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Global financial conditions, capital flows and the exchange rate regime in emerging market economies[☆]

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ABSTRACT

We examine if the sensitivity of private capital flows to global financial conditions varies across exchange rate regimes by focusing on 43 emerging market economies. We find that the flexible exchange rate regime stabilizes capital flows when the global risk aversion is low, particularly for gross liability flows; however, it fails to play such a role when the global risk aversion is high. We also show that larger covered interest parity deviations would amplify the impact of global risk aversion, which explains the failure of flexible exchange rate regimes during high global risk aversion periods.

1. Introduction

Over the past two decades, an overall trend has been the pursuit of financial openness and international financial integration.[1] As a result of financial globalization and efforts by emerging market economies (EMEs) to liberalize their capital accounts, large capital inflows have benefited many developing countries. However, this move is associated with increased risks and volatility, as demonstrated by the massive inflows and equally abrupt reversals that occurred during the 2008 global financial crisis (GFC) and most recently the COVID-19 pandemic. Many EMEs have been concerned with cross-border spillovers and their potentially adverse effects on financial stability.

The classic Mundellian trilemma argues that countries face a trade-off between free capital mobility, stable exchange rates, and monetary policy autonomy, for which flexible exchange rate's shock-absorption assumes a central role (Mundell, 1963). Therefore, the best policy when facing global financial shocks is to adopt flexible exchange rate regimes especially for EMEs (Obstfeld et al.,

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[1] Ilzetzki et al. (2019) document a trend over the past three decades toward a highly integrated world of markedly reduced capital controls.

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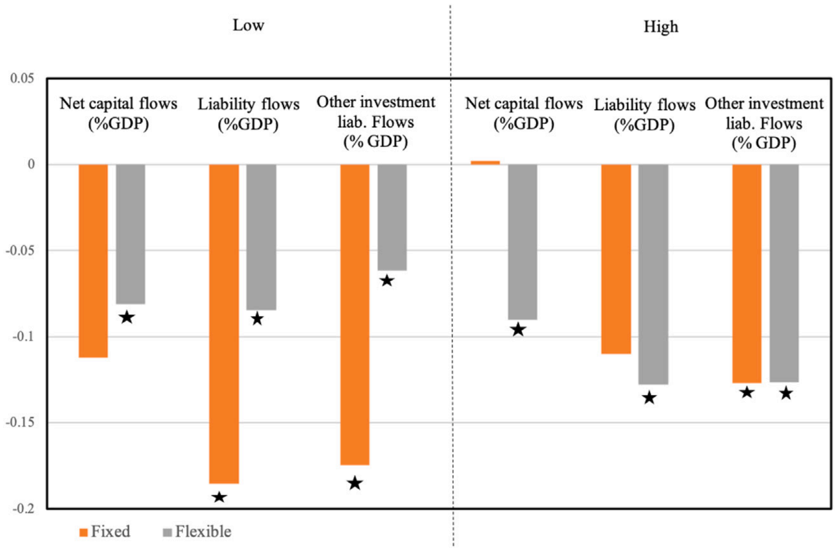

Fig. 1. Correlation between capital flows and low/high global risk aversion under both exchange rate regimes.
Note: Net capital flows (liability flows as well as other investment liability flows) exclude other investment liabilities of the general government and reserve assets.
Source: IMF, Obstfeld et al. (2019) and authors' calculations.

2005; Klein and Shambaugh, 2015). There are many theoretical analysis on macroeconomic outcomes of adopting different exchange change rate regimes when the domestic economy faces external shocks,[2] but none of them studies the behavior of different types of the capital flows. For theoretical works on capital flow patterns, such as Devereux and Sutherland (2009) and Evans and Hnatkovska (2014), they are silent on the role of exchange rate regimes. Therefore, studying the sensitivity of capital flows' response to global shocks would help us better understand the shock absorbing mechanism of exchange rate regimes.

Recent empirical works rekindle the debate on whether flexible exchange rate regimes could stabilize cross-border capital flows (Rey, 2016).[3] In a recent paper, Obstfeld et al. (2019) show that EMEs with flexible exchange rate regimes can better stabilize cross-border capital flows. They find that the unconditional correlation between the global investors' risk aversion (proxied by the VXO index[4]) is negative and tends to be higher (in absolute value) for fixed regimes compared with more flexible regimes.

Even a cursory look at the data suggests that flexible exchange rate regimes' ability to stabilize capital flows might depend on global financial conditions. We simply divide the global risk aversion into low and high regimes using the median of the VXO index. Fig. 1 shows the unconditional correlation between the VXO index and capital flows. A sharp contrast pattern appears: while the results in low global risk regimes are the same as (Obstfeld et al., 2019), flexible exchange rate regimes become *ineffective* to stabilize capital flows in high global risk regimes.

Motivated by this fact, we propose a simple model to explore how capital inflows react to the global risk aversion under different exchange rate regimes. We find that a flexible exchange rate regime could stabilize capital inflows with the exchange rate adjustment, but it fails to play such a role when the global risk aversion is high. We also discuss the role of covered interest parity (CIP) deviations in the framework and show that CIP deviations may underpin the failure of flexible exchange rate regimes during high global risk aversion periods.

Then, we conduct a comprehensive empirical study on the relation between capital flows and the VXO index under fixed and non-fixed (flexible) exchange rate regimes using panel data for 43 EMEs. After identifying low and high global risk regimes using a Markov switching method, we find that flexible exchange rate regimes *do* stabilize capital flows in low global risk regimes but become *ineffective* in high global risk regimes. These patterns indicate that the role of the flexible exchange rate regime might crucially be regime-dependent (low vs high global risk regimes). After examining different components of cross-border capital flows, we find that such patterns are significant for liability flows, including bank-to-bank flows. Such results indicate that bank lending is an essential channel for global risk pass-through among EMEs.

Further, we find evidence that the impact of global risk aversion on capital flows is linked to the CIP. When the CIP holds, exchange rate movements would absorb the external shocks. However, in the high global risk regimes, foreign exchange swap market frictions (due to the capital constraint of banks and/or sovereign default risk) in EMEs would lead to larger CIP deviations such that the exchange rate does not fully adjust to equalize the expected returns of the different currency-denominated assets

[2] See Farhi and Werning (2012), Chang et al. (2015), Davis and Presno (2017), and Blanchard (2017).
[3] By stabilizing capital flows we mean "smoothing the change of capital inflows" in this paper.
[4] The VXO index is CBOE S&P 100 implied volatility index. Their results remain very similar when the VIX (CBOE S&P 500 volatility index) is used instead.

(e.g., government bonds), therefore, flexible exchange rate's stabilization role is weakened.[5] We find empirical evidence that when the global risk aversion increases, CIP deviations increase. Furthermore, a larger CIP deviation magnifies the contraction of capital inflows for the EMEs.[6]

The remainder of this paper proceeds as follows. Section 2 discusses the related literature. Section 3 constructs a simple model to explain the stylized facts. Section 4 describes the data and methodology. Section 5 presents the empirical findings. Section 6 concludes.

2. Literature review

Recent studies debate the role of exchange rate regimes in cross-border shock transmission or, more broadly, the validity of the trilemma (Obstfeld et al., 2005; Aizenman et al., 2010; Klein and Shambaugh, 2015; Rey, 2016). Obstfeld et al. (2018) find that for EMEs, the data clearly shows that the exchange rate regime retains an essential role, as postulated by the trilemma. Conversely, Passari and Rey (2015) study a combined sample of advanced countries and EMEs, and show that the existence of the global financial cycle affects domestic credit and equity returns with similar force regardless of the exchange rate regime.[7] Han and Wei (2018) re-examine the international transmissions of monetary policy shocks from the United States to EMEs and find that flexible exchange rate regimes offer insulation for EMEs when the center country tightens its monetary policy but fail to do so when the center country cuts the interest rate. They label this pattern "2.5 lemma". Prior studies have no common consent on the stabilization role of flexible exchange rate regimes and such a role may be regime-dependent on global risk regimes as examined in this paper.

After the GFC in 2008, a burgeoning literature stream examines cross-border bank flows (Ivashina and Scharfstein, 2010; Milesi-Ferretti and Tille, 2011; Bruno and Shin, 2015) and their effects on domestic financial conditions (Tillmann, 2013; McKinnon, 2014; Obstfeld et al., 2018; Dinger and te Kaat, 2020). International bank lending mechanisms are discussed regarding the transmission of monetary policy shocks.[8] In particular, Bruno and Shin (2014) study cross-border bank lending and global liquidity under flexible exchange rate regimes. The drivers of cross-border bank flows have been extensively explored. For instance, Cerutti et al. (2014) find that global factors are important in driving cross-border bank flows, and their impact is different between the bank and nonbank sectors. Avdjiev and Hale (2019) find that the behavior of internationally active banks drives bank lending from advanced to emerging countries during episodes of both boom and stagnation. However, the author's focus is on the leverage channel, and they do not study whether bank flows are different across exchange rate regimes.

In the vast literature on push and pull factors in cross-border capital flows, recent studies include Fratzscher (2012), Ghosh et al. (2014), Cerutti et al. (2015), Byrne and Fiess (2016), and Avdjiev et al. (2017). Forbes and Warnock (2012) find that global factors, such as global risk, are significantly associated with extreme capital flow episodes while domestic pull factors are less important. Avdjiev et al. (2017) find that the co-movement of capital inflows and outflows is driven by the banking sector, and these flows decline for banks and corporates when global risk aversion increases. Cerutti et al. (2017) use bank flows to EMEs from 1990 to 2014 and find that the VIX index significantly affects the flows. Although both Cerutti et al. (2017) and Cerutti et al. (2019) point out that the explanatory power (R-squared) is lower in recent years, the impact of VIX may be nonlinear, so that a simple linear relationship may not capture the underlying mechanism. Other studies, such as Forbes and Warnock (2012), Miranda-Agrippino and Rey (2015), and Bruno and Shin (2015) also confirm the important role of global risk aversion. These studies find that the coefficients on monetary policy variables, namely, changes in the policy rate, typically have the expected signs but are rarely significant. Recently, Kalemli-Özcan (2019) find that capital flows in and out of EMEs are particularly sensitive to fluctuations in such risk perceptions and have a direct effect on local credit spreads. Du et al. (2018) and Du and Schreger (2021) find that factors for capital flow movements such as local sovereign risks and financial market frictions are closely linked to CIP deviations. However, the previous studies have not discussed the nonlinear effects of global risks nor have they combined it with local frictions.

This paper makes following contributions. First, our empirical results show that the stabilization role of a flexible exchange rate is nonlinear: a more flexible exchange rate regime stabilizes the cross-border capital flows well when the global risk aversion is low, but it fails to do so when the global risk aversion is high. Second, we empirically investigate the components of capital flows in detail, particularly bank flows, which constitute a growing share of the total gross flows in EMEs. We provide empirical evidence that bank-to-bank flows decrease more in EMEs with fixed exchange rate regimes while the sensitivity of bank-to-nonbank flows to global risk shocks is not significantly different across exchange rate regimes. Third, our paper complements the broad literature on how push and pull factors affect capital flows to emerging markets and discusses the role of CIP deviations in face of global risk shocks.

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[5] See the recent seminal works of Ivashina et al. (2015), Du et al. (2018), and Avdjiev et al. (2019) for a more detailed discussion on the foreign exchange swap market frictions, sovereign default risk in EMEs, and CIP deviations.

[6] These results are similar to the empirical findings of Avdjiev et al. (2019), who show that strengthening the dollar has a greater impact on the tail risk of banks' EME loan portfolios and translates into greater contractions in cross-border dollar lending to EMEs.

[7] The concept of a global financial cycle is discussed by Calvo et al. (1993), Reinhart and Reinhart (2008), and Ghosh et al. (2014). In contrast to previous works on global financial cycles, Rey (2015) state that cross-border financial spillovers are similar across exchange rate regimes. For more discussion on exchange rate regimes see Ilzetzki et al. (2019) and Lei et al. (2020).

[8] See Cetorelli and Goldberg (2012), Paligorova et al. (2017) and Correa et al. (2018).

3. A simple model

Here, we lay out an illustrative model to explore whether the float exchange rate regime has different impact on capital flows under low and high risk regimes. Based on Blanchard (2017), capital inflows (FI) in EMEs are mainly driven by expected returns during normal time and they are determined in the following equation.

$$FI = \alpha + \beta(d(R - R^{*} - \rho) + E) \tag{1}$$

where R^{*} represents foreign risk-free rate (e.g., the US interest rate) and R represents the domestic interest rate in EME. ρ is the global risk premium and E is the change between the spot exchange rate and the future exchange rate (defined in units of domestic currency per foreign currency). α is the constant term. The positive β reflects sensitivity of capital inflows to expected return. d is the duration of investments.[9]

In theory, the rise of global risk aversion will raise the risk premium. Although their policy rate adjustment is constrained in the short run (Blanchard, 2017), the movement of exchange rates can offset the change of risk premium. Thus, the interest rate parity holds under flexible exchange rate regimes (as shown in Eq. (2)).[10] On the contrary, the capital inflows in EMEs with fixed exchange rate regimes will respond more because the exchange rate can not make the needed adjustment to absorb the shock. With a hard peg, the expectation that the regime will hold in the future will be strong, so that the change between the forward exchange rate and the spot exchange rate is small. Therefore, flexible exchange rate regimes can act as a cushion in the normal period (low risk regimes) just as the classic Mundellian trilemma has claimed.

$$\Delta E = d\Delta\rho,\ \Delta FI_{flexible} = 0 \tag{2}$$

However, the emerging markets face additional risks and financial market frictions, which can be captured by a deviation of CIP (Du et al., 2018). Hence, exchange rates may not adjust fully even in a flexible exchange rate regime to meet Eq. (2). When facing the same shock, the adjustment of E becomes less than $d\Delta\rho$, and the country will face a decrease of capital inflows:

$$\gamma\Delta E < \Delta E = d\Delta\rho,\ \Delta FI_{flexible} < 0 \tag{3}$$

In addition, many EMEs may still prefer to adopt a fixed exchange rate regime since it brings lower exchange rate risks and facilitates international transactions. A higher volatility of exchange rate may discourage capital inflows due to the larger risk (Aizenman, 1992; Obstfeld and Rogoff, 1995; Cushman and De Vita, 2017). Based on this, we have the capital inflow determination in general form Eq. (4).

$$\begin{aligned} FI &= \alpha + \beta(d(R - R^{*} - \rho) + \gamma E) - V; \\ \gamma &= \gamma(\rho), \gamma_{\rho} < 0, 0 \le \gamma \le 1; \\ V &= V(\rho), 0 < V_{\rho} < \beta d, V_{\rho\rho} < 0 \end{aligned} \tag{4}$$

Specifically, γ represents the adjustment of exchange rates as the global risk aversion changes. When the global risk aversion surges, CIP deviates further and the adjustment of exchange rates is limited to meet the change of global risk aversion. Furthermore, the higher global risk aversion surges, the larger CIP deviates, and the smaller exchange rates adjust, so γ is a decreasing function of ρ. We assume that the upper bound of γ is 1, which is the no friction case. V represents the impact of exchange rate volatility on capital inflows. Since the global risk may transmit to the exchange rate risk, a higher ρ leads to higher exchange rate volatility. Therefore, V is an increasing function of ρ and $V_{\rho} > 0$. The exchange rate volatility becomes larger when ρ rises in a flexible exchange rate regime, and it discourages capital inflows due to the increase of exchange rate risk. So, V is non-negative, and it equals zero when the country adopts a fixed exchange rate regime. When the exchange rate volatility is large enough, the marginal loss of capital inflows is usually small, so that we assume that V is concave and $V_{\rho\rho} < 0$. Thus, global risk aversion ρ has a direct impact on capital inflows (represented by βd) and has an indirect impact through the exchange rate risk channel (represented by V_{ρ}), specifically. Since the indirect impact may have a smaller marginal effect, we have $V_{\rho} < \beta d$.

Now we can get the change of capital inflows under flexible exchange rate regimes (as shown in Eq. (5)) and fixed exchange rate regimes (as shown in Eq. (6)), respectively. Since the forward and spot exchange rate difference is relatively small in a hard peg, for simplicity, we assume that E does not react to risk premium changes in the fixed exchange rate regime.

$$\Delta FI_{flexible} = -\beta d\Delta\rho + \beta\gamma\Delta E + \beta\gamma_{\rho}E - V_{\rho}\Delta\rho \tag{5}$$

$$\Delta FI_{fixed} = -\beta d\Delta\rho + \beta\gamma_{\rho}E < 0 \tag{6}$$

[9] Depending on the types of financial flows (FDI, portfolio flows and other investment flows), the β can vary with larger β signifying larger response of financial flows to the changes of expected return. Note that in our simple model we use the reduced-form equation as in Blanchard (2017). Alternatively, we can use portfolio choice model (a risky local asset in emerging market and a risk-free foreign asset in the US) to derive the optimal share of risky asset holding to denote as capital inflows in the EMEs. See Campbell (2017) for more details.

[10] For simplicity, we assume that the forward exchange rate equals to the expected exchange rate, which means that there is no difference between UIP and CIP.

Then we can obtain the difference of financial inflows between two exchange rate regimes (flexible vs fixed) as shown in Eq. (7),

$$I = \Delta FI_{flexible} - \Delta FI_{fixed} = \beta\gamma\Delta E - V_\rho\Delta\rho = \beta\gamma d\Delta\rho - V_\rho\Delta\rho = (\beta\gamma d - V_\rho)\Delta\rho \tag{7}$$

As Eq. (7) shows, the difference of financial inflows I depends on the relative scale of $\beta\gamma d$ and V_ρ. And both of them are related to the global risk aversion ρ.

Since $V_\rho < \beta d$, Eq. (7) is greater than 0 when $\rho = 0$. Therefore, it indicates that the difference in the financial flow is positive, and the flexible regime plays a risk shock absorber role at the beginning. Both V_ρ and $\beta\gamma d$ is a decreasing function of ρ. As ρ rises, $\beta\gamma d$ reaches 0 first, and V_ρ approaches 0 when ρ goes to infinity. Therefore, there exist a ρ^*, when $\rho < \rho^*$, $I > 0$. As risk premium ρ continues to rise and exceed ρ^*, the $\beta\gamma d$ becomes lower than V_ρ, so we have Eq. (7)< 0. However, When the ρ is large enough, $\beta\gamma d$ drops to 0, and V_ρ is approaching 0. Then, the difference between fixed and flexible exchange rate regimes on shock absorption will be small again.

Furthermore, based on the assumption, as the risk premium ρ increases, the CIP deviation becomes larger, and thus γ decreases. Such an assumption is validated with empirical exercises later in the paper. In practice, local factors besides the global risk premium may also determine the level of γ. According to the model, since a lower level of γ will lead to a decrease of I in Eq. (7), we would also expect that the CIP deviation may amplify the impact of risk shock even in a flexible exchange rate regime.

According to the model, we obtain two main conclusions: (1) A flexible exchange rate regime may stabilize the capital inflows with the adjustment of exchange rates, but it fails to play such a role when the global risk aversion is high. (2) CIP deviations may amplify the impact of global risk shocks and weaken the role of flexible exchange rate regimes.

4. Data and methodology

We have proposed some theoretical motivations. Starting from this section, we focus on empirical analysis and validate the theoretical conclusions. In this section we first describe the data and how the variables are constructed. Then, we introduce our research methodology in testing the role of exchange rate regimes in stabilizing cross-border capital flows.

4.1. Data

To study the nexus of capital flows and exchange rate regimes, we obtain data on 43 EMEs from 1986 to 2018 in quarterly frequency. The data comes from various sources: the IMF's International Financial Statistics (IFS) and Balance of Payments (BOP), World Development Indicators (WDI), Bloomberg, Bank for International Settlements (BIS), Wharton Research Data Services (WRDS), and Federal Reserve Economic Data (FRED).

The key dependent variables are cross-border capital flows. Apart from net flows, we are particularly interested in gross flows of different components; that is, foreign direct investment (FDI), portfolio investments, and other investments.[11] The data is collected from the IMF's BOP database. We further distinguish gross flows between asset and liability flows (outflows versus inflows) and focus on gross liability flows, which represent the flows that non-residents bring in and take out from an EME, but not capital outflows by residents.[12] Additionally, we also supplement the data with bank-to-bank inflows and bank-to-nonbank inflows which are collected from the BIS's locational banking statistics (LBS) database.

For exchange rate regimes, we use the IMF's de facto exchange rate regime classification following Ghosh et al. (2015) and Obstfeld et al. (2018).[13] The classification also distinguishes among hard, conventional, and soft peg. Further, the classification has more recent cross-country coverage. In robustness tests, we also cross-check our results using other classifications such as Ilzetzki et al. (2019).

Since our analysis is based on quarterly data, we obtain period-average-of-quarter data for the VXO index (using the same method for other monthly variables) from Bloomberg. In this paper, we focus on the VXO which is the precursor of the VIX. We use VXO so as to maximize data coverage since its time series is longer than that of the VIX. VIX has been used as a proxy for global financial conditions by several recent studies (e.g., Ghosh et al., 2014; Bruno and Shin, 2014; Rey, 2016). These studies show that cross-border capital flows across countries are strongly and negatively associated with global market volatility and risk aversion (proxied by the VXO or VIX index). Although VXO has been identified as the most important global financial factor, we also control for other global factors, such as U.S. policy rates. Specifically, we collect the three-month U.S. T-bill rate from WRDS and federal fund rate (in the zero-lower-bound period, we use the shadow federal funds rate of Wu and Xia (2016)) from FRED. As a domestic pull factor, we collect policy rates of the analyzed EMEs from the IMF's IFS database and drop ultra high policy rate periods (greater than 50%) to eliminate noise from high inflation in a particular country. Of course, it is also possible that the high policy rate is due to a defending of speculative attack. Since the attack is associated with abnormal capital outflows, dropping these observations can also partially relieve the endogenous issue if we want to examine the impact of local rates to capital flows. Other variables like real GDP growth rate and the ratio of domestic private credit to GDP are collected from IFS and WDI database. Tables A.1 and A.2 provides the country list, data sources and variable constructions.

[11] Net financial flows exclude financing items and other investment liabilities of the general government while liability flows and other investment liability flows exclude other investment liabilities of the general government.

[12] We follow Kalemli-Özcan (2019) but leave the study of capital outflows to future work.

[13] Category 1 and 2 are defined as the fixed exchange rate regime and the remaining categories are defined as the flexible exchange rate regime.

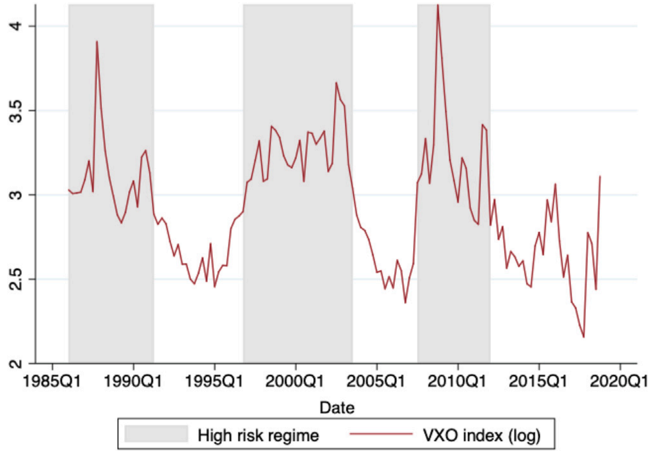

Fig. 2. Low and high risk regimes classified by Markov-regime switching method. **Note**: The shaded region refers to periods of high risk regime.

