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

Tri Vi Dang[†] Xiaoxi Liu[‡] Florian Morath[§]

February 25, 2022

Abstract

This paper shows that a transaction tax makes trades in decentralized markets more information sensitive and enlarges the range of information costs for which the equilibrium exhibits private information acquisition and endogenous adverse selection. A transaction tax reduces the probability of trade. The opposite implications hold for a tax on capital gains. The theoretical implications of a transaction tax are tested using a tax policy change in one segment of Singapore's housing market. Using various proxies for information sensitivity, the triple difference-in-difference analysis shows that a higher transaction tax reduces turnover more strongly when trades are more information sensitive.

Keywords: Bargaining; information acquisition; taxation; transaction tax; capital gains tax; tax incidence; decentralized markets; housing markets; policy experiment; information sensitivity

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

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1. INTRODUCTION

In this paper we conduct a theoretical and empirical analysis of the impact of taxation on information acquisition and trade in decentralized markets. Our theoretical framework is based on a bargaining game between a seller and a buyer where information is symmetric ex ante but private information can be acquired before deciding whether to trade. We show that a transaction (sales) tax and a tax on capital gains (profits) have opposite implications for the information sensitivity of trades, equilibrium behavior and welfare.

A transaction tax makes trades more information sensitive. Since investors have a stronger incentive to acquire private information, there is a larger range of information costs where equilibrium exhibits adverse selection. Furthermore, in an equilibrium with information acquisition, a higher transaction tax reduces the probability trade. The exact opposite implications hold for a capital gains tax. An increase of a tax on capital gains reduces the information sensitivity of trades. Since investors have less incentive to acquire information, the range of information costs is smaller where equilibrium exhibits costly information acquisition. Furthermore, even in an equilibrium with endogenous adverse selection a tax on capital gains increases the probability of trade. Consequently, in markets where there are gains from trade and private information acquisition creates endogenous lemons problems, a capital gains tax dominates a transaction tax from a welfare perspective.

The model captures trade between financial investors in over-the-counter markets.[1] Decentralized fixed income markets or interbank funding markets yield substantial gains from trade, as liquidity management is the main purpose of trade in such markets. Before the financial crisis in 2008, asymmetric information was not considered as an issue among participants in funding markets (Bank of Canada 2012; Deutsche Bank 2012; McKinsey 2013). Changes in macroeconomic conditions can make these markets more information sensitive and generate incentives for private information acquisition and problems of adverse selection which can cause a collapse of trades in such markets. Dang, Gorton and Holmstrom (2015a, 2015b) propose the information sensitivity theory of debt and financial crises.

Despite the importance of information asymmetries in the context of financial markets, little is known about how taxation of the financial sector affects the problems of asymmetric information. Since financial investors typically decide how much information they want to

[1] Trades of fixed income instruments are typically not conducted in centralized markets but in over-the-counter markets and are thus of bilateral nature. Examples include government bonds, corporate bonds, syndicated loans, mortgage-backed securities and asset-backed securities. Also, in three of the largest markets, 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 debt markets.

acquire, information is inherently endogenous, especially in secondary markets. Therefore, understanding the equilibrium incentive effects of taxation on information acquisition and bargaining behavior at the trading level is important for policy design and in light of recent discussion of taxation of the financial sector. Our results suggest differential efficiency effects of financial sector taxation depending on the information sensitivity of the respective markets.[2]

A second main application of our framework is trade in housing markets where some but not all relevant information may be publicly available and, thus, buyers or sellers may invest in acquiring information about the value of a certain object. In many cases, there is no particular reason to believe that one party is ex ante better informed and has private information about important factors such as the value of the location as influenced by (approval of) future development and infrastructure projects. But if an agent expects to trade with a sophisticated counterpart who is able to obtain private information, this may increase the awareness of potential adverse selection and influence trading behavior. As our theoretical contribution, we analyze the incidence effects of two common tax instruments in such settings.[3]

In the empirical part of the paper, we address the case of trade in housing markets and relate the importance of information sensitivity and information acquisition across different market segments to changes in turnover caused by a transaction tax increase. Concretely, we use a policy experiment in the housing market in Singapore in 2006 where a policy change effectively raised the transaction tax by 2-3% in one market segment, namely the so-called presale market where investors trade units before construction is completed. The so-called spot market where investors trade units that are completed does not face a change in taxes.

It is intuitive to expect that, in general, a higher transaction tax is likely to reduce trades or turnover. Our model makes more specific predictions and shows that there are differential effects of a transaction tax that depend on the information sensitivity of the respective markets. In order to test the information sensitivity mechanism of taxation we use different proxies for information sensitivity (information costs, the value of information, and the sophistication of investors) and a triple difference-in-difference approach which compares the changes in turnover in the presale market relative to the spot market conditional on the information sensitivity of trades. We find that the negative effect of an increased transaction

[2] Efficiency considerations are also central to the recent policy discussions on financial sector taxation; two main proposals are a financial transaction tax (as introduced already in some countries and backed, for instance, by the European Commission) and a financial activities tax on "supernormal" profits.

[3] Taxes on real estate constitute an important source of government revenue in many countries and are often levied on transactions as well as property values and gains from trade. For an overview on property taxes across different countries see, for instance, Norregaard (2013).

tax on turnover is stronger in regions with higher population density where information costs are supposed to be smaller. It is also stronger for smaller condominium projects where the value of private information acquisition is supposed to be larger due to limited publicly available information. Finally, based on trading activities we classify some trades as 'speculative trades' by sophisticated investors ('flippers') who face lower information costs and document that the effect on turnover is stronger in projects in which sophisticated investors are present. Overall, these empirical findings are consistent with the theoretical implications that the effects of taxation depend on the information sensitivity of trades.

Our paper makes several contributions. The theoretical part is at the intersection of two large but disconnected literatures on tax incidence and on bargaining. The discussion of 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).[4] More generally, our paper relates to the literature on tax incidence; among the few papers that analyze questions of tax incidence with (exogenous) asymmetric information are Cheung (1998) and Jensen and Schjelderup (2011) for competitive markets and Goerke (2011) and Kotsogiannis and Serfes (2014) for monopoly pricing.[5]

A key insight of the bargaining and contracting literature is that equilibrium outcomes are typically not efficient when agents have (exogenous) 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 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 can be 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 in equilibrium.

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[4] 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), Bierbrauer (2014), Dávila (2016), and Acharya et al. (2017).

[5] 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.

To our knowledge, there is no theoretical work that analyzes the impact of taxation on bargaining problems with (exogenous or endogenous) asymmetric information. One reason for this might be that (profit) taxation does not alter equilibrium outcomes when private information is exogenous, which is a common assumption in the bargaining and contracting literature. In particular, the effect of taxation on information acquisition has not yet been explored. Our paper hints at an aspect that is novel, namely that taxation can affect trade by influencing the emergence of information asymmetries. Dang, Gorton, and Holmstrom (2015, 2015a) propose the concept of information sensitivity of a security and a theoretical measure of the value of information in such markets. Our paper proposes a full characterization of the effects of two important tax instruments on the value of information, i.e., information sensitivity. A transaction tax increases the information sensitivity of trades whereas a tax on profits (capital gains) decreases the information sensitivity.

Our empirical analysis of trade in housing markets relates to a small literature that considers economic effects of real estate transfer taxes (stamp duties). An early paper is Benjamin, Coulson, and Yang (1993) who focus on the incidence effects of a tax increase in Philadelphia and find a strong decrease in the net sales price. Recent work uses discontinuities in the tax schedule in order to identify housing market reactions to changes in the transaction taxes (e.g., Kopczuk and Munroe 2015; Best and Kleven 2018). Our triple difference-in-difference approach is based on the fact that only a subset of transactions was affected by the change in the transaction tax and we focus on the differential effects conditional on information sensitivity and presumed costs and value of information.[6] In addition, our empirical results contribute to the new empirical literature on the information sensitivity of debt and financial crises. These papers show that when a macroeconomic or regulatory event causes debt to become more information sensitive, trade is reduced significantly. Dang, Gorton, and Holmstrom (2020) survey the empirical information sensitivity literature on money and corporate bond markets. Our paper shows that a transaction tax increase reduces turnover most strongly in markets that are more information sensitive.

The next section introduces the model. Section 3 provides an equilibrium analysis of the game. Section 4 analyzes the comparative statics effects of taxation on equilibrium information acquisition and pricing. Section 5 presents empirical results on the effect of a transaction tax. Section 6 concludes. All proofs are in Appendix A. Appendix B analyzes taxation and endogenous signaling. Additional empirical results are in Appendix C.

[6] A separate literature considers (recurrent) property taxes in the context of fiscal decentralization. A seminal paper is Oates (1967) who takes into account that house prices also depend on the value of local public goods financed by local property taxes.

2. THEORETICAL FRAMEWORK

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 payoff x to the buyer. The analysis below subsumes two cases: in one case, the seller is the proposer P and offers a price p which the buyer as the responder R can accept or reject; in the other case, the buyer proposes the price. Ex ante the asset's payoff x is unknown and the information is symmetric. It is common knowledge that the payoff x is distributed on the interval $[0, \infty)$ according to the distribution function F, which is assumed to be continuous and differentiable.

Agent i's valuation of the asset is denoted by $v_i(x)$ which is continuous and strictly increasing in the asset's realized payoff x. We make the following assumption:

$$v_S(x) < v_B(x) \text{ for all } x > 0. \tag{1}$$

This assumption implies that 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.[7] Below we assume that that the responder's valuation coincides with the asset's payoff, that is, $v_R(x) = x$ for $R \in \{S, B\}$.

The timing of the game is as follows. The proposing agent $P \in \{S, B\}$ (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 $\gamma \geq 0$. If the responder is indifferent, ties are broken in favor of trade.[8]

Conditional on trading ($q = 1$) and not trading ($q = 0$), respectively, the ex post utilities of seller S and buyer B (disregarding information costs) are given by

$$u_S(x, p, \tau, \kappa, q) = \begin{cases} p - T_S(p, p_0) & \text{if trade } (q = 1) \\ v_S(x) - T_S(x, p_0) & \text{if no trade } (q = 0) \end{cases} \tag{2}$$

and

$$u_B(x, p, \tau, \kappa, q) = \begin{cases} v_B(x) - (p + \kappa) - T_B(x, p + \kappa) & \text{if trade } (q = 1) \\ 0 & \text{if no trade } (q = 0). \end{cases} \tag{3}$$

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[7] An example is $v_B(x) = ax$ and $v_S(x) = bx$ where $a > b$. In the financial markets application, the difference in valuations 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. A similar motivation holds in housing markets where differences in v_S and v_B can be preference-based and related, for instance, to different consumption patterns across age cohorts.

[8] The exact tie-breaking rules are specified in the context of Definition 1 below. As is common in games with continuous strategy space, the tie-breaking rules are chosen as to ensure the existence of an equilibrium and avoid adding an infinitesimally small change in the price to break a possible indifference of the responder.

The seller either receives the price p if there is trade or realizes a value $v_S(x)$ if there is no trade, but might have to make a tax payment T_S on realized capital gains, as specified below. The buyer gets an outside option normalized to zero if there is no trade and gets $v_B(x)$ if there is trade; in the latter case, the buyer has to pay the price p plus a (per-unit) transaction tax $\kappa \geq 0$ and, in addition, might have to pay a tax T_B on realized capital gains. Hence, the transaction tax κ is formally levied on the buyer and increases the effective, tax-inclusive price to be paid by the buyer to $p + \kappa$.[9]

Realized capital gains (profits) are taxed at rate $\tau \in [0,1)$; the capital gains tax τ is assumed to apply to the difference of the realized return x and the price paid. The buyer realizes a positive profit if and only if she buys the asset and its payoff turns out to be larger than the purchase price $p + \kappa$. The seller realizes a positive profit either if she does not sell the asset and realizes a payoff x that is larger than some price $p_0 \geq 0$ initially paid for the asset (the 'book value') or if she resells the asset and receives a price p that is larger than p_0. If an agent realizes a negative capital gain, we include the possibility of a loss offset where a share $\lambda \in (0,1)$ of the loss can be credited against other (not specifically modeled) income that is subject to the same tax rate τ. Formally, if z denotes the realized return and $\check{p}$ is the purchase price (book value) deductible for tax purposes, the tax payment is

$$T_i(z, \check{p}) = \tau \max\{x - \check{p}, 0\} - \lambda\tau \max\{\check{p} - x, 0\}\,, \;\; i = S, B \tag{4}$$

and is positive if $x > \check{p}$ and negative if $x < \check{p}$.[10] (A negative tax payment reflects the reduction of other taxes on the same type of income due to the loss offset rule.) When considering effects of taxation of capital gains we focus on the side of the market that can acquire information and, hence, ignore taxation of the proposing agent's capital gains for simplicity.

Including information costs, the utility of agent $i = S, B$ is given by

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

where the indicator variable 1_{info} is equal to one if i is the responder and has acquired information, and zero otherwise. The outside option of the seller as responder is

$$\overline{U}_S := E_x[u_S(x, p, \tau, \kappa, 0)] = E_x[v_S(x) - T_S(x, p_0)]$$

and the outside option of the buyer as responder is $\overline{U}_B := E_x[u_B(x, p, \tau, \kappa, 0)] = 0$.

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[9] 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 an ad-valorem tax in percentage of the price paid; see the proof of Proposition 2 for details.

[10] In the formal analysis below we highlight the impact of a loss offset ($\lambda > 0$) on incentives and equilibrium behavior, as compared to the case of $\lambda = 0$.

Capturing trade in secondary markets such as OTC or housing markets, we assume that the traders have symmetric information ex ante. Traders who own an asset are, hence, not exogenously better informed about future market valuations or conditions than traders who are interested in buying. Moreover, we assume that some but not all traders can produce information about the asset, reflecting the fact that large investors may be more sophisticated and capable to produce information and analyze and interpret market data. Similar differences in sophistication or opportunity costs of acquiring information typically hold among private investors in housing markets. The assumption that only the responder can acquire information is made for tractability in order to abstract from endogenous signaling problems in the main analysis. Appendix B analyzes a version of the model in which the proposer can acquire information as well.

