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Capital control and monetary policy coordination: Tobin tax revisited

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ABSTRACT

With the relaxation of capital controls and enriching capital flow channels, the potential negative impact of short-term capital flight on emerging market economies (EMEs), such as China, has been developing. This paper develops a small open-economy dynamic stochastic general equilibrium (DSGE) model to address the policy coordination between capital control and monetary policy, thereby introducing the Tobin tax on capital flow. We simulate the applicability of the Tobin tax and its collaboration with monetary policy in the context of crossborder capital flows triggered by external monetary policy spillovers. Regarding the capital outflow from EMEs caused by the external monetary policy, we find that "enterprises Tobin tax + interest rate cut" or "household Tobin tax + interest rate hike" can prevent capital outflow. Based on the welfare analysis, we find that the former is more feasible. The simulation results suggest that although the Tobin tax can ease the pressures on monetary authority by restraining short-term capital outflows, its ability to stabilize the financial markets is limited.

1. Introduction

Emerging market economies (EMEs) generally encounter dilemmas in capital flow management. On the one hand, the deregulation of capital account has hidden systemic risks in the context of financial liberalization. On the other hand, conventional capital policy tools tend to be less effective, and monetary policy space is being squeezed out by efforts preventing speculation and maintaining exchange rate stability. One possible reason is that when the Fed reduces interest rates to zero, speculators profit from arbitrage by borrowing cheap dollars to buy higher-yield bonds or other currencies. However, when the Fed signals it will raise interest rates, it would lead to a stronger dollar and a squeeze on arbitrage space. Those speculators who brought assets by borrowing in dollars start selling their foreign assets, thereby triggering devaluation in currencies and capital outflow for the EMEs.

From the perspective of international capital flows, the spillover effects of American monetary policy can be summarized as follows. "Fed interest rate cuts→The dollar depreciates and Capital outflows from the U.S.→EMEs' assets are bought and asset price are increased→Fed interest rate raises→The dollar rises as the world's reserve currency shrinks→EMEs' assets are sold off and capital flows back to the U.S.→Capital flight, currency depreciation, and declining asset prices in EMEs→Crisis in EMEs." In this logic chain, the increase in the Fed interest rate is the key to ensuring a strong dollar and the motivation for capital speculation. When the subsequent rate-hiking cycle starts, and without effective capital management strategies, the siphoning effect of capital flowing back to the U.S.

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will lead to a similar pattern of capital outflows and economic turmoil for the EMEs.

In the context of global economic slowdown, China's crossborder investment channels have potential capital outflow risks. Because funds can purchase foreign currencies in the offshore market, even though the channels were regulated, eliminating the short-term outflow pressure is difficult. Under current policy arrangements, more reserves are needed if more capital inflows, and more loss of national wealth is observed when capital outflows.

The management of international financial risks in China is difficult because of the crossborder capital flows and potential speculation. With the market-oriented reform of the RMB exchange rate and the advancement of RMB internationalization, the policy space to intervene in the RMB exchange rate is shrinking. If the American monetary policy strengthens the expectation of the RMB depreciation, preserving exchange rate stability will prove more difficult. Therefore, more policy tools are necessary to stabilize capital flows.

Among the limited policy tools, the Tobin tax has attracted more attention as a price-type capital control tool to restrain speculative capital demand, realize orderly capital flow, and stabilize exchange rates. EMEs, including China, have actively conducted studies on the Tobin tax to manage short-term international capital speculation, ease monetary policy pressure, and expand the toolkit of macroprudential policies. To this end, we study the applicability of the China crossborder Tobin tax and its collaboration with monetary policy, thereby aiming at the capital outflow from China caused by the Fed monetary policy spillovers. Because of the absence of the effective experience of the EMEs in managing capital flows with the Tobin tax, this study provides a theoretical model and a design scheme for the Tobin tax.

Based on existing studies, we further examine the macroeconomic effects of the Tobin tax on the spillover of external monetary policy. We combine the Tobin tax with monetary policy to explore how it stabilizes financial fluctuations under the weakening of monetary policy independence. We found two optimal combinations of the Tobin tax and monetary policy. The first, termed "enterprises Tobin tax + interest rate cut (asynchronous)," is to levy taxes on overseas capital flowing into enterprises and take an asynchronous monetary policy. The second, termed "household Tobin tax + interest rate hike (synchronous)," is to levy taxes on households and raise interest rates to increase the cost of capital outflow and enable the household sector to allocate more domestic assets for boosting economic growth. Considering the welfare loss, taxing an enterprise's foreign capital with an interest rate cut is preferable.

The remainder of the paper is organized as follows. The second section is the literature review, which discusses the development of the Tobin tax and monetary policy coordination mode under the condition of capital flow. The third section is model construction, where we construct a dynamic stochastic general equilibrium (DSGE) model with four sectors. The fourth section is welfare loss measurement and parameter calibrations. The fifth section is crossborder capital flow characteristics and risk transmission mechanism analysis. The sixth section is the coordination between the Tobin tax and monetary policy, and the final section provides research conclusions and implications.

2. Literature review

Regarding crossborder capital flows caused by external monetary policies, Lim et al., 2014 anticipated the international capital flows of the developing countries after the Fed interest rates increased. They found that following the rise, capital inflows in developing countries declined by 10 % in 2 years. The transmission channels primarily included interest rate parity terms, foreign currency credit, and the financial cycle (Obstfeld, 2015). In particular, for EMEs with fixed or managed floating exchange rates, intervention in exchange rates tends to create negative market expectations, thereby leading to capital outflows. However, exchange rate mechanisms can insulate against adverse external shocks. Low interest rates in countries with floating exchange rates also make it difficult to avoid abnormal capital outflows (Benes et al., 2015). Chang et al. (2015) found that China's capital account management and foreign exchange sterilization measures have protected the economy from financial risks. Still, the ability to maintain macroeconomic stability under the conditions of economic opening has not improved significantly. China needs more capital management tools to serve the long-term marketization of the exchange rate.

Existing studies have found that EMEs' capital account liberalization is not the key to capital outflow; however, it is helpful to attract capital inflows. Capital control is not the optimal strategy to protect the home country against American monetary policy spillovers. With the development of financial innovation and financial integration, international capital flow channels present diversity, concealment, and complexity, which substantially increase the cost and challenges of capital management (Miniane and Rogers, 2007; Dedola et al., 2017). Given the high cost and time lag of crossborder capital management, economists have studied the establishment of transaction taxes to limit short-term capital speculation and to calm financial market volatility (Tobin, 1978, 1984, 1996; Stiglitz, 1989; Summers and Summers, 1989). Tobin (1978) advocated a 1% tax on foreign exchange transactions, which later became known as the "Tobin tax." The function mechanism of this tax was to reduce the speed of currency transactions and increase the cost by "adding some sand to the wheel of international financial accommodation," thereby limiting excessive fluctuations of the exchange rates caused by currency speculation. The theory is based on speculative currency transactions being more frequent than the demand for money generated through investment and trade. The Tobin tax suppresses short-term speculation by increasing transaction costs to reduce the expected profits from currency speculation. Although a currency transaction tax is levied on all traders, the tax burden on speculators is substantially higher. The application of this concept gradually expanded from exchange transactions to all financial activities (Becchetti et al., 2014; Lavicka et al., 2016; Capelle-Blancard and Havrylchyk, 2016; Bratis et al., 2017; Agapova and Volkov, 2021).

After the Bretton Woods System collapsed in the 1970s, the Tobin tax attracted attention as a tool to manage short-term crossborder capital flows. The financial crisis and the European debt crisis made European authorities realize that instead of benefiting, they had to

bear higher costs because of U.S. monetary policy spillovers. The Tobin tax is becoming a trend as the global capital flows increase. If market regulators introduce a transaction tax, other markets are likely to follow (Westerhoff and Dieci, 2006; Hanke et al., 2010). The global coordination of the Tobin tax has the feature of incentive compatibility, which minimizes market distortions caused by speculative trading and ensures less loss of trading volume than a unilateral tax. Although there is heterogeneity in the global capital market, the optimal tax rate is symmetrical under the effect of essentially the same law of capital market value (Gaffeo and Molinari, 2017).

