Taxation, Information Acquisition and Trade in Decentralized Markets: Theory and Test[*]

Tri Vi Dang[a] Xiaoxi Liu[b] Florian Morath[c]

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Abstract

This paper shows that a transaction tax and a tax on capital gains have opposite implications for information acquisition and trade in decentralized markets. A transaction tax increases the incentive to acquire private information. It reduces the probability of trade in equilibrium with information acquisition. Furthermore, it increases the range of information costs where equilibrium exhibits information acquisition and adverse selection. The exact opposite implications hold for a tax on capital gains. We use the introduction of a transaction tax in the Singaporean housing markets in 2006 as a quasi-natural experiment. Based on proxies for information costs, the value of information and investor's sophistication we provide evidence for this theory.

Keywords: Bargaining; information acquisition; taxation, transaction tax,

JEL Codes: C78; D82; D83; G18; H20

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[a] Columbia University, e-mail: td2332@columbia.edu.

[b] Chinese University of Hong Kong, e-mail:xiaoxiliu@baf.cuhk.edu.

[c] Goethe University Frankfurt and Max Planck Institute for Tax Law and Public Finance, e-mail: morath@econ.uni-frankfurt.de.

1. INTRODUCTION

In this paper we provide a theoretical and empirical analysis of the impact of taxation on information acquisition and trade in decentralized markets. Two prime examples of decentralized markets are real estate markets and over-the-counter markets where investors negotiate about the price and volume of trade. There is no centralized market prices and clearing. Since financial investors typically decides about how much information they want to learn, information is inherently endogenous. Therefore, understanding the equilibrium incentive effects of taxation on information acquisition and bargaining behavior at the trading level is interesting and important for regulation, policy and market design.[1]

Our model shows that a transaction tax and a tax on capital gains have opposite implications for equilibrium behaviors and outcomes in decentralized markets. A transaction tax increases the incentive to acquire private information. It reduces the probability of trade in equilibrium with information acquisition (e.g. when information costs are low). As an indirect effect, a transaction tax increases the range of information costs where equilibrium exhibits information acquisition and adverse selection. The exact opposite implications holds for a tax on capital gains.

In the empirical analysis we use a quasi-natural experiment to test our transaction tax theory. In December 2006 the Singaporean government imposed a 3% tax on the transaction price in the segment of the housing market where investors trade units before they are completed ("presale" market). The market where investors trade units that are completed does not face a change in the transaction tax ("spot" market). The simultaneous presence of a treated group and control group mitigates potential endogeneity problems. The main sample consists of 47,214 transactions in 813 projects where 47% of these transactions are from the presale market.

The empirical findings in our difference-in-difference analysis are consistent with the equilibrium implications of a transaction tax in the model. A transaction tax reduces turnover (as a proxy for the probability of trade) in the presale markets. It weakly reduces the pre-tax transaction price. We use different proxies for information costs, the value of information and

[1] For example, government bonds, corporate bonds, syndicated loans, mortgage-backed securities and asset-backed securities are all traded in decentralized markets Also, currencies, repos and (interest rate and credit default) swaps are traded bilaterally. Therefore, the workhorse models (Grossman and Stiglitz, 1981, Kyle, 1985 and 1989) in the market microstructure literature on centralized stock trading are less appropriate for studying the effects of taxation in decentralized markets.

the sophistication of traders. As it might be easier and thus cheaper to acquire information about properties in the Central region of Singapore we use the Central region as an indicator for low information cost. We show that the negative volume and price effects are stronger in the Central Region. We use project size as a proxy for the information value. Learning about smaller projects might be more profitable than about bigger projects, since there is less public information ceteris paribus. We show that the negative volume and price effects are stronger for traded units in smaller projects. Furthermore, based on trading activities we classified some investors as flippers (or sophisticated investors) and show that the negative volume and price effects in the presale markets are stronger for flippers' trades.

Our theoretical model builds on Dang (2008) and Dang, Gorton and Holmstrom (2015a,b) who analyze optimal security design with information acquisition. We use their concept of "information sensitivity" to characterize the properties of equilibrium outcomes in bargaining with information acquisition under a transaction tax versus a tax on capital gains. In order to highlight the effects of taxation we consider a take-it-or-leave-it offer bargaining game and focus on information acquisition of the responder. An endogenous signaling game in which the proposing agent can acquire information is analyzed in the Appendix. To illustrate the intuitions behind the results we discuss the case where the seller makes a price offer but all results also hold if the buyer makes the price offer.

Consider a tax on realized profits or capital gains. In the benchmark case where the buyer has exogenous private information, profit taxation reduces the buyer's profits from trade but has no effect on the buyer's decision to trade since the informed buyer always buys if the value is larger than the price. Technically speaking, the set of states with trade is independent of a profit tax. Therefore, the equilibrium price the seller proposes and the probability of trade are both independent of a profit tax.

If, however, becoming informed is costly for the buyer, three effects emerge. First, in equilibrium with information acquisition, for the buyer to cover the information costs when part of the profit is taxed, the seller needs to reduce the price and this increases the probability of trade. Second, a lower price reduces the buyer's incentive to acquire information. Third, changes in the incentives to acquire information also affect the seller's choice whether to induce information acquisition. It now becomes relatively less expensive to prevent information acquisition of the buyer (which the seller can do by setting a sufficiently low price). Overall, there will be less information acquisition in equilibrium and an increase in the probability of trade and in total welfare in markets where there are gains from trade.

If a transaction tax is imposed, there are also three effects but with exact opposite implications. As a direct effect, a transaction tax makes it more attractive for the buyer to acquire information, as the after tax price is higher and thus also the value of information since the expected loss he can avoid by having information is larger. In equilibrium with information acquisition, a higher offer price reduces the probability of trade. As an additional and less obvious effect, the transaction tax affects the seller's choice between different prices by making it relatively more expensive for the seller to propose a price at which the buyer has no incentive to acquire information. These effects lead to a larger range of information costs where there is information acquisition in equilibrium which reduces the probability of efficient trade and total welfare.

Our paper contributes to different strands of literature. The theoretical part of the paper is at the intersection of the large but disconnected literatures on taxation and bargaining. The discussion about the taxation of financial transactions dates back to Tobin (1978) and his proposal of a tax on foreign exchange markets. Originally proposed in the context of exchange rate systems, the discussion about the "Tobin tax" has subsequently been generalized to a financial transaction tax. Stiglitz (1989) and Summers and Summers (1989) advocate a financial transaction tax as a way to reduce speculative investments, but this view has also been disputed (Ross 1989).[2] The literature on tax incidence analyzes the conditions that determine the distribution of the burden of taxation among market participants and typically focuses on complete information (Fullerton and Metcalf 2002). Questions of tax incidence with *exogenous* asymmetric information have been analyzed in competitive markets (Cheung 1998; Jensen and Schjelderup 2011) and for monopoly pricing (Goerke 2011; Kotsogiannis and Serfes 2014).[3]

A key insight of the bargaining and contracting literature is that equilibrium outcomes are typically not efficient when agents have private information (Ausubel, Cramton and Deneckere 2002). However, in many bilateral transactions in secondary markets there is asymmetry in the agents' cost or ability to acquire information rather than asymmetry in the

[2] See McCulloch and Pacillo (2011) for an overview of the debate on the Tobin tax and the empirical evidence. Recent work on financial sector taxation includes Darvas and Weizsäcker (2010), Shackelford, Shaviro, and Slemrod (2010), Matheson (2011), Dávila (2013), Bierbrauer (2014), and Acharya, Pedersen, Philippon, and Richardson (2017).

[3] The effects of income and commodity taxation in the context of (exogenous) asymmetric information and moral hazard have been studied by Arnott and Stiglitz (1986), Kaplow (1992), Banerjee and Besley (1990) and in the context of signaling by Ireland (1994) and Anderson (1996). Ginsburgh, Legros, and Sahuguet (2010) analyze the incidence effects of commissions in auctions, which can be interpreted as a sales tax.

information that agents possess ex ante. There are a few papers that analyze information acquisition in bargaining and optimal contracting. Crémer and Khalil (1992) and Crémer, Khalil and Rochet (1998) show that the equilibrium outcome with endogenous information acquisition is very different from the equilibrium outcome under exogenous asymmetric information. Dang (2008) considers a bargaining model with common values and shows that the mere possibility of information acquisition can cause efficient trade to break down even though no agent acquires information and maintain symmetric information in equilibrium.

To our knowledge, there is no theoretical work that analyzes the impact of taxation on bargaining and information acquisition. We show that taxation can affect trade by influencing the problem of endogenous information asymmetries. By changing the incentives to acquire information, taxation can change the equilibrium price and hence the probability of trade, the parties' gains from trade and the division of the gains from trade. Our paper contributes to the discussions about the taxation of the financial sector and real estate markets by demonstrating that the welfare effects of taxation depend on the type of tax instruments if information asymmetries are endogenous.

In addition to the novel theoretical contributions we provide empirical evidences that are consistent with the implications of the model. The empirical finance literature mainly focuses on the implications of taxation on (centralized) stock markets. In contrast to stock trading in centralized markets, real estate and the majority of fixed income instruments are traded in decentralized over-the-counter markets where negotiation is a standard feature. The most related paper is Fu, Qian and Yeung (2016) who use the same dataset but their focus is on testing the implications of market microstructure models of centralized trading. Therefore, our empirical design is different since we tailor it to test the implications of our bargaining model. In particular, we attempt to test the comparative static implications of information costs and the value of information on trade and transaction prices. These aspects are absent in their paper. For example, the implications of location and project size on trading volume and price are unique and have not been studied.

The remainder of the paper is organized as follows. The next section introduces the model. Section 3 provides an equilibrium analysis of the game. Section 4 analyzes the comparative static effects of taxation on equilibrium information acquisition, pricing and trade. Section 5 provides the empirical analysis. And Section 6 concludes. All proofs are given in Appendix A. Appendix B analyzes taxation and endogenous signaling and the deductibility of a loss as a negative profit tax and shows that the main results of the paper still hold.

2. THE MODEL

We consider a take-it-or-leave-it offer bargaining game with two agents: a seller S and a buyer B. The seller can sell an indivisible asset with uncertain payoff x at a price p to the buyer. Ex ante the information is symmetric. It is common knowledge that the payoff x is distributed according to the distribution function F on the interval $[x_L, x_H]$ where $0 \leq x_L < x_H$. F is assumed to be continuous and differentiable on $[x_L, x_H]$.

The analysis below subsumes two cases: In one case, the seller is the proposer P; in the other case, the buyer is the proposer. The proposing agent (he) offers a price p. The other agent (the responder R) observes this price, decides whether to acquire information about the asset, and then decides whether to trade at price p. If the responder (she) decides to acquire information, she learns the true realization of x at cost $\gamma \geq 0$.

The ex post utility of agent $i = S,B$ is given by

$$U_i = u_i(x, p, \tau, \kappa, q) - \gamma \cdot 1_{\text{info}}, \quad i = S,B,$$

where $q \in \{0,1\}$ indicates whether there is trade ($q = 1$ if the asset is traded and $q = 0$ otherwise), τ is the tax rate on capital gains, κ is the transaction tax, and the indicator variable 1_{info} indicates whether the responding agent i has acquired information. Specifically, we assume that

$$u_S(x, p, \tau, \kappa, q) = \begin{cases} p - \tau \max\{p - p_0, 0\} & \text{if trade } (q = 1) \\ v_S(x) - \tau \max\{x - p_0, 0\} & \text{if no trade } (q = 0) \end{cases}$$

and

$$u_B(x, p, \tau, \kappa, q) = \begin{cases} v_B(x) - (p + \kappa) - \tau \max\{x - (p + \kappa), 0\} & \text{if trade } (q = 1) \\ 0 & \text{if no trade } (q = 0) \end{cases}.$$

Here, $v_i(x)$ is agent i's valuation of the asset, which is continuous, strictly increasing and linear in the asset's payoff x. In particular, we assume that the responder values the asset $v(x)=x$. Furthermore, we make the following assumption:

$$v_S(x) < v_B(x) \quad \text{for all } x \in (x_L, x_H].$$ [4]

[4] This captures the idea that the seller needs to raise cash for consumption or investment and the buyer wants to buy an asset to store cash. So the buyer has a higher valuation than the seller.

This assumption implies that (for all x>0) trade is efficient since the buyer derives a higher value from holding the asset than the seller so that in the first best the parties should trade with probability one and without information acquisition.

The transaction tax $\kappa \geq 0$ is levied on the buyer and increases the (effective) tax-inclusive price to be paid by the buyer from p to $p+\kappa$.[5] The tax $\tau \in [0,1)$ is a tax rate on positive realized profits. The buyer realizes a capital gains if he buys the asset and the payoff of the asset turns out to be larger than the price p. The seller realizes a positive profit either if he does not sell the asset and realizes a payoff x that is larger than some price p_0 that he initially paid for the asset (the 'book value') or if he sells the asset and receives a price p that is larger than p_0. When considering the effects of profit taxation we focus on the side of the market that can acquire information and, hence, ignore taxation of the proposing agent's profits for simplicity.

Given $u_S(x, p, \tau, \kappa, q)$ and $u_B(x, p, \tau, \kappa, q)$, the outside option of the seller is

$$\bar{u}_S := E_x[u_S(x, p, \tau, \kappa, 0)] = E_x[v_S(x)] - E_x[\tau \max\{x - p_0, 0\}]$$

and the outside option of the buyer is normalized to zero when there is no trade, i.e.

$$\bar{u}_B := E_x[u_B(x, p, \tau, \kappa, 0)] = 0.$$

We briefly provide a motivation for the main assumptions of the model which is supposed to capture trade in decentralized markets such as fixed income markets, interbank debt funding markets or real estate markets. (i) There are gains from trade, as liquidity management is the main purpose of trade in debt funding markets. (ii) Investors have symmetric information ex ante. Before the financial crisis, asymmetric information was not considered as an issue among participants in funding markets (Bank of Canada 2012; Deutsche Bank 2012; McKinsey 2013). Dang, Gorton and Holmstrom (2015a) actually argue that funding markets can only function if agents maintain symmetric information. (iii) Some but not all investors can produce information about the payoff of the asset. Large banks and hedge funds are more sophisticated and capable to produce information than pension funds, insurance companies and corporate cash managers. (iv) For tractability, we assume that only the responder can acquire information. Appendix B analyzes a signaling game in which the proposer can also acquire information and discuss the detectability of a loss as a negative profit tax.

[5] Equivalently, we could let the seller ask for a price $z = p+\kappa$, pay the transaction tax and keep p. Which side of the market has to formally pay the tax does not affect the equilibrium analysis (the economic tax incidence). Importantly, our results do not qualitatively depend on whether the transaction tax applies as a per-unit tax or in percentage of the price paid; see also the remarks in the proofs of Lemma 3 and Proposition 3.

