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ScienceDirect
European Journal of Political Economy 23 (2007) 228 – 244
European Journal of POLITICAL ECONOMY
www.elsevier.com/locate/ejpe

The advantage of showing your hand selectively in foreign exchange interventions

Richard C. Barnett [a,*], Saltuk Ozerturk [b,c]

[a] Department of Economics, Villanova University, Villanova School of Business, 3008 Bartley Hall, Villanova, PA 19085, USA
[b] Department of Economics, Southern Methodist University, Dallas, TX 75275–0496, USA
[c] Visiting Research Associate at CORE, Universite Catholique de Louvain, Belgium

Received 2 August 2005; accepted 13 December 2005
Available online 13 November 2006

Abstract

This paper studies the effectiveness of foreign exchange rate targeting by a central bank in a market microstructure framework. Unlike the existing literature, where the intervening central bank either makes its target exchange rate public or hides it completely, we present a model that emphasizes the value of selectively disclosing intervention relevant information to some but not all market participants. We show that if the market's uncertainty over the central bank's target is sufficiently high and if the central bank is targeting the exchange rate away from its fundamental value (attempting to move the exchange rate in the opposite direction of where the fundamental based trade takes it) selectively disclosing the exchange rate target improves the effectiveness of the intervention.

JEL Classification: D82; F31; G14; G15
Keywords: Market microstructure; Foreign exchange market; Targeting; Secret intervention; Selective disclosure

1. Introduction

Recent work on the so-called 'secrecy puzzle' surrounding official interventions in foreign exchange markets has rekindled the debate over the appropriate degree of transparency for foreign exchange intervention policy. The puzzle itself stems from the fact that operationally, most sterilized interventions are conducted in secret. Central bank interventions are reported, if at all, with a considerable time lag, and they may involve several exchange brokers or commercial banks in order to conceal the true size and intention of the intervention (Lyons, 2001; Neely,

* Corresponding author. Tel.: +1 610 519 6321; fax: +1 610 519 6054.
E-mail addresses: Richard.Barnett@villanova.edu (R.C. Barnett), ozerturk@mail.smu.edu (S. Ozerturk).

0176-2680/$ - see front matter
doi:10.1016/j.ejpoleco.2006.09.012

2001). As Sarno and Taylor (2001) argue, this secrecy is difficult to explain, given that the most common channel through which sterilized interventions are thought to work–the signaling channel–is ultimately more effective if the policy is announced publicly beforehand and the intervention is widely observed. Dominguez and Frankel (1993), in particular, make a strong case for transparency in central bank policy in foreign exchange markets, concluding, "intervention can be effective, especially if it is publicly announced and concerted."[1]

The literature has provided some answers to the secrecy puzzle. Eijffinger and Verhagen (1997) address the issue of why a central bank may want to retain some degree of ambiguity as to the size of its intervention and conclude that some secrecy is desirable for short-term targeting. In the specific context of keeping the exchange rate target secret, Bhattacharya and Weller (1997) and Vitale (1999) develop market microstructure models of sterilized interventions that exploit signaling channels.[2] Both of these papers follow the widely held view that sterilized interventions have no impact on the exchange rate's underlying fundamental value. Intervention can affect the interim exchange rate by changing market expectations regarding the fundamental. Vitale assumes the central bank knows the fundamental perfectly, and this information, along with its target exchange rate, determines the size of the bank's trade. In a market microstructure model à la Kyle (1985), the trades are obscured, since they are 'batched' along with orders originating from other traders. Conditioning on the total order flow, the market maker tries to extract information on the exchange rate fundamental.[3] By concealing its target, the central bank can more effectively 'fool' the market. The main conclusion of Vitale (1999) is stark and leaves no room for full transparency: Whenever the central bank publicly discloses its target, a sterilized intervention is completely ineffective and the central bank cannot target the exchange rate.[4]

By and large, the literature on secrecy of interventions has focused on models where the intervening central bank either makes its exchange rate target public or hides it completely. Central banks, however, while hiding their hand from most of the market participants, routinely communicate their intentions to other central banks prior to interventions. Additionally, Chiu (2003), in her survey of 10 central banks, notes that central banks may convey privy information to some players in the market in order to increase the impact of the intervention and propagate its effect. This paper presents a model of exchange rate intervention which emphasizes the advantage of selectively disclosing intervention information to some but not all market participants. Specifically, we explore the related issues of transparency and information sharing as they apply to sterilized central bank interventions in foreign exchange markets and ask the following question: can a central bank achieve a more effective intervention outcome in a regime where it

[1] See Lyons (2001), Sarno and Taylor (2001), and Humpage (2003) for detailed surveys of the theoretical and empirical literature on exchange rate interventions in traditional macroeconomic models. Neely (2001), Chiu (2003), and Lecourt and Raymond (2003) report findings of surveys of central banks on their intervention policies. Bernal (2004) and Beine and Bernal (2005) provide extensive analyses of recent interventions by the Bank of Japan.

[2] Beine and Bernal (2005) provide empirical evidence in support of these microstructure arguments for secret intervention.

[3] Similar information and trading constraints are observed in actual forex markets. Usually, the central banks transact through dealers or commercial banks. Kyle's batch order framework captures this lack of transparency in the order flows, since the market maker cannot distinguish the source of individual flows.

[4] Vitale's main result stems from the fact that if the dealer knows the target, she can completely filter out all target-based trades from the order flow. In contrast to Vitale (1999), in Bhattacharya and Weller (1997), some foreign exchange investors (speculators), but not the central bank, have better information on the exchange rate fundamental. They conclude there are circumstances in which it is in the interest of the central bank to reveal its target, though it is never advantageous to reveal the size of its intervention. To do so leaves the bank unable to target the exchange rate, along lines similar to why revealing the target in Vitale make targeting ineffective.

selectively discloses its target to certain market participants, like another central bank, while not making its intentions completely public? If so, how and when does this selective disclosure regime work?[5]

Our model builds on a market microstructure framework similar to Vitale's. This setting is particularly relevant for our exercise because of its stark conclusion in favor of the secrecy side of the debate. Different than previous applications, however, we exploit a novel feature of the market microstructure framework: too much market uncertainty on the central bank's target may also render intervention as ineffective. This follows, since in this case the price impact of any intervention is low. We show that precisely when the market has too much uncertainty on the central bank's targeting agenda, the bank may improve the price impact and hence the effectiveness of its intervention by selectively disclosing its target to another central bank trading in the market.[6]

We are drawn to the possibility that selective disclosure may improve the central bank's targeting on two accounts. The first is based on an insightful observation by Lyons (2001), which makes a distinction between speculative and target oriented trades regarding the price impact:[7]

> An important difference between private trades and central bank trades is that private traders typically want to minimize the price impact, whereas central banks want to maximize the price impact (page 236).

