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Central bank swap arrangements and exchange rate volatility: Evidence from China

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ABSTRACT

We examine how bilateral currency swap arrangements (BSAs) conducted by the People's Bank of China affect bilateral exchange rate volatility from 2009 to 2019. Applying an intervention analysis based on the model-selection approach, we find 21 (16) significant (negative) effects out of the 37 cases. The results imply that BSAs may depress bilateral exchange rate volatility, but the effects vary across countries and sometimes can even be reversed. Further investigation shows that financial market development and bilateral political relationships are significant determinants of such an influential pattern. These findings contribute to the study of central bank swap and Renminbi internationalization.

"*The bilateral local currency swap mechanism will further improve and will play an active role in facilitating bilateral trade and investment and maintaining financial stability.*"

—***2019 RMB Internationalization Report*** (The People's Bank of China (2019))

"*Through swap lines with fourteen other central banks, we supported dollar-denominated funding markets in Europe, Asia, and Latin America. The swap lines were our largest single program, with nearly $600 billion at their peak. They would prove crucial in containing global contagion.*"

—***The Courage to Act: A Memoir of a Crisis and Its Aftermat***h (Bernanke (2015))

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1. Introduction

Since its inception with the currency swap between IBM and the World Bank in 1981, currency swap has been widely used as hedging instruments for exchange risk exposure, with global firms as its primary end-users (Allayannis and Ofek, 2001; Géczy et al., 1997; Goswami et al., 2004). Such part of global financial architecture, nevertheless, has been deeply reshaped by central banks in the past decade (Bahaj and Reis, 2022a, 2022b), such as the noticeable official currency swap activities of the U.S. Federal Reserve during the 2007–2009 global financial crisis and the activities taken by the People's Bank of China (PBOC hereafter) in the past decade.

Unlike the conventional market players in the private sector, central banks use currency swaps to approach alternative goals. During the 2007–2009 global financial crisis, the Federal Reserve's U.S. dollar currency swap lines with 14 central banks helped to support the out-of-American dollar-denominated funding markets and prevent contagion (Bernanke, 2015; Fleming, 2012; Goldberg et al., 2010; Rose and Spiegel, 2012).[1] Although PBOC has been heavily involved in bilateral swap arrangements (BSAs hereafter) since that time, it aims to promote the usage of its currency—the Renminbi—in bilateral trade and investment (see The People's Bank of China, 2019). The bilateral currency swap is part of China's policy-oriented Renminbi internationalization (Prasad, 2017; Subacchi, 2016).

The number of central bank swap lines has been growing every year and becoming a non-negligible factor for the international financial system. Nowadays, there are over 170 BSAs between central banks worldwide; a growing literature related to global financial architecture has devoted significant attention to them (Bahaj and Reis, 2022a). Most of those studies argue that the central bank swap lines can significantly affect the exchange rate volatility like the ones conducted by the U.S. Federal Reserve during the 2007–2009 financial crisis (Aizenman et al., 2011; Fleming, 2012; Goldberg et al., 2010). Bahaj and Reis (2022b) argue that the swap line resembles the discount-window credit from the Federal Reserve to the recipient-country banks, which helps alleviate the U.S. dollar shortage in money markets, reduces *ex-post* financing risk, and encourages *ex-ante* investment. Therefore, it is critical to fully understand how the central bank swap lines affect the exchange rate volatility.

Such an argument is particularly relevant for the case of PBOC's BSAs. China is the second-largest economy in GDP and the largest economy in exports. But its currency, RMB, is a dwarf currency in the global financial system. Most of China's international trade and investments are priced and settled in the U.S. dollar (Subacchi, 2016). Thus, a strong incentive of China's policy-oriented RMB internationalization in the past decade is to eliminate the exchange rate risks caused by such currency mismatch. The exchange rate volatility is an intuitive measure of such risk and is what the conventional currency swap tries to hedge for. This paper, therefore, focuses on the impact of China's BSAs—the most active official currency swap activities in the past decade—on the exchange rate volatility.

Specifically, for each of the 37 countries (or regions) that signed a BSA with China from January 2009 to June 2019, we examine whether signing a BSA affects the monthly bilateral exchange rate volatility using an intervention analysis based on a model-selection approach.[2] The examinations proceed in two steps. First, for a given country signed BSAs with China, we model the bilateral exchange rate volatility in the best-fitted generalized autoregressive conditional heteroskedastic (GARCH) model selected by the information criteria. We next examine whether a BSA affects the exchange rate volatility by introducing an intervention item into the selected GARCH model.[3] We consider five scenarios that the (contemporaneous) impact of BSAs might last one month (i.e., pulse), one quarter (i.e., prolonged three months), half a year (i.e., prolonged six months), one year (i.e., prolonged 12 months), and forever (i.e., pure jump), respectively. We find 21 significant effects out of the 37 countries (or regions) under consideration, and there are 16 series among such significant cases having negative effects on the volatility. In addition, we find that 12 out of these 16 significant negative effects are detected lasting no more than six months (i.e., two pulses, four prolonged three months, and three prolonged six months), while three out of the five significant positive effects last much longer (i.e., pure jumps).[4] Further investigation shows that financial market development and bilateral political relationship appear to be the most significant determinants of such an influential pattern of BSAs.