3. EQUILIBRIUM ANALYSIS

The fact that the responder can acquire information adds constraints to the equilibrium price setting. First, in an equilibrium without information acquisition, the price offer must make sure that the responder indeed has no incentive to acquire information; this constraint does not bind for very high information costs (as in a setup without possibilities of information acquisition) but can bind for intermediate information costs. Second, in an equilibrium with information acquisition, the responder must expect to be able to cover her costs of information; this constraint does not bind for information costs close to zero (as in a model with an exogenously informed responder) but can bind for non-negligible information costs.

As a first step, we relate these constraints due to endogenous information to the responder's 'value of information' and consider how this value of information is affected by increases in the capital gains tax and the transaction tax, respectively. Then, we characterize the equilibrium for given tax rates (τ, κ). In the next section we use these results to explicitly analyze the consequences of the two taxes for equilibrium trade.

3.1 Taxation and 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 her 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.[11] The responder's 'value of information'

[11] To break a possible indifference, we assume that (a) if the responder is indifferent between acquiring information and her outside option (not participating), she acquires information, (b) if the responder is indifferent between information acquisition and trading without information acquisition, she trades without

depends on the alternative option she considers to choose.

<u>Definition 1 (*Value of information*)</u>

(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: knowing the true payoff x, she chooses $q = 1$ if and only if her utility from trading is larger than her utility from not trading. Second, V_I is defined as the responder's value of information when deciding between information acquisition (where she trades according to q^*) and trading without information acquisition ($q = 1$); V_I is equal to the difference in expected utility in the two cases, disregarding the costs of information γ. Hence, the condition $V_I(p,\tau,\kappa) \leq \gamma$ will be crucial for ensuring that the responder trades without information acquisition. Third, V_{II} is defined as the responder's value of information when deciding between information acquisition (where she trades according to q^*) and her outside option (no information acquisition and no trade). Consequently, a participation constraint for a responder who acquires information is $V_{II}(p,\tau,\kappa) \geq \gamma$.

Lemma 1 considers the effects of taxation on the constraints that endogenous information acquisition introduces via V_I and V_{II}. These comparative statics properties will be central for the intuition underlying the main propositions on the equilibrium effects of taxation. Recall that the transaction tax is formally levied on the buyer.

<u>Lemma 1 (*Effect of taxation on the value of information*)</u>

Let $p \in (0,\infty)$ be given.

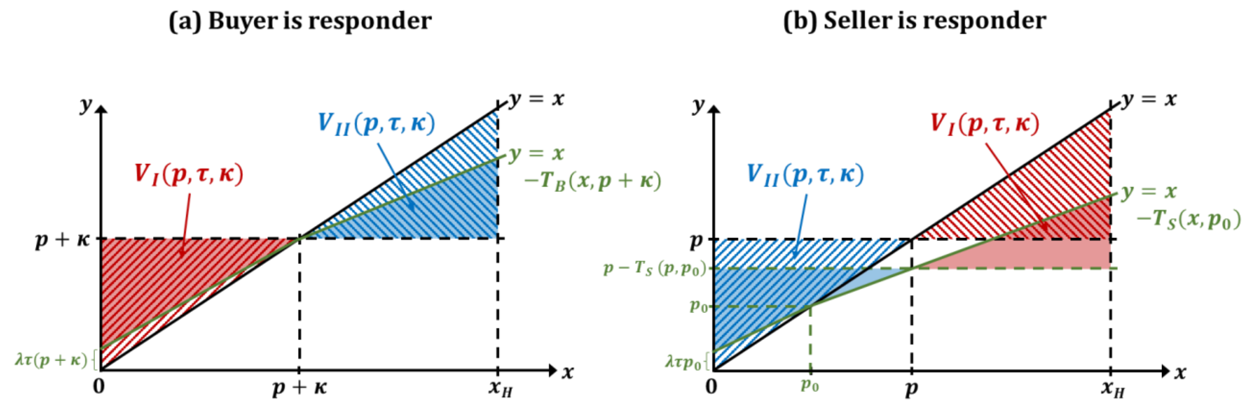
(i) *V_I and V_{II} are strictly decreasing in the capital gains tax τ.*

(ii) *If the buyer is the responder, V_I is strictly increasing and V_{II} is strictly decreasing in the tax-inclusive price $p+\kappa$. If the seller is the responder, V_I is strictly decreasing and V_{II} is strictly increasing in the net-of-tax price p and V_I and V_{II} are independent of κ.*

Figure 1 illustrates the value of information of the seller and the buyer as well as the effects of taxation on V_I and V_{II} summarized in Lemma 1. Consider first the case where the buyer is

information acquisition, and (c) if an informed responder is indifferent between trading and not trading, she decides to trade.

Figure 1: Effects of taxation on the value of information V_I and V_{II}.



Note: $v_R(x) = x$. Example for $p_0 < p$ for the seller as responder and $F(x) = x/x_H$ on $[0, x_H]$.

the responder and faces a tax-inclusive price $p + \kappa$ (Figure 1a). The return of the asset corresponds to the 45-degree line $y = x$. If the buyer knows the true payoff x, she only trades in high states $x \geq p + \kappa$. Compared to the option of trading with probability one, the value of information V_I is equal to the expected value of avoiding a loss in states $x < p + \kappa$. Intuitively, the buyer as the responder acquires information in order to avoid buying the asset when its true payoff is low. A tax on positive realized capital gains does not effect V_I directly; however, a higher capital gains tax increases the value of a loss offset and this latter effect reduces V_I for the buyer as responder (the net ex post utility $x - T_B(x, p + \kappa)$ is shifted upward for $x < p + \kappa$).[12] An increase in the transaction tax–or an increase in the tax-inclusive price $p + \kappa$ more generally–increases the value of information V_I in Figure 1a since it makes a loss more likely to occur and, in addition, increases the size of a potential loss. Overall, for the buyer as responder, a capital gains tax weakens the incentive to acquire information whereas a higher transaction tax strengthens the incentive to acquire information as captured by V_I.

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 $x \geq p + \kappa$. These gains are reduced by capital gains taxation; in Figure 1a, V_{II} becomes smaller the larger τ (the net ex post utility $x - T_B(x, p + \kappa)$ is shifted downward for $x \geq p + \kappa$). Similarly, V_{II} is reduced by a transaction tax–or an increase in the tax-inclusive price $p + \kappa$ more generally–as an informed buyer trades less often and pays a higher price. Hence, both types of taxes reduce the buyer's information rents V_{II} and tighten the buyer's participation constraint.

[12] Hence, if $\lambda = 0$ so that there is no possibility of loss offset, there is no direct effect on the buyer's incentive to acquire information. However, there is still an indirect of capital gains taxes on equilibrium caused by the proposer's choice between different candidate equilibrium prices; see below.

If the seller is the responder and knows the true payoff x, she only sells in low states $x \leq p$. Therefore, for the seller as the responder, V_I is equal to the expected value of keeping the asset in high states $x > p$ (the shaded area to the right of Figure 1b); V_I becomes smaller if a tax applies to the corresponding profits. Similarly, a capital gains tax also reduces the seller's value of information V_{II}, which is the profit an informed seller makes by selling in states $x \leq p$, compared to not participating (keeping the asset). Since by assumption the transaction tax κ is levied on the buyer, it does not directly affect the seller's value of information V_I or V_{II} (not yet taking into account reactions of the equilibrium price). However, as shown in Figure 1b, the incentive to acquire information V_I is lower the higher the (net-of-tax) price offer p to the seller as responder; moreover, her information rents V_{II} are increasing in p.

3.2 Best reply of the responder

With the definitions of V_I and V_{II}, the responder's optimal decisions on information acquisition and trading can directly be characterized as a function of the information cost γ.

Lemma 2 (*Best reply of responder*)

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^**.*

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

Lemma 2 covers all possible constellations. The responder acquires information if and only if both V_I and V_{II} are larger than the cost of information γ (part (ii)). Otherwise, the responder does not acquire information. In the latter case, 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 $E_x[u_R(x, p, \tau, \kappa, 1)] < E_x[u_R(x, p, \tau, \kappa, 0)]$).

3.3 Equilibrium price setting

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

Definition 2 (*Candidate equilibrium prices*)

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

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

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

The price $\bar{p}$ makes the responder exactly indifferent between trading with probability one and choosing her outside option $\bar{U}_R$ (no trade, no information acquisition). The price p_I is defined such that 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.[13] It can be interpreted as a "bribe" price such that the responder gets some rents and does not acquire information. Finally, p_{II} is the price that maximizes the proposer's expected utility in case the responder acquires information and trades according to q^*. Intuitively, p_{II} is similar to the price that a monopolistic proposer offers when facing an informed responder. Here, however, p_{II} takes into account the responder's participation constraint which requires that the responder's expected utility from producing information is at least as large as her reservation utility $\bar{U}_R$, i.e., $V_{II}(p_{II},\tau,\kappa) \geq \gamma$.

For the purpose of our analysis, the most interesting cases arise when the information costs are in an intermediate range so that they become relevant for equilibrium decision-making.

Definition 3 (*Critical information cost*)

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

The threshold $\underline{\gamma}$ is defined as the information cost at which the proposer is indifferent between offering the "bribe" price p_I where the responder trades without information acquisition ($q = 1$) and the price p_{II} where the responder acquires information and trades optimally according to q^* (given her information). Under the first strategy, trade occurs with probability one but for this to happen a bribe is required (which is larger the smaller the information costs). Under the second strategy, trade occurs with lower probability but the proposer only needs to compensate the responder for costly information acquisition. Thus, giving in to adverse selection can dominate a bribe if γ is small, and vice-versa if γ is large. Which strategy is optimal for the proposer depends on his valuation $v_P(x)$ and the probability distribution $F(x)$ of the payoff of the asset. There are cases where avoiding information acquisition dominates inducing information acquisition for all $\gamma > 0$ so that $\underline{\gamma} > 0$ does not exist.[14] We focus on the more interesting cases where $\underline{\gamma} > 0$ exists. Moreover, we consider the

[13] V_I is strictly monotone in p. 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 the price p_I is not relevant for the equilibrium characterization. To keep the definitions simple, we omit this case in Definition 2(ii).

[14] This can arise, for instance, if the buyer is the proposer and his valuation of the asset is sufficiently high. Then, it is optimal to propose a sufficiently high price p (which satisfies $V_I(p) = \gamma$) such that the seller accepts with probability one and without information acquisition.

case where the proposer is willing to trade with an informed responder, that is, $v_P(x)$ is sufficiently small relative to $v_R(x)$ or, put differently, the proposer's outside option $\overline{U}_P$ is sufficiently low. The next lemma relates the equilibrium price p^* to the information costs γ.

Lemma 3 (*Equilibrium price setting*)

Suppose that $E_x[u_P(x, p_{II}, \tau, \kappa, q^*(x, p_{II}, \tau, \kappa))] \geq \overline{U}_P$ *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^*.

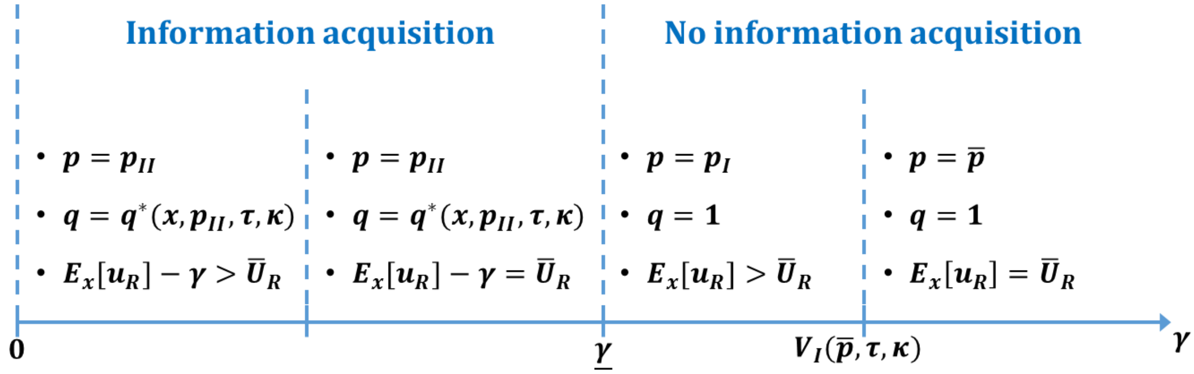
Lemma 3 characterizes the equilibrium properties which hold for the buyer as well as the seller being the proposer.[15] If the cost of information is high, information acquisition is irrelevant. In this case, the proposer offers the price $\bar{p}$ that gives the responder her outside option, i.e., no rents. Since trade occurs with probability one, this is the optimal price (Lemma 3(i)). In the absence of taxation, 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 incentive to acquire information (Lemma 3(ii)). Technically, the proposer chooses the price p_I that satisfies $V_I(p_I, \tau, \kappa) = \gamma$. (The buyer as a proposer increases the price while the seller as a proposer decreases the price so as to prevent information acquisition by the responder.) Here, even if there is no information acquisition in equilibrium, the responder gets an information rent: her 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). Below the threshold $\underline{\gamma}$, the nature of the equilibrium changes and the proposer chooses a price that induces the responder to acquire information (Lemma 3(iii)). This price

[15] Lemma 3 extends some results in Dang (2008) to the cases where the payoff x of the asset is continuous, follows an arbitrary distribution $F(x)$, and there are capital gains taxes and transaction taxes. Also, we use the concept of "information sensitivity" of Dang, Gorton and Holmstrom (DGH 2015a,b) to characterize the equilibrium but the equilibrium outcomes in our model summarized in Lemma 3 are different. In DHG (2015a,b), optimal security design can serve as a means to prevent information acquisition; DGH 2015b show that there is never information acquisition in equilibrium if the seller can acquire information and an uninformed buyer proposes a price and a security to buy. Our analysis focuses on an asset of fixed size (as we would typically have in housing markets) for which information acquisition occurs in equilibrium for low information costs and tax reforms have an impact on the emergence of problems of adverse selection, as analyzed in the main Section 4.