Jeanne and Korinek, 2010 discussed the feasibility and effects of international capital flow tax in developing countries. They found that restricting capital inflows at the time of bubble formation and capital outflows at the time of bubble bursting through tax can reduce the adverse effects of economic deleveraging, thereby complementing the policies of credit tightening and mortgage constraint. Berentsen et al. (2014) discussed the effect of the Tobin tax from the perspective of financial transaction tax and asset allocation. Their study found that the financial transaction tax increases the price of and the demand for liquid assets, thereby increasing the cost of asset portfolio adjustment for institutional investors and increasing the utility level of individual investors. Their optimal financial transaction rate for the U.S. capital markets is 1.6 %. Speculative trading increases volatility in asset returns and investment growth, increases risk premiums, and reduces welfare. Compared with asset position limits and financing constraints, the Tobin tax can significantly limit speculative trading without undermining the risk-sharing mechanism in capital markets (Berentsen et al., 2016; Buss et al., 2016). Hvozdyk and Rustanov, 2016 studied the effects of financial transaction tax on the Italian stock market and found that the transaction costs discouraged speculation, whereas the liquidity level of the capital market did not change significantly after tax. For stock traders, capital transaction tax can reduce their frequent trading and ensure the stability of the stock market, thus helping maintain market confidence (Khasawneh, 2017). For listed companies, capital transaction tax has no impact on dividend payment and other decisions, and may not be transmitted to enterprises to affect their normal operations (Khan et al., 2017). Kitano and Takaku (2017) found that with financial accelerators, capital flows are more difficult to manage indirectly through the exchange rate channel, whereas the Tobin tax worked. Korinek (2018) believes that the imposition of the Tobin tax on financial innovations helped restore social production constrained by capital outflows. Using data from Indonesia, he found that the optimal Tobin tax range is approximately 0% (FDI)–1.5 % (external debt). Thus, the Tobin tax can effectively cope with the external shocks and improve the welfare of the inhabitants within a certain range; there is an optimal Tobin tax rate that maximizes welfare improvement. Deng et al. (2018) studied the effect of the Tobin tax on the capital market regulation of different maturity levels. The Tobin tax reduces excessive volatility in immature capital markets and increases volatility in capital markets by increasing transaction costs. For this difference, they explained from the investor structure that immature capital markets are primarily irrational retail investors who are sensitive to transaction costs and prone to speculation. In comparison, mature capital markets primarily comprise rational institutional investors, who are more sensitive to capital market fundamentals and less sensitive to transaction costs. They concluded that a Tobin tax would be easier to implement in immature markets. Guo et al. (2020) believe that if the capital transaction tax is linked to the duration of asset holding, it will be conducive to encouraging long-term investment. In the case of a capital transaction tax as the main investment cost of the capital market, Guo and Ching (2021) hanve proposed a series of flexible investment strategies to reduce investment risks and increase the final net profits.

Some scholars have questioned the effectiveness of the financial transaction tax. Early studies on the restriction of speculative trading in the stock market and foreign exchange market found that setting a Tobin tax in these markets only reduced speculative trading without effectively suppressing the fluctuation range of asset prices. The resulting shrinkage of the transaction size was not conducive to the development and growth of the capital market (Umlauf, 1993; Jones and Seguin, 1997; Aliber et al., 2003). Although financial transaction taxes reduce the size and length of boom–bust cycles, they increase the likelihood of such cycles and the overall return volatility and wealth redistribution. Contingent financial transactions taxes, which are levied only above a certain price threshold, raise equilibrium multiplicity and nonexistence problems (Adam et al., 2015). On the one hand, the Tobin tax makes the real exchange rate excessively stable under the fixed exchange rate system. It performs poorly in promoting the welfare level when domestic and foreign goods are substitutes. At the same time, the Tobin tax improves welfare by enhancing the stability of the real exchange rate only under the inflation targeting system (Shin and Subramanian, 2016). The effect of the Tobin tax is more pronounced for noise traders; it depends on the market structure and the interaction between the Tobin tax and other transaction costs (Xu, 2010). On the other hand, the higher transaction costs associated with a financial transaction tax would reduce the trading volume in the market and generate greater volatility. Fluctuations in asset prices are roughly consistent with changes in tax rates, and transaction taxes significantly impact market behavior even at very low rates (Mannaro et al., 2008). In markets without market makers, a unilaterally imposed Tobin tax increases volatility (Kirchler et al., 2011). Some equity transaction taxes raise the cost of capital and affect enterprises' investment decisions and operating efficiency, thereby creating tax distortions (Lendvai et al., 2013). Veryzhenko et al. (2017) evaluated the effects of the French Tobin tax on high-frequency trading (HFT) and found that it led to decreased HFT activities and the deterioration of the capital market quality. The reduction in HFT activity resulting from a transaction tax reduced market efficiency and increased market deviations from fundamentals. Todtenhaupt et al. (2020) believes that a capital transaction tax is likely to shrink the merger and acquisition (M&A) market; their empirical study of 30 OECD and EU countries found that for every 1% increase in capital-transaction taxes, M&A activities fell by about 1%. In the United States, for example, that would cost US$9.3 billion. Holcomb et al. (2020) found that reducing the capital transaction tax could increase the acquisition activities of private equity funds. After the capital transaction tax is reduced, the premium paid by private equity funds to shareholders in target companies increases.

As the international capital flow becomes the most uncontrollable factor in the trilemma, the independence of monetary policy decreases (Schoenmaker and Tilburg, 2016). Escudé, 2014 analyzed the relationship between interest rate independence, exchange rate stability, and foreign debt Tobin tax under the framework of the Mundellian Trilemma to determine whether the local currency

bond, foreign exchange, and foreign debt markets could simultaneously reach equilibrium. They found that the Tobin tax could balance the three at the same time and yield minimum welfare loss. Improving the effectiveness of monetary policies in countries experiencing capital outflows caused by American monetary policy is critical (Ahmed, 2016), and scholars hold different opinions on adjusting the monetary policy to avoid the impacts.

The synchronous view is that EMEs should follow the American interest rates moderately or keep the interest rate differentials stable. Davis (2016) argued that the Fed interest rate hike would reverse the capital flow of developing economies and accelerate large-scale capital outflow and currency devaluation. The more the dependent developing countries are on foreign capital, the more they need to keep pace with the Federal interest rate. Although China's economic recovery was stronger than that of the U.S., prospectively raising interest rates before the Federal Reserve was difficult for China and had an adverse impact from the American monetary policy on China's economy. Caputo and Herrera (2016) found that compared to domestic inflation and output, the correlation between interest rates of developing countries and the Federal Reserve is higher. By following the U.S. monetary policy changes, they achieved more stable inflation and output.

The asynchronous view is that monetary policy in EMEs should target certain economic targets. Georgiadis (2016) conducted an empirical study by using data from 61 countries worldwide from 1999 to 2009 and found that monetary policy spillovers of the U.S. were significant, particularly for exchange rates, output, and inflation of EMEs. Following the interest rate of the U.S. is not the optimal choice to reduce risks for developing countries; better options include promoting trade integration, developing the domestic financial market, improving the degree of interest rate liberalization, and reducing labor market friction. After the Fed interest rate hike, China's interest rate showed a hump rise; the RMB spot devaluation was evident, and domestic inflation rose. Therefore, China's monetary policy should maintain a certain degree of independence and focus on the stability of the domestic financial market to avoid the effects of financial risks on the real economy. Bernanke (2017) believed that monetary policy is not an important path to solving the impact of the Fed interest rate on the current national economy and that national policies should not be confined to the trilemma. By contrast, nonmonetary policy tools should be sought, with a focus on achieving the endogenous growth of the national economy.