3. EQUILIBRIUM ANALYSIS

The analysis proceeds in two steps. First, we consider the responder's incentives to acquire information and her best reply given (p, τ, κ). Second, we derive the equilibrium price chosen by the proposer. In Section 4 we use these results to explicitly analyze the comparative statics effects of a profit tax and transaction tax on the responder's incentives to acquire information, and the consequences for the equilibrium price and trade.

3.1. Incentives for information acquisition

Given the tax rates τ and κ and observing a price p chosen by the proposer, the responder has three options. She can decide not to trade (choose his outside option), she can trade at price p without information acquisition, or she can acquire information and decide whether to trade conditional on the information received. The responder's value of information depends on the alternative option she considers to choose.

Definition 1 (*Value of information*)

(i) $q^*(x,p,\tau,\kappa)$ is defined such that $q^*(x,p,\tau,\kappa)=\begin{cases}1 & \text{if } u_R(x,p,\tau,\kappa,1)\geq u_R(x,p,\tau,\kappa,0)\\ 0 & \text{otherwise}\end{cases}$.

(ii) $V_I(p,\tau,\kappa)$ is defined as $V_I(p,\tau,\kappa)=E_x[u_R(x,p,\tau,\kappa,q^*(x,p,\tau,\kappa))]-E_x[u_R(x,p,\tau,\kappa,1)]$.

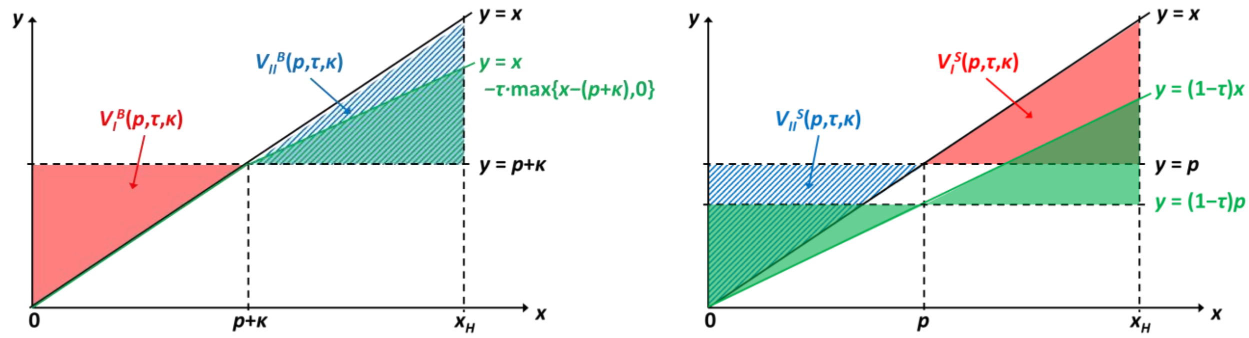
(iii) $V_{II}(p,\tau,\kappa)$ is defined as $V_{II}(p,\tau,\kappa)=E_x[u_R(x,p,\tau,\kappa,q^*(x,p,\tau,\kappa))]-E_x[u_R(x,p,\tau,\kappa,0)]$.

The function q^* in Definition 1(i) describes the *optimal decision rule* according to which an informed responder trades: She chooses $q = 1$ if and only if her utility from trading is larger than her utility from not trading, knowing the true payoff x. Second, V_I is defined as the responder's expected utility conditional on knowing the true payoff x of the asset (and trading according to q^*), minus her expected utility if she trades with probability one. Hence, V_I is the responder's *value of information* when deciding between information acquisition and trading without information acquisition ($q = 1$). Third, V_{II} is defined as the responder's expected utility conditional on knowing the true payoff x minus her expected utility if she does not trade being uninformed. In other words, V_{II} is the responder's *value of information* when deciding between information acquisition and being uninformed and not trading (q = 0).[6]

Figure 1 illustrates the value of information of the seller and the buyer and highlights the effect of taxation on V_I and V_{II} which are useful for the subsequent results. (Appendix A.1 contains formal proofs of the comparative statics effects.)

Figure 1: Effect of profit tax τ and transaction tax κ on the value of information V_I and V_{II}.

(a) Buyer is responder (b) Seller is responder



Note: $v_R(x) = x$; example for $x_L = 0$ and $p_0 = 0$.

Consider first the case where the buyer is the responder (Figure 1a). If the buyer knows the true payoff x, the buyer only trades in high states $x \geq p+\kappa$. There are two cases. Compared to the option of trading with probability one, the value of information V_I is equal to the expected value of avoiding the loss from trade in states $x < p+\kappa$. It follows directly that a tax that applies to positive realized profits does not affect V_I.[7] However, a transaction tax κ that increases the (tax-inclusive) price that the buyer has to pay causes V_I to become larger. Compared to the option of not trading at all, the buyer's value of information V_{II} is equal to the expected gains from trade in states $x \geq p+\kappa$ that otherwise would have been forgone. These gains are reduced by profit taxation; in Figure 1a, V_{II} becomes smaller the larger τ. Moreover, V_{II} is reduced by a transaction tax that increases the tax-inclusive price $p+\kappa$, as an informed buyer trades less often.

[6] Dang, Gorton and Holmstrom (2015a,b) introduce the terminology "information sensitivity" for the value of information in an optimal security design setting but without taxation. So V_I and V_{II} in Definition 1 generalize Lemma 1 in Dang, Gorton and Holmstrom (2015a) to the case where the value of information includes transaction and profit taxes.

[7] In Appendix B we show that the subsequent results are reinforced if we include the possibility of a tax treatment of losses.

If the seller as the responder knows the true payoff x, the seller only sells in states $x \leq p$. Therefore, for the seller as the responder, V_I is equal to the expected value of keeping the asset in good states $x > p$ (Figure 1b); V_I becomes smaller if a tax applies to the corresponding profits. Similarly, a profit tax also reduces the seller's value of information V_{II}, which is the profit an informed seller makes by selling in states $x < p$, compared to not participating at all. Since by assumption the transaction tax κ is levied on the buyer, it does not affect the seller's value of information V_I or V_{II} (not yet taking into account reactions of the equilibrium price).

The properties of V_I and V_{II} can be used to determine the best reply of the responder. Facing a price p, the optimal decisions on information production and trading can directly be characterized as a function of the information cost γ. Rather adding an infinitesimally small change in the price to break the indifference of the responder, we assume that (a) if the responder is indifferent between trading and not trading, she decides to trade and (b) if the responder is indifferent between information acquisition and no information acquisition, she does not acquire information.[8]

<u>Lemma 1 (Best response of responder)</u>

Let (p, τ, κ) *be given.*

(*i*) *If* $V_I \leq \min\{\gamma, V_{II}\}$, *the responder trades without information acquisition.*

(*ii*) *If* $\gamma < V_I$ *and* $\gamma \leq V_{II}$, *the responder acquires information and trades according to* $q^*(x,p)$.

(*iii*) *If* $V_{II} < \min\{\gamma, V_I\}$, *the responder does not acquire information and does not trade.*

Lemma 1 covers all possible constellations of best responses of the responder. The responder acquires information if and only if both V_I and V_{II} are larger than the cost of information γ. Otherwise, the responder does not acquire information; the comparison of V_I and V_{II} reveals whether or not an uninformed responder prefers to trade. An uninformed responder does not trade if $V_I > V_{II}$ (which, by Definition 1, is equivalent to $E_x[u_R(x, p, \tau, \kappa, 1)] < E_x[u_R(x, p, \tau, \kappa, 0)]$).

3.2. Equilibrium price setting

Taking into account the responder's best reply, there are three (types of) candidate equilibrium prices that the proposer may choose.

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[8] This tie-breaking rule is a common assumption in games with continuous strategies.

Definition 2 (*Candidate equilibrium prices*)

(i) $\bar{p}$ is defined such that $V_I(\bar{p}) = V_{II}(\bar{p})$.

(ii) p_I is defined such that $V_I(p_I, \tau, \kappa) = \gamma$.

(iii) p_{II} is defined as $p_{II} \in \arg\max_p E_x\left[u_P(x, p, \tau, \kappa, q^*(x, p, \tau, \kappa))\right]$ s.t. $V_{II}(p_{II}, \tau, \kappa) \geq \gamma$.

The price $\bar{p}$ makes the responder exactly indifferent between trading with probability one and choosing his outside option $\bar{u}_R$ (no trade, no information acquisition), i.e. expected gains and losses are equalized.[9] The price p_I is defined such that at p_I the responder is indifferent between acquiring information and trading according to q^* on the one hand and not producing information and trading with probability one on the other hand.[10] It can be interpreted as a "bribe" price such that the responder gets some rents and does not acquire information. In Figure 1(a), $V_I^B(p_I, \tau, \kappa) = \gamma$ means that the expected loss a buyer can avoid by being informed equals information cost. In Figure 1(b), $V_I^S(p_I, \tau, \kappa) = \gamma$ means that the expected loss a seller can avoid (by selling for a price that is lower than the true value) is equaled to information cost. Finally, p_{II} is the price that maximizes the proposer's expected utility in the case the responder acquires information and trades according to q^*.[11] p_{II} is the price that a monopolistic proposer offers when he faces an (induced) informed responder. Loosely speaking, the price p is chosen to maximize *p*prob(trade at p).* Here, p_{II} also takes into account the responder's participation constraint such that the responder's expected utility from producing information is as large as her reservation utility $\bar{u}_R$ (i.e., $V_{II}(p_{II}, \tau, \kappa) \geq \gamma$).

If the proposer's gains form trade are sufficiently small, he will not trade with an informed responder but rather choose his outside option $\bar{u}_P$. This is the case, for instance, if $v_P(x)$ is close to $v_R(x)$. In the following analysis, we will focus on situations where the proposer's incentives to trade are sufficiently strong or, in other words, $\bar{u}_P$ is sufficiently low.

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[9] By Definition 1(ii)-(iii), this is equivalent to $E_x\left[u_R(x, \bar{p}, \tau, \kappa, 1)\right] = E_x\left[u_R(x, \bar{p}, \tau, \kappa, 0)\right]$. This also implies $p = E[v_R(x)]$ if there is no taxation.

[10] As shown in Lemma A.1, V_I is strictly monotone in p for prices between x_L and x_H. For sufficiently low γ, p_I is uniquely defined. If γ is high and the seller is the responder, then $V_I(p) < \gamma$ for all $p \geq 0$, but in this case p_I will never be relevant for the equilibrium characterization. To keep the definitions simple, we omit this case in Definition 2(ii).

[11] For arbitrary functions F as well as v_S and v_B, p_{II} is not necessarily unique. When considering the effects of taxation, we neglect this possibility of multiple p_{II} as optimal solutions (where all yield the same expected utility to the proposer), which could be ruled out by some further assumptions on F.

Technically, we assume that $E_x\left[u_P(x, p_{II}, \tau, \kappa, q^*(x, p_{II}, \tau, \kappa))\right] \geq \bar{u}_P$, i.e., the proposer is willing to trade with an (endogenously) informed responder.[12]

Definition 3 (*Critical information cost*)

$\underline{\gamma}$ is defined such that $E_x\left[u_P(x, p_I, \tau, \kappa, 1)\right] = E_x\left[u_P(x, p_{II}, \tau, \kappa, q^*(x, p_{II}, \tau, \kappa))\right]$.

In other words, $\underline{\gamma}$ is defined as the information cost such that the proposer is indifferent between offering the "bribe" price p_I where the responder trades (*q=1*) without information acquisition and the price p_{II} where the responder acquires information and trades optimally according to q^*, given her information. Under the first strategy, the bribe is larger the smaller the information cost. Under the second strategy, trade only occurs with positive probability but the proposer only needs to compensate the responder for costly information acquisition. So if γ is small, giving in to adverse selection can dominate a bribe. Which strategy is the best response of the proposer depends on his utility derived from trade and *F(x)*. There are cases where avoiding information acquisition always dominates inducing information acquisition. This could arise if the buyer's utility from owning the asset is sufficiently high (e.g. $v_B(x)=Mx$ with *M* large) then $\underline{\gamma} > 0$ does not exist. His best response is to propose a sufficiently high price *p* (where $V_I(p) = \gamma$) such that the seller accepts with probability one and without information acquisition. We focus on the more interesting cases where $\underline{\gamma} > 0$ exists and there are three possible types of equilibrium outcomes.

Proposition 1

Suppose that $E_x\left[u_P(x, p_{II}, \tau, \kappa, q^*(x, p_{II}, \tau, \kappa))\right] \geq \bar{u}_P$ and $\underline{\gamma} > 0$.

(*i*) *If* $\gamma \geq V_I(\bar{p}, \tau, \kappa)$, *then* $p^* = \bar{p}$ *and the responder trades without information acquisition.*

(*ii*) *If* $\underline{\gamma} \leq \gamma < V_I(\bar{p}, \tau, \kappa)$, *then* $p^* = p_I$ *and the responder trades without information acquisition.*

(*iii*) *If* $\gamma < \underline{\gamma}$, *then* $p^* = p_{II}$ *and the responder acquires information and trades according to q*.*

[12] Note, $E_x[u_p(,)]$ is the expected utility of the proposer when he offers a price such that the responder acquires information and the informed responder trades optimally given his information. For example, if the buyer is the responder he only buys when $x \geq p_{II}$. So on average, the seller receives less than the expected payoff of the asset conditional on trade.

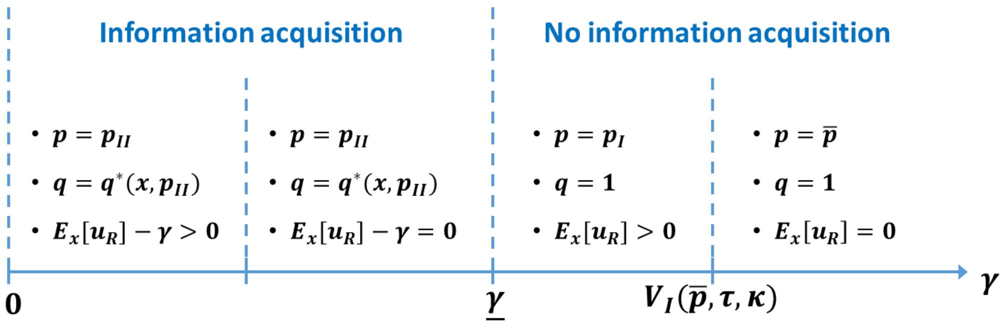
Proposition 1 characterizes the equilibrium properties which hold for the buyer as well as the seller being the proposer. The result on the equilibrium price p^* is intuitive. If the cost of information is high, information acquisition is irrelevant. In this case, the proposer offers the price $\overline{p}$ that gives the responder his outside option, i.e. no rents. Since trade occurs with probability one, this is the optimal price (Proposition 1(i)). Note, in the absence of taxation, for instance, this price would be equal to the responder's expected valuation $E[v_R(x)]$ of the asset.

For intermediate cost of information, the responder would react to such a price by acquiring information and then trading only when a gain can be realized. The proposer, however, is better off by adjusting the price such that the responder has no incentives to acquire information (Proposition 1(ii)). Technically, the proposer chooses a price p_I such that the value of information is $V_I(p_I, \tau, \kappa) = \gamma$.[13] Here, even if there is no information acquisition in equilibrium, the responder gets an information rent (his equilibrium utility is higher than $\overline{u}_R$).