Figure 2: Equilibrium price setting and information acquisition.



p_{II}, however, has to take into account that the responder is compensated for the cost of information in that her expected surplus from trade covers the cost of information production: $V_{II}(p_{II}, \tau, \kappa) \geq \gamma$. 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; 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., her expected utility in equilibrium is equal to her outside option $\bar{U}_R$). The results of Lemma 3 are summarized in Figure 2.

It is worth noting that the equilibrium payoff of the responder can be non-monotonic in the information cost. For low information cost, 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 an intermediate 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. With our focus on the effects of taxation on information acquisition, the two intermediate cases in Figure 2 are most interesting as in those cases one of the informational constraints ($V_{II} \geq \gamma$ or $V_I \leq \gamma$) binds.

4. THE EFFECTS OF TAXATION ON EQUILIBRIUM TRADE

The equilibrium characterization in the previous section has taxation implicitly captured in the utility functions. This section explicitly analyzes the effects of a marginal increase in the capital gains tax and in the transaction tax, respectively. The main propositions derived below focus on the equilibrium probability of trade; their proofs are based on the direct effect of taxation on the candidate equilibrium prices as well as an indirect effect via the proposer's choice between the candidate prices. The general implications of the two types of tax instruments do not depend on which side of the market has the bargaining power and takes the role of proposer.

For the remainder of this section, we assume that there is a unique solution p_{II} to the proposer's maximization problem when facing an informed responder.[16]

4.1 A tax on capital gains

We first consider the effects of a capital gains tax increase. If the cost of information is high and $\bar{p}$ is played in equilibrium, trade occurs with probability one and possibilities of information acquisition are irrelevant. In this case, a marginal increase of the capital gains tax only re-allocates the gains from trade among the buyer, seller and government but has otherwise no effect on trade.[17] Similarly, if the information costs approach zero, taxation of capital gains reduces the responder's information rents and increases tax revenue but neither affects the equilibrium price (the unconstrained optimum p_{II}) nor the probability of trade. However, taxation of capital gains has direct welfare implications if one of the informational constraints is binding, that is, if γ is in an intermediate interval. Our first main result identifies two effects of a capital gains tax, which both lead to more trade in equilibrium.

Proposition 1

Suppose that $\underline{\gamma} > 0$. An increase in the capital gains tax 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 1 identifies a direct and an indirect welfare effect of an increase in the capital gains tax τ. First, in an equilibrium with information acquisition (that is, for information costs $\gamma < \underline{\gamma}$), the probability of trade increases (Proposition 1(i)). The intuition behind this finding relies on the fact that an increase in τ reduces the responder's information rents. If the information cost γ is very small, equilibrium behavior remains unaffected. But if γ is non-negligible and the responder's participation constraint vis-à-vis information acquisition binds ($V_{II}(p_{II}, \tau, \kappa) = \gamma$), the reduction in the information rents must be compensated by a more favorable price p_{II} for the responder so that she can still expect to cover her information costs. A more favorable price means a strictly higher probability of trade. More specifically, if

[16] For arbitrary functions F as well as v_S and v_B, p_{II} is not necessarily unique. Due to the standard problems of multiplicity of equilibrium for comparative statics analysis, we neglect the possibility of multiple solutions p_{II}, which could be ruled out by assumptions on F that ensure quasi-concavity of u_P.

[17] Formally, $\bar{p}$ has to be adjusted so that $V_I(\bar{p}, \tau, \kappa) = V_{II}(\bar{p}, \tau, \kappa)$ holds (compare Definition 2(i)).

τ goes up, the seller as proposer has to lower the price so that the buyer trades more often and the buyer as proposer has to increase the price to that the seller accepts more often.

Second, as the indirect effect, an increase in the capital gains tax affects the proposer's choice between the candidate equilibrium prices. Since taxation of profits reduces the incentives to acquire information (captured by V_I; compare Lemma 1(i)), this makes it "cheaper" for the proposer to prevent information acquisition and propose p_I: The seller as proposer can increase the price and still prevent information acquisition; the buyer as proposer can reduce the price and still ensure that the seller does not acquire information. Moreover, since the responder's participation constraint becomes tighter (V_{II} is reduced), proposing p_{II} becomes less attractive for the proposer because more rents may have to be left to the responder (see part (i)). Overall, both effects make preventing information acquisition relatively more attractive to the proposer so that the range of costs γ for which there is information acquisition in equilibrium becomes smaller (the threshold $\underline{\gamma}$ strictly decreases; Proposition 1(ii)).[18] Again, this implies an increase in the probability of trade.

Proposition 1 holds independent of the identity of the proposer (seller or buyer) even though the incentives for information acquisition differ: The buyer acquires information in order to avoid buying in low payoff states whereas the seller acquires information in order to avoid selling in high payoff states. The resulting incentive effects of taxation, however, turn out to be very similar. Moreover, whereas an increase in the capital gains tax can affect equilibrium behavior when information is endogenous, it has no effect on the equilibrium probability of trade if asymmetric information is exogenous, as highlighted in Corollary 1.

Corollary 1

Suppose that $\gamma \to 0$ (private information is exogenous) or $\gamma \to \infty$ (information is symmetric). Then, an increase in the capital gains tax τ does not affect the equilibrium probability of trade.

The case of $\gamma \to 0$ can be interpreted as a situation with *exogenous* asymmetric information. Here, a marginal increase in τ reduces the responder's information rent as before. This, however, has no effect on the equilibrium price p_{II} and the equilibrium probability of trade if the constraints on information acquisition are irrelevant. For instance, an exogenously informed buyer as responder trades in states $x \geq p + \kappa$ and makes a profit of $(1 - \tau)(x - (p + \kappa))$; a capital gains tax does not affect the set of states with trade. Similarly, if γ is large (more precisely, $\gamma > V_I(\bar{p}, \tau, \kappa)$), information acquisition is irrelevant for equilibrium behavior and

[18] In case the buyer is the responder and there is no option of a loss offset ($\lambda = 0$), p_I does not depend on τ. However, p_{II} strictly decreases in τ if the condition $V_{II} \geq \gamma$ binds. Hence, for $R = B$, $\underline{\gamma}$ strictly decreases in τ if $\lambda > 0$ or $V_{II}(p_{II}, \tau, \kappa) = \gamma$ or both, and is independent of τ otherwise. For details see the proof of Proposition 1.

the proposer can capture the entire surplus from trade, as in a standard take-it-or-leave-it offer game with symmetric information. An increase in the capital gains tax changes the equilibrium price $\bar{p}$ and reduces the proposer's expected utility but does not affect the equilibrium probability of trade if there is no asymmetric information.

4.2 A transaction tax

Like in the case of taxation of capital gains, a transaction tax only redistributes the gains from trade among the buyer, seller and government if the information costs are large and $\bar{p}$ is played in equilibrium. A transaction tax can, however, affect the probability of trade in an equilibrium with information acquisition as well as the proposer's choice between p_I and p_{II}, by a similar logic as for the capital gains tax but with the opposite implications.

Proposition 2

Suppose that $\underline{\gamma} > 0$. *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 lowers the probability of trade (Proposition 2(i)). Intuitively, whenever possible, the proposer shifts part of the increased tax burden to the responder even though this reduces the probability of trade with an informed responder. This resembles the standard distortion of trade in case of a sales tax. For larger costs of information, however, the responder's participation constraint $V_{II} \geq \gamma$ binds and the tax burden cannot be shifted on to the responder without affecting the responder's participation decision. Thus, a marginal increase in the transaction tax does not affect the probability of trade in this case.[19] Overall, the probability of trade (weakly) decreases in κ in an equilibrium with information acquisition.

More interestingly, an increase in the transaction tax strictly increases the incentives to acquire information for the buyer as the responder. Intuitively, a higher tax-inclusive price implies that it is more valuable to learn the true payoff of the asset before making the buying decision. This increase in the buyer's value of information V_I makes it "more expensive" for the seller as proposer to prevent information acquisition, which increases the range of

[19] To be precise, since the transaction tax is formally paid by the buyer, a binding participation constraint for the buyer as responder implies that the tax-inclusive price $p_{II} + \kappa$ (and, thus, the buyer's trading decision) must remain unchanged. Similarly, a binding participation constraint for the seller as responder implies that the net-of-tax price p_{II} (and, thus, the seller's trading decision) must remain unchanged.

information costs in which there is information acquisition (Proposition 2(ii)). For the seller as responder, an increase in the transaction tax does not directly affect the incentive to acquire information (the statutory tax burden is on the buyer). Nevertheless, also in this case, an increase in the transaction tax makes the equilibrium candidate without information acquisition relatively less attractive because there trade occurs with higher probability and, hence, the total tax payment is higher. Altogether, the direct and indirect effects of a transaction tax lead to less trade and more information acquisition in equilibrium, again independent of which side of the market has the bargaining power and makes the offer.

To illustrate the effect on the probability of trade, suppose that the responder's cost of information is drawn from a probability distribution $\Gamma(\gamma)$ and is observed by both agents at the beginning of the game. Consider the case where the seller is the proposer. (The other case follows analogously.) Then, the ex ante expected probability of trade is equal to

$$\Pr(\text{trade}) = \int_0^{\underline{\gamma}} (1 - F(p_{II} + \kappa)) d\Gamma(\gamma) + \int_{\underline{\gamma}}^{\infty} 1 d\Gamma(\gamma)$$

where p_{II} is a function of γ. A marginal increase in the transaction tax changes the probability of trade by

$$\frac{\partial \Pr(\text{trade})}{\partial \kappa} = -\int_0^{\underline{\gamma}} F'(p_{II} + \kappa) \frac{\partial (p_{II} + \kappa)}{\partial \kappa} d\Gamma(\gamma) - F(p_{II}(\underline{\gamma}) + \kappa)\Gamma'(\underline{\gamma}) \frac{\partial \underline{\gamma}}{\partial \kappa} < 0 \,. \quad (5)$$

The two terms in (5) correspond to the two effects summarized in Proposition 2. As $\partial(p_{II} + \kappa)/\partial\kappa \geq 0$ in case the seller is the proposer, the first term reflects the direct effect of a reduction in trades among informed traders (those with $\gamma < \underline{\gamma}$). For traders with high information costs (those with $\gamma > \underline{\gamma}$), the probability of trade remains unaffected and equal to one. Since $\partial\underline{\gamma}/\partial\kappa > 0$, the second term in (5) represents the decrease in observed trades due to more investors being informed; for those buyers, the probability of trade decreases by $F(p_{II} + \kappa)$, which is the probability that they learn that the asset's payoff is lower than the tax-inclusive price to be paid. All else equal, the direct effect (the first term in (5)) is larger in absolute terms the larger $\Gamma(\underline{\gamma})$; in other words, the negative effect on turnover is predicted to be stronger in markets with generally low information costs, that is, when trades are more information sensitive.[20]

Propositions 1 and 2 imply that the two different types of taxes have the exact opposite welfare effects in markets with gains from trade. Capital gains taxes mitigate the (endogenous) lemons problem, whereas transaction taxes make it worse. Since the sum of the welfare of the

[20] To be precise, if $\gamma < V_{II}$, $p_{II} + \kappa$ and $\partial(p_{\mathrm{II}} + \kappa)/\partial\kappa$ are independent of γ and strictly positive. If γ is larger ($\gamma = V_{II}$ binds), $p_{II} + \kappa$ is a function of γ but $\partial(p_{\mathrm{II}} + \kappa)/\partial\kappa = 0$. Thus, for a probability distribution $\tilde{\Gamma}$ that is first-order stochastically dominated by Γ, the reduction in turnover described by the first term in (5) becomes stronger.

trading parties and tax revenue is highest if there is no information acquisition but trade with probability one, taxation of capital gains can be welfare-improving, while transaction taxes reduce welfare. Due to the effect on the probability of trade, this conclusion still holds if the cost of information is not socially wasteful but only redistributive from a welfare perspective. In general, the policy implications depend, of course, on the welfare criterion and on whether an increase in the probability of trade is socially desirable; compare also the discussion in the concluding section.

4.3 Discussion of information acquisition of the proposer

In this section we briefly discuss the effects of taxation on the proposer's incentives to acquire information before making the price offer. Adding the possibility to acquire information by the proposer requires the analysis of an endogenous signaling game. We consider a framework which is identical to the main model, except for the following: First, we allow the proposer to learn the asset's payoff at cost γ_P before he makes the price offer; we assume that information production of the proposer is unobservable by the responder and that the proposer cannot credibly reveal any private information.[21] Second, for simplicity we ignore taxation of the responder's capital gains and the resulting effects of taxation on the responder's decision to acquire information, which have been considered in the main analysis. Third, we focus on the case where the proposer chooses to avoid information acquisition by the responder and analyze how taxation affects the proposer's incentive to acquire information.[22]

Propositions B.1 and B.2 in Appendix B show that the resulting effects of taxation on the proposer's incentive to acquire information and on the efficiency of trade are similar to the main Propositions 1 and 2. In particular, capital gains taxes (transaction taxes) can enlarge (reduce) the range of information costs for which equilibrium trading is efficient. Intuitively, taxation of capital gains reduces the proposer's gains from deviating from the candidate equilibrium in which he does not acquire information so that an equilibrium without information acquisition can be supported for a larger range of information costs. The opposite holds for a transaction tax.

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[21] If the proposer could credibly reveal his private information, he would prefer to do so. This would allow him to extract the entire surplus by setting a price equal to the responder's valuation of the asset.

