgers are assumed to be infinitely small and of total mass normalized to measure one.[9] A fraction μ of the hedgers experience a shock to their income correlated with the random variable η. I call these agents 'η-hedgers'. Their date 3 income is given by $w_\eta = z_\eta \eta$, where $z_\eta \in \{-1, 1\}$ with equal probability. The remaining fraction $1-\mu$ of agents are 'ε-hedgers' whose random income is correlated with ε: $w_\varepsilon = z_\varepsilon \varepsilon$, where $z_\varepsilon \in \{-1, 1\}$ with equal probability. Realizations of z_η and z_ε are observed by the hedgers at $t = 0$. The risk averse hedgers only care about final (date 3) wealth and have a piece wise linear utility function $U(x) = min\{x, 0\}$.

At dates $t = 1, 2$ there are thus (potentially) informed speculators and risk averse hedgers who submit orders for the firm's stock. Orders are submitted to a market maker, who sets the price at which he is prepared to clear the market out of his inventory. The market maker only observes total order flow for an asset at a particular date, but not who submitted an individual order. This approach follows Kyle [20] with modified assumptions concerning the distribution of random variables and allowing for endogenous noise traders. Moreover, it is assumed that a market maker faces Bertrand competition and thus sets the price for an asset equal to its expected value, given his information set.

Denote by Q_t total order flow at date t. Denote by $\theta_t^s, \theta_t^l, \theta_t^\varepsilon, \theta_t^\eta$, the individual orders at date t from the short-term informed speculator, the long-term informed speculator, an individual ε-hedger and an individual η-hedger, respectively. Moreover, denote by p_t the share price at date t.

In the spirit of Dow and Rahi [11] assume that a firm manager does not know the productivity parameter of his firm. However, he can observe at which price the firm's shares trade, which allows him to draw inferences concerning the productivity parameter. Since the firm has to invest two periods before liquidation, the information contained in prices one period before liquidation cannot be used in guiding the investment decision. Hence, the date-2 speculator has no impact on the value of the firm. The long-term informed date-1 speculator, however, may affect firm value through the information her trade releases through the price. This in turn allows a firm to learn its own productivity before investing in some states of the world. The investment decision can then be made contingent on this information, which improves investment efficiency and firm value.

An equilibrium consists of:

(i) A price schedule set by the market maker, such that the stock price equals its expected value, given the order flow observed by the market maker.

[9] For the derivation of the demand by hedgers it is necessary to assume that they are competitive. The assumption plays no role otherwise.

(ii) An investment rule by the firm that maximizes the expected liquidation value conditional on information contained in stock prices.
(iii) A (possibly mixed) strategy of short-term and long-term speculators to incur the cost of information acquisition and a trading rule that maximizes expected trading profits.
(iv) A trading rule by both types of hedgers that maximizes their expected utility.

3 Order flows in equilibrium

I now proceed to describe the equilibrium order flows by all types of traders. First, consider the trading strategy of ε-hedgers who can trade at $t=1,2$ to hedge their wage shock. Since ε is revealed at date $t=2$, it will be fully reflected in the price $p_{t=2}$ (the 'short-term' price of an asset) and hence the ε-hedger can only hedge his wage risk by trading at date $t=1$. Hence, if the ε-hedger wishes to hedge his wage risk, he has to do so by trading at date $t=1$. Moreover, if the ε-hedger holds his position until the liquidation date $t=3$, he will be exposed to the additional risk originating from η, which is revealed only at date $t=3$, but *not* reflected in the date 2 price $p_{t=2}$. Hence, if the ε-hedger wishes to participate in the stock market at all, he will take a position at date $t=1$, which he will unwind at $t=2$. Hence, we get that $\theta^{\varepsilon}_{t=2}=-\theta^{\varepsilon}_{t=1}$ and total demand at $t=1$ originating from ε-hedgers of $(1-\mu)\theta^{\varepsilon}_{t=1}$. Since orders are symmetric around zero for either realization of z_{ε}, one can define the size of an individual ε-hedger's order as $\theta_{\varepsilon}\equiv|\theta^{\varepsilon}_{t=1}|$. The actual value of θ_{ε} is determined as part of the equilibrium (see Section 5).

Now consider the trading strategy by the η-hedger. If he trades at date $t=1$ he is exposed to the risk due to ε, which is not reflected in the price $p_{t=1}$ (the 'long-term' price). At date $t=2, \varepsilon$ gets impounded into the asset price and hence the η-hedger can avoid exposure to this risk by only trading at date $t=2$. Thus, if η-hedgers

Table 1. Illustrates the timing of agents' actions

	$t=0$	$t=1$	$t=2$	$t=3$
Date 1 speculator	First speculator born. Produces information with probability ν_l	Signal is received with probability $\nu_l\ q$. Submits order.	Unwinds the position, consumes and dies.	
Date 2 speculator		Second speculator born. Produces information with probability ν_s	Signal is received with probability $\nu_s\ q$. Submits order.	Firm is liquidated and trader's claims settled. Speculator consumes and dies.
ε-hedger	ε-hedgers learn shock z_{ε}.	Submit orders.	ε-hedgers unwind their positions.	
η-hedger	η-hedgers learn shock z_{η}.		η-hedgers submit orders.	Firm is liquidated and η-hedgers' claims settled.

participate in the stock market at all, they will first trade at date $t=2$. Hence, $\theta^{\eta}_{t=1}=0$, and $\theta^{\eta}_{t=2}\neq 0$ if the η-hedgers decide the trade. Therefore, at date $t=2$ there is a mass μ of η-hedgers who submit total order size $\mu\theta_{\eta}$, where $\theta_{\eta}\equiv|\theta^{\eta}_{t=2}|$.