The lower the cost of information, the more costly it becomes for the proposer to prevent information acquisition (the higher is the share of the surplus he has to offer to the responder). So there might exist a threshold $\underline{\gamma}$ below which the nature of the equilibrium changes and the proposer chooses a price that induces the responder to acquire information (Proposition 1(iii)). This price p_{II}, however, has to take into account that the responder is being compensated for the cost of information in that her expected surplus from trade covers the cost of information production (i.e. $V_{II} \geq \gamma$). While for very low cost of information this condition will always be fulfilled, it can be binding if γ is sufficiently close to $\underline{\gamma}$. In the former case, the responder gets a positive net surplus ($V_{II}(p_{II}, \tau, \kappa) > \gamma$); in the latter case, the responder's equilibrium surplus from trade net of information cost is zero ($V_{II}(p_{II}, \tau, \kappa) = \gamma$, i.e., his expected utility is equal to $\overline{u}_R$). The results of Proposition 1 are summarized in Figure 2 which hold both for the case where the buyer and where the seller makes the offer.

[13] The buyer as a proposer will increase the price while the seller as a proposer will decrease the price so as to prevent information production by the responder.

Figure 2: Equilibrium price setting and information acquisition.



It is worth noting that the equilibrium payoff of the responder can be non-monotonic in the information cost. For low information costs, she obtains some rents in the equilibrium with information acquisition. If the information cost increases, the responder's rents in the equilibrium with information acquisition are reduced to zero. If information cost is in a middle range, the responder gets rents again since she is "bribed" so as to trade without information acquisition. And if the information cost is high, the proposer is not concerned about information acquisition and the responder gets no rents.[14]

We use the concept of "information sensitivity" in Dang, Gorton and Holmstrom (DGH 2015a,b) to characterize equilibrium outcomes, but the results in Proposition 1 are different from their results. The setup in DGH (2015a,b) is more general in the sense that agents are not obliged to trade an asset of fixed size but can used it as a collateral to back the payoff of security that the agents design to trade. DGH (2015b) show that if the seller can acquire information and the uninformed buyer proposes a price and a security to buy, there is never information acquisition in equilibrium irrespective of the magnitude of gains from trade and even if information cost is vanishingly small. DGH (2015a) show that if the buyer can acquire information and the uninformed seller proposes a price and a security to sell, there might be information acquisition in equilibrium when information cost is small but the responder (buyer) never obtains any rents. Both of these equilibrium outcomes are not present in our model because agents trade an asset of fixed size and cannot tailor contracts to extract rents.

4. THE EFFECTS OF TAXATION ON EQUILIBRIUM PRICE AND TRADE

The equilibrium analysis in the previous section has taxation implicitly captured in the utility functions and there is no need to distinguish between whether the buyer or seller is the

[14] Proposition 1 extends some results in Dang (2008) to the cases where (i) the payoff x of the asset is continuous, (ii) x has arbitrary distribution $F(x)$, and (iii) there is taxation.

proposer. Now we explicitly analyze the effects of a marginal increase in the tax on capital gains and in the transaction tax, respectively, in two steps. First, we derive the effects of each of the tax instruments on the equilibrium candidate prices $\overline{p}$, p_I and p_{II} (taking into account the responder's best reply). Then, we show how a tax increase affects the proposer's choice between these candidate prices and in this way affects equilibrium information acquisition. For the intermediate step of the effect on the candidate equilibrium prices we need to distinguish who is the proposer and responder as the comparative statics results are different for the cases if the buyer is the proposer or the seller is the proposer. Yet the (final) equilibrium implications of the two types of tax instruments do not depend on who is the proposer.

4.1. The effect of a tax on capital gains

We first consider the price effects of an increase of a tax on capital gains.

Lemma 2 (Comparative statics of equilibrium prices)

Let $\overline{p}$, p_I, and p_{II} be defined as in Definition 2 and consider the effect of a profit tax τ.

(*i*) *If the seller is the proposer, then (a) $\partial\overline{p}/\partial\tau < 0$, (b) $\partial p_I/\partial\tau = 0$, and (c) $\partial p_{II}/\partial\tau \leq 0$ (with strict inequality if and only if $V_{II}(p_{II}) = \gamma$).*

(*ii*) *If the buyer is the proposer, then (a) $\partial\overline{p}/\partial\tau \leq 0$, (b) $\partial p_I/\partial\tau \leq 0$ (with strict inequality if $x_L < p_0 < x_H$), and (c) $\partial p_{II}/\partial\tau \geq 0$ (with strict inequality if and only if $V_I(p_{II}) = \gamma$).*

Although not immediately obvious, the economic mechanisms behind Lemma 2 are intuitive. First suppose that the cost of information is high (i.e., case (a)) and the proposer offers a price $\overline{p}$ such that the responder trades without information acquisition and obtains no rents, that is, expected gains and losses are equalized (i.e., $V_I(\overline{p},\tau) = V_{II}(\overline{p},\tau)$). If the buyer is the responder, then the gains, $V_{II}^B(\overline{p},\tau)$, become smaller the higher the profit tax while the expected loss V_I^B is independent of τ. Thus the seller must reduce the price in order to induce the buyer to participate.

Now suppose the seller is the responder. When selling at p the seller's utility is $p - \tau \cdot \max[p - p_0, 0]$. If the seller does not sell, her expected utility is $E[x] - \tau \cdot \int \max[x - p_0, 0] dF(x)$. The seller is indifferent if the two strategies yield the same expected utility. So the buyer proposes $\bar{p} = E[x] - \tau \int \max[x - p_0, 0] dF(x) + \tau \max[\bar{p} - p_0, 0]$. The maximum price the buyer needs to offer is $E[x]$. The second term is the expected tax payment when the seller keeps the asset. Therefore, the buyer can reduce the price by this amount. The third term is the tax payment if the seller sells above p_0. The buyer needs to compensate the seller for that tax payment. This amount is smaller than the tax payment of not selling since $\bar{p} \leq E[x]$. Intuitively, there is a tax disadvantage of not selling. Therefore, $d\bar{p} / d\tau < 0$ if $x_L < p_0 < x_H$. Otherwise, $d\bar{p} / d\tau = 0$. Note, if $p_0 \leq x_L$, at $\bar{p} = E[x]$, the seller pays the same tax with trade and without trade. So the buyer proposes $\bar{p} = E[x]$ for any τ. If $p_0 \geq x_H$ there is no tax payment at all.

For intermediate costs of information, the proposer chooses a price p_I which just prevents information acquisition of the responder by giving her some rents, i.e. $V_I(p_I, \tau) = \gamma$. If the buyer is the responder, information costs equals V_I^B which is her expected loss (see Figure 1(a)). The expected loss of the buyer is independent of profit tax τ. Therefore, the seller cannot adjust p_I. In contrast, if the buyer is the proposer, the seller's value of information (realizing a gain if the asset's payoff is high) is decreasing in τ, i.e. $dV_I^S(p_I, \tau) / d\tau < 0$. Note, keeping the asset in high states is less attractive because of the tax on capital gains. See Figure 1(b). Thus, if the profit tax is increased, the buyer can lower p_I and still prevent information acquisition of the seller. Formally, $\tau < \tau^{new}$, $dV_I^S(p_I, \tau) / d\tau < 0$, and $V_I^S(p_I^{new}, \tau^{new}) = \gamma$ imply that $p_I^{new} < p_I$.

Finally, if the cost of information is low, then the responder acquires information. Her information rent is reduced by a profit tax increase, but her trading decision is not directly affected by an increase in τ. Thus, the proposer's optimal price p_{II} does not change unless the responder's participation constraint is binding (that is, $V_{II} = \gamma$). In the latter case, the proposer must adjust the price p_{II} in order to compensate the responder for information cost in the light of a higher profit tax. In such a case the seller as the proposer lowers the price. An informed buyer trades more often. On the other hand, the buyer as the proposer increases the price. An informed seller trades more often.

If $\bar{p}$ or p_I is played in equilibrium profit taxation only shifts the gains from trade among the buyer, seller and government but does not affect the probability of efficient trade and there is no costly information acquisition. However, taxation of profits has welfare implications if p_{II}

is played in equilibrium. The next proposition identifies two effects and show how a tax on profit increases welfare.

Proposition 2

Suppose $\underline{\gamma} > 0$. *An increase in the tax on capital gains* τ

(i) increases the probability of trade in an equilibrium with information acquisition ($\gamma < \underline{\gamma}$ *).*

(ii) and lowers the threshold $\underline{\gamma}$ *below which there is information acquisition in equilibrium.*

Proposition 2 identifies a direct and an indirect welfare effect of an increase of the tax on capital gains. First, in an equilibrium with information acquisition (that is, for $\gamma < \underline{\gamma}$), capital gains taxation increases the probability of trade by reducing the responder's information rent, which must be compensated by a more favorable price for the responder: A more favorable price means higher probability of trade (Proposition 2(i)). Second, as the indirect effect, a tax on capital gains increase affects the proposer's choice between the equilibrium candidate prices. Since taxation of profits (weakly) reduces the incentives to acquire information (strictly for the seller), this makes it relatively more attractive for the proposer to prevent information production by offering a price p_I (Proposition 2(ii)).

Proposition 2 holds independently of the identity of the proposer and the responder. While profit taxation can affect the equilibrium price when information is endogenous, an increase of a tax on capital gains has no effect on the equilibrium probability of trade if asymmetric information is exogenous.

Corollary 1

Suppose that the responder is informed ($\gamma = 0$ *). An increase in the profit tax* τ *does not affect the equilibrium probability of trade.*

Since the case where the responder is informed can be interpreted as $\gamma = 0$, the proposer's choice of p_{II} is independent of τ.[15] Hence, although it reduces the responder's information rent, a marginal increase in τ has no effect on the equilibrium probability of trade. Note, the informed buyer trades in states x where $x \geq p$ and makes a profit of $\tau(x-p)$. Therefore, a tax on

[15] When $\gamma = 0$, this result follows from Lemma 1(ii) together with Lemma 2(i)c and (ii)c (where $V_{II} > \gamma$).

capital gains does not affect the set of states with trade. Similarly, an informed seller trades if $p \geq x$.

4.2. The effect of a transaction tax

Like in the case of capital gains taxation, if $\overline{p}$ or p_I is played in equilibrium a transaction tax only redistributes the gains from trade among the buyer, seller and government but does not affect the probability of efficient trade and there is no information acquisition. A transaction tax has welfare implications if p_{II} is played in equilibrium. The next Lemma characterizes the effects of a marginal increase in the transaction tax κ on the three equilibrium candidate prices.[16]

Lemma 3 (Comparative statics of equilibrium prices)

Let $\overline{p}$, p_I, and p_{II} be defined as in Definition 2 and consider the effect of a transaction tax κ.

(*i*) *If the seller is the proposer, then (a) $\partial(\overline{p}+\kappa)/\partial\kappa = 0$, (b) $\partial(p_I+\kappa)/\partial\kappa = 0$, and (c) $\partial(p_{II}+\kappa)/\partial\kappa > 0$ (and equal zero if $V_{II}(p_{II}) = \gamma$).*

(*ii*) *If the buyer is the proposer, then (a) $\partial\overline{p}/\partial\kappa = 0$, (b) $\partial p_I/\partial\kappa = 0$, and (c) $\partial p_{II}/\partial\kappa < 0$ (and equal zero if $V_{II}(p_{II}) = \gamma$).*

The intuition for Lemma 3 is as follows. The buyer as the responder bases his buying decision on the tax-inclusive price $p+\kappa$ while the seller as the responder cares about the net-of-tax price p. If the transaction tax is increased, the relevant prices which make the responder indifferent between trading uninformed and (a) his outside option and (b) information acquisition have to remain unchanged. Hence, the seller as the proposer has to adjust his offer such that the tax-inclusive prices $\overline{p}+\kappa$ and $p_I+\kappa$ remain unchanged, while the buyer as the proposer has to ensure that the net-of-tax prices $\overline{p}$ and p_I remain unchanged. The same argument holds for the price p_{II} whenever the responder's participation constraint is binding ($V_{II}(p_{II}) = \gamma$).

The most interesting case is a situation where $V_{II}(p_{II}) > \gamma$ and the responder gets a strictly positive rents when trading at p_{II}. Here, the proposer is able to shift (part of) the tax increase to the responder by adjusting the price accordingly. This will lead to an increase in the (tax-

[16] As for the comparative statics results for the profit tax, we assume that tax-inclusive prices are in some "interior" range (between x_L and x_H) and that p_{II} is unique.

inclusive) price if the seller makes the offer and to a decrease in the (net-of-tax) price if the buyer makes the offer.

Proposition 3

Suppose $\underline{\gamma} > 0$. *An increase in the transaction tax* κ

(*i*) *lowers the probability of trade in an equilibrium with information acquisition (* $\gamma < \underline{\gamma}$ *)*

(*ii*) *and increases the threshold* $\underline{\gamma}$ *below which there is information acquisition in equilibrium.*

If the cost of information is low and there is information acquisition in equilibrium, an increase in the transaction tax makes trade less attractive. Intuitively, whenever possible, the proposer shifts part of the increased tax burden to the responder although this reduces the probability of trade with an informed responder (Proposition 3(i)). Moreover, an increase in the transaction tax (weakly) increases the incentives to produce information (strictly for the buyer as the responder); in addition, the tax burden is higher in the candidate equilibrium without information acquisition because there trade occurs with higher probability. This makes it less attractive for the proposer to offer a price that prevents information acquisition (Proposition 3(ii)). Together, the direct and indirect effects of a transaction tax increase lead to less trade and more information acquisition.

Propositions 2 and 3 imply that the two different types of taxes have exactly the opposite welfare effects in a market with gains from trade. Profit taxation mitigates the (endogenous) lemons problem, whereas transaction taxes make it worse. Since the sum of the welfare of the trading parties and tax revenue is highest if there is trade with probability one and no information acquisition, profit taxation can be welfare-improving, while transaction taxes reduce welfare.[17] But the policy implications depend, of course, on the welfare criterion and on whether an increase in the probability of trade is socially desirable.

5. EMPIRICAL ANALYSIS

In this section we conduct an empirical analysis of our theory. We have access to dataset that allows us to test the theoretical implications of a transaction tax. The main part of the analysis

[17] Due to the effect on the probability of trade, this result still holds if the cost of information is not socially wasteful but only redistributive for welfare purposes.

is to test the comparative static implications of information costs and value of information for trading volume and prices.

5.1. Institutional Background

In Singapore, private condominium properties (or so-called non-landed properties) in new development projects are launched for sale before the project completion or even the commencement of construction. These new projects are typically located in developed areas and hence share similar building attributes as completed condominium projects. The ownership of these not-yet-completed properties can be freely traded and are demanded by homebuyers as well as investors. Following Fu, Qian and Yeung (2016) we refer to the market for uncompleted condominiums as "presale" and the market for completed condominiums as "spot" markets.