In summary, exchange rate intervention cannot solve the problems caused by crossborder capital flows. The management of international capital flows is crowding out more and more monetary policy space, and a tighter capital account is not the best solution for EMEs to avoid American monetary policy spillovers. Under the condition of an open economy, policy choice becomes increasingly difficult. In China's capital markets, the Tobin tax has received considerable attention in curbing capital speculation, but there is no practical experience to draw on. The Tobin tax is also not a sufficient means to manage capital flows, and coordination mechanisms, including monetary policy, need to be built. Existing studies have provided a theoretical basis and research methods for this paper to discuss a crossborder capital Tobin tax and monetary policy choice under the background of American monetary policy spillovers. However, these studies require further refinement. First, most studies have tried to manage capital flows through capital accounts. However, as international capital flows become more indirect and hidden, management under the trend of the financial opening becomes difficult; in particular, the large-scale capital outflow becomes more challenging to control. Capital account management and coordination with monetary policy have become more complex. Second, Tobin tax research must be further enriched. At present, the effectiveness of precautionary risk management tools, such as leverage ratio, capital adequacy ratio, and loan-to-value ratio, is decreasing because of hysteresis. A further expansion of the capital management toolkit is needed.

We explore whether the Tobin tax can help stabilize capital flows and exchange rates, capital accumulation, output, inflation, and consumption. In this way, the observation of the Tobin tax will be more comprehensive. We also analyze the potential impact of different forms of the Tobin tax on the level of economic welfare, considering that the Tobin tax will impact the level of social welfare because of its fiscal and tax nature. We adopt the minimized welfare loss as the criterion to distinguish the optimal policy combination.

3. Model

The basic building blocks of the DSGE model include households, firms, entrepreneurs, and government sectors. The household sector holds assets denominated in foreign currencies and domestic assets but is subject to a Tobin tax on overseas assets. The firms sector plays a role in price formation, including commodity prices and exchange rates. The entrepreneurs sector is responsible for providing the capital needed by production, some of which is foreign capital flowing into the country to earn excess returns and risk premiums. International capital flows must bear the Tobin tax, which is used to prevent capital speculation. This setting of the model realizes the integration of international capital with the real economy and financial system. The government sector includes the monetary policy department and the capital supervision department. The monetary policy department has different policy rules from which to choose. The capital supervision department imposes a Tobin tax on capital outflows from households that allocate assets abroad and on foreign capital inflows needed by domestic production, respectively, to restrict crossborder capital flows between different sectors. This DSGE model is based on an open economy, and the main shock to the economy is an external interest rate increase.

The DSGE model focuses on the connection between capital and the real economy. We are more attentive toward the international capital flow than capital account regulations because despite capital account regulations, international capital can still flow directly or indirectly in or out of China through various channels. Focusing on the capital flow directly is realistic. For crossborder capital flows, from 2018, the People's Bank of China started using foreign exchange risk reserves for increasing the cost for investors to short the RMB and long the U.S. dollar through forwarding sales of foreign exchange and curbing excessive fluctuations of the RMB exchange rate. This is essentially a Tobin tax tool, which means that the People's Bank has started to explore a capital flow management tool with the concept of a Tobin tax, thereby laying a realistic foundation for constructing the model.

3.1. Households

The representative household maximizes its discounted lifetime utility,

$$E_0 = \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{L_t^{1+\phi}}{1+\phi} \right) \tag{1}$$

Where E_t is the mathematical expectation of the household's utility function in period t; $\beta \in (0,1)$ is the discount factor; and C_t and L_t are the consumption and labor of the household sector, respectively. Consumption comprises domestic and foreign commodities,

$$C_t = \left[(1-\gamma)^{\frac{1}{\eta}} C_{h,t}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} C_{f,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{2}$$

Where $\eta > 0$ represents the elasticity of substitution of domestic and foreign consumer goods, and $\gamma \in (0,1)$ represents the proportion of foreign goods in total consumption and is used to measure the openness of the trade sector. $C_{h,t} = \left[\int_0^1 C_{h,t}(j)^{\varepsilon-1/\varepsilon} dj \right]^{\varepsilon/\varepsilon-1}$、$C_{f,t} = \left[\int_0^1 C_{f,t}(j)^{\varepsilon-1/\varepsilon} dj \right]^{\varepsilon/\varepsilon-1}$ represent domestic and foreign consumer goods, respectively, and $\varepsilon > 1$ is the elasticity of substitution of different consumer goods. Therefore, the demand function of the household sector for each consumer product can be expressed as follows,

$$C_{h,t}(j) = \left(\frac{P_{h,t}(j)}{P_{h,t}} \right)^{-\varepsilon} C_{h,t} \tag{3}$$

$$C_{f,t}(j) = \left(\frac{P_{f,t}(j)}{P_{f,t}} \right)^{-\varepsilon} C_{f,t} \tag{4}$$

Where $P_{h,t}(j)$ and $P_{f,t}(j)$ represent the local currency prices of different types of domestic and foreign commodities, respectively. $P_{h,t} = \left[\int_0^1 P_{h,t}(j)^{1-\varepsilon} dj \right]^{1/1-\varepsilon}$ and $P_{f,t} = \left[\int_0^1 P_{f,t}(j)^{1-\varepsilon} dj \right]^{1/1-\varepsilon}$ represent the overall price level of domestic goods and imported goods, respectively. According to the aforementioned integral equation, the consumption level of the household sector on domestic and foreign goods can be obtained as follows,

$$\int_0^1 P_{h,t}(j) C_{h,t}(j) dj = P_{h,t} C_{h,t} \tag{5}$$

$$\int_0^1 P_{f,t}(j) C_{f,t}(j) dj = P_{f,t} C_{f,t} \tag{6}$$

The relationship between domestic consumer goods $C_{h,t}$, foreign imported consumer goods $C_{f,t}$, and the total consumer demand of the household sector is as follows:

$$C_{h,t} = (1-\gamma) \left(\frac{P_{h,t}}{P_t} \right)^{-\eta} C_t \tag{7}$$

$$C_{f,t} = \gamma \left(\frac{P_{f,t}}{P_t} \right)^{-\eta} C_t \tag{8}$$

In the above formulas, the overall price level P_t can be expressed by the price level of domestic consumer goods and foreign consumer goods:

$$P_t = \left[(1-\gamma) P_{h,t}^{1-\eta} + \gamma P_{f,t}^{1-\eta} \right]^{\frac{1}{1-\eta}} \tag{9}$$

Based on Eqs. (7),(8), and (9), the consumption budget function of the household sector can be obtained as follows,

$$P_{h,t}C_{h,t} + P_{f,t}C_{f,t} = P_tC_t \tag{10}$$

Assuming that the wealth of the household sector comprises monetary income and assets, the monetary income is primarily comprised of wages W_tL_t, government transfer payments $T_{h,t}$, and enterprises' profit dividends Π_t^{firm}, which are used to meet the household sector's consumption. Assets such as the investment of the household sector are primarily comprised of local currency assets A_t and foreign currency assets B_t (Bonds). The assets in the current period are determined by the principal and interest income of the previous period's assets. Therefore, the budget constraint of the household sector can be expressed as follows,

$$P_tC_t + (1+i_{t-1})A_{t-1} + \left(1+\tau_{h,t-1}\right)\left(1+i_{t-1}^*\right)\varepsilon_tB_{t-1} + P_t\frac{\psi_b}{2}(B_t-B)^2 = A_t + \varepsilon_tB_t + W_tL_t + T_{h,t} + \Pi_t^{firm} \tag{11}$$