To summarize, the following orders are submitted at dates 1 and 2. At $t=1$, the early born speculator submits an order, if she receives a signal, and the ε-hedgers submit a total order of size $(1-\mu)\theta_{\varepsilon}$. Both orders are unwound at $t=2$. In addition, the late born speculator submits an order at $t=2$, if she receives a signal. Also, the η-hedgers submit orders with total size $\mu\theta_{\eta}$.

In order to hide their information, the speculators optimally submit orders of the same size as all the hedgers (see proof of Proposition 1 for a rigorous treatment of this issue).

This results in the possible total order flows in equilibrium at date $t=1$:[10]

$Q_{t=1}\in\{-2(1-\mu)\theta_{\varepsilon},(1-\mu)\theta_{\varepsilon}\}$: The early born speculator and ε-hedgers either both submitted a buy order, or both submitted a sell order. Each order flow occurs with probability 1/4ν_l q. The market maker can infer the direction of the speculator's trade. If the speculator submitted a buy (sell) order, this reveals that she received information indicating that the firm's productivity level is high (low).

$Q_{t=1}\in\{-(1-\mu)\theta_{\varepsilon},(1-\mu)\theta_{\varepsilon}\}$: Since ε-hedgers always submit an order, the market maker infers that the speculator did not trade. Order flow therefore contains no information about the productivity of the firm. Either realization occurs with probability 1/2(1 $-\nu_l$ q).

$Q_{t=1}=0$: Either the speculator submitted a buy order and the hedger a sell order, or vice versa. Since each of the two is *ex ante* equally likely, the market maker cannot infer any information about the productivity parameter of the firm. The probability of zero total order flow is 1/2ν_l q.

Regarding order flow at date $t=2$, note that there is a date-1 speculator and a generation of ε-hedgers who unwind their $t=1$ positions. Since the order flow due to unwinding old positions is known to the market maker in equilibrium, he can infer from total order flow $Q_{t=2}$, how much trade is due to 'new' orders, i.e. orders from late born speculators and η-hedgers. Define the 'new' order flow as $Q'_{t=2}=Q_{t=2}+Q_{t=1}$. Again, suppose that the informed date-2 speculator submits orders of size $\mu\theta_{\eta}$. This yields possible total order flows $Q'_{t=2}$: (i) $Q'_{t=2}\in\{-2\mu\theta_{\eta},2\mu\theta_{\eta}\}$, where each of the two outcomes has probability 1/4ν_s q, (ii) $Q'_{t=2}\in\{-\mu\theta_{\eta},\mu\theta_{\eta}\}$, where each outcome has probability 1/2(1 $-\nu_s$ q), and (iii) $Q'_{t=2}=0$, with probability 1/2ν_s q.

4 Price setting and investment policy

Let us now turn to the market maker's equilibrium price setting mechanism, the firm's investment policy and its resulting value.

[10] For some parameter values there exists an equilibrium in which the speculator submits twice the size of the hedgers' demand. The properties of that equilibrium (when it exists) are similar, but complicate the analysis, because prices are *partially* revealing in some states of the world.

Proposition 1. *The following trading strategy, price setting strategy and investment policy constitute an equilibrium. After observing $y=b$ $(y=a)$ the speculator submits a buy (sell) order of size $(1-\mu)\theta_\varepsilon$. If no signal is received the speculator does not submit an order. The market maker applies the following price rule $p_{t=1}(Q_{t=1})$:*

$$p_{t=1}\left(Q_{t=1}\right)=\begin{cases}\frac{b^2}{2c}+B & \text{for} \quad Q_{t=1}>2(1-\mu)\theta_\varepsilon\\ \frac{b^2}{2c} & \text{for} \quad (1-\mu)\theta<Q_{t=1}\leq 2(1-\mu)\theta_\varepsilon\\ \frac{(a+b)^2}{8c} & \text{for} \quad -(1-\mu)\theta\leq Q_{t=1}\leq(1-\mu)\theta_\varepsilon\\ \frac{a^2}{2c} & \text{for} \quad -(1-\mu)\theta>Q_{t=1}\geq -2(1-\mu)\theta_\varepsilon\\ \frac{a^2}{2c}-B & \text{for} \quad Q_{t=1}<-2(1-\mu)\theta_\varepsilon\end{cases} \tag{2}$$

Moreover, the price contingent investment decision by the firm is given by:

$$I=\begin{cases}\frac{b}{c} & \text{if} \quad p_{t=1}\geq\frac{b^2}{2c}\\ \frac{a+b}{2c} & \text{if} \quad p_{t=1}=\frac{(a+b)^2}{8c}\\ \frac{a}{c} & \text{if} \quad p_{t=1}\leq\frac{a^2}{2c}\end{cases} \tag{3}$$

This results in expected firm value of

$$E[V]=\frac{\nu_l q}{2}\cdot\frac{(b-a)^2}{8c}+\frac{(b+a)^2}{8c}. \tag{4}$$

Proof. See Appendix.