4.2. Methodology

Following Obstfeld et al. (2019), we conduct a formal empirical analysis on the relationship between cross-border capital flows, exchange rate regimes, and global risk aversion using a panel regression framework with country fixed effects. We run the following regression specification:

$$f_{it} = \beta_0 + \beta_1 Fixed_{it} + \beta_2 VXO_t + \beta_3 Fixed_{it} \times VXO_t + YX_{it} + \mu_i + \epsilon_{it} \tag{8}$$

where f_{it} is a flow variable (the different types of capital flows over the GDP ratio) in country i at time t in quarterly frequency; $Fixed$ is a dummy variable for fixed exchange rate regimes while the flexible is the reference category; The $Fixed$ dummy includes rigid pegs following Obstfeld et al. (2019). VXO is the VXO index (in log), which is a key proxy for global risk aversion (e.g., Bruno and Shin, 2014; Ghosh et al., 2015; Miranda-Agrippino and Rey, 2015); X_{it} are control variables for other push-and-pull factors, such as quarterly real GDP growth, the ratio of domestic private sector credit to GDP, a time trend, a dummy variable for the global financial crisis, U.S. policy rate, and domestic policy rate; μ_i captures country fixed effects; and ϵ_{it} is the error term. We are particularly interested in the coefficient β_3 on the interaction terms $Fixed_{it} \times VXO_t$. If less flexible exchange rate regimes magnify the transmission of global risk shocks, the coefficient should be *negative* and statistically significant.

Ghosh et al. (2015), Obstfeld et al. (2018, 2019) establish that exchange rate regimes matter for cross-border financial flows. The authors find systematic differences across exchange rate regimes: the transmission of global financial shocks to cross-border capital flows, particularly net and gross liability flows, is magnified under fixed exchange rate regimes compared to more flexible exchange rate regimes. However, based on the stylized facts shown in Fig. 1, we conjecture that the flexible exchange rate regime only plays the stabilization role when the global risk aversion is low but fails to do so when the global risk aversion is high. Therefore, we are particularly interested in the estimate of β_3 under low/high VXO regimes. To obtain the indicator of low/high VXO regimes, we run a two state Markov regime-switching on the VXO and obtain the estimated low/high global risk regimes. They are shown in Fig. 2. Accordingly, we can see that high risk regimes well capture the relatively high VXO periods.[14] Then we estimate Eq. (8) for each regime.

Eq. (8) is estimated with ordinary least squares (OLS) and standard errors are clustered at the country level. To eliminate the associated endogeneity concerns, we drop country-specific bank crisis/currency crisis periods to ensure the exchange rate regimes selected by the considered EMEs are exogenous. The crisis dummy is based on Laeven and Valencia (2020). For other domestic control variables (except policy rate), we lag them over one period to mitigate potential endogeneity concerns. To exclude financial autarky, country-specific periods with financial openness measures below the 25th percentile of the sample are dropped.[15] Kalemli-Özcan (2019) finds that local risk perceptions are also important. Therefore, we use the country and quarter-year fixed effects to capture these potential local time-varying factors.

5. Empirical results

Global financial conditions always transmit to financially open countries through capital flows. Obstfeld et al. (2019) also show that capital flows response differently to global risk aversion across exchange rate regimes. The question is the extent to which

[14] Using a Markov switching model may generate persistent regimes, which means that not only large crisis, but also some risk-on boom times of irrational exuberance are included in the high risk regimes. For robustness, we also use other methods to identify high and low regimes. See discussions in .

[15] We mainly rely on the capital account openness index of Quinn and Toyoda (2008) and cross-check with the index recently calculated by Fernández et al. (2016).

Table 1
Net capital flows in EMEs, 1986Q1–2018Q4 (different global risk regimes).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Low risk regimes						High risk regimes					
	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	2000–2018	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	2000–2018
Fixed regime	9.205	9.182	9.854	7.961	−24.446**	10.162	−12.887	−13.873	−13.643	−13.701	−11.676	−11.880
	(8.528)	(8.334)	(8.485)	(7.639)	(9.553)	(9.408)	(14.136)	(14.447)	(14.348)	(13.228)	(8.628)	(13.706)
Log (VXO)	−1.901	−2.368	−2.618*				−0.846	−1.862	−1.853			
	(1.346)	(1.442)	(1.497)				(1.748)	(1.954)	(1.844)			
Fixed × Log (VXO)	−3.178	−3.324	−3.504	−3.648	−1.143	−3.861	3.256	3.627	3.542	3.744	4.280	3.610
	(3.499)	(3.373)	(3.452)	(3.203)	(3.230)	(3.555)	(4.457)	(4.552)	(4.535)	(4.190)	(2.698)	(4.442)
Real GDP growth(lagged)	0.722***	0.628***	0.687***	0.517***	0.685***	0.823***	0.396***	0.357***	0.383***	0.391**	0.571***	0.727***
	(0.157)	(0.149)	(0.156)	(0.104)	(0.196)	(0.197)	(0.143)	(0.124)	(0.136)	(0.143)	(0.115)	(0.179)
Domestic private credit/GDP(lagged)	0.121***	0.133***	0.128***	0.108**	0.153**	0.141**	−0.076***	−0.070**	−0.068**	−0.093***	−0.029	−0.062*
	(0.042)	(0.036)	(0.038)	(0.047)	(0.060)	(0.052)	(0.026)	(0.026)	(0.026)	(0.031)	(0.047)	(0.031)
Trend	−0.111***	−0.286**	−0.216**				0.032	−0.360*	−0.249*			
	(0.028)	(0.104)	(0.079)				(0.025)	(0.193)	(0.140)			
Global financial crisis							−5.159***	−4.451***	−4.385***			
							(1.507)	(1.606)	(1.541)			
Real T-bill rate		−0.278*						−0.514**				
		(0.155)						(0.245)				
Real shadow rate			−0.151						−0.316**			
			(0.106)						(0.148)			
Fixed × real T-bill rate				0.249						−0.036		
				(0.147)						(0.087)		
Fixed × real shadow rate					0.634***						0.038	
					(0.062)						(0.076)	
Policy rate					0.200						0.003	
					(0.157)						(0.112)	
Observations	982	970	970	970	724	896	894	894	894	894	680	719
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	NO	NO	YES	YES	YES	NO	NO	NO	YES	YES	YES
R-squared	0.276	0.285	0.280	0.338	0.416	0.329	0.210	0.220	0.215	0.302	0.343	0.326
Adjusted R2	0.249	0.257	0.251	0.265	0.331	0.268	0.177	0.187	0.182	0.225	0.253	0.259

Note: The dependent variable is quarterly net capital flows (in percent of GDP). Columns 1 to 6 are estimated in low risk regimes while Columns 7 to 12 are estimated in high risk regimes. Fixed exchange rate regime is a binary variable (= 1 for hard and single currency peg). Reference category is flexible exchange rate regimes. All domestic control variables (except policy rate) are lagged to mitigate endogeneity concerns. Global financial crisis is a binary variable (= 1 for 2008Q4 and 2009Q1). The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

exchange rate regime variations affect the transmission of global financial shocks to cross-border private capital flows, especially under low and high global risk regimes.

Since different types of capital flows (FDI, portfolio, other flows, etc.) may heterogeneously react to the global risk shock due to their nature, which may affect the parameters values (β, α, etc.) discussed in Section 3. Therefore, we examine various types of capital flows in our empirical analysis.

5.1. Exchange rate regimes and global financial conditions

A. Net flows

We start with net capital flows at different global risk episodes. The results are shown in Table 1.[16] Under low global risk regimes, Column (1) to (6) shows that the coefficients on the interaction terms between fixed exchange rate regimes and VXO (β_3) are negative. By contrast, under high global risk regimes, Columns (7) to (12) shows that the coefficients are positive. However, none of the coefficients on the interaction terms are statistically significant. Such results mean that the difference between exchange rate regimes is not obvious and the flexible exchange rate regime does not act as a shock absorber.

B. Gross flows: assets vs. liabilities

Recent literature has increasingly focused on cross-border gross capital flows (Forbes and Warnock, 2012; Kalemli-Özcan, 2019). Therefore, we look at gross asset flows (resident net foreign asset acquisitions) and gross liability flows (non-resident net domestic asset acquisitions) separately. For gross asset flows, the results of Obstfeld et al. (2019)'s study show that the effect of exchange rate regimes is not obvious. So, we here will not explore them in depth.

According to the results shown in Table 2, under low global risk regimes, the effects of global risk shocks on gross liability flows are magnified under fixed exchange rate regimes relative to flexible exchange rate regimes (significantly negative β_3 in Columns (1) to (6)). By contrast, we find evidence that in high global risk regimes, β_3 is not significant. That is, for gross liability flows, the exchange rate regime plays a more important role in the transmission of global financial shocks. One explanation is that foreign investors are more sensitive to herding behaviors during low/high global risk regimes when the stabilization role of the exchange rate is restricted under less flexible regimes.

[16] An alternative method is to incorporate a high/low-risk regime dummy in Eq. (8) instead of splitting the sample. However, not only the regression coefficients, but also other parameters may be regime-dependent (such as the variance of the error term). Using a regime dummy may not accurately capture the regime heterogeneity.

Table 2
Gross liability flows in EMEs, 1986Q1–2018Q4 (different global risk regimes).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Low risk regimes						High risk regimes					
	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	2000–2018	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	2000–2018
Fixed regime	26.710**	26.405**	27.431**	24.137**	5.290	26.224**	0.821	−0.569	0.267	0.038	4.116	2.458
	(10.993)	(11.487)	(11.635)	(9.978)	(14.336)	(12.370)	(15.688)	(15.902)	(15.904)	(16.108)	(8.389)	(15.688)
Log (VXO)	−2.888**	−3.016**	−3.197***				−3.543***	−4.976***	−4.281***			
	(1.324)	(1.281)	(1.144)				(1.054)	(1.275)	(1.127)			
Fixed × Log (VXO)	−9.753**	−9.883**	−10.134**	−9.671**	−11.392**	−9.869**	−0.035	0.488	0.175	0.693	0.733	0.050
	(4.575)	(4.629)	(4.729)	(4.074)	(5.207)	(4.529)	(4.864)	(4.928)	(4.945)	(5.086)	(2.508)	(5.050)
Real GDP growth(lagged)	0.863***	0.733***	0.833***	0.556***	0.590***	0.876***	0.485***	0.430***	0.476***	0.466**	0.649***	0.818***
	(0.209)	(0.186)	(0.202)	(0.131)	(0.195)	(0.239)	(0.164)	(0.141)	(0.163)	(0.172)	(0.119)	(0.193)
Domestic private credit/GDP(lagged)	0.108*	0.124**	0.113**	0.092**	0.108**	0.137**	−0.053	−0.046	−0.048	−0.099**	−0.060	−0.046
	(0.056)	(0.049)	(0.052)	(0.045)	(0.040)	(0.060)	(0.036)	(0.035)	(0.035)	(0.044)	(0.082)	(0.040)
Trend	−0.102***	−0.362***	−0.221**				0.013	−0.540**	−0.193			
	(0.035)	(0.108)	(0.094)				(0.032)	(0.228)	(0.119)			
Global financial crisis							−4.924***	−3.926*	−4.357**			
							(1.748)	(1.928)	(1.808)			
Real T-bill rate		−0.418***						−0.724**				
		(0.152)						(0.281)				
Real shadow rate			−0.177						−0.231*			
			(0.125)						(0.128)			
Fixed × real T-bill rate				0.266*						−0.113		
				(0.156)						(0.110)		
Fixed × real shadow rate					0.616***						−0.102	
					(0.068)						(0.135)	
Policy rate					−0.021						0.007	
					(0.213)						(0.118)	
Observations	982	970	970	970	724	896	894	894	894	894	680	719
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	NO	NO	YES	YES	YES	NO	NO	NO	YES	YES	YES
R-squared	0.172	0.179	0.173	0.240	0.261	0.233	0.162	0.175	0.164	0.264	0.293	0.282
Adjusted R2	0.140	0.146	0.140	0.157	0.153	0.164	0.128	0.141	0.129	0.183	0.196	0.210

Note: The dependent variable is quarterly gross liability flows (in percent of GDP). Columns 1 to 6 are estimated in low risk regimes while Columns 7 to 12 are estimated in high risk regimes. See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

Table 3
FDI, Portfolio, and Other investment liability flows in EMEs, 1986Q1–2018Q4 (Low risk regimes).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	FDI flows			Portfolio investment flows			Other investment flows		
	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018
Fixed regime	13.552**	12.421**	8.909*	−3.307	−2.699	−10.714	18.295	15.392	8.508
	(5.936)	(5.572)	(4.987)	(7.342)	(7.314)	(14.583)	(11.790)	(10.833)	(17.921)
Log (VXO)	0.139			−0.803			−1.424		
	(0.685)			(0.730)			(1.247)		
Fixed × Log (VXO)	−5.318**	−5.342**	−9.303***	2.222	2.191	5.080	−7.322	−6.880	−7.368
	(2.203)	(2.222)	(1.806)	(2.773)	(2.796)	(4.815)	(4.895)	(4.448)	(6.529)
Real GDP growth(lagged)	0.200**	0.042	−0.028	0.050	0.080	0.176**	0.628***	0.436***	0.469***
	(0.077)	(0.066)	(0.156)	(0.045)	(0.048)	(0.082)	(0.183)	(0.127)	(0.169)
Domestic private credit/GDP(lagged)	0.002	−0.013	−0.014	0.033	0.046	0.085**	0.068	0.063	0.044*
	(0.014)	(0.017)	(0.021)	(0.025)	(0.030)	(0.039)	(0.045)	(0.038)	(0.025)
Trend	−0.015			−0.010			−0.076***		
	(0.009)			(0.015)			(0.025)		
Fixed × real T-bill rate		0.134			−0.076			0.206**	
		(0.082)			(0.045)			(0.091)	
Fixed × real shadow rate			0.345**			−0.026			0.290***
			(0.127)			(0.114)			(0.059)
Policy rate			0.036			−0.027			0.018
			(0.120)			(0.074)			(0.137)
Observations	972	968	724	972	968	724	982	970	724
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	YES	YES	NO	YES	YES	NO	YES	YES
R-squared	0.095	0.148	0.159	0.071	0.140	0.142	0.263	0.346	0.366
Adjusted R2	0.060	0.055	0.037	0.036	0.045	0.017	0.235	0.274	0.273

Note: The dependent variable is quarterly FDI flows (in percent of GDP) in Columns 1 to 3, Portfolio investment flows (in percent of GDP) in Columns 4 to 6, Other investment flows (in percent of GDP) in Columns 7 to 9. See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

C. Liability flows: FDI, portfolio, and other investments

Since different types of liability flows may behave differently, we further examine the three components of capital inflows: foreign direct investment (FDI), portfolio investment, and other investment flows separately.

According to results shown in Tables 3 and 4, we find that FDI flows has similar a significant pattern as liability flows: β_3 is negative and significant at 5% or 10% level under low global risk regimes but is not significant under high global risk regimes.

Table 4
FDI, Portfolio, and Other investment liability flows in EMEs, 1986Q1–2018Q4 (High risk regimes).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	FDI flows			Portfolio investment flows			Other investment flows		
	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018
Fixed regime	5.628	4.243	8.455	−10.148	−9.535	−7.593	5.712	6.073	4.111
	(4.876)	(5.172)	(8.644)	(9.486)	(8.786)	(6.742)	(12.241)	(12.599)	(6.501)
Log (VXO)	0.559			−2.158***			−1.914*		
	(0.982)			(0.763)			(1.056)		
Fixed × Log (VXO)	−1.838	−1.226	−1.943	3.065	2.994	2.549	−1.522	−1.562	−0.538
	(1.561)	(1.654)	(2.515)	(2.727)	(2.692)	(2.019)	(4.080)	(4.238)	(2.187)
Real GDP growth(lagged)	0.096	0.023	0.070	0.018	0.080	0.140**	0.363***	0.357***	0.438***
	(0.059)	(0.053)	(0.094)	(0.044)	(0.063)	(0.060)	(0.109)	(0.110)	(0.066)
Domestic private credit/GDP(lagged)	−0.005	−0.024	−0.045	−0.019	−0.037	−0.014	−0.027	−0.027	0.027
	(0.020)	(0.027)	(0.048)	(0.013)	(0.025)	(0.021)	(0.019)	(0.018)	(0.023)
Trend	0.006			0.020*			0.002		
	(0.012)			(0.010)			(0.017)		
Global financial crisis	0.518			−2.240**			−2.766*		
	(1.187)			(0.962)			(1.413)		
Fixed × real T-bill rate		−0.092**			−0.026			0.049	
		(0.042)			(0.073)			(0.068)	
Fixed × real shadow rate			−0.131			0.014			0.091*
			(0.081)			(0.041)			(0.049)
Policy rate			0.000			−0.028			0.078
			(0.062)			(0.035)			(0.067)
Observations	894	894	680	894	894	680	894	894	680
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	YES	YES	NO	YES	YES	NO	YES	YES
R-squared	0.104	0.165	0.172	0.100	0.180	0.281	0.173	0.328	0.383
Adjusted R2	0.067	0.072	0.058	0.064	0.090	0.182	0.139	0.254	0.298

Note: The dependent variable is quarterly FDI flows (in percent of GDP) in Columns 1 to 3, Portfolio investment flows (in percent of GDP) in Columns 4 to 6, Other investment flows (in percent of GDP) in Columns 7 to 9. See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

Table 5
Bank-to-bank and Bank-to-nonbank flows in EMEs, 1986Q1–2018Q4 (Low risk regimes).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Bank-to-bank flows						Bank-to-nonbank flows					
	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	2000–2018	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	2000–2018
Fixed regime	22.897*	26.821*	27.078*	23.840*	15.838	21.496	4.313	4.448	4.637	3.593	5.771**	6.351
	(12.853)	(14.042)	(14.063)	(12.112)	(14.958)	(13.104)	(7.001)	(6.812)	(6.732)	(6.804)	(2.726)	(7.295)
Log (VXO)	−1.636	−1.385	−1.110				−0.704	−1.169	−1.079			
	(0.984)	(0.846)	(0.790)				(1.043)	(1.044)	(1.027)			
Fixed × Log (VXO)	−8.224	−9.789*	−9.804*	−8.979*	−7.859	−7.676	−1.272	−1.369	−1.396	−1.035	−4.348***	−1.828
	(4.925)	(5.384)	(5.400)	(4.818)	(5.478)	(4.759)	(2.705)	(2.618)	(2.607)	(2.647)	(1.001)	(2.730)
Real GDP growth(lagged)	0.424***	0.398***	0.433***	0.314***	0.264***	0.514**	0.206***	0.180***	0.202***	0.134***	0.208***	0.175***
	(0.150)	(0.143)	(0.151)	(0.112)	(0.088)	(0.217)	(0.044)	(0.047)	(0.045)	(0.037)	(0.056)	(0.053)
Domestic private credit/GDP(lagged)	0.069**	0.076**	0.068**	0.067**	0.040*	0.088*	−0.004	−0.001	−0.005	0.006	0.034*	0.014
	(0.029)	(0.031)	(0.032)	(0.028)	(0.021)	(0.046)	(0.014)	(0.014)	(0.015)	(0.017)	(0.019)	(0.019)
Trend	−0.055***	−0.116**	−0.026				−0.012	−0.060	−0.013			
	(0.018)	(0.057)	(0.045)				(0.010)	(0.037)	(0.030)			
Real T-bill rate		−0.096						−0.073				
		(0.077)						(0.052)				
Real shadow rate			0.042						0.001			
			(0.062)						(0.036)			
Fixed × real T-bill rate				0.123						0.004		
				(0.101)						(0.044)		
Fixed × real shadow rate					0.066						0.140***	
					(0.041)						(0.020)	
Policy rate					0.048						0.039	
					(0.074)						(0.041)	
Observations	1,063	1,051	1,051	1,051	779	933	1,063	1,051	1,051	1,051	779	933
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	NO	NO	YES	YES	YES	NO	NO	NO	YES	YES	YES
R-squared	0.212	0.216	0.214	0.313	0.390	0.303	0.061	0.068	0.066	0.148	0.181	0.148
Adjusted R2	0.182	0.185	0.184	0.242	0.306	0.242	0.027	0.032	0.030	0.060	0.068	0.074

Note: The dependent variable is quarterly bank-to-bank flows (in percent of GDP) in Columns 1 to 6, bank-to-nonbank flows (in percent of GDP) in Columns 7 to 12. See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

Although not statistically significant, results for other investment flows have expected signs on β_3. However, according to the results, portfolio investment flows are not sensible to exchange rate regimes when facing the global financial shock.

D. Bank flows: Bank-to-bank and bank-to-nonbank flows

Cross-border bank flows, which are the main component of capital flows among EMEs, are studied extensively in the literature. For instance, Forbes and Warnock (2012) empirically describe the explanatory power of global risk for gross capital flows during

Table 6
Bank-to-bank and Bank-to-nonbank flows in EMEs, 1986Q1–2018Q4 (High risk regimes).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Bank-to-bank flows						Bank-to-nonbank flows					
	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	2000–2018	1986–2018	1986–2018	1986–2018	1986–2018	1986–2018	2000–2018
Fixed regime	11.493	10.852	11.207	9.688	−1.840	13.055	0.618	0.122	0.349	−0.153	0.028	0.381
	(8.631)	(9.008)	(8.755)	(8.111)	(4.872)	(8.433)	(3.198)	(3.338)	(3.214)	(3.339)	(3.802)	(3.386)
Log (VXO)	−0.590	−1.315	−0.957				0.366	−0.195	0.021			
	(0.999)	(0.998)	(1.048)				(0.604)	(0.634)	(0.632)			
Fixed × Log (VXO)	−3.696	−3.456	−3.590	−3.166	0.521	−4.021	0.045	0.230	0.144	0.330	0.215	0.267
	(2.803)	(2.887)	(2.838)	(2.590)	(1.354)	(2.713)	(1.002)	(1.026)	(1.003)	(1.047)	(1.145)	(1.004)
Real GDP growth(lagged)	0.239***	0.212***	0.234***	0.198**	0.318**	0.321***	0.160***	0.139***	0.156***	0.124***	0.169***	0.191***
	(0.082)	(0.069)	(0.080)	(0.079)	(0.137)	(0.102)	(0.039)	(0.030)	(0.037)	(0.033)	(0.023)	(0.041)
Domestic private credit/GDP(lagged)	−0.018	−0.014	−0.015	−0.017	0.003	−0.013	−0.013*	−0.010	−0.010	−0.024*	−0.011	−0.017
	(0.016)	(0.016)	(0.016)	(0.016)	(0.030)	(0.017)	(0.008)	(0.006)	(0.007)	(0.012)	(0.016)	(0.010)
Trend	0.007	−0.277*	−0.098				−0.001	−0.221**	−0.099**			
	(0.011)	(0.138)	(0.079)				(0.007)	(0.083)	(0.044)			
Global financial crisis	−4.458***	−3.962***	−4.178***				−3.045***	−2.661***	−2.782***			
	(1.481)	(1.436)	(1.469)				(0.764)	(0.762)	(0.771)			
Real T-bill rate		−0.369**						−0.285**				
		(0.176)						(0.107)				
Real shadow rate			−0.117						−0.109**			
			(0.082)						(0.045)			
Fixed × real T-bill rate				0.029						−0.014		
				(0.075)						(0.030)		
Fixed × real shadow rate					0.016						0.013	
					(0.055)						(0.031)	
Policy rate					0.035						0.019	
					(0.046)						(0.031)	
Observations	1,027	1,027	1,027	1,027	771	771	1,027	1,027	1,027	1,027	771	771
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	NO	NO	YES	YES	YES	NO	NO	NO	YES	YES	YES
R-squared	0.091	0.103	0.093	0.244	0.285	0.266	0.076	0.092	0.079	0.246	0.272	0.267
Adjusted R2	0.057	0.068	0.057	0.169	0.197	0.196	0.040	0.056	0.043	0.172	0.182	0.197

Note: The dependent variable is quarterly bank-to-bank flows (in percent of GDP) in Columns 1 to 6 and bank-to-nonbank flows (in percent of GDP) in Columns 7 to 12. See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

Table 7
Robustness Analysis: Alternative low/high VXO regimes (median of VXO).