The second building block of our analysis is the central feature of the Kyle (1985) type microstructure model mentioned above. From the perspective of the market, the uncertainty on the target of the central bank is similar to the noise in the total order flow stemming from liquidity traders. Both the liquidity trade and the target based trade are fundamentally irrelevant, since they do not convey any information on the fundamental. When this fundamentally irrelevant noise in the total order flow is high, the market maker's pricing response (hence the price impact) to the order flow is low. This implies that a central bank's ability to target the exchange rate may also be very poor, if the market is too uncertain about the target. Our analysis identifies an important property of the regime with selective disclosure compared to the regime of complete secrecy: the price impact of a given order flow is always higher in the selective disclosure regime.

Whether a selective disclosure regime achieves better targeting depends crucially on whether or not the central bank's targeting intention is consistent with the direction of the fundamental based trade. In other words, whether the central bank is targeting toward or away from the fundamental value is important. Interestingly, when the bank is targeting away from the fundamental value, (i.e., attempting to move the exchange rate counter to the direction of the fundamental based trade), selectively disclosing targeting information to another central bank trading in the market achieves a better targeting outcome if there is enough uncertainty on the

[5] While the focus of this paper centers around the uncertainty of a central bank's target and the responsiveness of the market maker to the order flow, our analysis also applies to cases in which the noise in the order flow originates from sources other than the uncertainty surrounding the bank's target, such as liquidity or 'noise' trades.

[6] The other central bank might be trading for profit maximization or portfolio balancing reasons. The profit maximization motivation may seem controversial, since central banks, as public or quasi-public institutions, are quite reluctant to admit that they could trade in these markets purely for speculative reasons. For example, Neely (2001) notes that the monetary authorities in his survey did not report that they intervene or trade solely for profits. However, Saacke (2002) provides recent evidence that Bank Negara (the central bank of Malaysia), for example, routinely speculated in forex markets during the 1990s. Other studies are divided over whether profitability is a consideration in central bank forex transactions (Edison, 1993; Sweeney, 1997).

[7] Recent empirical studies of the price impact of intervention trades in microstructure models include Peiers (1997), Evans and Lyons (2000), Payne and Vitale (2003), and Dominguez (2003).

intervening central bank's target. This follows, since as well as improving the price impact, selective disclosure also mollifies some of the fundamental based trade driving the exchange rate in the opposite direction from the target. On the other hand, when the bank wants to push further the exchange rate in the same direction as the fundamental based trade is taking it–an intervention policy that we call targeting toward the fundamental–the bank is never better off from selectively disclosing the target and complete secrecy is better. This follows, since doing so simply reduces the trades which would move the exchange rate in the same direction the bank wishes to take it.

The analysis provides a clear answer to the practical policy question not addressed in the literature: is the intervening central bank always better off from hiding its target from other market participants who are already informed about the fundamental and who are acting on self interest rather than cooperating with the central bank? This question is important, since in the case of communicating the targeting intentions to fellow central banks, there is no clear evidence of full cooperation with the intervening central bank even in episodes of concerted interventions. Often, the central banks only share information on their intervention agendas without an explicit agreement of cooperative play. This fact is clearly documented by Sarno and Taylor (2001):

> Coordinated official intervention in the foreign exchange market occurs when two or more central banks intervene simultaneously in the market in support of the same currency, according to an explicit agreement of cooperation. In practice, however, concerted official intervention in the foreign exchange market among the major industrialized nations has largely consisted of information sharing and discussions (page 846).

Our analysis has implications for the policy question of whether the central bank should always keep its target secret from major players who trade for their own interests without cooperation. In that respect, we show that information sharing between central banks can be a good policy alternative to complete secrecy, even if this communication does not involve a subsequent cooperative play. Therefore, we emphasize a point that seems to be overlooked in the literature: communication is not necessarily synonymous with cooperation.[8]

The paper proceeds as follows. Section 2 presents the model. Section 3 solves for the trading equilibria under complete secrecy and selective disclosure and compares the two regimes in terms of the price impact and the trading intensities. Section 4 provides a detailed comparison of targeting effectiveness under the two regimes and contains our main result. Section 5 concludes.

2. The model

We adopt a Kyle-type microstructure framework in the foreign exchange market. The basic ingredients of the model are as follows:

2.1. Market participants

(i) Market maker: there is a risk neutral dealer (the 'market maker') who trades the foreign currency with two central banks and a group of liquidity traders. Prior to trades, the fundamental value of the exchange rate, f, is known only to the two central banks. For the market maker, f is a normal random variable with mean s_0 and variance Σ. At the time of

[8] For a model where the central bank acquires information about transitory exchange rate disturbances and uses intervention to share that aggregated information with dealers, see Popper and Montgomery (2001).

the trading, the market maker calls an auction for the currency and observes a total order flow X. Competition between market makers and the risk neutrality assumption imply that the equilibrium exchange rate s_1 set by the market maker is given by the following zero profit condition:

$$s_1 = E[f|X] \tag{1}$$

(ii) Central banks: we assume that there are two central banks in the market. Both central banks know the exchange rate fundamental value f perfectly. To simplify our exposition, we assume only one central bank has an exchange rate targeting agenda. Call this bank, Central Bank A or simply A. It submits a market order x_{A} to minimize the expected value of the loss function:

$$c \equiv (s_1 - f)x_{\mathrm{A}} + q(s_1 - \bar{s})^2 \tag{2}$$

with s_1 set according to the market maker's pricing rule in Eq. (1) above. As in Vitale (1999), the first part of the loss function, $(s_1 - f)x_A$, reflects A's monetary losses or gains, whereas the second part, $q(s_1 - \bar{s})^2$describes its targeting agenda: $\bar{s}$ is the bank's exchange rate target and $q \geq 0$ describes the central bank's commitment to that target. Furthermore, interventions by A are sterilized completely and do not alter the underlying exchange rate fundamentals.[9] Central Bank B does not have a targeting agenda and submits a market order x_{B} to maximize its expected profits, $\pi \equiv (f - s_1)x_{\mathrm{B}}$.[10]

(iii) Liquidity traders: the market order of the liquidity traders, ε, is a normal random variable with mean zero and variance σ_ε^2 and it is independent from the fundamental value f.