[22] The other cases can be analyzed analogously. Even if both the proposer and responder have very low information costs, in any equilibrium where the proposer acquires information with positive probability the responder will randomize his information acquisition. There is no equilibrium where both players acquire costly information with probability one and trade occurs with probability one (see Dang 2008).

5. EMPIRICAL ANALYSIS

5.1 Policy experiment: transaction tax increase

In Singapore, private condominium properties (or so-called non-landed properties) in new development projects are launched for sale before 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 private condominium projects. The ownership of these not-yet-completed properties can be freely traded and are sought after by homebuyers as well as by 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" market.

In December 2006 the Singaporean government implemented a tax reform in the presale market. Specifically, the policy withdraws a stamp duty deferral and requires investors to pay three percent stamp duty 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 payments 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 main reasons why this policy intervention event can be used as a policy experiment to test our theoretical model. First, the market for condominiums is a decentralized market. Second, the introduction of a 3 percent 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 a difference-in-difference approach to mitigate potential endogeneity issues when identifying the policy impact. Proposition 2 implies the following main hypothesis.

<u>Hypothesis 1</u>

The effect of the transaction tax increase on turnover is stronger if (a) the information costs are lower and (b) the value of information is larger.

The level of the costs of information relative to its value typically depends on market characteristics (that is, a common cost component) as well as trader characteristics such as the investor's sophistication, access to market information and ability to process complex information. In the estimations we use several proxies that relate to common and investor-specific costs of information and the value of private information acquisition.

5.2 Data and descriptive statistics

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 (in square meters), and date of transaction. The transaction price does not include the stamp duty (tax) and other professional fees. The dataset also provides property-project level information such as location and completion date.[23]

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 sample excludes very small private non-landed projects with fewer than 5 units as well as properties bought out for redevelopment (en bloc sales). Moreover, to deal with very illiquid projects, we only include project-month observations for "active projects" where a project is assumed to be active in all months between the very first and last transaction we observe in the whole sample of transactions between 2002 and 2012.[24] Our main sample consists of 53,619 transactions in 1,868 different condominium projects. Around 48% of these transactions are from the presale market (uncompleted condominiums) while 52% are from spot market (completed condominiums). Panel A of Table 1 shows that the size of the units traded is comparable in the presale and in the spot market. The average transaction price is higher in the presale than in the spot market, as is to be expected since newer and possibly higher-quality units are traded in the presale market.

[23] 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 on the importance of information sensitivity.

[24] That means, if we do not observe a transaction before the start of our testing period (Dec 2005), we implicitly assume that the project has not yet started for trading and do not include project-month observations before the first transaction observed. If we do not observe a transaction after the end of our testing period (Dec 2007), we assume that the project has exited already and do not include project-month observations after the last transaction observed. As long as the project is assumed to be active, we include zero-trade observations if no trade is observed in a given project-month. Below we also use a more narrow definition of active projects where we only include observations for projects that are traded at least once during our main testing period.

Table 1: Summary statistics

Panel A: transactions in the presale and spot markets								
	Obs.	mean	min	p25	p50	p75	max	sd
Presale market								
Unit size (sqm)	25,515	132	32	90	117	149	752	65
Unit price (SGD/sqm)	25,515	11,934	2,222	7,103	9,536	15,077	56,638	7,059
Spot market								
Unit size (sqm)	28,104	151	31	108	122	153	1,404	65
Unit price (SGD/sqm)	28,104	7,851	1,229	5,018	6,618	9,500	50,000	4,209
Panel B: time series: number of transactions and projects traded per month								
	Obs.	mean	min	p25	p50	p75	max	sd
Presale market								
No. monthly transactions	24	1,063	375	647	797	1,488	2,609	571
No. projects traded	24	124	62	101	122	147	193	35
Spot market								
No. monthly transactions	24	1,171	584	804	1,015	1,323	2,306	518
No. projects traded	24	448	302	385	419	485	669	101
Panel C: project-level data: project size (total no. units) and no. of units traded								
	Obs.	mean	min	p25	p50	p75	max	sd
Projects in presale market								
Project size	305	122	5	24	52	137	1160	173
No. units traded	305	72	0	13	30	85	573	99
Projects in spot market								
Project size	1478	96	5	16	36	93	1232	154
No. units traded	1478	17	0	2	6	17	561	32
Projects traded in both markets								
Project size	85	135	6	26	55	201	778	167
No. units traded	85	49	2	12	25	70	332	58
Panel D: project-month sample								
	Obs.	mean	min	p25	p50	p75	max	sd
Presale market								
No. units traded	4,528	5.74	0	0	1	5	417	17
Transaction size (sqm)	4,528	745	0	0	167	622	48,993	2,385
Project turnover	4,528	0.052	0	0	0.016	0.050	1	0.110
Spot market								
No. units traded	32,013	0.93	0	0	0	1	218	3
Transaction size (sqm)	32,013	132	0	0	0	126	29,310	533
Project turnover	32,013	0.013	0	0	0	0.008	1.040	0.061

Note: Sample from Dec05:Dec07; month of policy change (Dec 2006) dropped. Project size is equal to the total number of units in a condominium project. Projects with size ≥ 5 only. Transaction value in SGD/sqm. Project turnover is equal to the number of units traded in project i in month t, divided by the project size of project i.

Panel B of Table 1 summarizes the transaction data across the 24 months of our testing period. Whereas the total number of monthly transactions is similar in the presale and the spot market, they stem from fewer projects in the presale market. Put differently, there are more transactions in projects that are under construction than in projects that have been completed already. Of the 1,868 projects for which a transaction is observed during our testing period, 1,478 projects are spot market projects; among the remaining projects, 305 projects are observed in the presale market only and 85 projects are observed both before and after project completion (compare Panel C of Table 1). Accordingly, the number of units traded per project is quite different in the two market segments. If we use transaction level data, the observations could be dominated by trades from big projects due to their large transaction volumes. Similar to Qian, Fu, and Yeung (2016), we transform the transaction-level observations into project-level observations so as to avoid project-size effects. This means we aggregate all individual transactions in a project in one month to a project-month observation, which yields 36,541 project-month observations as summarized in Panel D of Table 1. The main variable of interest–*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 condominium project. The average monthly turnover is 5.2 percent in the presale and 1.3 percent in the spot market. (If no trade occurred in an "active" project in a given month, project turnover is recorded as zero.)

5.3 Methodology

Our main hypothesis states that a transaction tax has stronger effects on the probability of trade in information-sensitive market segments. We use *project turnover* as a proxy for the probability of trade and incorporate different measures for costs and value of information into the following baseline specification

$$Y_{it} = \beta_0 + \beta_1 \times Presale_{it} + \beta_2 \times Post_t + \beta_3 \times Presale_{it} \times Post_t + \gamma_i + \delta_t + \varepsilon_{it}$$

where Y_{it} is project turnover in project i and month t (the number of units traded normalized by the total number of units in the project). γ_i represent project fixed effects and δ_t are month fixed effects. $Presale_{it}$ is a dummy variable which is equal to one if project i is in the presale market in month t and is zero otherwise.[25] $Post_t$ 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. (Observations from December 2006 as the month of the treatment are dropped.) The key explanatory variable in the difference-in-difference approach is, thus, the interaction term $Presale_{it} \times Post_t$, which indicates the effect of the transaction tax increase on presale

[25] This variable is identified in the estimations since we observe some projects in the presale and in the spot market in the time period considered.

Table 2: Treatment effect on project-level turnover: on average

	$Project\ turnover_{it}$				
	Dec05:Dec07	Jun06:Jun07	Sep06:Mar07	Dec05:Dec07 (3m gap)	Dec05:Dec07 (project size > 20)
$Presale_{it}$	0.0216***	0.0200***	0.0206***	0.0215***	0.0109***
(=1 if presale market)	(0.006)	(0.006)	(0.006)	(0.006)	(0.003)
$\boldsymbol{Presale_{it} \times Post_t}$	-0.0340***	-0.0297***	-0.0329***	-0.0287***	-0.0304***
	(0.005)	(0.007)	(0.007)	(0.005)	(0.005)
Project fixed effects	Yes	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	36,541	18,263	9,099	33,519	26,247
R-squared	0.3587	0.4239	0.5303	0.3737	0.2887

Note: $Project\ turnover_{it}$ is defined as the number of units traded in project i in month t, normalized by the project size. Month of policy change (Dec06) dropped. $Post_t$ and constant term absorbed by time fixed effects. Projects with size ≥ 5 only. Standard errors in parentheses, clustered by planning areas. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

turnover, as compared to a possible pre-post effect for (the unaffected) spot market projects. The constant and the $Post_t$ dummy are absorbed by the time fixed effects. We estimate the model using OLS. Standard errors are clustered at the level of planning areas. (The five regions in Singapore are subdivided into 55 administrative planning areas.)

Figure 3 in Appendix C shows the time series and confidence intervals of monthly turnover in the presale vs. the spot market, controlling for project fixed effects. The diverging trends after the policy change illustrate the difference-in-difference effects in our sample at the aggregate level. (Possible anticipation effects are controlled for in the estimations below.) Table 2 presents the corresponding baseline estimation results: as measured by the coefficient of $Presale_{it} \times Post_t$, the transaction tax increase reduces turnover in the presale market by about 3 percentage points relative to the spot market. This holds for the 12-month time frame (column (1)) as well as for the 6-month and 3-month time frame (columns (2) and (3)). Also, the results are robust to dropping additional months before and after the policy change in order to control for possible anticipation effects: column (4) of Table 2 shows that very similar results are obtained if observations from November 2006, December 2006 and January 2007 are dropped. Finally, the results are robust to excluding projects of smaller size for which markets are presumably less liquid; column (5) exemplarily drops observations from projects of size of 20 units or less.

The results on average turnover are consistent with the general negative effect of higher transaction taxes on turnover and provides the basis of our analysis. The next section provides specific evidence on differential effects as derived by our theory based on information acquisition (Hypothesis 1).

5.4 Main empirical results

Our main hypothesis states that the effect of a transaction tax on turnover is stronger if information costs are lower or the value of information is larger. By their very nature, neither information acquisition nor (monetary and non-monetary) 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.

5.4.1 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 regions with high population density than in relatively remote areas, we use the Central and the East region of Singapore as an indicator for low information costs.[26] The resulting "CentralEast" indicator variable is interacted with the main independent variables $Presale_{it}$ and $Post_t$ and their interaction term. Hence, the three-way interaction $Presale_{it} \times Post_t \times CentralEast_i$ measures the differential treatment effect for presale projects in the Central and East regions, as compared to the difference-in-difference effects on non-central-east projects when comparing pre-vs.-post-intervention turnover in the presale vs. the spot market. According to Hypothesis 1 (Proposition 2), the lower information costs in the Central-East regions should result in a negative coefficient of $Presale_{it} \times Post_t \times CentralEast_i$.

The estimation results are summarized in Table 3. Columns (1) to (3) use observations from the 12-month, 6-month and 3-month time frame, respectively. Column (4) drops the months directly before and after the policy change; column (5) drops smaller, less liquid projects. First of all, in non-central-east regions where information costs are supposedly higher, the effect of the policy change on turnover—as now measured by the coefficient of $Presale_{it} \times Post_t$—is weaker than in the baseline regressions of Table 2, both in terms of size of the coefficient as well as significant level. In the central-east regions, however, the effect on turnover is stronger and highly significant: the estimated coefficient of the interaction term $Presale_{it} \times Post_t \times CentralEast_i$ is negative and significant at the 5%-level (12-month time frame) and the 1%-level (columns (4) and (5)), respectively, suggesting a differential effect on turnover in locations with low vs. high information costs. Correspondingly, the sum of the

[26] According to the data of the Singapore Department of Statistics, population density at the beginning of 2006 was 6,715/km^2 in the central-east regions and 4,438/km^2 in the non-central-east regions. Table 8 in Appendix C shows that our results are robust to using population density directly (at the level of regions) and interacting it with the presale dummy.

Table 3: Treatment effect on project-level turnover: by location

	$Project\ turnover_{it}$				
	Dec05:Dec07	Jun06:Jun07	Sep06:Mar07	Dec05:Dec07 (3m gap)	Dec05:Dec07 (project size > 20)
$Presale_{it}$	0.0132*	0.0223**	0.0452**	0.0169*	0.0076
(=1 if presale market)	(0.008)	(0.009)	(0.018)	(0.010)	(0.011)
$Presale_{it} \times Post_t$	-0.0171**	-0.0092	-0.0254***	-0.0075	-0.0043
	(0.007)	(0.011)	(0.009)	(0.005)	(0.006)
$Presale_{it} \times CentralEast_i$	0.0101	-0.0028	-0.0305	0.0056	0.0039
	(0.010)	(0.011)	(0.019)	(0.012)	(0.011)
$Post_t \times CentralEast_i$	0.0018*	0.0046***	0.0058***	0.0010	0.0009
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\boldsymbol{Presale_{it} \times Post_t \times CentralEast_i}$	-0.0200**	-0.0243*	-0.0090	-0.0251***	-0.0304***
	(0.009)	(0.014)	(0.012)	(0.007)	(0.008)
Project fixed effects	Yes	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	36,541	18,263	9,099	33,519	26,247
R-squared	0.3589	0.4242	0.5307	0.3740	0.2894

Note: $Project\ turnover_{it}$ is defined as the number of units traded in project i in month t, normalized by the project size. Month of policy change (Dec06) dropped. $Post_t$ and constant term absorbed by time fixed effects. $CentralEast_i = 1$ if project i is located in the Central or East region, and zero otherwise. Projects with size ≥ 5 only. Standard errors in parentheses, clustered by planning areas. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

coefficients of $Presale_{it} \times Post_t$ and $Presale_{it} \times Post_t \times CentralEast_i$, which reflects the treatment effect on turnover in the central-east regions, is larger in absolute terms and significant at the 1%-level. The results are slightly stronger when controlling for anticipation effects (column (4)) or potential liquidity concerns (column (5)). Hence, the estimation results are consistent with Hypothesis 1(a). Table 8 in Appendix C confirms these findings when replacing the location dummy by actual population density at the regional level as a proxy for information costs.