Where i_{t-1} is the interest rate of domestic currency assets, i_{t-1}^* is the interest rate of foreign currency assets, ε_t is the nominal exchange rate, and $\tau_{h,t}$ is the tax on the foreign currency assets held by the domestic household sector. This variable reflects the capital control of the domestic government. The capital account has not completely opened in China, and individual foreign exchange quotas are limited to US$50,000 per year; however, residents can still configure overseas assets through more indirect channels, thereby weakening the constraint of capital account controls and exchange quota. Therefore, we set the Tobin tax of the household sector as the aforementioned form and the adjustment cost of the household sector to change the foreign asset portfolio as $P_t(\psi_b/2)(B_t-B)^2$. Based on the aforementioned setting, the optimal solution under the maximized utility function can be obtained as follows,

$$\lambda_t = C_t^{-\sigma} \tag{12}$$

$$\lambda_t = \frac{L_t^{\phi}}{W_t/P_t} \tag{13}$$

$$1 = \beta(1+i_t)E_t\left(\frac{\lambda_{t+1}}{\lambda_t}\frac{P_t}{P_{t+1}}\right) \tag{14}$$

$$1 = \beta\left(1+\tau_{h,t}\right)\left(1+i_t^*\right)\left[1-\frac{\psi_bP_t(B_t-B)}{\varepsilon_t}\right]^{-1}E_t\left(\frac{\lambda_{t+1}}{\lambda_t}\frac{P_t}{P_{t+1}}\frac{\varepsilon_{t+1}}{\varepsilon_t}\right) \tag{15}$$

By using Eqs. (14) and (15) to remove β, the interest rate parity condition under the open economy condition can be obtained as follows,

$$(1+i_t)E_t\left(\frac{\lambda_{t+1}}{\lambda_t}\frac{P_t}{P_{t+1}}\right) = \left(1+\tau_{h,t}\right)\left(1+i_t^*\right)\left[1-\frac{\psi_bP_t(B_t-B)}{\varepsilon_t}\right]^{-1}E_t\left(\frac{\lambda_{t+1}}{\lambda_t}\frac{P_t}{P_{t+1}}\frac{\varepsilon_{t+1}}{\varepsilon_t}\right) \tag{16}$$

According to the law of one price, the formula of trade terms for domestic and foreign goods can be obtained as follows,

$$S_t = \frac{P_{f,t}}{P_{h,t}} = \frac{\varepsilon_tP_t^*}{P_{h,t}} \tag{17}$$

Where P_t^* is the foreign consumer price index in foreign currency, and the relationship between inflation and the exchange rate can be obtained according to the trade terms as follows,

$$\frac{S_t}{S_{t-1}} = \frac{\Delta\varepsilon_t}{\pi_{h,t}} \tag{18}$$

Where $\pi_{h,t} = P_{h,t}/P_{h,t-1}$ is the domestic inflation rate and $\Delta\varepsilon_t = \varepsilon_{h,t}/\varepsilon_{h,t-1}$ is the local currency depreciation rate. To solve the overall inflation level under the condition of an open economy, according to Eqs. (9) and (17), we can obtain the following:

$$\frac{P_t}{P_{h,t}} = \left[(1-\gamma)+\gamma S_t^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{19}$$

Rewrite $\Omega(S_t) = \left[(1-\gamma)+\gamma S_t^{1-\eta}\right]^{1/1-\eta}$. Dividing Eq. (18) by its price level in the previous period, the inflation level in the open economy in period t can be obtained as follows,

$$\pi_t = \pi_{h,t}\frac{\Omega(S_t)}{\Omega(S_{t-1})} \tag{20}$$

According to Eqs. (17) and (19), the relationship between the real exchange rate Q_t and terms of trade S_t can be obtained as follows,

$$Q_t = \frac{\varepsilon_tP_t^*}{P_t} = \frac{S_t}{\Omega(S_t)} \tag{21}$$

3.2. Firms

Monopolistically competitive firms use capital $K_t(j)$ and labor $L_t(j)$ to produce consumer goods $Y_t(j)$ at average productivity level Z_t. The production function of a representative firm can be expressed as follows,

$$Y_t(j) = Z_t K_t(j)^{\alpha} L_t(j)^{1-\alpha} \tag{22}$$

Based on the cost minimization, the marginal cost of the enterprise department can be written as follows,

$$MC_t(j) = MC_t = Z_t \alpha^{-\alpha}(1-\alpha)^{\alpha-1}\left(R_t/P_{h,t}\right)^{\alpha}\left(W_t/P_{h,t}\right)^{1-\alpha} \tag{23}$$

Supposing the process of capital accumulation is as follows,

$$K_{t+1} = \left[\frac{I_t}{K_t} - \frac{\phi_i}{2}\left(\frac{I_t}{K_t} - \delta\right)^2\right]K_t + (1-\delta)K_t \tag{24}$$

Where I_t is the total investment in period t, δ is the depreciation cost of capital, $\phi_i/2(I_t/K_t - \delta)^2$ is the capital adjustment cost, and ϕ_i is the adjustment coefficient. In an open economy, the investment consists of both domestic and foreign investment,

$$I_t = \left[(1-\gamma)^{\frac{1}{\eta}} I_{h,t}^{\frac{\eta-1}{\eta}} + \gamma^{\frac{1}{\eta}} I_{f,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} \tag{25}$$

Where $I_{h,t} = \left[\int_0^1 I_{h,t}(j)^{\varepsilon-1/\varepsilon} dj\right]^{\varepsilon/\varepsilon-1}$ and $I_{f,t} = \left[\int_0^1 I_{f,t}(j)^{\varepsilon-1/\varepsilon} dj\right]^{\varepsilon/\varepsilon-1}$ represent domestic and foreign investments, respectively. The optimal arrangement of each investment commodity can be expressed as $I_{h,t}(j) = \left(P_{h,t}(j)/P_{h,t}\right)^{-\varepsilon} I_{h,t}$ and $I_{f,t}(j) = \left(P_{f,t}(j)/P_{f,t}\right)^{-\varepsilon} I_{f,t}$ as the exchangeable commodities under the condition of an open economy. The distribution of domestic and foreign investment products in total investment can be expressed as $I_{h,t} = (1-\gamma)\left(P_{h,t}/P_t\right)^{-\eta} I_t$ and $I_{f,t} = \gamma\left(P_{f,t}/P_t\right)^{-\eta} I_t$. For capital K_t, capital price Q_t can be obtained by solving its profit maximization problem:

$$Q_t = P_t\left[1 - \phi_i\left(\frac{I_t}{K_t} - \delta\right)\right]^{-1} \tag{26}$$

Under the condition of monopolistic competition, commodity price originates from the maximization of profit. Based on the setting of price stickiness by Calvo (1983), it is assumed that the $1-\zeta$ proportion of enterprises in each period adjusts product prices, and the prices of other enterprises remain unchanged. The domestic commodity prices can be expressed as follows,

$$P_{h,t} = \left[\zeta P_{h,t}^{1-\varepsilon} + (1-\zeta)\overline{P}_{h,t}^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} \tag{27}$$

Where $\overline{P}_{h,t}$ is the adjusted commodity price, and the relationship between inflation and the adjusted price can be obtained by further transforming the aforementioned formula,

$$1 = \zeta \pi_{h,t}^{\varepsilon-1} + (1-\zeta)\widetilde{P}_{h,t}^{1-\varepsilon} \tag{28}$$

Where $\widetilde{P}_{h,t} = \overline{P}_{h,t}/P_{h,t}$. Every enterprise should determine the price under its profit maximization problem,

$$\max_{\overline{P}_{h,t}} \sum_{k=0}^{\infty} \zeta^k E_t\left\{\Lambda_{t,t+k}\left[Y_{t+k|t}\left(\overline{P}_{h,t} - MC^n_{t+k|t}\right)\right]\right\} \tag{29}$$