Accordingly, the total order flow X that the market maker receives is

$$X = x_{\mathrm{A}} + x_{\mathrm{B}} + \varepsilon.$$

2.2. Information structure

Depending on Central Bank A's disclosure regime, the other market participants may or may not know the target $\bar{s}$, but its commitment to the target, q, is common knowledge. Without disclosure, the prior distribution of $\bar{s}$ is normal with mean $\hat{s}$ and variance σ_s^2 and it is independent from the fundamental value f. Within this setting, there are three interesting possibilities as regard to who knows the target $\bar{s}$ at the time of the trading.

Complete secrecy: the target $\bar{s}$ is secret and it is the private information of A.
Public disclosure: the target is publicly disclosed by A and thus it is common knowledge to all market participants.

[9] We abstract away from the important issue of timing of intervention, since we rather focus on the secrecy of the bank's target. In other words, the market maker knows that central bank is intervening with some targeting agenda. For a rigorous treatment of the case where the central bank strategically chooses the timing of intervention in a dynamic framework, see Cadenillas and Zapatero (1999).

[10] While in practice, a central bank may be concerned with a variety of issues, in this setting, which restricts a bank's preference to its targeting objective and the profit/loss of intervention, our central bank with no targeting objective may also be interpreted as a large informed currency trader.

Selective disclosure: A discloses its target to the other participant in the market that knows the underlying market fundamental f — in this case, Central Bank B.

Vitale (1999) compares the effectiveness of intervention between public disclosure and complete secrecy and shows that when the central bank's target $\bar{s}$ is publicly disclosed, intervention has no effect and the central bank cannot target the exchange rate. In contrast, when the target is completely secret, the central bank can target the exchange rate. This result establishes that for intervention to have any effect at all, the market maker must have some uncertainty on the central bank's target.[11] However, Vitale analyzes a trading game between one central bank and the market maker only. Therefore, disclosure can only be public, since there is no one else but the market maker to disclose the target. We allow for another central bank (Central Bank B) and ask the following question: can Central Bank A achieve better targeting by selectively (as opposed to publicly) disclosing its target to this other central bank? To answer this question formally, we now solve for the trading equilibria under the two regimes.

3. Trading equilibria under two regimes

In this section, we solve for the trading equilibria under two alternative disclosure regimes: No disclosure of the target and selective disclosure of the target to Central Bank B. We present these equilibria in the following proposition.

Proposition 1. *(i) (Complete secrecy). If the target $\bar{s}$ is completely secret, the unique linear Nash equilibrium of the trading game is such that*

$$x_A = \beta_A(f - s_0) + \theta_A(\bar{s} - \hat{s}) + \gamma_A(\hat{s} - s_0) \tag{3}$$

$$x_B = \beta_B(f - s_0) \tag{4}$$

$$s_1 = s_0 + \lambda^s[(\beta_A + \beta_B)(f - s_0) + \theta_A(\bar{s} - \hat{s}) + \varepsilon] \tag{5}$$

with the trading intensity coefficients β_A, β_B, θ_A, γ_A reported in Table 1 and the liquidity coefficient λ^s is the unique positive root for λ of the following equation

$$2\Sigma(1 + 2\lambda q) = \frac{\lambda^2(3 + 2\lambda q)^2\left[q^2\sigma_s^2 + (1 + \lambda q)^2\sigma_\varepsilon^2\right]}{(1 + \lambda q)^2}. \tag{6}$$

[11] To see the intuition behind Vitale's result, consider the equilibrium strategy of A, $x_A = \alpha(f - s_0) + \delta(\bar{s} - s_0)$, where the trading intensity coefficients α and δ are determined in equilibrium. The first part is the fundamental based part of A's order. The second part is target based. The market maker tries to filter out the target based part, since that part does not contain any information related to the fundamental f. Since orders are batched, the filtering is incomplete if she does not know the target $\bar{s}$. This allows some of the target based flow to actually affect the exchange rate s_1. If, on the other hand, the market maker knows the target, she filters out the entire target-based flow. In this case, the equilibrium exchange rate characterized by Eq. (1) is independent from $\bar{s}$.

Table 1
Equilibrium coefficients

Complete secrecy	Selective disclosure
$\beta_A = \frac{1-2\lambda^s q}{\lambda^s(3+2\lambda^s q)}$	$\hat{\beta}_A = \frac{1-2\lambda^d q}{\lambda^d(3+2\lambda^d q)}$
$\beta_B = \frac{1+2\lambda^s q}{\lambda^s(3+2\lambda^s q)}$	$\hat{\beta}_B = \frac{1+2\lambda^d q}{\lambda^d(3+2\lambda^d q)}$
$\theta_A = \frac{q}{1+q\lambda^s}, \theta_B = 0$	$\hat{\theta}_A = \frac{4q}{3+2q\lambda^d}, \hat{\theta}_B = \frac{-2q}{3+2q\lambda^d}$
$\gamma_A = 2q$	$\hat{\gamma}_A = 2q$

(ii) (Selective disclosure). If Central Bank A discloses $\overline{s}$ only to B, then the unique linear Nash equilibrium of the trading game is such that

$$x_A = \hat{\beta}_A(f - s_0) + \hat{\theta}_A(\overline{s} - \hat{s}) + \hat{\gamma}_A(\hat{s} - s_0) \tag{7}$$

$$x_B = \hat{\beta}_B(f - s_0) + \hat{\theta}_B(\overline{s} - \hat{s}) \tag{8}$$

$$s_1 = s_0 + \lambda^d\left[\left(\hat{\beta}_A + \hat{\beta}_B\right)(f - s_0) + \left(\hat{\theta}_A + \hat{\theta}_B\right)(\overline{s} - \hat{s}) + \varepsilon\right] \tag{9}$$

with the trading intensity coefficients $\hat{\beta}_A$, $\hat{\beta}_B$, $\hat{\theta}_A$, $\hat{\theta}_B$ and $\hat{\gamma}_A$ reported in Table 1 and the liquidity coefficient λ^d is the unique positive root for λ of the following equation

$$2\Sigma(1 + 2\lambda q) = 4\lambda^2 q^2 \sigma_s^2 + \lambda^2(3 + 2\lambda q)^2 \sigma_\varepsilon^2. \tag{10}$$

Proof. See Appendix A.