In December 2006 the Singaporean government imposed a tax on transactions in the presale markets. Specifically, the policy withdraws a stamp duty deferral and requires investors to pay three percent stamp duty in cash at the time of purchase. But transactions on the spot markets where investors trade properties that are completed do not face a change in the transaction tax. Homebuyers in Singapore typically pay a stamp duty (i.e., a transaction tax) of three percent of the full transaction price at the time of purchase. However, in June 1998 during the Asian financial crisis, the government gave concession for presale buyers to defer stamp duty payment until project completion or until the property was sold before completion. The concession encourages short term speculation because it allowed investors to finance their stamp duty from the sale proceeds when they eventually sell their properties before project completion. Consequently, the withdrawal of the deferral raises the upfront purchase cost for speculative investors, effectively raising their transaction cost.

There are three reasons why this policy intervention event can be used as a quasi-natural experiment to test our theoretical model. First, the market for condominiums is a decentralized market. Second, the introduction of a 3% tax on the transaction price is economically significant especially compared to the 10 to 20 percent down payment requirement in Singapore. And third, the simultaneous existence of an affected presale market and an unaffected spot market which does not face a change in transaction tax allows us to apply the difference-in-difference approach to mitigate potential endogeneity issues when trying to identify the policy impact.

5.2. Data, descriptive statistics and variable constructions

The housing market transaction data is from the Urban Redevelopment Authority (URA) REALIS database, which reports all transactions of private condominium properties lodged with the Singapore Land Authority. The REALIS dataset provides transaction level information, such as address, property type, transaction price, unit size, transaction date. The transaction price does not include the stamp duty (tax) and other professional fees. The unit size is measured in square meter (sqm). The dataset also provides property-project level information, such as location and completion date.

Fu, Qian and Yeung (2016) use the same dataset but their focus is on testing the implications of market microstructure models of centralized trading. Therefore, our empirical design is different since we tailor it to test the implications of our bargaining model. For example, our hypotheses that the change in transaction price is zero or negative in the presale market and the implications of the role of location and project size on trading volume and price are unique and not studied in their paper.

The main testing period is from December 2005 to December 2007, around one year before and one year after the implementation of the transaction tax in the presale markets in December 2006. Our baseline analysis is based on a sample which includes only the transactions in properties with more than 30 units to focus on relatively more liquid projects.[18] The sample consists of 47,214 transactions in 813 projects where 47% of these transactions are from the presale market. Around 20% of transactions in presale markets are secondary market trades.

Panel A of Table 1 shows that the average size of a unit traded is 131.36 sqm in the presale market and 142.60 sqm in the spot market. The average transaction price per sqm is 12,096 Singapore dollars (presale) and 8,086 SGD (spot). In the presale market 72% of the units traded are in projects located in the Central region versus 53% for spot transactions. Panel B shows that in the Central region per month there are on average 1,228 transactions and 225 projects (properties) which has units traded. The monthly average number of transactions and projects with units traded are smaller in other regions. Across all regions there are 1,970 transactions per month and the units traded are from 419 projects. In the subsample of presale

[18] We use the sample which includes projects with less than 30 and less than 20 units to conduct comparative statics analysis of our theory.

markets trades the corresponding numbers are 937 transactions and 88 projects versus 1,034 transactions and 330 projects in the spot market.

The project sizes are quite different. If we use the transaction level data, the observations could be dominated by trades from the big projects due to their large transaction volumes. Similar to Qian, Fu and Yeung (2015), we reshape the transaction level observations into project-level observations so as to avoid the project size effect. This means we aggregate all individual transactions in a project in one month to a project-month observation. We have 10,046 project-month observations. Panel C of Table 1 shows that on average 4.7 units are traded per project per month.[19] The unit price per sqm is 8,702 SGD. We define project turnover as the number of units traded in a project in a given month normalized by the total number of units in the project.[20] On average a project has 135.6 units. So the monthly average turnover is 0.036 (=4.7/135).

[Table 1 here]

5.3. Methodology

We use this quasi-natural experiment to test our transaction tax theory. Proposition 3 and Lemma 3 imply the following hypotheses.

Hypothesis 1: A transaction tax reduces the probability of trade, i.e. turnover.

Hypothesis 2: A transaction tax weakly decreases the (tax-exclusive) transaction price.

Hypothesis 3: The effects on turnover and price are stronger if information costs are lower.

Hypothesis 4: The effects on turnover and price are stronger if the value of information is larger.

Hypothesis 1 states that a transaction tax reduces the probability of trade. We use *Project turnover* as a proxy for the probability of trade. Project turnover is defined as the number of units traded in a project in a given month normalized by the total number of units in the project. Hypothesis 2 states that a transaction tax weakly decreases the (tax-exclusive) transaction price. We use the natural logarithm of the unit price per sqm (*lnPrice)* to measure

[19] Typically, a transaction is equivalent to one unit traded.

[20] We use the number of units (non-repeated address) sold during 2002-2012 as the project size, which could under estimate the true project size. The project size is not provided in REALIS.

the transaction price. We employ the difference-in-difference methodology to capture the residual effect of the implementation of the transaction tax on the endogenous variables. Our baseline specification is the following:

$$Y_{it} = \alpha + \beta_1 \cdot Presale_{it} \times Post_t + \beta_2 \cdot Presale_{it} + \theta \cdot Controls + \gamma_i + \delta_t + \varepsilon_{it}. \qquad \text{(R1)}$$

The endogenous variable *Y* is either *Project turnover* or *lnPrice*. $Presale_{it}$ is the presale market dummy of project *i* in month *t* and takes the value equal to one if the project is in the presale market at month *t*. Otherwise it is zero.[21] The transaction tax is implemented in December 2006. We exclude transactions from this month. $Post_t$ is the post-intervention dummy and takes a value equal to one for months after December 2006 and zero for the months before December 2006. Some of the control variables are discussed and added in the robustness section. The γ_i represents the project fixed effects and δ_t represents the time fixed effects. We like to emphasize that $Post_t$ is absorbed by the month fixed effect in the regression model and thus does not show up as another independent variable. Also project size, project age and locations are controlled and absorbed by project fixed effects.

We estimate the regression model (R1) using the OLS method. The standard errors are clustered to allow the residuals to be correlated within the same region. The key explanatory variable is the interaction term between $Presale_{it} \times Post_t$. The estimated coefficient indicates the transaction tax effect on presale market projects relative to spot markets projects after the policy change. The conjecture is that the sign of the coefficient is negative when the endogenous variable is *Project turnover* and weakly negative (or not different from zero) for *lnPrice*.

5.4. Empirical results on turnover and prices

Table 2 presents the regression results. The Column (1) in Table 2 shows that the coefficient of the interaction term $Presale \times Post$ for turnover is -0.0451 and statistically significant at the 1% level for the period from December 2005 to December 2007. In other words, on average turnover in the presale market exhibits a (net) decline of 4.5% after the implementation of the transaction tax. Column (3) reports similar results for the period from June 2006 to June 2007. These results show that turnover declines significantly in the presale market after the implementation of the transaction tax. This is consistent with Hypothesis 1.

[21] Note, some projects in the presale markets become projects in the spot market after its completion.

Regarding the price effects, Column (2) shows that the coefficient of the interaction term $Presale \times Post$ for transaction price (*lnPrice*) is -0.0471 and statistically significant at the 1% level during the period from December 2005 to December 2007. Column (4) shows that the coefficient is not different from zero for the period from June 2006 to June 2007. These results show that transaction prices weakly decline for trades in the presale market after the implementation of the transaction tax. This is consistent with Hypothesis 2.

[Table 2 here]

The results regarding the implications of a transaction tax on trading volume and price are consistent with our theory but it is also possible consistent with other trading models or hypotheses. The next section provides more direct and thus tighter evidences for our theory based on information acquisition.

5.5. Empirical results on the effects of information acquisition

Hypotheses 3 and 4 state that the effects of a transaction tax on turnover and price are stronger if information costs are lower or the value of information is larger. By its very nature, neither information acquisition nor information costs are observable. We use three variables to proxy for theses unobservable variables, namely the location of the project, the project size, and the sophistication of investors.

5.5.1. Location as a proxy for information costs

First we use the location of the project as a proxy for information costs. As it might be easier and thus cheaper to acquire information about properties in the Central region of Singapore we use the Central region as an indicator for low information cost. Hypothesis 3 states that the volume and price effects of a transaction tax are stronger for presale market trades in the Central region. Column (1) in Table 3 shows that the coefficient of the interactive term $Presale \times Post$ for turnover is -0.0457 and statistically significant at the 1% level for trades in the Central region while it is negative but insignificant for trades in other regions. The results are similar for the shorter sample period as shown Column (3).

Regarding the price effects of a transaction tax, Columns (2) and (4) report that the coefficient of the interaction term $Presale \times Post$ is negative and statistically significant for trades in the Central region but not significantly different from zero for trades in other regions. Consistent with Hypothesis 3, the results show that the transaction tax has a stronger effect on turnover and price when information costs are supposed to be smaller in the Central region.

[Table 3 here]

5.5.2. Project size as a proxy for the value of information

In order to test Hypothesis 4, we use project size as a proxy for the value of information. The information value for the trades of units in projects of smaller size might be larger than that for bigger projects, since there is less public information and learning would be more profitable. We conduct the analysis for a subsample of transactions in projects with unit sizes of less than 30 and 20 units, respectively. Column (1) in Panel A of Tale 4 shows that that the coefficient of the interaction term $Presale \times Post$ on turnover is -0.095 for projects with less than 30 units. This turnover effect is larger than -0.0451 as reported in Table 2 for projects with at least 30 units. Column (1) in Panel B shows that the coefficient (-0.1001) is even larger for projects with less than 20 units. Column (3) shows that similar results hold for a shorter sample period. Overall, the volume effects increase monotonically for transactions in smaller projects.

Regarding the price effects of a transaction tax, Column (2) in Panel A of Table 4 shows that the coefficient of the interaction term $Presale \times Post$ on transaction price (*lnPrice*) is -0.1582 for projects with less than 30 units. This price effect is stronger than -0.0471 as reported in Table 3 for projects with more than 30 units. Column (2) in Panel B shows that the coefficient (-0.1801) is even larger for projects with less than 20 units. Column (4) shows that similar results hold for a shorter sample period. These results are consistent with Hypothesis 4 which states that the volume and price effects of a transaction tax are stronger for smaller projects size, i.e. when the value of information is larger.

[Table 4 here]

5.5.3. Flipper's trade as a proxy for the sophistication of investors

As a third test of our information acquisition theory, we construct a proxy for investor sophistication. The ability and capability to learn about the value of the asset might differ for different investors. Therefore, different investors face different information acquisition costs. We construct a proxy for the sophistication of an investor. Some short-term investors buy units and turn them around rather than holding them.

Presale market is more attractive to those short-term speculators or so-called "flippers" (Qian, Fu and Yeung, 2015) than spot market. In our sample, flippers in presale market hold their investments for about 30 months on average, less than 43 months average holding time for non-flipper purchasers and spot market purchasers. Following Qian, Fu and Yeung (2015), we define a purchase in the presale market that subsequently sold before project completion as a *speculative trade* and those engaged in such round-trip transactions as *flippers*.

Since our test sample is project-month level, we further apply this concept for each project to define a *flipper traded project* through the following steps. First, for each presale project, we calculate the *speculative turnover*, which is the number of units sold in speculative trades in each month and scaled it by project size. Second, we determine the median of speculative turnover across all presale projects in each month. Third, we compare the presale project's speculative turnover in a month with the median in that month, and if the presale project speculative turnover is higher than the median, the project is defined to be traded by flippers in that month. Finally, a presale project is classified as *flipper traded project* if in most of the months (more than 50% of all months with trading records) the presale project's speculative turnover is higher than the monthly median of the whole presale market. Based on the definition above, 41% of the 22,404 presale transactions are speculative trades and 47.9% of the projects are classified as flipper traded projects in our test sample from December 2005 to December 2007. Our treatment group is flipper's trades in presale market. The control group is non-flipper trades in presale markets plus all trades in the spot markets.

Panel A of Table 5 shows that the coefficient of the interaction term $Presale \times Post$ is more significant for both turnover and price in the subsample of flipper's trades than non-flipper's trades in the presale market. Panel B shows that the results are similar for a shorter sample period. Since we assume that flippers are more sophisticated investors who face lower information costs, the results are constituent with Hypothesis 3.

[Table 5 here]

5.6. Robustness Results

In this section we provide some robustness results. We add lag variables to the baseline regression. Columns (1) and (4) of Panel A in Table 7 show that the impacts of the transaction tax on turnover and price in the presale markets are similar after controlling for the turnover and price in the last month, respectively. Column (2) and (5) show that the effects on turnovers and prices are stronger for projects that are located in the Central region. Panel B shows that similar results for the shorter sample period.

[Table 6 here]

6. CONCLUDING REMARKS

To our knowledge, this is the first paper that provides an equilibrium analysis of the effects of taxation on information acquisition and trade in decentralized markets and derives several novel results. We show that a profit tax and transaction tax have opposite implications for equilibrium behaviors and outcomes. An increase of a transaction tax increases the incentive to acquire private information. It reduces the probability of trade in equilibrium with information acquisition and adverse selection, Furthermore, as an indirect effect a transaction tax increases the range of information costs, where equilibrium exhibits adverse selection. The exact opposite holds for a tax on capital gains.

Since information is typically endogenous in financial and real estate markets, understanding the equilibrium incentive effects of taxation on information acquisition and bargaining behavior at the trading level is important for regulation, policy and market design. In the context of debt funding markets, proponents of transaction taxes often refer to "*creating appropriate disincentives for transactions that do not enhance the efficiency of financial markets thereby complementing regulatory measures to avoid future crises*." (European Commission, 2013, p.2). Our paper, however, shows that a transaction tax can potentially lead to more private information acquisition and increases the problem of asymmetric information.[22]

As a further contribution, we provide an empirical test of the transaction tax theory. We use the implementation of a 3% transaction tax in December 2006 on trades in the Singaporean (presale) housing markets as a quasi-natural experiment. The empirical findings in our difference-in-difference analysis are consistent with the equilibrium implications of a transaction tax in the model. A transaction tax reduces turnover (as a proxy for the probability of trade) in the presale markets. It weakly reduces the pre-tax transaction price. We use different proxies for information costs, the value of information and the sophistication of traders. The volume and price effects are stronger in the Central Region of Singapore where

[22] In the trivial case of a prohibitive high transaction tax, there will be no trade. But this is equivalent to de facto forbidding trade. Similarly, if the profit tax is 100%, the buyer will not buy.

information costs are supposed to be smaller. They are also stronger for traded units in smaller projects where the value of information is supposed to be larger. Furthermore, based on trading activity we classified some investors as flippers (or sophisticated investors) and show that the volume and price effects in the presale markets are stronger for flippers' trades.