Where the subscript $t+k|t$ indicates the firm that last adjusted its price relative to period t and $Y_{t+k|t} = \left(\overline{P}_{h,t}/P_{h,t+k}\right)^{-\varepsilon} Y_{t+k}$ represents the output of the aforementioned enterprises. $MC^n_{t+k|t}$ is the marginal cost, and $\Lambda_{t,t+k} = \beta^k(\lambda_{t+k}/\lambda_t)(P_t/P_{t+k})$ is the discount factor. According to the first-order conditions, we can obtain the following:

$$\widetilde{P}_{h,t} = \frac{\varepsilon}{\varepsilon-1}\frac{\sum_{k=0}^{\infty}\zeta^k E_t\left\{\Lambda_{t,t+k}\left[Y_{t+k|t}\left(P_{h,t}/P_{h,t+k}\right)^{-\varepsilon} Y_{t+k} MC^n_{t+k|t}\right]\right\}}{\sum_{k=0}^{\infty}\zeta^k E_t\left\{\Lambda_{t,t+k}\left[Y_{t+k|t}\left(P_{h,t}/P_{h,t+k}\right)^{-\varepsilon} Y_{t+k}\right]\right\}} \tag{30}$$

3.3. Entrepreneurs

With the deepening of economic integration, an increasing number of Chinese enterprises raise funds overseas, thereby promoting

the inflow of overseas capital. Thus, to simplify the model, it is further assumed that the financing services only depend on the assets and liabilities of the enterprise sector. Suppose the net value of the enterprise is N_t, then to make up for the lack of required capital, the enterprise sector requires overseas financing in addition to capital accumulation; its balance sheet can be expressed as follows,

$$\varepsilon_t D_t = Q_t K_{t+1} - P_{h,t} N_t \tag{31}$$

Where D_t refers to the scale of foreign currency borrowing by enterprises. The aforementioned formula shows that the dollarization of debt will increase the burden of enterprises in the case of exchange rate depreciation and will reduce the net asset value of domestic enterprises. According to Bernanke et al. (2001), foreign capital inflows will request a certain external risk premium based on the interest rate, and the enterprise will then make a trade-off between D_t and K_{t+1} to make the expected return of capital R^k equal to its borrowing cost,

$$R^k_{t+1} = \left(1+\tau_{e,t}\right)\left(1+i^*_t\right)\left(\frac{\varepsilon_{t+1}}{\varepsilon_t}\right)F_t \tag{32}$$

Where $\tau_{e,t}$ is the tax set to manage capital flows. Referring to the assumption of Cespedes et al. (2004), the external risk premium is an increasing function of the ratio of capital to the net worth of the enterprise, that is $F_t = \Psi\left(Q_t K_{t+1}/P_{h,t}N_t\right)$, $\Psi(1) = 1$, $\Psi^{'}(\bullet) > 1$. Ψ is in the form of an exponential function, $\Psi(g) = g^u$. $u > 0$ represents the elasticity of the external financing premium. At the beginning of the period, the enterprise will use capital gains to pay foreign currency debts. At this time, the net value of the enterprise can be expressed as follows,

$$P_{h,t}N_t = R^k_t Q_{t-1}K_t - \left(1+\tau_{e,t-1}\right)\left(1+i^*_{t-1}\right)\varepsilon_t F_{t-1} D_{t-1} + T_{e,t} \tag{33}$$

Where $T_{e,t}$ is the transfer payment of government departments to enterprises. The return on capital R^k_t can be expressed as nominal rate of return R_t and the nondepreciated capital stock paid by the real economy by using capital K_t for production:

$$R^k_{t+1} = \frac{R_{t+1}}{Q_t} + \frac{Q_{t+1}}{Q_t}\left[(1-\delta) + \phi_i\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)\frac{I_{t+1}}{K_{t+1}} - \frac{\phi_i}{2}\left(\frac{I_{t+1}}{K_{t+1}} - \delta\right)^2\right] \tag{34}$$

3.4. Government

3.4.1. The tobin tax

In the aforementioned model, we set the Tobin tax within the budget constraints of households and businesses. We further assume that the government will use the tax of the previous period in the form of transfer payments to mitigate the potential impact of external shocks on households and on enterprises in the current period. This assumption will be related to the level of social welfare, and we project the following:

$$\tau_{h,t-1}\left(1+i^*_{t-1}\right)\varepsilon_t B_{t-1} = T_{h,t} \tag{35}$$

$$\tau_{e,t-1}\left(1+i^*_{t-1}\right)F_{t-1}\varepsilon_t D_{t-1} = T_{e,t} \tag{36}$$

3.4.2. Monetary policy

China is in a period of transformation from a quantitative monetary policy to a price-based monetary policy, and substantial literature has proved that the latter is better than the former. The majority of the literature regarding the transmission mechanism of China's monetary policy adopts the Taylor Rule within their general equilibrium frameworks. Therefore, we set the Taylor Rule as the benchmark monetary policy that focuses on inflation and output, which does not directly change with the change in the Federal monetary policy. Considering the discussion on monetary policy, we set "synchronous" and "asynchronous" policy rules that adopt the same or opposite strategies for external monetary policy shocks, respectively. These three different monetary policy rules correspond to the current academic discussion on the corresponding strategies of domestic monetary policy under the influence of the spillover of the Federal monetary policy. The specific models are as follows,

$$Benchmark: (1+i_t) = (1+i_{t-1})^{\varphi_r}\left[(1+\bar{i})(\pi_t/\overline{\pi})^{\varphi_\pi}\left(Y_t\Big/\overline{Y}\right)^{\varphi_y}\right]^{1-\varphi_r} \tag{37}$$

$$Synchronous: (1+i_t) = (1+i_{t-1})^{\varphi_r}\left[(1+\bar{i})(\pi_t/\overline{\pi})^{\varphi_\pi}\left(Y_t\Big/\overline{Y}\right)^{\varphi_y}\left(i^*_t\Big/\bar{i}^*\right)^{\varphi^*}\right]^{1-\varphi_r} \tag{38}$$

$$Asynchronous: (1+i_t) = (1+i_{t-1})^{\varphi_r}\left[(1+\bar{i})(\pi_t/\overline{\pi})^{\varphi_\pi}\left(Y_t\Big/\overline{Y}\right)^{\varphi_y}\left(i^*_t\Big/\bar{i}^*\right)^{-\varphi^*}\right]^{1-\varphi_r} \tag{39}$$

Where φ_r is the interest rate smoothing factor; $\overline{\pi}$ and $\overline{Y}$ are the steady-state inflation and output level, respectively; and φ_π and φ_y are the central bank's preference factor for the inflation gap and output gap, respectively.

Table 1
Calibration of related parameters.

Parameters	Parameter meaning	Calibration	Parameters	Parameter meaning	Calibration
β	Discount factor	0.99	γ	Proportion of imported consumer goods	0.28
σ	Relative risk aversion for goods	1.5	μ	Elasticity of external financing premium	0.02
ϕ	Relative risk aversion for labor	0.5	B/Y	Steady-state value of bonds in GDP	0.4
η	Elasticity of substitution of domestic and foreign commodities	1.5	$Q_k K/MW$	Steady-state value of the ratio of net capital value	2
α	Proportion of capital input	0.33	φ_r	Smoothness coefficient of interest rate preference	0.75
δ	Capital discount factor	0.025	φ_π	Smoothness coefficient of inflation preference	1.50
ε	Elasticity of substitution for different products	6	φ_y	Smoothness coefficient of output preference	0.50
ζ	Stickiness of price adjustment	0.75	ρ_i	External rate shock duration coefficient	0.8
ψ_i	Capital adjustment cost coefficient	12	σ_i	Random standard deviation of interest rate shocks	0.01
ψ_b	Bond adjustment cost coefficient	0.0007			

3.5. Equilibrium conditions

$$Y_t = C_{h,t} + I_{h,t} + S_t EX_t = (1-\gamma) g(S_t)^{\eta} (C_t + I_t) + S_t EX_t \tag{40}$$

Where EX_t is domestic exports to foreign countries under the condition of an open economy. To simplify the model based on Kitano and Takaku (2017), the exogenous dynamic process can be given as follows: $\log EX_t = (1-\rho_{ex})\log EX + \rho_{ex}\log EX_{t-1}$.