This study contributes to related literature in two folds. First, to the best of our knowledge, our analysis is the first to examine the impact of BSAs on exchange rate volatility empirically. The impact of BSAs on the exchange rate has not received as much attention in the literature. Related literature on BSAs mainly focuses on the behaviors of two currency swap lines conducted by the U.S. Federal Reserve and the PBOC. In the case of the U.S. Federal Reserve, the literature has carefully documented the monetary policy effects, with special emphasis on its injection of dollar liquidity into the overseas markets and associated consequences (Aizenman et al., 2011; Bahaj and Reis, 2022b; Fleming, 2012; Goldberg et al., 2010; Rose and Spiegel, 2012). In the case of the PBOC, related studies mainly focus on its role as part of RMB internationalization. The first set of existing studies investigates the impact of PBOC's BSAs on the usage of RMB in international settlement (Batten and Szilagyi, 2016; Chey et al., 2019; Liu et al., 2019; Sato and Shimizu, 2018). The

[1] During the recent coronavirus shock in 2020, the U.S. Federal Reserve also conducted bilateral swap arrangements with nine central banks to address the oversea dollar shortage problem. Such bilateral currency swaps act as the lender of last resort for the foreign market. See Bahaj and Reis (2022a, 2022b) among others for the details.

[2] There are 38 countries (or regions) that signed BSAs with China. But Uzbekistan is excluded from this study because of the data available problem.

[3] This approach is named intervention analysis in Enders (2015), resembling the GJR-GARCH approach (Glosten et al., 1993).

[4] The main findings are quite similar when we restrict all the 37 bilateral exchange rate volatility models into the RiskMetrics' exponentially weighted moving average (EWMA) form, which has been widely used in risk management nowadays (Boucher et al., 2014; Nieto and Ruiz, 2016), and use the commonly used R-square approach to select the best-fitted models.

second set of studies explores how China chooses its swap counterparts (Garcia-Herrero and Xia, 2015; Liao and McDowell, 2015). Our study substantially enriches the growing literature on the consequences of BSAs by demonstrating that the BSA of PBOC does affect the bilateral exchange rate volatility for most of the swap cases as expected, and that the effects vary across countries (and regions). In addition, our findings also help answer the open question of Bahaj and Reis (2022b) that "…already today, any study of liquidity provision or of the international financial system will be incomplete without a discussion of the role of central bank swap lines…" [P. 1691].

Second, this study sheds new insights into the growing literature on RMB internationalization (Batten and Szilagyi, 2016; Bowles and Wang, 2013; Chey, 2013; Chey et al., 2019; Frankel, 2012; He et al., 2016; Ito, 2017; Liao and McDowell, 2015; Liu et al., 2019; Prasad, 2017; Sato and Shimizu, 2018) by revealing that BSAs can decrease exchange rate volatility for most of the swap cases. Exchange rate risks are highly correlated with the two main purposes of RMB internationalization: "facilitating bilateral trade and investment and "maintaining financial stability", proposed in the People's Bank of China (2019). Echoing the stability effects of the currency swap lines of the U.S. Federal Reserve (Bahaj and Reis, 2022b), our results reveal that paying more attention to the role of BSAs regarding such issues is beneficial and critical. In turn, our article helps policymakers, asset managers, and stakeholders involved in foreign exchange rate risk to comprehensively understand the effects and consequences of China's policy-oriented Renminbi internationalization strategies.

The remainder of this paper is organized as follows. Section 2 describes the data and empirical methodology. Section 3 interprets the empirical results. Section 4 explores the determinants that affect the influential pattern of BSAs. Section 5 concludes the paper.

2. Data and empirical methodology

2.1. Data

The data on bilateral currency swap arrangements (BSAs) are collected from the *2019 RMB Internationalization Report* issued by the People's Bank of China (PBOC). PBOC has already issued such a kind of report annually since 2015, in which a section titled "Highlights of Renminbi internationalization" summarizes the big events (including all BSAs till that time) since January 2009. We collect all related information about BSAs from the above annual report by hand. Table A-1 in the appendix summarizes all collected information on PBOC's BSAs signed with 38 countries (or regions). The most important information in this study is the initiation date of the agreement between China and its counterpart for each BSA, which will play a critical role in our model selection and intervention analysis to determine how the BSA affects bilateral exchange rate volatility.