The policy implications of the two tax instruments depend on whether an increase in the probability of trade (liquidity and turnover) is socially desirable and they are diametrically opposed. Trades though individually rational might be socially excessive because e.g. they have implications for financial stability and negative externalities on tax payers. Especially, this phenomenon is controversially discussed in the context of high frequency trading in stock markets, emphasizing distortionary and manipulative effects on equity prices as opposed to liquidity increases and the reduction of bid ask spreads and transaction costs for investors. Thus, parallel questions on the effects of taxes on capital gains versus transaction taxes arise.[23]

Asymmetric information has been considered a main problem in decentralized debt funding markets in the course of the financial crisis when investors became concerned about complexity and quality of the securities used to trade. In a setting where there are gains from trade and private information acquisition generates endogenous adverse selection, our theoretical analysis suggests that a tax on capital gains dominates a transaction tax. In contrast to a transaction tax, a tax on capital gains reduces the incentive to acquire information, mitigates endogenous adverse selection and increase liquidity and welfare in equilibrium.

[23] A further dimension of the problem relates to the choice between different types of information and situations in which information has a social value and agents can learn about the gains from trade. These are interesting questions but beyond the scope of this paper. Our model proposes a tractable setting that might be generalized so as to address further related questions.

Table 1: Summary Statistics

The main sample covers 47,214 transactions from 813 non-land projects in Singapore from December 2005 and December 2007. These transactions can be consolidated into 10,046 project-month observations. Panel A provides information about transactions. A transaction is in *Presale Market* if the unit traded is in a project that is still under construction at the transaction date. Otherwise it is labeled as *Spot Market*, i.e. the unit traded is in a completed one. *Unit size* is the size of a traded unit measured in square meter and *Unit Price* is the price per square meter in Singapore dollar (SGD). *Central* denotes that the project is located in the Central region. Panel B provides information about the geographic locations of the transactions and projects. The monthly average of total transactions and projects that have units traded in a month for the presale, spot and total markets, respectively are reported. Panel C provides information about transactions on the project-month level which is used for our empirical analysis. For each project, the *Project size* is the total number of available units in the project. *No. of transactions* is the total number of units traded in a project in a given month. *Project turnover* is defined as the number of transactions in a project in a month normalized by the project units. *Unit Price* is the average unit price of all transactions in a project in a month (per square meter in SDG). *Presale* is a dummy variable which is equal to 1 if a project is in presale market (uncompleted projects) in a given month, and 0 otherwise. *Total No. of transactions* is the number of all traded units across all projects in a month. *Total Transaction Value* is the sum of market prices of all transactions across all projects in a month in million SGD.

Panel A: Transactions in the presale and spot markets

	Obs	mean	min	p25	p50	p75	max	sd
Presale Market								
Unit size (sqm)	22,404	131	32	91	118	149	10,520	103
Unit price (SGD/sqm)	22,404	12,096	2,347	7,239	9,713	15,390	53,816	7,040
Central	22,404	0.72	0	0	1	1	1	0.45
Spot Market								
Unit size (sqm)	24,810	143	38	106	120	149	32,931	313
Unit price (SGD/sqm)	24,810	8,086	1,825	5,088	6,743	9,760	42,328	4,427
Central	24,810	0.53	0	0	1	1	1	0.50
Spot & Presale Market								
Unit size (sqm)	47,214	137	32	99	120	149	32,931	238
Unit price (SGD/sqm)	47,214	9,989	1,825	5,924	8,052	12,185	53,816	6,150
Central	47,214	0.62	0	0	1	1	1	0.48

Panel B: Number of transactions and projects with units traded (monthly average)

	Total		*Presale*		*Spot*	
Region	No. of transactions	No. of Projects	No. of transactions	No. of Projects	No. of transactions	No. of Projects
Central Region	1228	255	679	67	549	188
East Region	268	62	72	8	195	54
North East Region	118	33	30	4	89	29
North Region	59	14	19	2	41	12
West Region	297	55	137	8	160	48
Total	1970	419	937	88	1034	330

Panel C: Project-Month level characteristics								
	Obs	mean	min	p25	p50	p75	max	sd
Project-month observations								
No. of transactions	10,046	4.7	1	1	2	4	413	12
Transaction size (sqm)	10,046	646	32	146	288	593	48,993	1,771
Transaction value ('000 SGD)	10,046	6,763	160	997	2,049	4,791	891,000	25,000
Project turnover	10,046	0.036	0.001	0.011	0.020	0.033	1.000	0.073
Unit Price (SGD/sqm)	10,046	8,702	1,825	5,159	6,980	10,479	49,053	5,375
Cross-sectional variable								
Project Size	813	136	30	46	79	165	1,156	142
Time-series variable								
Total No. of transactions	24	1,970	834	1,300	1,566	2,424	4,388	950
Total Transaction value (mil SGD)	24	2,831	893	1,677	2,546	3,368	6,287	1,554

Table 2: Turnover, Prices and Transaction Tax

This table reports the regression results for the main sample. *Project turnover* is defined as the number of units traded in a project in a month normalized by the project size (the total number of units in the project). *lnprice* is defined as the natural logarithm of the project average unit price (before-tax) of observed transactions. *Post* is a dummy variable that takes the value 1 if the month is January 2007 or later. It is 0 if the month is November 2006 or earlier. *Presale* is a dummy variable which is equal to 1 if the project is in the presale market. It is 0 if the project is in spot market, i.e. completed projects. Project fixed effects are added to control for project size, project age and other time-invariant project characteristics. Month fixed effects are added to control for macroeconomic factors such as interest rate, GDP and income growth in Singapore. The standard errors are clustered by regions. We also report the statistical significance of coefficients based on a t-test, with ***, **, * denoting 1%, 5%, and 10% significance respectively. T-values are in bracket.

	[(2005:12):(2007:12)]		[(2006:6):(2007:6)]	
	(1)	(2)	(3)	(4)
	Project turnover	*lnPrice*	*Project turnover*	*lnPrice*
Presale×Post	-0.0451***	-0.0471*	-0.0345***	-0.0313
	(-9.2)	(-2.4)	(-5.7)	(-2.0)
Presale	0.0099**	0.0417***	0.0035	0.0222***
	(4.2)	(7.4)	(1.2)	(15.0)
Project Fixed Effect	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Observations	9,999	9,999	5,336	5,336
R-squared	0.329	0.96	0.394	0.97

Table 3: Location, Turnover, Prices and Transaction Tax

This table reports the regression results for subsamples according to the locations of the project. *Project turnover* is defined as the number of units traded in a project in a month normalized by the project size (the total number of units in the project). *lnprice* is defined as the natural logarithm of the project average unit price (before-tax) of observed transactions. *Post* is a dummy variable that takes the value 1 if the month is January 2007 or later. It is 0 if the month is November 2006 or earlier. *Presale* is a dummy variable which is equal to 1 if the project is in the presale market. It is 0 if the project is in spot market, i.e. completed projects. The results under *Central* subsample are for the observations located in the central region in Singapore, while the results under *Non-central* subsample are for the other observations. Project fixed effects and time fixed effects are added. The standard errors are clustered by regions. We also report the statistical significance of coefficients based on a t-test, with ***, **, * denoting 1%, 5%, and 10% significance respectively.

	Project turnover				*lnPrice*			
	[(2005:12):(2007:12)]		[(2006:6):(2007:6)]		[(2005:12):(2007:12)]		[(2006:6):(2007:6)]	
	(1)		(2)		(3)		(4)	
	Central	*Non-central*	*Central*	*Non-central*	*Central*	*Non-central*	*Central*	*Non-central*
Presale×Post	-0.0457***	-0.0421	-0.0368***	-0.0303	-0.0830***	-0.0545	-0.0584***	-0.0384
	(-7.5)	(-1.9)	(-4.7)	(-1.1)	(-12.8)	(-1.9)	(-7.9)	(-1.3)
Presale	0.0085**	0.0107	0.0069	-0.0023	0.0481***	0.0602**	0.0267**	0.0325
	(2.5)	(1.7)	(1.6)	(-0.6)	(5.1)	(5.3)	(2.2)	(1.9)
Project Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,074	3,925	3,283	2,053	6,074	3,925	3,283	2,053
R-squared	0.306	0.377	0.364	0.448	0.96	0.90	0.97	0.91

Table 4: Project Size, Turnover, Prices and Transaction Tax

This table reports the regression results for subsamples based on project size. In Panel A reports the results for projects with size of less than 30 units. Panel B reports the results for projects with size of less than 20 units. *Project turnover* is defined as the number of units traded in a project in a month normalized by the project size (the total number of units in the project). The *lnprice* is defined as the natural logarithm of the project average unit price (before-tax) of observed transactions. *Post* is a dummy variable that takes the value 1 if the month is January 2007 or later. It is 0 if the month is November 2006 or earlier. *Presale* is a dummy variable which is equal to 1 if the project is in the presale market. It is 0 if the project is in spot market, i.e. completed projects. Project fixed effects and time fixed effects are added. The standard errors are clustered by regions. We also report the statistical significance of coefficients based on a t-test, with ***, **, * denoting 1%, 5%, and 10% significance respectively.

	Project size<30 Units			
	[(2005:12):(2007:12)]		[(2006:6):(2007:6)]	
	(1)	(2)	(3)	(4)
	Project turnover	*lnPrice*	*Project turnover*	*lnPrice*
Presale×Post	-0.0950***	-0.1582***	-0.1014***	-0.1613***
	(-21.1)	(-15.4)	(-14.3)	(-8.0)
Presale	0.0788***	0.1438***	0.0521**	0.1281***
	(9.2)	(8.0)	(3.7)	(28.3)
	Project size<20 Units			
	[(2005:12):(2007:12)]		[(2006:6):(2007:6)]	
	(1)	(2)	(3)	(4)
	Project turnover	*lnPrice*	*Project turnover*	*lnPrice*
Presale×Post	-0.1001***	-0.1801***	-0.1048***	-0.1887***
	(-7.0)	(-8.1)	(-8.0)	(-5.2)
Presale	0.0900***	0.1703**	0.0704*	0.1558***
	(4.8)	(3.6)	(2.5)	(5.5)
Project Fixed Effect	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes

Table 5: Flippers' Trades, Turnover, Prices and Transaction Tax

This table reports the regression results for subsamples based on flipper's trades. The presale projects are separated in two types: the flipper traded projects and non-flipper traded projects. *Project turnover* is defined as the number of units traded in a project in a month normalized by the project size (the total number of units in the project). *lnprice* is defined as the natural logarithm of the project average unit price (before-tax) of observed transactions. *Post* is a dummy variable that takes the value 1 if the month is January 2007 or later. It is 0 if the month is November 2006 or earlier. *Presale* is a dummy variable which is equal to 1 if the project is in the presale market. It is 0 if the project is in spot market, i.e. completed projects. Project fixed effects and time fixed effects are added. The standard errors are clustered by regions. We also report the statistical significance of coefficients based on a t-test, with ***, **, * denoting 1%, 5%, and 10% significance respectively.

	(1)	(2)	(3)	(4)
Dependent Variable:	*Project turnover*		*lnPrice*	
	Flipper traded	*Non-Flipper Traded*	*Flipper traded*	*Non-Flipper Traded*
	[(2005:12):(2007:12)]			
Presale×Post	-0.0521***	-0.0364***	-0.0473*	-0.0451
	(-8.9)	(-7.1)	(-2.6)	(-1.9)
Presale	0.0157**	0.0055**	0.0256	0.0576***
	(3.9)	(2.9)	(1.1)	(4.8)
	[(2006:6):(2007:6)]			
Presale×Post	-0.0430***	-0.0244**	-0.0365**	-0.0237
	(-6.3)	(-4.0)	(-2.8)	(-1.1)
Presale	0.0042***	0.0029	-0.0023	0.0426***
	(4.6)	(0.6)	(-0.1)	(9.6)
Project Fixed Effect	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes

Table 6: Robustness

This table reports the robustness of benchmark regression results by adding the lag of depend variables as control. *Project turnover* is defined as the number of units traded in a project in a month normalized by the project size (the total number of units in the project). *lnprice* is defined as the natural logarithm of the project average unit price (before-tax) of observed transactions. *Post* is a dummy variable that takes the value 1 if the month is January 2007 or later. It is 0 if the month is November 2006 or earlier. *Presale* is a dummy variable which is equal to 1 if the project is in the presale market. It is 0 if the project is in spot market, i.e. completed projects. The *lagY* represents the *lagPrice* (*lagturnover)* which is the *LnPrice* (*Project turnover)* in last trading month. Project fixed effects and time fixed effects are added. The standard errors are clustered by regions. We also report the statistical significance of coefficients based on a t-test, with ***, **, * denoting 1%, 5%, and 10% significance respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable:		*Project turnover*			*lnPrice*	
	Full Sample	*Central*	*Non-central*	*Full Sample*	*Central*	*Non-central*
			[(2005:12):(2007:12)]			
Presale×Post	-0.0406***	-0.0414***	-0.0369	-0.027	-0.0568***	-0.0264
	(-10.4)	(-6.5)	(-2.0)	(-1.8)	(-9.0)	(-2.1)
Presale	0.0100***	0.0095***	0.0094	0.0294***	0.0372***	0.0411**
	(4.9)	(2.9)	(1.6)	(7.8)	(4.2)	(4.6)
LagY	0.0116	0.0224	-0.0326	0.3880***	0.3230***	0.3148***
	(0.8)	(0.6)	(-0.6)	(16.4)	(17.6)	(6.9)
			[(2006:6):(2007:6)]			
Presale×Post	-0.0368***	-0.0391***	-0.0301	-0.025	-0.0504***	-0.0236
	(-5.7)	(-4.4)	(-1.0)	(-1.8)	(-6.8)	(-1.3)
Presale	0.0028	0.0066	-0.0036	0.0187***	0.0246**	0.0268
	(0.9)	(1.5)	(-0.9)	(11.1)	(2.2)	(2.0)
LagY	-0.0614	-0.0289	-0.1620***	0.2622***	0.2085***	0.1682**
	(-1.7)	(-0.5)	(-9.0)	(12.3)	(7.7)	(4.7)
Project Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes

APPENDIX A

A.1 Comparative statics of the value of information V_I and V_{II}

Consider first the value of information V_I.

Lemma A.1 (Comparative statics of V_I)

(i) Suppose that $p+\kappa > x_L$. If the buyer is the responder, V_I is (a) strictly increasing in the price p, (b) independent of the profit tax τ, and (c) strictly increasing in the transaction tax κ.

(ii) Suppose that $p < x_H$. If the seller is the responder, V_I is (a) strictly decreasing in the price p, (b) strictly decreasing in the profit tax τ, and (c) independent of the transaction tax κ.