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low risk regimes				High risk regimes			
	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows
Fixed regime	41.189***	31.120*	26.939*	2.358	5.408	11.551	8.453	−0.776
	(13.191)	(18.042)	(13.292)	(6.095)	(19.564)	(17.019)	(9.827)	(3.899)
Log (VXO)	−1.563	−1.766	−1.168	−1.330	−3.721**	−2.679**	−0.047	1.058
	(1.524)	(1.313)	(1.152)	(1.163)	(1.372)	(1.079)	(0.956)	(0.808)
Fixed × Log (VXO)	−15.107***	−11.887	−9.698*	−0.535	−1.486	−3.273	−2.807	0.505
	(5.340)	(7.157)	(5.048)	(2.329)	(6.048)	(5.475)	(3.174)	(1.192)
Real GDP growth(lagged)	0.867***	0.609***	0.406**	0.189***	0.496***	0.382***	0.235***	0.161***
	(0.225)	(0.198)	(0.150)	(0.041)	(0.170)	(0.113)	(0.080)	(0.041)
Domestic private credit/GDP(lagged)	0.083	0.042	0.070**	−0.001	−0.023	−0.002	−0.017	−0.013
	(0.057)	(0.043)	(0.033)	(0.014)	(0.032)	(0.017)	(0.017)	(0.008)
Trend	−0.092**	−0.073***	−0.055**	−0.016	−0.019	−0.014	−0.007	−0.003
	(0.034)	(0.025)	(0.021)	(0.011)	(0.035)	(0.015)	(0.011)	(0.008)
Global financial crisis					−4.335**	−2.023	−4.713***	−3.581***
					(1.607)	(1.283)	(1.522)	(0.883)
Observations	980	980	1,063	1,063	896	896	1,027	1,027
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	NO	NO	NO	NO	NO	NO	NO
R-squared	0.166	0.281	0.215	0.075	0.167	0.237	0.088	0.081
Adjusted R2	0.134	0.254	0.186	0.041	0.130	0.204	0.052	0.045

Note: The dependent variable is quarterly capital flows (in percent of GDP). Low/High risk regime is based on that log VXO is lower/higher than cut-off point of the median value of log VXO (2.9). Columns 1 to 4 are estimated in low risk regimes while Columns 5 to 8 are estimated in high risk regimes. See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

surge episodes. What is more, cross-border bank flows are the most volatile part of capital flows (Kalemli-Özcan, 2019). Bruno and Shin (2014) and Rey (2016) find that the banking sector capital flows are closely associated with U.S. monetary policy. However, none of the studies relates them to different exchange rate regimes. Therefore, we decompose cross-border bank flows into bank-to-bank and bank-to-nonbank flows and explore the heterogeneous effects of exchange rate regimes on bank flows of different borrowing sectors.

The results of bank-to-bank and bank-to-nonbank flows under low and high global risk regimes are presented in Tables 5 and 6, respectively. The empirical results are robust for the different specifications. Under low global risk regimes, in Columns (1) to (6), most β_3 is negative statistically significant, showing that bank-to-bank flows under fixed exchange rate regimes react more to global risk shocks than do under flexible regimes. However, bank-to-nonbank flows generally present no significant difference across exchange rate regimes (except for the case when controlling for the US real shadow rate). Under high global risk regimes, consistent with our previous results, such a pattern disappears. The response of both these two bank flows to global risk aversion are not significantly obvious under different exchange rate regimes.

Table 8
Robustness Analysis: Disaggregated exchange rate regimes (Low risk regimes).

VARIABLES	(1) Net flows	(2) Gross liability flows	(3) Other investment liability flows	(4) Bank-to-bank flows	(5) Bank-to-nonbank flows
Fixed regime	22.229***	35.258***	22.898**	20.634**	−1.158
	(7.475)	(10.045)	(8.565)	(9.617)	(5.486)
Crawling peg	26.976**	26.522**	28.937	0.498	9.348
	(13.028)	(12.889)	(21.253)	(3.779)	(11.404)
Managed float	10.860	13.691*	7.882	7.642	−5.508
	(8.163)	(7.970)	(5.352)	(5.814)	(3.501)
Fixed × log (VXO)	−6.686**	−10.955***	−7.247**	−6.772*	0.616
	(2.624)	(3.426)	(3.187)	(3.500)	(2.005)
Crawling peg × log (VXO)	−9.555**	−8.862*	−10.038	0.354	−3.560
	(4.664)	(4.553)	(8.000)	(1.268)	(4.483)
Managed float × log (VXO)	−3.103	−3.710	−1.602	−2.240	2.007
	(2.795)	(2.747)	(1.862)	(2.019)	(1.268)
Real GDP growth(lagged)	0.548***	0.576***	0.465***	0.325**	0.134***
	(0.135)	(0.169)	(0.160)	(0.132)	(0.038)
Domestic private credit/GDP(lagged)	0.125***	0.110*	0.080	0.072*	0.006
	(0.044)	(0.057)	(0.053)	(0.039)	(0.014)
Constant	−9.262***	−8.941*	−8.002*	−7.675***	0.558
	(3.049)	(4.565)	(4.098)	(2.509)	(1.374)
Country fixed effects	YES	YES	YES	YES	YES
Quarter-year effects	YES	YES	YES	YES	YES
Observations	982	982	982	1,063	1,063
R-squared 0.335	0.243	0.346	0.307	0.151	
Adjusted R2	0.260	0.157	0.271	0.234	0.0612

Note: The dependent variable is quarterly flows (in percent of GDP). See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

Table 9
Robustness Analysis: Disaggregated exchange rate regimes (High risk regimes).

VARIABLES	(1) Net flows	(2) Gross liability flows	(3) Other investment liability flows	(4) Bank-to-bank flows	(5) Bank-to-nonbank flows
Fixed regime	−13.090	−3.263	9.244	5.321	0.632
	(14.777)	(17.832)	(11.326)	(6.570)	(4.301)
Crawling peg	1.808	−16.529	−1.688	2.552	3.336
	(11.338)	(10.770)	(7.259)	(7.319)	(5.794)
Managed float	1.741	−14.729*	−1.415	−6.295	−1.285
	(10.178)	(8.153)	(5.380)	(4.464)	(2.837)
Fixed × log (VXO)	3.697	2.861	−1.812	−1.332	0.479
	(4.408)	(5.106)	(3.578)	(1.995)	(1.243)
Crawling peg × log (VXO)	−0.344	5.825*	0.519	−0.827	−0.886
	(3.442)	(3.102)	(2.251)	(2.275)	(1.895)
Managed float × log (VXO)	−0.083	5.241**	0.698	2.081	0.533
	(3.045)	(2.411)	(1.600)	(1.321)	(0.849)
Real GDP growth(lagged)	0.384**	0.434**	0.335***	0.195**	0.118***
	(0.153)	(0.188)	(0.112)	(0.076)	(0.033)
Domestic private credit/GDP(lagged)	−0.087**	−0.062	−0.036**	−0.023	−0.017**
	(0.033)	(0.038)	(0.017)	(0.016)	(0.007)
Constant	5.570*	7.007**	−0.840	0.143	0.917
	(3.016)	(3.126)	(1.464)	(1.381)	(0.960)
Country fixed effects	YES	YES	YES	YES	YES
Quarter-year effects	YES	YES	YES	YES	YES
Observations	894	894	894	1,027	1,027
R-squared	0.305	0.272	0.337	0.245	0.253
Adjusted R2	0.226	0.188	0.261	0.168	0.177

Note: The dependent variable is quarterly flows (in percent of GDP). See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

The overall picture emerging from the results can be explained from two aspects. First, less flexible exchange rate regimes are more prone to financial vulnerabilities than flexible exchange rate regimes. Second, the role of exchange rate regimes crucially depends on global financial conditions: the stabilization role of flexible exchange rate regimes as shock absorbers is more effective under low VXO regimes.

Table 10
Robustness Analysis: Further checks with RR exchange rate classifications.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low risk regimes				High risk regimes			
	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows
Fixed regime	35.290	21.373	22.944	11.615*	−11.449	−5.032	6.859	1.317
	(23.110)	(19.340)	(23.645)	(6.476)	(11.179)	(7.226)	(8.888)	(4.484)
Log (VXO)	−4.251	−1.272	−1.097	−0.706	−4.476***	−2.611**	−0.781	0.541
	(3.438)	(1.640)	(0.944)	(1.571)	(1.310)	(1.044)	(0.935)	(0.656)
Fixed × Log (VXO)	−15.279*	−10.399	−10.511	−4.372*	3.049	1.113	−3.180	−0.711
	(8.356)	(6.735)	(8.464)	(2.430)	(3.247)	(2.392)	(2.826)	(1.259)
Real GDP growth(lagged)	0.832***	0.618***	0.503***	0.231***	0.486**	0.375***	0.249***	0.170***
	(0.233)	(0.187)	(0.146)	(0.062)	(0.177)	(0.116)	(0.086)	(0.038)
Domestic private credit/GDP(lagged)	0.048	0.042*	0.073***	−0.000	−0.050	−0.024	−0.018	−0.012
	(0.043)	(0.025)	(0.021)	(0.017)	(0.035)	(0.015)	(0.019)	(0.010)
Trend	−0.075***	−0.067***	−0.050**	−0.018	0.010	0.002	0.014	0.003
	(0.027)	(0.021)	(0.018)	(0.013)	(0.033)	(0.015)	(0.014)	(0.008)
Global financial crisis					−4.602**	−2.656*	−4.681***	−3.094***
					(1.864)	(1.551)	(1.570)	(0.779)
Observations	801	801	881	881	853	853	978	978
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	NO	NO	NO	NO	NO	NO	NO
R-squared	0.207	0.336	0.257	0.075	0.161	0.178	0.095	0.078
Adjusted R2	0.169	0.305	0.224	0.033	0.125	0.142	0.058	0.041

Note: The dependent variable is quarterly capital flows (in percent of GDP). Columns 1 to 4 are estimated in the low-risk regime while Columns 5 to 8 are estimated in the high-risk regime. The fixed and intermediate regime are based on the classification used in Ilzetzki et al. (2019). See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

Table 11
CIP deviations and global risk aversion.

	(1)	(2)	(3)	(4)
Log(VXO)(lagged)	1.597**	1.434**	1.428**	1.715**
	(0.678)	(0.545)	(0.544)	(0.633)
Δ Log(VXO)		−15.027	−15.150	−15.822
		(13.450)	(13.532)	(14.179)
Δ Dollar			0.013	0.004
			(0.021)	(0.029)
Δ BER				−0.244***
				(0.068)
Observations	41,562	40,780	40,780	37,520
Country fixed effects	YES	YES	YES	YES
R-squared	0.000	0.001	0.001	0.006

Note: The response of the change in CIP deviation to global risk aversion under three months. The sample is composed of 14 EME countries and no bank or currency crisis years. The constant is included in all specifications. Robust standard errors are in parentheses. $*** \ p < 0.01$, $** \ p < 0.05$, $* \ p < 0.1$.

E. Sensitivity analysis

To check the robustness of the main empirical results, we conduct a series of sensitivity tests by using alternative ways to define low/high VXO regimes, adopting alternative exchange rate classifications, further addressing relevant endogeneity concerns and employing different empirical specifications and samples.

Alternative low/high VXO regimes:

We are concerned with the robustness of the empirical results if we use an alternative method rather than the Markov switching method to define low/high VXO regimes. We first use the cut-off point of the median value of log VXO (2.9) (shown in Table 7). Then, we use the bottom 25th percentile and the top 25th percentile of the distribution of VXO (in logs) index as low and high regimes (shown in Table A.3). By using these alternative measures we find robust evidence that more flexible exchange rate regimes behave as a cushion for gross liability flows and bank-to-bank flows when global risk aversion is in low regime. However, this pattern breaks down when global risk aversion is in high regime. Here we report robustness test results of main types of capital flows by using the cut-off point of the median value of log VXO (2.9) to divide low and high VXO regime as shown in Table 7.

Other exchange rate classifications:

The results above show that exchange rate regimes are the main reasons of different reactions of capital flows to the global risk aversion. Here, we adopt a finer classification on exchange rate regimes and find the results are robust as Tables 8 and 9 shown. And we also check the robustness of our main results using alternative exchange rate regime classifications. With Ilzetzki et al. (2019)'s de facto exchange rate regime classification (with 15 categories of exchange rate flexibility), as shown in Table 10, we find that flexible exchange rate regimes behave as a cushion for gross liability flows when the global risk aversion is low while there is no obvious difference among exchange rate regimes when the global risk aversion is high. Besides, we also check our results using Shambaugh (2004)'s de facto classification, and find the main results are robust as shown in Table A.4.

Table 12
Capital flows, CIP deviations, and global risk aversion.

	(1) Gross liability flows	(2) Other investment liability flows	(3) Bank-to-bank flows	(4) Bank-to-nonbank flows
Log(VXO)	−4.986	−0.816	−1.256**	−0.872*
	(3.392)	(0.744)	(0.521)	(0.448)
CIP deviation × log(VXO)	−0.005*	−0.002	−0.002**	0.000
	(0.002)	(0.001)	(0.001)	(0.001)
Δ Log(VXO)	1.721	0.067	−0.784	−0.126
	(3.527)	(0.305)	(0.609)	(0.515)
CIP deviation	0.018	0.008	0.005*	−0.002
	(0.010)	(0.005)	(0.003)	(0.003)
Δ CIP deviation	0.003	0.000	0.000	0.001
	(0.003)	(0.001	(0.001)	(0.001)
Real GDP growth(lagged)	0.282**	0.249***	0.113***	0.108***
	(0.107)	(0.068)	(0.040)	(0.037)
Domestic private credit/GDP(lagged)	−0.086**	−0.010	−0.019	0.002
	(0.030)	(0.022)	(0.017)	(0.016)
Trend	−0.076	−0.052	−0.035***	−0.056***
	(0.050)	(0.030)	(0.012)	(0.009)
Global financial crisis	−2.840	−2.854**	−2.206***	−2.221***
	(3.790)	(1.198)	(0.682)	(0.602)
Observations	572	572	588	588
Country fixed effects	YES	YES	YES	YES
R-squared	0.063	0.207	0.119	0.142
Adjusted R2	0.027	0.176	0.086	0.111

Note: The response of capital flows to CIP deviation. The sample is composed of 14 EME countries and no bank or currency crisis years. The constant is included in all specifications. Robust standard errors are in parentheses. $***\ p < 0.01$, $**\ p < 0.05$, $*\ p < 0.1$.

Endogeneity:

Endogeneity and reverse causality are important concerns for any empirical analysis. Here, flow variables (particularly in quarterly frequency) are quite volatile while exchange rate regimes tend to be persistent (particularly in yearly frequency). Thus, the concern of reverse causality between exchange rate regimes and capital flows is less pertinent. However, both flexible exchange rate regimes and capital flows could be driven by some common factors, such as increasing concerns regarding a financial crisis in a country. Further, capital outflows may facilitate collapses of a fixed exchange rate regime. For example, Mexico's government was forced to abandon its fixed exchange rate regime during the 1994 Peso crisis. Some countries with flexible exchange rate regimes may be vulnerable to financial crises. Therefore, for all estimations, we drop the observations one year before and one year after crisis periods. The empirical results are robust as shown in Table A.5. To further address reverse causality concerns, we drop periods when exchange rate regime switch happened. Although the sample size decreases, our findings remain qualitatively unchanged as shown in Table A.6.

Alternative empirical specifications and samples:

We control several relevant domestic and global variables like country fixed effects, quarter-year effects that might influence domestic financial conditions and be correlated with the VXO and exchange rate regimes in the estimation of the above results. Here, we add other control variables, such as the change in the log VXO and the ratio of U.S. dollar debt over foreign debt. Our findings are generally robust as shown in Table A.7.

In addition, our results are robust when we restrict the sample to major EMEs (countries covered in Passari and Rey, 2015) as shown in Table A.8. Our sample size decreases and the results are similar, which means the pattern is not driven by specific countries. Similarly, we test whether the pattern is robust in more open countries and periods (i.e., defined as those in the top 25th percentile distribution of capital account openness). We can see that the sample size decreases by more than 50%, yet the results are robust in Table A.9.

Moreover, we also exclude extreme observations (defined as those in the bottom and top 0.25th percentile of the distribution of capital flows) and our main results remain robust as shown in Table A.10.

5.2. Capital flows, VXO and deviations from covered interest parity

We have shown that a flexible exchange rate may play a stabilization role during the increased global risk aversion. However, the role is failed when the aversion is high, which indicates that the cushion mechanism is weakened in these episodes. The model proposed in Section 3 indicates that CIP deviations may also be essential in explaining such a phenomenon. This section empirically discusses the relationship among CIP deviations, capital flows, and global financial conditions.

It is well known that CIP deviation has been a puzzle among advanced countries since the 2008 financial crisis. The recent work by Avdjiev et al. (2019) documents a triangular relationship, in that a strong dollar goes hand-in-hand with larger CIP deviations and contractions of cross-border bank lending for G10 countries. Furthermore, Du et al. (2018) and Du and Schreger (2021) find CIP deviations are significantly larger than that of developed countries. CIP deviations may be due to heightened sovereign default risk, as argued by Du et al. (2018), or/and foreign exchange swap market frictions caused by the capital constraints of banks, as argued by Ivashina et al. (2015).[17] All these factors are closely linked to capital flows. When the global risk aversion rises, CIP deviation becomes larger and the local exchange rate fails to adjust to equalize returns of domestic and foreign assets, therefore, the role of flexible exchange rate regime is weakened.

We therefore hypothesize for EMEs that a higher VXO goes hand-in-hand with larger CIP deviations and contractions of cross-border flows. Especially when the global risk aversion is at a high level. Factors such as sovereign risks and/or financial market frictions lead the capital flows in each country to follow the global financial cycle instead of making the needed adjustments to their CIP, weakening the role of flexible exchange rate regimes for stabilization.

To find evidence to support our hypothesis, we conduct the following empirical test to determine the triangular relationship among the VXO, CIP deviations, and cross-border flows in EMEs. Following Du et al. (2018), we obtain the CIP deviation: $y^i_{n,t} = r^i_{n,t} - r_{n.t} - \rho^i_{n,t}$, where $r^i_{n,t} - r_{n.t}$ is the n-year interest rate differential in the government bond market. $\rho^i_{n,t} = \frac{1}{n}[log(F^i_{n,t}) - log(S^i_t)]$ represents the market-implied forward premium to hedge currency risk between foreign currency and the US dollar since S^i_t and $F^i_{n,t}$[18] are the dollar spot exchange rate and the n-year outright forward rate for currency i, respectively.

The sample of CIP deviations includes post-1998 Asia crisis data of 14 core EME currencies with flexible exchange rate regimes: Brazil, Colombia, Hungary, Korea, Peru, Philippines, Poland, Turkey, Mexico, Malaysia, Indonesia, Russia, Thailand, and South Africa. To examine the conditional correlation between CIP deviations and the VXO, we estimate the following equation:

$$\Delta y_{i,3M,t} = \alpha_i + \beta VXO_{t-1} + \delta' CONTR_{i,t} + \epsilon_{i,t}. \tag{9}$$

$\Delta y_{i,3M,t}$ is the change in the CIP deviation under a 3-month tenor at time t. If our hypothesis is supported, β should be positive and statistically significant. We add the change of VXO (in log), the U.S. dollar index, and exchange rates as control variables.

We find robust results that β is positive in Table 11. That means that when the VXO level increases, there will be a larger CIP deviation. This is consistent with the findings of Ivashina et al. (2015), Du et al. (2018), and Avdjiev et al. (2019). The main difference is that Avdjiev et al. (2019) find that the US dollar index is a key indicator of the CIP deviation for G10 currencies while we find that VXO is more important for EMEs currencies.

Since we show that CIP deviations for EMEs are closely related to the level of VXO, we test our postulation on capital flows by re-conducting the panel regression. We replace the interaction term between VXO and the exchange rate regime with the new interaction term between VXO and the CIP deviation. The empirical analysis is conducted for the 14 countries with non-fixed exchange rate regimes. The results are presented in Table 12, which shows that the deviation of covered interest rate parity can be an effective explanation for the behavior of types of capital flows. The coefficient on the interaction terms between the deviation of covered interest rate parity and the VXO is negative and significant for liability and bank-to-bank flows, meaning a larger deviation will magnify the decline of capital flows when global risk aversion increases.[19]

The above empirical results highlight the triangular relationship among capital flows, VXO and CIP deviations. We find a higher VXO is associated with wider CIP deviations under a flexible exchange rate regime and a larger contraction of cross-border liability flows.

6. Concluding remarks

Despite recent relevant studies, there is no consensus of opinion on how global financial shocks affect the cross-border capital flows to EMEs under different exchange rate regimes. On the one hand, Rey (2015) argues that cross-border financial flows are affected by global financial cycles *regardless of the exchange rate regime*. Specifically, gross capital flows, banking sector leverage, and domestic credit are strongly and negatively related to the measure of global market volatility and risk aversion. On the other hand, Obstfeld et al. (2019) examine the salience of exchange rate regimes in EMEs and find that flexible exchange rate regimes *do* act as shock absorbers. One possible explanation for the lack of conclusive empirical evidence is that the stabilization role of flexible exchange rate regimes in transmitting global financial risk to capital flows might be *time-varying and type-dependent*. That is, the role of exchange rate regimes depends on both the degree of global risk aversion and capital flow types.

Our paper provides some theoretical analysis of the debates of exchange rate regimes. We extend the model put forward by Blanchard (2017) by considering the impacts of global risk aversion and exchange rate risks. The model also indicates that CIP deviations may impact the effectiveness of the flexible exchange rate regime as a shock-absorber.

[17] For sovereign default risk, Du et al. (2018) find that, compared to G10 countries, the CIP deviations in EMEs show strong co-movement with the CDS differential, which indicates CIP deviations capture default risk fluctuations. For financial frictions, Ivashina et al. (2015) investigate global banks, frictions in FX swap markets, and the failure of covered interested parity. Avdjiev et al. (2017) also find evidence that during periods of high global risk aversion, financial frictions are binding for domestic banks. Other factors, such as capital controls and segmented markets, may also play a role. However, we are not interested in explaining the reasons for the failure of CIP. Instead, we focus on finding the linkages among CIP failure, global risks, and capital flows given that such strong connections may dampen the role of the exchange rate regime as a shock absorber.

