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Asset trade, Real investment and a tilting Financial transaction tax

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Abstract

We study the impact of a Financial Transaction Tax (FTT) in a model that combines asset trading and real investment. An informed trader holds private information about the fundamental value of a firm, and the firm's manager relies on the asset price to infer such information and invest accordingly. We characterize an informative, but illiquid, equilibrium where the firm's value is optimal but trade is inefficiently low, together with an uninformative equilibrium with maximal liquidity but inefficient firm value. Although an FTT inefficiently reduces trading, it may tilt the market's equilibrium and make asset prices more informative. We characterize the situations in which one or the other of these two effects prevails. The analysis also helps us to reconcile some puzzling empirical evidence regarding the adoption of the FTT.

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JEL Classification: G12, G14, G18, G31

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1 Introduction

The idea of taxing asset trading has been the focus of economic debate since Keynes (1936), with the suggestion being that a Financial Transaction Tax (FTT) would reduce any trade not driven by fundamentals. An FTT was then famously advocated by Tobin in 1972 in his Janeway Lectures at Princeton University, shortly after the end of the Bretton Woods system in 1971. Tobin suggested a new system of international currency stability, and proposed that such a system include an international charge on foreign-exchange transactions. The goal was to dissuade short-term investors and reduce exchange rate fluctuations. More recently, this logic has been extended to other forms of financial transaction. Proponents of the FTT argue that financial markets are populated by a great many short-term traders whose actions are not based on long-term fundamental values, and thus they impair the informativeness of asset prices (see Stiglitz (1989) among others). According to this view, an FTT improves market quality and transparency by reducing the amount of short-term trading.

However, the FTT has also raised concerns, especially among financial economists (Schwert and Seguin, 1993; Ross, 1989). The main argument against an FTT is based on the adverse effects it may have on asset market liquidity. That is, an FTT would discourage short-term trading and therefore make financial markets less liquid. Critics of the FTT give considerable importance to financial market liquidity.

Since there are merits to both the proponents' and the opponents' arguments, it is only natural to wonder what the overall welfare effect of an FTT is? In this paper we specifically examine the trade-off between price informativeness and market liquidity, and we establish the conditions under which an FTT increases welfare, and those under which it does not. Moreover, we provide a novel explanation for the adoption of an FTT based on the possibility of "tilting" the asset market to different, preferable equilibria. Finally, our model's predictions reconcile the empirical evidence of the adoption of Financial Transaction Taxes.[1]

[1] An FTT has been introduced in numerous countries (Matheson, 2011). The UK has a long-standing tradition of so-called "Stamp Duty", that is, a tax on equity purchases, which currently amounts to 0.5%. An FTT was introduced in France in August 2012, and in Italy in March 2013. The adoption of a European-wide FTT is

We develop a model of asset trading and real investment in which trading and prices in the financial market and the firm's investment decisions are co-determined. This allows us to study the impact of the FTT on the informativeness of asset prices, trading volumes and the real value of investments. The asset traded is a share of a firm whose value depends on a real investment decision and the unknown fundamental value of the investment. The model comprises the firm's manager, an informed trader and many uninformed traders. The informed trader has superior information about the fundamental value of the investment, as in e.g. Kyle (1985) and Laffont and Maskin (1990). The manager makes the investment decision on the basis of the information conveyed by prices (Leland, 1992; Dow and Rahi, 2003; Goldstein and Gümbel, 2008; Edmans et al., 2015).[2] The value of the information is measured in terms of its impact on the manager's investment decision. For example, the value of information is considered to be high when efficient investment only takes place if prices reveal all available information. Trading in the asset market occurs because the informed trader and the uninformed traders have different liquidity needs.[3] To illustrate this, let the informed trader be less liquidity-constrained than uninformed traders, so that the former buys assets from the latter. Formally, uninformed traders discount future payoffs more than the informed trader does.[4]

Given the information about the fundamental, the informed trader decides the amount of the firm's shares she wants to buy, and the price she pays is subject to a proportional, ad-valorem FTT. Observing this trading amount, uninformed traders sell up to a point at which they break even and competition pins down the asset price to the expected present value of the firm. In turn, the manager invests accordingly having observed the asset's price. In this chain of events,

also being considered by the EU member countries. The latest proposal by the European Commission can be found here: https://ec.europa.eu/taxation_customs/taxation-financial-sector_en.

[2]As in the burgeoning literature on feedback effects, informed traders have information about the external environment, such as the firm's competitors, market demand, and financing opportunities, as well as about relevant macroeconomic factors and policies. The firm's manager thus uses the stock price to inform the investment decision. Empirical evidence for the feedback effect is provided by, among others, Chen et al. (2006), Edmans et al. (2012), Foucault and Fresard (2014) and Edmans et al. (2017).

[3]No trade theorems (Tirole, 1982; Milgrom and Stokey, 1982), establish that asymmetric information alone does not imply trade. Heterogeneous liquidity constraints serve the purpose of generating trade.

[4]We also discuss the alternative case in which the informed trader discounts future payoffs more than the uninformed traders do, and "short-selling" arises.

information about the actual state of the fundamental possibly flows from the informed trader to uninformed traders via the proposed trade, and then to the manager via the equilibrium price. Ultimately, the informed trader decides how many units to buy by anticipating the equilibrium price and the "real feedback" on the firm's investment and expected value.

If the information about the fundamental is available to all players, investment is efficient and guarantees the firm's optimal value. Asset prices reflect this value. Traders are able to reap the benefits of the difference in liquidity needs, by exchanging the maximal amount of the asset: in this case, we say the asset market is liquid. The only impediment to trade is the FTT, as this creates a wedge between the liquidity needs of the traders. For trade to take place, the difference in the liquidity needs of uninformed and informed traders must be large enough to account for the FTT.

In the case of a privately informed trader, on the other hand, the market outcome depends on the possibility of information being gleaned by the asset market and the firm's manager from the decisions of the informed trader. Order flows and prices may carry information. Formally, the environment we are examining is that of a signaling game where inefficiencies arise in different types of equilibrium.

When the informed trader buys different amounts of assets depending on the fundamental value of the firm, uninformed sellers observe and learn from the flow of orders, and set an asset price that reflects this information. Observing the asset price, the firm's manager gleans information and makes an efficient investment decision. However, the market is not fully liquid in this case: when the fundamental value of the investment is low, trade must also be low. Otherwise an informed trader holding strong fundamental information would pretend that the firm's prospects are weak, thus taking advantage of a low asset price. In this *informative but illiquid equilibrium*, the informativeness of the price, and the ensuing efficient real investment, are independent of the FTT, whereas the amount traded in the asset market decreases as a result of the transaction tax. The informative but illiquid equilibrium is a separating equilibrium of the signaling game.

On the other hand, when the informed trader buys the same amount of assets regardless of the fundamentals, the amount of trading and the corresponding price do not convey information. Although maximal trading may occur, also independently of the FTT, the investment is inefficient thus reducing the firm's value. The informed trader pays an "average price" that is larger than the effective value of the firm when the fundamentals are weak. An informed trader possessing weak fundamental information thus only buys the asset if the liquidity difference with uninformed traders is sufficiently large, i.e. the gains from liquidity trading outweigh the cost of uninformed investment. The uninformative but liquid equilibrium is a pooling equilibrium of the signaling game. For this *uninformative but liquid equilibrium* to realize, the difference in the liquidity needs of informed and uninformed traders, net of the tax, must be sufficiently large; indeed, the necessary difference in liquidity needs must be larger than in the informative but illiquid equilibrium.

In this environment, an FTT not only affects the level of trade, but also differentially impacts the conditions for the existence of the two types of equilibrium. In particular, the introduction of an FTT first eliminates the possibility of any uninformative but liquid equilibria, so that only informative but illiquid equilibria survive.[5] For trade to take place, the difference in the liquidity needs of traders must be larger in uninformative equilibria than in informative equilibria.

When both types of equilibrium coexist, the welfare ranking depends on the trade-off between market liquidity and information transmission. In particular, when the value of information is high, the informative equilibrium is preferable even if it may mean that liquidity is sacrificed. Importantly, when assessing this trade-off, the FTT plays a dual role: it both reduces the level of trade in a situation of informative equilibrium, and may make an uninformative equilibrium impossible. We thus specify if, and when, an FTT is socially optimal. We show that if the value of information is sufficiently great, then there is an optimal FTT that "tilts" the asset market from an uninformative to an informative equilibrium.

[5] Then a prohibitively high FTT would make trade impossible altogether.

This optimal FTT policy also suggests that markets and asset classes featuring large trading volumes and low price volatility, i.e. markets in a pooling equilibrium, should be considered for adopting an FTT.[6] Our model predicts that the introduction of an FTT in these markets reduces trading, increases price informativeness and volatility, and renders investment decisions more efficient.

Our results help to account for some rather puzzling empirical findings concerning the FTT. Colliard and Hoffmann (2017) study an FTT introduced in France on August 1, 2012. They find a decline in intra-day trading volume together with a positive, albeit small, effect on price efficiency. Considering the same policy change, Do (2019) focuses on the effect of the FTT on corporate investment decisions, and finds that both investment and investment sensitivity to growth opportunities were positively affected. Umlauf (1993) shows that in Sweden the adoption of an FTT in the 1980s increased price volatility and reduced trade. Similarly, other papers show a positive association between financial market transaction costs, such as an FTT, and price volatility (Jones and Seguin, 1997; Hau, 2006; Deng et al., 2018). While the evidence regarding a positive correlation between transaction costs and price volatility has been interpreted negatively as far as the adoption of an FTT is concerned, in our model price volatility is beneficial as it implies that prices become more informative. Our result sheds new light on this well-established evidence.

Related literature. Our paper contributes to the theoretical literature on the rationale for adopting an FTT. Davila (2021) studies the welfare effects of an FTT and establishes its optimal value. The rationale underlying the adoption of an FTT is rooted in a behavioral bias. Traders hold different beliefs, and thus some of them are optimistic while others are pessimistic. The presence of such bias generates non-fundamental trading in the market. Davila (2021) shows that the optimal FTT is positive if non-fundamental trading is uncorrelated to fundamental trading. The FTT improves the allocation of risk by reducing non-fundamental

[6] The optimal FTT, and its policy implications, follow the same argument also when the informed trader is more liquidity-constrained and chooses to sell the asset.

trading. However, if traders share the same beliefs, that is, that non-fundamental trading does not take place, then imposing an FTT would inefficiently reduce fundamental trading. Even if we model the FTT as a trading cost, our model does not rely on behavioural biases and non-fundamental trading in order to justify an FTT. In our model, trading is fundamental due to different liquidity needs and the differing information possessed by traders. While the adoption of an FTT reduces valuable trading, it may still increase welfare.

Our paper also relates to the literature on Financial Transaction Taxes as transaction costs, and on their impact on welfare.[7] While this literature is concerned with how the financial market produces information and aggregates it, we extend the analysis to the impact of financial market information on real investment, the information transmission channel. Dow and Rahi (2000) consider a model in which both uninformed liquidity traders and informed competitive traders buy assets.[8] Whether or not prices reveal information depends on the share of traders who are uninformed. The inefficiency in their model arises from the presence of uninformed liquidity traders. The inefficiency in our model arises from the strategic informed trader and her ability to influence the market outcome. Dow and Rahi (2000) evaluate an FTT in a model without any value of information, and show that it may increase speculative profits. In our model, the informed trader internalises the trade-off between gains from trade and the divulgence of information. Davila and Parlatore (2021) study the effect of an FTT on information aggregation and acquisition in financial markets. They show that the impact of a transaction cost on information aggregation in regard to prices is ambiguous, and crucially depends on the sources of noise and of traders' heterogeneity. We derive a complementary result for information transmission. When trade takes place between heterogeneous investors, there is an optimal FTT that maximizes welfare. Kurlat (2019) and Kurlat and Scheuer (2021) analyse models in which traders choose information endogenously, and show that too much information may be acquired; therefore an FTT could help discourage information acquisition. Vives (2017)

[7] There is also a strand of literature that focuses exclusively on the positive effects of transaction costs on equilibrium choices like portfolios, prices and volume. We refer to Vayanos and Wang (2012) for a survey.

[8] This assumption is crucial since informed competitive traders do not consider the effects of their trading on information revelation, unlike the informed strategic trader in our model.

and Gümbel (2005) examine models in which an FTT improves welfare by correcting traders' information acquisition choices. Biais and Rochet (2020) show that an FTT is part of the optimal tax mix to generate fiscal revenue when wealth is not perfectly observable, and rich people are more likely to engage in financial transactions.

It is important to distinguish between information aggregation and information transmission. There are several studies pointing to the fact that dispersed information is aggregated in stock prices: these include Grossman (1976) and Grossman and Stiglitz (1980) , and more recently Han et al. (2016). The focus of the present article on information transmission follows the seminal works by Glosten and Milgrom (1985) and Kyle (1985) and, more recently, Goldstein and Gümbel (2008) and Edmans et al. (2015). Our model can be seen as an intersection of the models in Kyle (1985) and Glosten and Milgrom (1985). We consider risk-neutral traders as in Glosten and Milgrom (1985); however, the informed trader has market power and private information, as in Kyle (1985) ,which naturally leads to the strategic consideration present in a Perfect Bayesian equilibrium as highlighted by Laffont and Maskin (1990). This generates an interesting trade-off between the volume of trading and the price' information content. As in the previous literature (Glosten and Milgrom, 1985; Kyle, 1985), in our model competitive uninformed market makers receive market orders from the informed trader. In order to generate trade among risk-neutral traders, we adopt heterogeneous liquidity needs in the spirit of Glosten and Milgrom (1985).

The seminal papers by Kyle (1985) and Glosten and Milgrom (1985), together with a large part of the subsequent literature, are concerned with positive analysis, and in particular with how trading affects information transmission, the bid-ask spread and market liquidity. This literature makes use of noise traders as a reduced form for other trading motives. The presence of noise traders makes it hard to perform a normative analysis and evaluate welfare. By modeling rational liquidity-constrained traders who only generate fundamental trading, this paper sidesteps these concerns.

For information transmission to have social value, prices need to have a real effect. We incorporate this into our model by adopting real investment, following the literature on the feedback effect between asset prices and real investment (Leland, 1992; Dow and Rahi, 2003; Goldstein and Gümbel, 2008; Edmans et al., 2015). Similar to the seminal contribution of Leland (1992), our model embraces the idea that informed trading is beneficial to real investment.

The remainder of the paper is organized as follows. Section 2 introduces the model. Section 3 derives the constrained first-best solution. Section 4 characterizes separating and pooling equilibria. Section 5 studies welfare in both equilibria, and analyses the welfare effect of the FTT. Section 6 discusses some extensions of the model. Section 7 concludes. Appendix A collects all the proofs, and Appendix B contains the formal analysis of the model's extensions.

2 The Model

A firm's manager faces a risky investment opportunity whose value depends on the realization of the *prospect* of the investment, or *state* of the world, and on the *level* of investment, as described momentarily. The state of the world is the random variable $\omega \in \{L, H\}$ where the H-state occurs with probability β and the L-state with complementary probability $1 - \beta$.

The firm's stock is traded in a financial market populated by a single informed trader, I, who privately observes the prospect of the investment ω, together with a unit measure of perfectly competitive, uninformed traders, U, who own all of the firm's assets $E = 1$.[9] Traders are risk-neutral and the assumption of unitary endowment is designed to simplify notation without losing any generality.

The uninformed traders are also more liquidity-constrained than the informed trader. In particular, they discount future earnings more than the informed trader, i.e. the discount factors are respectively $\delta_U < \delta_I$.[10] This difference in liquidity requirements determines the gains to be had from trading, and motivates the informed trader I to buy $T \in [0, 1]$ units of the asset.[11]

[9] We start by assuming that uninformed traders are the initial owners of the asset. In section 6.3 we examine the case where the informed trader is the initial owner of the assets and results are qualitatively the same.

[10] Heterogeneous liquidity needs can arise from different sources, including: fund inflows or outflows, margin calls, differential funding costs.

[11] In section 6.1 we consider the alternative case where a possibly more liquidity-constrained informed trader

After observing the quantity T, uninformed traders revise their belief $Pr(H|T)$ and trade the asset with the informed trader at price P.[12] Upon observing P, the firm's manager revises her belief $Pr(H|P)$ and invests k.

The buyer, i.e. the informed trader, may have to pay the government a financial transaction tax (FTT) $\tau \geq 0$ that is proportional to the purchase value $P \times T$.[13] If this is the case, the tax is paid at $t = 2$. Figure 1 reports the timing.