3.6. Shock

To simulate and analyze the changes of variables under the impact of the external interest rate, we set an external interest rate hike as the shock term that triggers domestic capital outflows:

$$i_t^* = (1-\rho_i) i^* + \rho_i i_{t-1}^* + \varepsilon_{i,t}, \varepsilon_{i,t} \sim i.i.d.N\left(0, \sigma_i^2\right) \tag{41}$$

4. Welfare loss measurement and parameter calibration

4.1. Welfare loss measurement

Considering that the Tobin tax has certain tax attributes, Tobin tax collection may impact the level of welfare. In this paper, the welfare loss function is used to evaluate the effects of different policy combinations. The expected lifetime utility level of representative families is considered the measurement of economic welfare. The welfare loss under different policy combinations is compared and analyzed based on the minimization of welfare loss. In simple terms, after selecting a benchmark scheme, the welfare level is denoted as W_0, and the change ratio of equivalent compensation for consumption is denoted as λ, which is used as the measurement index of welfare loss. The welfare level after equivalent compensation is denoted as $W(\lambda)$:

$$W_0 = E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t) \tag{42}$$

$$W(\lambda) = E_0 \sum_{t=0}^{\infty} \beta^t U(C_t(1+\lambda\%), L_t) \tag{43}$$

Where $U(C_t, L_t)$ is the residents' effect function to ensure that $W(\lambda) = W_0$ can obtain welfare loss as $\lambda = -100\left[1 - e^{(1-\beta)(W_0 - W)}\right]$. Based on the analysis of welfare loss, we will compare the welfare losses caused by different policy combinations under external interest rate shocks.

4.2. Parameter calibration

With the deepening of the research, the general parameters of the DSGE model and the special parameters of Chinese problems become more accurate and mature, thereby laying a solid foundation for follow-up research. Therefore, this paper calibrates relevant parameters based on the previous Bayesian estimation and calibration results. For the relevant parameters of China's monetary policy, based on the applicability of the Taylor Rule in research on Chinese academic problems, Ozkan and Unsal (2014) discussed the parameters of monetary and macroprudential policies for small open economies, which are consistent with the theme of China's

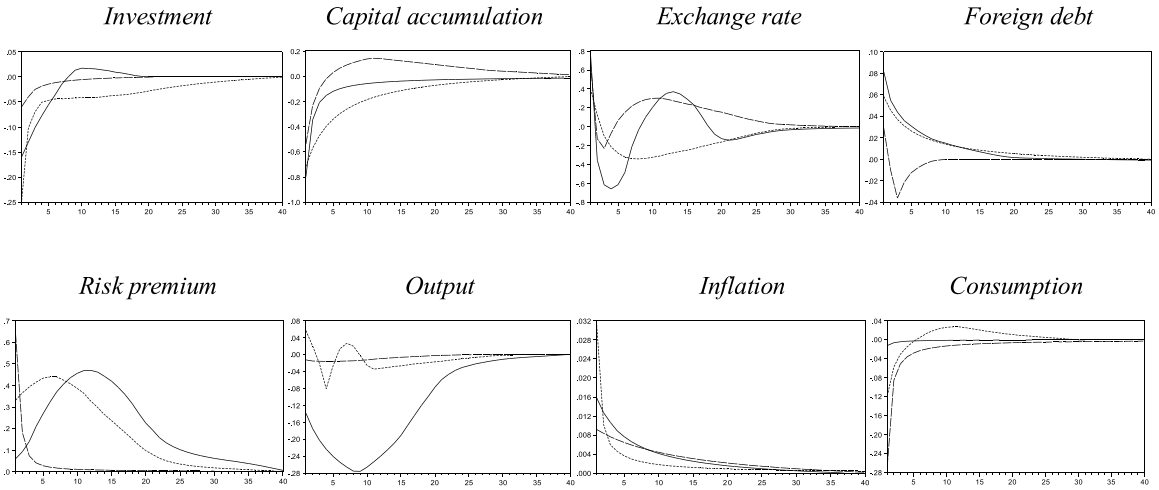

Fig. 1. Capital flows under the impact of external interest rate hikes and the effects of monetary policies regulations.
Note: "—," "— —," and "——" represent "benchmarks," "synchronous," and "asynchronous" monetary policies in the external impact of interest rates, respectively. The same representations are used below.

monetary policy. By referring to their study, the smoothness coefficient of China's monetary policy interest rate preference φ_r, inflation preference φ_π, and output preference φ_y are set as 0.75, 1.50, and 0.50, respectively. For the discount factor β, the value is set as 0.99, corresponding to the actual risk-free interest rate of 2% in China's economic data. The relative risk aversion for goods σ is set as 1.5, the relative risk aversion for labor ϕ is set as 0.5, and the proportion of capital input α is set as 0.33 (Escudé, 2014). According to Ravenna and Natalucci (2008), the substitution elasticity of domestic and foreign commodities η is set at 1.5. According to Devereux et al. (2006), the capital depreciation factor δ, capital adjustment cost coefficient ψ_i, bond adjustment cost coefficient ψ_b, and the steady-state value of bonds in GDP B/Y are set as 0.025, 12, 0.0007, and 0.4, respectively. According to Cook (2004), the proportion of imported consumer goods γ is set as 0.28. According to Gali and Monacelli (2005), the elasticity of substitution ε and stickiness of price adjustment ζ for different products are set as 6 and 0.75, respectively. Referring to Bernanke et al. (2001), the steady-state value of the ratio of net capital value $Q_k K/MW$ is set as 2. Referring to Merola (2010), the elasticity of external financing premium μ is set as 0.02. The parameters are summarized in Table 1.

5. Analysis of characteristics of crossborder capital flows and risk transfer mechanism

We first looked at the transmission of risk from crossborder capital flows in the absence of a Tobin tax. The shock is one positive standard deviation of the external interest rate. The domestic monetary policy authority can select the response strategy from "benchmark monetary policy," "synchronous monetary policy," and "asynchronous monetary policy." By observing the performance of the investment level, capital accumulation, real exchange rate, external debt, risk premium, output, inflation, and consumption related to international capital flows, we analyzed the characteristics and risk transmission mechanism of crossborder capital flows and the differences under different monetary policy operations. Fig. 1 shows the impulse responses of relevant variables.

Analysis of the impulse responses of the investment level, capital accumulation, and exchange rate fluctuation in Fig. 1 determined that the monetary policy only focuses on domestic inflation and output when an external interest rate hike occurs; the risks caused by the external interest rate hike cannot be avoided. On the one hand, under the impact of external interest rate hikes, the investment level decreases dramatically, and production capital accumulation is affected. On the other hand, the exchange rate fluctuates substantially, a phenomenon attributed to an external interest rate hike triggering capital outflows and the country not adopting policies to limit capital outflows. This approach further leads to financing difficulties for domestic enterprises reflected in the foreign debt scale in terms of foreign currency, thereby increasing the burden of enterprises in the case of the devaluation of domestic currency and increasing the risk premium demanded by foreign capital, which further increases the financing cost. When the external interest rate hike is transmitted to output, inflation, and consumption through capital flows and enterprise financing, the overall production declines, consumption declines, and inflation increases.