[18] Both the forward and spot exchange rates are defined in units of currency i per dollar.

[19] Here, our findings refer to correlation rather than causality. In future work, it would be interesting to find a creative identification strategy to formally establish the direction of the causality.

Motivated by the model, our paper finds empirical evidence supporting Obstfeld et al. (2019)'s argument by studying the relationship among global financial conditions, capital flows and the exchange rate regime for EMEs. Specifically, we investigate if the sensitivity of private capital flows to global financial shocks varies across exchange rate regimes. Based on a sample of 43 EMEs for the period from 1986 to 2018, we find that the salience of exchange rate regimes in the open economy context depends crucially on the strength of global financial cycles. When the global risk aversion is low, the classic Mundellian trilemma works as the exchange rate plays an essential role stabilizing capital flows in the face of global financial shocks, particularly for gross liability flows. However, when the global risk aversion is high, cross-border financial spillovers are similar for fixed and flexible exchange rate regimes, implying a weakened role of the exchange rate. A further investigation into the components of gross liability flows shows that FDI flows and bank-to-bank flows are more prone to exchange rate movements where the flexible exchange rate regime provides a buffer for global risk shocks. We also find evidence that global risk aversion leads to larger CIP deviations among EMEs, and the CIP deviation may amplify the impact of global risk shocks.

However, our analysis leaves scope for future research along two important dimensions. First, while this paper focuses on gross liability flows and other investment flows (bank flows), it would be interesting to study portfolio investment flows using disaggregated data such as EPFR (Emerging Portfolio Fund Research) fund flows. Second, while we have documented a triangular relationship among CIP deviations, VXO, and capital flows, a creative empirical identification strategy is still required in future empirical work to uncover the direction of the causality.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

See Tables A.1–A.10.

Table A.1
List of countries in the sample.

Argentina	Dominican Rep.	Jamaica	Philippines	Turkey
Belarus	Ecuador	Jordan	Poland	Uruguay
Brazil	Egypt	Kazakhstan	Romania	Venezuela
Bulgaria	El Salvador	Korea, Rep.	Russia	
Chile	Estonia	Latvia	Serbia	
China	Georgia	Lithuania	Slovak Rep.	
Colombia	Guatemala	Malaysia	South Africa	
Costa Rica	Hungary	Mexico	Sri Lanka	
Croatia	India	Morocco	Thailand	
Czech Rep.	Indonesia	Peru	Tunisia	

Table A.2
Variable description and data sources.

Variables	Description	Source
Capital openness	Index(higher values indicating greater openness) Index(lower values indicating greater openness)	Quinn and Toyoda (2008). Fernández et al. (2016)[a]
Capital flows	In USD millions	IMF's BOP database(BPM6 presentation); BIS database
Annual GDP	In USD	WDI database
Capital flows/GDP	In percent. Capital flows scaled by (1/4)*annual GDP	Obstfeld(2019); Updated by authors' calculations
Exchange rate regime	De facto	Updated data from https://www.elibrary-areaer.imf.org/Pages/Home.aspx
Nominal quarterly GDP	In local currency (LC)	IMF's IFS database
GDP deflator	Index	IMF's IFS database
Real GDP growth	Quarter-on-quarter percentage change in real GDP	Authors' calculations
Domestic private credit to GDP	In percent	Obstfeld(2019); Updated data from WDI database
Consumer price index (CPI)	Index	IMF's IFS database

(continued on next page)

Table A.2 (*continued*).

Variables	Description	Source
VXO/VIX index	Chicago Board Options Exchange Market Volatility Index; Quarterly average of monthly data	Bloomberg
Policy rate	Money market rate, treasury bill rate or discount rate(in percent)	IMF's IFS database
U.S. interest rate	U.S. 3-month Treasury bill rate(in percent)	WRDS
U.S. interest rate (in real terms)	In percent. Computed as [(1+nominal interest rate)/(1+expected inflation)]-1, where expected inflation is one-period ahead inflation	Authors' calculations
Shadow interest rate	In percent	Board of Governors of the Federal Reserve System, and Wu and Xia (2016)[b]
Shadow interest rate (in real terms)	In percent. In real terms computed as [(1+nominal interest rate)/(1+expected inflation)]-1, where expected inflation is one-period ahead inflation	Authors' calculations
Global financial crisis (GFC)	Binary variable equal to 1 for 2008Q4/2009Q1, 0 otherwise	Obstfeld et al.(2019)

[a]Fernandez, Andres, Michael Klein, Alessandro Rebucci, Martin Schindler, and Martin Uribe, "Capital Control Measures: A New Dataset,"IMF Economic Review 64, 2016, 548-574.

[b]Updated data using effective federal funds rate from Board of Governors of the Federal Reserve System (US), effective Federal Funds Rate [FEDFUNDS], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/FEDFUNDS, June 27, 2019.

Table A.3

Robustness Analysis: Alternative low/high VXO regimes (Bottom and top 25th percentile of VXO).

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low risk regimes				High risk regimes			
	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows
Fixed regime	54.786	20.931	34.811**	2.125	−13.528	−1.082	12.745	3.873
	(41.847)	(19.757)	(16.925)	(6.507)	(14.693)	(11.481)	(15.722)	(5.803)
Log (VXO)	1.386	−3.490*	−4.151*	−1.368	−3.543	−0.796	4.692**	2.677***
	(6.018)	(1.963)	(2.299)	(0.972)	(3.922)	(1.776)	(2.128)	(0.944)
Fixed × Log (VXO)	−20.569	−8.125	−13.188*	−0.628	3.604	0.165	−4.383	−0.614
	(16.375)	(7.784)	(6.608)	(2.551)	(5.204)	(4.452)	(4.938)	(1.481)
Real GDP growth(lagged)	1.143***	0.802***	0.626**	0.178**	0.220	0.168***	0.071	0.109*
	(0.254)	(0.256)	(0.238)	(0.075)	(0.142)	(0.059)	(0.058)	(0.056)
Domestic private credit/GDP(lagged)	0.228**	0.096*	0.116**	−0.017	−0.145**	−0.087*	−0.055**	−0.009
	(0.108)	(0.056)	(0.049)	(0.025)	(0.068)	(0.043)	(0.022)	(0.015)
Trend	−0.150**	−0.088***	−0.079**	−0.023	0.041	0.035	−0.019	−0.036**
	(0.056)	(0.028)	(0.030)	(0.014)	(0.046)	(0.027)	(0.021)	(0.016)
Global financial crisis					−3.876	−2.925*	−6.196***	−3.707***
					(2.609)	(1.649)	(1.782)	(0.889)
Observations	521	521	574	574	511	511	581	581
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	NO	NO	NO	NO	NO	NO	NO
R-squared	0.316	0.391	0.294	0.228	0.223	0.162	0.126	0.129
Adjusted R2	0.266	0.347	0.245	0.175	0.166	0.100	0.065	0.068

Note: The dependent variable is quarterly capital flows (in percent of GDP). Columns 1 to 4 are estimated in the low-risk regime while Columns 5 to 8 are estimated in the high-risk regime. Here we use the bottom 25th percentile and the top 25th percentile of the distribution of VXO (in logs) index as low and high risk regimes. See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

Table A.4

Robustness Analysis: Further checks with Shambaugh exchange rate classifications.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low risk regimes				High risk regimes			
	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows
Fixed regime	11.788	−5.649	16.684*	−0.753	19.490*	17.621*	6.159	4.072
	(12.801)	(6.368)	(8.765)	(7.612)	(9.605)	(8.643)	(3.715)	(4.266)
Log (VXO)	−3.148	−4.760***	−0.676	−2.437**	−0.886	−0.504	0.039	0.271
	(2.316)	(0.921)	(1.490)	(0.974)	(1.145)	(1.046)	(0.788)	(0.550)
Fixed × Log (VXO)	−4.730	1.762	−7.186**	0.288	−7.445**	−5.941*	−2.552*	−1.257
	(5.318)	(1.704)	(3.459)	(2.418)	(3.508)	(2.934)	(1.384)	(1.427)
Real GDP growth(lagged)	0.921***	0.460***	0.671***	0.362***	0.508***	0.250***	0.224***	0.169***
	(0.208)	(0.163)	(0.181)	(0.113)	(0.163)	(0.089)	(0.051)	(0.042)
Domestic private credit/GDP(lagged)	0.132**	−0.052	0.088*	−0.026	0.082***	−0.018	0.002	−0.010
	(0.055)	(0.037)	(0.045)	(0.020)	(0.029)	(0.014)	(0.015)	(0.010)
Trend	−0.121***	0.011	−0.087***	0.002	−0.073***	0.010	−0.016	−0.005
	(0.039)	(0.032)	(0.026)	(0.017)	(0.021)	(0.013)	(0.011)	(0.007)

(*continued on next page*)

Table A.4 (*continued*).

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low risk regimes				High risk regimes			
	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows
Global financial crisis		−4.126**		−2.626*		−4.913***		−2.903***
		(1.608)		(1.490)		(1.595)		(0.701)
Observations	932	872	932	872	932	872	932	872
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	NO	NO	NO	NO	NO	NO	NO
R-squared	0.174	0.167	0.281	0.173	0.239	0.105	0.082	0.086
Adjusted R2	0.142	0.134	0.253	0.139	0.209	0.069	0.046	0.049

Note: The dependent variable is quarterly capital flows (in percent of GDP). The fixed and intermediate regime are based on the classification used in Shambaugh (2004). Columns 1 to 4 are estimated in low risk regimes while Columns 5 to 8 are estimated in high risk regimes. See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

Table A.5
Robustness Analysis: Drop 1 year before and after crisis.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low risk regimes				High risk regimes			
	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows
Fixed regime	31.284***	21.157*	24.646*	7.383	−3.943	−4.510	9.034	1.897
	(10.790)	(12.067)	(13.080)	(6.378)	(7.503)	(7.902)	(7.861)	(3.460)
Log (VXO)	−2.289*	−1.090	−1.359	−0.004	−3.094**	−2.166**	−0.904	−0.200
	(1.263)	(1.280)	(1.072)	(0.652)	(1.229)	(0.790)	(1.115)	(0.430)
Fixed × Log (VXO)	−11.746**	−8.685*	−8.970*	−2.411	1.656	1.693	−3.293	−0.462
	(4.458)	(5.012)	(5.012)	(2.468)	(2.375)	(2.558)	(2.732)	(1.069)
Real GDP growth(lagged)	0.921***	0.677***	0.559***	0.225***	0.441**	0.319***	0.254**	0.197***
	(0.215)	(0.184)	(0.173)	(0.056)	(0.163)	(0.086)	(0.103)	(0.051)
Domestic private credit/GDP(lagged)	0.087*	0.059	0.072**	−0.009	−0.043	−0.040	−0.028	−0.021
	(0.050)	(0.038)	(0.029)	(0.015)	(0.051)	(0.026)	(0.024)	(0.019)
Trend	−0.091**	−0.070***	−0.062***	−0.010	0.003	0.008	0.011	−0.004
	(0.034)	(0.023)	(0.023)	(0.012)	(0.040)	(0.019)	(0.017)	(0.011)
Global financial crisis					−4.657***	−1.892**	−3.817**	−2.523***
					(1.059)	(0.921)	(1.460)	(0.711)
Observations	954	954	954	954	802	802	802	802
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	NO	NO	NO	NO	NO	NO	NO
R-squared	0.168	0.254	0.229	0.072	0.179	0.176	0.091	0.094
Adjusted R2	0.136	0.225	0.199	0.036	0.142	0.139	0.050	0.052

Note: The dependent variable is quarterly capital flows (in percent of GDP). Columns 1 to 4 are estimated in the low-risk regime while Columns 5 to 8 are estimated in the high-risk regime. We drop the observations one year before and one year after crisis periods due to endogeneity concern. See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

Table A.6
Robustness Analysis: No exchange rate regimes switch.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low risk regimes				High risk regimes			
	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows
Fixed regime	28.404**	19.278	23.680*	4.564	1.158	7.570	6.545	1.034
	(11.094)	(12.003)	(13.018)	(7.082)	(16.622)	(12.123)	(7.362)	(2.957)
Log (VXO)	−2.794**	−1.397	−1.617	−0.663	−3.523***	−1.801*	−1.175	0.074
	(1.351)	(1.261)	(0.998)	(1.052)	(1.177)	(1.014)	(0.980)	(0.667)
Fixed × Log (VXO)	−10.263**	−7.616	−8.454*	−1.351	−0.271	−2.245	−2.057	−0.140
	(4.595)	(4.953)	(4.975)	(2.730)	(5.121)	(4.059)	(2.225)	(0.891)
Real GDP growth(lagged)	0.859***	0.623***	0.421***	0.207***	0.493***	0.367***	0.241***	0.159***
	(0.211)	(0.185)	(0.150)	(0.045)	(0.171)	(0.112)	(0.085)	(0.040)
Domestic private credit/GDP(lagged)	0.110*	0.069	0.070**	−0.003	−0.053	−0.025	−0.020	−0.009
	(0.056)	(0.046)	(0.029)	(0.014)	(0.040)	(0.021)	(0.017)	(0.008)
Trend	−0.105***	−0.077***	−0.056***	−0.013	0.012	−0.001	0.007	−0.003
	(0.036)	(0.026)	(0.018)	(0.010)	(0.032)	(0.017)	(0.012)	(0.007)
Global financial crisis					−5.650***	−3.362**	−3.619**	−2.573***
					(1.728)	(1.489)	(1.415)	(0.774)
Observations	974	974	1,055	1,055	867	867	997	997
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	NO	NO	NO	NO	NO	NO	NO
R-squared	0.172	0.264	0.213	0.062	0.165	0.179	0.083	0.071
Adjusted R2	0.140	0.235	0.183	0.027	0.130	0.145	0.046	0.034

Note: The dependent variable is quarterly capital flows (in percent of GDP). Columns 1 to 4 are estimated in the low-risk regime while Columns 5 to 8 are estimated in the high-risk regime. We drop periods when exchange rate regime switch happened due to endogeneity concern. See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

Table A.7
Robustness Analysis: Control other variables.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low risk regimes				High risk regimes			
	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows
Fixed regime	27.933**	22.111*	28.043*	2.535	17.103	17.132	20.692*	2.227
	(10.402)	(12.052)	(14.445)	(8.598)	(19.494)	(17.476)	(11.470)	(3.435)
Log (VXO)	−3.472*	−1.132	−1.598	−0.653	−4.176***	−2.553**	−0.962	0.383
	(2.029)	(1.151)	(1.083)	(0.641)	(0.917)	(1.162)	(0.950)	(0.565)
Fixed × Log (VXO)	−10.149**	−8.737*	−10.184*	−0.611	−5.172	−5.142	−6.735*	−0.493
	(4.260)	(4.938)	(5.532)	(3.281)	(5.967)	(5.603)	(3.727)	(1.054)
Real GDP growth(lagged)	0.820***	0.632***	0.498***	0.206***	0.428***	0.325***	0.223**	0.171***
	(0.225)	(0.201)	(0.166)	(0.050)	(0.137)	(0.091)	(0.081)	(0.045)
Domestic private credit/GDP(lagged)	0.108*	0.069	0.063**	−0.009	−0.081**	−0.048**	−0.029**	−0.017
	(0.056)	(0.046)	(0.029)	(0.012)	(0.036)	(0.021)	(0.013)	(0.013)
Trend	−0.111***	−0.077***	−0.058***	−0.011	0.002	−0.005	0.002	−0.008
	(0.034)	(0.024)	(0.019)	(0.009)	(0.044)	(0.027)	(0.017)	(0.010)
Global financial crisis					−4.228**	−2.256*	−4.243***	−2.993***
					(1.646)	(1.275)	(1.375)	(0.698)
US debt ratio(lagged)	−0.000	0.004	−0.042	−0.028	−0.073	−0.057**	−0.038**	−0.020*
	(0.069)	(0.045)	(0.035)	(0.029)	(0.052)	(0.026)	(0.016)	(0.012)
Δ Log (VXO)	1.135	−0.780	−0.257	1.136	0.571	0.877	0.276	−0.721*
	(2.486)	(1.073)	(0.947)	(1.455)	(0.951)	(0.667)	(0.611)	(0.392)
Fixed regime × Δ Log (VXO)	0.694	3.114	5.382**	−2.113	11.173**	7.796*	4.786*	1.136
	(4.048)	(3.158)	(2.123)	(2.182)	(4.342)	(4.063)	(2.762)	(1.031)
Observations	971	971	971	971	892	892	892	892
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	NO	NO	NO	NO	NO	NO	NO
R-squared	0.173	0.265	0.235	0.076	0.182	0.213	0.115	0.092
Adjusted R2	0.138	0.234	0.203	0.037	0.146	0.178	0.076	0.051

Note: The dependent variable is quarterly capital flows (in percent of GDP). Columns 1 to 4 are estimated in the low-risk regime while Columns 5 to 8 are estimated in the high-risk regime. See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

Table A.8
Robustness Analysis: Major EME samples.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low risk regimes				High risk regimes			
	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows
Fixed regime	26.305**	12.980	13.143	−0.076	−1.552	3.538	10.645	1.932
	(11.635)	(11.180)	(9.316)	(7.547)	(21.652)	(16.246)	(12.417)	(4.033)
Log (VXO)	−3.111*	−1.684	−2.206	−2.301*	−3.366**	−1.660	−1.371	0.031
	(1.584)	(1.157)	(1.293)	(1.151)	(1.264)	(1.218)	(1.039)	(0.789)
Fixed × Log (VXO)	−9.673*	−5.539	−4.429	0.593	0.547	−1.011	−3.858	−0.303
	(4.887)	(4.749)	(3.640)	(2.917)	(6.597)	(5.337)	(3.971)	(1.264)
Real GDP growth(lagged)	0.829***	0.662***	0.499**	0.183***	0.490**	0.383***	0.192**	0.167***
	(0.244)	(0.218)	(0.190)	(0.058)	(0.197)	(0.134)	(0.072)	(0.048)
Domestic private credit/GDP(lagged)	0.109	0.060	0.076**	−0.004	−0.057	−0.023	−0.008	−0.017*
	(0.064)	(0.052)	(0.033)	(0.016)	(0.045)	(0.023)	(0.017)	(0.009)
Trend	−0.113**	−0.074**	−0.061***	−0.022	0.025	0.014	0.017	0.001
	(0.042)	(0.030)	(0.021)	(0.013)	(0.035)	(0.019)	(0.011)	(0.009)
Global financial crisis					−5.291**	−3.472*	−4.496**	−2.966***
					(2.348)	(1.719)	(1.849)	(1.010)
Observations	724	724	760	760	696	696	746	746
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	NO	NO	NO	NO	NO	NO	NO
R-squared	0.131	0.269	0.202	0.120	0.148	0.183	0.117	0.078
Adjusted R2	0.099	0.242	0.173	0.088	0.114	0.150	0.084	0.043

Note: The dependent variable is quarterly capital flows (in percent of GDP). Columns 1 to 4 are estimated in the low-risk regime while Columns 5 to 8 are estimated in the high-risk regime. The countries are based on samples of Passari and Rey (2015). See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

Table A.9
Robustness Analysis: Higher financial openness samples.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low risk regimes				High risk regimes			
	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows
Fixed regime	26.400	28.774**	32.648**	11.592**	1.393	6.668	14.914	0.100
	(15.455)	(13.447)	(14.781)	(4.358)	(17.388)	(12.703)	(11.086)	(3.753)
Log (VXO)	−3.098	−0.357	−1.263	−0.030	−2.881**	−1.350	−0.224	0.050
	(2.220)	(1.527)	(1.377)	(1.317)	(1.353)	(1.369)	(2.055)	(0.806)
Fixed × Log (VXO)	−10.299	−11.751**	−11.975**	−4.104**	0.461	−1.550	−4.690	0.273
	(5.990)	(5.193)	(5.530)	(1.697)	(5.234)	(4.193)	(3.662)	(1.225)
Real GDP growth(lagged)	1.042***	0.817**	0.654**	0.279***	0.822***	0.542***	0.432***	0.304***
	(0.300)	(0.292)	(0.279)	(0.089)	(0.188)	(0.163)	(0.109)	(0.060)
Domestic private credit/GDP(lagged)	0.196**	0.108	0.083*	0.017	−0.062	−0.024	0.029	0.021
	(0.073)	(0.068)	(0.042)	(0.028)	(0.054)	(0.031)	(0.042)	(0.022)
Trend	−0.147***	−0.101***	−0.084***	−0.021	−0.025	−0.045	−0.056	−0.049*
	(0.051)	(0.035)	(0.027)	(0.019)	(0.057)	(0.036)	(0.047)	(0.027)
Global financial crisis					−6.512**	−4.256*	−6.459**	−3.870***
					(2.429)	(2.055)	(2.348)	(0.990)

(*continued on next page*)

Table A.9 (*continued*).

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low risk regimes				High risk regimes			
	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows
Observations	539	539	539	539	478	478	478	478
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	NO	NO	NO	NO	NO	NO	NO
R-squared	0.172	0.366	0.263	0.078	0.188	0.226	0.136	0.117
Adjusted R2	0.128	0.332	0.224	0.029	0.141	0.181	0.086	0.066

Note: The dependent variable is quarterly capital flows (in percent of GDP). Columns 1 to 4 are estimated in the low-risk regime while Columns 5 to 8 are estimated in the high-risk regime. More open countries and periods (i.e., defined as those in the top 25th percentile distribution of capital account openness) are included in regressions. See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

Table A.10
Robustness Analysis: Drop extreme observations.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low risk regimes				High risk regimes			
	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows	Gross liability flows	Other investment liability flows	Bank-to-bank flows	Bank-to-nonbank flows
Fixed regime	25.475**	18.962*	18.018*	7.251	−4.647	−3.349	−3.932	−0.868
	(11.622)	(10.776)	(9.588)	(5.115)	(7.984)	(7.680)	(5.603)	(3.173)
Log (VXO)	−3.283	−0.308	−1.228	−0.330	−4.496***	−2.595**	−2.162***	−0.568**
	(2.023)	(0.783)	(0.776)	(0.535)	(1.052)	(0.962)	(0.780)	(0.276)
Fixed × Log (VXO)	−9.229*	−7.538	−6.448*	−2.430	2.126	1.330	1.415	0.479
	(4.831)	(4.454)	(3.722)	(1.952)	(2.434)	(2.503)	(1.759)	(0.996)
Real GDP growth(lagged)	0.912***	0.630***	0.423***	0.190***	0.397***	0.319***	0.208***	0.174***
	(0.210)	(0.179)	(0.147)	(0.045)	(0.130)	(0.083)	(0.065)	(0.044)
Domestic private credit/GDP(lagged)	0.125**	0.059	0.048*	0.000	−0.041	−0.027	−0.021	−0.009
	(0.060)	(0.038)	(0.027)	(0.014)	(0.024)	(0.020)	(0.017)	(0.008)
Trend	−0.112***	−0.073***	−0.052***	−0.015	0.008	0.001	0.009	−0.004
	(0.038)	(0.022)	(0.018)	(0.010)	(0.030)	(0.017)	(0.011)	(0.007)
Global financial crisis					−3.308**	−1.449	−1.876**	−2.540***
					(1.304)	(1.064)	(0.879)	(0.554)
Observations	978	979	973	977	887	892	888	892
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Quarter-year effects	NO	NO	NO	NO	NO	NO	NO	NO
R-squared	0.331	0.323	0.201	0.120	0.218	0.170	0.079	0.096
Adjusted R2	0.305	0.297	0.171	0.087	0.185	0.137	0.041	0.059

Note: The dependent variable is quarterly capital flows (in percent of GDP). Columns 1 to 4 are estimated in the low-risk regime while Columns 5 to 8 are estimated in the high-risk regime. We drop observations in the bottom and top 0.25th percentile of the distribution of capital flows. See the notes of Table 1 for more details. The constant is included in all specifications. Clustered standard errors (by country) are reported in parentheses. ***, **, * indicate statistical significance at the 1, 5, and 10% levels, respectively.