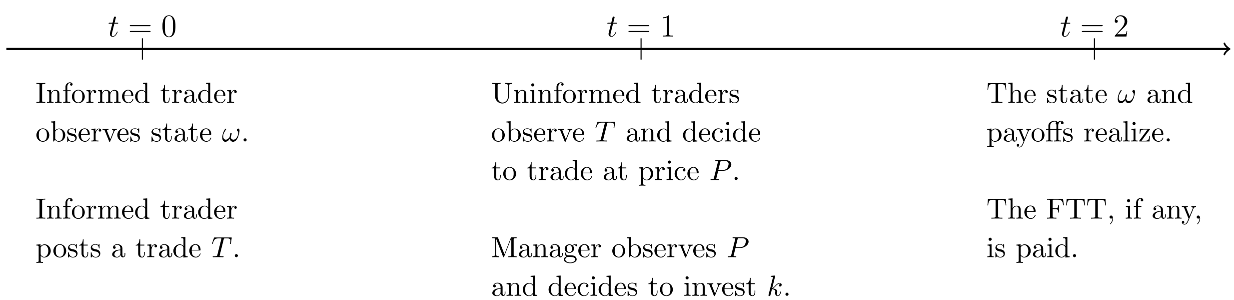


Figure 1: Timeline

The manager decides to invest k which, combined with the prospect ω, determines the firm's value. Knowing ω, the manager will invest optimally, leading to the optimal ex-post value of the firm F_ω.[14] Without any loss of generality, we assume that the firm's value in the H-state is larger than in the L-state, $F_H > F_L$.

The manager may have to invest without knowing the actual state of the world ω. We use $\bar{F}_\omega$ to indicate the ex-post value of the firm when ω realizes; however, the manager, at $t = 1$, had to establish the optimal level of investment from an ex-ante viewpoint, in the belief that

short-sells the asset, $T \leq 0$. Results are qualitatively the same.

[12] One can view uninformed traders as competitive market makers receiving market orders from the informed trader, similar to Kyle (1985) and Glosten and Milgrom (1985). In any given equilibrium, there has to be a unique price-quantity bundle $\{P, T\}$ and market clearing is achieved through uninformed traders' participation (the supply), together with the informed trader's incentives (the demand). The uninformed traders' participation constraint determines a step function for the price-quantity supply relation. At any price weakly higher than the reservation value, uninformed traders are willing to sell any positive quantity. Given the asset price, the informed trader determines the optimal level of trade, taking into account the information revealed by her trading decisions when other parties do not have knowledge of ω.

[13] In section 6.2, we consider two additional cases: when the tax is only levied on the seller, and when it is levied on both seller and buyer.

[14] What matters most for the purposes of our analysis are the different firms' values. Hence we do not need to explicitly indicate how the level of investment k maps into the firm's value. In section 5, when we study the welfare effects of the FTT, we further specify a model of investment for clearer comparison.

$Pr(H) = \beta$. Since the investment was made without knowing the state of the world, we have $F_\omega \geq \bar{F}_\omega$. We assume $\bar{F}_H > \bar{F}_L$.

Finally, we use $F_\omega^{-\omega}$ to indicate the value of the firm when the realization of the state at $t = 2$ is ω but at $t = 1$ the manager chose what would have been an optimal investment had the observed value of the state been $-\omega$. Clearly, if the manager had invested according to belief β instead of mistakenly thinking that the true state was $-\omega$, the firm's value would have been greater, $\bar{F}_\omega \geq F_\omega^{-\omega}$. Summarizing, the *ex-post* values of the firm, conditional on the realized value of ω, are as follows:

$$F_\omega \geq \bar{F}_\omega \geq F_\omega^{-\omega}. \tag{1}$$

The *ex-ante* expected value of the firm when the manager invests without knowing the actual state of the world, is $\bar{F} = \beta\bar{F}_H + (1-\beta)\bar{F}_L$. The increase in the firm's value when investing according to the actual state of the world, rather than according to the prior $\beta = Pr(H)$, is

$$\beta F_H + (1-\beta)F_L - \bar{F} \geq 0. \tag{2}$$

There is *value of information* if the inequality in expression (2) is strict. When the level of optimal investment is independent of the state of the world then all the terms in (1) are identical and the value of the information in expression (2) is nil. Consequently the firm's manager cannot benefit from learning from prices. We refer to this as the *no-feedback-case*.

To limit the number of cases, but without losing insights, we further assume,

$$F_H^L > F_L, \qquad F_L^H > 0. \tag{3}$$

The first inequality implies that even a distorted investment in state H results in a higher value of the firm than the best investment in state L. The second inequality states that a distorted investment in the L-state still results in a higher value of the firm than investing in the outside asset does.

For the main analysis, we define the following terminology. First, the **information gap**, $\frac{\bar{F}}{\bar{F}_\omega}$, is the ratio of the value of the firm attributed by uninformed traders and the firm's manager, in the numerator, to the value attributed to the firm by the informed trader, in the denominator. When there is asymmetric information, the information gap is larger than 1 when the informed trader knows the realized state is L. It is lower than 1 when the realized state is H. When instead there is symmetric information, everybody holds the same expectation on the firm value and the information gap is then equal to 1. Second, the **adjusted-liquidity ratio**, $\frac{\delta_I}{\delta_U(1+\tau)}$, as the ratio of liquidity preferences adjusted by the FTT.

3 Full information benchmark

When players are fully informed about the state ω, the manager induces a firm value F_ω and the firm trades at price P_ω. Uninformed traders prefer trading T_ω units of the asset at a price of P_ω rather than holding on to them, if

$$P_\omega T_\omega + \delta_U(1 - T_\omega)F_\omega \geq \delta_U F_\omega. \tag{4}$$

The left hand side of the inequality reflects uninformed traders' profits from selling T_ω units which they compare to the value of holding the asset on the right-hand side.

Competition among them drives the price down to a level at which they become indifferent, so that equation (4) holds with equality and the equilibrium asset price is

$$P_\omega = \delta_U F_\omega. \tag{5}$$

The more liquidity-constrained uninformed traders are, i.e. the smaller δ_U, the lower the price is.

The informed trader, in turn, is willing to trade T_ω units if the net gains from trade are weakly larger than those resulting from investment in the riskless asset,

$$(-(1+\tau)P_\omega + \delta_I F_\omega)T_\omega \geq 0. \tag{6}$$

Since the informed trader's profit is linear in T_ω, the profit-maximizing level of trade is given by a corner solution, i.e. $T_\omega \in \{0,1\}$. In order for the informed trader to buy, $T_\omega = 1$, the net price, $P_\omega(1+\tau)$, has to be weakly smaller than the discounted value of the firm $\delta_I F_\omega$. We say that the adjusted liquidity ratio has to be weakly larger than the information gap, which is equal to 1 under symmetric information. The following proposition summarizes these observations.

Proposition 1. *Given full information,*

(i) the asset price reflects information about the state ω, $P_\omega = \delta_U F_\omega$, and maximal trade realizes in any state ω, $T_\omega = 1$, if the adjusted liquidity ratio is weakly larger than one:

$$\frac{\delta_I}{(1+\tau)\,\delta_U} \geq 1, \tag{7}$$

(ii) otherwise, no trading takes place, $T_\omega = 0$.

Given full information, the only motive for trading are heterogeneous liquidity preferences, that is, the different discount factors for informed and uninformed traders, accounting for the FTT. In case (i), the *adjusted liquidity ratio* $\frac{\delta_I}{(1+\tau)\delta_U}$ being larger than one shows that the informed trader values future gains net of tax more than uninformed traders do, $\frac{\delta_I}{(1+\tau)} \geq \delta_U$. Therefore, there is room for trading between informed and uninformed traders. Point (ii) shows that the FTT can distort the level of trade. A sufficiently large FTT, $\tau \geq \frac{\delta_I}{\delta_U} - 1$, reduces the adjusted liquidity ratio, and when it becomes smaller than one there is no longer any room for trading because the informed trader values future earnings less than uninformed traders do.

The welfare loss of an FTT, in this case, is as follows. When the informed trader buys (case (i)), the FTT does not affect trade but simply induces a welfare-neutral transfer $-\tau P_\omega T_\omega$ from the informed trader to the government's coffers. By defining welfare W as the expected sum of traders' payoff and government revenue, we have:

$$
\begin{aligned}
W^* =& \sum_{\omega} Pr(\omega)\Big[-(1+\tau)P_\omega T_\omega + \delta_I T_\omega F_\omega + P_\omega T_\omega + \delta_U(1-T_\omega)F_\omega + \tau P_\omega T_\omega\Big] \\
=& \delta_I(\beta F_H + (1-\beta)F_L), \qquad (8)
\end{aligned}
$$

which is the expected value of the firm as perceived by the final owner, the informed trader.

When the FTT is high enough to discourage trade, welfare is equal to

$$W_0 = \delta_U(\beta F_H + (1-\beta)F_L), \tag{9}$$

since the firm remains in the hands of uninformed traders.

The distortionary effect of an FTT that moves the economy away from trade towards no-trade, is

$$W^* - W_0 = (\delta_I - \delta_U)(\beta F_H + (1-\beta)F_L) > 0 \tag{10}$$

and this amounts to the loss of the asset remaining in the hands of the uninformed traders, who value future returns less than the informed trader does. Let us call $\tau_{FB} = (\frac{\delta_I}{\delta_U} - 1)$. Then any $\tau \in [0, \tau_{FB}]$ supports the constrained first-best solution with the efficient level of trade.

4 Liquidity and information trade-off

We consider an informed trader who possesses private information about the prospects of the investment ω. The trader's strategy is a mapping $T : \{L, H\} \to \Re_0^+$ that prescribes a quantity T_ω on the basis of her private information ω. The uninformed traders' strategy maps the level of trade to the asked price, $P : \Re_0^+ \to \Re_0^+$. The firm manager's strategy maps the observed price to the investment and to the value of the firm.

A Perfect Bayesian equilibrium of this signaling game consists of a triple of players' strategies (trade, prices and investment/firm value) and a family of posterior conditional beliefs such that strategies are sequentially rational given the other players' strategies and beliefs, and beliefs are consistent (using Bayes rule) with the strategy of the informed trader.[15] Since the asset price P reflects the informed trader's decision T, and uninformed traders act competitively, P conveys the same information as T, and thus uninformed traders and the manager hold the same beliefs, $q = Pr(H|T) = Pr(H|P)$.

4.1 Informative but illiquid trade

Let us suppose that the informed trader buys T_ω after observing ω with $T_H \neq T_L$. In turn, observing T_ω, uninformed traders adjust their conditional beliefs q. We posit the following:

$$q = Pr(H|T) = \begin{cases} 1 & \text{if } T = T_H \\ 0 & \text{if } T = T_L \\ 1 & \textit{otherwise.} \end{cases} \tag{11}$$

These conditional beliefs postulate that after observing a level of proposed trade T_L, uninformed traders believe that they face the informed trader in the L-state, and that this will determine a price P_L to be discussed momentarily. If they observe any other level of trade on the other hand, they believe they are facing the informed trader in the H-state, and that this will determine a price P_H.[16]

Upon observing the price P_ω, with $P_H \neq P_L$, the manager believes to be in the ω-state, i.e. $Pr(H|P_H) = 1$, $Pr(H|P_L) = 0$.[17] Hence, in a separating equilibrium, the asset trade T_ω perfectly reveals information through prices P_ω, and the manager thus makes the optimal investment which delivers the maximum firm value conditional upon the state, F_ω.

[15] A signaling model seems to offer a better description of reality than a screening game does, since it is the informed trader rather than the uninformed market makers who initiates the trade. We rely on pure strategies equilibria to convey the trade-off between liquidity and information.

[16] Appendix B.1 shows that these beliefs are not knif-edge: there are other more elaborate beliefs which support the same equilibrium we examine here. Moreover, Appendix B.2 shows that these beliefs are consistent with the Intuitive Criterion (Cho and Kreps, 1987).

[17] Consistently with the off-equilibrium beliefs of uninformed traders, when observing any other price, the manager believes to be in the H-state.

Accounting for the manager's reaction, equilibrium prices satisfy the following participation constraint for each uninformed trader,

$$P_\omega T_\omega + \delta_U(1 - T_\omega)F_\omega \geq \delta_U F_\omega, \tag{12}$$

as in the full information benchmark. The right hand side shows that since uninformed traders are atomistic, the informational content of the price is unaffected if one of them decides not to trade, as is the manager's decision. In virtue of the previous condition, competition between uninformed traders drives prices down until their participation constraint binds,

$$P_\omega = \delta_U F_\omega, \tag{13}$$

as in the full information benchmark. The difference here is that the information reaches uninformed traders and the manager, respectively, via the levels of trade and the associated prices.

The informed trader is willing to buy the risky asset if its present value, net of the FTT τ, outweighs the zero return on the riskless asset,

$$-(1 + \tau)P_\omega T_\omega + \delta_I T_\omega F_\omega \geq 0. \tag{14}$$

With the equilibrium price P_ω as in expression (13), the informed trader's participation constraint is thus satisfied if,

$$\frac{\delta_I}{(1 + \tau)\delta_U} \geq 1. \tag{15}$$

As with full information, in a separating equilibrium the gains from trade accrue from the different liquidity needs of informed and uninformed traders. Uninformed traders are eager to sell assets because of their liquidity needs, while the informed trader benefits from the discounted price. Given that asset trade provides the same information to uninformed traders and the firm's manager, for any ω, trade will occur when the adjusted liquidity ratio is weakly larger than the information gap, which is one in the case of a separating equilibrium, since the manager, uninformed traders and informed trader all possess the same information.

However, the possibility of conveying information through trade comes with constraints. The informed trader may try to exploit her superior information and induce uninformed traders into believing that the economy is in the L-state, since in this way the price said informed trader has to pay is lower, as $P_L < P_H$. To avoid this mimicking incentive, the level of trades T_H and T_L must differ in order to convey information. This is guaranteed by the following incentive compatibility constraints, one for any ω,

$$-(1+\tau)P_\omega T_\omega + \delta_I T_\omega F_\omega \geq -(1+\tau)P_{-\omega}T_{-\omega} + \delta_I T_{-\omega} F_\omega^{-\omega}. \tag{16}$$

The incentive compatibility constraints (16) impose restrictions on the levels of trade T_H and T_L as the following proposition states.

Proposition 2. *(Separating equilibrium) An informative equilibrium exists if and only if* $\frac{\delta_I}{\delta_U(1+\tau)} \geq 1$*, in which case:*

(i) in state H*, trade is efficient,* $T_H = 1$*;*

(ii) in state L*, trade* T_L *is distorted downwards, with* $1 > \bar{T}_L \geq T_L \geq \underline{T}_L$ *(expressions of boundaries* $\bar{T}_L, \underline{T}_L$ *in Appendix A), if*

$$\frac{F_H - F_L}{F_H - F_H^L} \geq \frac{\delta_I}{\delta_U(1+\tau)}, \tag{17}$$

where $\bar{T}_L$ *and* $\underline{T}_L$ *are decreasing in the FTT. Otherwise,* T_L *is arbitrarily close to* 1 *and independent of* τ *("no-envy" case);*

(iii) prices in the two states differ with $P_H > P_L$*, whereby they reveal information about the firm's prospects, and the manager invests optimally resulting in the maximization of the firm's value* F_ω*.*

For the informed trader not to induce a low price P_L, regardless of the state ω, the proposition shows that the level of trade in the L-state, T_L, must be distorted downwards. When condition (17) holds, equilibrium levels of trade feature less than the efficient amount of trade, $T_L < 1$, including the Pareto optimal equilibrium with maximum trade, $\bar{T}_L < 1$. Observing trading in the market in this separating equilibrium, an empiricist sees price and liquidity volatility. On the one hand, this is beneficial for real investment because price volatility is associated with information revelation. On the other hand, trade may not be optimal, and the empiricist sees cases in which the trading market is relatively illiquid, $T < 1$. We say the financial market in the separating equilibrium is illiquid, with traders not always able to meet their liquidity needs in full.

Condition (17) for restricted trade is interpreted as follows. By making uninformed traders wrongly believe that the state is $\omega = L$, the informed trader generates a price reduction of $\delta_U(F_H - F_L)$. At the same time, she also induces a reduction in the firm's future value, due to suboptimal investment by the manager, who expects a state L, equal to $\frac{\delta_I}{1+\tau}(F_H - F_H^L)$. When the price reduction is greater than the loss in the firm's value, i.e. (17) holds, the level of trade T_L must be reduced, as otherwise with $T_L = 1$ the informed trader in state $\omega = H$ would gain more by mimicking the state $\omega = L$.

