Securities Transaction Taxes: Macroeconomic Implications in a General-Equilibrium Model*

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Abstract

This paper studies the impact of a financial transaction tax (FTT) on financial trading, stock prices and real economic variables in a dynamic stochastic general-equilibrium model featuring a financial intermediary sector with two types of financial frictions: 1.) intermediaries face an incentive constraint a la Gertler and Karadi (2011) which puts an upper bound on their leverage ratio; 2.) we allow for noise shocks to traders' sentiment which will drive non-fundamental trade. Financial market shocks and taxes have an impact on the aggregate outstanding share value and its volatility, which is in turn transmitted to firms' capital financing costs and investment decisions. The model is calibrated to match stylised facts of financial trading and firms' financing. Our results suggest that the FTT is highly distortive - similarly to a capital income tax. At the same time, the FTT reduces volatility in financial markets. However, the stabilisation gain in terms of a reduction in excess real volatility is very small.

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1 Introduction

The banking and financial crisis of recent years has triggered a broad debate on the reform of the financial sector regulation in order to avoid a replay of events and improve the resilience of the sector. Given the costs that bank rescues

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have inflicted on taxpayers, the demand to make the financial sector contribute to the financing of crisis-intervention costs has also gained political voice and support (IMF, 2010). In the European Union, the European Commission has proposed an EU-wide financial transaction tax that would cover a broad array of financial assets. The political debate suggests financial sector taxation as a toolbox to prevent the occurrence of further financial crises as well as a means of cost recovery from the financial sector which has been heavily subsidised in the past years. In contrast to the public discussion, however, there is little public finance literature on financial sector taxation, its regulatory merits and drawbacks or its potential to generate government revenue. Empirical work is also scarce. Consequently, governments have been largely unguided by academic research (Keen, 2011).

Against this background, this paper aims at contributing to the literature by providing an analysis of the macro-economic effects of the introduction of a financial transaction tax (FTT) in a dynamic stochastic general equilibrium (DSGE) framework. We focus on the the type of financial transaction tax levied on secondary market trade in equities (henceforth equities transaction tax or ETT). Hence, we ignore other potential tax bases, like foreign currency, derivatives and bank repos, the discussion of which is beyond the scope of this paper. The two main questions that our paper addresses are: (1) What is the ETT's long-term impact on financing costs, investment and economic activity? (2) Does the ETT succeed in reducing (non-fundamental) volatility of asset prices and real economic variables?

While the adverse impact on the financing costs for companies' real investment is generally seen as the major potential drawback of an ETT, the reduction of non-fundamental volatility is usually regarded to be its principal regulatory merit. The model-based analysis in this paper makes an attempt to quantify both effects and their macroeconomic implications. The exercise also discusses the parameters that shape their relative importance.

The model we use is an RBC model featuring two types of financial frictions. First, we incorporate financial institutions specified as intermediaries collecting depositis from households and investing in corporate equity. The financial sector is subject to an agency problem like in Gertler in Karadi (2011). This creates a channel for financial sector shocks to be transmitted to other parts of the economy. Second, we assume that some financial intermediaries act as noise traders in the sense of De Long et al. (1990) and Shleifer and Summers (1990). Such idiosyncratic noise shocks drive non-fundamental trade in financial assets in the model. This feature also introduces some scope for the ETT to be welfare enhancing through the dampening of unproductive financial transactions and related real economic fluctuations. We calibrate our model to match some stylised facts of financial markets and firms' financing.

The contribution and novelty of discussing the ETT in a DSGE framework is the emphasis on the ETT's macroeconomic impact and the exposition of relevant transmission channels. The approach contrasts with partial equilibrium approaches (e.g. Kupiec, 1996; Song and Zhang, 2005) that exclude feedback effects accross different markets and over time and conjecture the imapct of

ETTs on the real economy off-model.

Our results suggest that the ETT is a highly distortive tax, with long-run effects similar to those of capital income taxation. At the same time, the ETT does somewhat reduce financial volatility. However, the stabilisation gain in terms of a reduction in real economc volatility is rather small.

Section 2 of the paper reviews the debate on financial transaction taxes, listing the main arguments for and against ETTs to place our analysis in context. Section 3 develops a DSGE model with noise trading and ETT as the paper's analytical framework. Section 4 presents the parameterisation of the model. Section 5 presents the scenarios and simulation results and compares them to related findings in the literature. Section 6 summarises and concludes.

2 The debate on financial transaction taxes

The paper contributes to the ongoing debate on the merits and drawbacks of financial transaction taxes. Hemmelgarn and Nicodème (2010), IMF (2010) and Matheson (2011) provide a comprehensive survey of the current state of policies and research. Our discussion focuses on two main aspects of the regulatory and budgetary potential of transaction taxes, namely their potential to reduce the volume and volatility of (socially unproductive) transactions in financial markets and the implications of FTTs for capital costs and real investment. The DSGE model we propose in this paper provides an integrated view of these aspects.[1]

2.1 Financial markets

The impact of FTTs on financial market volatility is highly debated in the literature. FTT proponents have traditionally focused on the potential of transaction taxes to curb non-fundamental short-term trading in financial markets by raising the cost of financial transactions. According to this view, curbing short-term trade could reduce asset mispricing and non-fundamental market volatility and the consumption of ressources in socially non-productive activities (e.g., Stiglitz, 1989; Summers and Summers, 1989). However, discriminating between productive and noisy or zero-sum transactions is problematic in practice, so that restricting short-term trades by increasing the trading costs may also prolong imbalances and increase the costs of risk hedging. If all transactions are taxed at equal rates and independent of their respective risk profiles, the FTT is unlikely to reduce risk-taking and fragility in the financial sector (Keen, 2011). Even a reduction in non-fundamental trading does not necessarily translate into a reduction in non-fundamental asset price volatility in markets with heterogenous beliefs as reducing trade volumes increases the impact of individual transactions on asset prices (e.g., Habermeier and Kirilenko, 2003). Partial-equilibrium heterogenous-agent models (e.g., Demay, 2006, 2010; Hanke

[1] Other aspects of the debate concern the FTT's potential to raise revenues, PLEASE COMPLETE. For a comprehensive overview of these points see e.g. Hemmelgarn and Nicodeme (2010).

et al., 2010; Mannaro et al., 2008; Kirchler et al., 2011; Pellizzari and Westerhoff, 2009; Westerhoff and Dieci, 2006) indicate mixed results, which depend on financial market micro structure.