Note that with selective disclosure, the equilibrium exchange rate depends on the target, and the central bank can still target the exchange rate (see Eq. (9)). This is not surprising: as long as the market maker has some uncertainty on $\overline{s}$, she cannot completely filter out the target oriented flow and the equilibrium s_1 she sets depends on the target.

In what follows, we compare the two equilibria on the following accounts: first, how does Central Bank B respond to A's target in the case of selective disclosure? Second, how does the total target oriented flow differ in the two regimes? Third, and perhaps most importantly, how does the price impact of the order flow, measured by the liquidity coefficient λ in the market maker's pricing rule, differ in the two regimes?

Central Bank B's response: note that in the equilibrium with selective disclosure, B's response to A's target level is given by $\hat{\theta}_B < 0$. The negative sign of this trading intensity implies that B always reacts in an offsetting fashion to A's target oriented flow. The intuition behind this result can best be described by a case example. Suppose A's actual target is above the target mean, so $\overline{s} > \hat{s}$, and, without loss of generality, assume $f > s_0$, so B's profit oriented flow is positive. When B does not observe the target, it of course expects A to target at the mean, $\hat{s}$, and incorporates this into its expectation of the price s_1. When B knows the target, it knows–all else the same–that A is trying to push the price higher (since $\overline{s} > \hat{s}$ and since A's trading intensity $\hat{\theta}_A > 0$). This lowers expected profit per-unit. In response, B reduces its order flow, i.e. $\hat{\theta}_B < 0$. This feature will play an important role in our comparison of targeting under the two regimes.

Total target oriented flow: in order to compare the total target oriented flow across two regimes, fix a liquidity coefficient λ. For a *given* λ, A's target based order intensity $\hat{\theta}_{\mathrm{A}}$ is higher than its intensity in the complete secrecy case (given by θ_{A}). This means that A's target oriented order is more aggressive when B knows the target. However, the offsetting reaction of B makes the total target oriented flow, given by $(\hat{\theta}_{\mathrm{A}}+\hat{\theta}_{\mathrm{B}})(\bar{s}-\hat{s})$, lower in the selective disclosure regime. To see this, note that, given a pricing response λ of the market maker, we have

$$\hat{\theta}_{\mathrm{A}}+\hat{\theta}_{\mathrm{B}}=\frac{2q}{3+2\lambda q}<\theta_{\mathrm{A}}=\frac{q}{1+\lambda q}. \tag{11}$$

The implication of this trading behavior on the market maker's response to the total order flow (given by the liquidity coefficient λ) is instrumental for our comparison of the two equilibria in terms of targeting.

Proposition 2. *For any parameter configuration, the equilibrium liquidity coefficient λ^s in case of complete secrecy is lower than the equilibrium liquidity coefficient λ^d of the case with selective disclosure.*

Proof. See Appendix B.

Finally, we identify how σ_s^2, the market maker's uncertainty over the central bank's target, affects the equilibrium liquidity coefficient in the two regimes. The following result is immediate from Eqs. (6) and (10) that characterize the equilibrium liquidity coefficient λ in each case.

Proposition 3. *Regardless of the disclosure regime, the liquidity coefficient λ is decreasing in σ_s^2.*

Proof. See Appendix C.

The above implication of higher uncertainty on the central bank's target is consistent with the general intuition of Kyle's batch framework. For the market maker, σ_s^2 is another source of noise, like the liquidity trade noise σ_ε^2, and its effect on the market maker's signal extraction problem is similar: a higher level of uncertainty on the target makes the total order flow a more noisy indicator of the fundamental f. Therefore, as σ_s^2 increases, the market maker updates her prior on the fundamental less. To see this, note that

$$E(s_1|\bar{s})=s_0+\frac{2}{3+2\lambda^s q}(f-s_0)+\frac{\lambda^s q}{1+\lambda^s q}(\bar{s}-\hat{s}) \tag{12}$$

for the complete secrecy case and

$$E(s_1|\bar{s})=s_0+\frac{2}{3+2\lambda^d q}(f-s_0)+\frac{2\lambda^d q}{3+2\lambda^d q}(\bar{s}-\hat{s}) \tag{13}$$

for the selective disclosure case. In both cases, as σ_s^2 increases and as a result, the liquidity coefficient becomes smaller, the expected equilibrium exchange rate becomes less and less dependent on the central bank's target $\bar{s}$. In the limit, as σ_s^2 approaches infinity, the liquidity coefficient approaches zero and $E(s_1|\bar{s})$ becomes completely independent from the target.

The above observations establish that too much uncertainty on the target may also have a deleterious effect on targeting. When σ_s^2 is high, the market maker's response to a given order

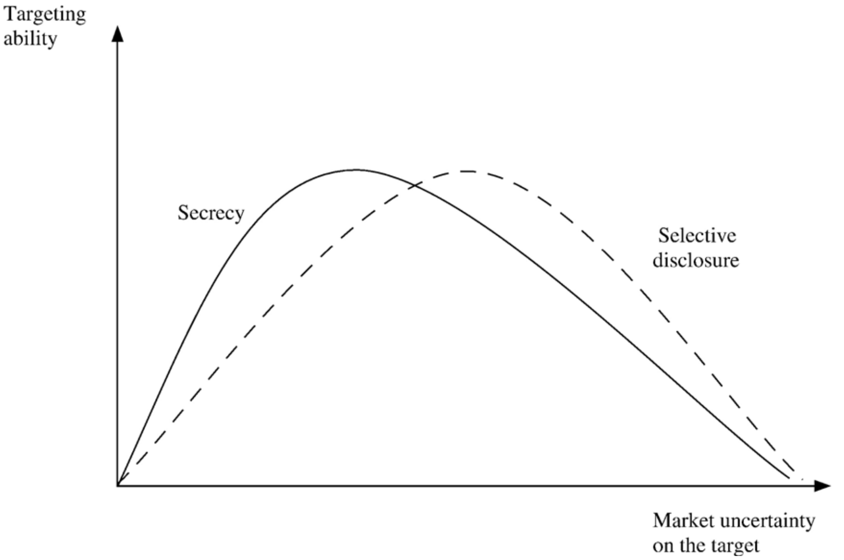

Fig. 1. Targeting ability and market uncertainty on the target.

flow is low and moreover it is even lower in case of complete secrecy and it takes Central Bank A a very large order to have any measured impact on the exchange rate. To achieve better targeting, A may prefer to improve the market maker's response to the total order flow (causing her to set a higher λ) by decreasing the noise she attributes to target oriented flow, as in the case with selective disclosure. This will be more likely to be a concern for the central bank, the higher is σ_s^2.