The proposition also concerns the effects of an FTT. The first of these is that when the informed trader has to pay a tax on purchases, the gain from the liquidity difference shrinks just like in the benchmark case of symmetric information. If this effect is strong enough, i.e. $\frac{\delta_I}{\delta_U(1+\tau)} < 1$, then the difference between the liquidity needs of informed and uninformed traders vanishes, and no trading takes place. Secondly, and specific to asymmetric information, the maximal amount of trade in the L-state $\bar{T}_L$ is decreasing in τ. The reason for this is that a higher tax results in a greater gain of the informed trader in the H-state from mimicking the informed trader in the L-state. This in turn makes the incentive compatibility condition (16) tighter, and as a consequence, the distortion on the level of trade T_L increases.

When there is no value of information, $F_\omega = \bar{F}_\omega = F_\omega^{-\omega}$, the informed trader in the H-state has a stronger incentive to deviate to the L-state contract since there is no adverse effect on the firm's value. In fact, the reduction in firm value is now equal to $\frac{\delta_I}{1+\tau}(F_H - F_H^L) = 0$. To deter the informed trader in the H-state from deviating, the incentive-compatible level of trade in the L-state has to be sufficiently low, and specifically it needs to be lower than when information is of social value. Moreover, trade is always illiquid in state L since the left-hand side of (17) becomes arbitrarily large.

4.2 Liquid but uninformative trade

In this section we study the possibility of an maximally liquid market, independently of state ω, which however foregoes the possibility of conveying information and ends up with the firm's value being suboptimal.

In such a pooling equilibrium, the informed trader buys an identical quantity T_P regardless of state ω. Therefore, uninformed traders and the manager cannot infer the informed trader's private information. Observing the informed trader's demand T_P, uninformed traders' conditional posterior beliefs are equal to their priors, and a "pooling" price P_P emerges regardless of the state. In turn, the manager cannot infer the state of the world from this price, and consequently she invests by maximizing the firm's ex-ante value, which leads to the expected firm value $\bar{F}$. We pin down on and off equilibrium beliefs as follows,[18]

$$q = Pr(H|T) = \begin{cases} \beta & \text{if } T = T_P, \\ 1 & \text{for any other } T. \end{cases} \tag{18}$$

After observing the informed trader's demand, uninformed traders decide whether to trade the asset. The uninformed traders' participation constraint is now given by,

$$P_P T_P + \delta_U (1 - T_P) \bar{F} \geq \delta_U \bar{F}, \tag{19}$$

[18] As with the separating equilibrium, we can show that beliefs are not knife-edge. Moreover, Appendix B.2 shows that the beliefs are consistent with the Intuitive Criterion (Cho and Kreps, 1987).

and competition among uninformed traders pins the price down to,

$$P_P = \delta_U \bar{F}.$$

Let us now consider the informed trader's incentives. She knows the state ω and she knows that by purchasing T_P units of the asset, given the manager's decision, the actual value of the firm will be $\bar{F}_\omega$. Hence, knowing ω and buying T_P units of the asset, the informed trader improves with regard to investing in the riskless asset if,

$$(-(1+\tau)\delta_U \bar{F} + \delta_I \bar{F}_\omega)T_P \geq 0. \tag{20}$$

Since $\bar{F}_H > \bar{F} > \bar{F}_L$, the informed trader in the H-state benefits from a relatively low asset price, while the informed trader in the L-state has to pay a relatively high price.

However, the informed trader may try to buy a quantity of assets T' rather than the quantity T_P. Given said quantity T' and the associated price of P', the manager believes the economy to be in the H-state and invests accordingly. The resulting price would be,

$$P' = \delta_U F_H.$$

Bearing in mind this chain of reactions, the incentive compatibility constraint of the informed trader in state ω will be,

$$(\delta_I \bar{F}_\omega - (1+\tau)\delta_U \bar{F})T_P \geq (\delta_I F_\omega^H - (1+\tau)\delta_U F_H)T'. \tag{21}$$

Taking into account the traders' incentives and the manager's investment, we can identify conditions that guarantee trading takes place in equilibrium with no information revelation.

Proposition 3. *(Pooling equilibrium)*

Pooling equilibria exist if and only if,

$$\frac{F_H - \bar{F}}{F_H - \bar{F}_H} \geq \frac{\delta_I}{\delta_U (1+\tau)} \geq \frac{\bar{F}}{\bar{F}_L} \tag{22}$$

in which case:

(i) trade is $1 \geq T_P \geq \underline{T}_P$ *(expression of boundary* $\underline{T}_P$ *in Appendix A), independently of the state of the world, where* $\underline{T}_P$ *is decreasing in the FTT;*

(ii) the asset price is uninformative about the state of the world, $P_P = \delta_U \bar{F}$ *for any* ω*;*

(iii) the manager remains uninformed and consequently invests inefficiently, i.e. for any ω *the firm value is* $\bar{F}_\omega < F_\omega$*.*

When a pooling equilibrium exists, it comprises a range of equilibrium trading levels, with a lower threshold of $\underline{T}_P$. The Pareto optimal pooling equilibrium features an efficient level of trade, $T_P = 1$. We say the market is fully liquid. An empiricist observing the economy in a pooling equilibrium would identify relatively high levels of trade and limited price volatility over time. Market quality in terms of price informativeness is however poor. In this sense, a liquid market does not always equate to informative prices.

The second condition in (22) sets a lower bound for the adjusted liquidity ratio. It ensures participation of the informed trader in the L-state who has the least incentive to participate. Given that she has to pay a price reflecting the value of the firm $\bar{F}$, which is above he own valuation $\bar{F}_L$, she demands a sufficiently large discount on said price. The condition states that the adjusted liquidity ratio must be higher than the information gap in the L-state $\bar{F}/\bar{F}_L$. This condition is more easily met the larger the probability of being in the L-state is, since in this case $\bar{F}$ would be close to $\bar{F}_L$.

At the same time, the adjusted liquidity ratio should not be too high, otherwise the informed trader in the H-state would prefer to slightly reduce the level of trade, provide correct information to uninformed traders and the manager, and thus induce the appropriate level of investment and the optimal firm value F_H. This move would increase the value of the firm by $F_H - \bar{F}_H$. However, the change in beliefs of uninformed traders would also imply a price increase of $F_H - \bar{F}$. The first inequality in (22) therefore guarantees the incentive compatibility of the informed trader in the H-state. The upper bound of condition (22) decreases in β which implies that the condition is more easily satisfied if the probability of being in the L-state is large.[19] We also note that the FTT affects the pooling equilibrium of Proposition 3 through the participation constraint of the informed trader. In the second inequality in (22), a high FTT makes the pooling equilibrium impossible.

In the case of no information value, $F_\omega = \bar{F}_\omega = F_\omega^{-\omega}$, as with the separating equilibrium, the deviation of the informed trader in the H-state does not adversely affect the firm's value, $F_H - \bar{F}_H = 0$; at the same time, the price still increases, $F_H - \bar{F} > 0$. As a result, the adjusted liquidity ratio can now be arbitrarily large without this affecting the condition for the existence of the pooling equilibrium (22).

4.3 Equilibria existence

In Section 5 we identify the trade-off between market liquidity and price informativeness. It is useful to establish beforehand to what extent the two types of equilibrium can co-exist, depending on the adjusted liquidity ratio. To avoid any uninteresting cases, we disregard that of no trade.

Proposition 4. *(Equilibrium existence)*

(i) If $1 \leq \frac{\delta_I}{\delta_U(1+\tau)} \leq \frac{\bar{F}}{\bar{F}_L}$ *only a separating equilibrium exists.*

(ii) If $\frac{\bar{F}}{\bar{F}_L} < \frac{\delta_I}{\delta_U(1+\tau)} \leq min\{\frac{F_H - \bar{F}}{F_H - \bar{F}_H}, \frac{F_H - F_L}{F_H - F_H^L}\}$ *both a pooling equilibrium and a separating equilibrium exist.*

As discussed in the preceding sections, trade takes place on the basis of different liquidity needs, net of the FTT, and can contribute to information revelation. In the separating

[19] This observation, together with the analogous one regarding the second condition in (22), shows a small probability β of the H-state renders the existence of a pooling equilibrium more likely.

equilibrium, information is fully revealed by trading, and so the information trade motive is dominant. In fact, the ability to convey information implies that the condition of the existence of a separating equilibrium becomes the same as with complete information. In the pooling equilibrium, on the other hand, the information trade motive is absent, since trade does not provide any information. As a consequence, this equilibrium's region of existence is smaller than that of the separating equilibrium.

The different regions of existence of the two types of equilibrium have important implications for welfare and the optimality of an FTT. By increasing the FTT τ enough one can impact the market to the point where only a separating equilibrium exists, with all the associated welfare implications. In the next section we analyse the welfare consequences of adopting such a "tilting FTT".[20]

5 Welfare effects of FTT

First of all we compare welfare between of pooling equilibrium and separating equilibrium. Secondly, we investigate the effects and potential optimality of an FTT. The welfare comparison focuses on the two relevant cases. First, we provide a comparison between the Pareto optimal separating and pooling equilibria. This is the most natural comparison since it gives both equilibria a "fair" chance. Second, we compare the separating equilibrium with the lowest welfare, to the pooling equilibrium with the largest welfare. That is, even when the FTT has the worst possible chance to improve welfare, we demonstrate that there is still scope for an optimal FTT.

To obtain explicit and more transparent expressions for welfare comparisons, we specify the firm's profit value function as follows,

$$F_\omega = V_\omega + v, \qquad \bar{F}_\omega = V_\omega, \qquad F_\omega^{-\omega} = V_\omega - v, \tag{23}$$

[20] Separating and pooling equilibria also coexist with no information value, i.e. $F_\omega = \bar{F}_\omega = F_\omega^{-\omega}$. However, Section 5 shows that the trade-off between informativeness and liquidity vanishes in this case.

where $V_H > V_L > 0$.[21] When $v > 0$ condition (1) holds with strict inequality, and therefore the value of information, given in condition (2), is equal to v. Indeed, we have,

$$\beta F_H + (1-\beta)F_L - [\beta \bar{F}_H + (1-\beta)\bar{F}_L] = v,$$

In this case the firm's loss in value in state ω when investing as if the state were $-\omega$ becomes $F_\omega - F_\omega^{-\omega} = 2v$. The firm-value function adopted, together with condition (3), imply that $V_H - V_L > 2v$ and $V_L > v$.

5.1 Information vs. liquidity

The separating equilibrium guarantees the revelation of information, more efficient investment and the higher value of the firm. However, it may come with reduced market liquidity, $T_L < 1$, which is necessary to guarantee incentive compatibility. The pooling equilibrium, on the other hand, can guarantee the maximal level of trade and liquidity, at the cost of leaving the economy with limited information and inefficient investment.

Let us first consider the separating equilibrium. Substituting the equilibrium and efficient level of trade in the H-state, $T_H = 1$, and for a given level of trade in the L-state, $T_L < 1$, welfare in the separating equilibrium can be written as,

$$W_S = W^* - (1-\beta)(\delta_I - \delta_U)(1-T_L)F_L, \tag{24}$$

where W^* is the welfare of the first-best equilibrium with full information. In the H-state, the level of trade is efficient and the firm changes hands entirely having a value of $\delta_I F_H$ to the informed trader. The welfare loss in the separating equilibrium stems from the inefficient

[21] This specification is qualitatively equivalent to more articulate models in which the value of the firm is proportional to the level of investment k and the realization of the state, combined with a convex cost of investment. For example, $F = kV - ck^2/2$. We consider this firm-value function in a previous version of the paper, and obtain qualitatively identical results.

level of trade in the L-state. Proposition 2 establishes that trade is inefficiently low, as only a fraction $T_L < 1$ of the company is traded. This incomplete change in ownership is inefficient, as uninformed traders cannot satisfy their liquidity needs. Thus welfare is decreasing in the amount of trade, T_L, the difference in liquidity needs, $\delta_I - \delta_U$ and the probability of the L-state occurring.

As per Proposition 2, both the Pareto optimal level of trade, $\bar{T}_L$, and the smallest admissible trade in the L-state, $\underline{T}_L$, decrease in the FTT. Therefore, welfare in the separating equilibrium, W_S, decreases in the FTT.

In a pooling equilibrium with Pareto optimal trade, uninformed traders sell all of their shares to the informed trader. Thus in a pooling equilibrium, welfare is the expected discounted value of the firm from the informed trader's perspective. However, regardless of the nature of ω , the uninformed manager invests inefficiently and the real value of the asset is reduced to $\bar{F}_\omega$ instead of being the efficient value F_ω. In this case, welfare W_P does not depend on the FTT τ. Welfare in the pooling equilibrium yields,

$$W_P = W^* - \delta_I(\beta(F_H - \bar{F}_H) + (1-\beta)(F_L - \bar{F}_L)) = W^* - \delta_I v \tag{25}$$

where the loss compared to the first best, is the reduced value of the firm as perceived by its final owner, the informed trader.

There are multiple equilibria within each type of equilibrium with different levels of trade. First of all, we compare the Pareto optimal separating ($T_L = \bar{T}_L$) and pooling ($T_P = 1$) equilibrium. We then compare the Pareto optimal pooling equilibrium ($T_P = 1$) with the separating equilibrium characterized by the smallest admissible level of trade ($T_L = \underline{T}_L$), which in turn delivers the lowest level of welfare attainable in a separating equilibrium. This last case is useful since it provides a robust comparison between the separating and pooling equilibria, considering the worst case scenario for the separating equilibrium.

Comparing the level of welfare in the separating and pooling equilibria, the main trade-off is apparent by eyeballing the expressions (24) and (25). Price informativeness guarantees efficient investment in the separating equilibrium, thus yielding greater values of the firm compared to the firm values in the pooling equilibrium $F_\omega > \bar{F}_\omega$. In contrast, due to reduced market liquidity in the separating equilibrium, liquidity-constrained uninformed traders cannot sell all of the assets like they can in the pooling equilibrium $T_L < T_P = 1$. The difference in welfare levels between the two types of equilibrium is as follows,

$$\Delta W = W_S - W_P = \delta_I v - (\delta_I - \delta_U)(1-\beta)F_L(1-T_L). \tag{26}$$

The next proposition, which considers the situation in which there is no FTT, establishes the welfare comparison by focusing on the two key factors, namely the value of information and the different liquidity needs. Let us call the value of information at which welfare levels in separating and pooling equilibria are identical $\bar{v}$. At the threshold $\bar{v}$, the value of information in the separating equilibrium equals the value from liquidity-motivated trades in the pooling equilibrium. The value of information clearly differs in the two scenarios, i.e. the one in which we compare the two Pareto optimal equilibria ($\bar{v} = v_0$), and the one in which we compare the Pareto optimal pooling equilibrium with the least-trade separating equilibrium ($\bar{v} = v_1$). Therefore, the cut-off value can take two values $\bar{v} \in \{v_0, v_1\}$.

Proposition 5. *(Welfare comparison.) Let us assume that there is no FTT, $\tau = 0$, and that both pooling and separating equilibria exist. A value of information $v = \bar{v} \geq 0$ exists for which $\Delta W = 0$ and:*

(i) if the value of information is low, $v \leq \bar{v}$, then the pooling equilibrium is socially optimal, $W_P \geq W_S$;

(ii) if information is sufficiently valuable, $v > \bar{v}$, then the separating equilibrium is socially optimal, $W_S > W_P$.

Proposition 5 states the central trade-off. Information revelation through asset trade improves real investment, but requires a smaller expected level of trade reducing market liquidity.

In (i), when the value of information is small, information revelation is less important and the benefit of market liquidity in the pooling equilibrium outweighs the benefit of efficient real investment in the separating equilibrium. On the contrary, in (ii), the value of information revelation in the separating equilibrium is sufficiently large that its benefit outweighs the market liquidity in the pooling equilibrium. Note that case (i) also accounts for the situation in which information has no value, $v = 0$, and in this case the welfare comparison always favours the liquid pooling equilibrium.

Before deriving the optimal FTT, we summarize the effects of an FTT from Propositions 4 and 5.