The scarce empirical evidence does not document a market-stabilising impact of financial transaction taxes and financial transaction costs in general. Hau (2006) finds that increasing transaction costs have increased the volatility of individual share prices at short frequencies in the French stock market. Jones and Seguin (1997) find that declining transaction costs have increased trade volumes and reduced share prices volatility in the NYSE. Baltagi et al. (2006) find that the Chinese stamp tax has reduced trade volumes, increased market volatility and lenghtened the time it takes for the stock market to absorb external shocks.

Absent a clear link between short-term trading and long-run cycles of asset mispricing, the recent banking and financial crisis does not provide a strong argument in favour of transaction taxes as the best way, from a regulatory perspective, to tax the financial sector. Financial instruments that triggered the 2008 crisis and the collapse of financial institutions did generally not belong to the class of frequently traded assets (e.g., Hemmelgarn and Nicodème, 2011; Matheson, 2011). Transaction taxes do not address the problems of leverage, maturity mismatch, currency mismatch or the underestimation of investment risk.

2.2 Real economy

Besides the potentially ambivalent impact on financial volatility, the strongest objection against FTTs concerns their impact on the financing costs for firms in the real economy. To the extent that FTTs lower equity prices, the costs of capital for investors in the real sector increase. Under decreasing returns to capital, higher capital costs reduce the capital stock, labour productivity and real output in the long run.

In the presence of financial frictions as in our model, an FTT may affect capital costs in the real economy even if it applies only to transactions in the secondary market. Lower liquidity in the secondary market may, e.g., increase the interest premium that investors charge to cover potential costs of premature disinvestment in the case of materialising investment risks or the sudden tightening of individual budget constraints. Collateral constraints of firms would also tighten if the FTT reduced equity prices and the firm value.

Empirical studies support the view that FTT imposition lowers equity prices. Bond et al. (2005) find a positive impact of (announced) cuts in the UK stamp duty on the relative price of more frequently traded shares. Hu (1998) reports a negative impact of rising stamp-duty rates on stock prices in Asian markets. The point estimates in Jackson and O'Donnell (1985) suggest that share prices rose by around 8 percent in response to the one percentage-point reduction in the UK stamp duty in 1984. Westerholm (2003) estimates similar elasticities for response of share prices to transaction costs in Finland and Sweden. Umlauf (1993) finds a share price decline by 5% in response to the announcement of the 1984 1% FTT introduction in Sweden.

Another concern (e.g., IMF, 2010; Shackelford et al., 2010) is that a broad-based FTT may reinforce vertical integration of production lines in the real sector. Notably, an FTT that applies also to business-to-business financial transactions would provide incentives for economic concentration in goods and factor markets to avoid the cascading tax burden on the production by non-integrated firms.

3 Model description

In our model, we focus on the type of financial transaction tax which is levied on secondary market trade in equties. To study the impact of an equities transaction tax on financial and real economic variables, the paper incorporates financial frictions in a standard closed-economy RBC model. Financial frictions are introduced along two dimensions:

First, we incorporate short-lived financial institutions, called in the paper intermediaries or traders, which collect depositis from households and invest in corporate equity. The financial sector is subject to an agency problem like in Gertler in Karadi (2011): financial intermediaries, who manage deposits obtained from households, may choose to run away with the resources instead of investing them into equity to generate profit for their owners. In order to prevent managers from this illicit behavior, an incentive constraint has to hold, which puts an upper bound on the leverage ratio of intermediaries.

Second, we assume that a fraction of intermediaries are "noise traders" in the sense of De Long et al. (1990) and Shleifer and Summers (1990). Noise traders have noisy expectations about stock returns which may deviate from fundamentals-based rational expectations. Non-fundamental "noise shocks" that capture changes in the noise traders' beliefs increase the volatility of asset prices and trading. The model is so constructed that the noise-driven trade is the only trade that takes place between traders (as opposed to trade between firms issuing shares and traders investing in shares). Hence, in the paper, secondary market transactions are identified as noise trade.

The setup of the model allows for two transmission channels of financial transaction taxes on the non-financial sector (which we will informally dub the 'real economy'). First, given that firms finance a part of their capital investment via public share issuance, any tax on shares which has an impact on the outstanding share value will have an impact on the firms' cost of capital and hence on the level of capital and output. Second, the incentive constraint is a vehicle which transmits purely financial-sector-related shocks to the rest of the economy. In particular, it makes noise trade matter for the aggregate share value and also for real economic volatility. Thereby, taxing these transactions will also have an impact on firms' financing costs. At the same time, this channel gives scope for an ETT to potentially eliminate the excess volatility.

The remaining sectors of the economy (households, capital producers and consumption goods producers) are standard. We use a closed-economy framework and assume the ETT to be effectively implementable and enforceable. The analysis abstracts from the problem of tax avoidance in internationally integrated financial markets. Alternatively, the setup can be interpreted as representing the world economy under globally unified transaction taxation.

To align sequences of financial and real investment decisions, and despite the quantitative importance of high-frequency asset trading, we impose homogenous time intervals for financial trading and decisions on real economic variables. In line with standard practice in business-cycle models, the time intervals correspond to quarters of years. The following subsections describe the details of the model structure. All model variables are formulated in per capita terms.

3.1 Households

There is a continuum of identical households of measure 1. They consume, save and supply labour. Each household has access to several alternative saving vehicles. They can invest in riskless government bonds B_t^G and corporate bonds B_t^C or lend to a financial intermediary (by creating a deposit F_t). By arbitrage, the return on all these assets is the same and will be denoted R_t. Households also own the financial intermediaries and hence receive all the proceeds from the financial market operations. Households set up a new intermediary by providing it with an initial net worth NW_t. Finally, households also own the capital producing firms and indirectly, through the ownership of the financial institutions, the firms producing the final good.