Table A-1 shows that most of the countries (or regions) that signed a BSA with China are emerging market countries. The official exchange rate data for these countries (or regions) have not been reported by the PBOC. Thus, following Campbell et al. (2010), we use the bilateral exchange rates calculated from the Special Drawing Right (SDR) data, which are collected from the International Financial Statistics (IFS) of the IMF.[5] The IFS dataset contains exchange rate information for almost all the countries (or regions) that have signed a BSA with China, except for Uzbekistan. Therefore, the final sample contains 37 countries (or regions) and covers the period from August 2005 to June 2019. We choose August 2005 as the initial date point because Renminbi (RMB, hereafter) was strictly pegged to the U.S. dollar before that period.

We process the data as follows. First, we calculate the bilateral exchange rate of foreign currency to RMB for each of its counterparts as:

$$f = \frac{\text{Foreign currency per SDR}}{\text{Renminbi per SDR}}.$$

Second, we calculate the logarithm returns (i.e., $100 \times [log(f_t) - log(f_{t-1})]$) for each of the 37 bilateral exchange rates. Table 1 reports the summary statistics for these 37 logarithms to return series, along with an ADF test for each series examining whether it contains a unit root. Although the logarithm returns vary across countries (and regions) and appear apparent volatility patterns for some cases, all these series are stationary. Without loss generality, we still refer to the logarithm return series as the exchange rate in later studies for simplicity.

To further investigate what factors affect the influential pattern of the BSAs on bilateral exchange rate volatility, we consider gravity model factors, international trade factors, financial development factors, macroeconomic factors, institutional factors, and bilateral diplomatic relationship factors. Here, we use the five-year average value for each variable to avoid the possible endogenous problem. Table A-2 in the appendix provides detailed information about these factors. The six daily official exchange rates reported by the PBOC (i.e., EUR, Hong Kong SAR, Japan, UK, Canada, and Russia) are also used in exporting the impact of BSAs on exchange rate volatility on daily frequency.

2.2. Methodology

The empirical method employed in this study is an intervention analysis based on model selection. Compared to the common method of detecting volatility effects by using only a uniform shock, our approach can capture such effects under different scenarios by

[5] In later examination, we also reexamine our main results using the data of available six daily official exchange rates reported by the PBOC.

Table 1
Summary Statistics for the 37 bilateral exchange rates, logarithm returns, 2005/8–2019/6.

Country and Region	Max	Min	Mean	Std.	ADF (Difference)
Albania	0.1481	2.1875	7.8054	−6.4762	−4.6890***
Argentina	1.7364	3.4305	24.3333	−5.0728	−4.6183***
Armenia	0.1190	2.1320	17.9623	−4.3443	−4.2478***
Australia	0.1515	2.8634	16.8199	−6.8008	−4.7604***
Belarus	1.4606	4.9551	34.1633	−4.7653	−4.1946***
Brazil	0.3928	3.5526	18.8437	−10.2606	−4.5224***
Canada	0.1560	2.0077	11.2735	−6.0629	−4.8396***
Chile	0.2390	2.5068	15.3791	−7.2239	−4.6323***
Hong Kong, SAR	0.1008	0.7640	2.6038	−3.8296	−5.8690***
Egypt	0.7370	4.7655	56.7021	−9.1942	−5.5046***
EUR	0.1477	2.1500	7.5547	−5.6873	−4.8082***
Hungary	0.3153	3.3228	14.3178	−8.0040	−5.0327***
Iceland	0.5012	3.6551	22.3631	−8.9512	−4.1745***
Indonesia	0.3110	2.3742	15.9048	−7.5164	−4.9001***
Japan	0.0819	2.3582	7.2674	−6.2107	−5.5316***
Kazakhstan	0.7213	2.9662	22.7305	−3.4930	−5.5843***
Korea	0.1812	2.4211	15.4594	−8.2950	−4.7075***
Malaysia	0.1580	1.5753	5.0067	−3.8815	−4.4708***
Mongolia	0.5748	2.1533	8.3685	−8.7365	−5.1235***
Morocco	0.1390	1.8138	6.7785	−4.8473	−4.7653***
New Zealand	0.1280	2.7848	9.4773	−7.4741	−4.6225***
Nigeria	0.6061	2.8745	22.7289	−3.8609	−5.5018***
Pakistan	0.6750	1.5228	6.5088	−5.3388	-3.1710*
Qatar	0.0966	0.7542	2.5271	−3.8424	−5.7511***
Russia	0.5866	4.0087	19.2392	−12.7034	−5.1477***
Serbia	0.3527	2.8285	13.6038	−5.1147	−4.8299***
Singapore	−0.0231	1.1361	3.8096	−2.7960	−4.7830***
South Africa	0.5869	3.6669	19.0038	−15.076	−5.7094***
Sri Lanka	0.4345	1.2133	6.7037	−3.6751	−5.7999***
Suriname	0.6998	3.1902	27.2474	−7.6164	−4.6583***
Switzerland	−0.0510	2.2625	12.1052	−6.3298	−5.7551***
Tajikistan	0.7534	1.6747	8.4262	−6.1997	−5.4953***
Thailand	−0.0716	1.2682	4.4395	−3.4801	−4.1663***
Turkey	0.9809	3.5683	17.9233	−9.2417	−5.7932***
Ukraine	1.0952	4.8075	43.5901	−7.9751	−4.9737***
UAE	0.0966	0.7542	2.5271	−3.8424	−5.7511***
UK	0.3055	2.2435	9.6170	−6.1276	−5.4828***