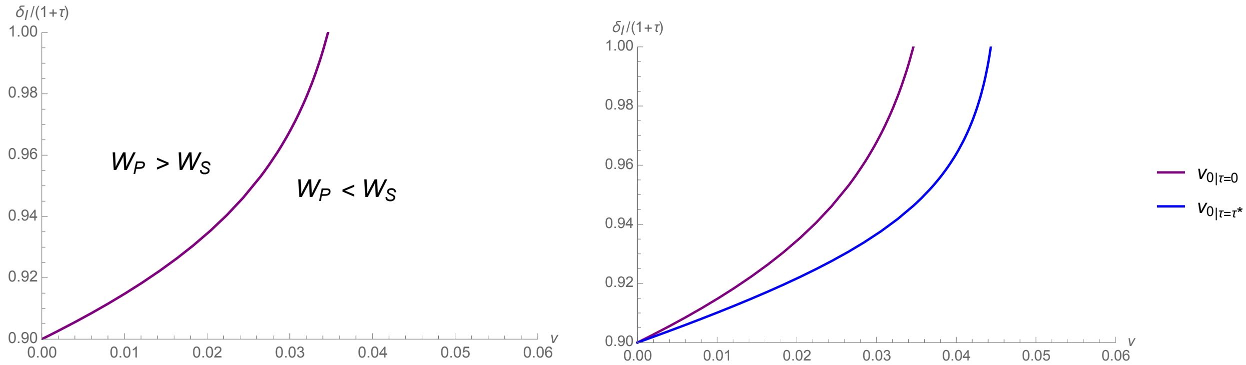
Corollary 1. *(Effects of an FTT on equilibria.) The FTT:*

(i) only reduces the level of trade in the L-state of the separating equilibrium if $T_L \in \{\underline{T}_L, \bar{T}_L\}$*;*

(ii) affects the existence of the pooling equilibrium, making it impossible to exist for a sufficiently high FTT.

Point (i) implies that the introduction of, or increase in, the FTT reduces welfare in the separating equilibrium while leaving welfare in the pooling equilibrium unaffected. Point (ii) implies that it is always possible to guarantee the existence of the separating equilibrium by setting a low FTT, e.g. $\tau = 0$, as long as the liquidity ratio is larger than one, i.e. trading takes place. On the other hand, it is possible to rule out a pooling equilibrium by setting a sufficiently high FTT that the adjusted liquidity ratio $\delta_U/(\delta_I(1+\tau))$ falls below the information gap $\bar{F}/\bar{F}_L$. Note that Corollary 1 also carries over when information has no value.

Corollary 1 delivers an important result for policy makers. The FTT is useful to tilt the equilibrium in the economy. We exploit this possibility in the next section, where we consider an FTT that makes certain types of equilibrium impossible. On the other hand, we disregard the case where the FTT shifts the market away from a given equilibrium either towards another of the same type or to a different type of equilibrium, when the original equilibrium remains feasible. The latter case would provide rather weak support for policy.



(a) Welfare trade-off

(b) Welfare shift

Figure 2: Welfare comparison

Figure 2 illustrates Proposition 5 and Corollary 1 (i). That is, the trade-off between the value of information v, on the horizontal axis, and the difference in liquidity needs $\frac{\delta_I}{\delta_U(1+\tau)}$, on the vertical axis in Figure 2a and the welfare effect of an FTT in Figure 2b. On the vertical axis we fix $\delta_U = 0.9$ and let $\frac{\delta_I}{(1+\tau)}$ vary. The curves represent the value of information, v_0, at which welfare is identical in both pooling and separating equilibria, i.e. the trade-off between the value of information and the value of liquidity trades is balanced. In Figure 2a, on the left-hand side of the curve, trade motivated by liquidity needs outweighs the value of information, while the opposite holdson the right-hand side of the curve. In Figure 2b, when introducing the FTT, ex-ante welfare in the separating equilibrium decreases as trade in the L-state is reduced. The decrease in welfare implies a shift to the right of the v_0-curve. For a given liquidity difference, the value of information has to be larger with an FTT than without one in order that the separating equilibrium yield a greater level of welfare than the pooling equilibrium.

5.2 The Optimal FTT

We first consider an economy where no FTT is levied. We address the following question: does the introduction of an FTT improve welfare? The next proposition provides a qualified positive answer to that question.

From expression (26) we derive the tax, $\bar{\tau}$ for which welfare in pooling and separating equilibria is identical, $\Delta W = 0$. This tax differs for the two scenarios, i.e. the one in which we compare Pareto optimal equilibria ($\bar{\tau} = \tau_0$) and the one in which we compare Pareto optimal pooling equilibrium with least-trade separating equilibrium ($\bar{\tau} = \tau_1$).

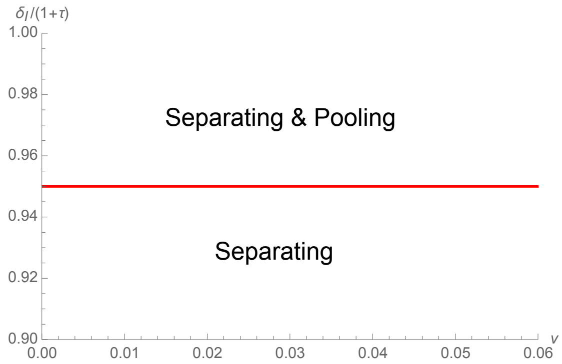
Proposition 6. *(Efficient FTT.) Consider an economy with no FTT, $\tau = 0$ in a pooling equilibrium. A strictly positive FTT $\tau^* = \frac{\delta_I}{\delta_U}\frac{\bar{F}_L}{\bar{F}} - 1$ is optimal if the value of information is sufficiently high, i.e. when $v > \bar{v}$ and $\tau^* \leq \bar{\tau}$.*

The reasoning behind this result relies on Corollary 1. If the market is in a pooling equilibrium, it is possible to tilt it to a separating equilibrium by adopting a sufficiently large FTT. This policy is beneficial if welfare is higher in the separating equilibrium than in the pooling equilibrium, and in particular if the value of information outweighs the value of liquidity trades, i.e. $v > \bar{v}$ as in Proposition 5 (ii). Focusing on the Pareto optimal pooling equilibrium, welfare does not depend on the FTT, whereas in the separating equilibrium it decreases in the FTT. Hence, for a positive FTT to be optimal, it must be equal to the minimum FTT capable of shifting the economy from a pooling equilibrium to a separating equilibrium, that is τ^*.[22] Indeed, for the FTT to be optimal, sufficiently valuable information, $v > \bar{v}$, is only a necessary condition, since welfare in the separating equilibrium decreases in the FTT. Therefore, the sufficient condition for an optimal FTT is given by $\tau^* \leq \bar{\tau}$.

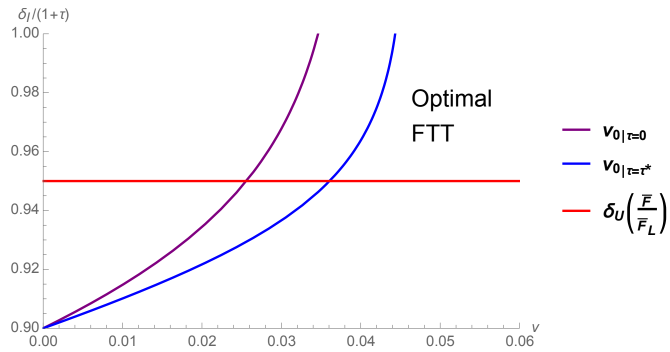
Figure 3 illustrates the idea behind the proof of Proposition 6. Figure 3a recalls the conditions for the existence of separating and pooling equilibria from Proposition 4. For small liquidity differences, there is only a separating equilibrium, whereas for large liquidity differences both a pooling and a separating equilibrium exist. Figure 3b shows that there is scope for an optimal FTT if the parameters are such that the economy is above the horizontal line, the prevailing equilibrium is pooling and the value of information exceeds $v_{0|\tau=\tau^*}$.

Two further observations are in order here. First, since any tax in the range $[\tau^*, \bar{\tau})$ strictly improves welfare, the introduction of an FTT can increase welfare even if it produces other negative economic effects that are not modelled here. In other terms, the condition for an

[22] We consider the case in which the optimal FTT is a tax, $\tau^* > 0$, and not a subsidy, otherwise traders could agree to buy and sell assets simply to obtain the subsidy. This would become a serious concern were policy makers not to perfectly observe liquidity needs.



(a) Existence



(b) Welfare and existence

Figure 3: The optimal FTT

optimal FTT is neither tight nor knife-edge. Secondly, an optimal policy may also consider the introduction of a *temporary* FTT. This would allow the economy to move away from a pooling equilibrium, and a subsequent, gradual reduction of the tax may reduce on the degree to which it distorts liquidity, and thus may keep the economy in the informative separating equilibrium.

The next results show, on the other hand, when an FTT should not be used.

Proposition 7. *(Inefficient FTT.) The optimal FTT is nil if:*

(i) only the separating equilibrium exists, absent an FTT,

(ii) both pooling and separating equilibria co-exist, but the pooling equilibrium's level of welfare is greater than that of the separating equilibrium, i.e. when $v < \bar{v}$.

If the market is already in a separating equilibrium, then the optimal FTT is $\tau = 0$. The reason for this is that even if welfare is greater in the pooling equilibrium, varying the FTT cannot shift the market towards a pooling equilibrium as shown in Corollary 1. The optimal FTT is also nil when the pooling equilibrium is associated to a higher level of welfare, for example when the value of information is low or nil, as discussed in Proposition 6.

We summarize the content of Propositions 6 and 7 in the following Corollary.

Corollary 2. *An FTT is optimal if, and only if:*

(i) welfare is higher in the separating equilibrium than in the pooling equilibrium, and

(ii) the FTT enables the economy to be tilted from a pooling equilibrium to a separating equilibrium.

Corollary 2 informs about the possibility of using an FTT as a policy tool. Firstly, if a policy maker decides to use an FTT, the implications that the FTT has for market informativeness and liquidity must be taken into account. If the market is informative but illiquid, then an FTT can only reduce welfare levels. Vice-versa, when the market is liquid but uninformative, a desirable FTT can be conceived. The design of the tax constitutes a trade-off between the gain from tilting the market towards an informative equilibrium, and the cost of reduced liquidity. If there is a significant gain to be had from revealing information, even at the cost of reduced liquidity, then introducing a tax is desirable. If, on the other hand, the liquidity motive prevails, the FTT should be nil in order to offer the greatest possible opportunity for the pooling equilibrium to exist. Another important point here is that if the value of information is nil, then the case for an FTT is rather weak, as one should hope that the economy be in the Pareto optimal pooling equilibrium.

Secondly, even though a positive, welfare-increasing FTT may exist, policy makers should carefully design and apply it in the right conditions. From a practical perspective, policy makers may consider the following steps. Observing a large amount of trade with little price variation, an FTT may be introduced with an iterative process, starting from a very small FTT and then increasing it gradually if liquidity and price variation have not changed, that is, if the economy is still in a pooling equilibrium. At some point, the level of trade falls, and furthermore, the price variation increases as the economy tilts to a separating equilibrium. The corresponding FTT is then the optimal one. At that point, the tax could be phased out as long as the economy remains in the desirable informative equilibrium.

Thirdly, Propositions 6 and 7 also inform policy makers as to which asset classes should be subject to the tax. The FTT should target those classes characterized by low price volatility and high volumes of trade.

6 Extensions

In this section we consider some extensions of the model to show that the results obtained in the main analysis carry over into other contexts. In particular, in turn we consider different liquidity needs, different tax regimes and a different distribution of the initial endowment. The irrelevance results we obtain highlight that regardless of liquidity needs, the tax regime or the initial wealth allocation, the optimal FTT renders financial market prices more informative, and thus results in a more efficient allocation of resources.

6.1 Short Selling

The informed trader is more liquidity-constrained than uninformed traders are when the adjusted liquidity ratio is smaller than one, $\frac{\delta_I}{\delta_U(1+\tau)} < 1$. The informed trader wants to trade on the basis of her information, and at the same time needs liquidity. That trader can therefore short-sell the assets in the initial period, thus obtaining immediate liquidity, and then buy them back in the final period. When short selling takes place, we obtain qualitatively the same results as in the previous section. We provide a short discussion here, and refer to Appendix B.3 for the formal analysis.

As when the informed trader buys from uninformed traders, there is a pooling equilibrium in which the market is liquid, and thus the more liquidity-constrained informed trader can entirely satisfy her liquidity needs. There also exists a separating equilibrium in which asset prices are informative, so that the firm's value is maximized but trade is inefficiently low. Pooling and separating equilibria co-exist for a large difference in tax-adjusted liquidity needs, i.e., when the informed trader is considerably more liquidity-constrained than uninformed traders are. A separating equilibrium also exists for small differences in liquidity needs. The intuition whereby a pooling equilibrium only exists for a large adjusted liquidity ratio, while a separating equilibrium also exists for a small ratio, is the same as the one seen in the case examined in the previous sections. Since there is only one price in the pooling equilibrium, the informed trader in the H-state, all else being equal, sells the asset at a price below its fundamental value, and therefore requires higher gains from liquidity trade. On the other hand, in a separating equilibrium the informed trader short sells the asset at its fundamental value.

Welfare in the separating equilibrium decreases in the FTT since it reduces the amount traded in the H-state. Comparing welfare in the separating and pooling equilibria when the value of information is considerable, an optimal FTT exists which tilts the market from a pooling to a separating equilibrium. If the market is in a separating equilibrium, or if it is in a pooling equilibrium and the value of information is low, then the optimal FTT is nil.

6.2 Different tax regimes

It is irrelevant which agent pays the FTT. Regardless of whether the FTT is levied on the informed trader, uninformed traders or both, welfare remains unaffected. We defer the formal derivations to Appendix B.4, while providing the intuition of the result here. Call τ_B the FTT paid by the buyer, the informed trader, and τ_S the FTT paid by the sellers, the uninformed traders. To illustrate the result we consider the model in which the informed trader is less liquidity-constrained than are uninformed traders, $\delta_I > \delta_U$. The irrelevance result can be understood from the following two observations.

Firstly, in an economy with risk neutral, competitive uninformed traders, regardless of the tax incidence, the burden of the tax is borne by the informed trader. Consider the price in the pooling equilibrium,

$$P_P = \frac{\delta_U}{1-\tau_S}\bar{F},$$

which requires the informed trader to compensate uninformed traders for the FTT τ_S. The informed trader is only willing to purchase the asset if the participation constraint is satisfied, and this now corresponds to,

$$\frac{\delta_I(1-\tau_S)}{\delta_U(1+\tau_B)} \geq \frac{\bar{F}}{\bar{F}_L}. \tag{27}$$

This expression resembles the characterization of the pooling equilibrium in condition (22), except that the tax paid by uninformed traders modifies the adjusted liquidity-ratio on the left-hand side.[23]

As with Proposition 3 and Corollary 1, the FTTs only affect the pooling equilibrium through its existence condition. The separating equilibrium, however, is affected by the FTTs both through the existence condition and by reducing the level of trade in the L-state, T_L, and hence the expected welfare level. Consequently, the optimal FTT, regardless of whom it is levied on, is given by condition (27). The idea of the optimal FTTs is exactly the same as in Proposition 6.

Secondly, recall that the level of trade in the L-state is derived from the incentive compatibility constraint in the H-state, and ensures that the informed trader does not want to mimic the informed trader in the L-state and to pay a lower price

$$-(1+\tau_B)P_H T_H + \delta_I T_H F_H \geq -(1+\tau_B)P_L T_L + \delta_I T_L F_H^L,$$

where $P_\omega = \frac{\delta_U}{1-\tau_S} F_\omega$. We obtain

$$T_L = \frac{((1-\tau_S)\delta_I - (1+\tau_B)\delta_U)F_H}{(1-\tau_S)\delta_I F_H^L - (1+\tau_B)\delta_U F_L}. \tag{28}$$

By deriving the optimal FTT from condition (27), regardless of whether the tax is levied solely on the informed trader, $\tau_S = 0$, on uninformed traders, $\tau_B = 0$ or on both, $\tau_S = \tau_B$, the level of trade in expression (28) remains unaffected. Since the informed trader bears the cost of the tax no matter the tax incidence, only the FTT total cost to trading matters, and this is established by condition (27). Welfare in the separating equilibrium is therefore independent of the tax system producing the irrelevance result.

[23] As this condition is central to the main result, we shall reiterate here its underlying rationale. It ensures that the informed trader in the L-state is willing to buy at the same price as the informed trader in the H-state. More specifically, it requires the gains from the liquidity trade to be sufficiently large.