To that end, we will have to examine further to understand if reducing interest rates (asynchronous) can improve these problems. By observing the variables performances of domestic interest rate cuts under the impact of an external interest rate hike in Fig. 1, the investment level and capital accumulation decrease more. Although the exchange rate and foreign debt scale do not change considerably compared to the benchmark monetary policy, the capital risk premium increases significantly under the influence of domestic and foreign interest rate spreads. In contrast to the benchmark monetary policy, domestic interest rate cuts help increase output and consumption, and inflation does not fluctuate much. Thus, can higher interest rates (synchronous) maintain the growth of the economy and limit capital outflows? By observing the impulse response in the case of the interest rate hike in Fig. 1, the domestic interest rate hike reduces the decline in the investment level and capital accumulation. This indicates that it plays a role in limiting capital outflow

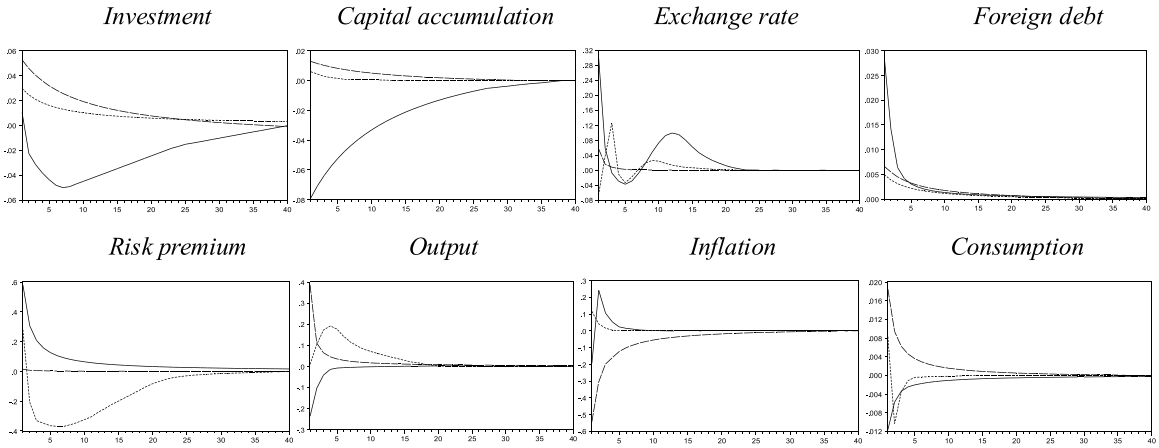

Fig. 2. The impulse response of the household sector Tobin tax.

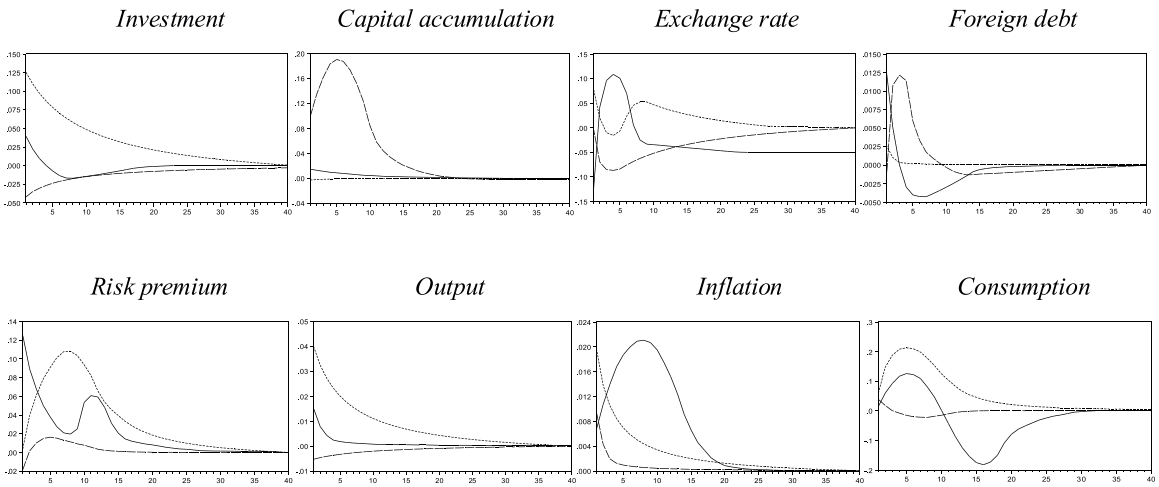

Fig. 3. The impulse response of the enterprise sector Tobin tax.

and has a certain effect on suppressing exchange rate fluctuations. However, the increase in the interest rate affects domestic production, which is reflected in the output decline and lower consumption level between the benchmark and asynchronous monetary policies. Although the synchronous interest rate hike helps suppress the capital outflow, the decline in production and inflation rise indicate that capital is not flowing back into the real economy under the synchronous monetary policy; instead, it flows into other sectors with higher yields.

These findings also echoed the contradiction of numerous EMEs on the monetary policy choice, not just for China. On the one hand, to manage the adverse impact of external monetary policy spillover on the domestic economy, the synchronous monetary policy is adopted to maintain stable interest rate spreads, stabilize the capital flow, and promote the formation of investment; however, it has little effect on increasing output. When the external interest rate rises, the capital released from the real economy may not necessarily flow back to the real economy after relevant domestic policies are adopted. On the other hand, if policy authorities only focus on the changes in domestic economic conditions and adopt interest rate cuts, it will to some extent help increase output. Still, the widening of interest rate spreads will aggravate capital outflow, which is not conducive to sustainable growth in the long run.

6. Tobin tax and monetary policy coordination

6.1. Effects of Tobin tax with different monetary policies

In practice, the primary forms of the Tobin tax include the “foreign exchange transaction tax” on foreign exchange transactions of domestic residents; the “income tax” on local currency assets held by nondomestic residents, the “withholding tax” on the initial stage of obtaining funds; and the “unremunerated reserve ratio” on crossborder capital investment to the central bank in proportion. The economic activities involved in the Tobin tax include private cross-border asset allocation and corporate external financing, so we start

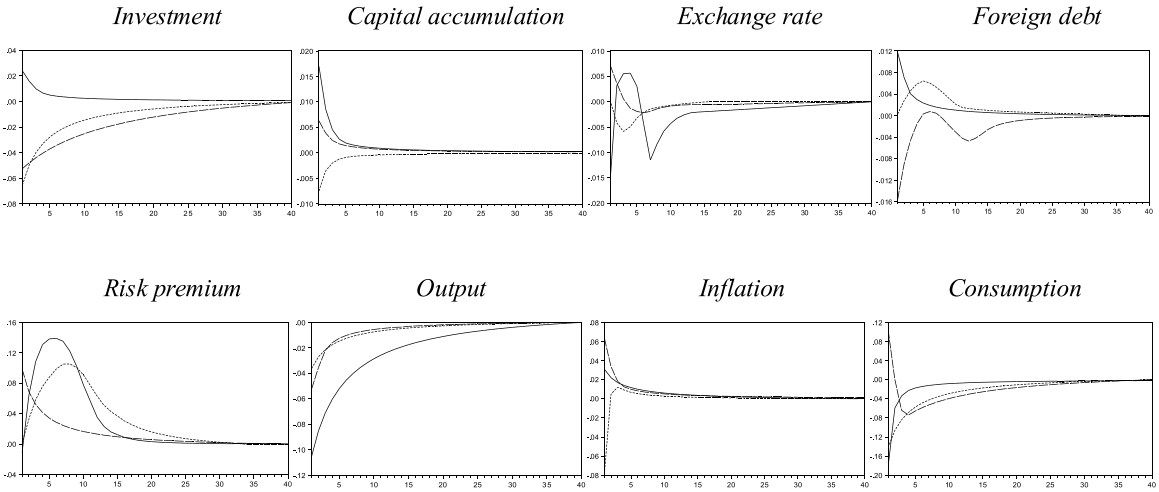

Fig. 4. The impulse response of the "household + enterprise" Tobin tax.

with these two economic activities to conduct simulations on the effect of the Tobin tax. Moreover, the aforementioned contradictions in monetary policy choices demonstrate that monetary policy alone cannot effectively manage crossborder capital flows and ensure domestic economic stability. In combination with the academic discussions on the Tobin tax, we integrate two types of Tobin tax schemes into the DSGE model. We then analyze the impulse response of variables under the spillover effects of the external interest rate increase and examine whether the Tobin tax can reduce monetary policy pressure and achieve a better policy combination effect. In particular, the first scheme is to tax the overseas asset investment of households to constrain the outflow of domestic residents' capital. The second scheme is to tax the foreign capital needed by enterprises before capital flees, which reflects the restriction of the outflow of foreign capital from the domestic production sector. Figs. 2–4 show the impulse responses of endogenous economic variables when the Tobin tax is levied on the household sector, the enterprise sector, and on both "household + enterprise" sectors.