Proposition 1 shows that the equilibrium pricing and investment rules are particularly simple. If order flow reveals to the market maker the underlying productivity parameter of the firm, this will be reflected in price. The firm can then extract this information from the price and choose a first-best investment level, given its productivity. If the price does not contain any information concerning productivity, the firm makes a medium sized investment, which is optimal given the firm's (lack of) information. The expected firm value, however, is lower when stock prices do not reveal the firm's underlying productivity parameter. The expected firm value is therefore an increasing function of the probability ν_l of long-term information production.

To complete the treatment of the equilibrium pricing rule, we can state the following result concerning the stock price $p_{t=2}$, one period before liquidation.

Proposition 2. *In equilibrium the market maker sets price $p_{t=2}$ as follows. The price $p_{t=2}$ is a function $\phi(p_{t=1},Q'_{t=2})$ of past price and current order flow, where*

$$\phi(p_{t=1},Q'_{t=2})=\begin{cases}p_{t=1}+\varepsilon & \text{if} \quad p_{t=1}\geq\frac{b^2}{2c}\\ \frac{4b^2-(b-a)^2}{8c}+\varepsilon & \text{if} \quad p_{t=1}=\frac{(a+b)^2}{8c},\, Q'_{t=2}>\mu\theta_\eta\\ p_{t=1}+\varepsilon & \text{if} \quad p_{t=1}=\frac{(a+b)^2}{8c},\, -\mu\theta_\eta\leq Q'_{t=2}\leq\mu\theta_\eta\\ \frac{4a^2-(b-a)^2}{8c}+\varepsilon & \text{if} \quad p_{t=1}=\frac{(a+b)^2}{8c},\, Q'_{t=2}<-\mu\theta_\eta\\ p_{t=1}+\varepsilon & \text{if} \quad p_{t=1}\leq\frac{a^2}{2c}\end{cases}$$

Proof. See Appendix.

Note that the firm cannot use the information that may potentially be revealed by the late-born speculator's trade, since its investment decision must be taken two periods before liquidation. Hence, by construction the probability ν_s with which the late-born speculator acquires information does not affect investment efficiency.

5 Equilibrium for general tax rates

This Section derives the speculators' probabilities of information production ν_s and ν_l. Concerning the taxation of trade consider the following set-up. Assume that a social planner can tax date-1 and date-2 trade separately. One way of achieving the desired difference in tax treatment becomes feasible if claims on dividends can be traded separately. In that case a security is clearly defined by the time horizon at which it has a claim on a dividend payment, and correspondingly, different tax rates can be applied to dividend payments of differing time horizons.

Assume that the following types of taxes/subsidies may be levied. Trade at $t=1$ $(t=2)$ can be taxed at rate τ_l (τ_s), where the tax is imposed linearly on the traded volume.[11] Hence, trading a number θ of shares incurs total transaction cost (on one round trip) of $\theta\tau$. Since the analysis permits negative tax rates (subsidies), it is necessary to make the following provision on the payability of a subsidy $\tau_s<0$. It is assumed that the tax authority only pays a subsidy on date-2 trade, if the share price in the preceding period has not been revealing. Otherwise, the speculator (or any risk neutral agent for that matter), would immediately wish to trade infinitely large quantities of the stock, because at the time of trading the stock is fairly priced, and orders no longer move the price (see Proposition 2). The possibility of infinite market depth stems from the assumption that prices are set by a risk neutral market maker. The problem could be mitigated by assuming that all traders, including the market maker, are risk averse.

The payment of a high subsidy might give speculators an incentive to trade, even when they have no private information. The tax authority therefore has to limit the subsidy if it wants to ensure that information acquisition is not undermined. The following Lemma states the highest possible subsidy payments such that speculators only trade after having received information.

Lemma 1. *The date-1 and date-2 speculators do not trade in the absence of private information if tax rates are*

$$\tau_l \geq -\frac{\nu_s q b(b-a)}{8c}, \tag{5}$$

[11] Subrahmanyam [29], Dow and Rahi [10] and Gümbel and Sussman [15] have to assume for technical reasons that the tax is a quadratic function of order size. This gives traders an incentive to split their orders into many small orders, which, in the above papers, they cannot do by assumption.

and

$$\tau_s \geq -\frac{B}{2}. \tag{6}$$

Proof. See Appendix.

Note that it is trivially sub-optimal to have subsidies exceeding (5) and (6), because it would lead to infinitely large tax losses: since no information acquisition would take place, prices would never be revealing and speculators could trade infinite quantities and receive the subsidy. In the rest of the paper it is assumed that tax rates satisfy (5) and (6).