6.3 Alternative endowment allocation

In the main analysis, we have assumed that uninformed traders possess the initial endowment. Here, we analyse the alternative scenario in which the informed trader owns the initial endowment. We focus on the case where uninformed traders are more liquidity-constrained than the informed trader, such that $T > 0$. This implies that uninformed traders are short selling the asset. As with the short selling case discussed in Section 6.1, we assume that the borrowing costs of the asset are equal to zero. We provide a brief discussion here and defer the formal analysis to Appendix B.5.

The trade motives remain unchanged. The informed trader attempts to benefit from superior information, and there are gains to be made from trade between uninformed and informed traders due to their different liquidity needs. As in the case in which uninformed traders possess the initial endowment, there exist both an informative but illiquid separating equilibrium, and also an uninformative but liquid pooling equilibrium. When separating and pooling equilibria co-exist, an optimal FTT exists which can improve welfare by tilting the economy from an uninformative but liquid pooling equilibrium, to an informative but illiquid separating equilibrium. Hence the result presented in Proposition 6 also applies to the case in which the informed trader possesses the initial endowment.

7 Conclusion

This paper contributes to the long standing debate about the adoption of a Financial Transaction Tax. The proponents of an FTT typically emphasise the role of prices in efficiently allocating resources in the economy. When there is excessive trade which is not related to fundamentals, prices become distorted and do not fulfill the aforementioned role. The FTT is thus intended to curb non-fundamental trade and thereby improve the economy's resource allocation. The opponents of an FTT are concerned that curbing non-fundamental trade may impair financial markets' role in risk sharing and in providing short-term liquidity. We conceive a model comprising both of the roles of financial markets, that is, resource allocation and market liquidity. We show that multiple equilibria exist which feature the two roles to different extents. By establishing a welfare ranking depending on the relative value of the two roles, we are able to establish the conditions under which an optimal FTT tilts the economy to the efficient and informative equilibrium. Our results can guide policy makers as to which markets should be subject to an FTT, and they help explain the rather puzzling empirical evidence concerning the introduction of FTTs in France and Sweden.

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A Proofs

Proof of Proposition 2. Assume that $\delta_I \geq (1+\tau)\delta_U$.

Consider first the informed trader in the L-state. Deviating and proposing a level of trade as the informed trader in the H-state, she would induce a price change from P_L to a higher price P_H. From incentive compatibility constraint (16), the informed trader in the L-state does not mimic the informed trader in the H-state if,

$$T_L \geq \frac{\delta_I F_L^H - (1+\tau)\delta_U F_H}{(\delta_I - (1+\tau)\delta_U)F_L} T_H. \tag{29}$$

This provides a lower bound on the amount of trade T_L.

The informed trader in the H-state may want to mimic the informed trader in the L-state to purchase assets at a lower price $P_L < P_H$. But if the amount of trade of the informed trader in the L-state, T_L, is sufficiently low, the informed trader in the H-state prefers the larger amount of trade, T_H even at a higher price P_H. From condition (16), we obtain that incentive compatibility for the informed trader in the H-state as an upper bound on T_L,

$$\frac{(\delta_I - (1+\tau)\delta_U)F_H}{\delta_I F_H^L - (1+\tau)\delta_U F_L} T_H \geq T_L. \tag{30}$$

In fact, the ratio on the left hand side (L.H.S.) in (30) is positive which follows from $\delta_I - (1+\tau)\delta_U \geq 0$ and $\delta_I F_H^L - (1+\tau)\delta_U F_L > 0$, which follows from $F_H^L > F_L$.

Besides choosing T_ω, the informed trader with private information ω can choose any other quantity T' in addition to $T_{-\omega}$. In order to ensure optimality of T_ω towards these deviations, consider the following incentive compatibility constraints in either state ω, or any T' different from T_L and T_H:

$$(\delta_I - (1+\tau)\delta_U)T_\omega F_\omega \geq (\delta_I F_\omega^H - (1+\tau)\delta_U F_H)T' \tag{31}$$

where we used that, as specified by the off-equilibrium belief in equation (11), uninformed traders believe that they are facing an informed trader in state H after observing T' and thus request a price P_H. The firm manager too believes to observe trade by the informed trader in state H and invests accordingly. If the true state is $\omega = H$, ex-post firm value is $F_H^H = F_H$ and if $\omega = L$, the firm value is F_L^H. Then for the informed trader in state H, condition (31) simplifies to $T_H \geq T'$ for any $T' > 0$. This condition is satisfied if and only if $T_H = 1$. In other terms, the only incentive compatible level of trade in state H is maximal, i.e. $T_H = 1$.

For the informed trader in state L, condition (31) is identical to condition (16). Note that if $\frac{\delta_I}{(1+\tau)\delta_U} < \frac{F_H}{F_L^H}$, the R.H.S. of (31) for the informed trader in state L is negative and hence always satisfied. If on the contrary, $\frac{\delta_I}{(1+\tau)\delta_U} > \frac{F_H}{F_L^H}$, the R.H.S. increases in T'. The largest possible profit off equilibrium is hence obtained if $T' = 1$. In which case condition (31) is indeed identical to (29) for $T' = T_H = 1$.

We now have to determine the level of trade for the informed trader in state L, T_L. For what stated above, all the incentive compatibility constraints are satisfied by the following:

$$\frac{(\delta_I - (1+\tau)\delta_U)F_H}{\delta_I F_H^L - (1+\tau)\delta_U F_L} \geq T_L \geq \frac{\delta_I F_L^H - (1+\tau)\delta_U F_H}{(\delta_I - (1+\tau)\delta_U)F_L} \tag{32}$$

where the largest amount of trade possible for the informed trader in state L is given by the upper bound from condition (30). Since the upper bound on T_L is always larger than the lower bound on T_L, there exists a non empty range for T_L that satisfies the two incentive compatibility constraints.

Consider first the upper bound

$$\bar{T}_L := \frac{(\delta_I - (1+\tau)\delta_U)F_H}{\delta_I F_H^L - (1+\tau)\delta_U F_L}.$$

This level of trade is strictly smaller than one if (17) is satisfied, as in the text of the proposition. If this condition is instead reversed, then T_L can be arbitrarily close to one and the informed trader would not prefer to mimic, which corresponds to the "no envy case". Also, the denominator in T_L must be positive (because the numerator is positive), and this is the case if,

$$\frac{\delta_I}{(1+\tau)\delta_U} > \frac{F_L}{F_H^L}$$

which is implied by our condition $\delta_I \geq (1+\tau)\delta_U$ since $F_L < F_H^L$.

Moreover, we next show that $\bar{T}_L$ is decreasing in τ:

$$\frac{\partial \bar{T}_L}{\partial \tau} = \frac{\delta_I \delta_U F_H (F_L - F_H^L)}{(\delta_I F_H^L - \delta_U F_L(1+\tau))^2} < 0$$

by assumption (3).[24]

Consider now the lower bound in (32):

$$\underline{T}_L := \frac{\delta_I F_L^H - (1+\tau)\delta_U F_H}{(\delta_I - (1+\tau)\delta_U) F_L}.$$

This is always smaller than one. It is positive if,

$$\frac{\delta_I}{(1+\tau)\delta_U} \geq \frac{F_H}{F_L^H}$$

so that if this condition is not verified the actual lower bound in (32) is zero. We also have :

$$\frac{\partial \underline{T}_L}{\partial \tau} = \frac{\delta_I \delta_U (F_L^H - F_H)}{F_L(\delta_I - \delta_U(1+\tau))^2} < 0$$

since $F_H > F_L^H$.

Now consider the participation constraints. For an informed trader in state ω it is equivalent to,

$$\frac{\delta_I}{(1+\tau)\delta_U} \geq 1$$

which is implied by our condition $\delta_I \geq (1+\tau)\delta_U$.

We conclude by observing that what we have shown above implies that the level of trade in state L, that must belong to the set $[\underline{T}_L, \bar{T}_L]$, is weakly decreasing in τ. In fact, we have seen that both boundaries are decreasing in τ and the lower bound becomes nil for large enough τ. **End of proof.**

Proof of Proposition 3.

Consider the participation constraints of the informed trader. Since $\bar{F}_L < \bar{F}_H$, the left hand side of inequality (20) is smaller if $\omega = L$ than if $\omega = H$ and the participation constraint (20)

[24]If it was $F_L > F_H^L$, then (17) would imply that $\bar{T}_L$ is already at its extremal level $\bar{T}_L = 1$ even if $\tau = 0$ and thus it would so for any $\tau > 0$. In this case the comparison with the pooling equilibrium would be trivial.

for the informed trader in state H is irrelevant. Substituting the equilibrium price P_P, the participation constraint for the informed trader in state L can only be satisfied with a positive level of trade if

$$\frac{\delta_I}{\delta_U(1+\tau)} \geq \frac{\bar{F}}{\bar{F}_L}. \tag{33}$$

The informed trader needs to be considerably less liquidity constrained than uninformed traders since $\frac{\bar{F}}{\bar{F}_L} > 1$. Observe that $\frac{\bar{F}}{\bar{F}_L}$ increases in β. That is the more likely the H-state, the larger needs to be the difference between the informed trader's liquidity constraints and uninformed traders' liquidity constraint. The mechanism behind the previous condition is driven by the prospect of the informed trader in state L, i.e. $\delta_I \bar{F}_L$. Given the L-state of the firm, the informed trader does not want to buy the asset since, for a given δ_U, the pooling equilibrium price $P = \delta_U \bar{F}$ is high relative to the prospect and it increases the larger the probability of the H-state. The informed trader in state L is hence only willing to buy if uninformed traders are sufficiently liquidity constrained, i.e. δ_U is small relative to δ_I.

We now need to pin down the traded quantity T_P which is determined by the informed trader's incentive compatibility constraint. As shown in section 4.2 this can be rewritten as,

$$T_P \geq \frac{(\delta_I F_\omega^H - (1+\tau)\delta_U F_H)}{(\delta_I \bar{F}_\omega - (1+\tau)\delta_U \bar{F})} T'.$$

Since T' can be any value in $[0,1)$, to satisfy the previous condition with maximal trade $T_P = 1$, it must be that,

$$\frac{(\delta_I F_\omega^H - (1+\tau)\delta_U F_H)}{(\delta_I \bar{F}_\omega - (1+\tau)\delta_U \bar{F})} \leq 1$$

that is,

$$\delta_I(F_\omega^H - \bar{F}_\omega) \leq (1+\tau)\delta_U(F_H - \bar{F}).$$

Note that the latter condition for state L is implied by that for state H. Hence, considering that for state H delivers the following existence condition $\frac{F_H - \bar{F}}{F_H - \bar{F}_H} \geq \frac{\delta_I}{(1+\tau)\delta_U}$ and there exists a pooling equilibrium with maximal trade if and only if (20) is satisfied.

Finally, for pooling equilibria with lower level of trade, i.e. $T_P < 1$, the set of admissible levels of trade is:

$$1 \geq T_P \geq \underline{T}_P := \frac{(\delta_I - (1+\tau)\delta_U)F_H}{\delta_I \bar{F}_H - (1+\tau)\delta_U \bar{F}},$$

where the lower bound $\underline{T}_P$ is decreasing in τ.

End of proof.

Proof of Proposition 5. The proof of the first part of the proposition is in two steps.

Step 1 We show that when equilibria co-exist, that is $\frac{F_H - \bar{F}}{F_H - \bar{F}_H} \geq \frac{\delta_I}{\delta_U} \geq \frac{\bar{F}}{\bar{F}_L}$, then

$$\frac{\partial \Delta W}{\partial v} = \delta_I - (1-\beta)(\delta_I - \delta_U)\frac{\partial((1-T_L)F_L)}{\partial v} > 0.$$

Note that $\frac{\partial((1-T_L)F_L)}{\partial v} < 0$ for all $\frac{F_H - \bar{F}}{F_H - \bar{F}_H} \geq \frac{\delta_I}{\delta_U} \geq \frac{\bar{F}}{\bar{F}_L}$ if $\beta > \frac{(V_H - V_L - 2v)^2 V_L}{2(V_H V_L + 2vV_H - v^2)(V_H - V_L)}$. It is straightforward to show that there exists a non-empty range for β since $1 > \frac{(V_H - V_L - 2v)^2 V_L}{2(V_H V_L + 2vV_H - v^2)(V_H - V_L)}$ for $V_H > V_L > v > 0$ and $V_H - V_L > 2v$ as required by the assumption in condition (3).

Step 2 Consider the welfare difference with $\tau = 0$

$$\begin{aligned}\Delta W =& W_S - W_P = \delta_I v - (1-\beta)(\delta_I - \delta_U)(1-T_L)F_L, \\ =& \delta_I v + \frac{(1-\beta)(\delta_I - \delta_U)(V_L + v)(2\delta_I v - \delta_U(V_H - V_L))}{\delta_I(V_H - v) - \delta_U(V_L + v)}.\end{aligned}$$

Recall that for existence and multiplicity we require $0 \leq v \leq a$ where $a \equiv min\{\beta(V_H - V_L), \frac{V_H - V_L}{2}, \frac{1-\beta}{\beta}V_L\}$. With (i) $\frac{\partial \Delta W}{\partial v} > 0$, (ii) $\Delta W|_{v=0} < 0$ and (iii) $\Delta W|_{v=a} > 0$, there exists a cutoff value $0 \leq v_0 \leq a$ beyond (below) which the separating (pooling) equilibrium yields larger welfare than the pooling (separating) equilibrium.

The second part of the proposition is derived as follows. Consider again the welfare difference

$$\Delta W = W_S - W_P = \delta_I v - (1-\beta)(\delta_I - \delta_U)(1-T_L)F_L.$$

This condition is positive if

$$T_L \geq 1 - \frac{\delta_I v}{(1-\beta)(\delta_I - \delta_U)(V_L + v)}.$$

Note that $\underline{T}_L \geq 1 - \frac{\delta_I v}{(1-\beta)(\delta_I-\delta_U)(V_L+v)}$ if $v \geq v_1 = \frac{(1-\beta)\delta_U(V_H - V_L)}{\delta_I(-1+2\beta)}$. Note, $v_1 > 0$ if $\beta > 1/2$.

End of proof.

Proof of Corollary 1. (i) From the proof of Proposition 3 we have that increasing τ enough makes the pooling equilibrium impossible, independently of the level of trade T_P. In fact, the existence condition (33) does not depend on T_P.

From the proof of Proposition 2, instead, we have that, for any T_L, increasing τ reduces the upper-bound $\bar{T}_L$ (and the lower bound $\underline{T}_L$). However, as we have shown in that proof, $\bar{T}_L$ is positive as long as there is room for trade, i.e.

$$\frac{\delta_I}{(1+\tau)\delta_U} \geq 1$$

which is always satisfied by assumption. Hence, whatever the level of trade T_L, and τ, a separating equilibrium always exists.

(ii) Take any pooling equilibrium with some level of trade $T_P \in [\underline{T}_P, 1]$. Then increasing τ only reduces $\underline{T}_P$, thus leaving the equilibrium level of trade T_P unaffected. Consider now any separating equilibrium. We know that it must contemplate $T_H = 1$ and some $T_L \in [\underline{T}_L, \bar{T}_L]$, where both these boundaries are decreasing in τ. Hence, if $T_L \in [\underline{T}_L, \bar{T}_L)$ nothing changes in the equilibrium level of trade when τ increases. Instead, in the Pareto dominant equilibrium, $T_L = \bar{T}_L$, the level of trade reduces when τ increases.

End of proof.

Proof of Proposition 6.

To derive the optimal FTT, we consider $\frac{\bar{F}}{\bar{F}_L} \leq \frac{\delta_I}{\delta_U(1+\tau)} \leq min\{\frac{F_H - \bar{F}}{F_H - \bar{F}_H}, \frac{F_H - F_L}{F_H - F_H^L}\}$. For liquidity ratios outside this range the optimal FTT is always nil since only a separating equilibrium exists. Observe that,

$$\frac{\partial W_S}{\partial \tau} = \frac{\partial W_S}{\partial T_L}\frac{\partial T_L}{\partial \tau} = (1-\beta)(\delta_I - \delta_U)F_L\frac{\partial T_L(\tau)}{\partial \tau}$$

and we know that

$$\frac{\partial T_L}{\partial \tau} = \frac{\delta_I \delta_U F_H (F_L - F_H^L)}{(\delta_I F_H^L - \delta_U F_L(1+\tau))^2} < 0.$$

since $F_L < F_H^L$.