Notes: Exchange rates are calculated from SDRs collected from the International Financial Statistics Database of IMF. Std. denotes a standard error. ***, **, * denote the ADF test rejects the null hypothesis of the unit-root process at 1%, 5%, and 10% significant level, respectively.

introducing different intervention items, and thus disclose the consequence of each certain shock. This approach, similar to the classical GJR-GARCH (Glosten et al., 1993), introduces an exogenous shock item (e.g., dummy variable) into the selected best-fitted time-series model to evaluate the impact on volatility (see, Enders, 1990, 2015; Enders and Sandler, 1993). Considering such an approach might potentially introduce selection bias, we also use the exponentially weighted moving average (EWMA) volatility model and the criteria of adjusted R^2 as a robustness check.[6]

2.2.1. *GARCH models and intervention analysis*

Following Enders (1990, 2015) and Enders and Sandler (1993), the intervention analysis proceeds in two steps. In the first step, our approach selects the best data generating process (DGP) from 12 candidate models using the sample period either before or after the exogenous shock, whichever is longer. In financial time series, it is common that the literature in investigating exchange rate volatility is keen to start with the GARCH (1,1) model as a benchmark case, since the super performance of this basic GARCH model in modeling the exchange rate volatility (Hansen and Lunde, 2005). As in Bollerslev (1986), the log return series r_t follows a GARCH (1,1) model if

$$\begin{aligned} r_t &= \gamma_0 + \varepsilon_t, \varepsilon_t = v_t\sqrt{h_t} \\ h_t &= \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \beta_1 h_{t-1} \end{aligned} \tag{1.1}$$

where $\{v_t\}$ is a white-noise process, the conditional and unconditional means of ε_t are equal to zero. The important point is that the conditional variance of ε_t is the ARMA process given by the expression h_t, where the coefficients need to satisfy the constraints: $\alpha_0 > 0$, $\alpha_1 \geq 0, \beta_1 \geq 0$, and $\alpha_1 + \beta_1 < 1$, respectively.

[6] We thank a referee for pointing out this issue.

In addition, we estimate the model with a one-month lag log-return r_{t-1} since we are using monthly data. Hence, we consider the following formulation:

$$\begin{aligned} r_t &= \gamma_0 + \gamma_1 r_{t-1} + \varepsilon_t, \varepsilon_t = v_t\sqrt{h_t} \\ h_t &= \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \beta_1 h_{t-1} \end{aligned} \tag{1.2}$$

where the coefficient γ_1 captures potential mean-reversion or momentum trend process in exchange markets.

It is worth noting that in finance, the return of a financial instrument may depend on its volatility. To model such a phenomenon, we consider the GARCH-M model, where M stands for GARCH in the mean. In this study, we next fit the data using the basic GARCH (1,1)-M model:

$$\begin{aligned} r_t &= \gamma_0 + \gamma_2 h_t + \varepsilon_t, \varepsilon_t = v_t\sqrt{h_t} \\ h_t &= \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \beta_1 h_{t-1} \end{aligned} \tag{1.3}$$

It is easy to see that this formulation considers the serial correlations introduced by those in the volatility process $\{h_t\}$, where the parameter γ_2 captures how the return is related to its volatility. In other words, the volatility (i.e., risk) needs to be compensated in the returns.

Naturally, for completeness, we combine the above two effects and give serious consideration to the GARCH (1,1)-M with the one-month lagged model as follows:

$$\begin{aligned} r_t &= \gamma_0 + \gamma_1 r_{t-1} + \gamma_2 h_t + \varepsilon_t, \varepsilon_t = v_t\sqrt{h_t} \\ h_t &= \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \beta_1 h_{t-1} \end{aligned} \tag{1.4}$$

Besides the above four formulations in Eqs. (1.1)–(1.4) varied by considering autocorrelation and GARCH-M effect in the mean equation, several extensions of the basic GARCH model have been developed that are especially suited to estimating the conditional volatility of the exchange rate. In this study, we consider more candidate models beyond GARCH (1,1) because a large portion of PBOC's BSAs happened between small and developing countries (and regions), and the behavior of the exchange rate series would thus differ from that of the developed countries shown in earlier literature (Hansen and Lunde, 2005). For example, West and Cho (1995) cannot model the exchange rates of Italy in the commonly used GARCH (1,1) form.