Our main result can be illustrated with Fig. 1 above. Full transparency makes the bank unable to target the exchange rate. However, as indicated, a noisy order flow also limits the bank's targeting ability. This leaves open the possibility that the bank can improve its targeting if it discloses the target to another player in the market. Precisely when this occurs is discussed in detail in Section 4.

4. Targeting: secrecy versus selective disclosure

We turn now to the central focus of the paper. We are interested in providing a comparison of the central bank's targeting ability across the two regimes. To this end, note that A's loss function Eq. (2) is quadratic in the difference of the exchange rate from the target, given by $s_1 - \bar{s}$. Therefore, as in Vitale (1999), it is enough to compare the expected conditional deviation from the target, given by $E[(s_1 - \bar{s})^2 | \bar{s}]$, across regimes. Given the linear pricing rule of the market maker and using the properties of a non-central chi-square distribution, the expected conditional deviation of the exchange rate from the target can be written as (see Appendix D):

$$E\left[(s_1 - \bar{s})^2 | \bar{s}\right] = [E(s_1 | \bar{s}) - \bar{s}]^2 + Var(s_1 | \bar{s}) \tag{14}$$

The first term, $[E(s_1 | \bar{s}) - \bar{s}]^2$, measures the dispersion of the expected exchange rate from the target, while the second term, $Var(s_1 | \bar{s})$, measures the conditional volatility of the exchange rate given the target. Furthermore, the volatility term is simply $Var(s_1 | \bar{s}) = \lambda^2 \sigma_\varepsilon{}^2$. It follows that conditional volatility of the exchange rate is always higher in the selective disclosure case, since $\lambda^s < \lambda^d$ by Proposition 3. However, selectively disclosing the target to B can reduce the dispersion $[E(s_1|\bar{s}) - \bar{s}]^2$ and result in better targeting through two effects.

The first one is the direct effect on the liquidity coefficient λ, which describes the extent that the market maker's pricing rule responds to the total order flow in setting the new exchange rate. With selective disclosure, the price impact of any order flow is higher. This is especially important in light of the observation by Lyons (2001) which we highlighted in the Introduction. We refer to this effect as the *price impact effect*.

The second effect is related to the equilibrium composition of the total order flow. Note that the trading intensity coefficients in the complete secrecy case, β_A, β_B in Table 1 have the same functional form as $\hat{\beta}_A$, $\hat{\beta}_B$ for the selective disclosure case. The only difference is that λ is smaller with complete secrecy. With selective disclosure, a higher λ, then, reduces the amount of the *equilibrium* profit oriented (fundamental based) order flow. We refer to this second effect as the *order flow effect*.

Whether these two effects improve overall targeting or not depends critically on the direction of the profit oriented order flow compared to the direction A wishes to move the exchange rate. Given the parameters s_0, f, and $\bar{s}$, we describe Central Bank A's targeting policy as being one that either targets toward or against the fundamental.

Targeting toward the fundamental: a targeting policy that targets toward the fundamental value is one that attempts to drive the exchange rate in the same direction as implied by the profit oriented portion of the order flow. For instance, suppose $\bar{s} > f > s_0$ ($s_0 > f > \bar{s}$). This parameter configuration implies that the current exchange rate s_0 is undervalued (overvalued) and any fundamental based order will drive the new exchange rate s_1 up (down) and closer to f. A's target is consistent with this direction and actually A's target requires an appreciation (depreciation) beyond the fundamental value f.

Targeting away from the fundamental: a targeting policy targets away from the fundamental value if the intervention attempts to reverse the normal course of the exchange rate, as implied by profit oriented trades, or else drives the exchange rate in the same direction as the rest of the trade flow but not to the same extent, and hence, blocks that normal trend. For instance, suppose $\bar{s} > s_0 > f$ (or $f > s_0 > \bar{s}$). This parameter configuration implies that the current exchange rate s_0 is overvalued (undervalued) and any fundamental based order will drive the new exchange rate s_1 down (up) and closer to f. A's target is not consistent with this direction and actually A's target requires a move in the opposite direction.

The table below classifies an intervention policy in terms of the current exchange rate s_0, the fundamental exchange rate f, and the target $\bar{s}$. (Table 2)

When will a central bank have the incentive to keep its target completely secret? Interestingly, this occurs whenever the bank attempts to target toward the fundamental. In this case, the fundamental oriented portion of the flow is already moving the exchange rate in the direction of the target. Take for instance the case with $\bar{s} > f > s_0$. The currency is initially undervalued compared to the fundamental. Any fundamental based order will move the exchange rate closer to f. Moreover, the central bank wants to move the exchange rate in that direction too and beyond f. Selectively disclosing the target reduces some of the fundamental based flow (the effect of λ on β

Table 2
Intervention policies

Targets toward the fundamental	$\bar{s} > f > s_0$	$s_0 > f > \bar{s}$
Targets away from the fundamental	$\bar{s} > s_0 > f$	$f > s_0 > \bar{s}$