Given the equilibrium levels of trade $T_P = T_H = 1$ and T_L, welfare in the separating equilibrium is larger than in the pooling equilibrium if

$$\Delta W = W_S - W_P = \delta_I(\beta(F_H - \bar{F}_H) + (1-\beta)(F_L - \bar{F}_L)) - (1-\beta)(\delta_I - \delta_U)(1-T_L)F_L > 0. \quad (34)$$

Since W_S is decreasing in τ, expression (34) is decreasing in τ, implying that the difference between welfare in the separating equilibrium and welfare in the pooling equilibrium is maximal if $\tau = 0$.

Pareto optimal pooling and separating equilibrium. We start with the welfare comparison when the levels of trade are $T_H = T_P = 1$ and $T_L = \bar{T}_L$.

As a preparatory step to obtain the optimal FTT, we define the FTT τ_0 for which there is no difference in welfare between the separating equilibrium and the pooling equilibrium, $\Delta W = 0$

$$\tau_0 = \frac{(1-\beta)(\delta_I - \delta_U)F_L(\delta_I(F_H - F_H^L) - \delta_U(F_H - F_L)) + \delta_I(\delta_I F_H^L - \delta_U F_L)v}{\delta_U F_L((1-\beta)(\delta_I - \delta_U)(F_H - F_L) + \delta_I v)}.$$

Moreover, with $F_H^L > F_L$, we show that ΔW is decreasing in τ at a decreasing rate

$$\frac{\partial^2 \Delta W}{\partial \tau^2} = -\frac{2(1-\beta)\delta_I \delta_U^2(\delta_I - \delta_U)(F_H^L - F_L)F_H F_L^2}{(\delta_I F_H^L - (1+\tau)\delta_U F_L)^3} < 0.$$

Hence, τ_0 is unique and the separating equilibrium yields greater welfare than the pooling equilibrium if and only if $\tau < \tau_0$.

The next step is to show that there exists a tax, $\tau > 0$, for which the pooling equilibrium ceases to exist and only the separating equilibrium prevails, i.e. $\frac{\bar{F}}{\bar{F}_L} \geq \frac{\delta_I}{\delta_U(1+\tau)} > 1$. Reformulating the conditions in term of τ yields $\tau \in [\frac{\delta_I}{\delta_U}\frac{\bar{F}_L}{\bar{F}} - 1, \frac{\delta_I}{\delta_U} - 1]$. For the tax to be welfare improving with the separating equilibrium, the condition $\tau < \tau_0$ has to be satisfied.

Now, since the economy is in the pooling equilibrium with $\tau = 0$, the condition for existence must be satisfied, i.e. $\frac{\delta_I}{\delta_U} \geq \frac{\bar{F}}{\bar{F}_L}$. This implies that the smallest FTT which makes the pooling equilibrium cease to exist, i.e. $\tau^* = \frac{\delta_I}{\delta_U}\frac{\bar{F}^L}{\bar{F}} - 1$ is positive. Also note that, from the proof of Proposition 3, the condition of existence of the pooling equilibrium is $\frac{\delta_I}{\delta_U} \geq \frac{\bar{F}}{\bar{F}_L}$, independently of the actual level of trade T_P, i.e. also for Pareto dominated trade $T_P < 1$. Hence, the optimal level of the FTT is invariant on T_P.

As a final step, we need to show that τ^* is also smaller than τ_0. The denominator of $\tau_0 - \tau^*$ is always positive since $\frac{\delta_I}{\delta_U} > \frac{(1-\beta)(V_H-V_L)}{(1-\beta)(V_H-V_L)+v}$. The numerator of $\tau_0 - \tau^*$ is positive if

$$\delta_U[\beta^2(V_H - V_L)^2(V_L + v) - V_L(V + V_L)(V_H - V_L - 2v) - \beta(V_L + v)(V_H^2 - 3V_HV_L + 2V_L(V_L + v))]$$
$$+\delta_I[-\beta^2(V_H - V_L)^2(V_L + v) + V_L^2(V_H - V_L - 2v) + \beta(V_L + v)(V_H^2 - 3V_HV_L + 2V_L^2 + v(V_H + V_L))] > 0$$

The term in the first square brackets is positive since

$$(V_L + v)(V_H - V_L)[\beta(1 - \beta)(V_H - V_L) + (1 - \beta)(V_L - \frac{2vV_L}{V_H - V_L})] > 0,$$

and the term in the second square brackets is positive as long as

$$(V_H - V_L)[\beta(1 - \beta)(V_H - V_L)(V_L + v) + V_L^2(1 - \frac{2v}{V_H - V_L}) + \beta(V_L + v)(-V_L + v\frac{V_H + V_L}{V_H - V_L})] > 0$$

which is satisfied as long as $v > \frac{V_H-V_L}{V_H+V_L}V_L$. Note in fact that the other term in the expression is positive because $F_H^L \geq F_L$ is equivalent to $\frac{V_H-V_L}{2} \geq v$.[25] Finally note that $\frac{V_H-V_L}{2} > \frac{V_H-V_L}{V_H+V_L}V_L$ which shows the non-empty set for v. This shows that there exists indeed a welfare improving FTT τ^*.

Pareto optimal pooling and least trade separating equilibrium. Next, we perform the welfare comparison when the levels of trade are $T_H = T_P = 1$ and $T_L = \underline{T}_L$.

We define again the FTT τ_1 for which there is no difference in welfare between the separating

[25]If it was $F_H^L < F_L$, we should have to consider another possibility. In fact, a high v increases ΔW directly but it would also reduce it through a higher T_L (the latter being increasing in v).

equilibrium and the pooling equilibrium, $\Delta W = 0$

$$\tau_1 = \frac{(\delta_I - \delta_U)(\delta_I(2\beta - 1)v - \delta_U(1-\beta)(V_H - V_L))}{\delta_U(\delta_I v + (\delta_I - \delta_U)(1-\beta)(V_H - V_L))}.$$

Note $\frac{\partial^2 \Delta W}{\partial \tau^2} < 0$.

Then it is straightforward to show that there exist admissible parameters such that $\tau^* \leq \tau_1$.

End of proof.

Proofs of Proposition 7 and Corollary 2. These proofs are omitted as they are immediate from the discussion in the main text.

B Extensions

B.1 Other beliefs

In the following we show that the separating equilibrium that we characterize is not knife-edge, that is it does not rely on the particular beliefs that we postulate. In other terms, there are other beliefs that support exactly the same levels of trade. For brevity we show this for the separating equilibrium, but it can similarly be shown in the pooling equilibrium as well.

Let us parametrize the following probability $\eta \equiv \Pr(V_H|T')$. We then define,

$$\bar{F}(\eta) \equiv \left[\eta \bar{F}_H + (1-\eta)\bar{F}_L\right],$$

where $\bar{F}_\omega$ is independent of η. Note that

$$\bar{F}_H > \bar{F}(\eta) > \bar{F}_L \quad \forall\ \eta \in (0,1).$$

A generic IC constraint, considering any possible deviation, i.e. to any T', can be written as,

$$(\delta_I - (1+\tau)\delta_U)F_\omega T_\omega \geq (\delta_I \bar{F}_\omega - (1+\tau)\delta_U \bar{F}(\eta))T'.$$

For what we want to show here we can assume $\delta_I \geq (1+\tau)\delta_U$, so that the IC can be written as,

$$T_\omega \geq \frac{\delta_I \bar{F}_\omega - (1+\tau)\delta_U \bar{F}(\eta)}{(\delta_I - (1+\tau)\delta_U)F_\omega} T' \tag{35}$$

The RHS is maximised when $T' = 1$. Then we can write condition (35), with $T_H = 1$, for the H-type

$$\begin{aligned} 1 \geq & \frac{\delta_I \bar{F}_H - (1+\tau)\delta_U \bar{F}(\eta)}{(\delta_I - (1+\tau)\delta_U)F_H}, \text{ which implies} \\ \eta \geq & \frac{F_H - \bar{F}_L}{\bar{F}_H - \bar{F}_L} - \frac{\delta_I}{(1+\tau)\delta_U} \frac{F_H - \bar{F}_H}{\bar{F}_H - \bar{F}_L}. \end{aligned}$$

Next, we write condition (35) for the L-type

$$\begin{aligned} T_L \geq & \frac{\delta_I \bar{F}_L - (1+\tau)\delta_U \bar{F}(\eta)}{(\delta_I - (1+\tau)\delta_U)F_L}, \text{ which implies} \\ \eta \geq & \left(\frac{\delta_I}{(1+\tau)\delta_U} - 1 \right) \frac{\bar{F}_L - F_L T_L}{\bar{F}_H - \bar{F}_L}. \end{aligned}$$

To summarize, we need the off-equilibrium belief to satisfy

$$\eta \geq \max \left\{ \left(\frac{\delta_I}{(1+\tau)\delta_U} - 1 \right) \frac{\bar{F}_L - F_L T_L}{\bar{F}_H - \bar{F}_L}, \frac{F_H - \bar{F}_L}{\bar{F}_H - \bar{F}_L} - \frac{\delta_I}{(1+\tau)\delta_U} \frac{F_H - \bar{F}_H}{\bar{F}_H - \bar{F}_L} \right\}. \tag{36}$$

In order to show that the off-equilibrium belief in the main model is not knife-edge, it is sufficient to show that there exist admissible parameter ranges for which the elements in the *max*-function are smaller than one. We start with

$$\begin{aligned} 1 \geq & \frac{F_H - \bar{F}_L}{\bar{F}_H - \bar{F}_L} - \frac{\delta_I}{(1+\tau)\delta_U} \frac{F_H - \bar{F}_H}{\bar{F}_H - \bar{F}_L}, \text{ which implies} \\ & \frac{\delta_I}{(1+\tau)\delta_U}(F_H - \bar{F}_H) \geq F_H - \bar{F}_H + \bar{F}_L - \bar{F}_L, \end{aligned}$$

which is always satisfied since $\delta_I \geq (1+\tau)\delta_U$.

Next we consider

$$1 \geq \left(\frac{\delta_I}{(1+\tau)\delta_U} - 1 \right) \frac{\bar{F}_L - F_L T_L}{\bar{F}_H - \bar{F}_L}.$$

We prove this in two steps. First, observe that $\left(\frac{\delta_I}{(1+\tau)\delta_U} - 1 \right) < 1$ if $\frac{\delta_I}{(1+\tau)\delta_U} < 2$ which allows for a non-empty range of the adjusted liquidity ratio. Next, observe that $\frac{\bar{F}_L - F_L T_L}{\bar{F}_H - \bar{F}_L} < 1$ if

$$T_L > \frac{2\bar{F}_L - \bar{F}_H}{F_L}, \text{ which implies}$$
$$\frac{\delta_I}{(1+\tau)\delta_U} > \frac{F_H + \bar{F}_H - 2\bar{F}_L}{F_H - \frac{F_H^L}{F_L}(2\bar{F}_L - \bar{F}_H)}.$$

Note that $F_H - \frac{F_H^L}{F_L}(2\bar{F}_L - \bar{F}_H) > 0$. In the separating equilibrium, for there to be a non-empty range of the adjusted liquidity ratio

$$\frac{F_H - F_L}{F_H - F_H^L} > \frac{F_H + \bar{F}_H - 2\bar{F}_L}{F_H - \frac{F_H^L}{F_L}(2\bar{F}_L - \bar{F}_H)},$$

which is always satisfied. We can therefore conclude that there exist other off-equilibrium beliefs which are not one and satisfy condition (36).

B.2 Intuitive Criterion

The analysis in the main text contemplates off equilibrium belief to put probability one on the informed trader in the H-state for any level of trade T' different from the equilibrium ones, i.e. $\mu(H|T') = 1$. Here we show that these beliefs satisfy the Intuitive Criterion (Cho and Kreps, 1987). Recall that both for the separating and the pooling equilibrium we restrict the analysis to $\delta_I \geq (1+\tau)\delta_U$.

Separating equilibrium. The equilibrium payoff of the sender, i.e. the informed trader, is:

$$U^*(\omega) = -(1+\tau)P_\omega T_\omega + \delta_I T_\omega F_\omega = (-(1+\tau)\delta_U + \delta_I)F_\omega T_\omega.$$

We compare the equilibrium payoff to the payoff that would maximize the informed trader's profit that is compatible with individually rational behavior of uninformed traders and the manager when the informed trader opts for an off-equilibrium trade T'.

Note that when the firm's manager observes an asset price $P = \delta_U F_\omega$, she infers the state ω and invests accordingly.[26] Hence, the maximal off-equilibrium payoff for the informed trader

[26]Since we are considering off-equilibrium levels of trade, one could allow uninformed traders and the manager to hold different beliefs. We can show that the results qualitatively hold unchanged with this different

in state ω is,

$$max\left\{(-(1+\tau)\delta_U+\delta_I)F_\omega, (-(1+\tau)\delta_U F_{-\omega}+\delta_I F_\omega^{-\omega})\right\}T'$$

where we account for the fact that uninformed traders can interpret T' as with the actual state ω or the other state $-\omega$. In H-state, we have

$$(-(1+\tau)\delta_U+\delta_I)F_H < (-(1+\tau)\delta_U F_L+\delta_I F_H^L)$$

since $\frac{F_H-F_L}{F_H-F_H^L} \geq \frac{\delta_I}{(1+\tau)\delta_U}$. In the L-state, we have instead,

$$(-(1+\tau)\delta_U+\delta_I)F_L > (-(1+\tau)\delta_U F_L+\delta_I F_H^L)$$

since $F_H - F_L > F_L^H - F_L$.

With these results, we can now compare these off-equilibrium payoffs to the equilibrium payoff. For the H-state we obtain,

$$U^*(H) = (-(1+\tau)\delta_U+\delta_I)F_H T_H > (-(1+\tau)\delta_U F_L+\delta_I F_H^L)T'$$

or

$$\frac{(\delta_I-(1+\tau)\delta_U)F_H}{\delta_I F_H^L-(1+\tau)\delta_U F_L} > T',$$

where the L.H.S. is equal to T_L. For the L-state instead we have,

$$U^*(L) = (-(1+\tau)\delta_U+\delta_I)F_L T_L > (-(1+\tau)\delta_U+\delta_I)F_L T'$$

which is equivalent to $T_L > T'$.

Then we can summarise the following:

- Any $T' \in (0, T_L)$ is equilibrium dominated for both the informed trader in state H and state L.

- Any $T' \in (T^L, 1)$ is not equilibrium dominated for either trader.

assumption.

Hence, the beliefs specified in the main text satisfy the intuitive criterion.

Pooling equilibrium. The equilibrium payoff of the sender, here the informed trader, is:

$$U^*(\omega) = -(1+\tau)P_P T_P + \delta_I T_P \bar{F}_\omega = (-(1+\tau)\delta_U \bar{F} + \delta_I \bar{F}_\omega)T_P$$

and we compare the equilibrium payoff to the payoff maximising the informed trader's profit

$$(-(1+\tau)\delta_U F_L + \delta_I F_\omega)T'$$

Here, the price that maximizes the informed trader's profit and at the same time satisfies uninformed traders' individual rationality is $P' = \delta_U F_L$. As for the manager, the price level $P' = \delta_U F_L$ is different from the candidate equilibrium price in the pooling equilibrium. Thus the manager interprets it as an off-equilibrium price and we thus have to consider a manager's decision that grants the informed trader the highest possible payoff. This requires that for type ω we consider a level of investment that leads to the efficient firm value F_ω.

Thus, for the informed trader in the H-state:

$$(-(1+\tau)\delta_U \bar{F} + \delta_I \bar{F}_H)T_P > (-(1+\tau)\delta_U F_L + \delta_I F_H)T'$$

or, equivalently,

$$\frac{\delta_I \bar{F}_H - (1+\tau)\delta_U \bar{F}}{\delta_I F_H - (1+\tau)\delta_U F_L} T_P > T'.$$

where we used that the best investment for this trader is one that delivers a value of the firm equal to F_H. Call $\frac{\delta_I \bar{F}_H - (1+\tau)\delta_U \bar{F}}{\delta_I F_H - (1+\tau)\delta_U F_L} = b$. Both numerator and denominator of b are positive since $\bar{F}_H > \bar{F}$ and $F_H > F_L$, and $b < 1$ since $\delta_I(F_H - \bar{F}_H) > (1+\tau)\delta_U(F_L - \bar{F})$.