In order to illustrate more clearly the interaction between the information acquisition decision by each speculator, we can write down expected trading profits for each, depending on whether the other speculator also acquires information. Firstly, note that from Lemma 1 we know that a speculator who does not acquire information, also does not trade. Her expected profits are therefore zero. If she does acquire information, we denote by π_l and π_s the profit of the date-1 (long-term informed) and the date-2 (short-term informed) speculator respectively. Moreover, denote by $e_l, e_s \in \{0, 1\}$ their respective decision to acquire information, where $e = 1$ denotes information acquisition.

From Propositions 1 and 2 follow the date-1 speculator's expected profits, if the date 2 speculator *does* acquire information:

$$E\left[\pi_l | e_s = 1\right] = \frac{q^2}{4} B\theta_\varepsilon \left(1-\mu\right) - q\theta_\varepsilon \left(1-\mu\right)\tau_l - \kappa. \tag{7}$$

When the date-2 speculator does *not* acquire information, the date-1 speculator cannot make trading profits by unwinding his position at date $t = 2$. He is thus left with the tax payment and the cost of information acquisition:

$$E\left[\pi_l | e_s = 0\right] = -q\theta_\varepsilon (1-\mu)\tau_l - k. \tag{8}$$

where $E[\pi_l | e_s = 1] > E[\pi_l | e_s = 0]$.

Conversely, when the date-1 speculator does not acquire information, the date-2 speculator's expected profits are given by

$$E\left[\pi_s | e_l = 0\right] = \frac{q}{2} B\theta_\eta \mu - q\theta_\eta \mu \tau_s - k \tag{9}$$

If, on the other hand, the date-1 speculator produces information, the date-2 speculator's profit falls, because prices reveal her costly information, before she can trade on it:

$$E\left[\pi_s | e_l = 1\right] = \left(1 - \tfrac{q}{2}\right)\left(\tfrac{q}{2} B\theta_\eta \mu - q\theta_\eta \mu \tau_s\right) - \kappa \tag{10}$$

Each traders' overall trading profits can then be written as

$$E\left[\pi_l\right] = \nu_s E\left[\pi_l | e_s = 1\right] + (1-\nu_s) E\left[\pi_l | e_s = 0\right], \tag{11}$$

and

$$E\left[\pi_s\right] = \nu_l E\left[\pi_s | e_l = 1\right] + (1-\nu_l) E\left[\pi_s | e_l = 0\right]. \tag{12}$$

From (7), (8) and (11) it is clear that it becomes more profitable for the date-1 speculator to acquire (long-term) information, if the date-2 speculator is more likely to acquire (short-term) information. But conversely, an increase in the date-1 speculator's probability of producing information renders it less attractive for the date-2 trader to become informed, i.e., the long-term informed trader drives out short-term information acquisition. This result differs from Froot, Scharfstein and Stein [13] and Hirshleifer, Subrahmanyam and Titman [17], where traders only learn their identity, after they have taken the information acquisition decision. It also differs from Dow and Gorton [8], where speculators receive information at no cost, and therefore early informed speculators do not drive out late informed speculators. This is important, because in my model any policy that increases information acquisition incentives for the long-term informed speculator, directly drives out short-term informed trade. This reduces information acquisition incentives for the long-term informed speculator and the policy may therefore have a severely reduced effect of what it intended to achieve. Let us now turn to the fully solved equilibrium.

Proposition 3. *In equilibrium the probabilities of information production are given by* $\nu_l = max\{0, min\{1, L\}\}$ *and* $\nu_s = max\{0, min\{1, S\}\}$*, where*

$$L = \frac{q\theta_\eta \mu(\frac{B}{2} - \tau_s) - k}{\frac{q^2}{2}\theta_\eta \mu(\frac{B}{2} - \tau_s)} \tag{13}$$

and

$$S = 4\frac{q\theta_\varepsilon(1-\mu)\tau_i + k}{q^2 B\theta_\varepsilon(1-\mu)} \tag{14}$$

Furthermore, for $\tau_s \in \left(-B\frac{2-\nu_s q}{2+\nu_s q}, B\frac{2-\nu_s q}{2}\right)$*, the* η*-hedgers' order size is given by*

$$\theta_\eta = \frac{B}{2B + \tau_s}, \tag{15}$$

and for $\tau_i \in \left(-B, B\frac{1-\nu_s q + \frac{\nu_s \nu_l q^2}{4}}{1+\frac{\nu_s \nu_l q^2}{4}}\right)$*, the* ε *-hedgers' order size is given by*

$$\theta_\varepsilon = \frac{B}{B + |\tau_l|}. \tag{16}$$

Proof. See Appendix.

The equilibrium considered here may be in mixed strategies.[12] Taxation affects the equilibrium via changes in the probabilities of information acquisition (equations (13) and (14)). A positive tax on the short-term informed speculator always reduces long-term information acquisition. This contrasts with Dow and Rahi [10], where (one generation of) competitive speculators trade too intensively from a joint profit maximisation point of view. A tax leads them to scale back equilibrium trades, which increases profits.