Now, we focus on the volatility equation and illustrate the modification of the GARCH (1,1) specification. First, recall that when we estimate the above GARCH (1,1) model, it is supposed to be that the sum of α_1 and β_1 is strictly less than 1. However, in financial time series, the conditional volatility may appear quite persistent. This fact makes the estimation of the GARCH (1,1,) with the sum of α_1 and β_1 approaching one. Thus, considering this volatility persistence phenomenon, we have an integrated-GARCH (IGARCH) model, whose volatility equation can be written as

$$h_t = \alpha_0 + (1-\beta_1)\varepsilon_{t-1}^2 + \beta_1 h_{t-1}.$$

Combined with the previous four scenarios in the mean equation, we will estimate the following IGARCH (1,1) formulations:

$$\begin{aligned} r_t &= \gamma_0 + \varepsilon_t, \varepsilon_t = v_t\sqrt{h_t} \\ h_t &= \alpha_0 + (1-\beta_1)\varepsilon_{t-1}^2 + \beta_1 h_{t-1} \end{aligned} \tag{2.1}$$

$$\begin{aligned} r_t &= \gamma_0 + \gamma_1 r_{t-1} + \varepsilon_t, \varepsilon_t = v_t\sqrt{h_t} \\ h_t &= \alpha_0 + (1-\beta_1)\varepsilon_{t-1}^2 + \beta_1 h_{t-1} \end{aligned} \tag{2.2}$$

$$\begin{aligned} r_t &= \gamma_0 + \gamma_2 h_t + \varepsilon_t, \varepsilon_t = v_t\sqrt{h_t} \\ h_t &= \alpha_0 + (1-\beta_1)\varepsilon_{t-1}^2 + \beta_1 h_{t-1} \end{aligned} \tag{2.3}$$

$$\begin{aligned} r_t &= \gamma_0 + \gamma_1 r_{t-1} + \gamma_2 h_t + \varepsilon_t, \varepsilon_t = v_t\sqrt{h_t} \\ h_t &= \alpha_0 + (1-\beta_1)\varepsilon_{t-1}^2 + \beta_1 h_{t-1} \end{aligned} \tag{2.4}$$

Another interesting model of conditional variance is the exponential-GARCH (EGARCH) model, in which there is a strong negative correlation between the current return and the future volatility. This tendency for volatility to decline when return rises and to rise when returns fall is often called the leverage effect, which captures the fact that "bad" news seems to have a more pronounced effect on volatility than does "good" news. Following Nelson (1990, 1991), we consider the EGARCH process that allows for the asymmetric effect of news:

$$ln(h_t) = \alpha_0 + \alpha_1\left(\varepsilon_{t-1}/h_{t-1}^{0.5}\right) + \lambda_1\left|\varepsilon_{t-1}/h_{t-1}^{0.5}\right| + \beta_1 ln(h_{t-1}).$$

Note that the EGARCH model allows for a leverage effect. If the term $\varepsilon_{t-1}/h_{t-1}^{0.5}$ is positive, the effect of the shock on the log of the conditional variance is $\alpha_1 + \lambda_1$. If this term is negative, the effect of the shock on the log of the conditional variance is $-\alpha_1 + \lambda_1$.

We again combine the new specification in the volatility equation with the above four scenarios in the mean equation, and then we will consider the following candidates EGARCH (1,1) model:

$$\begin{aligned} & r_t = \gamma_0 + \varepsilon_t, \varepsilon_t = v_t\sqrt{h_t} \\ & ln(h_t) = \alpha_0 + \alpha_1\left(\varepsilon_{t-1}/h_{t-1}^{0.5}\right) + \lambda_1\left|\varepsilon_{t-1}/h_{t-1}^{0.5}\right| + \beta_1 ln(h_{t-1}) \end{aligned} \tag{3.1}$$

$$\begin{aligned} & r_t = \gamma_0 + \gamma_1 r_{t-1} + \varepsilon_t, \varepsilon_t = v_t\sqrt{h_t} \\ & ln(h_t) = \alpha_0 + \alpha_1\left(\varepsilon_{t-1}/h_{t-1}^{0.5}\right) + \lambda_1\left|\varepsilon_{t-1}/h_{t-1}^{0.5}\right| + \beta_1 ln(h_{t-1}) \end{aligned} \tag{3.2}$$

$$\begin{aligned} & r_t = \gamma_0 + \gamma_2 h_t + \varepsilon_t, \varepsilon_t = v_t\sqrt{h_t} \\ & ln(h_t) = \alpha_0 + \alpha_1\left(\varepsilon_{t-1}/h_{t-1}^{0.5}\right) + \lambda_1\left|\varepsilon_{t-1}/h_{t-1}^{0.5}\right| + \beta_1 ln(h_{t-1}) \end{aligned} \tag{3.3}$$

$$\begin{aligned} & r_t = \gamma_0 + \gamma_1 r_{t-1} + \gamma_2 h_t + \varepsilon_t, \varepsilon_t = v_t\sqrt{h_t} \\ & ln(h_t) = \alpha_0 + \alpha_1\left(\varepsilon_{t-1}/h_{t-1}^{0.5}\right) + \lambda_1\left|\varepsilon_{t-1}/h_{t-1}^{0.5}\right| + \beta_1 ln(h_{t-1}) \end{aligned} \tag{3.4}$$