Consider now the informed trader in the L-state:

$$(-(1+\tau)\delta_U \bar{F} + \delta_I \bar{F}_L)T_P > (-(1+\tau)\delta_U F_L + \delta_I F_L)T'$$

or, equivalently,

$$\frac{\delta_I \bar{F}_L - (1+\tau)\delta_U \bar{F}}{(\delta_I - (1+\tau)\delta_U)F_L} T_P > T'$$

Call $d = \frac{\delta_I \bar{F}_L-(1+\tau)\delta_U \bar{F}}{(\delta_I-(1+\tau)\delta_U)F_L}$. We have $0 < d < 1$. In fact, $\frac{\delta_I}{(1+\tau)\delta_U} \geq \frac{\bar{F}}{\bar{F}_L}$ and $\delta_I(F_L - \bar{F}_L) > (1+\tau)\delta_U(F_L - \bar{F})$. Also, we have $b < d$ if

$$F_H(\delta_I \bar{F}_L - (1+\tau)\delta_U \bar{F}) > F_L((\delta_I - (1+\tau)\delta_U)\bar{F}_H - (1+\tau)\delta_U(\bar{F} - \bar{F}_L)). \tag{37}$$

(We further discuss this condition below.)

Hence, we summarize the cases with the pooling equilibrium as follows:

- For $T' \in (0, b)$ is equilibrium dominated for both the informed trader in L-state and H-state.
- For $T' \in (b, d)$ is equilibrium dominated for the informed trader in the L-state only.
- For $T' \in (d, 1)$ is not equilibrium dominated for the informed trader in either state.

These results imply that for $T' \in (b, d)$ the Intuitive Criterion prescribes to set $Pr(H|T') = 1$. For any other T' the Intuitive Criterion is silent with respect to which off equilibrium belief to specify. Hence, the beliefs specified in the main text satisfy the intuitive criterion.

We conclude this section further specifying condition (37). In particular, anticipating a model for the value of the firm that follows the one assumed in Section 5, we show how to rewrite (37). Consider the following (the interpretation of this model is discussed in Section 5),

$$F_\omega = V_\omega + v_\omega, \qquad \bar{F}_\omega = V_\omega, \qquad F_\omega^{-\omega} = V_\omega - v_\omega, \tag{38}$$

where $V_H > V_L > 0$ and $v_\omega \geq 0$. In condition (37), call $y = \delta_I \bar{F}_L - (1+\tau)\delta_U \bar{F}$ and $z = (\delta_I - (1+\tau)\delta_U)\bar{F}_H - (1+\tau)\delta_U(\bar{F} - \bar{F}_L)$, which are positive and independent of v_ω. Then condition (37) becomes equivalent to

$$v_H > (V_L + v_L)\frac{y}{z} - V_H,$$

which is satisfied for v_H sufficiently high.

B.3 Short selling

In this section we highlight the main changes with respect to the "buying" case presented in the main text. The main change is that the trade variable is negative, $T < 0$. Traders have to pay a financial transaction tax (FTT) $\tau \geq 0$ on the value of purchases. In case of short selling the tax is paid by uninformed traders.

Separating equilibrium. The conditional beliefs of uninformed traders are:

$$q = Pr(H|T) = \begin{cases} 1 & \text{if } T = T_H \\ 0 & \text{if } T = T_L \\ 0 & \text{if } T = T'. \end{cases}$$

Participation constraints of the informed trader become

$$-P_\omega T_\omega + \delta_I T_\omega F_\omega \geq 0,$$

and for uninformed traders

$$(1+\tau)P_\omega T_\omega + \delta_U(1 - T_\omega)F_\omega \geq \delta_U F_\omega.$$

The informed trader's incentive compatibility constraint becomes

$$-P_\omega T_\omega + \delta_I T_\omega F_\omega \geq -P_{-\omega} T_{-\omega} + \delta_I T_{-\omega} F_\omega^{-\omega}. \tag{39}$$

In addition we have to assure that the informed trader does not deviate to any other off-equilibrium trade level T'

$$-P_\omega T_\omega + \delta_I T_\omega F_\omega \geq -P' T' + \delta_I T' F_\omega^L. \tag{40}$$

The firm value function is identical but the firm value in case of the incentive compatibility changes due to the change in off-equilibrium belief.

With perfect competition among uninformed traders $P_\omega = \frac{\delta_U}{1+\tau} F_\omega$. For the informed trader to short sell the asset $P_\omega \geq \delta_I F_\omega$. This condition is satisfied if $\frac{\delta_U}{1+\tau} \geq \delta_I$. To pin down trade quantities, consider incentive compatibility constraints. From condition (40) in the L-state, with $P' = \frac{\delta_U}{1+\tau} F_L$, we obtain $T_L \leq T' \; \forall \; T' \in [0, -1]$, which is satisfied if $T_L = -1$.

From condition (40) and since $-P_\omega + \delta_I F_\omega < 0$,

$$\frac{-P_L + \delta_I F_L}{-P_H + \delta_I F_L^H} T_L \leq T_H \leq \frac{-P_L + \delta_I F_H^L}{-P_H + \delta_I F_H} T_L.$$

Consider the equilibrium with $T_L = -1$. Then the incentive compatibility constraint of the informed trader in the L-state holds with equality if $T_H = -\frac{(\frac{\delta_U}{1+\tau} - \delta_I) F_L}{\frac{\delta_U}{1+\tau} F_H - \delta_I F_L^H} > -1$. Observe $\frac{(\frac{\delta_U}{1+\tau} - \delta_I) F_L}{\frac{\delta_U}{1+\tau} F_H - \delta_I F_L^H} < 1$. We require, $-\frac{(\delta_U - \delta_I) F_L}{\delta_U F_H - \delta_I F_L^H} < -\frac{\delta_U F_L - \delta_I F_H^L}{(\delta_U - \delta_I) F_H}$ which is always satisfied since $F_H^L - F_L \geq F_H - F_L^H$. Existence of the separating equilibrium is hence defined by $\frac{\delta_U}{1+\tau} \geq \delta_I$.

Pooling equilibrium. The conditional beliefs of uninformed traders:

$$q = Pr(H|T) = \begin{cases} \beta & \text{if } T = T_P \\ 0 & \text{if } T = T' \end{cases}.$$

Participation constraints of the informed trader are

$$(-P_P + \delta_I \bar{F}_\omega) T_P \geq 0, \tag{41}$$

and incentive compatibility constraints are

$$(-P_P + \delta_I \bar{F}_\omega) T_P \geq (-P' + \delta_I F_\omega^L) T'. \tag{42}$$

Uninformed traders break even when

$$(1+\tau) P_P T_P + \delta_U (1 - T_P) \bar{F} = \delta_U \bar{F}.$$

The firm values remain as in the buying case in the pooling equilibrium.

With perfect competition among uninformed traders, $P_P = \frac{\delta_U}{1+\tau} \bar{F}$. From the informed trader $P_P \geq \delta_I \bar{F}_\omega$ with $T_P < 0$. Therefore, $\frac{\delta_I(1+\tau)}{\delta_U} \leq \frac{\bar{F}}{\bar{F}_H}$. To pin down traded quantities consider incentive compatibility constraints in the (42) with $P' = \frac{\delta_U}{1+\tau} F_L$:

- L-state: $(-\frac{\delta_U}{1+\tau}\bar{F} + \delta_I \bar{F}_L)T_P > (-\frac{\delta_U}{1+\tau}F_L + \delta_I F_L)T'$
- H-state: $(-\frac{\delta_U}{1+\tau}\bar{F} + \delta_I \bar{F}_H)T_P > (-\frac{\delta_U}{1+\tau}F_L + \delta_I F_H^L)T'$

With $T' = T_P = -1$, the condition for the informed trader in the L-state is always satisfied since $\delta_U(F_L - \bar{F}) < \delta_I(F_L - \bar{F}_L)$. Similarly the condition for the informed trader in the H-state is satisfied if $\frac{\bar{F}-F_L}{\bar{F}_H - F_H^L} > \frac{\delta_I(1+\tau)}{\delta_U}$.

There exists a pooling equilibrium with $T_P = -1$, $P_P = \frac{\delta_U}{1+\tau}\bar{F}$. Participation constraints and incentive compatibility constraints are satisfied if $\frac{\delta_I(1+\tau)}{\delta_U} \leq \frac{\bar{F}}{\bar{F}_H}$. Note, $\frac{\bar{F}-F_L}{\bar{F}_H - F_H^L} > \frac{\bar{F}}{\bar{F}_H}$ if $\frac{\beta V_H(V_H - V_L)}{\beta(V_H - V_L) + V_H + V_L} > \upsilon$.

Equilibrium co-existence. Ranking existence conditions we obtain $1 > \frac{\bar{F}}{\bar{F}_H}$. Characterizing equilibria in case of short-selling therefore yields:

- only a separating equilibrium if $\frac{\bar{F}}{\bar{F}_H} < \frac{\delta_I(1+\tau)}{\delta_U} \leq 1$ and
- both a separating equilibrium and a pooling equilibrium if $\frac{\delta_I(1+\tau)}{\delta_U} \leq \frac{\bar{F}}{\bar{F}_H}$.

Welfare is given by the sum of the informed trader's expected profits, uninformed traders' expected profits and the government's tax revenue. Welfare in the separating equilibrium is given by

$$\begin{aligned} W_S =& \beta(\delta_U F_H - (\delta_U - \delta_I)T_H F_H) + (1-\beta)(\delta_U F_L - (\delta_U - \delta_I)T_L F_L) \\ =& (2\delta_U - \delta_I)(\beta F_H + (1-\beta)F_L) - (\delta_U - \delta_I)\beta F_H(1 + T_H) \end{aligned}$$

with $T_L = -1$. Note the first-best welfare level in case of short selling is equal to $(2\delta_U - \delta_I)(\beta F_H + (1-\beta)F_L)$. Welfare in the separating equilibrium is distorted due to the relatively low level of trade in the H-state. Note that since $\frac{\partial T_H}{\partial \tau} > 0$, $\frac{\partial W_S}{\partial \tau} < 0$. Furthermore since $\frac{\partial^2 T_H}{\partial \tau^2} > 0$, $\frac{\partial^2 W_S}{\partial \tau^2} < 0$.

Welfare in the pooling equilibrium is given by

$$
\begin{aligned}
W_P =& (2\delta_U - \delta_I)\bar{F} \\
=& (2\delta_U - \delta_I)(\beta F_H + (1-\beta)F_L) - (2\delta_U - \delta_I)(\beta(F_H - \bar{F}_H) + (1-\beta)(F_L - \bar{F}_L)).
\end{aligned}
$$

since $\beta \bar{F}_H + (1-\beta)\bar{F}_L = \bar{F}$. Welfare in the pooling equilibrium is distorted due to the lack of information revelation. The difference between welfare in the separating equilibrium and pooling equilibrium is

$$
\begin{aligned}
\Delta W =& W_S - W_P \\
=& (2\delta_U - \delta_I)(\beta(F_H - \bar{F}_H) + (1-\beta)(F_L - \bar{F}_L)) - (\delta_U - \delta_I)\beta F_H(1 + T_H) \\
=& (2\delta_U - \delta_I)\upsilon - (\delta_U - \delta_I)\beta F_H(1 + T_H).
\end{aligned}
$$

Since welfare in the separating equilibrium is decreasing in the FTT, $\frac{\partial W_S}{\partial \tau} < 0$, so is the difference, $\frac{\partial \Delta W}{\partial \tau} < 0$.

The FTT. Define the unique level of FTT, τ_0, for which there is no difference in welfare between separating equilibrium and pooling equilibrium, $\Delta W = 0$

$$
\begin{aligned}
\tau_0 =& \Bigg[\beta F_H\Bigg(- \delta_I^2 F_L - \delta_I\delta_U(\bar{F}_H - \bar{F}_L - F_L) + \delta_U^2(2\bar{F}_H - 2\bar{F}_L - F_H + F_L)\Bigg) \\
&+ \beta\delta_I\Bigg(\delta_U(-2\bar{F}_H + 2\bar{F}_L + F_H - 2F_L) + \delta_I(\bar{F}_H - \bar{F}_L + F_L)\Bigg)F_L^H - (2\delta_U - \delta_I)(\bar{F}_L - F_L)(\delta_I F_L^H - \delta_U F_H)\Bigg] \\
&/\Bigg[\beta\delta_I(\delta_I - \delta_U)F_H F_L - \delta_I\Bigg(\beta\delta_U(-2\bar{F}_H + 2\bar{F}_L + F_H - 2F_L) \\
&+ (\delta_I - 2\delta_U)(\bar{F}_L - F_L) + \beta\delta_I(\bar{F}_H - \bar{F}_L + F_L)\Bigg)F_L^H\Bigg].
\end{aligned}
$$

Consider a case in which the pooling equilibrium prevails with no FTT, which requires

$$
\frac{\delta_I(1+\tau)}{\delta_U} \leq \frac{\bar{F}}{\bar{F}_H}.
$$

Since W_S is decreasing in τ, if an optimal $\tau > 0$ exists, it must be the one just enough to eliminate the pooling equilibrium and guaranteeing that only the separating equilibrium exists, i.e.

$$\tau^* = \frac{\bar{F}}{\bar{F}_H}\frac{\delta_U}{\delta_I} - 1 > 0.$$

The inequality holds by construction.

If there exists a welfare increasing tax $\tau^* < \tau_0$, this implies that $\tau_0 > 0$ and that the separating equilibrium yields indeed larger welfare. Indeed it is straightforward to show that $\tau_0 > \tau^*$ for $\frac{\delta_I}{\delta_U} \leq \frac{\bar{F}}{\bar{F}_H}$, $\frac{V_H - V_L}{2} > v$ and $\frac{1}{2} > \beta$ there exist parameters which satisfy $\tau_0 > \tau^*$.

B.4 Different tax regimes

Traders have to pay a financial transaction tax (FTT) $\tau \geq 0$ on the value of purchases/sales. This is closer to taxing net positions rather than purchases (if traders only either sell or purchase, as is the case in our model, the tax is equivalent to taxing net positions). The tax is linear in the size of the trade. The results are unchanged when the tax is levied on both purchases and sales or only sales. We consider the case of $\delta_I > \delta_U$, so the informed trader buys from uninformed traders. The informed trader's profit function is:

$$(-(1 + \tau_B)P + \delta_I F)T.$$

Uninformed traders' profit is:

$$(1 - \tau_S)PT + \delta_U(1 - T)F.$$

Uninformed traders generate a gross revenue of PT from selling, but have to pay a proportional tax on the sold position; so they retain $(1 - \tau_S)$ of PT.

Full Information. From the binding PC of uninformed traders, under full information, the price becomes:

$$P_\omega = \frac{\delta_U F_\omega}{(1 - \tau_S)}.$$

The informed trader's participation constraint is:

$$(-(1+\tau_B)P_\omega + \delta_I F_\omega)T_\omega \geq 0.$$

Substituting the price into the informed trader's participation constraint, buying takes places if (analogous to point (i) in Proposition 1):

$$\frac{\delta_I(1-\tau_S)}{\delta_U(1+\tau_B)} \geq 1.$$

Separating equilibrium. In the separating equilibrium the price is the same as in the full information case. The informed trader participates only if:

$$\frac{\delta_I(1-\tau_S)}{\delta_U(1+\tau_B)} \geq 1.$$

Differently from the full information case, the informed agent's incentive compatibility constraint needs to be satisfied:

$$-(1+\tau_B)P_\omega T_\omega + \delta_I T_\omega F_\omega \geq -(1+\tau_B)P_{-\omega}T_{-\omega} + \delta_I T_{-\omega}F_\omega^{-\omega}.$$

In the IC constraint everything is as in the taxing the purchases case, but P_ω and $P_{-\omega}$ are different here. From this constraint, we derive the bounds on T_L and T_H.