In this model a subsidy on date 2 trade has two effects: Firstly, it directly increases the date-2 speculator's trading profits. Secondly, it encourages trade by η-hedgers who increase their order size θ_η (equation (15)), which allows the date-2 speculator to submit larger orders. Effectively, the increase in date 2 liquidity that results from a subsidy $\tau_s < 0$ indirectly increases the date-2 speculator's expected trading profits. Overall, this implies that the date-1 speculator can become informed more often without driving out date-2 information production. This highlights a complication of Summers and Summers' [30] 'telescoping' argument when information acquisition is costly: An increase in long-term information acquisition now becomes unprofitable very rapidly, because it reduces the necessary information production by the subsequent speculator. The subsidy remedies this problem.

6 Improving investment efficiency

From equation (13) it is clear that the date 1 tax τ_l has no impact on the likelihood ν_l of long horizon information production. It follows that a tax/subsidy on the date-1 speculator and ε-hedger only redistributes welfare between traders and the tax authority, without affecting investment efficiency. Since the latter is our main concern, we can safely set $\tau_l = 0$. Let us now consider the welfare implications of a change in τ_s, firstly by establishing how a subsidy $\tau_s < 0$ affects hedgers' welfare.

Lemma 2. *Suppose $\tau_l = 0$. Then, no hedger is made worse off by the payment of a small subsidy $\tau_s < 0$.*

Proof. See Appendix.

Note that the η-hedgers are made better off by reducing τ_s: they pay a smaller tax (receive a higher subsidy). Reducing τ_s increases the probability ν_l with which the date-1 speculator acquires information and trades on it. Therefore, the date-2 speculator will be able to trade on private information with a smaller probability, which reduces the adverse selection cost of trading for the η-hedgers. Lemma 2 shows that ε-hedgers are unaffected by the tax on date-2 speculators. Hence, a very weak criterion for the desirability of a subsidy on date-2 speculators is, whether

[12] The advantage of this set-up is that it combines the simplicity of a non-competitive model (speculators can be modeled as risk neutral), with particularly simple welfare analysis: Regardless of the tax regime, speculators make zero profits in equilibrium, which is typically only true in models with competitive entry.

the expected increase in firm value more than outweighs the cost of paying a subsidy. Moreover, we have to ensure that the subsidy does not exceed the value in condition (6) and the restriction in Proposition 3. A subsidy that satisfies these conditions is referred to as a 'small subsidy'. The following Proposition 4 states for which parameter values a small subsidy may be socially desirable.

Proposition 4. *The cost of paying a small subsidy to date-2 speculators is less than the ex ante gain in firm value, if*

$$4\kappa\mu < Bq(1-\mu)\left(\frac{5(b-a)}{2(b+a)} - \mu\right). \tag{17}$$

No trader is made worse off by the payment of such a subsidy.

Proof. See Appendix.

From inequality (17) it follows that an increase in $b-a$ (keeping $b+a$ constant) increases the set of parameters κ, μ, q, c, for which a subsidy on date-2 speculators is desirable. This is the case, because as the difference between the two possible productivity levels increases, the firm's liquidation value becomes more sensitive to taking the correct investment decision. Essentially, the difference in firm value from knowing the productivity parameter and investing accordingly, and from not knowing the productivity parameter and taking a 'middle-of-the-road' investment decision increases with $b-a$.

Corollary *When firm investment is more sensitive to stock price movements, a subsidy on date 2 trade is more desirable.*

The sensitivity of changes in firm investment to stock price changes is directly proportional to $1/(b+a)$ (from equation (2) in Proposition 1). An increase in $1/(b+a)$ increases the set of parameter values for which a subsidy is desirable. In this sense an increase in $1/(b+a)$ makes the subsidy more desirable. While other parameters also influence the desirability of a subsidy, investment sensitivity takes a special significance, (i) because it is a directly observable parameter, and (ii) because it may have implications on the cost of a tax depending on the financial system of a particular country.

A higher sensitivity of investment to stock price movements implies a higher real cost of having a tax. For this reason, different countries may incur a different cost when imposing a speculation tax, depending on how sensitive that country's firms' investment varies with stock price movements. Moreover, there might be a relationship between the financial system of a particular country and the cost of a tax imposed on the real economy. One might conjecture that in some financial systems information aggregation in stock prices is more important than in other countries. As a result a tax on speculation (or the abolition of such a tax) would affect the real sector differently. For example, in the US and the UK the financial system is more strongly market based, while financial intermediaries play a more important role in the financial system of Germany and other continental European countries (Allen and Gale [1]). One might expect information contained in stock prices to be more important in a market-based system than in a bank-based system. One policy implication therefore is that a tax is more harmful in a market-based system than in a bank-based system.

7 Conclusion

When speculators have short horizon trading objectives, long-term information may get reflected in prices through trade by a sequence of overlapping generations of speculators. I show that an early born speculator exerts a negative externality over informed trading by a later born speculator, and conversely, a late speculator exerts a positive externality over the early born speculator. The presence of these externalities calls for a securities transaction tax in order to align information acquisition incentives with social welfare. When long-term information improves capital allocation, a subsidy on short-term trade can improve welfare, because it increases information production by the early born, long-term informed speculator.