Households' preferences are given by:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t)^{1-\gamma}}{1-\gamma} - \frac{\omega}{1+\kappa} N_t^{1+\kappa} \right]$$

where C_t is individual consumption stream and N_t hours worked supplied to final goods producing firms. The budget constraint of a household is:

$$\begin{aligned} & C_t + B_t^G + B_t^C + F_t + NW_t \\ = \; & \left(1-\tau^l\right) W_t N_t + R_{t-1} B_{t-1}^G + R_{t-1} B_{t-1}^C + R_{t-1} F_{t-1} - T_t^{ls} + \Pi_t^F + \Pi_t^K \end{aligned}$$

where W_t denotes the wage rate, τ^l is the labour income tax rate and T_t^{ls} are lump-sum taxes. Finally, Π_t^F and Π_t^K stand for profits of operations of financial intermediaries and capital producers, respectively.

The households' first order conditions with respect to labor supply and consumption/saving are standard:

$$\frac{\omega N_t^{\kappa}}{C_t^{-\gamma}} = \left(1-\tau^l\right) W_t$$

$$\lambda_t^l = \beta R_t E_t \left[\lambda_{t+1}^l\right]$$

where $\lambda_t^l = C_t^{-\gamma}$ is the Lagrange multiplier on the households' budget constraint.

3.2 Financial intermediaries

The specification of financial intermediaries is based on Gertler and Karadi (2011) with an extension allowing for not fully rational trade in equities along the lines De Long et al. (1990) and Shleifer and Summers (1990).

Financial intermediaries' basic activity is to collect deposits F_t from households and invest in corporate shares. An intermediary lives for two periods and we assume that the financial market has an overlapping generations structure. A trader j born in period t receives a transfer from its owners, NW_t^j, which will be called his/her net worth. In addition, the trader collects deposits F_t^j from other households; this assumption allows us to motivate the agency problem of intermediaries which will be discussed below. The funds raised are then invested in firms' equity S_t^j. An intermediary j's balance sheet in period t is then given by:

$$S_t^j P_t^S = F_t^j + NW_t^j$$

where P_t^S is the price of corporate shares.

In the following period, the intermediary sells its stock of shares and transfers all its profits, equal to the return on the sold equity net of repayment of the loan and taxes, to its owners. Hence an intermediary born at t maximizes:

$$\max E_t^j\left[\frac{\lambda_{t+1}^l}{\lambda_t^l}\Pi_{t+1}^{F,j}\right] = \beta E_t^j\left[\frac{\lambda_{t+1}^l}{\lambda_t^l}\left(\left(P_{t+1}^S + Div_{t+1}\right)S_t^j - R_t F_t^j - \tau^{STT} f\left(P_t^S S_t^j\right)\right)\right]$$

where Div_t are dividends obtained from the final goods producers and $\tau^{STT} f\left(P_t^S S_t^j\right)$ is the amount of ETT to be paid to the government which we specify below.

Traders discount the expected return from their investment with the discount factor of their owners. Note that the expectations operator $E_t^j[\cdot]$ bears the superscript j to make expectations trader-dependent. This is because, as mentioned earlier, a fraction of intermediaries will be assumed to have noisy expectations. We elaborate on this feature of our model below.

Given the balance sheet identity, the maximization problem of an intermediary can be rewritten as:

$$\max \beta E_t^j\left[\frac{\lambda_{t+1}^l}{\lambda_t^l}\left(\left(R_{t+1}^S - R_t - \frac{\tau^{STT} f\left(P_t^S S_t^j\right)}{P_t^S S_t^j}\right)P_t^S S_t^j + R_t NW_t^j\right)\right]$$

where $R_t^S \equiv \frac{P_t^S + Div_t}{P_{t-1}^S}$ is a risky return on corporate shares.

An intermediary will only invest in corporate shares if the net expected return on investment is non-negative:

$$\beta E_t^j\left[\frac{\lambda_{t+1}^l}{\lambda_t^l}\left(R_{t+1}^S - R_t - \frac{\tau^{STT} f\left(P_t^S S_t^j\right)}{P_t^S S_t^j}\right)\right]P_t^S S_t^j \geq 0$$

In a perfect market, equality would hold: intermediaries would borrow and expand their assets to the point where the risk and tax-adjusted premium on shares would disappear. In this case, idiosyncratic shocks hitting the financial market (like the noise shock) would have only redistributive nature and would hence not be transmitted to the real economy. To make the model more realistic, we introduce financial frictions along the lines of Gertler and Karadi (2011). In particular, we introduce an agency problem: if the expected net return on equity is too low, the trader may decide to divert the fraction $\chi < 1$ of deposits he/she obtained. In doing so, the trader gives up the remaining fraction $1 - \chi$ of deposits that is recovered by the depositors as well as the return from foregone investment. Accordingly, for households to be willing to provide funds to intermediaries, the following incentive constraint must hold:

$$E_t^j \left[\frac{\lambda_{t+1}^l}{\lambda_t^l} \Pi_{t+1}^{F,j} \right] \geq \chi P_t^S S_t^j$$

i.e. the intermediary's expected return on investment must exceed the payoff from diverting the funds. Subsituting for $\Pi_{t+1}^{F,j}$ and rearranging terms one obtains:

$$P_t^S S_t^j \leq \frac{1}{1 + \chi - \beta E_t^j \left[\frac{\lambda_{t+1}^l}{\lambda_t^l} R_{t+1}^S - \tau^{STT} \frac{f\left(P_t^S S_t^j\right)}{P_t^S S_t^j} \right]} NW_t^j$$

Note that the above constraint will be binding if and only if:

$$\chi > \beta E_t^j \left[\frac{\lambda_{t+1}^l}{\lambda_t^l} R_{t+1}^S - \tau^{STT} \frac{f\left(P_t^S S_t^j\right)}{P_t^S S_t^j} \right] - 1 > 0$$

The second inequality guarantees that the net expected return on shares is positive. In this case it is profitable for the intermediary to expand its assets. The first inequality then imposes that the intermediary is not able to expand its assets indefinitly. It hence borrows so much from the households as to make the incentive constraint binding.