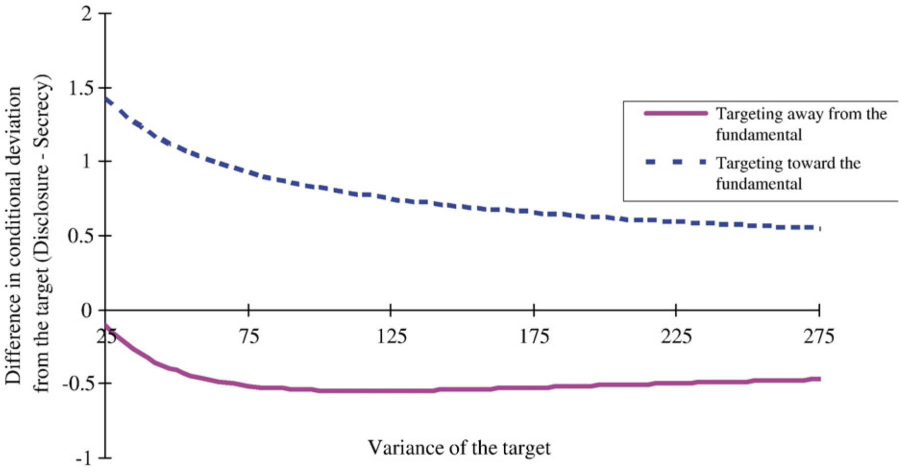

Fig. 2. A comparison of targeting across regimes.

mentioned above), as well as undercuts a portion of the target based flow (since the trading intensity parameter, $\hat{\theta}_B < 0$). Therefore, secrecy achieves better targeting.

On the other hand, if the bank is targeting away from the fundamental value, it may be in the interest of the bank to selectively disclose its target to B. Consider the case with $f > s_0 > \bar{s}$. Here, the fundamental based flow will take the exchange rate in the opposite direction and further away from the target. Selectively disclosing the target may then improve targeting, as it mutes some of the fundamental based flow. Unlike the case of targeting toward the fundamental, this is in favor of A's targeting objective. Therefore, we have

Proposition 4. *(i) Central Bank A achieves better targeting under complete secrecy over selective disclosure whenever it attempts to target toward the fundamental. (ii) If Central Bank A is targeting away from the fundamental and if the uncertainty regarding its target, σ_s^2, is high enough, Central Bank A achieves better targeting in the selective disclosure regime.*

Proof. See Appendix E.[12]

We close this section with an illustrative example. Assume the parameter values $\sigma_s^2 = 200$, $\Sigma = 25$, $q = 200$, $f = 100$, $\hat{s} = 100$, and $\bar{s} = 95$. Allowing different values for the prior, $s_0 = 98$ and $s_0 = 102$, our example which we depict in Fig. 2, captures the characterization of the two intervention policies shown in the second column of Table 2.

The figure above shows the difference in the second moment $E[(s_1 - \bar{s})^2 | \bar{s}]$ for the two regimes, as a function of the variance of the target, σ_s^2. Negative values for this difference indicate that selective disclosure achieves better targeting. As illustrated in the figure, selective disclosure reduces the deviation of the exchange rate from the target in the case where the central bank tries to move the exchange rate away from the fundamental, provided there is enough uncertainty on bank's target.[13]

[12] The proof of the proposition also provides some comments on the cases where the target lies between the prior and the fundamental, i.e., when $s_0 > \bar{s} > f$ or $s_0 < \bar{s} < f$.

[13] Incidentally, we also solved for the equilibria when both central banks have a targeting agenda and compared the conditional deviations from the targets numerically. In this case, selective disclosure may improve both banks' targeting, even when one bank is attempting to target toward the fundamental.

5. Conclusion

To summarize, the main contributions of the paper are as follows:

(i) Unlike the existing literature, we consider an intervention regime where the central bank is not restricted to disclose the target to all or keep it secret from all. The possibility of disclosing the target to some but not all market participants (selective disclosure) is clearly a practical policy alternative to be considered.

(ii) In a framework where a publicly known target renders intervention as ineffective, we show that too much market uncertainty on the target also undermines effective intervention. If the market is highly uncertain about the central bank's target, the equilibrium price impact of a given order flow is low and this makes it more difficult for intervention to work. Therefore, we point out that too much secrecy may not be the best intervention strategy either.

(iii) We characterize the circumstances under which selective disclosure is the preferred intervention regime in terms of better targeting.[14] We explore the price impact channel (i.e., the equilibrium response of the market price to the total order flow) and show that price impact under selective disclosure is always higher relative to complete secrecy. Since selective disclosure mutes some of the fundamental based order flow, the bank can achieve better targeting with complete secrecy when it is trying to move the exchange rate in the same direction as the market fundamental trade flow (target toward the fundamental). On the other hand, if the central bank is targeting away from the fundamental value, selective disclosure achieves better targeting when the public uncertainty on its target is high enough. Our analysis also emphasizes that information sharing between the central banks can be a good policy alternative for intervention, even if this communication does not involve a subsequent concerted and cooperative play.

We should preface that intervention during currency crises differ substantially from the type of interventions considered here and in Vitale (1999) and Bhattacharya and Weller (1997). Crises typically emerge when market participants believe that a country is unable to maintain a fixed exchange rate. In this context, the central bank's target (the fixed exchange rate) is known by all market participants — what is not known by the market is the bank's stock of foreign reserves. In defending the exchange rate, a central bank may forgo its usual sterilization procedures in order to send a more convincing statement to the market. These may include a variety of policy initiatives that play a fundamental role in determining the banks reserves — one of the last, of course, being a change in the exchange rate. By contrast, one may think of interventions in the Vitale model as part of a normal operating procedure of the bank; the bank has sufficient foreign reserves, and the exchange rate–though targeted–is not fixed by the bank. The intervention practices of the Bank of Japan for the last quarter century seem to best fit this description.

[14] As an alternative to our treatment of selective disclosure, one could allow the intervening central bank to determine how much information about the target it wishes to reveal to the other large informed trader. Our treatment, which effectively reduces the other trader's subjective variance on the target to zero, admittedly works against a policy of selective disclosure.

One broader implication of our work centers on the policy alternatives available to a central bank when it wants to reduce some of the uncertainty surrounding its target.[15] The bank can adjust the market's priors and reduce the variance of its target directly, by making public pronouncements about its target before trades commence. Alternatively, it can reduce the variance selectively (and in our case, to zero), for some but not all market participants. The bank will, presumably, need to reveal more information selectively to an informed trader than it would reveal publicly in order to achieve the same targeting effect. Both require that the information the bank relays is credible. Arguably, it should be easier for the bank to convey its true intentions to a portion of the market only, especially if such communications are limited to other central banks. Moreover, transmitting noisy messages publicly is a blunt, and potentially more costly, approach. For example, the central bank may run the risk that its message is confused by the general public with other aspects of its monetary policy, thereby affecting the market's priors on the fundamental itself. In the event that this occurs, it may be difficult if not impossible for the bank to retract its pronouncements, which will, no doubt, come at considerable cost to the bank's reputation.