The analysis is developed in a set-up where telescoping long-term information to the present through a sequence of short horizon speculators is in principle possible. Recently, Allen, Morris and Shin [2] have shown that this may not always be the case, because 'telescoping' requires that the law of iterated expectations applies: short horizon speculators need to estimate the average expected asset valuation of the subsequent generation of traders. This estimate is not necessarily the same as their own estimate of the fundamental asset value. In my model this is not an issue, because prices are set by a long-lived, risk neutral market maker. Without such an agent the telescoping argument itself may not work, which raises the issue of how policy should then be designed. One interesting question for future research that arises is to what extent prices can then be used to extract information about, say, allocational decisions. Even if prices are not an unbiased estimator of future fundamentals, they may allow inferences over such fundamentals. However, as Allen, Morris and Shin [2] point out, public information contained in past prices may receive too much weight in trading decisions, which affects the inferences that can be drawn from price observations. An analysis of the welfare and policy implications in this case is left for future research.

Appendix

Proof of Proposition 1. Following the discussion in Section 3, the market maker learns that $y = b$, when $Q_{t=1} = 2(1-\mu)\theta_\varepsilon$. This information will get reflected in the price, which allows the firm to deduce in equilibrium its own productivity level. From (1) we can write down the first-order condition for firm value maximization:

$$y - cI = 0 \qquad \Rightarrow \qquad I^* = y/c.$$

Hence, in this case the optimal investment level is b/c, resulting in firm value $V = b^2/2c$. In equilibrium the market maker sets price equal to expect firm value:

$p_{t=1} = b^2/2c$. The equilibrium prices and investment levels for order flow $Q_{t=1} = -2(1-\mu)\theta_\varepsilon$ can be derived analogously.

When order flow is not informative ($Q_{t=1} \in [-(1-\mu)\theta_\varepsilon, (1-\mu)\theta_\varepsilon]$), the optimal investment level is $(a+b)/2c$. This results in expected firm value (and price) of

$$E[V|Q_{t=1} \in [-(1-\mu)\theta_\varepsilon, (1-\mu)\theta_\varepsilon]] = \frac{(a+b)^2}{8c}. \tag{18}$$

With probability $\nu_l\, q/2$ the state of the world is such that the firm learns its productivity parameter, while it does not learn anything with the complementary probability. Expected firm value is then given by (4).

Now consider the optimality of the speculator's trading rule. Firstly, note that a speculator has no incentive to trade without information. By submitting an order she moves the price with a positive probability. This results in an expected trading loss, because the price move is not justified by fundamental value. Secondly, consider the market maker's out-of-equilibrium beliefs that support order size $(1-\mu)\theta_\varepsilon$. Suppose that the speculator receives good news (the case of trading on bad news can be dealt with analogously), and submits a buy order of size $(1-\mu)\theta_\varepsilon + \delta$, where $\delta \in (0, (1-\mu)\theta_\varepsilon)$. Then total order flow can take the values δ or $2(1-\mu)\theta_\varepsilon + \delta$.

Note, that for $Q_{t=1} > 2(1-\mu)\theta_\varepsilon$, the price set by the market maker is supported by the following out-of-equilibrium belief: If total order flow exceeds $2(1-\mu)\theta_\varepsilon$, the market maker believes that there is another informed trader who trades on information concerning ε. This out-of-equilibrium belief leads the market maker to adjust price, taking into account that the ε-informed trader knows that $\varepsilon = B$. Calculating expected trading profits (given that a signal has been received) for $\delta \in (0, (1-\mu)\theta_\varepsilon]$, yields zero expected profits. For $\delta = 0$, expected profits from trading are $Bq(1-\mu)\theta_\varepsilon/4 > 0$.[13] Hence, the date 1 speculator does not wish to deviate from the proposed equilibrium order size. ■

Proof of Proposition 2. The 'short-term' price $p_{t=2}$ depends on current order flow *and* the previous price. Two cases need to be distinguished:
Case 1. At date $t-1$, order flow (and thus $p_{t=1}$) revealed the speculator's private information. Then, the only new information at $t=2$ is the realization of ε. Hence, in this case $p_{t=2} = p_{t=1} + \varepsilon$.
Case 2. The 'long-term' price $p_{t=1}$ did not reveal private information. We know from Proposition 1 that the firm chooses $I = (a+b)/2c$. If the order flow $Q_{t=2}$ reveals y, the market maker can calculate expected firm value (and thus price $p_{t=2}$), by substituting the investment level I and the revealed y into equation (1). If order flow $Q_{t=2}$ does not reveal y ($Q_{t=2} \in [-\mu\theta_\eta, \mu\theta_\eta]$) the price $p_{t=2}$ continues to be uninformative. Again, the only new information in that case is the realization of ε. Hence, $p_{t=2} = p_{t=1} + \varepsilon$. ■

[13] Note that calculating profits requires knowledge of prices $p_{t=2}$, which are derived in the subsequent Proposition 2. For presentational clarity I chose to treat date 2 variables in a separate proposition at a later stage.

Proof of Proposition 3. The mixed strategy equilibrium is given by substituting (7) and (8) into (11) and solving for ν_s yields (14). Similarly, substituting (9) and (10) into (12) and solving for ν_l yields (13).