Under the parameter values and shock processes we will consider, the incentive constraint will be binding at any t. Hence, we can write:

$$P_t^S S_t^j = \phi_t^j NW_t^j$$

with

$$\phi_t^j \equiv \frac{1}{1 + \chi - \beta E_t^j \left[\frac{\lambda_{t+1}^l}{\lambda_t^l} R_{t+1}^S - \tau^{STT} \frac{f\left(P_t^S S_t^j\right)}{P_t^S S_t^j} \right]}$$

where $\phi_t^j > 0$ is the private leverage ratio of intermediary j.

We depart from Gertler and Karadi (2011) by assuming that a share of intermediaries are noise traders like in De Long et al. (1990) and Shleifer and Summers (1990): their expectations about the future share return are noisy in the sense that they may deviate from the rational expectations by a noise shock. This will lead to differences in the expectations between noise traders and informed traders, to different asset positions and to the creation of what can be interpreted as irrational, non-fundamentals-driven trade. This non-fundamental trade is useful for discussing potential gains from financial transaction taxes: if noise trading introduces an excess volatility in the real economy, an ETT which may be expected to curb noise trading may thereby also reduce noise-trade-driven excess real volatility.

Formally, the $1 - s_n$ informed traders are assumed to have perfectly rational expectations of future (discounted) returns:

$$E_t^I \beta \frac{\lambda_{t+1}^l}{\lambda_t^l} \left[R_{t+1}^S\right] = E_t \beta \frac{\lambda_{t+1}^l}{\lambda_t^l} \left[R_{t+1}^S\right]$$

In contrast, the expectations of the s_n noise traders are:

$$E_t^N \beta \frac{\lambda_{t+1}^l}{\lambda_t^l} \left[R_{t+1}^S\right] = E_t \beta \frac{\lambda_{t+1}^l}{\lambda_t^l} \left[R_{t+1}^S e^{\nu_t}\right]$$

where ν_t is the noise shock following a white noise process with standard deviation σ_ν.[2]

The final asset positions of informed and noise traders are governed by their respective leverage ratios ϕ_t^I and ϕ_t^N such that:

$$\begin{aligned} \phi_t^I &= \frac{1}{1 + \chi - \beta E_t \left[\frac{\lambda_{t+1}^l}{\lambda_t^l} R_{t+1}^S - \tau^{STT} \frac{f\left(P_t^S S_t^I\right)}{P_t^S S_t^I} \right]} \\ \phi_t^N &= \frac{1}{1 + \chi - \beta E_t \left[\frac{\lambda_{t+1}^l}{\lambda_t^l} R_{t+1}^S e^{\nu_t} - \tau^{STT} \frac{f\left(P_t^S S_t^N\right)}{P_t^S S_t^N} \right]} \end{aligned}$$

In equilibrium, the sum of all share holdings has to equal the supply of shares S_t:

$$s_n S_t^N + (1 - s_n) S_t^I = S_t$$

where S_t^N and S_t^I are the share holdings per noise and informed trader, respectively.

The timing of the financial investment decision is as follows: all intermediaries born at time t have initially identical return expectations and hence

[2] We define this shock as a white noise process because non-zero persistence of the noise shock would imply a systematic component in the response of noise traders to disturbances. Also, persistent noise shocks would be difficult to reconcile with 1-period lived traders.

purchase the same amount of corporate shares from the firms. Then, the sentiment of a share s_n of intermediaries changes and they adjust their position accordingly, purchasing or selling an amount of corporate assets from/to the informed traders. The period then ends.

In accordance with these assumptions, secondary market trade in the model will be defined as the trade *between* financial intermediaries, i.e. the trade driven by the noise shock.

To close the part of the model concerning the financial sector we note that every intermediary born at t receives the same initial transfer from his/her owners so that:

$$NW_t^j = NW_t.$$

Further, we follow Gertler and Karadi (2011) and assume that intermediaries receive as their intial transfer an equivalent of a fraction ρ of the total supply of shares:

$$NW_t = \rho P_t^S S_t.$$

The ETT we consider is levied on secondary market transactions only. We shall assume the following particular form of the tax function:

$$\tau^{STT} f\left(P_t^S S_t^j\right) = \tau^{STT}\left(P_t^S S_t^j - P_t^S S_t\right)^2$$

where the quadratic term for the tax base proxies the assumption that the tax applies to both sides of the transaction. The quadratic expression for the tax base is common in the modelling of transaction taxes (e.g., Subrahmanyam, 1998, and Xu, 2010). The quadratic term avoids the situation where traders receive a subsidy for selling assets, which would happen in the case of a linear term.

The fact that, by assumption, ETT is introduced on secondary market transactions which are purely driven by noise shocks in our model increases the potential of the ETT to eliminate inefficient non-fundamentals-driven trading activities and thereby reduce their negative impact on the real economy. Since in reality, it is impossible to distinguish between fundamental and non-fundamental trade when levying this tax, the gains suggested by our simulations might be an upper bound to those that may be expected in the real world.

Finally, the amount of trading due to shifts in traders' sentiments, $trade_t^N$, can be defined as:

$$trade_t^N = s_n \left|S_t^N - S_t\right|$$

which in equilibrium will be equal to:

$$trade_t^I = (1 - s_n)\left|S_t^I - S_t\right|$$

3.3 Capital producers

We follow Christiano et al. (2010) and Gertler and Karadi (2011) to separate capital producers from final goods producers.

Capital producers are representative, competitive and long-lived. They are owned by households. They buy capital K_t^{bought} from final goods producing firms. K_t^{bought} is the capital which was in use for production in period t. Capital producers refurbish this capital make an additional investment I_t and sell the new capital K_t^{sold} to final goods producers to be used in their production of the following period. As is standard in the literature, it is assumed that the price of the used-up capital and the new capital, P_t^K, are the same ("used-up capital is already installed"). Hence, the problem of a capital producer is to maximize Π_t^K such that:

$$\max_{K_t^{sold}, K_t^{bought}, I_t} \Pi_t^K = \left(P_t^K K_t^{sold} - P_t^K K_t^{bought} - I_t - \frac{\gamma_i}{2} \left(\frac{I_t}{\bar{K}_t^{bought}} - \delta \right)^2 \bar{K}_t^{bought} \right)$$

subject to a capital accumulation equation:

$$K_t^{sold} = K_t^{bought} + I_t$$

The FOC of capital producers is:

$$P_t^K = 1 + \gamma_i \left(\frac{I_t}{K_t^{bought}} - \delta \right)$$

The capital producers' profits are:

$$\Pi_t^K = P_t^K K_t^{sold} - P_t^K K_t^{bought} - I_t$$

3.4 Final goods producers

Final goods producers (firms) maximize the present value of their future dividend flow discounted at the stochastic discount factor of their owners:

$$\max_{K_{t+i}, N_{t+i}} E_t \sum_{i=0}^{\infty} \beta^i \frac{\lambda_{t+1+i}^l}{\lambda_t^l} \left[DIV_{t+i}(K_{t+i-1}, N_{t+i}) \right]$$