Fig. 2 shows that the imposition of the Tobin tax on the household sector positively impacts output, thereby indicating that the imposition of the Tobin tax will limit households' demand for overseas assets, and in turn restrict domestic capital. Levying the Tobin tax on the household sector, however, plays a limited role in improving investment and capital accumulation, which indicates that the household sector is not an important precipitation sector of capital. This finding echoes the reality that households in China have limited funds to allocate to overseas assets. Moreover, the Tobin tax levied on the household sector under the benchmark monetary policy shows few positive effects on the exchange rate and on capital accumulation stability. Under the impact of external interest rate hikes, the real exchange rate fluctuations are still large, and the investment and capital accumulation have not improved significantly because even though residents' ability to allocate overseas assets is limited, the capital outflow is not primarily from the household sector. Therefore, restrictions cannot completely reverse the capital outflow under the impact of interest rate hikes. Among the three types of monetary policy operations, the household Tobin tax worked best when combined with a synchronous monetary policy, which produces the least volatility in exchange rates and risk premiums.

Fig. 3 shows that the imposition of the Tobin tax on enterprises can effectively increase the level of domestic investment and capital accumulation and has a positive effect on the level of output because enterprises attract capital into China through overseas financing, which is an important form of using foreign capital in China. Increasing the capital flow cost can reduce the capital outflow under the cycle of raising the external interest rate. Although the real exchange rate and scale of enterprises' foreign debt exhibit some fluctuations, the range is small from the perspective of the vertical coordinate. From the point of output and consumption, the asynchronous monetary policy with the enterprise Tobin tax is the optimal policy choice that provides the most significant positive effects on output and consumption. Although this policy coordination triggers a rise in risk premiums, it also reduces the enterprise financing cost. It makes the enterprise access capital timely when capital outflows, which can offset the negative impact of the risk premium rises.

Fig. 4 shows the Tobin tax applied to both the households and enterprises. The level of investment and capital accumulation, compared with the aforementioned two types of situations, does not increase, but instead shows adverse effects. This finding suggests that an overly stringent Tobin tax could trigger capital outflows, which may help explain the volatility of the exchange rate and risk premium and the increasing domestic enterprises' foreign debt scale. Therefore, if the Tobin tax is too strict, it will not impose controls on capital outflow but will aggravate capital outflow and pessimism, trigger currency devaluation risk and debt crisis, and negatively impact output. In this case, the operation effects of the three monetary policies are not ideal.

6.2. *Welfare analysis under different policy combinations*

Based on the simulation analysis, we find two prudent policy combinations: "household capital Tobin tax + interest rate hike (synchronous)" and "enterprises Tobin tax + interest rate cut (asynchronous)." To explore the effects of the two collocation methods,

Table 2
Welfare losses of different policy portfolios under the impact of external interest rate hikes.

Policy combination		Tobin tax			
		No Tobin tax	Household Tobin tax	Enterprises Tobin tax	"Household + Enterprises" Tobin tax
Monetary policy	Benchmark	—	1.1586	0.6607	8.4625
	Synchronous	6.4861	1.2253	1.1815	12.5135
	Asynchronous	15.9816	2.0128	0.3341	4.1568

Note: Reference policy combination from the benchmark model is marked as "—.".

we must calculate and compare the welfare losses of the aforementioned policy combinations as shown in Table 2.

The welfare analysis indicates that the comprehensive levy of the Tobin tax causes the highest welfare loss and thus not desirable. "Household Tobin tax + interest rate hike (synchronous)" is not the minimum welfare loss in the family Tobin tax policy portfolio; however, it is not far from the minimum welfare loss level and can still be considered the optimal policy portfolio. Although the household Tobin tax reduces the income of its overseas assets and weakens welfare levels, the increase in the domestic interest rate increases the income of domestic assets, which is equivalent to indirectly making up for the loss of households' overseas assets and welfare losses. At the same time, a synchronous monetary policy will help ease the exchange rate volatility and reduce the risk premium, thereby locking in some international capital in the domestic market and reducing the capital outflow.

By analyzing the Tobin tax policy portfolio of the enterprise sector, we find that the welfare loss caused by the Tobin tax on the enterprise is smaller than that of the overall household sector because the impact of the Tobin tax on the income and consumption level of the household sector is more significant and direct, which weakens the welfare level. From the optimal policy portfolio perspective, the "enterprises Tobin tax + interest rate cut (asynchronous)" policy can adapt to cope with the capital outflow caused by increases in the external interest rate, with the smallest welfare loss.

7. Conclusions and implications

In the context of crossborder capital flows caused by external monetary policy spillovers, we simulate the effects of a crossborder capital Tobin tax and the optimal Tobin tax and monetary policy combination. This provides feasible suggestions for the current discussion on China's capital Tobin tax. The conclusions are as follows:

First, there are two optimal combinations of the Tobin tax and monetary policy. The first combination is to tax overseas capital flowing into the enterprise and adopt an asynchronous monetary policy, named "enterprises Tobin tax + interest rate cut (asynchronous)." When external interest rates increase, this policy arrangement can increase the cost of capital outflow and reduce the costs of using capital through interest rate cuts, thus avoiding liquidity attenuation. The second combination, named "household Tobin tax + interest rate hike (synchronous)," is to tax households and raise interest rates, thereby increasing the cost of capital outflow and enabling the household sector to allocate more domestic assets to boost economic growth.

Second, the overall imposition of the Tobin tax on households and enterprises causes a high welfare loss, which suggests that the Tobin tax should be applied with caution. Otherwise, it will lead to a substantial loss of economic welfare. From the current characteristics of China's capital flow, even though there exist many channels through which Chinese residents can allocate overseas assets, residents remain restricted by financial regulations and average income level. The actual scale of overseas assets of China's household sector is limited. Therefore, "tax on enterprises' foreign capital + interest rate cut" is preferable.

Third, our simulation results provide theoretical support for EMEs that do not advocate for establishment of a comprehensive collection mechanism for financial account transactions of residents and enterprises for the Tobin tax. Because this paper and related practices show that the Tobin tax's "scare" function is greater than its "sanction" function, a comprehensive and draconian Tobin tax would subsequently trigger capital flight. Grasping the theoretical effect of "adding sand to the roulette wheel of international finance" is difficult, which is why the current Tobin tax rate is controversial. For the theme of this paper, differences between theory and practice do not affect our discussion on the collocation between the Tobin tax and monetary policy. Furthermore, as SDR currency, RMB must meet the standards of "the further opening of domestic financial market" and "the further loosening of foreign exchange control," which seems to conflict with the Tobin tax's concept of "controlling capital flow." IMF has agreed that emerging market countries can control short-term speculative capital under special circumstances. Therefore, the free convertibility of open economy currency indicates more targeted management, not that there is no distinction between short- and long-term capital or between speculative and nonspeculative capital. The degree of management can be flexibly controlled.

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.

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