5.4.2 Project size as a proxy for the value of private information

To test part (b) of our main hypothesis, we use project size as a proxy for the value of private information acquisition. Here, the value of information acquisition for trades in projects of smaller size is assumed to be larger since there is less public information available in smaller than in bigger condominium projects and thus private information acquisition would be more

Table 4: Treatment effect on project-level turnover: by project size

	$Project\ turnover_{it}$				
	Dec05:Dec07	Jun06:Jun07	Sep06:Mar07	Dec05:Dec07 (3m gap)	Dec05:Dec07 (project size > 20)
$Presale_{it}$	-0.0738**	-0.0924***	-0.0705***	-0.0765***	-0.0334***
(=1 if presale market)	(0.028)	(0.026)	(0.024)	(0.028)	(0.011)
$Presale_{it} \times Post_t$	0.0352**	0.0363*	0.0170	0.0321**	0.0277**
	(0.014)	(0.018)	(0.024)	(0.014)	(0.013)
$Presale_{it} \times SmallProject_i$	0.0866***	0.1028***	0.0849***	0.0889***	0.0412***
	(0.030)	(0.027)	(0.027)	(0.030)	(0.011)
$Post_t \times SmallProject_i$	0.0068***	0.0106***	0.0061*	0.0064***	0.0019
	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)
$\boldsymbol{Presale_{it} \times Post_t \times SmallProject_i}$	-0.0647***	-0.0609***	-0.0459*	-0.0571***	-0.0556***
	(0.015)	(0.019)	(0.025)	(0.016)	(0.015)
Project fixed effects	Yes	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	36,541	18,263	9,099	33,519	26,247
R-squared	0.3596	0.4247	0.5308	0.3745	0.2897

Note: $Project\ turnover_{it}$ is defined as the number of units traded in project i in month t, normalized by the project size. Month of policy change (Dec06) dropped. $Post_t$ and constant term absorbed by time fixed effects. $SmallProject_i = Max\{Projectsize_i\} - Projectsize_i$, in thousand units. Projects with size ≥ 5 only. Standard errors in parentheses, clustered by planning areas. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

profitable. We define a continuous variable "small project" by the distance between the maximum project size observed in the sample and project i's project size. Thus, a larger value of the $SmallProject_i$ variable reflects a lower number of total units in project i. Interacting this variable with the difference-in-difference effect as for the previous results, we thus expect the coefficient of the three-way interaction term with $SmallProject_i$ to be negative.

Table 4 shows that the transaction tax increase reduces turnover more strongly in projects of smaller size. The estimated coefficients of the interaction term $Presale_{it} \times Post_t \times SmallProject_i$ in columns (1) to (5) indicate that the effect of the transaction tax on turnover is significantly more negative in smaller condominium projects. The estimated coefficients of -4.6 to -6.5 percentage points correspond to the differential effect per 1,000 units; one standard deviation decrease in project size thus increases the drop in turnover due to the policy change by 0.8 to 1.1 percentage points, relative to comparable spot market projects. This is economically significant given an average turnover around 5.2 percent in presale market. These results obtained for a continuous variable for project size are confirmed when using dummy variables for smaller projects (compare Table 9 in Appendix C). Overall, the results in Table 4 are consistent with the theory prediction that the tax increase reduces turnover more strongly if the value of information is high and, hence, problems of endogenous asymmetric information are more severe (Hypothesis 1(b)).[27]

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

As a third test of the information acquisition theory, we construct a proxy for investor sophistication. The ability and resources to learn about the value of the asset might differ for different investors. Hence, there typically is heterogeneity in the investor-specific information acquisition costs. We construct a proxy for the sophistication of an investor, which is based on the observation that some (short-term) investors buy units and turn them around rather than holding them.

The presale market is more attractive to short-term speculators than the spot market (Qian, Fu, and Yeung 2016). We define a speculative trade as a purchase in the presale market that is subsequently sold before the construction of the condominium project is completed.[28] Since our sample uses data at the project-month level, we further apply this concept in order to distinguish the projects depending on their attractiveness for short-term speculators: First, for each project ever been in presale market, we calculate its speculative trade size, which is the total number of "flipper trades" (i.e. total number of units bought and sold before project completion) and scale it by the total number of units traded in the project in the period December 2005 to December 2007. By definition, this speculative trade size is zero for projects never been in presale market. Second, we determine the median of the scaled speculative sizes across all projects ever been in presale market and define a dummy variable $FlipperProject_{it}$ which defines a presale project as a "flipper-traded project" if the presale project's scaled speculative size is above the median. Finally, we adjust the dummy variable to 0 when a project exits from the presale market and enters the spot market. Based on the definition above, 24% of the 25,515 presale transactions are speculative trades and 51% of

[27] The average project size is lower in the Central and East regions than in the other three regions; thus, the effect of project size does not capture location effects. If we separate the sample according to location, the significantly negative coefficient of $Presale_{it} \times Post_t \times SmallProject_i$ prevails both in the Central-East and in the Non-Central-East subsamples. Similarly, if we run the estimations in Table 3 separately for smaller and larger projects, we find that the coefficient of the interaction term $Presale_{it} \times Post_t \times CentralEast_i$ is negative and statistically significant both for projects below and above the median project size (total number of units).

[28] There can, of course, be a variety of reasons for why an investor may resell a unit before project completion. Our identifying assumption is that, on average, a high presence of such round-trip transactions in a given project reflects the presence of relatively many sophisticated investors. In our sample, such investments are held for about 30 months on average, compared to about 43 months average holding time for the remaining purchases.

Table 5: Treatment effect on project-level turnover: by flipper projects

	$Project\ turnover_{it}$				
	Dec05:Dec07	Jun06:Jun07	Sep06:Mar07	Dec05:Dec07 (3m gap)	Dec05:Dec07 (project size > 20)
$Presale_{it}$	0.0223***	0.0199***	0.0212***	0.0225***	0.0111***
(=1 if presale market)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
$Presale_{it} \times Post_t$	-0.0038	-0.0017	-0.0035	-0.0031	0.0023
	(0.004)	(0.006)	(0.007)	(0.004)	(0.004)
$Presale_{it} \times FlipperProject_{it}$	-0.0210	-0.0076	-0.0299***	-0.0238	-0.0565
	(0.018)	(0.006)	(0.007)	(0.017)	(0.073)
$\boldsymbol{Presale_{it} \times Post_t \times FlipperProject_{it}}$	-0.0396***	-0.0366***	-0.0384***	-0.0335***	-0.0427***
	(0.007)	(0.009)	(0.010)	(0.006)	(0.006)
Project fixed effects	Yes	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	36,541	18,263	9,099	33,519	26,247
R-squared	0.3598	0.4249	0.5316	0.3745	0.2912

Note: $Project\ turnover_{it}$ is defined as the number of units traded in project i in month t, normalized by the project size. Month of policy change (Dec06) dropped. $Post_t$ and constant term absorbed by time fixed effects. $FlipperProject_{it} = 1$ if the share of speculative trades (units bought and resold before project completion) out of total trades of project i is above the median for the sample of projects ever been in presale market in the period of Dec 2005 to Dec 2007. $FlipperProject_{it} = 0$ if project i is not in the presale market (any more). Projects with size ≥ 5 only. Standard errors in parentheses, clustered by planning areas. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

the 390 projects observed in the presale market are classified as flipper-traded projects in our test sample from December 2005 to December 2007.

Table 5 summarizes the main estimation results. Since flipper-traded projects are, by definition, in the presale market, the terms $Post_t \times FlipperProject_{it}$ and $FlipperProject_{it}$ are omitted in the regressions. The main variable of interest is the interaction term $Presale_{it} \times Post_t \times FlipperProject_i$ whose coefficient is expected to be negative. Indeed, as compared to the non-flipper projects in the presale market, turnover reacts to the transaction tax increase by additional 3.3 to 4.3 percentage points; the estimated coefficients are significant at the 1%-level. This holds in the 12-month time frame (column (1)) as well as in the shorter time frames (columns (2) and (3)) and when excluding the months directly before and after the policy change in order to control for possible anticipation effects (column (4)). It holds also when we exclude more illiquid properties as in column (5). This differential effect is consistent with the prediction that trades that involve sophisticated investors with high ability (low costs) of information acquisition react more strongly to the increased transaction tax (Hypothesis 1(a)).

5.5 Placebo tests

Since we use a difference-in-difference estimation for our quasi-experimental evidence on the transaction tax increase, we can conduct placebo tests in case that (i) the presale and spot markets (treated group and control group) actually capture other property characteristics, or (ii) the post-event dummy captures a trend due to other factors than the policy change itself.

Cross-sectional placebo test. We separate the spot market observations into two equal-sized groups and assign one group as a fake "treated" group to re-run the regressions. Table 6 in Appendix C shows that the previous findings become insignificant for the fake "treated" group which has not been affected by the policy. The results are robust when the size of the fake "treated" group is kept identical to that of the true treated group in the main regressions.[29]

Time-series placebo test. We repeat the baseline test for 24 times, each time using a different month in our test period as the fake "event month." We find that our baseline coefficients (for the true event month) always lie in the lower-end of the distributions of the estimated coefficients based on the 24 regressions. For the 12-month time frames, Table 7 in Appendix C shows that, in terms of magnitude, the key coefficients from our main regressions are below the 10th percentile of the respective coefficients from the 24 tests based on fake event months.

5.6 Robustness checks

Our main results are robust to various different robustness checks such as alternative definitions of variables or different specifications. Appendix C contains several robustness checks along different dimensions.

Alternative proxies. Table 8 in Appendix C replaces the Central-East dummy by population density as a measure for location and, accordingly, a higher cost of information acquisition in less densely populated areas. Table 9 defines different dummy variables for "small projects" instead of assuming a linear effect of project size. These alternative proxies yield very similar conclusions regarding the difference-in-difference estimates.

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[29] Since flipper projects are in the presale market by definition, the placebo tests run on spot market projects (selected as fake treated group or control group) is not applicable for tests with interactions of flipper projects. Given this, we further conduct a similar placebo test for treatment effects between flipper projects and non-flipper projects. Specifically, we randomly separate non-flipper presale projects into two groups, assign one group as the fake flipper projects (with $FlipperProject_{it} = 1$) and re-run the regressions in Table 5. For instance, for our main testing period (as in column (1) of Table 5), the coefficient of $Presale_{it} \times Post_t \times FlipperProject_{it}$ is 0.02 and insignificant (with standard error of 0.02) for the fake flipper projects.

Alternative indicator for trading activity. The previously reported results are based on a sample of all "active" condominium projects (between the first and the last transaction observed in the period from 2002 to 2012; see the exact definition in Section 5.2 above). This includes (a few) illiquid projects that are traded very rarely or not traded at all during our test period. As a robustness check, we exclude those illiquid projects and narrow down our sample to those projects traded at least once during our test period (see Table 10 in Appendix C). An even stricter way to deal with non-active projects is to exclude the no-trade observations and focus on the effect of the tax increase conditional on trade taking place (see Table 11 in Appendix C). The main effects based on more narrow indicators for trading activity are qualitatively very similar, that is, the reduction in turnover among projects with trade exhibits the same differential effects as obtained for the full sample.

Alternative econometric specifications. Table 12 in Appendix C shows that our previous findings generally hold when the one-month lag of the dependent variable (turnover) is also controlled for. Table 13 addresses the issue of censoring of turnover at zero. By and large, our main results are robust to using Tobit models instead of standard OLS. As the only difference, the "Central-East" indicator becomes insignificant in the 12-month time frame but is significant at the 1% level in other specifications such as when controlling for anticipation effects. Reverting to population density as a proxy for location also yields significant estimates based on Tobit models.

6. CONCLUDING REMARKS

This paper analyzes the effects of taxation on information acquisition and trade in decentralized markets. In the theory part, we show that taxation has both a direct and indirect effect on equilibrium behavior and derive the novel result 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 profits (capital gains). Our empirical results for a transaction tax increase are consistent with the differential effects on trade conditional on incentives for information acquisition.

Since information is typically endogenous in financial markets or real estate markets, understanding the equilibrium incentive effects of taxation on information acquisition and bargaining behavior at the trading level is important for policy design. In the context of 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.[30] We show that a tax on profits (capital gains) dominates a transaction tax in decentralized markets such as housing markets or debt funding markets in which private information acquisition is a concern among market participants since it creates endogenous adverse selection.

In general, the policy implications of the two tax instruments depend on whether an increase in the probability of trade (liquidity) 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 other traders or 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.[31] A similar issue becomes evident in housing markets where real estate bubbles and unaffordable prices in metropolitan areas, respectively, are an important concern to policy-makers often linked to problems of speculative transactions. Nevertheless, it appears difficult to define and, consequently, fight socially undesirable trades. Hence, whether one considers centralized or decentralized markets, providing a precise definition of "socially excessive trade" remains a challenge for a corresponding analysis of the welfare effects of taxation. Focusing on aspects of asymmetric information, our theoretical analysis suggests that a profit tax dominates a transaction tax if endogenous adverse selection is considered a problem and trade is efficient.

[30] 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.

[31] Thus, parallel questions on the effects of profit taxes versus transaction taxes arise in centralized markets. 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.

APPENDIX A: PROOFS

A.1 Proof of Lemma 1

We show the comparative statics properties of V_I and V_{II} separately for the cases where the buyer and where the seller is the responder.