The dividends DIV_t are defined as:

$$\begin{aligned} DIV_t \equiv\; & (1-\tau^c)(Y_t - W_t N_t) + \tau^c \delta K_{t-1} \\ & + P_t^K (1-\delta) K_{t-1} - P_t^K K_t + B_t^C - R_{t-1}^B B_{t-1}^C \end{aligned}$$

Firms pay a capital income tax at rate τ^c. K_t denotes the capital stock installed at the end of period t and used in the production of period $t+1$. As in Christiano and Fischer (1995) or Gertler and Karadi (2011), it is assumed that after the production process, firms sell the (depreciated) capital used in the production of period t to capital producing firms and then buy from them the new capital stock for the production of the following period. When making their capital installment decision, firms have to ensure the financing of the new capital stock: i.e. that the loans B_t^C they take out and the stocks they issue suffice to cover the capital stock. Formally:

$$B_t^C + P_t^S S_t \geq P_t^K K_t^d$$

For the sake of simplicity, we assume that in equilibrium:

$$B_t^C = \theta P_t^K K_t^d$$

where $\theta < 1$.

The technology of firms is standard:

$$Y_t = A_t (N_t)^{\alpha} (K_{t-1})^{1-\alpha}$$

where A_t stands for total factor productivity characterised by the exongenous law of motion:

$$\log(A_t) = (1-\rho_a)\log\left(\bar{A}\right) + \rho_a \log(A_{t-1}) + \varepsilon_t^a$$

The parameter ρ_a indicates the persistence of TFP shocks and $\varepsilon_t^a \sim N(0, \sigma_a)$.

The first order conditions of firms are:

$$\alpha \frac{Y_t}{N_t} = W_t$$

and:

$$P_t^K + \mu_t (1-\theta) P_t^K = \beta E_t \left[\frac{\lambda_{t+1}^l}{\lambda_t^l} \left((1-\tau^c)(1-\alpha)\frac{Y_{t+1}}{K_t} + \tau^c \delta + (1-\delta) P_{t+1}^K \right) \right]$$

where μ_t is the Lagrangian multiplier associated with the financing constraint.

3.5 Government

The government consumes an exogenous amount of goods (G_t) and receives tax income from wages, corporate income and financial transactions. Current government debt (B_t^G) is the sum of outstanding government debt, debt service and the primary deficit:

$$B_t^G = R_{t-1} B_{t-1}^G + G_t - \tau^l W_t L_t - \tau^c (Y_t - W_t L_t) + \tau^c \delta K_{t-1} - T_t^{STT} - T_t^{ls}$$

where T_t^{STT} denotes the aggregate proceeds from taxing securities transactions:

$$T_t^T = \tau^{STT} \left[s_n f\left(P_{t-1}^S S_{t-1}^N\right) + (1-s_n) f\left(P_{t-1}^S S_{t-1}^I\right) \right]$$

Lump-sum taxes T_t^{ls} are adjusted in each period to keep the government debt-to-GDP ratio constant. The use of lump-sum taxes to stabilise the debt-to-GDP ratio eliminates the income effect of the ETT. Reducing distortive instead of lump-sum taxes to rebate the STT receipts would tend to improve the overall assessment of ETT introduction in efficiency terms. The setup in this paper, which isolates the ETT's distortionary effects without, at the same time, lowering other distortive taxes to reimburse the ETT revenue, implies a rather critical assessment of ETT-related inefficiencies.

3.6 Market clearing

In the equilibrium, the goods, the capital and the financial markets clear. The total number of shares S_t is normalised to 1.

In the market of physical capital:

$$\begin{aligned} K_t^{bought} &= (1-\delta)\, K_{t-1} \\ K_t^{sold} &= K_t \end{aligned}$$

Finally, equilibrium in the final goods market implies:

$$Y_t = C_t + G_t + I_t$$

4 Parametrisation

Our model comprises 18 parameters. Out of these, 12 parameters are related to the real economy part of the model; the remaining six (χ, θ, s_n, ρ, τ^{STT}, σ_ν) are related to the financial sector and the noise trade extension. Table 1 lists the choice of our benchmark parameter values. Table 2 reports implied steady-state ratios.

4.1 Real economy

The parameter values of the real economy are set to standard values in the RBC literature. In particular, the discount factor is $\beta = 0.99$, implying an annualised steady-state risk-free interest rate of 4%. We assume $\gamma = 1$ (log utility in consumption) and $\kappa = 1$ (a unitary Frisch elasticity of labor supply). The weight of the disutility of employment ω is calibrated to imply a steady-state $L = 0.34$, i.e. households devote around one third of their time to work. The labour share in the production function is $\alpha = 0.64$; the depreciation rate of physical capital equals $\delta = 0.025$ (implying a 10% annual rate). Steady-state TFP, $\bar{A}$, is normalised to 1, the TFP shock has an innovation with standard deviation $\sigma_a = 0.0072$ and an autoregression coefficient of $\rho_a = 0.95$. Capital adjustment costs γ_i are set to zero. All these values are common in the business cycle literature.

The steady-state shares and parameter values for the government sector correspond to EU average values: government purchases, G, account for around

15% of GDP. The labour income tax rate τ^l is set to 40% and the corporate income tax rate $\tau^l = 20\%$.

4.2 Financial sector

Parameter values for the financial sector partly follow Gertler and Karadi (2011) and are chosen to match some stylised facts of financial markets and firms' financing.