Missing here, as in much of the microstructure literature, is a clear connection between exchange rate interventions strategies and the broader concerns of monetary policy. This remains an important and potentially fruitful area for future research.

Acknowledgements

Earlier versions of this paper were presented at the Meetings of the North American Econometric Society, the Canadian Economics Association, the International Conference on Policy Modeling, the International Conference on Finance at the University of Copenhagen, the National Bank of Poland, and the Economics Departments at Bates, Southern Methodist, Villanova, and Wesleyan Universities. We thank the participants of these conferences and seminars, along with James Chapman, Sylvester Eijffinger, Lubos Komarek, and two anonymous referees for their comments and suggestions.

Appendix A. Proof of Proposition 1

The proof applies the standard solution procedure of the Kyle's batch framework. In order to find a Nash equilibrium, we need to find three strategies; trading rules for the two central banks and a pricing rule for the market maker.

A.1. Equilibrium under complete secrecy

Let us start with Central Bank A, which minimizes expected value of the loss function $c \equiv (s_1 - f)x_A + q(s_1 - \bar{s})^2$, taking the pricing rule of the market maker and the trading rule of the other bank as given. Suppose A conjectures that the market maker's pricing rule is $s_1 = s_0 + \lambda[x_A + x_B + \varepsilon - h(\hat{s} - s_0)]$ and B's

[15] An interesting extension of our work along these lines would allow the intervention to occur over several periods. Here, the targeting bank may choose to adopt interim exchange rate targets. Is there a point within the intervention period that the targeting bank chooses to share some information with another informed trader? If so, how much information is shared and at what point will the bank share it? How will the other informed trader respond? This sort of extension may also be used to address how a country may discretely unload its cache of foreign assets to achieve a 'soft' versus a 'hard' landing of the exchange rate.

trading rule is $x_B = \beta_B(f - s_0)$. Plugging these into the bank's objective function, taking expectations over the noise trade ε and minimizing it with respect to x_A, one gets

$$x_A = \beta_A(f - s_0) + \theta_A(\bar{s} - \hat{s}) + \gamma_A(\hat{s} - s_0) \tag{15}$$

with the coefficients as defined in Table 1. B maximizes the expected value of $(f - s_1)x_B$ and conjectures that the market maker is setting s_1 according to the rule above and A follows Eq. (15). Plugging these and taking expectations over noise trade ε and unknown target and maximizing the resulting expression with respect to x_B yields $x_B = \beta_B(f - s_0)$, where β_B is as defined in Table 1. Finally, the market maker conjectures the above trading rules of the two central banks and sets the exchange rate according to the zero profit condition $s_1 = E[f|X]$ where $X = x_A + x_B + \varepsilon$. Using the projection theorem with the normal distribution, the posterior mean can be written as $s_1 = E[f|X] = s_0 + \lambda X$ where

$$\lambda = \frac{1}{\beta_A + \beta_B}\frac{\Sigma}{\Sigma + Var[f|X]} \tag{16}$$

with

$$Var[f|X] = \left(\frac{\theta_A}{\beta_A + \beta_B}\right)^2 \sigma_s^2 + \left(\frac{1}{\beta_A + \beta_B}\right)^2 \sigma_\varepsilon^2 = \left(\frac{\lambda q(3 + 2\lambda q)}{2(1 + \lambda q)}\right)^2 \sigma_s^2 + \left(\frac{\lambda(3 + 2\lambda q)}{2}\right)^2 \sigma_\varepsilon^2 \tag{17}$$

Plugging this last expression back into Eq. (16), one obtains the characteristic equation that describes the equilibrium λ in Eq. (6).

A.2. Equilibrium under selective disclosure

In this case, B knows Central Bank A's target $\bar{s}$. Accordingly, B chooses a trading rule

$$x_B = \hat{\beta}_B(f - s_0) + \hat{\theta}_B(\bar{s} - \hat{s})$$

to maximize expected value of profits, $(f - s_1)x_B$, given that A follows a trading rule

$$x_A = \hat{\beta}_A(f - s_0) + \hat{\theta}_A(\bar{s} - \hat{s}) + \hat{\gamma}_A(\hat{s} - s_0)$$

and the market maker sets $s_1 = s_0 + \lambda[x_A + x_B + \varepsilon - h(\hat{s} - s_0)]$. Plugging these and taking expectations over just the noise trade ε (but not the target, since it is known by B in this case) and maximizing the resulting expression with respect to x_B yields Eq. (8) with the trading intensity coefficients $\hat{\beta}_B$ and $\hat{\theta}_B$ described as in Table 1. Similarly, given B's strategy and the market maker's pricing rule, *A*'s optimal linear trading rule x_A that minimizes Eq. (2) yields Eq. (7) with coefficients $\hat{\beta}_A$, $\hat{\theta}_A$, and $\hat{\gamma}_A$ described in Table 1. Finally, the market maker's pricing rule solves $s_1 = E[f|X] = s_0 + \lambda X$ where

$$\lambda = \frac{1}{\hat{\beta}_A + \hat{\beta}_B}\frac{\Sigma}{\Sigma + Var[f|X]} \tag{18}$$

with

$$Var[f|X] = \left(\frac{\hat{\theta}_A + \hat{\theta}_B}{\hat{\beta}_A + \hat{\beta}_B}\right)^2 \sigma_s^2 + \left(\frac{1}{\hat{\beta}_A + \hat{\beta}_B}\right)^2 \sigma_\varepsilon^2 = \lambda^2 q^2 \sigma_s^2 + \left(\frac{\lambda(3 + 2\lambda q)}{2}\right)^2 \sigma_\varepsilon^2 \tag{19}$$

Plugging this last expression back into Eq. (18), one obtains the characteristic equation that describes the equilibrium λ in Eq. (10). □