Proof: This result follows directly from the definition of V_I. Consider first part (i). The buyer pays a profit tax if and only if he buys and the payoff of the asset is above the price paid. Hence, for the buyer,

$$\begin{aligned} V_I(p,\tau,\kappa) &= \int_{p+\kappa}^{x_H}(1-\tau)(x-(p+\kappa))dF(x) - \left[\int_{x_L}^{p+\kappa}(x-(p+\kappa))dF(x) + \int_{p+\kappa}^{x_H}(1-\tau)(x-(p+\kappa))dF(x)\right] \\ &= \int_{x_L}^{p+\kappa}((p+\kappa)-x)dF(x), \end{aligned}$$

which is strictly increasing in p and in κ but independent of τ.

For part (ii), the seller pays a profit tax if he does not sell and the return is above the 'book value' p_0 or if he sells at price p above p_0. Thus, for the seller as responder we get

$$\begin{aligned} V_I(p,\tau,\kappa) &= \int_{x_L}^{p}(p-\tau\max\{p-p_0,0\})dF(x) + \int_{p}^{x_H}(x-\tau\max\{x-p_0,0\})dF(x) - \int_{x_L}^{x_H}(p-\tau\max\{p-p_0,0\})dF(x) \\ &= \int_{p}^{x_H}(x-p-(\tau\max\{x-p_0,0\}-\tau\max\{p-p_0,0\}))dF(x), \end{aligned}$$

which is strictly decreasing in p (due to $\tau < 1$) and independent of κ (since by definition the relevant price for the seller is the net-of-tax price p). Moreover,

$$\frac{\partial V_I}{\partial \tau} = \int_{p}^{x_H}(\max\{p-p_0,0\}-\max\{x-p_0,0\})dF(x) < \int_{p}^{x_H}(\max\{x-p_0,0\}-\max\{x-p_0,0\})dF(x) = 0.$$

Thus, V_I is strictly decreasing in τ if the seller is the responder. ■

Now we turn to the value of information V_{II}.

Lemma A.2 (Comparative statics of V_{II})

(i) Suppose that $p+\kappa < x_H$. If the buyer is the responder, V_{II} is (a) strictly decreasing in the price p, (b) strictly decreasing in the profit tax τ, and (c) strictly decreasing in the transaction tax κ.

(ii) If the seller is the responder, V_{II} is (a) strictly increasing in the price p, (b) decreasing in the profit tax τ (strictly decreasing only if p_0 < p), and (c) independent of the transaction tax κ.

Proof: Part (i) follows directly from the fact that for the buyer as responder,

$$V_{II}(p,\tau,\kappa) = \int_{p+\kappa}^{x_H} (1-\tau)\big(x-(p+\kappa)\big)dF(x)\,.$$

For part (ii), note that for the seller as responder

$$V_{II}(p,\tau,\kappa) = \int_{x_L}^{p} \big(p-x-\big(\tau\max\{p-p_0,0\}-\tau\max\{x-p_0,0\}\big)\big)dF(x),$$

which is independent of κ and strictly increasing in p (due to $\tau < 1$). Finally,

$$\frac{\partial V_{II}}{\partial \tau} = \int_{x_L}^{p} \big(\max\{x-p_0,0\}-\max\{p-p_0,0\}\big)dF(x) \le \int_{x_L}^{p} \big(\max\{x-p_0,0\}-\max\{x-p_0,0\}\big)dF(x) = 0,$$

therefore V_{II} decreases in τ (strictly if and only if $p_0 < p$; otherwise, V_{II} is independent of τ). ■

A.2 Proof of Lemma 1

Part (i): Since $V_I \le V_{II}$ is equivalent to $E_x[u_R(x,p,\tau,\kappa,0)] \le E_x[u_R(x,p,\tau,\kappa,1)]$, the responder prefers to trade uninformed over no trade. Moreover, $V_I \le \gamma$ implies that the responder prefers to trade uninformed over information acquisition.

Part (ii): With $V_I > \gamma$, the responder prefers information acquisition over trading uninformed. Moreover, the responder's expected gain from information acquisition compared to his outside option is $V_{II} - \gamma \ge 0$; hence, he can cover the information cost.

Part (iii): Since $V_{II} < V_I$ is equivalent to $E_x[u_R(x,p,\tau,\kappa,0)] > E_x[u_R(x,p,\tau,\kappa,1)]$, an uninformed responder does not trade. Moreover, since $V_{II} < \gamma$, the gain from information acquisition is smaller than the cost, and the responder's optimal choice is his outside option (no information acquisition and no trade), irrespectively of whether $V_I > \gamma$ or not.

A.3 Proof of Proposition 1

At $\gamma = \underline{\gamma}$, the proposer is indifferent between inducing the responder to trade with probability one (without information acquisition) on one hand and information acquisition and trade according to q* on the other hand.

Part (i): Suppose that $\gamma \ge V_I(\bar{p},\tau,\kappa)$. With Definition 2(i) and the definitions of V_I and V_{II}, this implies that $V_I(\bar{p},\tau,\kappa) = V_{II}(\bar{p},\tau,\kappa) \le \gamma$; hence, by Lemma 1(i), the responder trades without information acquisition. In fact, the responder's expected utility is the same as if he chooses not to participate; therefore, there is no other price that the proposer strictly prefers to $\bar{p}$ and where the responder still trades with probability one. Moreover, the proposer also strictly prefers $\bar{p}$ to p_{II} since, at p_{II}, there is trade with lower probability and, in addition, the responder has to be compensated for the cost of information (he must still get at least what he gets when choosing not to participate). This shows part (i).

Part (ii): Note first that $E_x[u_P(x, p_I, \tau, \kappa, 1)]$ is continuous and increasing in γ. Continuity in γ follows from continuity of $u_P(x,p,\tau,\kappa,1)$ in p and the definition of p_I. For monotonicity in γ, notice that $p_I \in \arg\max_p E_x[u_P(x, p_I, \tau, \kappa, 1)]$ s.t. $V_I(p,\tau,\kappa) \leq \gamma$ and that, at the optimal price p_I, the constraint $V_I \leq \gamma$ must be binding. Hence, if p_I is charged and trade occurs with probability one, then an increase in the cost of information makes the proposer strictly better off. (Intuitively, the constraint $V_I \leq \gamma$ is relaxed.)

By part (i), at $\gamma = V_I(\bar{p}, \tau, \kappa)$ the proposer strictly prefers an offer $\bar{p} = p_I$ over an offer p_{II}. By continuity and monotonicity of $E_x[u_P(x, p_I, \tau, \kappa, 1)]$, there exists $\delta > 0$ such that the proposer strictly prefers p_I over p_{II} for all $\gamma \in (V_I(\bar{p}, \tau, \kappa) - \delta, V_I(\bar{p}, \tau, \kappa)]$. Finally, if $\gamma < V_I(\bar{p}, \tau, \kappa)$ and the proposer offers $\bar{p}$, then the responder will acquire information; thus, by definition of p_{II}, the proposer (weakly) prefers p_{II} over $\bar{p}$. Altogether this shows part (ii).

Part (iii): First of all, if γ approaches zero, then the proposer cannot avoid information acquisition of the responder, and therefore the proposer's optimal choice will be p_{II}. (This requires, of course, that the proposer is willing to trade with an informed responder, i.e., it requires that the value of the proposer's outside option is sufficiently low such that $E_x[u_P(x, p_{II}, \tau, \kappa, q^*(x, p_{II}, \tau, \kappa))] \geq \bar{u}_P$.) Second, $E_x[u_P(x, p_{II}, \tau, \kappa, q^*(x, p_{II}, \tau, \kappa))]$ is (weakly) decreasing in γ: If p_{II} is the unconstrained optimum, i.e. $V_{II}(p_{II},\tau,\kappa) < \gamma$, then a marginal increase in γ does not affect p_{II} (because then the proposer's utility does not depend on γ). If, however, $V_{II}(p_{II},\tau,\kappa) = \gamma$, an increase in γ makes the proposer worse off. (Intuitively, the proposer must leave a higher share in the surplus to the responder in order to compensate him for the higher cost of information and to ensure that the responder does not choose his outside option $\bar{u}_R$.) Therefore, the monotonicity properties of $E_x[u_P(x, p_I, \tau, \kappa, 1)]$ and $E_x[u_P(x, p_{II}, \tau, \kappa, q^*(x, p_{II}, \tau, \kappa))]$ imply there is a threshold $\underline{\gamma}$ such that the proposer offers p_{II} if and only if $\gamma < \underline{\gamma}$.

A.4 Proof of Lemma 2

Part (i): Consider first the effect on $\bar{p}$. By Definition 2(i), $V_I(\bar{p},\tau,\kappa)=V_{II}(\bar{p},\tau,\kappa)$. If the buyer is the responder, V_I is independent of τ (Lemma A.1(i)). Since V_{II} is strictly decreasing in τ and in p (Lemma A.2(i)), an increase in τ must be compensated by a decrease in p; thus, $\partial\bar{p}/\partial\tau < 0$. By a similar argument, since V_I is independent of τ and p_I is defined such that $V_I = \gamma$ (Definition 2(ii)), we get $\partial p_I/\partial\tau = 0$.

Now consider the effect on p_{II}. Suppose first that the buyer's participation constraint is binding: $V_{II}(p_{II},\tau,\kappa) = \gamma$. Since V_{II} is strictly decreasing in τ, the seller must strictly lower the price p_{II} if τ is increased; otherwise, $V_{II} < \gamma$ and the buyer strictly prefers his outside option $\bar{u}_B = 0$ to information acquisition (Lemma 1(iii)). If the buyer's participation constraint does not bind ($V_{II}(p_{II},\tau,\kappa) > \gamma$), a marginal increase in the profit tax τ has no effect on the price p_{II}; it does not affect the buyer's buying decision but only reduces the buyer's profit that results from his informational advantage. Altogether, this shows part (i).

Part (ii): Consider first the effect on $\bar{p}$ and suppose that $p_0 \leq x_L$. If the seller does not trade, she always pays a tax and her expected utility is $E[x]-\tau\cdot(E[x]-p_0)$. If she sells her utility is $p-\tau(p-p_0)$. Thus the buyer proposes $\bar{p}=E[x]$ and $d\bar{p}/d\tau=0$. For $p_0 > x_H$, there is no tax to be paid. The buyer offers $\bar{p}=E[x]$ and $d\bar{p}/d\tau=0$. For $x_L < p_0 < x_H$, the seller compares $E[x]-\tau\left(\int_{p_0}^{x_H}(x-p_0)dF(x)\right)$ with $p-\tau\cdot\max[p-p_0,0]$. So $\bar{p}=E[x]$ $-\tau\left(\int_{p_0}^{x_H}(x-p_0)dF(x)-(\bar{p}-p_0)\right)$. Since $\bar{p}\leq E[x]$ (which is the maximum price the buyer offers if $\tau=0$) the first term in the bracket is larger than the second term and thus $d\bar{p}/d\tau<0$

Now turn to p_I. Since V_I is strictly decreasing in p and strictly decreasing in τ (Lemma A.1), we have $\partial p_I/\partial\tau < 0$. Similarly, since V_{II} is strictly decreasing in τ and strictly increasing in p, we must have $\partial p_{II}/\partial\tau > 0$ if $V_{II}(p_{II},\tau,\kappa) = \gamma$ such that the seller's participation constraint binds. Otherwise, if $V_{II}(p_{II},\tau,\kappa) > \gamma$, then profit taxation reduces the seller's information rents but does not affect the price p_{II}, just as in the case where the buyer is the responder.

A.5 Proof of Proposition 2

Part (i) follows directly from Lemma 2. If the buyer is the responder and the price p_{II} decreases, then the probability of trade is increased (as an informed buyer trades if and only if $x > p$). If the seller is the responder and the price p_{II} increases, then again the probability of trade is increased (as an informed seller trades if and only if $x < p$). In both cases, an increase in the profit tax *strictly* increases the probability of trade if and only if $V_{II}(p_{II},\tau,\kappa) = \gamma$.

For part (ii), recall that, at $\gamma = \underline{\gamma}$, we have $E_x[u_P(x, p_I, \tau, \kappa, 1)] = E_x[u_P(x, p_{II}, \tau, \kappa, q^*)]$. Suppose first that the seller makes the offer. By Lemma 2(i), $\partial p_I/\partial\tau = 0$ and $\partial p_{II}/\partial\tau \leq 0$. Therefore, the seller's utility from charging p_I is not affected by an increase in τ, but his expected utility in the equilibrium candidate with information acquisition is (weakly) reduced because the price p_{II} decreases. (Since, in the equilibrium candidate with information acquisition, the seller could have charged a lower price already before the tax increase, lowering the price p_{II} must make him (weakly) worse off.) Therefore, at $\gamma = \underline{\gamma}$, the seller now (weakly) prefers p_I over p_{II}, which shifts the threshold $\underline{\gamma}$ to the left. If $\partial p_{II}/\partial\tau = 0$, then $\partial\underline{\gamma}/\partial\tau = 0$, and if $\partial p_{II}/\partial\tau < 0$, then $\partial\underline{\gamma}/\partial\tau < 0$.

Now suppose that the buyer makes the offer. By Lemma 2(ii), a marginal increase in τ leads to a reduction in p_I, which makes the buyer strictly better off (he still gets the asset with probability one but at a lower price). Moreover, a marginal increase in τ (weakly) increases p_{II}, which makes the buyer (weakly) worse off: He gets the asset with a higher probability but pays a higher price for it. Since the buyer could have offered this higher price already before the increase in τ, the price increase must reduce his profit. (For prices p above p_{II}, an informed seller's participation constraint $E_x[u_S(x, p, \tau, \kappa, q^*)] - \gamma \geq \bar{u}_S$ is still fulfilled.) The two effects of an increase in τ on p_I and p_{II} directly imply that, at $\gamma = \underline{\gamma}$, the buyer now strictly prefers p_I over p_{II}. Therefore, $\underline{\gamma}$ shifts to the left if τ is increased: $\partial\underline{\gamma}/\partial\tau < 0$.

A.6 Proof of Lemma 3

Part (i): Since, by definition, the sales tax has to be paid by the buyer, the relevant price for the buyer is the tax-inclusive price $p+\kappa$. At $\bar{p}$, it holds that $E_x[u_B(x, \bar{p}, \tau, \kappa, 1) = 0$. Thus, if κ is increased, the net-of-tax price $\bar{p}$ must be lowered by exactly the same amount such that the tax-inclusive price remains unchanged: $\partial(\bar{p} + \kappa)/\partial\kappa = 0$. By definition of p_I, the same arguments shows that $\partial(p_I+\kappa)/\partial\kappa = 0$.