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Government intervention through informed trading in financial markets[☆]

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ABSTRACT

We develop a theoretical model of government intervention in which a government with private information trades strategically with other market participants to achieve its policy goal of stabilizing asset prices. When the government has precise information and prioritizes its policy goal, both the government and the informed insider engage in reversed trading strategies, but they trade against each other. Government intervention can improve both market liquidity and price efficiency, and the effectiveness of government intervention depends crucially on the quality of information possessed by the government.

1. Introduction

Government intervention is a common way to stabilize financial markets, especially during a financial crisis or a stock market meltdown. For example, during the COVID-19 pandemic in 2020, the Federal Reserve of America, Bank of Japan and other central banks purchased massive quantities of government bonds, Asset-Backed Securities (ABS), Exchange Traded Fund (ETF) and other financial assets.[1] While the government's goal is to ensure financial stability, whether or not government intervention has some externalities when deployed against market fluctuations remains an open question. For example, Brunnermeier et al. (2021, BSX hereafter) show that government intervention reduces the informational efficiency of asset prices.

From 2015 to 2016, China's stock market experienced three major market crashes, and the market index decreased approximately 50% in 6 months. The intervention of Chinese government was very aggressive during the period, especially the organization of a "national team" which directly purchased stocks of more than 1000 firms (Huang et al., 2019). It is

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[1] Government intervention does not necessarily happen in a financial crisis. For instance, the Japanese government expands its stock purchase program gradually to control deflation (Shirai, 2018).

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well known that the majority of investors in China's stock market are inexperienced retail investors, and some believe that those investors contributed significantly to the market crash. For this reason, Brunnermeier et al. (2021) analyzed the implications of government intervention to reduce price volatility induced by noise traders. However, some insiders who have superior information about the firms also trade strategically during the period of government intervention. For example, the managers of the listed firm, Mei Yan Ji Xiang, bought their own firm stocks in July of 2015 and cleared the positions after 6 months.[2] Given various investor structures, how does government intervention affect the strategic trading of informed traders? What are the corresponding market-quality implications? In this paper, we study those questions by developing a multi-period model including price impact and informed trading.

We develop a two-period Kyle (1985) model to analyze the impact of government intervention through direct trading in the stock market. We consider an economy with two assets, a risky and a risk-free asset, respectively. There are four types of traders: a risk-neutral insider with perfect information, a representative risk-neutral competitive market maker, noise traders and a government with imperfect information.[3] The objective function of the government includes two parts. The first part is to minimize the price volatility, which is policy related. The second part is profit maximization, which is the same as that of the insider. We consider a linear equilibrium in which the trading strategies and the pricing functions are all linear. We solve the linear perfect Bayesian equilibrium and explore the trading behavior of the government and the insider as well as the effectiveness of government intervention through trading in the financial market.

Our analysis delivers two important messages. First, we find that both the government and the insider can engage in reversed trading strategies, but in opposite directions, which implies that they effectively trade against each other in both periods. This situation arises when the government has very precise information and cares much about its policy goal of price stability. Specifically, in this situation, seeing strong fundamental information, the insider sells (as opposed to buys) in the first period and then buys in the second period. Meanwhile, the government buys in the first period and then sells in the second period. The intuition is primarily driven by the fact that the insider wants to conceal his information in period 1 and exploits more information advantage in period 2. If the government has very precise information and weighs its policy goal heavily, the insider trades against the government to conceal his information in period 1, and at the same time, the government trades against the insider to stabilize prices.

On the other hand, when the government's information quality is low, the insider is not heavily influenced by the presence of the government and so it will trade in a way similar to that in the standard Kyle model with one insider, without reversed trading strategies. Similarly, when the government does not care much about its policy goal, the model is similar to a standard Kyle setting with two insiders, and again, no reversed trading strategies arise.

The second important message delivered by our analysis is that government intervention can not only stabilize the financial market but also improve market liquidity and price efficiency simultaneously and that the effectiveness of government intervention is positively related to the government's information quality. This result suggests that it is most effective for the government to intervene via direct trading only when it has private information with great quality. Otherwise, the effect of government trading is limited.

Specifically, in terms of market-liquidity implications, we find that relative to the standard Kyle setting, government intervention only slightly affects the period-1 market liquidity but improves the period-2 market liquidity. When the government has no policy concerns and very precise information, market liquidity is slightly smaller than that of the Kyle model in period 1, which shows that private information has a mild negative effect on market liquidity. When the government has imprecise information and cares more about price stability, the market liquidity is larger than that of the Kyle model in period 1. In period 2, the market liquidity is always larger than that of the Kyle model and does not hinge on the policy weight of the government. When the government's information quality is very low, the market liquidity measures in two periods converge to that of the Kyle model. The negative effect of information on market liquidity cancels out the positive effect of policy concerns.

In regard to the implications for price efficiency, government intervention effectively increases price discovery/efficiency in two periods. Because the government has information about fundamentals, its informative trading improves price discovery of the financial market. More interestingly, price discovery increases in the policy weight of the government in period 1 and decreases in the policy weight in period 2. Intuitively, in period 1, the insider trades less by hedging on the larger policy weight of the government. To hedge on the insider's reserved trading, the government trades more, which increases the total amount of the informational trading and hence improves price discovery. In period 2, the insider exploits the remaining information advantage and trades more aggressively to hedge on the larger policy weight. Since the government cares more about price stability, it has to trade less aggressively, so price discovery decreases in period 2. Moreover, if the government's information quality is very low, the price discovery measures in two periods are very close to and slightly less than those of the standard Kyle model.

*Related literature*Our paper contributes to the literature studying the implications of government intervention in asset markets, with a focus on China's stock market. Government intervention happens in many regions and countries and is extensively analyzed in the literature. For example, Veronesi and Zingales (2010) analyze the costs and benefits of Paulson's

[2] On August 4, 2015, the firm of "Mei Yan Ji Xiang" made an announcement that China Central Huijin Investment Limited (CCH), a member of the "national team," became the largest shareholder. In the next 10 trading days, the stock price increased over 250%.

[3] We use "he/him" to refer to the insider, "she/her" to refer to the market maker, and "it/its" to refer to the government.

plan in the United States, and Cheng et al. (2000) and Su et al. (2002) study the implications of the intervention of the Hong Kong government during the financial crisis in 1998.

Moreover, the analysis of government intervention needs to model a stylized government with explicit policy goals. Bhattacharya and Weller (1997); Pasquariello (2017), and Pasquariello et al. (2020) study a central bank with a policy goal to minimize the expected squared distance between the traded asset's equilibrium price and the target. In our model, the government is represented by the "national team" which directly trades in China's stock market, and its policy goal is to minimize the expected squared distance between two equilibrium prices in different periods.

Various policy tools were used to stabilize the market through government intervention in China's stock market in 2015.[4] Chen et al. (2019) study destructive market behaviors induced by the daily price limits; and Chen et al. (2019) analyze the dark side of circuit breakers. Moreover, Bian et al. (2021) find that marginal investors are forced to resell during a market crash, and Huang et al. (2019) show that government intervention in 2015 both created value and improved liquidity. Our paper, complementary to the literature, analyzes how government intervention affects the informed and strategic trading behaviors of market participants. Moreover, our theoretical prediction about liquidity is consistent with Huang et al. (2019).

Our paper is closely related to the work of Brunnermeier et al. (2021), who analyze the implications of government intervention to reduce price volatility induced by noise traders (e.g., De Long et al., 1990). In particular, Brunnermeier et al. (2021) find that information efficiency of asset prices is reduced. In Brunnermeier et al. (2021), the market volatility comes from noisy trading, and the government has no private information. For this reason, government intervention to reduce price volatility decreases information efficiency. By contrast, in our model, the market volatility stems from speculative insider trading and the government has information about the fundamentals, which implies that government intervention effectively stabilizes the asset prices and improves the price efficiency of the financial markets.

Our model considers price impact and informed trading, which originates from Kyle (1985). Huddart et al. (2001) solve a two period Kyle model that is treated as a benchmark in our paper. We solve the model by conjecturing linear trading strategies and linear pricing, which were developed by Bernhardt and Miao (2004) and Yang and Zhu (2020). Finally, for asset pricing implications, we consider market liquidity and price discovery measures emphasized by O'Hara (2003) and Bond et al. (2012).

The rest of the paper is organized as follows. We first present a model of government intervention in Section 2 and solve the model in Section 3. We then present the equilibrium results in Section 4 and conduct numerical analysis in Section 5. Finally, we conclude in Section 6. All proofs and figures are provided in the Appendix.

2. A model of government intervention

In this section, we develop a two-period Kyle (1985) model to analyze the impact of government intervention on the stock market. In particular, we model government trading in the financial market to capture government intervention.

2.1. The financial market with government intervention

We consider an economy with two trading periods ($t = 1, 2$). Two assets, a risky asset and a risk-free asset, are traded in the financial market. The risky asset pays a liquidation value v at the end of period 2, and v is a normally distributed random variable with mean p_0 and variance Σ_0. The risk-free asset has an infinitely elastic supply with a constant return r (normalized to be zero) for each period.

The economy is populated by four types of traders: a risk-neutral insider (i.e., informed trader), a representative risk-neutral competitive market maker, a large government player ("national team") and noise traders. As usual, the insider submits market orders to maximize profits, noise traders provide randomness to hide the insider's private information, and the market maker sets the price. The new player is the government, and its behavior serves regulation purposes.

Specifically, in each period, the government submits a market order g_t to minimize the expected value of the following loss function:

$$\phi_p(\Delta p)^2 + \phi_c c, \tag{1}$$

where ϕ_p and ϕ_c are two exogenous positive constants. The first term $(\Delta p)^2$ captures the government's policy motive, "price stability". Formally, $(\Delta p)^2 \equiv (p_2 - p_1)^2$, where p_2 and p_1 are the equilibrium prices in the two periods. The second component in (1), c, is the cost of intervention, which comes from the trading loss (negative of trading revenue). Specifically, we have

$$c = c_1 + c_2, \text{ with } c_t = (p_t - v)g_t \text{ for } t = 1, 2, \tag{2}$$

[4] More details are summarized by Song and Xiong (2018) and Brunnermeier et al. (2021).

where g_t is the government's order flow submitted at date t, and $(p_t - v)g_t$ is its trading loss at date t. We can show that the government makes profits in equilibrium, and so $c < 0$.[5] The specification of the loss function (1) is similar in spirit to Bhattacharya and Weller (1997), Pasquariello (2017), Stein (1989), Vitale (1999) and Pasquariello et al. (2020).[6]

If $\phi_p = 0$, the government trades just as another insider who maximizes the expected profit from trading. When $\phi_p > 0$, the government cares about its policy goal. The greater ϕ_p is, the more important is the government's policy goal (financial stability). To economize notations, let us define $\phi \equiv \phi_p/\phi_c \in [0, \infty)$: the loss function of the government, (1), is thus equivalent to

$$\phi(\Delta p)^2 + c, \tag{3}$$

where ϕ is the relative weight placed by the government on its policy motives.

2.2. Information structure and pricing

Similar to Kyle (1985), the insider learns v at the beginning of the first period and places market orders x_1 at $t = 1$ and x_2 at $t = 2$, respectively. Noise traders do not receive any information, and their net demands in the two periods, u_1 and u_2, are normally distributed with mean zero and variance σ_u^2. The government is likely to have first-hand knowledge of macroeconomic fundamentals.[7] Thus, we assume that the government is endowed with a private and noisy signal about the liquidation value of the financial asset, namely,

$$s = v + \varepsilon, \tag{4}$$

where $\varepsilon \sim N\left(0, \sigma_\varepsilon^2\right)$. Random variables v, ε, u_1 and u_2 are mutually independent.

In (4), s is normally distributed with mean p_0 and variance $\Sigma_0 + \sigma_\varepsilon^2$, and hence the parameter σ_ε^2 controls the information quality of the signal. A large σ_ε^2 corresponds to less accurate information about v. In particular, we can allow σ_ε^2 to take values of 0, which corresponds to the case in which s perfectly reveals v. Moreover, when σ_ε^2 goes to ∞, s reveals nothing about v. The government places market orders g_1 with information $\{s\}$ at the beginning of period 1 and g_2 with information $\{s, p_1\}$ at the beginning of period 2.

The market maker determines the prices p_1 and p_2 at which she trades the quantity necessary to clear the market. The market maker observes the aggregated order flows $y_t = x_t + u_t + g_t$ for $t \in \{1, 2\}$. The weak-form-efficiency pricing rule of the market maker implies that the market maker sets the price equal to the posterior expectation of v given public information as follows:

$$p_1 = E(v|y_1) \text{ and } p_2 = E(v|y_1, y_2). \tag{5}$$

3. Solving the model

Given the model described in the previous section, we search for a perfect Bayesian equilibrium, in which the insider and the government choose their trading strategies to optimize their objectives. The market maker's strategy is pinned down by (5). An equilibrium is formally defined as follows:

Definition 1. A perfect Bayesian equilibrium of the two-period trading game is a collection of functions

$$\{x_1(v), x_2(v, p_1), g_1(s), g_2(s, p_1), p_1(y_1), p_2(y_1, y_2)\},$$

1. Optimization:

$$x_2^* \in \arg\max_{\{x_2\}} E[(v - p_2)x_2|v, p_1],$$

$$x_1^* \in \arg\max_{\{x_1\}} E[(v - p_1)x_1 + (v - p_2)x_2^*|v],$$

[5] Note that we do not directly incorporate a measure of price efficiency in the objective function of the government. On one hand, our modelling choice is consistent with Brunnermeier et al. (2021) who do not incorporate price efficiency directly in the objective function of the government. On the other hand, as argued by Stein and Sundarem (2018) and Brunnermeier et al. (2021), price volatility is much easier to measure in practice than the market efficiency, and policy-makers often view reducing price volatility as a more operational intervention objective. In fact, the direct reason for government intervention is the market breakdown (or instable prices), not inefficient asset prices. For this reason, we only consider price stability in the objective function of the government. Acturally, in a two-period Kyle model, the measure for price stability contains some information about the measures of price efficiency. For example, we can easily derive the price stability as: $E(p_2 - p_1)^2 = E(v - p_1)^2 + E(v - p_2)^2 - 2E(v - p_1)(v - p_2)$.

[6] In Pasquariello (2017) and Pasquariello et al. (2020), there is only one trading period, and meanwhile, the government (central bank) has a nonpublic price target p_T as its private information and seeks to minimize the squared distance between the traded asset's equilibrium price and the target p_T. In our model, there are two trading periods, and the government minimizes the expected squared distance between two equilibrium prices as its policy goals, endowed with the noisy signal about the liquidation value of the risky asset.

[7] In fact, many investors in China's stock market rely on macroeconomic information, which is normally a sector for investment banks. Thus, when government trades directly, its trading may reveal some macroeconomic information.

$$g_2^* \in \arg\min_{\{g_2^*\}} E\left[\phi(p_2 - p_1)^2 + (p_2 - v)g_2 | s, p_1\right],$$

$$g_1^* \in \arg\min_{\{g_1^*\}} E\left[\phi(p_2 - p_1)^2 + (p_1 - v)g_1 + (p_2 - v)g_2^* | s\right].$$

2. Market efficiency: p_1 and p_2 are determined according to Eq. (5).

Given the model structure, we are interested in a linear equilibrium in which the trading strategies and the pricing functions are all linear. Formally, a linear equilibrium is defined as a perfect Bayesian equilibrium in which there exist six constants

$$(\beta_1, \beta_2, \gamma_1, \gamma_2, \lambda_1, \lambda_2) \in \mathbb{R}^6,$$

such that

$$x_1 = \beta_1(v - p_0), \tag{6}$$

$$x_2 = \beta_2[v - E(v|y_1)], \tag{7}$$

$$g_1 = \gamma_1(s - p_0), \tag{8}$$

$$g_2 = \gamma_2[s - E(s|y_1)], \tag{9}$$

$$p_1 = p_0 + \lambda_1 y_1, \text{ with } y_1 = x_1 + g_1 + u_1, \tag{10}$$

$$p_2 = p_1 + \lambda_2 y_2, \text{ with } y_2 = x_2 + g_2 + u_2. \tag{11}$$

Eqs. (6)–(9) indicate that the insider and the government trade based on their information, respectively. The linear forms are motivated by Bernhardt and Miao (2004) and Yang and Zhu (2020), who specify that the trading strategy of an informed agent is a linear function of each piece of private information. The pricing Eqs. (10) and (11) state that the price in each period is equal to the expected value of v before trading, adjusted by the information carried by the arriving aggregated order flows. Since our model includes two periods, we derive the linear equilibrium of the model backwards.

3.1. The insider's problems

The insider trades in both periods, and so we solve his problems by backward induction. Let $\pi_t = (v - p_t)x_t$ denote the insider's profit that is directly attributable to his period-t trade, $t \in \{1, 2\}$. In period 2, the insider has information $\{v, p_1\}$ and chooses x_2 to maximize $E(\pi_2|v, p_1)$. Using Eqs. (9) and (11), we can compute

$$E[(v - p_2)x_2|v, p_1] = \{v - p_1 - \lambda_2 x_2 - \lambda_2\gamma_2 E[s - E(s|y_1)|v, y_1]\}x_2.$$

Taking the first-order-condition (FOC) results in the solution as follows:

$$x_2 = \frac{v - p_1}{2\lambda_2} - \frac{\gamma_2}{2}E[s - E(s|y_1)|v, y_1] = \frac{1}{2\lambda_2}(1 - \lambda_2\gamma_2\delta_1)(v - p_1), \tag{12}$$

where

$$\delta_1 \equiv \frac{cov(s, v|y_1)}{var(v|y_1)} = \frac{\sigma_u^2 - \beta_1\gamma_1\sigma_\varepsilon^2}{\sigma_u^2 + \gamma_1^2\sigma_\varepsilon^2}. \tag{13}$$

The expression for the conditional expectation in Eq. (12), $E[s - E(s|y_1)|v, y_1]$, shows that the insider learns the government's noisy signal s by using his information set. The second-order-condition (SOC) is

$$\lambda_2 > 0. \tag{14}$$

Comparing Eq. (12) with the conjectured strategy (7), we have

$$\beta_2 = \frac{1}{2\lambda_2}(1 - \lambda_2\gamma_2\delta_1). \tag{15}$$

In period 1, the insider has information $\{v\}$ and chooses x_1 to maximize

$$E(\pi|v) = E(\pi_1 + \pi_2|v) = E\left[(v - p_1)x_1 + \frac{(1 - \lambda_2\gamma_2\delta_1)^2}{4\lambda_2}(v - p_1)^2|v\right]. \tag{16}$$

The second term in the bracket is obtained by inserting (12) into $\pi_2 = (v - p_2)x_2$, which yields

$$E(\pi_2|v, p_1) = \frac{(1 - \lambda_2\gamma_2\delta_1)^2}{4\lambda_2}(v - p_1)^2. \tag{17}$$

Using (8) and (10), we can further express $E(\pi|v)$ as follows:

$$E(\pi|v) = \left(\begin{array}{c} [v - p_0 - \lambda_1 x_1 - \lambda_1\gamma_1 E(s - p_0|v)]x_1 + \\ \frac{(1-\lambda_2\gamma_2\delta_1)^2}{4\lambda_2} \left\{ \begin{array}{c} (v - p_0)^2 + \lambda_1^2 x_1^2 + \lambda_1^2\gamma_1^2 E\left[(s - p_0)^2|v\right] \\ +\lambda_1^2\sigma_u^2 - 2\lambda_1 x_1(v - p_0) - \\ 2\lambda_1\gamma_1(v - p_0)E(s - p_0|v) + 2\lambda_1^2 x_1\gamma_1 E(s - p_0|v) \end{array} \right\} \end{array} \right). \tag{18}$$

The FOC of x_1 then yields

$$x_1 = \frac{1 - \lambda_1\gamma_1}{2\lambda_1} \frac{1 - \frac{\lambda_1}{2\lambda_2}(1 - \lambda_2\gamma_2\delta_1)^2}{1 - \frac{\lambda_1}{4\lambda_2}(1 - \lambda_2\gamma_2\delta_1)^2}(v - p_0).$$

Compared with the conjectured pure strategy (6), we have

$$\beta_1 = \frac{1 - \lambda_1\gamma_1}{2\lambda_1} \frac{1 - \frac{\lambda_1}{2\lambda_2}(1 - \lambda_2\gamma_2\delta_1)^2}{1 - \frac{\lambda_1}{4\lambda_2}(1 - \lambda_2\gamma_2\delta_1)^2}. \tag{19}$$

The SOC is

$$\lambda_1\left[1 - \frac{\lambda_1}{4\lambda_2}(1 - \lambda_2\gamma_2\delta_1)^2\right] > 0. \tag{20}$$

3.2. The government's decisions

The government's optimization problem is also solved by backwards induction. In period 2, the government has the information $\{s, p_1\}$. Using Eqs. (7) and (11), we can compute

$$E\left[\phi(p_2 - p_1)^2 + (p_2 - v)g_2|s, p_1\right] = \left\{ \begin{array}{c} \phi\lambda_2^2 \left[\begin{array}{c} \beta_2^2 E\left((v - p_1)^2|s, y_1\right) + g_2^2 + \\ \sigma_u^2 + 2\beta_2 g_2 E(v - p_1|s, y_1) \end{array} \right] + \\ [-(1 - \lambda_2\beta_2)E(v - p_1|s, y_1) + \lambda_2 g_2]g_2 \end{array} \right\}, \tag{21}$$

where

$$E(v - p_1|s, y_1) = \delta_2[s - E(s|y_1)],$$

$$\begin{aligned} E\left((v - p_1)^2|s, y_1\right) &= E^2(v - E(v|y_1)|s, y_1) + var(v - E(v|y_1)|s, y_1) \\ &= \delta_2^2[s - E(s|y_1)]^2 + var(v - E(v|y_1)|s, y_1), \end{aligned}$$

$$\delta_2 = \frac{cov(v, s|y_1)}{var(s|y_1)} = \frac{\left(\sigma_u^2 - \beta_1\gamma_1\sigma_\varepsilon^2\right)\Sigma_0}{\left(\beta_1^2\sigma_\varepsilon^2 + \sigma_u^2\right)\Sigma_0 + \sigma_u^2\sigma_\varepsilon^2}. \tag{22}$$

The expressions for conditional moments in (21), $E\left((v - p_1)^2|s, y_1\right)$, $E(v - p_1|s, y_1)$, show that the government learns the private information of the insider, v, by using its information set $\{s, y_1\}$.[8] The FOC of g_2 yields

$$g_2 = \frac{1 - \lambda_2\beta_2 - 2\phi\lambda_2^2\beta_2}{2\lambda_2 + 2\phi\lambda_2^2}\delta_2[s - E(s|y_1)]. \tag{23}$$

Combining (23) with the conjectured trading strategy (9) leads to

$$\gamma_2 = \frac{1 - \lambda_2\beta_2 - 2\phi\lambda_2^2\beta_2}{2\lambda_2 + 2\phi\lambda_2^2}\delta_2. \tag{24}$$

The SOC is $2\phi\lambda_2^2 + 2\lambda_2 > 0$, which holds accordingly if (14) holds.