Appendix B. Proof of Proposition 2

The left hand sides of the characteristic Eqs. (6) and (10) are the same affine function of λ with limit 2Σ as $\lambda\rightarrow 0$. Both right hand sides of these equations are convex functions of λ, with limit 0 as $\lambda\rightarrow 0$. Subtract the right hand side of Eq. (10) from the right hand side of Eq. (6); the difference is positive for any $\lambda>0$. It follows from these properties of the characteristic equations that the positive roots of these equations satisfy $\lambda^s<\lambda^d$. □

Appendix C. Proof of Proposition 3

Note that the right hand sides of the characteristic Eqs. (6) and (10) are increasing in $\sigma_s{}^2$, while the left hand sides of Eqs. (6) and (10) are independent of σ_s^2. It follows that the greater the variance, the smaller the positive root in both cases. □

Appendix D. Derivation of Eq. (14)

Given $s_1=s_0+\lambda X$, define $z\equiv s_1-\bar{s}$. Then we have,

$$z|\,\bar{s}\equiv(s_1-\bar{s}|\,\bar{s}\,)\sim N(E(s_1|\,\bar{s}\,)-\bar{s},\,Var(s_1|\,\bar{s}\,)),$$

which implies that $Y\equiv\frac{(s_1-\bar{s}|\,\bar{s}\,)^2}{\mathrm{Var}(s_1|\,\bar{s}\,)}$ has a non-central chi-square distribution with a non-centrality parameter $E(s_1|\bar{s})-\bar{s}$. Using the moment generating function of non central chi-square distribution (see Hogg and Craig (1978), page 289), one obtains

$$E(Y)=\frac{\mathrm{Var}(s_1|\,\bar{s}\,)+[E(s_1|\,\bar{s}\,)-\bar{s}\,]^2}{\mathrm{Var}(s_1|\,\bar{s}\,)}$$

which yields Eq. (14). □

Appendix E. Proof of Proposition 4

Let $\Delta\equiv E[(s_1-\bar{s})^2|\bar{s},\textit{selective disclosure}]-E[(s_1-\bar{s})^2|\bar{s},\textit{complete secrecy}]$ denote the difference between the conditional deviation from the target, under selective disclosure and under complete secrecy. Using Eqs. (12), (13) and (14), we have

$$\begin{aligned}\Delta=&\left[(s_0-\bar{s}\,)+\frac{2\lambda^d q(\bar{s}-\hat{s})}{3+2\lambda^d q}+\frac{2(f-s_0)}{3+2\lambda^d q}\right]^2+\left(\lambda^d\right)^2\sigma_\varepsilon^2\\&-\left[(s_0-\bar{s}\,)+\frac{\lambda^s q(\,\bar{s}-\hat{s})}{1+\lambda^s q}+\frac{2(f-s_0)}{3+2\lambda^s q}\right]^2-(\lambda^s)^2\sigma_\varepsilon^2.\end{aligned}\tag{20}$$

When there is little uncertainty on the target, secrecy always achieves better targeting. Our focus, therefore, will be on how targeting compares across the regimes for large values of the variance for the target, σ_s^2. In our proof, we utilize the following property of equilibrium liquidity coefficients, λ^s and λ^d:

$$\lim_{\sigma_s^2 \to \infty} \lambda^i = 0$$

for i $\in$ {s,d}. This property follows directly from Eqs. (16) and (18). Given this property, we note that for a large enough σ_s^2, Δ can be made arbitrarily close to $\tilde{\Delta}$, where

$$\tilde{\Delta} \equiv \left[(s_0 - \bar{s}) + \frac{2(f - s_0)}{3 + 2\lambda^d q}\right]^2 - \left[(s_0 - \bar{s}) + \frac{2(f - s_0)}{3 + 2\lambda^s q}\right]^2. \tag{21}$$

Therefore, if we can establish the sign of $\tilde{\Delta}$ for large σ_s^2, we can determine the sign of Δ, and hence, identify the regime that achieves better targeting. Negative $\tilde{\Delta}$ (Δ) implies that the conditional deviation from the target is higher under secrecy, i.e., selective disclosure achieves better targeting.

Case a) targeting away from the fundamental. If A is targeting away from the fundamental, we have $f > s_0 > \bar{s}$ or $f < s_0 < \bar{s}$. By Proposition 3, $\lambda^d > \lambda^s$. In both of these cases, the first term of (21) is less then the second (since $\lambda^d > \lambda^s$), so $\tilde{\Delta} < 0$. Hence, for large enough σ_s^2, we have $\Delta < 0$ and thus selective disclosure achieves better targeting.

Case b) targeting toward the fundamental. If A is targeting toward the fundamental, we have $s_0 > f > \bar{s}$ or $\bar{s} > f > s_0$. Take for example, the case where $s_0 > f > \bar{s}$. In this case, since $\lambda^d > \lambda^s > 0$, both terms under the squared brackets are positive and

$$(s_0 - \bar{s}) + \frac{2(f - s_0)}{3 + 2\lambda^s q} < (s_0 - \bar{s}) + \frac{2(f - s_0)}{3 + 2\lambda^d q},$$

and hence $\tilde{\Delta} > 0$. Now consider $\bar{s} > f > s_0$ and note that both terms under the squared brackets are negative and

$$(s_0 - \bar{s}) + \frac{2(f - s_0)}{3 + 2\lambda^s q} > (s_0 - \bar{s}) + \frac{2(f - s_0)}{3 + 2\lambda^d q}$$

and hence $\tilde{\Delta} > 0$.

It follows that for σ_s^2 large enough, in both cases, we have $\Delta > 0$ and targeting is better under complete secrecy when targeting toward the fundamental. □

What about the cases when $s_0 > \bar{s} > f$ or $s_0 < \bar{s} < f$? In these cases, the bank's policy fits neither of our policy definitions of targeting toward or away from the fundamental. However, we have been able to compare the two regimes as well by imposing more conditions on the parameters. Take, for instance, $s_0 > \bar{s} > f$. One can show that complete secrecy (selective disclosure) achieves better targeting for large σ_s^2 provided

$$\bar{s} < (>) \frac{1}{3} s_0 + \frac{2}{3} f.$$

For $s_0 < \bar{s} < f$, complete secrecy (selective disclosure) achieves better targeting if

$$\bar{s} > (<) \frac{1}{3} s_0 + \frac{2}{3} f.$$

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