Regarding p_{II}, recall that V_{II} is strictly decreasing in κ (Lemma A.2(i)). Therefore, if the buyer's participation constraint is binding at p_{II} ($V_{II}(p_{II},\tau,\kappa) = \gamma$) and κ is increased, then again p_{II} must be lowered by the same amount such that $\partial(p_{II}+\kappa)/\partial\kappa = 0$. Now suppose instead that the buyer's participation constraint is not binding ($V_{II}(p_{II},\tau,\kappa) > \gamma$). Then, p_{II} is the solution to the first order condition $\partial E_x[u_S(x, p, \tau, \kappa, q^*(x, p, \tau, \kappa)) / \partial p = 0$; hence, p_{II} solves

$$(v_S(p_{II} + \kappa) - p_{II})F'(p_{II} + \kappa) + 1 - F(p_{II} + \kappa) = 0.$$

With $\partial(p_{II}+\kappa)/\partial\kappa = \partial p_{II}/\partial\kappa + 1$, total differentiation yields

$$\frac{\partial(p_{II}+\kappa)}{\partial\kappa} = -\frac{(v_S'(p_{II}+\kappa)-1)F'(p_{II}+\kappa)+(v_S(p_{II}+\kappa)-p_{II})F''(p_{II}+\kappa)}{(v_S'(p_{II}+\kappa)-2)F'(p_{II}+\kappa)+(v_S(p_{II}+\kappa)-p_{II})F''(p_{II}+\kappa)}+1$$
$$= -\frac{F'(p_{II}+\kappa)}{\partial^2 E_x[u_S(x,p,\tau,\kappa,q^*(x,p,\tau,\kappa))]/\partial p^2\,|_{p=p_{II}}} > 0.$$

Therefore, a marginal increase in κ strictly increases the tax-inclusive price $p_{II}+\kappa$ if the buyer's participation constraint is not binding.[24] It is worth mentioning that this result is robust to the case of an ad valorem sales tax (where the tax-inclusive price equals $(1+\kappa)p$).[25]

Part (ii): Since the seller's decision whether to trade is based only on the net-of-tax price p, it follows directly that $\bar{p}$ and p_I are independent of κ. Moreover, if for a price p_{II} the seller's participation constraint is binding such that $V_{II}(p_{II},\tau,\kappa) = \gamma$, then $\partial V_{II}/\partial\kappa = 0$ (Lemma A.2(ii)) implies that $\partial p_{II}/\partial\kappa = 0$. (Even if the buyer wants to shift part of the tax increase to the seller by lowering his offer, this is not possible because then the seller would prefer his outside option of no trade.)

If instead $V_{II}(p_{II},\tau,\kappa) > \gamma$, then p_{II} solves the first order condition

$$\frac{\partial}{\partial p}E_x\left[u_B(x,p,\tau,\kappa,q^*(x,p,\tau,\kappa))\right] = (v_B(p)-(p+\kappa))F'(p)-F(p) = 0.$$

Total differentiation yields

$$\frac{\partial p_{II}}{\partial\kappa} = -\frac{-F'(\kappa)}{\left.\frac{\partial^2}{\partial p^2}E_x[u_B(x,p,\tau,\kappa,q^*(x,p,\tau,\kappa))]\right|_{p=p_{II}}} < 0.$$

Again, this result on the sales tax does not qualitatively depend on the sales tax being a per unit tax; if instead we consider an ad valorem sales tax κ, which raises the buyer's price from p to $(1+\kappa)p$, then, by total differentiating, we also obtain $\partial p_{II}/\partial\kappa < 0$ if the seller's participation constraint is not binding.

A.7 Proof of Proposition 3

Part (i): By Lemma 3(i), if the seller makes the offer, the tax-inclusive price is increasing in κ, which reduces the probability that an informed buyer buys. By Lemma 3(ii), if the buyer makes the offer, the net-of-tax price is decreasing in κ, which again leads to less trade. In both

[24] Note that, for the net-of-tax price, it is not obvious whether $\partial p_{II}/\partial\kappa$ is positive or negative. If, for instance, F is a uniform distribution and $v_S(x) = 0$ (the seller derives no value from holding the asset), then $\partial p_{II}/\partial\kappa = -0.5$: The seller shifts 50% of the tax increase to the buyer and reduces the net-of-tax price by the remaining amount.

[25] For an ad valorem sales tax, we obtain, $\partial((1+\kappa)p_{II})/\partial\kappa = -v_S((1+\kappa)p_{II})F'((1+\kappa)p_{II})/(\partial^2 E_x[u_S(x,p,\tau,\kappa,q^*)]/\partial p^2)$ which is strictly positive unless $v_S(x) = 0$. The latter case is a special case in which the optimal tax-inclusive price $z = (1+\kappa)p_{II}$ is independent of κ.

cases, the probability of trade is *strictly* reduced if and only if the responder's participation constraint does not bind ($V_{II}(p_{II},\tau,\kappa) > \gamma$).

Part (ii): Suppose first that the seller is the proposer. From Lemma 3(i), $\partial(p_I+\kappa)/\partial\kappa = 0$ and $\partial(p_{II}+\kappa)/\partial\kappa \geq 0$. Since $u_S(x,p_I,\tau,\kappa,1) = p_I$, we get

$$\partial u_S(x, p_I, \tau, \kappa, 1)/\partial\kappa = \partial p_I/\partial\kappa = \partial(p_I+\kappa)/\partial\kappa - 1 = -1.$$

Regarding the candidate price p_{II}, notice that

$$E_x\left[u_S(x, p_{II}, \tau, \kappa, q^*(x, p_{II}, \tau, \kappa))\right] = \int_{x_L}^{p_{II}+\kappa} v_S(x)dF(x) + \int_{p_{II}+\kappa}^{x_H} p_{II}dF(x).$$

Suppose first that $\partial(p_{II}+\kappa)/\partial\kappa = 0$. Then,

$$\partial E_x\left[u_S(x, p_{II}, \tau, \kappa, q^*(x, p_{II}, \tau, \kappa))\right]/\partial\kappa = (1 - F(p_{II}+\kappa))(\partial p_{II}/\partial\kappa) = -(1 - F(p_{II}+\kappa)).$$

Thus, the seller's profit from charging p_{II} decreases by less than his profit from charging p_I, and $\underline{\gamma}$ shifts to the right if κ is increased ($\partial\underline{\gamma}/\partial\kappa > 0$). Now suppose that $\partial(p_{II}+\kappa)/\partial\kappa > 0$. If the equilibrium candidate price $p_{II}+\kappa$ is increased following a tax increase, the seller must be strictly better off than if he had not changed the price (which would have been possible; lower prices would not violate the buyer's participation constraint). But as shown before, even if $p_{II}+\kappa$ remained unchanged, the seller would, at $\gamma = \underline{\gamma}$, strictly prefer p_{II} over p_I. Therefore, this must still hold true if the seller adjusts the price p_{II} such that $\partial(p_{II}+\kappa)/\partial\kappa > 0$. Hence, again we get $\partial\underline{\gamma}/\partial\kappa > 0$.[26]

If the buyer is the proposer, indifference of the buyer as the proposer at $\gamma = \underline{\gamma}$ implies that

$$E[v_B(x)] - (p_I + \kappa) = \int_{x_L}^{p_{II}} (v_B(x) - (p_{II}+\kappa))dF(x).$$

By Lemma 3(ii), a marginal increase in κ has no effect on p_I but increases the buyer's tax burden. The marginal change in the buyer's profit is −1 (which can be obtained by deriving the left hand side in the above equality with respect to κ). Again by Lemma 3(ii), if the seller's participation constraint is binding, a marginal increase does not have any effect on p_{II} either; however, the buyer faces a higher tax burden only with probability $F(p_{II})$ (in case he buys).[27] Therefore, the marginal change in the buyer's profit when offering p_{II} is equal to −

[26] Qualitatively the same result holds for an ad valorem transaction tax (levied as percentage of the price): Due to the same comparative statics effects for p_I and p_{II} as in Lemma 5 (unless $v_S(x) = 0$ for all $x < (1+\kappa)p_{II}$ in the case where the seller is the proposer), similar arguments as in the proof of Proposition 3 can be applied for an ad valorem tax.

[27] In case of a per unit transaction tax, the change in the tax burden does not depend on the price. For an ad valorem tax, this is no longer true; here, however, the argument becomes even stronger: Since it holds that $p_{II} < p_I$ (the buyer offers a lower price when buying from an informed seller who only sells in low payoff states), the increase in the tax-inclusive price for a given increase in the ad valorem transaction tax is lower if the buyer offers p_{II}.

$F(p_{II}) > -1$. Moreover, if the seller's participation constraint is not binding, it holds that $\partial p_{II}/\partial\kappa < 0$. The first order effect of this marginal change in the optimal price p_{II}, however, is equal to zero, and again the marginal change in the buyer's profit when offering p_{II} is equal to $-F(p_{II}) > -1$. (This can easily be verified by deriving the right hand side of the above equation with respect to κ, taking into account that $\partial E_x[u_B(x,p_{II},\tau,\kappa,q^*)]/\partial p_{II} = 0$ if p_{II} is the unconstraint maximum.) Since the buyer's expected profit from offering p_I is reduced more strongly than his expected profit from offering p_{II}, the buyer now strictly prefers p_{II} over p_I if $\gamma = \underline{\gamma}$. Hence, $\partial\underline{\gamma}/\partial\kappa > 0$.

APPENDIX B

In this appendix we analyze the effects of taxation on the proposer's incentives to produce information before making the price offer. We are focusing on the cases where absent of the ability of the proposer to acquire information (or in case his information cost is high), the proposer chooses to avoid information production by the responder. We consider a framework which is identical to the main model, except for the followings: First, we allow the proposer to learn the asset's payoff x at cost γ_P before he makes the price offer; we assume information production of the proposer to be unobservable to the responder and that the proposer cannot credibly reveal any private information. Second, for simplicity we ignore taxation of the responder's profits and the effects of taxation on the responder's decision to acquire information, which has been considered in the main analysis.

Consider the candidate equilibrium in which no agent acquires information. Here, the candidate equilibrium price p^* is either equal to $\overline{p}$ (as given in Definition 2(i) such that the responder is indifferent between trading uninformed and not participating) or equal to p_I (as given in Definition 2(ii) such that the responder is indifferent between trading uninformed and information production); compare also Proposition 1. If the proposer deviates from this candidate equilibrium and produces information, his price choice depends on the responder's posterior beliefs about x conditional on the offer p. We assume the following out-of-equilibrium beliefs of the responder: If the proposer offers a price $\hat{p} \neq p^*$, the responder thinks that the asset's payoff is such that trade is most unfavorable for him; that is, the buyer as the responder believes that $x = x_L$ with probability one and the seller as the responder believes that $x = x_H$ with probability one. (We still assume that x is continuous.) Given these beliefs, a proposer who deviates from the candidate equilibrium and acquires information only considers to trade at the candidate equilibrium price.[28]

Define the trading rule $\tilde{q}(x,p,\tau,\kappa)$ such that $\tilde{q}(x,p,\tau,\kappa)=1$ if $u_P(x,p,\tau,\kappa,1)\geq u_P(x,p,\tau,\kappa,0)$ and $\tilde{q}(x,p,\tau,\kappa)=0$ otherwise. Then, the proposer gets an expected utility of $E_x\left[u_P(x,p^*,\tau,\kappa,1)\right]$ in the candidate equilibrium and gets an expected utility of $E_x\left[u_P(x,p^*,\tau,\kappa,\tilde{q}(x,p^*,\tau,\kappa))\right]-\gamma_P$ if he deviates and acquires information. Thus, the proposer does not deviate if and only if $V_P(p^*,\tau,\kappa) \leq \gamma_P$ where $V_P(p,\tau,\kappa) := E_x\left[u_P(x,p,\tau,\kappa,\tilde{q}(x,p,\tau,\kappa))\right]-E_x\left[u_P(x,p,\tau,\kappa,1)\right]$.

Consider first the effect of a profit tax increase on the proposer's incentive to acquire information and suppose for simplicity that the transaction tax is equal to $\kappa = 0$.

Proposition B1

If the proposer can acquire information, an increase in the tax rate τ on the proposer's profits enlarges the range of the information cost γ_P for which trade takes place with probability one.

Proof of Proposition B1

We show that, for a given candidate equilibrium price, an increase in the profit tax τ reduces the value of information $V_P(p^*)$ and therefore enlarges the range for the information cost γ_P for which the proposer does not want to deviate and produce information. Note that the proof does not need to distinguish whether the candidate equilibrium price is $\bar{p}$ or p_I. We allow for the possibility of a loss offset as in Section 5.1.

Case (a): Suppose the seller is the proposer. The seller's expected utility in the candidate equilibrium is

$$E_x\left[u_S(x,p^*,\tau,\kappa,1)\right]=p^*-\tau\max\{p^*-p_0,0\}+\lambda\tau\max\{p_0-p^*,0\}.$$

The seller gets the price p^* and pays a profit tax if $p^* > p_0$ where p_0 is the price initially paid and is deductible for tax purposes; otherwise, if $p^* < p_0$, the seller's accounting profits are negative and the loss offset rule applies (losses are "subsidized" at rate $\lambda \geq 0$). If the seller deviates and acquires information, he trades at the candidate price p^* if and only if $v_S(x) \leq p^*$, which yields

[28]The seller as the proposer would have to choose $p = x_L$ in order to make the buyer willing to trade and prefers the higher candidate equilibrium price $p^*\in\{p_I,\bar{p}\}$ to $p = x_L$. The buyer as the proposer would have to choose $p = x_H$ in order to make the seller willing to trade and prefers the candidate equilibrium price over $p = x_H$.

$$E_x\left[u_S(x,p^*,\tau,\kappa,\tilde{q}(x,p^*,\tau,\kappa))\right]=\int_{x_L}^{v_S^{-1}(p^*)}\left(p^*-\tau\max\{p^*-p_0,0\}+\lambda\tau\max\{p_0-p^*,0\}\right)dF(x)$$
$$+\int_{v_S^{-1}(p^*)}^{x_H}\left(v_S(x)-\tau\max\{x-p_0,0\}+\lambda\tau\max\{p_0-x,0\}\right)dF(x)$$

and consists of the seller's expected utility when x is low and he sells (the first integral) and the seller's expected utility when x is high and he does not sell (the second integral), disregarding the cost of information. For the seller as the proposer, the value of deviating and producing information is equal to

$$V_P=\int_{v_S^{-1}(p^*)}^{x_H}(v_S(x)-p^*)\,dF(x)-\int_{v_S^{-1}(p^*)}^{x_H}(\tau\max\{x-p_0,0\}-\tau\max\{p^*-p_0,0\})\,dF(x)$$
$$+\int_{v_S^{-1}(p^*)}^{x_H}(\lambda\tau\max\{p_0-x,0\}-\lambda\tau\max\{p_0-p^*,0\})\,dF(x).$$

Note that V_P is very similar to the expression for V_I (compare, for instance, the proof of Lemma 1).