In particular, the share of firms' capital financed by debt is $\theta = 0.5$ in the benchmark parameterisation, implying a debt-to-equity ratio of 100% which is roughly in line with its empirical value in the U.S. and Europe (see, e.g., Kalemli-Ozcan *et al.*, 2011). The parameter ρ determines the leverage of financial intermediaries. In our benchmark cabliration we set this parameter to 0.2, which implies a debt-to-equity ratio of 4. This calibration follows Gertler and Karadi (2011). At the same time, it may be at the lower end of empirical values. Kalemli-Ozcan *et al.* (2011) report ratios of around 10 for financial institutions and even as high as 25 for investment banks. Given the value of parameter ρ, we follow Gertler and Karadi (2011) to set χ, the share of funds which can be diverted by intermediaries, so as to match an excess return $R_t^S - R_t$ of 100 basis points in the stochastic steady state. The share of noise traders is set to $s_n = 0.5$ in line with survey evidence on the role of fundamental versus non-fundamental information among participants in (foreign-exchange) markets at quarterly horizions (e.g., Cheung et al., 2004; Menkhoff, 2001; Menkhoff and Taylor, 2007; Oberlechner, 2001). The volatility of the noise shock is calibrated to match an annual secondary market turnover (trade/market capitalisation) of 80 to 100%, a value which has been characteristic of European stock markets in the past years. Given the uncertainties surrounding the choice of these parameter values we will discuss the robustness of our results with respect to the financial sector parameters.

Finally, we set the ETT rate so as to match a revenue-to-GDP ratio of 0.1% in line with European Commission estimates of revenue that could be raised by taxing spot market transactions. Our results are approximately linear with respect to the targeted transaction tax revenue.

The results discussed below are computed with 2nd-order perturbation methods using Dynare. We report the stochastic moments of model variables calculated over simulations of a length of 10000 periods for each scenario considered.

5 Results

5.1 ETT in the benchmark model

This subsection presents simulation results that gauge the impact of an ETT in the model with the benchmark parameterisation (see previous section). The

Name	Symbol	Value
Discount factor	β	0.99
Intertemporal elasticity of substitution	γ	1
Inverse Frisch elasticity	κ	1
Labour weight in utility	ω	5
Labour share in production	α	0.64
Capital depreciation rate	δ	0.025
Capital adjustment costs	γ_i	0
Labour tax rate	τ^l	0.4
Capital tax rate	τ^c	0.2
Steady-state TFP	$\overline{A}$	1
Standard deviation of TFP shock	σ_a	0.0072
Persistence of TFP shock	ρ_a	0.95
Trader endowment	ρ	0.2
Share of divertible funds	χ	0.2215
Debt-to-capital ratio (firms)	θ	0.5
Share of noise traders	s_n	0.50
Standard deviation of noise shock	σ_ν	0.01

Table 1: Model parameters

Steady-state ratio	Value
$\frac{C}{Y}$	0.66
$\frac{I}{Y}$	0.19
$\frac{G}{Y}$	0.14
$\frac{K}{4Y}$	2
L	0.34

Table 2: Steady-state ratios

ETT rate is set such as to raise tax revenues by 0.1% of GDP. For the computation of our results, we use random draws of the TFP and the noise shock and calculate the model's equilibrium for 10000 periods first setting $\tau^{ETT} = 0$ and then setting τ^{ETT} such that the revenue raised is equal to 0.1% of GDP.

The ETT's impact on financial variables and economic aggregates is summarised in Table 3. Values in the first column ("mean") report the change (in percent or percentage points) in the average stochastic steady-state levels of the main economic aggregates and financial variables in response to the introduction of the ETT. The next column gives the percentage change in standard deviations of the variables. However, a change in the simulated standard deviation may be misleading as a measure of the impact of ETT on volatility as it does not take into account the changes in the mean. For this reason, in the last column ("std/mean") we show the percentage-point change in the standard deviation normalised by the mean of the respective variables before and after the introduction of the ETT.

	Mean (%)	Std (%)	Std./mean (pp)
Output	-0.20	-0.03	0.01
Capital	-0.46	-0.04	0.01
Investment	-0.46	-0.18	0.04
Consumption	-0.16	-0.09	0.00
Employment	-0.02	-0.22	0.00
Real wage	-0.18	-0.02	0.01
Marginal product of capital	0.41	-0.04	-0.01
Financial trade	-0.46	-0.47	0.00
Share price	-0.46	-0.04	0.01
	Mean (pp)	Std (%)	Std./mean (pp)
Risk-free return	0.00	-0.27	-0.70
Return on share	0.13	-0.21	-2.27
ETT revenue to GDP	0.10		
Implicit ETT rate	0.11		

Note: The numbers are percentage (%) or percentage point (pp) effects of ETT introduction on means and volatilities of the respective variables.

Table 3: ETT in the benchmark model

The introduction of an ETT generating 0.1% of GDP tax revenue has a considerable negative impact on the overall economy, with output falling by -0.2% in the long run (see Table 3). As the table illustrates, the impact of the tax is transmitted to the rest of the economy via the capital cost channel. The introduction of the tax has the direct effect of decreasing the average leverage ratio ϕ_t of financial institutions in the economy. The subsequent deleveraging of financial intermediaries depresses stock prices, raises the cost of capital and, hence, leads to lower investment (both share prices and investment falling by about 0.5%. In the long run, the level of capital falls accordingly.

Consumption decreases by 0.16%, less than capital and slightly less than total output. Households, facing lower consumption, become willing to provide relatively more labour at the same wage rate. In effect, total employment is hardly affected, but real wages fall by about 0.2%. With the decline in the capital stock and stagnating employment, the marginal product of capital raises by around 0.4%. The return on shares increases by around 13 basis points, which reflects the increase in capital costs, while trade in shares in the secondary market drops by around 0.5%.

The overall impact of the ETT on the economy is markedly negative. As our results demonstrate, the ETT's long-run effects are like those of a tax on firms' capital in our framework. Indeed, the ETT leads to an identical output loss as an increase in the corporate income tax that would raise identical tax revenue (table 4) in our model. Both taxes have a very similar long-term impact also on other main aggregates and financial variables (see tables 3 and 4). Hence, despite the seemingly distinct character of financial transaction taxes, they are no less distortive than direct capital income taxation.

than with the unique focus on macroeconomic volatility.