In sum, we consider various scenarios for leverage effect, GARCH in mean effect, and with or without autocorrelation in the mean equation. Thus, there will be three potential forms of the volatility equation for selection. Combined with the four mentioned forms of the mean equation, there will be 12 candidate models for each bilateral exchange return series. Then, the best-fitted one is selected by Bayesian Information Criterion (BIC) using the sample period either before or after the BSA shock, whichever is longer.[7]

The second step, in this study, is introducing an intervention item into the selected model and re-estimate the model with an exogenous shock variable using the full-sample observations. That is, the volatility equation in the GARCH (1,1) formulations (1.1)–(1.4), in the IGARCH (1,1) formulations (2.1)–(2.4), and in the EGARCH (1,1) ones (3.1)–(3.4) will be modified into the forms as follows

$$\text{GARCH}(1,1): h_t = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \beta_1 h_{t-1} + \gamma d_t,$$

$$\text{IARCH}(1,1): h_t = \alpha_0 + (1-\beta_1)\varepsilon_{t-1}^2 + \beta_1 h_{t-1} + \gamma d_t,$$

$$\text{EARCH}(1,1): ln(h_t) = \alpha_0 + \alpha_1\left(\varepsilon_{t-1}/h_{t-1}^{0.5}\right) + \lambda_1\left|\varepsilon_{t-1}/h_{t-1}^{0.5}\right| + \beta_1 ln(h_{t-1}) + \gamma d_t,$$

where d_t is the BSAs shock item with its coefficient γ capturing the contemporary impact of BSAs. The long-term impact, take the $\text{GARCH}(1,1)$ as an example, will be $\frac{\gamma}{1-\alpha_1-\beta_1}$. The other formats of the volatility equations can be interpreted alike, though more complicated.

We consider five scenarios that the impact of BSAs might last one month (i.e., pulse), one quarter (i.e., prolonged three months), half a year (i.e., prolonged six months), one year (i.e., prolonged 12 months), and forever (i.e., pure jump). Fig. 1 plots how each scenario is modeled as an intervention item in the volatility equation. For the results from these five scenarios, again, we use the model-selection approach to choose the best result for each country (and region) and stick to these results in later analysis. The selection is also based on the BIC. If the BIC statistic values are too close to distinguish, we chose the best one in which the coefficient γ is estimated most significantly.

2.2.2. *Using the EWMA model*

As discussed previously, the intervention analysis based on the model selection approach depends heavily on the value of statistics per se (e.g., BIC) or the statistical significance (i.e., *p*-values). Although this approach allows the potential disparity of data generating process (DGP) in the 37 countries' exchange rate volatility series as revealed in earlier literature (Hansen and Lunde, 2005; West and Cho, 1995), it might also introduce model selection bias. Therefore, we model all the 37 exchange rates volatility series into Risk-Metrics' exponentially weighted moving average (EWMA) form with model selection based on the R-square approach (Foster et al., 1997).[8]

Specifically, in this scenario, we model each of the 37 bilateral exchange rates volatility in the following EWMA form:

$$h_t = \lambda h_{t-1} + (1-\lambda)r_{t-1}^2 \tag{4}$$

The λ parameter, with $0 < \lambda < 1$, is also called the decay factor. In general, RiskMetrics has chosen $\lambda = 0.94$ for daily data and $\lambda = 0.97$ for monthly data (Jorion, 2011, p. 119). Compared to the IGARCH model shown in Eq. (2.1)–(2.4), we can find that the EWMA volatility model is a special case of the IGARCH model, in which α_0 is set to zero and β_1 is set to a given value, λ. Therefore, for a given exchange rate series, we can directly calculate the volatility series without *ex-ante* parameter estimation. Similar to the selection of important factors affecting asset prices (Foster et al., 1997), for each country (or region) *i*, we regress the calculated volatility series on each of the five intervention variables as:

$$h_{it} = \alpha_0 + \gamma d_t + e_{it} \tag{5}$$

[7] We can obtain similar results using the Akaike Information Criterion (AIC). Results are available on request.

[8] The EWMA volatility model is essentially a special case of IGARCH model without estimating related parameters, which is widely used for risk management in financial sector (Boucher et al., 2014; Jorion, 2007, 2011; Nieto and Ruiz, 2016).