The candidate equilibrium price p^* is not affected by an increase in the tax on the proposer's profits, that is, $\partial p^*/\partial\tau = 0$. With $v_S(x) < v_B(x) = x$ and, hence, $x < v_S^{-1}(x)$, suppose first that $p_0 < p^* < v_S^{-1}(p^*)$. Then,

$$V_P=\int_{v_S^{-1}(p^*)}^{x_H}(v_S(x)-p^*)\,dF(x)-\int_{v_S^{-1}(p^*)}^{x_H}\tau(x-p^*)\,dF(x),$$

which directly implies that $\partial V_P/\partial\tau < 0$. If instead $p^* \le p_0$, then

$$V_P=\int_{v_S^{-1}(p^*)}^{x_H}(v_S(x)-p^*)\,dF(x)+\int_{v_S^{-1}(p^*)}^{\max\{p_0,v_S^{-1}(p^*)\}}\lambda\tau(p_0-x)\,dF(x)$$
$$-\int_{\max\{p_0,v_S^{-1}(p^*)\}}^{x_H}\tau(x-p_0)\,dF(x)-\int_{v_S^{-1}(p^*)}^{x_H}\lambda\tau(p_0-p^*)\,dF(x)$$

which again yields $\partial V_P/\partial\tau < 0$. Intuitively, if τ is increased, the seller pays more taxes if he does not sell and x turns out to be high, and he gets a higher subsidy if he sells and realizes a negative accounting profit $p^* - p_0 \le 0$; both effects lower V_P and, hence, the threshold above which trade takes place with probability one.[29]

Case (b): Suppose the buyer is the proposer. The buyer's expected utility in the candidate equilibrium is

$$E_x\left(u_B(x,p^*,\tau,\kappa,1)\right)=E_x\left(v_B(x)\right)-p^*+\int_{x_L}^{p^*}\lambda\tau(p^*-x)\,dF(x)-\int_{p^*}^{x_H}\tau(x-p^*)\,dF(x),$$

[29] Intuitively, if τ is increased, the seller pays more taxes if he does not sell and x turns out to be high; in addition, if $p^* \le p_0$, he gets a higher subsidy if he sells and realizes a negative accounting profit.

that is, his expected utility from buying the assed plus/minus the expected tax payment (which depend on whether the asset's payoff turns out to be lower or higher than the price paid). If the buyer deviates and acquires information, he proposed the candidate price p^* if and only if $v_B(x) \geq p^*$ and does not participate otherwise (or proposes any $p < p^*$, for instance). With $v_B(x) > v_S(x) = x$, the buyer's deviation payoff is

$$E_x\left(u_B(x, p^*, \tau, \kappa, \tilde{q})\right) = \int_{v_B^{-1}(p^*)}^{x_H} (x - p^*)\, dF(x) + \int_{v_B^{-1}(p^*)}^{p^*} \lambda \tau (p^* - x)\, dF(x) - \int_{p^*}^{x_H} \tau (x - p^*)\, dF(x) \cdot$$

Therefore, the buyer does not deviate from the candidate equilibrium if and only if γ_B is larger than

$$V_P = \int_{x_L}^{v_B^{-1}(p^*)} (p^* - v_B(x))\, dF(x) - \int_{x_L}^{v_B^{-1}(p^*)} \lambda \tau (p^* - x)\, dF(x) \cdot$$

This threshold is determined by an informed buyer's gain from avoiding to buy the asset in low payoff states (the first term), corrected by the tax payment in this case (the second term). Since $v_B^{-1}(p^*) < p^*$, we get $\partial V_P/\partial \tau \leq 0$, with strict inequality if and only if $\lambda > 0$. This result mirrors the result for V_I in the main analysis which is independent of τ for the buyer as the responder if $\lambda = 0$ (Lemma A.1(i)) and strictly decreasing in τ if $\lambda > 0$ (compare Figure 3).[30] Since the buyer acquires information in order to avoid the loss of buying in low payoff states, the profit tax affects the buyer's value of information (as responder or proposer) only if there is a tax treatment of losses. **QED**

The proof of this result and its intuition are similar to showing that the value of information V_I for the responder is decreasing in τ. By reducing the proposer's gain from deviating to information acquisition, profit taxation makes it more likely that trade is efficient in equilibrium. The seller as the proposer benefits from information acquisition in high payoff states where he would not sell when being informed; higher profit taxes reduce this benefit. The buyer as the proposer benefits from information acquisition in low payoff states where he would not buy when being informed; taxation of positive profits does not affect this informational benefit, but as soon as there is a tax treatment of losses, the value of information of the buyer as proposer is strictly reduced. Thus, profit taxation lowers the threshold for the information cost above which there is trade with probability one and, hence, enlarges the range in which all gains from trade are realized.

[30] Intuitively, since p^* is not affected by an increase in the tax on the proposer's profits, it follows directly that $\partial V_P/\partial \tau \leq 0$, with strict inequality if and only if $\lambda > 0$.

Now consider the effect of an increase in the transaction tax κ on the proposer's incentive to acquire information and assume for simplicity that $\tau = 0$.

<u>Proposition B2</u>

If the proposer can acquire information, an increase in the transaction tax κ reduces the range of the information cost γ_P for which trade takes place with probability one.

Proof of Proposition B2

Recall that the sales tax is levied on the buyer. Suppose first that the seller is the proposer. With p^* is the net-of-tax candidate equilibrium price which the seller proposes, we get

$$V_P = \int_{v_S^{-1}(p^*)}^{x_H} (v_S(x) - p^*)\, dF(x),$$

since the seller gains from deviating if and only if $v_S(x) > p$. For the seller as proposer, V_P depends on κ only through the effect of κ on the candidate equilibrium price. Since, by Lemma 3(i), $\bar{p} + \kappa$ and $p_I + \kappa$ are independent of κ, p^* must be strictly decreasing in κ. Thus, we get $\partial V_P/\partial\kappa > 0$. Intuitively, a higher transaction tax reduces the seller's gains from trade and hence increases his incentive to deviate and learn the true payoff of the asset, in which case he trades less often.

If the buyer is the proposer, then

$$V_P = \int_{x_L}^{v_B^{-1}(p^*+\kappa)} ((p^* + \kappa) - v_B(x))\, dF(x),$$

since the buyer's value of producing information corresponds to the value of avoiding a loss in low payoff states (which occurs if and only if $v_B(x) < p^*+\kappa$). By Lemma 3(ii), $\bar{p}$ and p_I are independent of the sales tax levied on the buyer; thus, $\partial(p^*+\kappa)/\partial\kappa > 0$, which implies that $\partial V_P/\partial\kappa > 0$. If κ goes up, the buyer's loss from buying the asset in low payoff states is increased and, thus, the range in which the buyer as the proposer trades uninformed becomes smaller. **QED**

Transaction taxes make trade more expensive and thus increase the proposer's incentive to deviate to information acquisition and learn the true payoff of the asset. In the latter case, individually unfavorable trades can be avoided, which becomes more valuable if the transaction tax is increased. Thus, the range in which there is trade with probability one becomes smaller and mutually beneficial trade becomes less likely.

Altogether, profit taxation may help to solve the signaling problem by reducing the incentives to make use of an informational advantage. In contrast, a transaction tax makes trade less attractive and increases the proposer's incentive to produce information. These results for the case where both parties can acquire information confirm the intuition for the mechanisms underlying the effects of taxation in markets where information is endogenous.

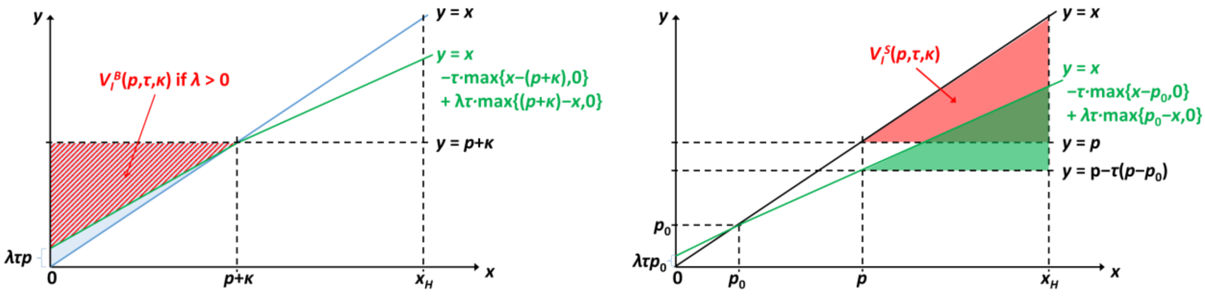
Discussion of profit taxation and deductibility of losses

This section discusses how a tax treatment of losses affects the results in Proposition 2. Suppose that losses are partly deductible for tax purposes, for instance because they can be credited against future gains and/or other current income. This option becomes more valuable in high-tax regimes. Formally, we can model a loss offset by a parameter $\lambda \in [0,1]$ that determines the share of the loss that is tax-deductible. This is equivalent to a "subsidy" $\lambda\tau$ per unit of a loss from trading asset x. See Figure 3.

Consider the case of the responder being the buyer who acquires information in order to avoid the loss of buying the asset in low payoff states $x < p$. Here, increases in the profit tax *reduce* the buyer's value of information V_I (Figure 3a). As a consequence, charging the price p_I becomes relatively more attractive for the seller.[31] Therefore, with a tax treatment of losses, the effect of profit taxation on the threshold $\underline{\gamma}$ becomes even stronger in this case. By similar arguments, the statements in Proposition 2 continue to hold for the case where the seller is the responder (compare Figure 3b).

Figure 3: Effect of profit taxation on the value of information V_I in case of a loss offset.

(a) Buyer is responder (b) Seller is responder



Note: $v_R(x) = x$; example for $x_L = 0$ and $0 < p_0 < p$.

[31] Formally, the same steps as in the analysis above (Lemma 2 and Proposition 2) yield $\partial p_I/\partial\tau > 0$ and $\partial\underline{\gamma}/\partial\tau < 0$.

REFERENCES

ACHARYA, Viral V., PEDERSEN, Lasse Heje, PHILIPPON, Thomas, RICHARDSON, Matthew P., 2017. Measuring systemic risk. Review of Financial Studies 30(1), 2-47.

ANDERSON, Fredrik, 1996. Income taxation and job-market signaling. Journal of Public Economics 59, 277-298.

ARNOTT, Richard, STIGLITZ, Joseph E., 1986. Moral hazard and optimal commodity taxation. Journal of Public Economics 29, 1-24.

AUSUBEL, Laurence M., CRAMTON, Paul, DENECKERE Reynold J., 2002. Bargaining with incomplete information, in: R. Aumann, S. Hart (Eds.), Handbook of Game Theory with Economic Applications, vol. 3, 1897-1945, (Chapter 50).

BANERJEE, Anindya, BESLEY, Timothy, 1990. Moral hazard, limited liability and taxation: a principal-agent model. Oxford Economic Papers 42(1), 46-60.

BANK OF CANADA 2012. Improving the resilience of core funding markets. Working paper.

BIERBRAUER, Felix, 2014. Tax incidence for fragile financial markets. Journal of Public Economics 120, 107-125.

CHEUNG, Francis K., 1998. Excise taxes on a non-uniform pricing monopoly: ad valorem and unit taxes compared. Canadian Journal of Economics 31(5), 1192-1203.

CRÉMER, Jacques, KHALIL, Fahad, 1992. Gathering information before signing a contract. American Economic Review 82(3), 566-578.

CRÉMER, Jacques, KHALIL, Fahad, ROCHET, Jean-Charles, 1998. Strategic information gathering before a contract is offered. Journal of Economic Theory 81(1), 163-200.

DANG, Tri Vi, 2008. Bargaining with endogenous information. Journal of Economic Theory 140, 339-354.

DANG, Tri Vi, GORTON, Gary, HOLMSTRÖM, Bengt, 2015a. The information sensitivity of a security. Working Paper.

DANG, Tri Vi, GORTON, Gary, HOLMSTRÖM, Bengt, 2015b. Ignorance, debt, and financial crises. Working Paper.

DARVAS, Zsolt, VON WEIZSÄCKER, Jakob, 2010. Financial-transaction tax: Small is beautiful. Bruegel Policy Contribution Issue 2010/02.

DÁVILA, Eduardo, 2013. Optimal financial transaction taxes. Working Paper.

DEUTSCHE BANK, 2012. Capital market bank funding. DB Research August.

EUROPEAN COMMISSION, 2013. Proposal for a COUNCIL DIRECTIVE implementing enhanced cooperation in the area of financial transaction tax. (http://ec.europa.eu/taxation_customs/resources/documents/taxation/com_2013_71_en.pdf)

FU, Yuming, QIAN, Wenlan, YEUNG, Yin Bernard, 2016. Speculative investors and transaction tax: Evidence from the housing market. Management Science, 62, 11, 3254-3270.

FULLERTON, Don, METCALF, Gilbert E., 2002. Tax incidence. Handbook of Public Economics, Volume 4, Chapter 26, 1787-1872.

GINSBURGH, Victor, LEGROS, Patrick, SAHUGUET, Nicolas, 2010. On the incidence of commissions in auction markets. International Journal of Industrial Organization 28, 639-644.

GOERKE, Laszlo, 2011. Commodity tax structure under uncertainty in a perfectly competitive market. Journal of Economics 103, 203-219.

GROSSMAN, Sanford J., STIGLITZ, Joseph E., 1980. On the impossibility of informationally efficient markets. American Economic Review 70(3), 393-408.

IRELAND, Norman J., 1994. On limiting the market for status signals. Journal of Public Economics 53, 91-110.

JENSEN, Sissel, SCHJELDERUP, Guttorm, 2011. Indirect taxation and tax incidence under nonlinear pricing. International Tax and Public Finance 18, 519-532.

KAPLOW, Louis, 1992. Income tax deductions for losses as insurance. American Economic Review 82(4), 1013-1017.

KEEN, Michael, 2011. The taxation and regulation of banks. IMF Working Paper 11/206.

KOTSOGIANNIS, Christos, SERFES, Konstantinos, 2014. The comparison of ad valorem and specific taxation under uncertainty. Journal of Public Economic Theory 16(1), 48-68.

KYLE, Albert S., 1985. Continuous auctions and insider trading. Econometrica 53(6), 1315-1335.

KYLE, Albert S., 1985. 1989. Informed speculation with imperfect competition. Review of Economic Studies 56(3), 317-355.

MATHESON, Thornton, 2011. Taxing financial transactions: issues and evidence. IMF Working Paper 11/54.

MCCULLOCH, Neil, PACILLO, Grazia, 2011. The Tobin tax: A review of the evidence. IDS Research Report 68, Institute of Development Studies, University of Sussex.

MCKINSEY, 2013. Between deluge and drought: The divided future of European bank funding markets. McKinsey Working Papers on Risk, No.41.

ROSS, Stephen A., 1989. Commentary: Using tax policy to curb speculative short-term trading. Journal of Financial Services Research 3, 117-120.

SHACKELFORD, Douglas A., SHAVIRO, Daniel N., SLEMROD, Joel, 2010. Taxation and the financial sector. National Tax Journal 63(4), 781-806.

STIGLITZ, Joseph E., 1989. Using tax policy to curb speculative short-term trading. Journal of Financial Services Research 3(2-3), 101-115.

SUMMERS, Lawrence H., SUMMERS, Victoria P., 1989. When financial markets work too well: a cautious case for a securities transactions tax. Journal of Financial Services Research 3(2-3), 261-286.

TOBIN, James, 1978. A proposal for international monetary reform. Eastern Economic Journal 4(3/4), 153-159.