	Mean (%)	Std (%)	Std./mean (pp)
Output	-0.20	-0.15	0.00
Capital	-0.52	-0.34	0.01
Investment	-0.52	-0.26	0.04
Consumption	-0.15	-0.05	0.00
Employment	-0.03	-0.05	0.00
Real wage	-0.17	-0.06	0.00
Marginal product of capital	0.30	0.46	0.00
Financial trade	-0.51	-0.52	0.00
Share price	-0.52	-0.34	0.01
	Mean (pp)	Std (%)	Std./mean (pp)
Risk-free return	0.00	0.01	0.28
Return on share	0.01	0.01	-0.08
Corporate tax revenue to GDP	0.10		
Corporate tax rate	0.55		

Note: The numbers are percentage (%) or percentage point (pp) effects of ETT introduction on means and volatilities of the respective variables.

Table 4: Corporate income tax in the benchmark model

As mentioned in section 2 of this paper, financial transaction taxes are also thought of as having some positive effects on the economy. Apart from raising additional revenue, the most frequent argument in favour of such taxes is the potential reduction of macroeconomic volatility. Leaving aside the question whether volatility reduction is unambigously welfare improving (this should depend on the shock sources and frictions in the model, with some volatility rather reflecting optimal adjustment behaviour), some economists predict that the opposite could happen. Namely, a transaction tax that reduces liquidity in financial markets may increase the volatility of asset prices by increasing the impact of individual transactions on prices (e.g., Hau, 2006).

Introducing an ETT in our model leads to a clear result in this respect. The volatility of the risk-free rate and stock returns clearly decreases in response to noise shocks after the introduction of the transaction tax, for both the absolute volatility (second column of Table 3) as well as the relative volatility (as measured by the standard deviation of a variable to its mean). On the other hand, the tax has very little impact on the volatility of real aggregates. While the standard deviation of these variables decreases upon the introduction of the ETT, the effect is proportional to the decrease in their mean levels. In effect, the relative volatility is not affected.

In sum, our results suggest that the ETT's effects in efficiency terms are rather negative: (1) The ETT introduces economic inefficiencies by increasing the cost of capital; and (2) it dampens fluctuations in financial markets, but has very little impact on the volatility the real economic variables.

Our result on the distortiveness of an ETT is in line with empirical studies that have analysed the impact of stamp duties and financial transaction costs in general on share prices and capital costs (e.g., Bond et al., 2005; Jackson and O'Donnell, 1985; Umlauf, 1993; Westerholm, 2003). Quantitative results are similar, despite the fact that our model simplifies reality and leaves out real-world features that might affect the results either way. E.g., the narrow tax base in our model does not capture cascading effects of broad-based transaction taxes or the potential negative impact of transaction taxes on liquidity, risk pooling and insurance costs. Furthermore, the model assumes that the tax can be targeted to non-fundamental trade in the secondary market, whereas in practice a transaction tax will not be able to discriminate between fundamental-based and noise trade and apply to 'productive' and zero-sum transactions alike. On the other hand, the model focuses on volatility reduction as the potential benefit of a transaction tax. It does not include additional transaction costs or labour and capital use in the financial sector, which would make noise trading socially wasteful. In the latter case, a transaction tax could save resources by reducing socially unproductive financial activities as argued, e.g., by Summers and Summers (1989) and would, consequently, have a more favourable impact on welfare

5.2 Sensitivity checks

The purpose of this subsection is to assess the robustness of our conclusions to changes in the model calibration. We consider four scenarios: 1) a change in the parameter χ to double the equity risk premium to an annualised 8% (Table 5); 2) a change in the structure of the financing mix of the corporate sector, so that 80% of their capital is financed by debt ($\theta = 0.8$; Table 6); 3) a change in the average leverage of the financial sector to nine ($\rho = 0.1$,Table 7); and 4) an increase in the share of noise traders among financial intermediaries to $s_n = 0.75$ (Table 8). For the compuation of the results we repeat the same exercise as under the benchmark parametrisation with the respective parameter adjusted. As in the benchmark case, Tables 5-8 report the impact of the introduction of the ETT in the respective scenarios on the first and second moments of selected variables.

	Mean (%)	Std (%)	Std./mean (pp)
Output	-0.20	-0.04	0.01
Capital	-0.47	-0.05	0.01
Investment	-0.47	-0.21	0.04
Consumption	-0.17	-0.10	0.00
Employment	-0.02	-0.26	0.00
Real wage	-0.19	-0.03	0.01
Marginal product of capital	0.41	-0.06	-0.01
Financial trade	-0.47	-0.47	0.00
Share price	-0.47	-0.05	0.01
	Mean (pp)	Std (%)	Std./mean (pp)
Risk-free return	0.00	-0.31	-0.79
Return on share	0.15	-0.24	-1.27
ETT revenues to GDP	0.10		
Implicit ETT rate	0.12		

Note: The numbers are percentage (%) or percentage point (pp) effects of ETT introduction on means and volatilities of the respective variables.

Table 5: ETT in the model with higher equity risk premium

As is immediately visible from the tables, the impact of the ETT on the real economy is virtually identical in every scenario. In other words, the main result of the benchmark experiment that the ETT is similarly distortive as the coporate income tax holds regardless of the exact parametrisation of the model, at least within reasonable parameter bounds. On the other hand the implicit tax rate consistent with raising revenue of 0.1% of GDP varies across scenarios. This is an effect of the varying tax base. For example, increasing the share of debt financing in the corporate financing mix from $\theta = 0.5$ to $\theta = 0.8$ approximately halves the taxbase. As a result, the implicit tax rate needed to raise a fixed

	Mean (%)	Std (%)	Std./mean (pp)
Output	-0.22	-0.02	0.01
Capital	-0.53	-0.03	0.02
Investment	-0.53	-0.14	0.04
Consumption	-0.16	-0.05	0.00
Employment	-0.03	-0.27	0.00
Real wage	-0.19	-0.01	0.01
Marginal product of capital	0.38	-0.01	-0.01
Financial trade	-0.53	-0.53	0.00
Share price	-0.53	-0.03	0.02
	Mean (pp)	Std (%)	Std./mean (pp)
Risk-free return	0.00	-0.51	-0.55
Return on share	0.27	-0.37	-5.97
ETT revenue to GDP	0.10		
Implicit ETT rate	0.21		

Note: The numbers are percentage (%) or percentage point (pp) effects of ETT introduction on means and volatilities of the respective variables.