[8] Eq. (10) shows that the information sets $\{p_1\}$ and $\{y_1\}$ are informationally equivalent.

In period 1, the government chooses g_1 to minimize

$$E\left[\phi(p_2-p_1)^2+(p_1-v)g_1+(p_2-v)g_2|s\right].$$

Inserting (9) into $E[(p_2-v)g_2|v,p_1]$, the objective function becomes

$$E\left\{\left[\phi(p_2-p_1)^2+(p_1-v)g_1+\left[-(1-\lambda_2\beta_2)\gamma_2\delta_2+\lambda_2\gamma_2^2\right][s-E(s|y_1)]^2\right]|s\right\}. \tag{25}$$

Using (7), (9), and (11), and applying the projection theorem repeatedly, we can compute (25) as a polynomial of g_1 as follows:

$$\left(\begin{array}{c}\phi\lambda_2^2\left\{\begin{array}{c}\beta_2^2\left[\left((1-\lambda_1\beta_1)\frac{\Sigma_0}{\Sigma_0+\sigma_\varepsilon^2}(s-p_0)-\lambda_1 g_1\right)^2+var(v-p_1|s)\right]\\ \gamma_2^2\left[\begin{array}{c}(s-p_0)^2+\beta_1^2\delta_3^2E\left((v-p_0)^2|s\right)+\delta_3^2g_1^2+\sigma_u^2\delta_3^2-2\delta_3g_1(s-p_0)\\ -2\beta_1\delta_3(s-p_0)E(v-p_0|s)+2\delta_3^2g_1\beta_1E(v-p_0|s)\end{array}\right]+\sigma_u^2+\\ 2\beta_2\gamma_2\left[\begin{array}{c}(1-\delta_4\beta_1)(s-p_0)E(v-p_0|s)-\delta_3\beta_1(1-\delta_4\beta_1)E\left((v-p_0)^2|s\right)\\ -\delta_4g_1(s-p_0)-\delta_3g_1(1-\delta_4\beta_1)E(v-p_0|s)\\ +\delta_3\delta_4g_1\beta_1E(v-p_0|s)+\delta_3\delta_4g_1^2+\delta_3\delta_4\sigma_u^2\end{array}\right]\end{array}\right\}\\ -g_1\left[(1-\lambda_1\beta_1)\frac{\Sigma_0}{\Sigma_0+\sigma_\varepsilon^2}(s-p_0)-\lambda_1g_1\right]+\\ \left[\lambda_2\gamma_2^2-(1-\lambda_2\beta_2)\gamma_2\delta_2\right]\left\{\begin{array}{c}(s-p_0)^2+\delta_3^2\beta_1^2E\left((v-p_0)^2|s\right)+\\ \delta_3^2g_1^2+\delta_3^2\sigma_u^2-2\delta_3\beta_1(s-p_0)E(v-p_0|s)\\ -2\delta_3g_1(s-p_0)+2\delta_3^2g_1\beta_1E(v-p_0|s)\end{array}\right\}\end{array}\right). \tag{26}$$

We then conduct FOC with respect to g_1 and derive

$$g_1=\frac{\left\{\begin{array}{c}\left[\begin{array}{c}(1-\lambda_1\beta_1)\left(1+2\phi\lambda_1\lambda_2^2\beta_2^2\right)+2\phi\lambda_2^2\gamma_2\delta_3(\beta_2-\beta_1\gamma_2\delta_3-2\beta_1\beta_2\delta_4)\\ +2\beta_1\delta_3^2\left(\gamma_2\delta_2-\lambda_2\gamma_2^2-\lambda_2\gamma_2\beta_2\delta_2\right)\end{array}\right]\frac{\Sigma_0}{\Sigma_0+\sigma_\varepsilon^2}\\ +2\phi\lambda_2^2\gamma_2(\gamma_2\delta_3+\beta_2\delta_4)+2\delta_3\left(\lambda_2\gamma_2^2-\gamma_2\delta_2+\lambda_2\beta_2\gamma_2\delta_2\right)\end{array}\right\}}{2\phi\lambda_2^2\left(\lambda_1^2\beta_2^2+\gamma_2^2\delta_3^2+2\beta_2\gamma_2\delta_3\delta_4\right)+2\lambda_1+2\delta_3^2\left(\lambda_2\gamma_2^2-\gamma_2\delta_2+\lambda_2\beta_2\gamma_2\delta_2\right)}(s-p_0).$$

Combined with the conjectured pure strategy (8), we have

$$\gamma_1=\frac{\left\{\begin{array}{c}\left[\begin{array}{c}(1-\lambda_1\beta_1)\left(1+2\phi\lambda_1\lambda_2^2\beta_2^2\right)+2\phi\lambda_2^2\gamma_2\delta_3(\beta_2-\beta_1\gamma_2\delta_3-2\beta_1\beta_2\delta_4)\\ +2\beta_1\delta_3^2\left(\gamma_2\delta_2-\lambda_2\gamma_2^2-\lambda_2\gamma_2\beta_2\delta_2\right)\end{array}\right]\frac{\Sigma_0}{\Sigma_0+\sigma_\varepsilon^2}\\ +2\phi\lambda_2^2\gamma_2(\gamma_2\delta_3+\beta_2\delta_4)+2\delta_3\left(\lambda_2\gamma_2^2-\gamma_2\delta_2+\lambda_2\beta_2\gamma_2\delta_2\right)\end{array}\right\}}{2\phi\lambda_2^2\left(\lambda_1^2\beta_2^2+\gamma_2^2\delta_3^2+2\beta_2\gamma_2\delta_3\delta_4\right)+2\lambda_1+2\delta_3^2\left(\lambda_2\gamma_2^2-\gamma_2\delta_2+\lambda_2\beta_2\gamma_2\delta_2\right)}, \tag{27}$$

where

$$\delta_3\equiv\frac{cov(s,y_1)}{var(y_1)}=\frac{(\beta_1+\gamma_1)\Sigma_0+\gamma_1\sigma_\varepsilon^2}{(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2}, \tag{28}$$

$$\delta_4\equiv\frac{cov(v,y_1)}{var(y_1)}=\frac{(\beta_1+\gamma_1)\Sigma_0}{(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2}. \tag{29}$$

The SOC is

$$\phi\lambda_2^2\left(2\lambda_1^2\beta_2^2+2\gamma_2^2\delta_3^2+4\beta_2\gamma_2\delta_3\delta_4\right)+2\lambda_1+2\delta_3^2\left(\lambda_2\gamma_2^2-\gamma_2\delta_2+\lambda_2\beta_2\gamma_2\delta_2\right)>0. \tag{30}$$

3.3. The market maker's decisions

In period 1, the market maker observes the aggregate order flow y_1 and sets $p_1=E(v|y_1)$. By Eq. (5) and the projection theorem, we can compute

$$\lambda_1=\frac{(\beta_1+\gamma_1)\Sigma_0}{(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2}(=\delta_4). \tag{31}$$

Similarly, in period 2, the market maker observes $\{y_1,y_2\}$ and sets $p_2=E(v|y_1,y_2)$. By Eqs. (5)–(9) and (11), and applying the projection theorem, we have

$$\lambda_2=\frac{cov(v,y_2|y_1)}{var(y_2|y_1)}=\frac{(\beta_2+\gamma_2)\left(\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2\right)\Sigma_0-(\beta_1+\gamma_1)\gamma_1\gamma_2\sigma_\varepsilon^2\Sigma_0}{\left(\begin{array}{c}\beta_2^2\left(\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2\right)\Sigma_0+2\beta_2\gamma_2\left(\sigma_u^2-\beta_1\gamma_1\sigma_\varepsilon^2\right)\Sigma_0+\\ \gamma_2^2\left(\beta_1^2\sigma_\varepsilon^2\Sigma_0+\sigma_u^2\sigma_\varepsilon^2+\sigma_u^2\Sigma_0\right)+\sigma_u^2\left[(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2\right]\end{array}\right)}. \tag{32}$$

4. Equilibrium characterization

Following the procedure in the previous section, we characterize the perfect Bayesian equilibrium in this section. The linear equilibrium is defined by six unknowns, which are the solutions of six equations. In general, the model cannot be solved in closed form and so we have to rely on numerical analysis. To examine the asset pricing implications numerically, we focus on several variables, including expected price volatility, price discovery/efficiency, the expected lifetime and period profits of the insider and expected lifetime and period costs of the government, and the correlation coefficients between the trading positions of the insider, the government and the market maker, respectively. The equilibrium variables are formally characterized by the following proposition.

Proposition 1. *A linear pure strategy equilibrium is defined by six unknowns $\beta_1, \beta_2, \gamma_1, \gamma_2, \lambda_1$, and λ_2, which are characterized by six Eqs. (15), (19), (24), (27), (31), and (32), together with three SOCs ((14), (20), and (30)). In equilibrium, the expected price volatility is*

$$E(p_2-p_1)^2=\frac{\lambda_2^2\left\{\begin{array}{c}\beta_2^2\left(\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2\right)\Sigma_0+\gamma_2^2\left(\beta_1^2\sigma_\varepsilon^2\Sigma_0+\sigma_u^2\Sigma_0+\sigma_\varepsilon^2\sigma_u^2\right)+\\ 2\beta_2\gamma_2\left(\sigma_u^2-\beta_1\gamma_1\sigma_\varepsilon^2\right)\Sigma_0+\sigma_u^2\left[(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2\right]\end{array}\right\}}{(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2}.$$

The price discovery/efficiency variables are

$$\Sigma_1=var(v|y_1)=E(v-y_1)^2=\frac{\left(\gamma_1\sigma_\varepsilon^2+\sigma_u^2\right)\Sigma_0}{(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2},$$

$$\Sigma_2=var(v|y_1,y_2)=E(v-y_2)^2=\frac{(1-\lambda_2\beta_2-\lambda_2\gamma_2)\left(\gamma_1\sigma_\varepsilon^2+\sigma_u^2\right)\Sigma_0+\lambda_2(\beta_1+\gamma_1)\gamma_1\gamma_2\sigma_\varepsilon^2\Sigma_0}{(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2}.$$

The expected lifetime and period profits of the insider and expected lifetime and period costs of the government are,

$$E(\pi)=E(\pi_1)+E(\pi_2),$$

$$E(\pi_1)=(1-\lambda_1\beta_1-\lambda_1\gamma_1)\beta_1\Sigma_0,$$

$$E(\pi_2)=\frac{\left[(1-\lambda_2\beta_2)\left(\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2\right)-\lambda_2\gamma_2\left(\sigma_u^2-\beta_1\gamma_1\sigma_\varepsilon^2\right)\right]\beta_2\Sigma_0}{(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2},$$

$$E(c)=E(c_1)+E(c_2),$$

$$E(c_1)=\gamma_1\left[\lambda_1\gamma_1\sigma_\varepsilon^2-(\lambda_1\beta_1+\lambda_1\gamma_1-1)\Sigma_0\right],$$

$$E(c_2)=-\frac{\gamma_2\left[(1-\lambda_2\beta_2)\left(\sigma_u^2-\beta_1\gamma_1\sigma_\varepsilon^2\right)\Sigma_0-\lambda_2\gamma_2\left(\beta_1^2\sigma_\varepsilon^2\Sigma_0+\sigma_u^2\Sigma_0+\sigma_\varepsilon^2\sigma_u^2\right)\right]}{(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2}.$$

The correlation coefficients between the trading positions of the insider and the government are

$$corr(x_1,g_1)=\frac{\beta_1\gamma_1\Sigma_0}{\sqrt{\beta_1^2\gamma_1^2\Sigma_0\left(\Sigma_0+\sigma_\varepsilon^2\right)}},$$

$$corr(x_2,g_2)=\frac{\beta_2\gamma_2\left(\sigma_u^2-\beta_1\gamma_1\sigma_\varepsilon^2\right)\Sigma_0}{\sqrt{\beta_2^2\gamma_2^2\Sigma_0\left(\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2\right)\left(\beta_1^2\sigma_\varepsilon^2\Sigma_0+\sigma_u^2\Sigma_0+\sigma_\varepsilon^2\sigma_u^2\right)}}.$$

The correlation coefficients between the trading positions of the government and those of the market maker are

$$corr(g_1,y_1)=\frac{\beta_1\gamma_1\Sigma_0+\gamma_1^2\left(\Sigma_0+\sigma_\varepsilon^2\right)}{\sqrt{\gamma_1^2\left(\Sigma_0+\sigma_\varepsilon^2\right)\left[(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2\right]}},$$

$$corr(g_2, y_2) = \frac{\beta_2\gamma_2\left(\sigma_u^2 - \beta_1\gamma_1\sigma_\varepsilon^2\right)\Sigma_0 + \gamma_2^2\left(\beta_1^2\sigma_\varepsilon^2\Sigma_0 + \sigma_u^2\Sigma_0 + \sigma_\varepsilon^2\sigma_u^2\right)}{\sqrt{\gamma_2^2\begin{pmatrix}\beta_1^2\sigma_\varepsilon^2\Sigma_0 + \\ \sigma_u^2\Sigma_0 + \sigma_\varepsilon^2\sigma_u^2\end{pmatrix}\begin{bmatrix}\beta_2^2\left(\gamma_1^2\sigma_\varepsilon^2 + \sigma_u^2\right)\Sigma_0 + \\ \gamma_2^2\left(\beta_1^2\sigma_\varepsilon^2\Sigma_0 + \sigma_u^2\Sigma_0 + \sigma_\varepsilon^2\sigma_u^2\right) \\ +2\beta_2\gamma_2\left(\sigma_u^2 - \beta_1\gamma_1\sigma_\varepsilon^2\right)\Sigma_0 + \\ \sigma_u^2\left[(\beta_1+\gamma_1)^2\Sigma_0 + \gamma_1^2\sigma_\varepsilon^2 + \sigma_u^2\right]\end{bmatrix}}}.$$

Proof. The proof is in Appendix A. □

For the purpose of comparison, we consider two degenerate economies: the economy with $\sigma_\varepsilon^2 = 0$ and the economy with $\sigma_\varepsilon^2 = +\infty$ (i.e., the standard Kyle setting). The first economy corresponds to the case in which the government has perfect information about the future liquidation value of the risky asset (i.e., $s = v$). In this case, the government and the insider have the same information and the equation system (composed of (15), (19), (24), (27), (31), and (32)) can be further simplified as a polynomial of a single variable λ_2. In the second economy, the government has no information and does not participate in the market. Thus, the model is essentially the standard two-period Kyle model. We summarize the results of the two special cases in Corollaries 1 and 2, respectively.

Corollary 1. *If $\sigma_\varepsilon^2 = 0$, the government has perfect information about the liquidation value of the risky asset, and the equation system describing the linear pure strategy equilibrium degenerates to a polynomial of λ_2. To be specific, λ_2 solves the following polynomials:*

$$a_{10}\lambda_2^{10} + a_9\lambda_2^9 + a_8\lambda_2^8 + a_7\lambda_2^7 + a_6\lambda_2^6 + a_5\lambda_2^5 + a_4\lambda_2^4 + a_3\lambda_2^3 + a_2\lambda_2^2 + a_1\lambda_2 + a_0 = 0, \quad (33)$$

where

$$a_{10} = 2304\theta^2\phi^6 + 256\theta^3\phi^4,\ a_9 = 16128\theta^2\phi^5 + 1536\theta^3\phi^3,$$

$$a_8 = 45504\theta^2\phi^4 + 3456\theta^3\phi^2,\ a_7 = 65408\theta^2\phi^3 - 1536\theta\phi^5 + 3456\theta^3\phi,$$

$$a_6 = 49468\theta^2\phi^2 - 6912\theta\phi^4 + 1296\theta^3,\ a_5 = 18480\theta^2\phi - 11520\theta\phi^3,$$

$$a_4 = 2628\theta^2 - 8832\theta\phi^2 + 256\phi^4,\ a_3 = -3168\theta\phi + 512\phi^3,$$

$$a_2 = -432\theta + 384\phi^2,\ a_1 = 128\phi,\ a_0 = 16.$$

All the other variables can be solved as expressions of λ_2 as follows:

$$\beta_2 = \frac{1+2\phi\lambda_2}{3\lambda_2 + 2\phi\lambda_2^2},\ \gamma_2 = \frac{1-2\phi\lambda_2}{3\lambda_2 + 2\phi\lambda_2^2},\ \lambda_1 = \frac{3\left(3\lambda_2 + 2\phi\lambda_2^2\right)^2 - (2+4\phi\lambda_2)/\theta}{4\lambda_2},$$

$$\beta_1 = \frac{1}{\lambda_1}\left[1 - \lambda_1\left(3 - \frac{(2+4\phi\lambda_2)^2}{4\theta\lambda_2\left(3\lambda_2 + 2\phi\lambda_2^2\right)^2}\right)\right]\left[1 - \frac{\lambda_1(2+4\phi\lambda_2)^2}{2\lambda_2\left(3\lambda_2 + 2\phi\lambda_2^2\right)^2}\right],$$

$$\gamma_1 = \frac{1}{\lambda_1}\left[1 - \lambda_1\left(3 - \frac{(2+4\phi\lambda_2)^2}{4\theta\lambda_2\left(3\lambda_2 + 2\phi\lambda_2^2\right)^2}\right)\right]\left[1 + \frac{2\lambda_1\lambda_2\left(4\phi^2\lambda_2^2 + 4\phi\lambda_2 - 1\right)^2}{\left(3\lambda_2 + 2\phi\lambda_2^2\right)^2}\right],$$

where $\theta \equiv \sigma_u^2/\Sigma_0$. The expected price volatility is then

$$E(p_2 - p_1)^2 = \frac{(3+2\phi\lambda_2)}{1+2\phi\lambda_2}\lambda_2^2\sigma_u^2.$$

The measures for price discovery/efficiency are

$$\Sigma_1 \equiv var(v|y_1) = E(v - p_1)^2 = \frac{\left(3\lambda_2 + 2\phi\lambda_2^2\right)^2}{2+4\phi\lambda_2}\sigma_u^2,$$

$$\Sigma_2 \equiv var(v|y_1, y_2) = E(v - p_2)^2 = \frac{(3+2\phi\lambda_2)}{2}\lambda_2^2\sigma_u^2.$$

The expected lifetime profits of the insider and expected lifetime costs of the government are, respectively,

$$E(\pi) = \underbrace{\beta_1\left[1 - \lambda_1\left(3 - \frac{(2+4\phi\lambda_2)^2}{4\theta\lambda_2\left(3\lambda_2 + 2\phi\lambda_2^2\right)^2}\right)\right]\Sigma_0}_{=E(\pi_1)} + \underbrace{\beta_2[1 - \lambda_2(\beta_2 + \gamma_2)]\frac{\sigma_u^2\Sigma_0}{(\beta_1+\gamma_1)^2\Sigma_0 + \sigma_u^2}}_{=E(\pi_2)},$$

$$E(c) = \underbrace{-\gamma_1\left[1-\lambda_1\left(3-\frac{(2+4\phi\lambda_2)^2}{4\theta\lambda_2\left(3\lambda_2+2\phi\lambda_2^2\right)^2}\right)\right]\Sigma_0}_{=E(c_1)}\underbrace{-\gamma_2[1-\lambda_2(\beta_2+\gamma_2)]\frac{\sigma_u^2\Sigma_0}{(\beta_1+\gamma_1)^2\Sigma_0+\sigma_u^2}}_{=E(c_2)}.$$

The correlation coefficients between the trading positions of the insider and the government are

$$corr(x_1,g_1)=\frac{\beta_1\gamma_1}{\sqrt{\beta_1^2\gamma_1^2}} \text{ and } corr(x_2,g_2)=\frac{\beta_2\gamma_2}{\sqrt{\beta_2^2\gamma_2^2}}.$$

The correlation coefficients between the trading positions of the government and the market maker are

$$corr(g_1,y_1)=\frac{\gamma_1(\beta_1+\gamma_1)}{\sqrt{\gamma_1^2}}\sqrt{\frac{\Sigma_0}{\left[(\beta_1+\gamma_1)^2\Sigma_0+\sigma_u^2\right]}},$$

$$corr(g_2,y_2)=\frac{\gamma_2(\beta_2+\gamma_2)}{\sqrt{\gamma_2^2\left[(\beta_2+\gamma_2)^2+(\beta_1+\gamma_1)^2+\theta\right]}}.$$

Proof. The proof is in Appendix B. □

As is shown in Corollary 1, when the government has perfect information about the future liquidation value of the risky asset as the insider, the learning processes between the insider and the government degenerate. In particular, four learning variables defined in (13), (22), (28), and (29) are degenerated as $\delta_1=\delta_2=1$ and $\delta_3=\delta_4=\lambda_1$. The equation system describing the equilibrium is greatly simplified and can be solved as a 10th order polynomial about λ_2.

Corollary 2 (Two-Period Kyle Model)**.** *If $\sigma_\varepsilon^2=+\infty$, the government has no information about the fundamentals and does not trade in the financial market. The general model degenerates to the standard two-period Kyle model. In this case, a subgame perfect linear equilibrium exists in which*

$$x_t=\beta_t(v-p_{t-1}),\, t\in\{1,2\}, \tag{34}$$

$$p_t=p_{t-1}+\lambda_t y_t,\, t\in\{1,2\}, \tag{35}$$

$$\beta_1=\sqrt{\frac{2k-1}{2k}}\frac{\sigma_u}{\sqrt{\Sigma_0}},\ \beta_2=\sqrt{\frac{4k-1}{2k}}\frac{\sigma_u}{\sqrt{\Sigma_0}}, \tag{36}$$

$$\lambda_1=\frac{\sqrt{2k(2k-1)}}{4k-1}\frac{\sqrt{\Sigma_0}}{\sigma_u},\ \lambda_2=\sqrt{\frac{k}{2(4k-1)}}\frac{\sqrt{\Sigma_0}}{\sigma_u}, \tag{37}$$

$$E(\pi)=\underbrace{\frac{\sqrt{2k(2k-1)}}{4k-1}\sigma_u\sqrt{\Sigma_0}}_{=E(\pi_1)}+\underbrace{\frac{1}{2}\sqrt{\frac{2k}{4k-1}}\sigma_u\sqrt{\Sigma_0}}_{=E(\pi_2)}, \tag{38}$$

$$E(p_2-p_1)^2=\frac{k}{4k-1}\Sigma_0, \tag{39}$$

$$\Sigma_1=E(v-p_1)^2=\frac{2k}{4k-1}\Sigma_0,\ \Sigma_2=E(v-p_2)^2=\frac{k}{4k-1}\Sigma_0, \tag{40}$$

where

$$k\equiv\frac{\lambda_2}{\lambda_1}=\frac{1}{6}\left[1+2\sqrt{7}\cos\left(\frac{1}{3}\left(\pi-\arctan 3\sqrt{3}\right)\right)\right]\approx 0.901,$$

and two associated SOCs are $\lambda_1>0$, $\lambda_2>0$.[9]

Corollary 2 shows that when $\sigma_\varepsilon^2=+\infty$, the general model becomes a two-period Kyle (1985) benchmark that can be solved explicitly (see Huddart et al., 2001). All results are intuitive: the trading intensities (β_1, β_2) increase in the amount

[9] The proof of Corollary 2 can be found in Huddart et al. (2001). In addition, since there is no government in the standard Kyle model, the correlation coefficients ($corr(x_i,g_i)$, $corr(y_i,g_i)$) are all zero.