Step 1: Suppose first that the buyer is the responder. Independent of (τ, λ), an informed buyer trades if and only if $x \geq p + \kappa$. Comparing her expected utility to the option of trading uninformed,

$$V_I(p, \tau, \kappa) = \int_{p+\kappa}^{\infty} \big(x - (p + \kappa) - T_B(x, p + \kappa)\big) dF(x) - \int_0^{\infty} \big(x - (p + \kappa) - T_B(x, p + \kappa)\big) dF(x)$$

which, with T_B given in (4), simplifies to

$$V_I(p, \tau, \kappa) = \int_0^{p+\kappa} \big((1 - \lambda\tau)(p + \kappa - x)\big) dF(x). \tag{6}$$

In words, if $x < p + \kappa$, an uninformed buyer who buys incurs a loss $p + \kappa - x$, of which a share λ can be credited against other capital gains taxed at rate τ. If $x \geq p + \kappa$, the ex post utility of the buyer is the same if she trades uninformed and if she acquires information before deciding whether to trade. From (6), it follows directly that V_I is strictly decreasing in τ and strictly increasing in κ and in p. (Note that if there is no tax treatment of losses ($\lambda = 0$), the buyer's value of information V_I is independent of a capital gains tax since V_I captures the value of avoiding losses from buying a low-value asset.)

The value of information V_{II} reflects the information rent as compared to not participating. Hence,

$$V_{II}(p, \tau, \kappa) = \int_{p+\kappa}^{\infty} (1 - \tau)\big(x - (p + \kappa)\big) dF(x)\,, \tag{7}$$

which is strictly decreasing in τ, κ, and p. This shows parts (i) and (ii) for the buyer as responder.

Step 2: Now suppose that the seller is the responder. An informed seller trades if and only if $x \leq p$. Hence, V_I corresponds to the net gain of keeping a high-value asset in states $x > p$, that is,

$$V_I(p, \tau, \kappa) = \int_p^{\infty} \big((x - T_S(x, p_0)) - (p - T_S(p, p_0))\big) dF(x). \tag{8}$$

Consider the difference in the seller's tax payments without and with trade. Using (4),

$$\frac{\partial}{\partial \tau}\big(T_S(x, p_0) - T_S(p, p_0)\big)$$
$$= (\max\{x - p_0, 0\} - \max\{p - p_0, 0\}) + \lambda(\max\{p_0 - p, 0\} - \max\{p_0 - x, 0\}), \tag{9}$$

which is strictly positive if $x > p$ and strictly negative if $x < p$.[32] Thus, V_I is strictly decreasing in τ. (This also holds if $\lambda = 0$ as long as p_0 is in the support of F so that a tax payment can occur.) Moreover, V_I is independent of κ, which formally has to be paid by the buyer. Finally, V_I strictly decreases in p.

Compared to not participating (keeping the asset), the seller's value of information V_{II} is

$$V_{II}(p, \tau, \kappa) = \int_0^{p} \big((p - T_S(p, p_0)) - (x - T_S(x, p_0))\big) dF(x). \tag{10}$$

[32] If $x > p$, the first term in brackets is non-negative (strictly positive if $p_0 < x$) and the second term in brackets is non-negative (strictly positive if $p_0 > p$), hence, (9) is strictly positive for all $p_0 \geq 0$. If $x < p$, the first term in brackets is non-positive (strictly negative if $p_0 < p$) and the second term in brackets is non-positive (strictly negative if $p_0 > x$), hence, (9) is strictly negative for all $p_0 \geq 0$.

Since $T_S(x, p_0) - T_S(p, p_0)$ is strictly decreasing in τ for $x < p$, it follows that V_{II} is strictly decreasing in τ. Moreover, V_{II} strictly increases in p but is independent of κ. This shows parts (i) and (ii) for the seller as responder.

A.2 Proof of Lemma 2

Part (i): Since $V_I \leq V_{II}$ is equivalent to $E_x[u_R(x, p, \tau, \kappa, 0)] \leq E_x[u_R(x, p, \tau, \kappa, 1)]$, the responder prefers trading uninformed over no trade. Moreover, $V_I \leq \gamma$ implies that the responder prefers trading 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 her outside option is $V_{II} - \gamma \geq 0$; hence, she is compensated for 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. Thus, the responder's optimal choice is her outside option (no information acquisition and no trade), irrespective of whether $V_I > \gamma$ or not.

A.3 Proof of Lemma 3

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 $\gamma \geq V_I(\bar{p}, \tau, \kappa)$. With Definition 2(i), this implies that $V_I(\bar{p}, \tau, \kappa) = V_{II}(\bar{p}, \tau, \kappa) \leq \gamma$; hence, by Lemma 2(i), the responder trades without information acquisition. In fact, the responder's expected utility is the same as if she 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 (she must still get at least her outside option). 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 $p_I \in \arg\max_p E_x[u_P(x, p, \tau, \kappa, 1)]$ s.t. $V_I(p, \tau, \kappa) \leq \gamma$ and that, at the optimal price p_I, the constraint $V_I \leq \gamma$ must bind. Hence, if p_I is charged and trade occurs with probability one, 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): If γ approaches zero, the proposer cannot avoid information acquisition of the responder; thus, the proposer's optimal choice is p_{II}.[33] Moreover, $E_x[u_P(x, p_{II}, \tau, \kappa, q^*(x, p_{II}, \tau, \kappa))]$ is (weakly) decreasing in γ: If p_{II} is the unconstrained optimum, i.e. $V_{II}(p_{II}, \tau, \kappa) < \gamma$, 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 strictly reduces the proposer's utility when proposing p_{II}. Intuitively, the proposer must leave a higher share in the surplus to the responder in order to compensate her for the higher cost of information and ensure that the responder does not choose her outside option $\bar{u}_R$. Therefore, the monotonicity properties of $E_x[u_P(x, p_I, \tau, \kappa, 1)]$ and $E_x[u_P(x, p_{II}, \tau, \kappa, q^*(x, p_{II}, \tau, \kappa))]$ together with part (ii) 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 Proposition 1

Part (i): If $\gamma < \underline{\gamma}$, the equilibrium price is p_{II} defined in Definition 2(ii). Suppose first that the responder's participation constraint is binding: $V_{II}(p_{II}, \tau, \kappa) = \gamma$.

If the buyer is the responder, V_{II} strictly decreases in τ and in p (Lemma 1); hence, $\partial p_{II}/\partial \tau < 0$. (If the seller does not lower p_{II} if τ is increased, then $V_{II} < \gamma$ and the buyer strictly prefers her outside option $\overline{U}_B = 0$ to information acquisition; Lemma 2(iii).) The probability of trade is equal to $1 - F(p_{II} + \kappa)$ and, hence, strictly increases in τ.

If the seller is the responder, V_{II} strictly decreases in τ and strictly increases in p (Lemma 1); hence, $\partial p_{II}/\partial \tau > 0$ if the seller's participation constraint binds. Thus, the probability of trade–equal to $F(p_{II})$–strictly increases in τ.

If the responder's participation constraint does not bind, that is, if $V_{II}(p_{II}, \tau, \kappa) > \gamma$, a marginal increase in τ has no effect on the price p_{II}: it does not affect the informed responder's buying decision but only reduces her profit that results from her informational advantage. Hence, the probability of trade is not affected by a marginal increase in τ if γ is negligible.

Part (ii): At $\gamma = \underline{\gamma}$, the proposer is indifferent between p_{II} and p_I where p_I solves $V_I(p_I, \tau, \kappa) = \gamma$. Thus, $\partial p_I/\partial \tau = -(\partial V_I/\partial \tau)/(\partial V_I/\partial p)$ where $\partial V_I/\partial \tau < 0$ by Lemma 1.

If the seller is the proposer, $\partial V_I/\partial p > 0$ (Lemma 1) so that $\partial p_I/\partial \tau > 0$. By part (i), $\partial p_{II}/\partial \tau \leq 0$. Therefore, if τ is increased, (a) the seller's utility when preventing information acquisition goes up and (b) his expected utility in the equilibrium candidate with information acquisition is weakly

[33] 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 $E_x[u_P(x, p_{II}, \tau, \kappa, q^*(x, p_{II}, \tau, \kappa))] \geq \bar{u}_P$.

reduced because the price p_{II} weakly decreases (strictly if the constraint $V_{II}(p_{II},\tau,\kappa) = \gamma$ binds).[34] Therefore, at $\gamma = \underline{\gamma}$, the seller now strictly prefers p_I over p_{II} so that $\partial\underline{\gamma}/\partial\tau < 0$.

If the buyer is the proposer, $\partial V_I/\partial p < 0$ (Lemma 1) so that $\partial p_I/\partial\tau < 0$. By part (i), $\partial p_{II}/\partial\tau \geq 0$. Thus, at $\gamma = \underline{\gamma}$, the buyer now strictly prefers proposing p_I over p_{II} so that $\partial\underline{\gamma}/\partial\tau < 0$.[35]

A.5 Proof of Proposition 2

Step 1: Consider the comparative statics properties of p_I and p_{II} in κ. By definition, the transaction tax has to be paid by the buyer. Hence, the relevant price for the buyer is the tax-inclusive price $p+\kappa$ and the relevant price for the seller is the net-of-tax price p. Since p_I solves $V_I(p_I,\tau,\kappa)=\gamma$, this implies that $\partial(p_I+\kappa)/\partial\kappa = 0$ if the buyer is the responder and $\partial p_I/\partial\kappa = 0$ if the seller is the responder. By a similar argument, if the constraint $V_{II}(p_{II},\tau,\kappa) \geq \gamma$ binds at the candidate price p_{II}, then $\partial(p_{II}+\kappa)/\partial\kappa = 0$ if the buyer is the responder and $\partial p_{II}/\partial\kappa = 0$ if the seller is the responder.

Now suppose that the responder's participation constraint does not bind at the candidate price p_{II}, i.e., $V_{II}(p_{II},\tau,\kappa) > \gamma$. Then, p_{II} solves the first-order condition $\partial E_x\left[u_P\left(x,p,\tau,\kappa,q^*(x,p,\tau,\kappa)\right)\right]/\partial p = 0$. If the seller is the proposer,

$$E_x[u_S\left(x,p,\tau,\kappa,q^*(x,p,\tau,\kappa)\right)] = \int_0^{p+\kappa} v_S(x)dF(x) + \int_{p+\kappa}^{\infty} p dF(x) \tag{11}$$

so that the necessary condition for the unconstrained optimum p_{II} is

$$(v_S(p_{II}+\kappa) - p_{II})F'(p_{II}+\kappa) + 1 - F(p_{II}+\kappa) = 0. \tag{12}$$

With $\partial(p_{II}+\kappa)/\partial\kappa = \partial p_{II}/\partial\kappa + 1$, total differentiation of (12) yields

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

Therefore, a marginal increase in κ strictly increases the tax-inclusive price $p_{II}+\kappa$ if the buyer/responder's participation constraint does not bind at p_{II}. It is worth mentioning that this finding is robust to the case of an ad-valorem transaction tax (where the tax-inclusive price equals $(1+\kappa)p$).[36]

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[34] Since, in the equilibrium candidate with information acquisition, the seller could have proposed a lower price already before the tax increase (lower prices relax the buyer's participation constraint $V_{II}(p_{II},\tau,\kappa) \geq \gamma$), lowering p_{II} must make him weakly worse off. Note that p_I is independent of τ if the seller is the proposer and $\lambda = 0$ (there is no loss offset). In this case, $\partial\underline{\gamma}/\partial\tau \leq 0$ with strict inequality if and only if $V_{II}(p_{II},\tau,\kappa) = \gamma$.

[35] By a similar argument as for the seller as proposer, the buyer could have proposed a higher price p_{II} already before the tax increase (higher prices relax the seller's participation constraint $V_{II}(p_{II},\tau,\kappa) \geq \gamma$) so that increasing p_{II} must make him weakly worse off. For the buyer as proposer, the strict inequality $\partial\underline{\gamma}/\partial\tau < 0$ also holds for $\lambda = 0$.

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

If the buyer is the proposer,

$$E_x[u_B(x,p,\tau,\kappa,q^*(x,p,\tau,\kappa))] = \int_0^p (v_B(x) - (p+\kappa))dF(x). \tag{13}$$

Necessary condition for the unconstrained optimum p_{II} is

$$(v_B(p_{II}) - (p_{II}+\kappa))F'(p_{II}) - F(p_{II}) = 0. \tag{14}$$

Total differentiation of (14) yields

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

so that the net-of-tax price p_{II} strictly decreases in κ if information costs are negligible. Again, this finding does not qualitatively depend on the transaction tax being a per-unit tax; if instead we consider an ad-valorem 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/responder's participation constraint is not binding.

Part (i): If $\gamma < \underline{\gamma}$, the equilibrium price is p_{II} defined in Definition 2(ii). By Step 1, if the seller makes the offer, $\partial(p_{II}+\kappa)/\partial\kappa \geq 0$ (with strict inequality if and only if $V_{II}(p_{II},\tau,\kappa) > \gamma$), which reduces the probability that an informed buyer buys. If the buyer makes the offer, $\partial p_{II}/\partial\kappa \leq 0$ (with strict inequality if and only if $V_{II}(p_{II},\tau,\kappa) > \gamma$), which reduces the probability that an informed seller sells. In both cases, the probability of trade *strictly* decreases if and only if the responder's participation constraint $V_{II}(p_{II},\tau,\kappa) \geq \gamma$ does not bind at the status-quo.

Part (ii): At $\gamma = \underline{\gamma}$, the proposer is indifferent between p_{II} and p_I.

Suppose first that the seller is the proposer. By Step 1, $\partial(p_I+\kappa)/\partial\kappa = 0$ and $\partial(p_{II}+\kappa)/\partial\kappa \geq 0$. Since $u_S(x,p_I,\tau,\kappa,1) = p_I$, we get

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

Regarding the candidate price p_{II}, suppose first that the buyer's participation constraint binds and, hence, $\partial(p_{II}+\kappa)/\partial\kappa = 0$ (see Step 1). With u_S given in (11) for $p = p_{II}$,

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

Thus, the seller's expected 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 $p_{II}+\kappa$ goes up following a tax increase, the seller must be strictly better off than if he had not changed the price (which would have been feasible; 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 $\partial\underline{\gamma}/\partial\kappa > 0$.