Indeed, the effective liquidity ratio is steeper in τ_s than τ so a relatively smaller τ_s would lead to the necessary flip from multiplicity to separating. From incentive compatibility we obtain that indeed $T_H = 1$ and T_L is given by the incentive compatibility constraint in the H-state

$$T_L = \frac{((1-\tau_S)\delta_I - (1+\tau_B)\delta_U)F_H}{(1-\tau_S)\delta_I F_H^L - (1+\tau_B)\delta_U F_L}. \tag{43}$$

We derive the existence condition of the separating ensuring that $T_H > T_L$ (analogous to Proposition 2):

$$\frac{F_H - F_L}{F_H - F_H^L} \geq \frac{\delta_I(1-\tau_S)}{\delta_U(1+\tau_B)} \geq 1.$$

Pooling equilibrium. The pooling price is given as:

$$P_P = \frac{\delta_U \bar{F}}{1-\tau_S}.$$

The informed trader's participation constraint is:

$$-(1+\tau)P_P T_P + \delta_I T_P \bar{F}_\omega \geq 0.$$

Again, the PC is identical to the main analysis, except that P_P is different. Incentive compatibility is satisfied if $\frac{F_H-\bar{F}}{F_H-\bar{F}_H} \geq \frac{\delta_I(1-\tau_S)}{\delta_U(1+\tau_B)}$. Traders' participation is satisfied if $\frac{\delta_I(1-\tau_S)}{\delta_U(1+\tau_B)} \geq \frac{\bar{F}}{\bar{F}_L}$. We can therefore summarize the existence condition of the pooling equilibrium (analogous to Proposition 3):

$$\frac{F_H-\bar{F}}{F_H-\bar{F}_H} \geq \frac{\delta_I(1-\tau_S)}{\delta_U(1+\tau_B)} \geq \frac{\bar{F}}{\bar{F}_L}.$$

Equilibrium characterization.

(i) If $\frac{\bar{F}}{\bar{F}_L} > \frac{\delta_I(1-\tau_S)}{\delta_U(1+\tau_B)} \geq 1$, the separating equilibrium exists, the pooling equilibrium does not exist.

(ii) If $\frac{F_H-F_L}{F_H-F_H^L} \geq \frac{\delta_I(1-\tau_S)}{\delta_U(1+\tau_B)} \geq \frac{\bar{F}}{\bar{F}_L}$, both separating equilibrium and pooling equilibrium exist.

Tilting FTT. We know that the introduction of an FTT $\tau > 0$ changes the liquidity ratio to $\frac{\delta_I(1-\tau_S)}{\delta_U(1+\tau_B)}$ and increasing the FTT enough, the ratio becomes smaller than $\frac{\bar{F}}{\bar{F}_L}$ so that the pooling equilibrium ceases to exist. With a sufficiently large FTT the economy tilts into a separating equilibrium. More precisely, this is the case when

$$\frac{\bar{F}}{\bar{F}_L} \geq \frac{\delta_I(1-\tau_S)}{\delta_U(1+\tau_B)} \geq 1.$$

In addition to the case in the main model, we study further two cases. First, when both informed and uninformed traders are taxed at the same rate $\tau_S = \tau_B = \tau$. From the first inequality, we derive the optimal FTT:

$$\tau^* = \frac{\delta_I \bar{F}_L - \delta_U \bar{F}}{\delta_U \bar{F} + \delta_I \bar{F}_L}.$$

Second, when only the seller is taxed, i.e. $\tau_S > 0$ and $\tau_B = 0$, we have

$$\frac{\bar{F}}{\bar{F}_L} \geq \frac{\delta_I(1-\tau_S)}{\delta_U} \geq 1.$$

Than the tilting FTT is

$$\tau_S^* = \frac{\delta_I \bar{F}_L - \delta_U \bar{F}}{\delta_I \bar{F}_L}.$$

In the main model, the optimal FTT, $\tau_B^* = \frac{\delta_I \bar{F}_L - \delta_U \bar{F}}{\delta_U \bar{F}}$ is larger than in the other two cases, $\tau_B^* > \tau_S^* > \tau^*$.

FTT and trade. Welfare is impacted directly through the level of trade in the L-state in the separating equilibrium. Therefore we study the effect of the different FTTs on T_L. The derivative with respect to a tax on the buyer given that there is no tax on the seller, $\tau_S = 0$ is

$$\frac{\partial T_L}{\partial \tau_B} = -\frac{\delta_I \delta_U F_H (F_H^L - F_L)}{(\delta_I F_H^L - \delta_U F_L(1+\tau_B))^2} < 0.$$

Furthermore, $\frac{\partial^2 T_L}{\partial \tau_B^2} < 0$.

The derivative with respect to a tax on the seller given that there is no tax on the buyer, $\tau_B = 0$ is

$$\frac{\partial T_L}{\partial \tau_S} = -\frac{\delta_I \delta_U F_H (F_H^L - F_L)}{(\delta_I F_H^L (1-\tau_S) - \delta_U F_L)^2} < 0.$$

Furthermore, $\frac{\partial^2 T_L}{\partial \tau_S^2} < 0$.

If there is a symmetric tax on both buyers and sellers, $\tau_B = \tau_S = \tau$, The derivative with respect to the tax is

$$\frac{\partial T_L}{\partial \tau} = -\frac{2\delta_I \delta_U F_H (F_H^L - F_L)}{(\delta_I F_H^L (1-\tau) - \delta_U F_L(1+\tau))^2} < 0.$$

Furthermore, $\frac{\partial^2 T_L}{\partial \tau^2} < 0$.

Optimal FTT. We are now ready to study the effect of a FTT on welfare. The FTT directly affects only the separating equilibrium. The change in welfare with respect to the FTT is given by

$$\frac{\partial W_S}{\partial \tau} = \frac{\partial W_S}{\partial T_L}\frac{\partial T_L}{\partial \tau} = (1-\beta)(\delta_I - \delta_U) F_L \frac{\partial T_L(\tau)}{\partial \tau}.$$

Given the equilibrium levels of trade $T_P = T_H = 1$ and T_L, welfare in the separating equilibrium is larger than in the pooling equilibrium if

$$\Delta W = W_S - W_P = \delta_I(\beta(F_H - \bar{F}_H) + (1-\beta)(F_L - \bar{F}_L)) - (1-\beta)(\delta_I - \delta_U)(1-T_L)F_L > 0. \quad (44)$$

Since W_S is decreasing in τ, expression (44) is decreasing in τ, implying that the difference between welfare in the separating equilibrium and welfare in the pooling equilibrium is maximal if $\tau = 0$. Moreover, with $F_H^L > F_L$, we show that ΔW is decreasing in τ at a decreasing rate

$$\frac{\partial^2 \Delta W}{\partial \tau^2} < 0$$

for any tax regime, i.e. for an FTT only on the buyer, for an FTT only on the seller and for a symmetric FTT on both buyer and seller.

It is only the welfare in the separating equilibrium which changes directly through the FTT and that only through the level of trade in the L-state. We therefore study the level of trade in the different regimes for the different levels of optimal FTT. It is straightforward to see that with T_L from expression (43)

$$T_L(\tau_B, \tau_S = 0)|_{\tau=\tau_B^*} = T_L(\tau_B = 0, \tau_S)|_{\tau=\tau_S^*} = T_L(\tau_B = \tau_S = \tau)|_{\tau=\tau^*}.$$

Therefore, regardless of the tax regime, welfare in the separating equilibrium at the optimal tax level is always the same. Moreover, the tax in the main model is larger than the symmetric tax, $\tau_B^* > \tau^*$, and larger than the tax on sellers, $\tau_B^* > \tau_S^*$. The proof in the main model showing that $\tau_0 > \tau_B^*$ is therefore sufficient to proof that any of the three regimes can be welfare increasing.

B.5 Alternative endowment allocation

We show that the initial allocation of the assets is irrelevant for the optimality of the FTT. We proceed in the same steps as in the main analysis.

First Best. To establish a benchmark we derive the case of symmetric information. Uninformed traders make zero profit if

$$P_\omega T_\omega - \delta_U T_\omega F_\omega = 0$$

which determines the price $P_\omega = \delta_U F_\omega$.

The informed trader participates if

$$-(1+\tau)P_\omega T_\omega + \delta_I(1+T_\omega)F_\omega \geq \delta_I F_\omega$$

which implies $\dfrac{\delta_I}{\delta_U(1+\tau)} \geq 1$.

Separating equilibrium. With asymmetric information there exists a separating equilibrium. Uninformed traders make zero profit if

$$P_\omega T_\omega - \delta_U T_\omega F_\omega = 0$$

so the asset is traded at the following price $P_\omega = \delta_U F_\omega$.

The informed trader participates if

$$-(1+\tau)P_\omega T_\omega + \delta_I(1+T_\omega)F_\omega \geq \delta_I \bar{F}_\omega$$

$$(-(1+\tau)\delta_U + \delta_I)F_\omega T_\omega + \delta_I(F_\omega - \bar{F}_\omega) \geq 0.$$

Observe, the informed trader's PC is satisfied if $\frac{\delta_I}{\delta_U(1+\tau)} \geq 1$ and $F_\omega \geq \bar{F}_\omega$.

Incentive compatibility for the informed trader now is

$$-(1+\tau)P_\omega T_\omega + \delta_I(1+T_\omega)F_\omega \geq -(1+\tau)P_{-\omega}T_{-\omega} + \delta_I(1+T_{-\omega})F_\omega^{-\omega}.$$

Suppose that $T_H = 1 > T_L$. We will show that this holds in equilibrium. Then from incentive compatibility we obtain

$$\frac{-(1+\tau)\delta_U F_H + \delta_I(2F_H - F_H^L)}{-(1+\tau)\delta_U F_L + \delta_I F_H^L} \geq T_L \geq \frac{-(1+\tau)\delta_U F_H + \delta_I(2F_L^H - F_L)}{(-(1+\tau)\delta_U + \delta_I)F_L}.$$

It is straightforward to show that the set for T_L is indeed non-empty.

Now we show that $T_H = 1$ and T_L is indeed the upper bound of the IC above. Assume the following system of beliefs

$$q = Pr(H|T) = \begin{cases} 1 & \text{if } T = T_H \\ 0 & \text{if } T = T_L \\ 1 & otherwise. \end{cases} \tag{45}$$

Then, with $P' = \delta_U F_H$, incentive compatibility becomes

$$-(1+\tau)P_\omega T_\omega + \delta_I(1+T_\omega)F_\omega \geq -(1+\tau)P'T' + \delta_I(1+T')F_\omega^H.$$

For the H-type, with $\frac{\delta_I}{\delta_U(1+\tau)} \geq 1$, $T_H \geq T'$ such that $T_H = 1$.

For the L-type it is always satisfied if $\frac{\delta_I}{\delta_U(1+\tau)} \leq \frac{F_H}{F_L^H}$. Else, it boils down to the IC above.

Finally, for $T_H > T_L$ we have to make sure that

$$1 > \frac{-(1+\tau)\delta_U F_H + \delta_I(2F_H - F_H^L)}{-(1+\tau)\delta_U F_L + \delta_I F_H^L}$$
$$\text{which implies } \frac{F_H - F_L}{2(F_H - F_H^L)} > \frac{\delta_I}{\delta_U(1+\tau)}.$$

We require $\frac{F_H - F_L}{2(F_H - F_H^L)} > 1$ that is $2F_H^L - F_L - F_H > 0$ which is satisfied since $V_H - V_L > 2v$.

Pooling equilibrium. With asymmetric information there also exists a pooling equilibrium.

Uninformed traders make zero profit if

$$P_P T_P - \delta_U T_P \bar{F} = 0$$
$$\text{which determines the price } P_P = \delta_U \bar{F}.$$

The informed trader participates if

$$-(1+\tau)P_P T_P + \delta_I(1+T_P)\bar{F}_\omega \geq \delta_I \bar{F}_\omega$$
$$\text{which implies } \frac{\delta_I}{\delta_U(1+\tau)} \geq \frac{\bar{F}}{\bar{F}_\omega}.$$

The latter condition is binding in the L-state. With the following system of beliefs

$$q = Pr(V_H|T) = \begin{cases} \beta & \text{if } T = T_P, \\ 1 & \text{for any other } T, \end{cases} \tag{46}$$

the off-equilibrium price becomes

$$P' = \frac{\delta_I}{1+\tau} F_H.$$

Incentive compatibility of the informed trader is satisfied if,

$$-(1+\tau)P_P T_P + \delta_I(1+T_P)\bar{F}_\omega \geq -(1+\tau)P'T' + \delta_I(1+T')F_\omega^H.$$

Given that both the equilibrium and off-equilibrium per unit profits are positive, then with $T_P = T' = 1$, incentive compatibility is satisfied in both states if $\frac{F_H - \bar{F}}{2(F_H - \bar{F}_H)} \geq \frac{\delta_I}{\delta_U(1+\tau)}$. Observe that $\frac{F_H - \bar{F}}{2(F_H - \bar{F}_H)} > \frac{\bar{F}}{\bar{F}_L}$ if $\frac{V_L(V_H - V_L - v)}{(V_H - V_L)(V_L + 2v)} > \beta$.

Equilibrium co-existence.

- If $\frac{F_H - F_L}{2(F_H - F_H^L)} > \frac{\delta_I}{\delta_U(1+\tau)} \geq 1$, there exists a separating equilibrium.
- If $\frac{F_H - \bar{F}}{2(F_H - \bar{F}_H)} > \frac{\delta_I}{\delta_U(1+\tau)} \geq \frac{\bar{F}}{\bar{F}_L}$, there exists a pooling equilibrium.

Observe $\frac{F_H - F_L}{2(F_H - F_H^L)} > \frac{\bar{F}}{\bar{F}_L}$ if $V_H - V_L > 4v$ and $\frac{(V_H - V_L - 4v)V_L}{v(V_H - V_L)} \geq \beta > 0$. Moreover $\frac{F_H - \bar{F}}{2(F_H - \bar{F}_H)} > \frac{F_H - F_L}{2(F_H - F_H^L)}$ if $\frac{1}{2} > \beta$. Then separating and pooling equilibrium co-exist if $\frac{F_H - F_L}{2(F_H - F_H^L)} > \frac{\delta_I}{\delta_U(1+\tau)} \geq \frac{\bar{F}}{\bar{F}_L}$.

Welfare. In case of full information welfare is yields:

$$\begin{aligned} W_{FB} =& \beta\Big(-(1+\tau)P_H T_H + \delta_I(1+T_H)F_H + P_H T_H - \delta_U T_H F_H + \tau P_H T_H\Big) \\ &+ (1-\beta)\Big(-(1+\tau)P_L T_L + \delta_I(1+T_L)F_L + P_L T_L - \delta_U T_L F_L\Big) \\ &= (2\delta_I - \delta_U)(\beta F_H + (1-\beta)F_L). \end{aligned}$$

In the separating equilibrium welfare is:

$$\begin{aligned}W_S =&\beta\Big(-(1+\tau)P_H T_H + \delta_I(1+T_H)F_H + P_H T_H - \delta_U T_H F_H + \tau P_H T_H\Big)\\ &+(1-\beta)\Big(-(1+\tau)P_L T_L + \delta_I(1+T_L)F_L + P_L T_L - \delta_U T_L F_L\Big)\\ &=W_{FB} - (1-\beta)F_L(\delta_I - \delta_U)(1-T_L).\end{aligned}$$

In the pooling equilibrium welfare is:

$$\begin{aligned}W_P =&\beta\Big(-(1+\tau)P_P T_P + \delta_I(1+T_P)\bar{F}_H + P_P T_P - \delta_U T_P \bar{F}\Big)\\ &+(1-\beta)\Big(-(1+\tau)P_P T_P + \delta_I(1+T_P)\bar{F}_L + P_P T_P - \delta_U T_P \bar{F}\Big) + \tau P_P T_P\\ &=W_{FB} - (2\delta_I(\beta(F_H - \bar{F}_H) + (1-\beta)(F_L - \bar{F}_L)) - \delta_U(\beta F_H + (1-\beta)F_L - \bar{F})).\end{aligned}$$

Optimal FTT. The FTT affects welfare through existence conditions and in case of the separating through the amount of trade in state L. With $V_H - V_L > 4v$ and V_H sufficiently small $\frac{\partial T_L}{\partial \tau} < 0$.

When equilibria co-exist, the difference in welfare is

$$\Delta W = W_S - W_P = (2\delta_I - \delta_U)v - (1-\beta)F_L(\delta_I - \delta_U)(1-T_L).$$

With $\frac{\partial T_L}{\partial \tau} < 0$ it follows that $\frac{\partial \Delta W}{\partial \tau} < 0$. And since $\frac{\partial^2 T_L}{\partial \tau^2} < 0$, $\frac{\partial^2 \Delta W}{\partial \tau^2} < 0$. Then it is enough to show that the FTT that switches the equilibrium, $\tau^* = \frac{\delta_I}{\delta_U}\frac{\bar{F}_L}{\bar{F}} - 1$ is smaller than τ_0, i.e. $\Delta W(\tau_0) = 0$. Indeed $\tau^* < \tau_0$ if $v \geq \frac{2-\sqrt{2}}{2\sqrt{2}}V_L$.