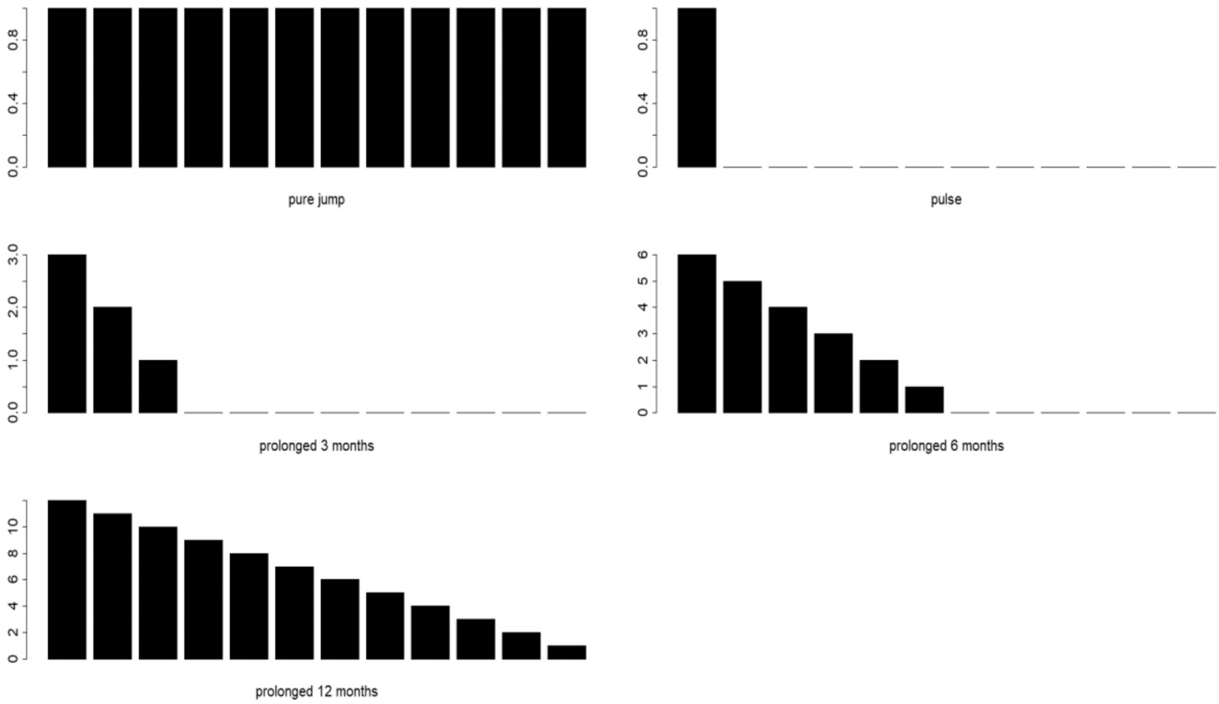

Fig. 1. Patterns of the intervention item under the five scenarios.

The impact of BSAs on exchange rate volatility can be detected in which case Eq. (5) is estimated with the highest adjusted R^2 and with the estimated sign and significance of γ. Compared to the previous model selection approach, this approach can avoid the possible volatility-model selection bias and answer the two key questions of this study: (1) whether signing a BAS with China affects the bilateral exchange rate volatility; (2) if the answer is yes, whether the effect is positive or negative. Therefore, the EWMA approach with model selection based on adjusted R^2 can act as a robustness check against potential model selection bias of the proposed intervention analysis.

2.2.3. Determinants of BSAs' effects on volatility

We further use logistic regression analysis to investigate the determinants for the influential pattern of BSAs, if applicable. Following the literature (Yang et al., 2021; Yang and Zhou, 2013; Yu et al., 2023), the regression can be expressed as follows:

$$\text{Prob}(Y_i = 1) = \alpha_0 + \beta X_i + \varepsilon_i \tag{6}$$

where $\text{Prob}(Y_i = 1)$ is the dependent variable indicating whether the intervention item is estimated significantly at a 5% level for the whole sample or whether the intervention item is estimated significantly negative. The vector X_i is the specific factor(s) that may affect the value of Y, the term α_0 is the constant intercept, and as usual, ε_i is the error term. Following Yang and Zhou (2013) and Yang et al. (2021), we first run a simple regression to investigate the statistically significant factors, and then conduct a multiple regression, as the detected significant variables may highly correlate with each other.

3. Results

3.1. Intervention analysis

According to the demonstrated model-selection approach, our first step is to choose the best-fitted time-series volatility model out of the 12 candidates using the sample period either before or after the BSAs shock, whichever is longer. Table 2 reports the model selected by BIC for each country and has several interesting results. First, the GARCH (1,1) process dominates in modeling the bilateral exchange rate volatility compared to other alternatives, even if there exists a non-negligible portion of bilateral exchange rate volatility shall be best fitted into IGARCH (1,1) or EGARCH (1,1). Our first result solves the concern that GARCH (1,1) process may not be suitable to model the exchange rate volatility for all developing countries (Hansen and Lunde, 2005; West and Cho, 1995). Second, there exist some countries (and regions) whose bilateral exchange rate volatility are best fitted by the EGARCH model. This fact means that the volatility effect is asymmetric. Note that they are almost all of China's neighborhood countries, such as Japan, Korea, Mongolia, and Thailand. The only exception is Serbia, an eastern European country with well-developed economic and diplomatic

Table 2
The selected volatility model for the sample countries/regions.