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price $z = (1+\kappa)p_{II}$ is independent of κ. Hence, parts (i) and (ii) of Proposition 2 carry over to an ad-valorem transaction tax (levied in percentage of the price).

If the buyer is the proposer and offers p_I, his expected utility is $E_x[v_B(x)] - (p_I + \kappa)$. Hence,

$$\frac{\partial E_x[u_B(x,p_I,\tau,\kappa,1)]}{\partial \kappa} = -1$$

since $\partial p_I / \partial \kappa = 0$ by Step 1. If the buyer offers p_{II}, his utility is given in (13), replacing $p = p_{II}$. Thus,

$$\frac{\partial E_x[u_B(x,p_{II},\tau,\kappa,q^*(x,p_{II},\tau,\kappa))]}{\partial \kappa} = -F(p_{II}) + \frac{\partial E_x[u_B(x,p,\tau,\kappa,q^*(x,p,\tau,\kappa))]}{\partial p}\bigg|_{p=p_{II}} \cdot \frac{\partial p_{II}}{\partial \kappa}\,, \qquad (15)$$

which is equal to $-F(p_{II})$. (The second term in (15) equals zero since either $\partial E_x[u_B(x, p_{II}, \tau, \kappa, q^*)]/\partial p_{II} = 0$ if p_{II} is the unconstrained optimum or $\partial p_{II}/\partial \kappa = 0$ if the seller's participation constraint binds.) For both candidate prices, the buyer's utility is reduced by the tax increase; however, in the equilibrium with information acquisition, the buyer pays the transaction tax only with probability $F(p_{II})$, in case he buys.[37] Since the buyer's expected utility from offering p_I is reduced more strongly by the increase in κ than his expected utility from offering p_{II}, $\underline{\gamma}$ shifts to the right ($\partial \underline{\gamma}/\partial \kappa > 0$).

SUPPLEMENTARY APPENDIX B: INFORMATION ACQUISITION OF THE PROPOSER

In this appendix we analyze the effects of taxation on the proposer's incentives to produce information before making the price offer. We focus 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 capital gains 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 $\bar{p}$ (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 Lemma 3. 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

[37] 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 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} so that the ad-valorem transaction tax distorts the choice toward an offer p_{II}.

believes that the asset's payoff is most unfavorable for her so that she does not trade. Concretely, we may assume that the buyer as responder believes that $x < \hat{p}$ with probability one (that $x = 0$ if $\hat{p} = 0$) and the seller as responder believes that $x > \hat{p}$ with probability one. Given these beliefs, a proposer who deviates from the candidate equilibrium and acquires information only considers to trade at the candidate equilibrium price or not to trade at all.

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 $E_x[u_P(x, p^*, \tau, \kappa, 1)]$ in the candidate equilibrium and gets an expected utility of $E_x[u_P(x, p^*, \tau, \kappa, \tilde{q}(x, p^*, \tau, \kappa))] - \gamma_P$ 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

$$V_P(p, \tau, \kappa) := E_x[u_P(x, p, \tau, \kappa, \tilde{q}(x, p, \tau, \kappa))] - E_x[u_P(x, p, \tau, \kappa, 1)].$$

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

Proposition B.1

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

Proof: We show that, for a given candidate equilibrium price, an increase in the capital gains tax τ reduces the value of information $V_P(p^*, \tau, \kappa)$ and therefore enlarges the range for the information cost γ_P for which the proposer does not want to deviate to information acquisition. The proof does not need to distinguish whether the price in the equilibrium without information acquisition is $\bar{p}$ or p_I.

Step 1: Suppose the seller is the proposer. The seller's expected utility in the candidate equilibrium is

$$E_x[u_S(x, p^*, \tau, \kappa, 1)] = p^* - T_S(p^*, p_0).$$

The seller gets the price p^* and makes a tax payment $T_S(p^*, p_0)$ where, as before, p_0 is the 'book value' deductible for tax purposes. If the seller deviates and acquires information, he trades at the candidate price p^* if and only if $v_S(x) \leq p^*$. Thus, for the seller as proposer, the value of deviating and acquiring information corresponds to the net gain of keeping the asset whenever $v_S(x) > p^*$, that is,

$$V_P = \int_{v_S^{-1}(p^*)}^{\infty} ((v_S(x) - T_S(x, p_0)) - (p^* - T_S(p^*, p_0))dF(x)$$

Note that V_P is very similar to the expression for V_I (compare, for instance, equation (8) in the proof of Lemma 1). The candidate equilibrium price p^* is not affected by an increase in the tax on the proposer's profits, i.e., $\partial p^*/\partial \tau = 0$. Moreover, the difference in tax payments, $T_S(x, p_0) - T_S(p, p_0)$ is strictly increasing in τ if and only if $x > p$ (see the proof of Lemma 1). By assumption, $v_S(x) < v_B(x) = x$ and, hence, $x < v_S^{-1}(x)$. Thus, $x > v_S^{-1}(p^*)$ implies $x > p^*$ so that $\partial V_P/\partial \tau < 0$.

Step 2: Suppose the buyer is the proposer. The buyer's expected utility in the candidate equilibrium is

$$E_x[u_B(x,p^*,\tau,\kappa,1)] = \int_0^\infty \big(v_B(x) - p^* - T_B(x,p^*)\big)dF(x).$$

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). Hence, the buyer's net gain from deviating and information acquisition (disregarding information costs) is equal to

$$V_P = \int_0^{v_B^{-1}(p^*)} \big(p^* - v_B(x) + T_B(x,p^*)\big)dF(x).$$

V_P reflects an informed buyer's gain from avoiding to buy the asset in low payoff states where $v_B(x) < p^*$, corrected by the tax payment in this case. With $v_B(x) > v_S(x) = x$ and, hence, $v_B^{-1}(p^*) < p^*$, it follows that $T_B(x,p^*) = -\lambda\tau(p^* - x)$ for all $x \leq v_B^{-1}(p^*)$. Therefore, V_P is strictly decreasing in τ.[38] ■

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. Here, as compared to trading with probability one, the seller as the proposer benefits from information acquisition in high payoff states where he would not sell when being informed. Higher capital gains taxes reduce this benefit since the seller pays more taxes if he does not sell and x turns out to be high. The buyer as 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 ($\lambda > 0$), the value of information of the buyer as proposer is strictly reduced. Thus, by reducing the proposer's gain from deviating to information acquisition, taxation of capital gains lowers the threshold for the information cost γ_P above which there is trade with probability one and, hence, enlarges the range in which all gains from trade are realized.

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 $\tau = 0$.

Proposition B.2

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: Recall that the transaction tax is levied on the buyer. We show that the deviation profit V_P strictly increases in κ.

[38] If there is no loss offset ($\lambda = 0$), V_P is independent of τ. This mirrors the result for V_I in the main analysis which is independent of τ for the buyer as the responder if $\lambda = 0$ and strictly decreasing in τ if $\lambda > 0$ (compare the proof of Lemma 1).

Step 1: Suppose first that the seller is the proposer. With p^* as the net-of-tax candidate equilibrium price which the seller proposes, we get

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

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 its effect on the equilibrium price. Since $p_I + \kappa$ is independent of κ (see Step 1 of the proof of Proposition 2; the same holds for $\bar{p} + \kappa$), $\partial p^*/\partial\kappa < 0$. Thus, $\partial V_P/\partial\kappa > 0$.

Step 2: If the buyer is the proposer, then

$$V_P = \int_0^{v_B^{-1}(p^*+\kappa)}\big(p^* + \kappa - v_B(x)\big)dF(x).$$

For the buyer, V_P corresponds to the value of avoiding a loss in low payoff states (if $v_B(x) < p^* + \kappa$). Since p_I and $\bar{p}$ are independent of the transaction tax to be paid by the buyer (compare again the proof of Proposition 2), it follows that $\partial(p^* + \kappa)/\partial\kappa > 0$ and, hence, $\partial V_P/\partial\kappa > 0$. ■

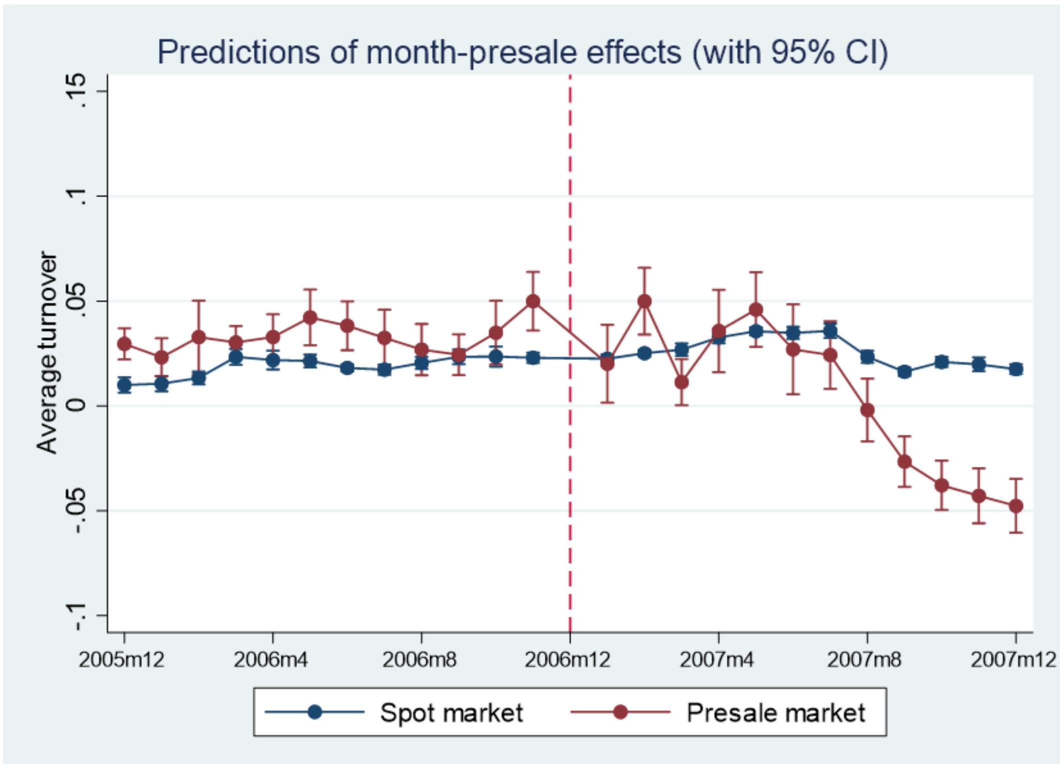
Transaction taxes make trade more expensive and thus increase the proposer's incentive to deviate to information acquisition and learn the true payoff of the asset. In the latter case, individually unfavorable trades can be avoided, which becomes more valuable if the transaction tax is increased. More precisely, for the seller as proposer, a transaction tax increase leads to a lower price in the equilibrium without information acquisition, which increases his incentive to deviate and learn the true payoff of the asset. For the buyer as proposer, if the transaction tax goes up, this increases the potential loss from buying the asset in low payoff states and, hence, strengthens the incentive to acquire information. In both cases, the range in which there is trade with probability one becomes smaller and mutually beneficial trade becomes less likely.

Altogether, taxation of capital gains 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.

SUPPLEMENTARY APPENDIX C: ADDITIONAL EMPIRICAL RESULTS

C.1 Turnover around the policy change

Figure 3: Predictions of monthly turnover (controlling for project fixed effects).



Note: The graph is based on the set of projects with at least 20 units (taking into account potential liquidity concerns). The results are robust to various definitions of active projects employed for the estimations results.

C.2 Placebo tests: cross-sectional and time series

Table 6: Placebo test: randomly picked spot market observations as "treated" group

	Project turnover$_{it}$		
	Dec05:Dec07	Dec05:Dec07	Dec05:Dec07
$X =$		$CentralEast_i$	$SmallProject_i$
$RdmSpot_{it}$	-0.0007	0.0037	0.0017
(=1 if fake treatment group)	(0.001)	(0.003)	(0.002)
$\boldsymbol{RdmSpot_{it} \times Post_t}$	0.0016	-0.0053	-0.0051
	(0.002)	(0.003)	(0.005)
$RdmSpot_{it} \times X$		0.0037	-0.0021
		(0.003)	(0.003)
$Post_t \times X$		-0.0053	0.0061***
		(0.003)	(0.002)
$\boldsymbol{RdmSpot_{it} \times Post_t \times X}$		-0.0052	0.0060
		(0.003)	(0.006)
Project fixed effects	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes
Observations	32,013	32,013	32,013
R-squared	0.3794	0.3796	0.3795

Note: $Project\ turnover_{it}$ is defined as the number of units traded in project i in month t, normalized by the project size. Month of policy change (Dec06) dropped. $Post_t$ and constant term absorbed by time fixed effects. $RdmSpot_{it} = 1$ in randomly selected spot market projects (placebo group). Projects with size ≥ 5 only. Standard errors in parentheses, clustered by planning areas. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: Placebo test: tests for different "event" months

	Our coefficient	*Coefficient of interaction term from 24 tests*					
Model		N	mean	P1	P10	P25	P50
Baseline	-0.0340***	24	0.002	-0.0536	-0.0405	**-0.0036**	0.009
Location	-0.0200**	24	0.002	-0.059	**-0.015**	-0.003	0.005
SmallProject	-0.0647***	24	0.005	-0.088	**-0.043**	-0.014	-0.014
FlipperProject	-0.0396***	24	0.006	-0.044	**-0.023**	-0.012	0.009

Note: Specifications from Table 2, Table 3, Table 4, and Table 5 (Dec05:Dec07) where $Post_t$ is replaced by $RdmPost_t$ based on fake event month.