Now consider the trading strategy by ε-hedgers. Their optimal demand has to be calculated somewhat tediously by explicitly considering case distinctions depending on whether a chosen demand results in a payoff to the left or to the right of the kink in their utility functions. Consider the case $z_\varepsilon = -1$, i.e., the agent has a positive hedging demand ($\theta^\varepsilon_{t=1} \geq 0$). The following 3 payoffs with associated probabilities result if the ε-hedger chooses order size θ_ε.

Payoff: $x_\varepsilon = \theta_\varepsilon(p_{t=2} - p_{t=1}) + z_\varepsilon \varepsilon$	Probability
$(\theta_\varepsilon - 1)\varepsilon - \theta_\varepsilon \tau_l$	$1 - q\nu_s(1 - q\nu_s q\nu_l/2)/2$
$\theta_\varepsilon B + (\theta_\varepsilon - 1)\varepsilon - \theta_\varepsilon \tau_l$	$q\nu_s(1 - q\nu_l)/4$
$-\theta_\varepsilon B + (\theta_\varepsilon - 1)\varepsilon - \theta_\varepsilon \tau_l$	$q\nu_s/4$

Taking into account that ε takes the values $-B$, B with equal probability, there are six possible payoffs for the ε-hedger denoted by $x_1, x_2, \dots, x_6$. Depending on the choice of θ_ε, x_i can be positive or negative (to the left or right of the kink in the utility function), which yields several intervals of θ_ε for which we need to make case distinctions. For each interval we can explicitly calculate the value of θ_ε that maximizes expected utility *within* that interval. Comparing across the intervals yields the global maximum. This exercise has to be carried out separately for $\tau_l \geq 0$ and for $\tau_l < 0$.

In particular, when $\tau_l \geq 0$ and $\theta_\varepsilon < B/(B + \tau_l)$, expected utility is increasing in θ_ε, iff

$$\tau_l < \tau_u = B \frac{1 - \nu_s - q + \frac{\nu_s \nu_l q^2}{4}}{1 + \frac{\nu_s \nu_l q^2}{4}}. \tag{20}$$

If $\tau_l > \tau_u$, the hedger would not want to participate in the market. Moreover, for $\theta_\varepsilon > B/(B + \tau_l)$, expected utility is decreasing in θ_ε for any positive tax rate τ_l. Hence, for a positive tax rate the optimal order size is $\theta_\varepsilon = B/(B + \tau_l)$ (or zero if $\tau_l > \tau_u$).

Similarly, for the case $\tau_l < 0$, it is possible to show that when $\theta_\varepsilon < B/(B - \tau_l)$, then for any negative tax rate, the hedger wishes to increase order size θ_ε. If, on the other hand, $\theta_\varepsilon > B/(B - \tau_l)$, then the expected utility is decreasing in order size, as long as $\tau_l > -B$. Hence, the optimal order size for an ε-hedger is given by $B/(B + |\tau_l|)$ for an interval of τ_l as specified in the proposition. At this point, the ε-hedgers' expected utility is given by

$$EU_\varepsilon = -\frac{B}{B + |\tau_l|} \left(\frac{B}{4} q\nu_s + 2\tau_l \left[\tfrac{1}{2} - \tfrac{1}{8} q\nu_s + \tfrac{1}{8} q\nu_s q\nu_l \right] \right). \tag{21}$$

Now consider the trading strategy by an η-hedger. Firstly, the long-term price $p_{t=1}$ may already have revealed the speculator's private information (probability $q\nu_l/2$). In this case the tax rate is simply set to zero. From Proposition 2, we know that $p_{t=2} = p_{t=1} + \varepsilon$. Hence, the η-hedger's payoff is given by $x_\eta = \theta_\eta \eta + z_\eta \eta$. From this it follows that full hedging, i.e. $\theta_\eta = -z_\eta$ is optimal.

If, on the other hand, the long-term price does not reveal the information (probability $1 - q(\nu_l/2)$, the η-hedger faces a residual risk exposure to y. Suppose the hedger faces a positive hedging need $(z_\eta = -1)$ and chooses a positive order $\theta^\eta_{t=2} \geq 0$. Then, with probability $q_s/2$ the productivity level is high, *and* revealed to be so by date 2 prices. In this case the risk associated with y is cancelled. With complementary probability the date 2 price does not reflect the underlying productivity parameter, which can be either high or low. Altogether, this yields the following outcomes for the η-hedger:

Payoff: $x_\eta = \theta_\eta(V - p_{t=1}) + z_\eta \eta$	Probability
$(\theta_\eta - 1)\eta - \theta_\eta \tau_s$	$q\nu_s/2$
$\theta_\eta B + (\theta_\eta - 1)\eta - \theta_\eta \tau_s$	$(1 - q\nu_s)/2$
$-\theta_\eta B + (\theta_\eta - 1)\eta - \theta_\eta \tau_s$	1/2

Again, η can take the values $-B$, B with equal probability, yielding 6 different outcomes that can be numbered $x_1, \ldots, x_6$. As before, it is possible to make case distinctions as to the sign of x_i depending on the value of θ_η. Going through the calculations in a similar vein as for the ε-hedger it can be shown that the optimal order size is as in (7) for tax rates $\left(-B\frac{2-\nu_s q}{2+\nu_s q}, B\frac{2-\nu_s q}{2}\right)$. An η-hedger's equilibrium expected utility is given by

$$EU_\eta = -\frac{B}{2B + \tau_s}\left(\tfrac{B}{2} + \tfrac{\tau_s}{2}\left[1 + q\nu_s\right]\right)\left(1 - \tfrac{q\nu_l}{2}\right). \tag{22}$$

■

Proof of Lemma 1. Firstly, consider the case where the date-1 speculator receives a subsidy $\tau_l < 0$. When she deviates from the equilibrium of trading only when having received information, such a deviation remains unnoticed by the market maker and the firm. When trading without information, it does not matter for the speculator whether she buys or sells the security. Consider therefore w.l.o.g. the case where she always buys.