Table 6: ETT in the model with higher share of debt-financed investment

	Mean (%)	Std (%)	Std./mean (pp)
Output	-0.18	-0.07	0.00
Capital	-0.40	-0.09	0.01
Investment	-0.40	-0.36	0.01
Consumption	-0.16	-0.19	0.00
Employment	-0.01	-0.41	-0.01
Real wage	-0.17	-0.05	0.00
Marginal product of capital	0.48	-0.12	-0.02
Financial trade	-0.40	-0.40	0.00
Share price	-0.40	-0.09	0.01
	Mean (pp)	Std (%)	Std./mean (pp)
Risk-free return	0.00	-0.44	-1.34
Return on share	0.16	-0.42	-3.78
ETT revenue to GDP	0.10		
Implicit ETT rate	0.07		

Note: The numbers are percentage (%) or percentage point (pp) effects of ETT introduction on means and volatilities of the respective variables.

Table 7: ETT in the model with higher leverage of financial intermediaries

	Mean (%)	Std (%)	Std./mean (pp)
Output	-0.21	-0.02	0.01
Capital	-0.51	-0.03	0.02
Investment	-0.51	-0.05	0.10
Consumption	-0.17	-0.03	0.01
Employment	-0.02	-0.07	0.00
Real wage	-0.19	-0.02	0.01
Marginal product of capital	0.39	-0.02	-0.01
Financial trade	-0.53	-1.56	-1.06
Share price	-0.51	-0.03	0.02
	Mean (pp)	Std (%)	Std./mean (pp)
Risk-free return	0.00	-0.11	-0.38
Return on share	0.13	-0.03	-1.74
ETT revenue to GDP	0.10		
Implicit ETT rate	0.14		

Note: The numbers are percentage (%) or percentage point (pp) effects of ETT introduction on means and volatilities of the respective variables.

Table 8: ETT in the model with higher share of noise traders

amount of revenue doubles compared to the benchmark scenario.

The results obtained in the four additional scenarios may differ as far as the financial variables are concerned. First, the value of parameter θ governs the magnitude of the impact of the ETT on stock returns. Second, if there is a larger share of noise traders among the financial intermediaries, the introduction of an ETT leads to a stronger decline in the (relative) volatility of trade. Finally, the quantitative impact of the ETT on the volatilities of the return to shares and the return to risk-free assets varies across the different scenarios.

Despite some differences in the impact of the ETT on the volatility of some variables across the scenarios, the basic conclusions from the benchmark case still hold: The ETT appears to be a relatively distortionary tax. Moreover, while it is able to reduce volatility in the financial market, it has little impact on the volatility of the macroeconomic aggregates.

6 Conclusions

Very little theoretical work has been done so far to assess the impact of financial transaction taxes on the real economy. Those papers that make such attempt (Kupiec, 1996; Song and Zhang, 2005) use a partial equilibrium framework. To the best of our knowledge, the only paper analysing the impact of a transaction tax with non-fundamental volatility (noise trading) in a general-equilibrium framework is Xu (2010) who does, however, focus on the foreign exchange market and does not consider financial market imperfections beyond the presence of noise traders. Similarly, model-based (even partial-equilibrium) assessments of the impact of an FTT on equity prices and the cost of capital are scarce. Matheson (2011) uses a simple formula to assess the FTT's effect on equity prices for given interest rates and dividends.

Against this background, our model integrates one particular type of FTT, namely an Equities Transaction Tax, into a coherent DSGE framework that integrates the interaction between the financial and non-financial sectors of the economy and allows for potentially inefficient (noise) financial trading. This approach allows to model two channels via which a financial transaction tax could influence the economy. On the one hand, the ETT increases the cost of capital and hence reduces levels of investment, capital and output. On the other hand, it can dampen the excess volatility associated with non-fundamental trading.

The main conclusions from simulations with the benchmark model are that a transaction tax generating tax revenue of 0.1% of GDP would (1) reduce physical investment and the capital stock by above 0.4% in the long run, implying a long-term 0.2% decline in real GDP, and (2) considerably reduce the volatility of financial variables such as risk-free and stock returns, while at the same time having very little impact on the volatility of non-financial variables. The first finding fits the general picture that emerges from empirical studies that have analysed the impact of stamp duties and financial transaction costs on asset prices and financing costs (e.g., Bond et al., 2005; Jackson and O'Donnell, 1985; Umlauf, 1993; Westerholm, 2003). On the other hand, our finding that an ETT reduces the volatility on financial markets appears optimistic in view of the empirical research that rather settles for the opposite result (e.g., Hau, 2006). A part of the discrepancy might be linked to the fact that our model assumes the ETT to be targeted to non-fundamental trade, whereas in practice transaction taxes are unable to discriminate between fundamental and non-fundamental transactions.

The output loss associated with the introduction of an ETT in our model is of the same magnitude as the output loss associated with an increase in the capital income tax that would raise the same revenue. Hence, despite the fact that it is imposed only on secondary market and non-fundamental transactions, the ETT is as distortive as a direct tax on capital in our model. Sensitivity checks confirm the findings for deviations from the benchmark calibration.

The current version of the model makes a number of simplifying assumptions that may be relaxed in further work. First, the functioning of financial intermediaries is assumed not to require/consume any resources. This makes it impossible to capture the efficieny gain that would occur if an ETT reduced the consumption of resources in non-fundamental and unproductive financial transactions ("social waste"). To overcome this omission, one could assume financial intermediation to require labour and/or capital input or impose an additional adjustment costs on financial flows. Second, the firms' financing mix (or the firms' leverage ratio) is currently fixed exogenously. An extension could consider a situation where firms choose the degree of their indebtness as compared to other forms of financing strategies endogenously. This extension would allow analysing how taxation changes the firms financing mix. Future work could also introduce an explicit welfare analysis of the ETT effects. Finally, the representative household framework in the current model precludes an analysis of the distributional consequences of the transaction tax.

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