C.3 Robustness checks: location as proxy for information costs

Table 8: Treatment effect on project-level turnover: by population density

	Project turnover$_{it}$				
	Dec05:Dec07	Jun06:Jun07	Sep06:Mar07	Dec05:Dec07 (3m gap)	Dec05:Dec07 (project size > 20)
$Presale_{it}$	0.0251	0.0258	0.0270	0.0287	0.0237
(=1 if presale market)	(0.031)	(0.030)	(0.033)	(0.032)	(0.025)
$Presale_{it} \times Post_t$	0.0085	0.0208	-0.0241	0.0156	0.0109
	(0.019)	(0.029)	(0.037)	(0.020)	(0.017)
$Presale_{it} \times Dens_i$	-0.0006	-0.0010	-0.0011	-0.0012	-0.0021
	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)
$Post_t \times Dens_i$	0.0007*	0.0015**	0.0016*	0.0005	0.0002
	(0.000)	(0.001)	(0.001)	(0.0004)	(0.0002)
$\boldsymbol{Presale_{it} \times Post_t \times Dens_i}$	-0.0069**	-0.0082*	-0.0014	-0.0072**	-0.0067**
	(0.003)	(0.005)	(0.006)	(0.003)	(0.003)
Project fixed effects	Yes	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	36,541	18,263	9,099	33,519	26,247
R-squared	0.3588	0.4241	0.5303	0.3739	0.2889

Note: $Project\ turnover_{it}$ is defined as the number of units traded in project i in month t, normalized by the project size. Month of policy change (Dec06) dropped. $Post_t$ and constant term absorbed by time fixed effects. $Dens_i$ is equal to population per km^2 (in thousand units, measured at the beginning of 2006) of the region where project i is located. Projects with size ≥ 5 only. Standard errors in parentheses, clustered by planning areas. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

C.4 Robustness checks: project size as proxy for value of information

Table 9: Treatment effect on project-level turnover: alternative proxies for project size

	$Project\ turnover_{it}$				
	Dec05:Dec07	Jun06:Jun07	Sep06:Mar07	Dec05:Dec07	Jun06:Jun07
	< 50 units	< 50 units	< 50 units	lowest 50%	lowest 50%
$Presale_{it}$ (=1 if presale market)	0.0048*	0.0052	0.0083	0.0068**	0.0063
	(0.003)	(0.005)	(0.005)	(0.003)	(0.005)
$Presale_{it} \times Post_t$	-0.0255***	-0.0189***	-0.0218***	-0.0269***	-0.0203***
	(0.004)	(0.006)	(0.007)	(0.004)	(0.006)
$Presale_{it} \times SmallProject_i$	0.0409***	0.0376***	0.0368*	0.0431**	0.0420***
	(0.014)	(0.014)	(0.019)	(0.016)	(0.014)
$Post_t \times SmallProject_i$	0.0043***	0.0057***	0.0045***	0.0047***	0.0057***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)
$\boldsymbol{Presale_{it} \times Post_t \times SmallProject_i}$	-0.0215**	-0.0254**	-0.0263**	-0.0233*	-0.0287*
	(0.010)	(0.012)	(0.012)	(0.013)	(0.016)
Project fixed effects	Yes	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	36,541	18,263	9,099	36,541	18,263
R-squared	0.3597	0.4248	0.5313	0.3598	0.4250

Note: $Project\ turnover_{it}$ is defined as the number of units traded in project i in month t, normalized by the project size. Month of policy change (Dec06) dropped. $Post_t$ and constant term absorbed by time fixed effects. In columns (1) to (3), $SmallProject_i = 1$ if project i has less than 50 units, and zero otherwise. In columns (4) to (5), $SmallProject_i = 1$ if project i is in the lowest 50% according to the total number of units, and zero otherwise. Projects with size ≥ 5 only. Standard errors in parentheses, clustered by planning areas. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

C.5 Robustness checks: treatment effect conditional on trade activity

Table 10: Treatment effect on project-level turnover: only using projects traded at least once during the test period of Dec05 to Dec07.

	$Project\ turnover_{it}$			
	Dec05:Dec07	Dec05:Dec07	Dec05:Dec07	Dec05:Dec07
$X =$		$CentralEast_i$	$SmallProject_i$	$FlipperProject_{it}$
$Presale_{it}$	0.0219***	0.0134	-0.0049*	0.0225***
(=1 if presale market)	(0.006)	(0.008)	(0.003)	(0.006)
$\boldsymbol{Presale_{it} \times Post_t}$	-0.0345***	-0.0173**	-0.0258***	-0.0040
	(0.005)	(0.007)	(0.004)	(0.005)
$Presale_{it} \times X$		0.0102	0.0414***	-0.0212
		(0.010)	(0.014)	(0.018)
$Post_t \times X$		0.0019*	0.0048***	
		(0.001)	(0.001)	
$\boldsymbol{Presale_{it} \times Post_t \times X}$		-0.0204**	-0.0218**	-0.0396***
		(0.009)	(0.010)	(0.007)
Project fixed effects	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes
Observations	35,161	35,161	35,161	35,161
R-squared	0.3576	0.3578	0.3586	0.3587

Note: $Project\ turnover_{it}$ is defined as the number of units traded in project i in month t, normalized by the project size. Month of policy change (Dec06) dropped. $Post_t$ and constant term absorbed by time fixed effects. $CentralEast_i = 1$ if project i is located in the Central or East region, and zero otherwise. $SmallProject_i = Max\{Projectsize_i\} - Projectsize_i$, in thousand units. $FlipperProject_{it} = 1$ if the share of speculative trades (units bought and resold before project completion) out of total trades of project i is above the median for the sample of projects ever been in presale market in the period of Dec 2005 to Dec 2007. $FlipperProject_{it} = 0$ if project i is not in the presale market (any more). Projects with size ≥ 5 only. Standard errors in parentheses, clustered by planning areas. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Treatment effect on project-level turnover: without the no-trade observations

	$Project\ turnover_{it}$			
	Dec05:Dec07	Dec05:Dec07	Dec05:Dec07	Dec05:Dec07
$X =$		$CentralEast_i$	$SmallProject_i$	$FlipperProject_{it}$
$Presale_{it}$	0.0144***	0.0172**	0.0522***	0.0150***
(=1 if presale market)	(0.004)	(0.007)	(0.018)	(0.004)
$\boldsymbol{Presale_{it} \times Post_t}$	-0.0407***	-0.0187***	0.0410***	-0.0098*
	(0.006)	(0.006)	(0.014)	(0.006)
$Presale_{it} \times X$		-0.0033	0.0634***	-0.0247
		(0.009)	(0.020)	(0.028)
$Post_t \times X$		0.0002	0.0025	
		(0.001)	(0.003)	
$\boldsymbol{Presale_{it} \times Post_t \times X}$		-0.0264***	-0.0809***	-0.0374***
		(0.009)	(0.016)	(0.008)
Project fixed effects	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes
Observations	13,721	13,721	13,721	13,721
R-squared	0.7174	0.7177	0.7184	0.7180

Note: $Project\ turnover_{it}$ is defined as the number of units traded in project i in month t. Project-month observations with trade only. Month of policy change (Dec06) dropped. $Post_t$ and constant term absorbed by time fixed effects. $CentralEast_i = 1$ if project i is located in the Central or East region, and zero otherwise. $SmallProject_i = Max\{Projectsize_i\} - Projectsize_i$, in thousand units. $FlipperProject_{it} = 1$ if the share of speculative trades (units bought and resold before project completion) out of total trades of project i is above the median for the sample of projects ever been in presale market in the period of Dec 2005 to Dec 2007. $FlipperProject_{it} = 0$ if project i is not in the presale market (any more). Projects with size ≥ 5 only. Standard errors in parentheses, clustered by planning areas. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

C.6 Robustness checks: adding lagged turnover

Table 12: Treatment effect on project-level turnover: with one-year lag of dep. variable

	$Project\ turnover_{it}$			
	Dec05:Dec07	Dec05:Dec07	Dec05:Dec07	Dec05:Dec07
$X =$		$CentralEast_i$	$SmallProject_i$	$FlipperProject_{it}$
$Presale_{it}$	0.0183***	0.0044	-0.0603**	0.0181***
(=1 if presale market)	(0.006)	(0.011)	(0.027)	(0.006)
$\boldsymbol{Presale_{it} \times Post_t}$	-0.0248***	-0.0076	0.0205*	-0.0002
	(0.004)	(0.005)	(0.012)	(0.003)
$Presale_{it} \times X$		0.0166	0.0710**	-0.0009
		(0.012)	(0.029)	(0.007)
$Post_t \times X$		0.0021*	0.0083***	
		(0.001)	(0.002)	
$\boldsymbol{Presale_{it} \times Post_t \times X}$		-0.0204***	-0.0423***	-0.0324***
		(0.007)	(0.012)	(0.005)
$Turnover_{i,t-1}$	0.0858***	0.0852***	0.0846***	0.0839***
	(0.015)	(0.015)	(0.015)	(0.015)
Project fixed effects	Yes	Yes	Yes	Yes
Month fixed effects	Yes	Yes	Yes	Yes
Observations	33,247	33,247	33,247	33,247
R-squared	0.2113	0.2116	0.2119	0.2123

Note: $Project\ turnover_{it}$ is defined as the number of units traded in project i in month t, normalized by the project size. Month of policy change (Dec06) dropped. $Post_t$ and constant term absorbed by time fixed effects. $CentralEast_i = 1$ if project i is located in the Central or East region, and zero otherwise. $SmallProject_i = Max\{Projectsize_i\} - Projectsize_i$, in thousand units. $FlipperProject_{it} = 1$ if the share of speculative trades (units bought and resold before project completion) out of total trades of project i is above the median for the sample of projects ever been in presale market in the period of Dec 2005 to Dec 2007. $FlipperProject_{it} = 0$ if project i is not in the presale market (any more). Projects with size ≥ 5 only. Standard errors in parentheses, clustered by planning areas. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

C.7 Regressions using Tobit models

Table 13: Treatment effect on project-level turnover: Tobit model

	Project turnover$_{it}$				
	Dec05:Dec07	Dec05:Dec07	Dec05:Dec07 (3m gap)	Dec05:Dec07	Dec05:Dec07
$X =$		$Dens_i$	$CentralEast_i$	$SmallProject_i$	$FlipperProject$
$Presale_{it}$	0.0507***	0.0154	0.0195	-0.1509***	0.0518***
(=1 if presale market)	(0.012)	(0.049)	(0.014)	(0.055)	(0.012)
$\boldsymbol{Presale_{it} \times Post_t}$	-0.0524***	0.0111	-0.0088	0.0742***	0.0028
	(0.009)	(0.032)	(0.010)	(0.021)	(0.012)
$Presale_{it} \times X$		0.0059	0.0096	0.1863***	-0.0385
		(0.008)	(0.015)	(0.057)	(0.031)
$Post_t \times X$		0.0014	-0.0001	0.0350***	
		(0.002)	(0.003)	(0.006)	
$\boldsymbol{Presale_{it} \times Post_t \times X}$		-0.0104**	-0.0392***	-0.1201***	-0.0697***
		(0.005)	(0.013)	(0.025)	(0.013)
Project fixed effects	Yes	Yes		Yes	Yes
Month fixed effects	Yes	Yes		Yes	Yes
Observations	36,541	36,541		36,541	36,541

Note: *Project turnover*$_{it}$ is defined as the number of units traded in project i in month t. Month of policy change (Dec06) dropped. $Post_t$ and constant term absorbed by time fixed effects. $CentralEast_i = 1$ if project i is located in the Central or East region, and zero otherwise. $SmallProject_i = Max\{Projectsize_i\} - Projectsize_i$, in thousand units. $FlipperProject_{it} = 1$ if the share of speculative trades (units bought and resold before project completion) out of total trades of project i is above the median for the sample of projects ever been in presale market in the period of Dec 2005 to Dec 2007. $FlipperProject_{it} = 0$ if project i is not in the presale market (any more). Projects with size ≥ 5 only. Standard errors in parentheses, clustered by planning areas. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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, Ch. 50, 1897-1945.

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.

BENJAMIN, John D., COULSON, N. Edward, YANG, Shiawee X., 1993. Real-estate transfer taxes and property values: The Philadelphia story. *Journal of Real Estate Finance and Economics* 7, 151-157.

BEST, Michael C., KLEVEN, Henrik J., 2018. Housing market responses to transaction taxes: Evidence from notches and stimulus in the UK. *Review of Economic Studies* 85(1), 157-193.

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.

DANG, Tri Vi, GORTON, Gary, HOLMSTRÖM, Bengt, 2020. The information view of financial crises. *Annual Review of Financial Economics* 12, 39-65.

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

DÁVILA, Eduardo, 2016. 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.

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.

KOPCZUK, Wojciech, MUNROE, David, 2015. Mansion tax: The effect of transfer taxes on the residential real estate market. *American Economic Journal: Economic Policy* 7(2), 214-257.

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.

NORREGAARD, John, 2013. Taxing immovable property: Revenue potential and implementation challenges. IMF Working Paper 13/129.

OATES, Wallace E., 1969. The effects of property taxes and local public spending on property values: An empirical study of tax capitalization and the Tiebout hypothesis. *Journal of Political Economy* 77(6), 957-971.

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.

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Tri Vi Dang, Xiaoxi Liu, Florian Morath

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

Abstract
This paper shows that a transaction tax makes trades in decentralized markets more information sensitive and enlarges the range of information costs for which the equilibrium exhibits private information acquisition and endogenous adverse selection. A transaction tax reduces the probability of trade. The opposite implications hold for a tax on capital gains. The theoretical implications of a transaction tax are tested using a tax policy change in one segment of Singapore's housing market. Using various proxies for information sensitivity, the triple difference-in-difference analysis shows that a higher transaction tax reduces turnover more strongly when trades are more information sensitive.

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