With probability 1/4 the productivity level is high $(y = b)$, and the price is 'revealing', in which case the deviant speculator makes zero expected trading profits. With probability 1/8 q_s productivity is high, the price is not revealing and the date 2 speculator moves the price in the subsequent period, resulting in expected trading profits of B. With probability $1/4(1 - q_s/2)$ we are in the above case, except that the date 2 speculator does *not* move the price, so again zero expected trading profits result.

With probability 1/4 the productivity level is low, but the long-term price is high. The firm then takes the wrong investment decision ($k = b/c$ when it should be a/c). In the subsequent period, the true productivity level may be revealed by the date-2 speculator. Note that in equilibrium a date-2 speculator does not trade after the long-term price has been revealing. After the off-the-path observation 'high price and negative signal,' however, she does have an incentive to trade. The market maker then must have an off-the-path belief consistent with this. He therefore sets the price equal to $b(2a-b)/2c+\varepsilon$. On the other hand, the short-term price may remain unchanged if the date-2 speculator does not receive a signal or her order remains hidden. Then, the date-1 speculator's profit is zero. Moreover, if the productivity level is low and the date-1 speculator's order remains hidden, she may incur a trading loss of magnitude B, when the date 2 price is 'revealing'.

Overall the trading profits from trading without information are then given by

$$E[\hat{\pi}_l] = -\theta_\varepsilon (1-\mu)\left(\frac{q_s b(b-a)}{8c} + \tau_l\right). \tag{23}$$

Setting $E[\hat{\pi}_l] \leq 0$ and solving for τ_l yields the desired result.

Consider now the date-2 speculator's deviation. Note, that the date-2 speculator only receives the subsidy when the long-term price has not yet been revealing, which is the case with probability $1-q_l/2$. Hence,

$$E[\hat{\pi}_s] = -\theta_\eta \mu \left(1-\frac{q_l}{2}\right)\left(\frac{B}{2}+\tau_s\right). \tag{24}$$

Setting $E[\hat{\pi}_s] \leq 0$ and solving for τ_s yields the desired result. ■

Proof of Lemma 2. The equilibrium expected utility of an ε-hedger is given by equation (24). For $\tau_l = 0$, a change in τ_s (and ν_l) does not affect expected utility of ε-hedgers, hence a small subsidy does not affect them. Equilibrium expected utility of η-hedgers is given by equation (25), which is a decreasing function of τ_s, hence a small subsidy makes them better off. ■

Proof of Proposition 4. First, calculate the gain/loss in expected firm value as a function of the tax rate τ_s. Denote this gain by $E[G(\tau_s)]$. Moreover, denote by $E[V^{rev}]$ the expected firm value, when the long-term price reveals the speculator's information. We get

$$E[V^{rev}] = \frac{b^2+a^2}{4c}. \tag{25}$$

Denote by $E[V^{non}]$ the expected firm value when the long-term price is not revealing. This yields

$$E[V^{non}] = \frac{(a+b)^2}{8c}. \tag{26}$$

The change in expected firm value resulting from a change in the probability of long-term information acquisition can then be written as.

$$E[G(\tau_s)] = \Delta V(v_l(\tau_s) - v_l(\tau_s = 0))q/2, \tag{27}$$

where $\Delta V \equiv E[V^{rev}] - E[V^{non}]$.

Now consider the cost/revenue of a subsidy/tax on date 2 trade. Since the tax/subsidy only accrues when the long-term price has not yet been revealing, there will only be any revenue/expenditure with probability $(1-\nu_l q/2)$. In that case, the η-hedger trades for sure, while the date 2 trader only trades with probability $\nu_s\, q$. Tax revenue $E[T(\tau_s)]$ can thus be written as

$$E[T(\tau_s)] = (1+\nu_s q)(1-\nu_l q/2)\theta_\eta \mu \tau_s. \tag{28}$$

Defining $W(\tau_s) \equiv E[T(\tau_s)] + E[G(\tau_s)]$ yields

$$W(\tau_s) = \left(\nu_s q + 1 - \frac{5\Delta V}{B\mu}\right) \frac{\kappa \tau_s}{q\left(\frac{B}{2} - \tau_s\right)} \tag{29}$$

From this it is straightforward to see that $W(\tau_s)$ is a decreasing function of τ_s iff

$$\nu_s q + 1 - \frac{5\Delta V}{B\mu} < 0 \tag{30}$$

Substituting ν_s from equation (14) and ΔV from (25) and (26) into (30) yields the result in the proposition. ■

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