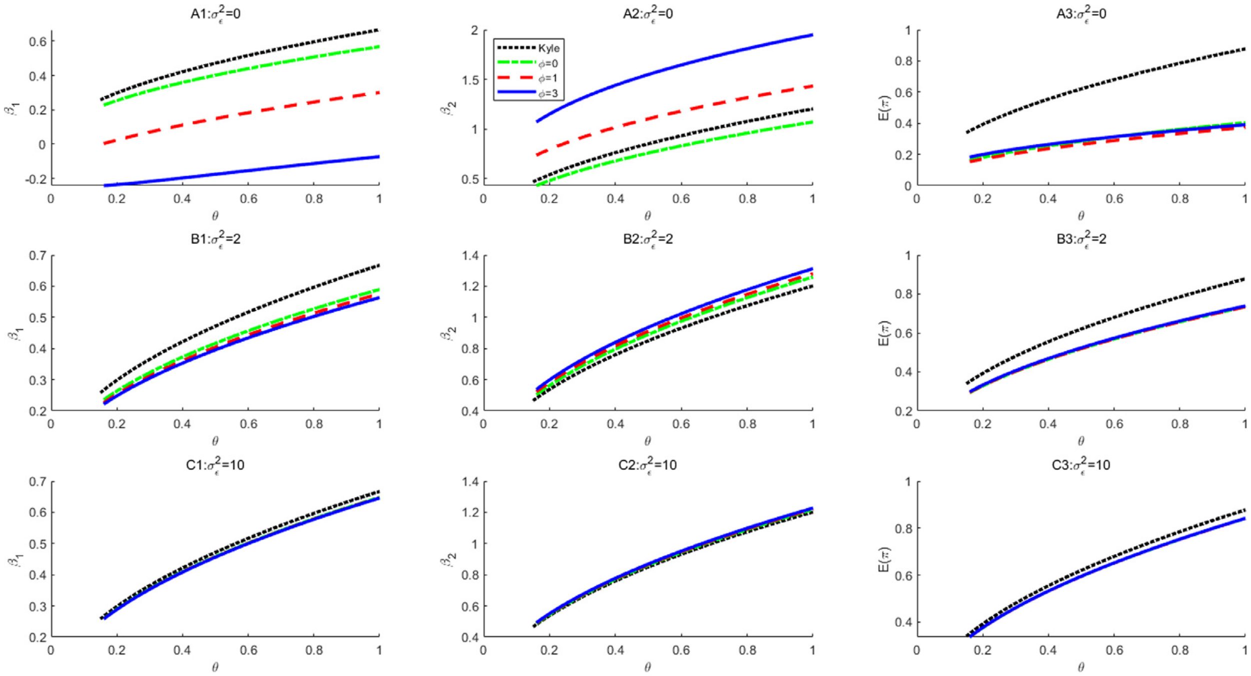

Fig. 1. Insider's trading intensities, β_1, β_2, and expected lifetime profits, $E(\pi)$, for $\sigma_\varepsilon^2 = 0$, 2, and 10, respectively. In each panel, the dotted black line represents the standard Kyle equilibrium without the government intervention, the dotted dashed green line represents the equilibrium with policy weight $\phi = 0$, the dashed red line represents the equilibrium with policy weight $\phi = 1$, and the solid blue line represents the equilibrium with policy weight $\phi = 3$.

of noisy trading per unit of private information (defined as $\theta \equiv \sigma_u^2/\Sigma_0$); the market liquidity $(1/\lambda_1,\ 1/\lambda_2)$ increases in the amount of noisy trading per unit of private information; the expected lifetime profit of the insider, $E(\pi)$, increases both in the amount of noisy trading (σ_u^2) and in the amount of private information (Σ_0); and as Eq. (40) shows, the equilibrium prices reveal information gradually.

Note that, as shown in Eq. (39), the expected squared price change, $E(p_2 - p_1)^2$, increases in the amount of private information, Σ_0, and does not depend on noisy trading, σ_u^2. Thus, in the Kyle-type models, price instability is driven by the speculative trading of the insider with private information and does not relate to noisy trading. De Long et al. (1990) and Brunnermeier et al. (2021) show that stock market turbulence originates from noisy trading, and Brunnermeier et al. (2021) also consider government intervention to reduce price volatility. Our paper complements theirs by providing an alternative origin of stock market turbulence.

5. Numerical results

There are four exogenous variables in the model: the variance of the liquidation value of the risky asset, Σ_0, the variance of the noisy trading in each period, σ_u^2, the variance of the information noise of the government, σ_ε^2, and the policy weight of the government, ϕ. For analytical convenience, we make several specifications about parameters. First, we define $\theta \equiv \sigma_u^2/\Sigma_0$ as the amount of noisy trading per unit of private information and change its values continuously in [0, 1]. Second, we choose three possible values for $\sigma_\varepsilon^2 : \{0, 2, 10\}$. When $\sigma_\varepsilon^2 = 0$, the government has perfect information about the liquidation value of the risky asset. When $\sigma_\varepsilon^2 = 2$, the government's information quality is relatively high, and when $\sigma_\varepsilon^2 = 10$, the government's information quality is low. Third, we choose three possible values for $\phi : \{0, 1, 3\}$. When $\phi = 0$, the government is another insider. When $\phi = 1$, the government places equal weight on its policy goal and profit maximization. When $\phi = 3$, the government cares more about the policy goals than about profit maximization.

5.1. The insider's behavior

Fig. 1 describes the insider's trading intensities in two periods and his expected lifetime profits. For any given values of σ_ε^2 and ϕ, the trading intensities of the insider in two periods, (β_1, β_2), increase in the amount of noisy trading per unit of private information. Since the insider maximizes his profits, the larger trading intensities are associated with greater expected profits. Hence, the expected lifetime profits $(E(\pi))$ increase in noisy trading per unit of private information, θ.[10]

[10] In Fig. 3, we also show that the expected profits in two periods $(E(\pi_1), E(\pi_2))$ increase in noisy trading per unit of private information.

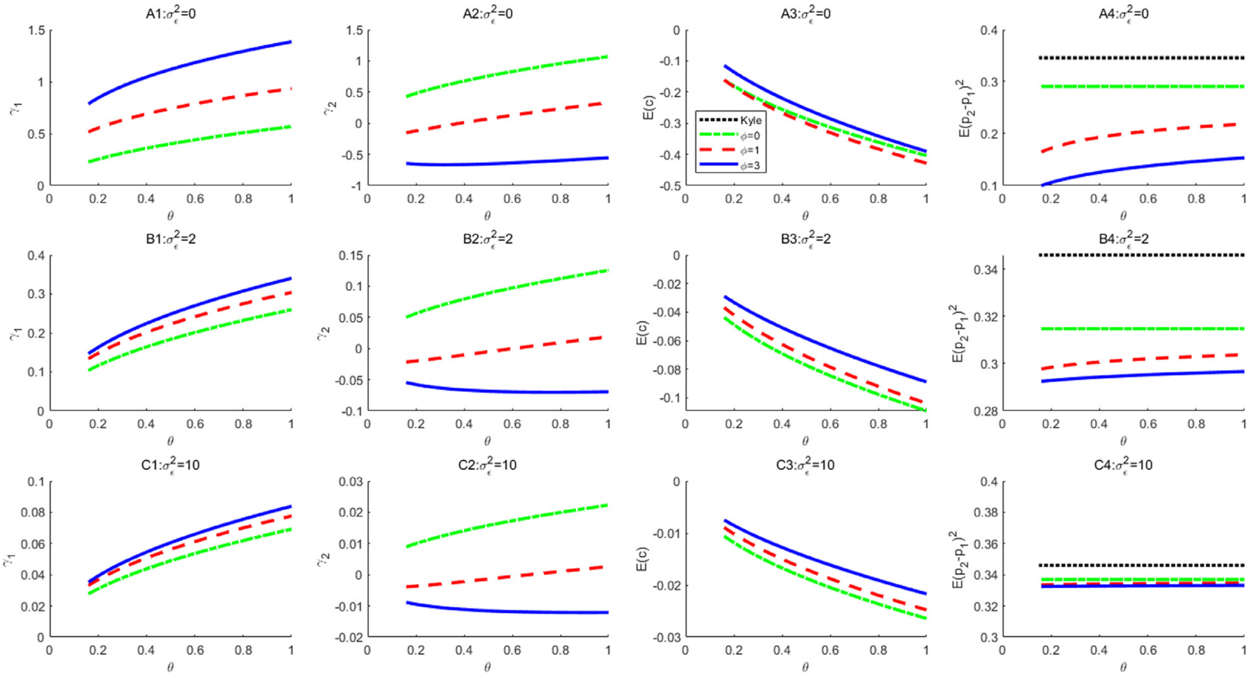

Fig. 2. The government's trading intensities, γ_1, γ_2, the expected lifetime profits, $E(c)$, and the expected squared price change, $E(p_2 - p_1)^2$, for $\sigma_\varepsilon^2 = 0$, 2, and 10, respectively. In each panel, the dotted black line represents the standard Kyle equilibrium without the government intervention, the dotted dashed green line represents the equilibrium with policy weight $\phi = 0$, the dashed red line represents the equilibrium with policy weight $\phi = 1$, and the solid blue line represents the equilibrium with policy weight $\phi = 3$.

We want to highlight two messages. First, as a very striking result, the insider may trade against his signal in period 1 (i.e., $\beta_1 < 0$). This will happen when the government has perfect information and cares a lot about its policy goal (i.e., $\sigma_\varepsilon^2 = 0$ and $\phi = 3$). In this case, seeing strong information, the insider will sell (as opposed to buy) in period 1 and buy in large quantities in period 2, i.e., β_1 is negative and β_2 is positive and large. This is because – in the presence of a very informed government player who cares about price stability – the insider wants to hide his information in period 1 and then trades aggressively in period 2 to exploit his uncovered information and maximize profits.[11]

Second, we can compare our results to the standard Kyle model to highlight the implications of government intervention. When the government's information is imperfect but its quality is relatively high (i.e., $\sigma_\varepsilon^2 = 2$), compared to the standard Kyle model, the insider trades less aggressively (lower β_1) in period 1 but more aggressively (higher β_2) in period 2 for any given values of σ_ε^2 and θ.[12] Intuitively, when the government's information quality is relatively high, the insider tries to conceal his information by trading less aggressively in period 1. In period 2, however, the insider exploits all of his information advantage and trades more aggressively than he would in the standard Kyle model. Moreover, the trading intensity of the insider in period 1 decreases in the policy weight of the government, ϕ, and the trading intensity in period 2 increases in ϕ for any given values of σ_ε^2 and θ. As shown by the third column of Fig. 1, when the government's information quality increases, it is more difficult for the insider to earn profits.

The first two columns of Fig. 3 display expected trading profits of the insider in two periods $(E(\pi_1), E(\pi_2))$. When the insider trades against his signal (i.e., $\beta_1 < 0$), he loses money (i.e., $E(\pi_1) < 0$) in period 1. However, in period 2, he trades on his signal more aggressively (i.e., $\beta_2 > \beta_2^{Kyle} > 0$) and makes more money than the standard Kyle model (i.e., $E(\pi_2) > E\left(\pi_2^{Kyle}\right) > 0$). Both the trading intensity and trading profits of the insider in period 1 decrease in the policy weight of the government, ϕ, and in period 2, both of them increase in ϕ for any given values of σ_ε^2 and θ. When the government's information quality increases, it is more difficult for the insider to earn profits. If the government's information quality is very low (i.e., $\sigma_\varepsilon^2 = 10$), the willingness of the insider to conceal his information is very weak, and in both periods, he trades similar to a standard Kyle insider. Due to the low information quality, the government trades similar to a noise trader and provides more liquidity for the insider. If the information quality of the government is sufficiently low, it is optimal for the government to quit the financial market.

[11] As shown in the first two columns of both Figs. 1 and 2, if the government cares only about profits (i.e., $\phi = 0$) or it cares about two goals when encountering relatively high values of θ, then the insider and the government will trade in the same direction.

[12] Note that if the government has perfect information ($\sigma_\varepsilon^2 = 0$) and cares only about profits ($\phi = 0$), the insider's trading intensities in two periods are less than that in the standard Kyle model.

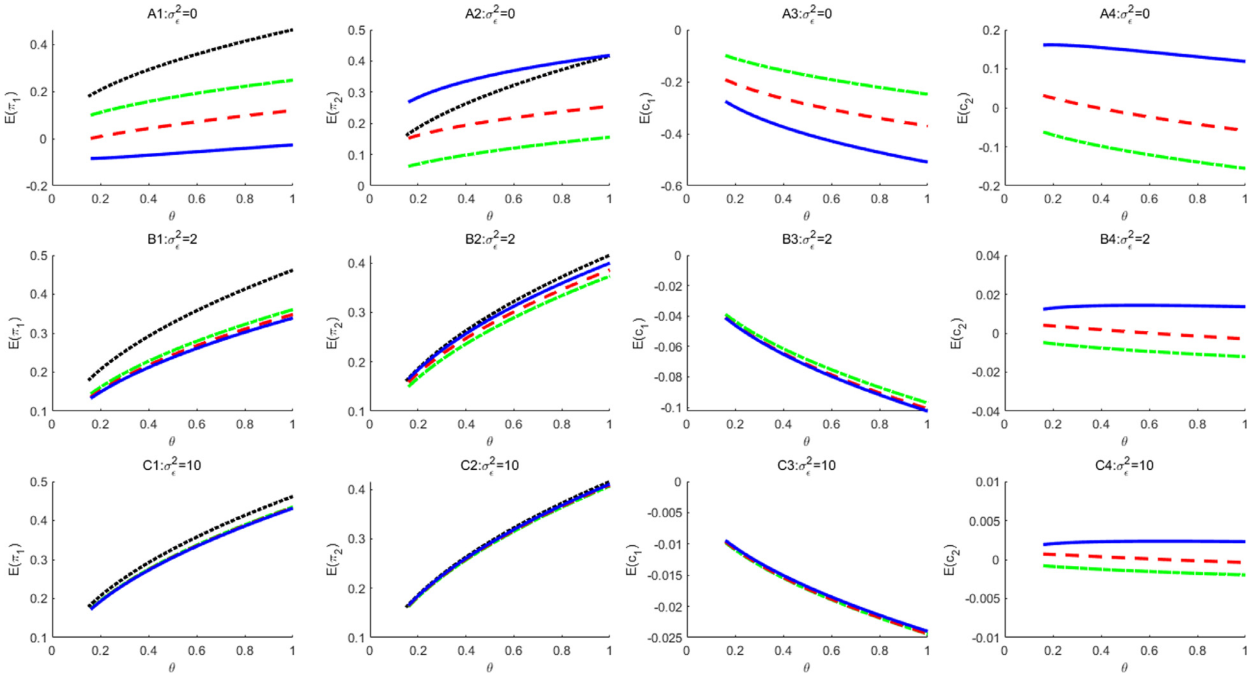

Fig. 3. The expected profits of the insider in two periods, $E(\pi_1)$, $E(\pi_2)$, the expected costs of the government in two periods, $E(c_1)$, $E(c_1)$, for $\sigma_\varepsilon^2 = 0$, 2, and 10, respectively. In each panel, the dotted black line represents the standard Kyle equilibrium without the government intervention, the dotted dashed green line represents the equilibrium with policy weight $\phi = 0$, the dashed red line represents the equilibrium with policy weight $\phi = 1$, and the solid blue line represents the equilibrium with policy weight $\phi = 3$.

5.2. The government's behavior

Fig. 2 displays the government's trading intensities in two periods (γ_1, γ_2), as well as the two elements in its objective function, the government's expected lifetime costs $E(c)$ and expected squared price change $E(p_2 - p_1)^2$. The first two columns of Fig. 2 and the last two columns of Fig. 3 show that for any given values of σ_ε^2 and ϕ, the government's trading intensities (γ_1, γ_2) and trading profits $(-E(c_1), -E(c_2))$ in two periods increase in the amount of noisy trading per unit of private information (θ). Echoing the insider's trading behavior, a striking result here is that the government's trading patterns depend crucially on the weight of the policy goal in its objective function. In particular, when the government cares strongly about its policy goal (i.e., $\phi = 3$), it will engage in reverse trading: seeing strong information, the government buys in period 1 but sells in period 2 (i.e., $\gamma_1 > 0$ and $\gamma_2 < 0$), as a result, the government makes money in period 1 but loses money in period 2 (i.e., $E(c_1) < 0$ and $E(c_2) > 0$). In combination with the result on the insider's trading, this implies that when the government has very precise information and cares a lot about its policy goal (i.e., $\sigma_\varepsilon^2 = 0$ and $\phi = 3$), the government and the insider are trading against each other in both periods. In this case, the insider loses money in period 1 but makes more money in period 2, and the government makes money in period 1 but loses money in period 2.[13]

As shown in the third column of Fig. 2, the expected lifetime profits of the government are always positive when it trades in the financial market (i.e., $E(c) < 0$). On one hand, it is intuitive to see that the government's expected lifetime profits are lower when it places more weight on policy goals relative to profit concerns. On the other hand, the expected lifetime profits of the government increase in its information quality. Empirical evidence of the model prediction is shown by Huang et al. (2019). They estimate the value creation of the government intervention that increases the value of the rescued non-financial firms by RMB 206 billion after subtracting the average purchase cost, which was approximately one percent of the Chinese GDP in 2014.[14]

The fourth column in Fig. 2 demonstrates the resulting price stability due to government intervention. We observe that relative to the standard Kyle model, government intervention effectively lowers price volatility for all parameter values, which implies that government intervention is effective in enhancing price stability. Moreover, the price volatility $E(p_2 - p_1)^2$ increases in σ_ε^2 and decreases in ϕ with good information quality. When information quality is low ($\sigma_\varepsilon^2 = 10$), the price volatility is insensitive to ϕ.[15] Thus, government intervention's price-stabilizing effect on the financial market

[13] Note that both the expected lifetime profits of the insider and expected lifetime profits of the government are positive (i.e., $E(\pi) > 0$, $-E(c) > 0$), while their sum is less than the lifetime profits of the insider in the standard Kyle model (i.e., $E(\pi) - E(c) < [E(\pi)]^{Kyle}$).

[14] The value estimated is for the stocks purchased by the Chinese government between the period starting with the market crash in mid-June of 2015 and the market recovery in September.

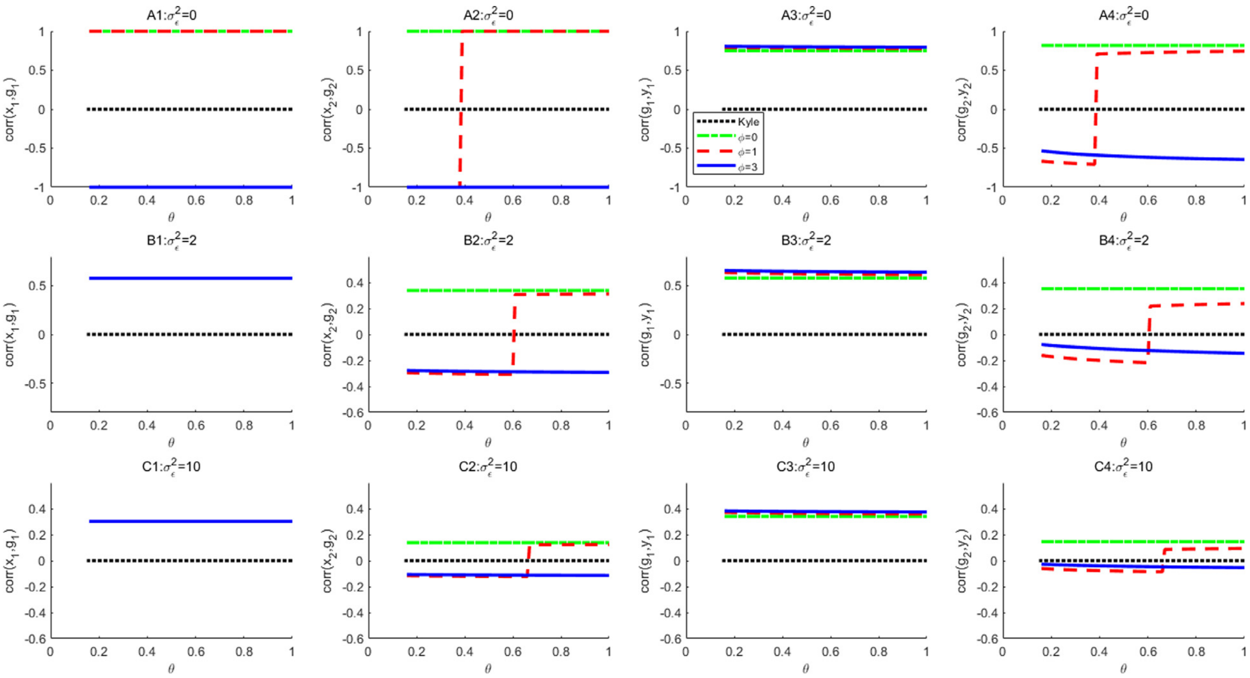

Fig. 4. The correlation coefficients between the government's and the insider's trading positions in the two periods, $corr(x_1, g_1)$, $corr(x_2, g_2)$, and the correlation coefficients between the government's trading positions and the total order flows in the two periods, $corr(g_1, y_1)$, $corr(g_2, y_2)$, for $\sigma_\varepsilon^2 = 0$, 2, and 10, respectively. In each panel, the dotted black line represents the standard Kyle equilibrium without the government intervention, the dotted dashed green line represents the equilibrium with policy weight $\phi = 0$, the dashed red line represents the equilibrium with policy weight $\phi = 1$, and the solid blue line represents the equilibrium with policy weight $\phi = 3$.

hinges crucially on information quality. If the government's information quality is high, the government stabilizes the financial market effectively. If the government's information quality is low, government intervention is not effective no matter how strongly the government values financial stability. Finally, the intervention effect is less effective when noisy trading is prevalent, since price volatility increases with noisy trading. This result is consistent with that derived by Brunnermeier et al. (2021), although through a different mechanism.

5.3. Position correlations

As the analysis in the previous two subsections shows, the insider and the government can trade against each other, which is true when the government has precise information and cares strongly about its policy goal. In this subsection, we further sharpen this result by examining the correlations among the positions of the government, the insider, and the market maker (or equivalently, the total order flows).

The first two columns in Fig. 4 show the correlation coefficients between the government's and the insider's trading positions in the two periods. In period 1, if the government has perfect information ($\sigma_\varepsilon^2 = 0$) and cares more about policy goals ($\phi = 3$), the insider and the government trade exactly against each other with opposite directions ($corr(x_1, g_1) = -1$). If the government is less concerned about policy goals or has imperfect information, it trades in the same direction as the insider ($corr(x_1, g_1) > 0$). In period 2, if the government cares more about policy goals ($\phi = 3$), it trades in the opposite direction of the insider. If the government cares more about profits ($\phi = 0$), it trades in the same direction as the insider. If the government places these two goals ($\phi = 1$) on an equal footing, the trading correlation depends on the amount of noisy trading per unit of private information (θ). When θ is below a certain threshold, the government and the insider trade in the opposite directions. When θ is above the threshold, the government and the insider trade in the same direction. Moreover, the value of the threshold decreases in the quality of information held by the government.

The last two columns in Fig. 4 show the correlation coefficients between the government's trading positions and the total order flows. In period 1, the correlation coefficient between the government's trading positions and the total order flow is positive and increases in the quality of information known by the government. In period 2, similarly, if the government cares more about policy goals, the correlation is negative. If the government cares more about profits, the correlation is positive. If the government assigns equal footing to these two goals, there is a threshold in which the sign of the correlation can switch. Moreover, given σ_ε^2, the switching points for $corr(x_2, g_2)$ and $corr(g_2, y_2)$ are the same, and the government, as a

[15] When σ_ε^2 approaches infinity, the equilibrium $E(p_2 - p_1)^2$ will converge to its value in the standard Kyle model, 0.346, as shown in Corollary 2.

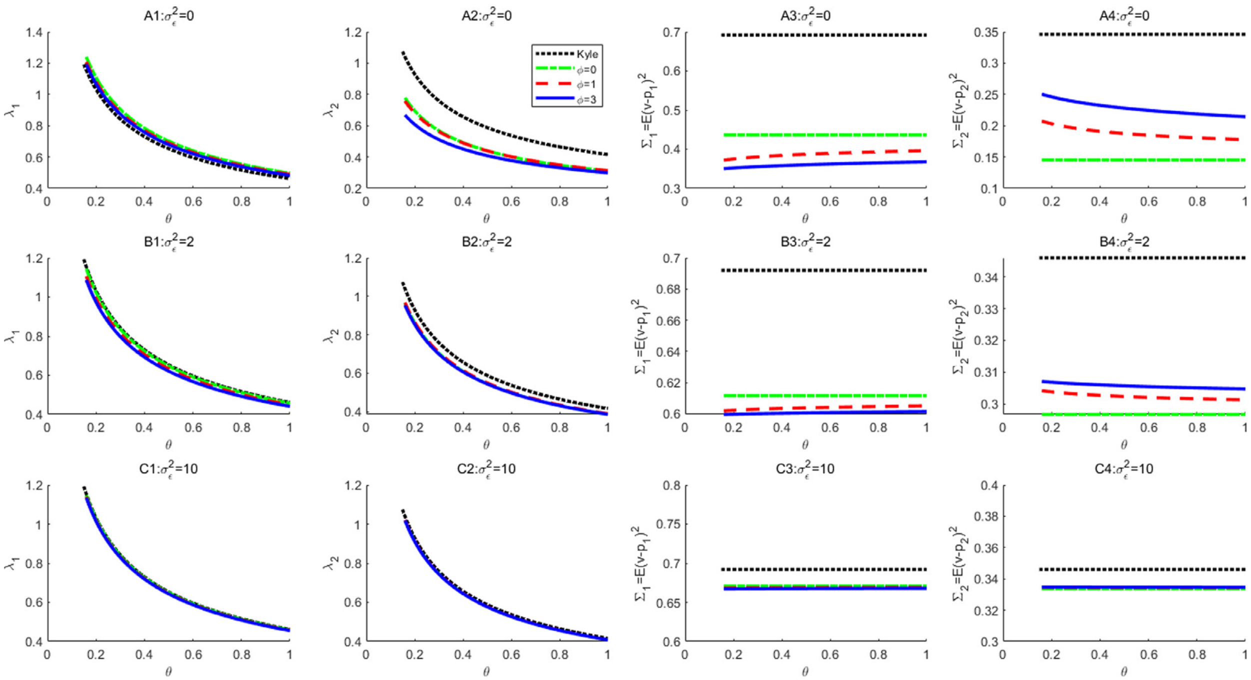

Fig. 5. The market liquidities in two periods, $1/\lambda_1$, $1/\lambda_2$, and the price discoveries/efficiencies in two periods, Σ_1, Σ_2, for $\sigma_\varepsilon^2 = 0$, 2, and 10, respectively. In each panel, the dotted black line represents the standard Kyle equilibrium without the government intervention, the dotted dashed green line represents the equilibrium with policy weight $\phi = 0$, the dashed red line represents the equilibrium with policy weight $\phi = 1$, and the solid blue line represents the equilibrium with policy weight $\phi = 3$.

large player in the financial market, dominates the market maker (with trading volumes $-y_i, i = 1, 2$) to trade against the insider.

5.4. Market liquidity and price efficiency

Fig. 5 examines the market-quality implications of government intervention. For market-quality measures, we mainly focus on market liquidity and price discovery (e.g., Bond et al., 2012; Goldstein and Yang, 2017; O'Hara, 2003). Market liquidity is measured by the inverse of Kyle's lambda $(1/\lambda_1, 1/\lambda_2)$, and a lower λ_t indicates that the period-t market is deeper and more liquid.[16] Price discovery measures how much information about the asset value v is revealed through prices. Given that price functions (10) and (11) are linear functions of aggregate order flows (y_1 and y_2), price discovery is measured by the market maker's posterior variances of v in periods 1 and 2: $\Sigma_1 = var(v|y_1)$, $\Sigma_2 = var(v|y_1, y_2)$. A lower Σ_t implies a more informative period-t price with respect to v for $t \in \{1, 2\}$.

The first two columns of Fig. 5 present the equilibrium market liquidity in two periods. First, as in the standard Kyle model, for any given σ_ε^2 and ϕ, the market liquidity measures in two periods $(1/\lambda_1, 1/\lambda_2)$ increase in θ, the amount of noisy trading per unit of private information. Second, relative to the standard Kyle model, government intervention exerts mild effects on the market liquidity in period 1 but raises the market liquidity in period 2. If the government has perfect information($\sigma_\varepsilon^2 = 0$) and no policy concerns($\phi = 0$), the market liquidity is slightly smaller than that of the Kyle model in period 1, which shows that private information has a mild negative effect on market liquidity. If the government has imperfect information ($\sigma_\varepsilon^2 \neq 0$) and cares about price stability ($\phi > 0$), the market liquidity is slightly larger than that of the Kyle model in period 1. In period 2, the market liquidity is larger than that of the Kyle model and does not hinge on the policy weight of the government. Third, if the government's information quality is very low ($\sigma_\varepsilon^2 = 10$), the market liquidity measures in two periods converge to that of the Kyle model. With respect to market liquidity, the negative effect of information and the positive effect of policy concerns cancel out. This, again, suggests that the effectiveness of government intervention crucially hinges on the quality of information known by the government.

The last two columns of Fig. 5 show that government intervention effectively raises price discovery in two periods relative to the standard Kyle model. Because the government has information about fundamentals, its informative trading improves price discovery/efficiency of the financial market. Thus, in contrast to the results in

[16] One important reason to care about market liquidity is that it is related to the welfare of noise traders, who can be interpreted as investors trading for non-informational, liquidity or hedging reasons that are decided outside the financial markets. In general, noise traders are better off in a more liquid market.

Brunnermeier et al. (2021), Fig. 5 shows that government intervention improves price stability and price efficiency simultaneously. In Brunnermeier et al. (2021), the market volatility comes from noisy trading and the government has no private information, so government intervention to reduce price volatility decreases information efficiency. However, in our model, the market volatility stems from speculative insider trading and the government has information about the fundamentals. For this reason, government intervention effectively stabilizes the asset prices and improves the price efficiency of the financial markets.[17]

More interestingly, price discovery increases in the policy weight of the government in period 1 while decreases in the policy weight in period 2.[18] Intuitively, in period 1, the insider trades less by hedging on the larger policy weight of the government. To hedge on the insider's reserved trading, the government trades more, which increases the total amount of the informational trading and hence improves price discovery. In period 2, the insider exploits the remaining information advantage and trades more aggressively to hedge on the larger policy weight. Since the government cares more about price stability, it has to trade less aggressively, so price discovery decreases in period 2. Moreover, if the government's information quality is very low ($\sigma_\varepsilon^2 = 10$), the price discovery measures in two periods are very close to and sightly less than those of the standard Kyle model.

6. Conclusions

In this paper, we explore the implications of government intervention in a two period Kyle (1985) model in which a government with private information directly trades in financial markets to achieve its policy goal of stabilizing the financial market. We find that when the government has very precise information and cares much about price stability, it effectively trades against the informed insider in the financial markets, and both the government and the insider engage in reversed trading strategies, although in different directions. In terms of market quality implications, we find that in general, government intervention can effectively stabilize the financial markets and improve price efficiency, but the effectiveness crucially depends on the government's information quality. Higher information quality leads to more effective government intervention. If the government's information quality is very low, government intervention becomes ineffective. Our analysis also makes other predictions that are consistent with the empirical findings. For instance, the government makes trading profits in equilibrium; price volatility increases with the noise trading in the financial markets.

Appendix A

A1. Proof of Proposition 1

Proof of Proposition (sketched).. The insider's and the government's problems in period 2 are solved in the main text. In period 1, the objective function of the insider, Eq. (18), is derived by substituting (8) and (10) into (16), and the objective function of the government is shown as the expression (25). Using the Eqs. (7), (9) and (11), we can derive the expression (25) as

$$\begin{pmatrix} \phi\lambda_2^2 \left\{ \begin{array}{l} \beta_2^2 E\left[(v-p_1)^2|s\right] + \gamma_2^2 E\left[s - E(s|y_1)^2|s\right] \\ +\sigma_u^2 + 2\beta_2\gamma_2 E[(v - E(v|y_1))(s - E(s|y_1))|s] \end{array} \right\} \\ -g_1 E(v - p_1|s) + \left[\lambda_2\gamma_2^2 - (1-\lambda_2\beta_2)\gamma_2\delta_2\right] E\left[(s - E(s|y_1))^2|s\right] \end{pmatrix}. \tag{41}$$

By using the projection theorem repeatedly, we have the following calculations:

$$E(v - p_1|s) = (1-\lambda_1\beta_1)\frac{\Sigma_0}{\Sigma_0+\sigma_\varepsilon^2}(s - p_0) - \lambda_1 g_1,$$

$$var(v - p_1|s) = \frac{\left(\gamma_1^2\sigma_\varepsilon^2 + \sigma_u^2\right)\Sigma_0}{(\beta_1+\gamma_1)^2\Sigma_0 + \gamma_1^2\sigma_\varepsilon^2 + \sigma_u^2} - \frac{\left[(1-\lambda_1\beta_1-\lambda_1\gamma_1)\Sigma_0 - \lambda_1\gamma_1\sigma_\varepsilon^2\right]^2}{\Sigma_0+\sigma_\varepsilon^2},$$

$$E\left[(v-p_1)^2|s\right] = \left[(1-\lambda_1\beta_1)\frac{\Sigma_0}{\Sigma_0+\sigma_\varepsilon^2}(s-p_0) - \lambda_1 g_1\right]^2 + \frac{\left(\gamma_1^2\sigma_\varepsilon^2 + \sigma_u^2\right)\Sigma_0}{(\beta_1+\gamma_1)^2\Sigma_0 + \gamma_1^2\sigma_\varepsilon^2 + \sigma_u^2} - \frac{\left[(1-\lambda_1\beta_1-\lambda_1\gamma_1)\Sigma_0 - \lambda_1\gamma_1\sigma_\varepsilon^2\right]^2}{\Sigma_0+\sigma_\varepsilon^2},$$

[17] As shown in the fourth columns of both Figs. 2 and 5, in period 2, we observe price stability increases in the policy weight of the government but price efficiency decreases in the policy weight of the government, which displays potential tradeoffs between price stability and price efficiency.

[18] Note that in the two-period Kyle setting, $E(p_2 - p_1)^2$ is the sole measure for price stability, while price efficiency has two measures (i.e., $E(v - p_1)^2$ and $E(v - p_2)^2$).

$$E[(v-E(v|y_1))(s-E(s|y_1))|s]=\left\{\begin{array}{c}(1-\delta_4\beta_1)(s-p_0)E(v-p_0|s)-\delta_3\beta_1(1-\delta_4\beta_1)E\left[(v-p_0)^2|s\right]-\\ \delta_3 g_1(1-\delta_4\beta_1)E(v-p_0|s)-\delta_4 g_1(s-p_0)\\ +\delta_4\delta_3 g_1\beta_1 E(v-p_0|s)+\delta_4\delta_3 g_1^2+\delta_4\delta_3\sigma_u^2\end{array}\right\},$$

$$E(v-p_0|s)=\frac{\Sigma_0}{\Sigma_0+\sigma_\varepsilon^2}(s-p_0),\qquad var(v-p_0|s)=\frac{\Sigma_0\sigma_\varepsilon^2}{\Sigma_0+\sigma_\varepsilon^2},$$

$$E\left[(v-p_0)^2|s\right]=\left(\frac{\Sigma_0}{\Sigma_0+\sigma_\varepsilon^2}\right)^2(s-p_0)^2+\frac{\Sigma_0\sigma_\varepsilon^2}{\Sigma_0+\sigma_\varepsilon^2},$$

$$E\left[(s-E(s|y_1))^2|s\right]=\left[\begin{array}{c}(s-p_0)^2+\delta_3^2\beta_1^2E\left[(v-p_0)^2|s\right]+\delta_3^2g_1^2+\delta_3^2\sigma_u^2-\\ 2\delta_3\beta_1(s-p_0)E(v-p_0|s)-2\delta_3 g_1(s-p_0)+2\delta_3^2 g_1\beta_1E(v-p_0|s)\end{array}\right].$$

Substituting the above expressions into (41) leads to the government's period-1 objective function (26).[19]

The market maker's problem is to solve conditional expectations. Combining (5) and (10) and applying the projection theorem, we have (31). Since $E(y_2|y_1)=0$, by (5) and (11), using the projection theorem, we know that

$$\lambda_2=\frac{cov(v,y_2|y_1)}{var(y_2|y_1)}. \tag{42}$$

Using the projection theorem, we have that

$$var(y_2|y_1)=\left[\begin{array}{c}\beta_2^2 var(v-p_1)+2\beta_2\gamma_2 cov(v-E(v|y_1),s-E(s|y_1))\\ +\gamma_2^2 var(s-E(s|y_1))+\sigma_u^2\end{array}\right], \tag{43}$$

where

$$var(v-p_1)=\frac{\Sigma_0\left(\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2\right)}{(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2}, \tag{44}$$

$$cov(v-E(v|y_1),s-E(s|y_1))=\left[\begin{array}{c}(1-\beta_1\delta_4-\gamma_1\delta_4)(1-\beta_1\delta_3-\gamma_1\delta_3)\Sigma_0\\ -\gamma_1\delta_4(1-\gamma_1\delta_3)\sigma_\varepsilon^2+\delta_3\delta_4\sigma_u^2\end{array}\right], \tag{45}$$

and

$$var(s-E(s|y_1))=var(s|y_1)=\frac{\beta_1^2\sigma_\varepsilon^2\Sigma_0+\sigma_u^2\Sigma_0+\sigma_u^2\sigma_\varepsilon^2}{(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2}. \tag{46}$$

Substituting (44), (45) and (46) into (43) gives rise to

$$var(y_2|y_1)=\frac{\left(\begin{array}{c}\beta_2^2\Sigma_0\left(\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2\right)+2\beta_2\gamma_2\left(\sigma_u^2-\beta_1\gamma_1\sigma_\varepsilon^2\right)\Sigma_0+\\ \gamma_2^2\left(\beta_1^2\sigma_\varepsilon^2\Sigma_0+\sigma_u^2\Sigma_0+\sigma_u^2\sigma_\varepsilon^2\right)+\sigma_u^2\left[(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2\right]\end{array}\right)}{(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2}. \tag{47}$$

Using (5), (11), (7) and (9), we can derive

$$cov(v,y_2|y_1)=(\beta_2+\gamma_2)var(v|y_1)+\gamma_2E(v-E(v|y_1))(s-E(s|y_1)), \tag{48}$$

where

$$var(v|y_1)=var(v)-\frac{cov(v,y_1)^2}{var(y_1)}=\frac{\left(\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2\right)\Sigma_0}{(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2}, \tag{49}$$

$$E(v-E(v|y_1))(s-E(s|y_1))=-\frac{(\beta_1+\gamma_1)\gamma_1\sigma_\varepsilon^2\Sigma_0}{(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2}. \tag{50}$$

Substituting (49) and (50) into (48) leads to

$$cov(v,y_2|y_1)=\frac{(\beta_2+\gamma_2)\left(\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2\right)\Sigma_0-(\beta_1+\gamma_1)\gamma_1\gamma_2\sigma_\varepsilon^2\Sigma_0}{(\beta_1+\gamma_1)^2\Sigma_0+\gamma_1^2\sigma_\varepsilon^2+\sigma_u^2}. \tag{51}$$

[19] The FOC and SOC are shown in the main text.

Substituting (47) and (51) in (42) leads to (32).

$E(p_2 - p_1)^2$, Σ_1, Σ_2, $E(\pi)$ and $E(c)$ in Proposition 1 are derived by utilizing the projection theorem. □

Proof of Corollary 1.. If $\sigma_\varepsilon^2 = 0$, then the government has the same perfect information about the liquidation value of the risky asset as the insider. The four δ's describing the learning processes between the insider and the government are degenerated as: $\delta_1 = \delta_2 = 1$, $\delta_3 = \delta_4 = \lambda_1$. Setting $\sigma_\varepsilon^2 = 0$ in (15), (19), (24), (27), (31), and (32), we obtain the degenerated equation system

$$\beta_2 = \frac{1}{2\lambda_2}(1 - \lambda_2\gamma_2), \tag{52}$$

$$\beta_1 = \frac{1 - \lambda_1\gamma_1}{2\lambda_1}\frac{1 - \frac{\lambda_1}{2\lambda_2}(1 - \lambda_2\gamma_2)^2}{1 - \frac{\lambda_1}{4\lambda_2}(1 - \lambda_2\gamma_2)^2}, \tag{53}$$

$$\gamma_2 = \frac{1 - \lambda_2\beta_2 - 2\phi\lambda_2^2\beta_2}{2\lambda_2 + 2\phi\lambda_2^2}, \tag{54}$$

$$\gamma_1 = \frac{1 + 2\lambda_1\left[\phi\lambda_2^2(\beta_2 + \gamma_2)^2 + \lambda_2\gamma_2(\beta_2 + \gamma_2) - \gamma_2\right]}{1 + \lambda_1\left[\phi\lambda_2^2(\beta_2 + \gamma_2)^2 + \lambda_2\gamma_2(\beta_2 + \gamma_2) - \gamma_2\right]}\frac{1 - \lambda_1\beta_1}{2\lambda_1}, \tag{55}$$

$$\lambda_1 = \frac{(\beta_1 + \gamma_1)\Sigma_0}{(\beta_1 + \gamma_1)^2\Sigma_0 + \sigma_u^2}, \tag{56}$$

$$\lambda_2 = \frac{(\beta_2 + \gamma_2)\Sigma_0}{(\beta_2 + \gamma_2)^2\Sigma_0 + (\beta_1 + \gamma_1)^2\Sigma_0 + \sigma_u^2}, \tag{57}$$

with three SOCs:

$$\lambda_2 > 0,$$

$$\lambda_1\left[1 - \frac{\lambda_1}{4\lambda_2}(1 - \lambda_2\gamma_2)^2\right] > 0,$$

$$2\lambda_1^2\left[\phi\lambda_2^2(\beta_2 + \gamma_2)^2 + \lambda_2\gamma_2(\beta_2 + \gamma_2) - \gamma_2\right] + 2\lambda_1 > 0.$$

Solving the linear equation system composed of (15) and (24) gives rise to

$$\beta_2 = \frac{1 + 2\phi\lambda_2}{3\lambda_2 + 2\phi\lambda_2^2}, \gamma_2 = \frac{1 - 2\phi\lambda_2}{3\lambda_2 + 2\phi\lambda_2^2}. \tag{58}$$

Substituting (58) into (53), (55), and (56), respectively, we obtain

$$\frac{\lambda_1\beta_1}{1 - \lambda_1(\beta_1 + \gamma_1)} = 1 - \frac{\lambda_1}{2\lambda_2}\left(\frac{2 + 4\phi\lambda_2}{3 + 2\phi\lambda_2}\right)^2, \tag{59}$$

$$\frac{\lambda_1\gamma_1}{1 - \lambda_1(\beta_1 + \gamma_1)} = 1 + \frac{2\lambda_1\lambda_2\left(4\phi^2\lambda_2^2 + 4\phi\lambda_2 - 1\right)}{\left(3\lambda_2 + 2\phi\lambda_2^2\right)^2}, \tag{60}$$

$$\frac{\lambda_1(\beta_1 + \gamma_1)}{1 - \lambda_1(\beta_1 + \gamma_1)} = \frac{(\beta_1 + \gamma_1)^2\Sigma_0}{\sigma_u^2}. \tag{61}$$

Combining (59), (60) and (61) leads to

$$(\beta_1 + \gamma_1)^2 = \frac{\sigma_u^2}{\Sigma_0}\left[2 - \frac{4\lambda_1\lambda_2}{\left(3\lambda_2 + 2\phi\lambda_2^2\right)^2}\right]. \tag{62}$$

Solving (31) for $\beta_1 + \gamma_1$ and substituting (62) into it, we obtain

$$\beta_1 + \gamma_1 = \lambda_1\frac{\sigma_u^2}{\Sigma_0}\frac{3\left(3\lambda_2 + 2\phi\lambda_2^2\right)^2 - 4\lambda_1\lambda_2}{\left(3\lambda_2 + 2\phi\lambda_2^2\right)^2}. \tag{63}$$

Solving (32) for λ_2 and substituting (62) into it, we solve for

$$\lambda_1 = \frac{3\left(3\lambda_2 + 2\phi\lambda_2^2\right)^2 - (2 + 4\phi\lambda_2)\frac{\Sigma_0}{\sigma_u^2}}{4\lambda_2}. \tag{64}$$

Substituting (64) into (63) leads to

$$\beta_1 + \gamma_1 = \left[3 - \frac{(2 + 4\phi\lambda_2)\frac{\Sigma_0}{\sigma_u^2}}{\left(3\lambda_2 + 2\phi\lambda_2^2\right)^2}\right]\frac{2 + 4\phi\lambda_2}{4\lambda_2}. \tag{65}$$

Substituting (64) into (62) gives rise to

$$(\beta_1 + \gamma_1)^2 = -\frac{\sigma_u^2}{\Sigma_0} + \frac{2 + 4\phi\lambda_2}{\left(3\lambda_2 + 2\phi\lambda_2^2\right)^2}. \tag{66}$$

Combining (65) and (66) gives us the polynomial listed in Corollary 1, (33). The expressions for all other endogenous variables can be derived by substitution and using the projection theorem. □

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