Country and Region	Model specification	Country and Region	Model specification
Albania	AR(0) − GARCH	Morocco	AR(0) − GARCH
Argentina	AR(1) − IGARCH	New Zealand	AR(0) − GARCH
Armenia	AR(0) − GARCH − M	Nigeria	AR(1) − IGARCH
Australia	AR(0) − GARCH	Pakistan	AR(1) − IGARCH
Belarus	AR(0) − GARCH − M	Qatar	AR(0) − GARCH
Brazil	AR(0) − GARCH	Russia	AR(1) − IGARCH
Canada	AR(1) − IGARCH	Serbia	AR(0) − EGARCH
Chile	AR(0) − GARCH	Singapore	AR(1) − IGARCH
Hong Kong, SAR	AR(0) − GARCH	South Africa	AR(0) − GARCH
Egypt	AR(1) − IGARCH	Sri Lanka	AR(0) − GARCH − M
EUR	AR(0) − GARCH	Suriname	AR(1) − IGARCH
Hungary	AR(0) − GARCH	Switzerland	AR(0) − GARCH
Iceland	AR(1) − GARCH	Tajikistan	AR(0) − EGARCH
Indonesia	AR(1) − IGARCH	Thailand	AR(0) − EGARCH
Japan	AR(0) − EGARCH	Turkey	AR(0) − GARCH
Kazakhstan	AR(1) − GARCH	Ukraine	AR(1) − IGARCH
Korea	AR(1) − EGARCH	UAE	AR(0) − GARCH
Malaysia	AR(0) − GARCH	UK	AR(0) − GARCH
Mongolia	AR(0) − EGARCH		

Notes: AR(0) − GARCH − M indicates AR(0) is used in the mean model, GARCH(1, 1) is employed in the variance model, with GARCH in the mean (−M) effect, resembling the others.

Table 3
Results of intervention analysis, volatility equation, 37 countries/regions.

Country and Region	α	β	Intervention Item	α + β	Types of intervention Item
Albania	0.2119**	0.5745***	0.0563	0.7865	Prolonged 3 Month
	(2.4807)	(3.7741)	(0.1364)		
Argentina	0.4455***	0.5544	1.1124***	1.0000	Pure Jump
	(5.5251)	NA	(2.7093)		
Armenia	0.1155***	0.8189***	−8.9354***	0.9344	Prolonged 3 Month
	(11,909.6769)	(126,322.1343)	(−10,385.6508)		
Australia	0.1898*	0.5425***	−0.3147**	0.7324	Pure Jump
	(1.9152)	(4.8485)	(−2.0803)		
Belarus	0.0000	0.9970***	0.0000	0.9970	Prolonged 12 Month
	(0.0000)	(112,561.3857)	(0.0000)		
Brazil	0.3457***	0.0984	−2.0951**	0.4442	Pulse
	(2.6310)	(0.4800)	(−2.0471)		
Canada	0.4595***	0.5404	0.1273	1.0000	Prolonged 12 Month
	(3.3763)	NA	(1.1125)		
Chile	0.4707***	0.1551***	−26.0786***	0.6259	Prolonged 6 Month
	(462.8283)	(7.0695)	(−120.5792)		
Hong Kong, SAR	0.0201	0.9508***	0.1220***	0.9709	Prolonged 6 Month
	(0.2614)	(46.7948)	(3.7897)		
Egypt	0.2090***	0.7909	0.0000	1.0000	Pure Jump
	(9.7782)	NA	(0.0000)		
EUR	0.1633***	0.8145***	−37.7973***	0.9779	Prolonged 3 Month
	(112.1412)	(130.4443)	(−72.3019)		
Hungary	0.2537***	0.7368***	−0.3164**	0.9905	Pure Jump
	(3.4377)	(7.0886)	(−2.1437)		
Iceland	0.4961***	0.3968***	0.3888	0.8930	Prolonged 6 Month
	(3.1688)	(3.7791)	(0.8664)		
Indonesia	0.7564***	0.2435	0.0000	1.0000	Prolonged 12 Month
	(6.6966)	NA	(0.0000)		
Japan	0.0184	0.0039	−31.9295***	0.0224	Pulse
	(0.1569)	(0.0795)	(−9.2581)		
Kazakhstan	0.1119	0.3020***	3.0943***	0.4140	Pure Jump
	(0.7575)	(10.3809)	(17.4970)		
Korea	0.3598***	0.5642***	−0.4295***	0.9240	Pure Jump
	(5.6271)	(11.0567)	(−6.2409)		
Malaysia	0.1211	0.6306***	−27.9630***	0.7517	Prolonged 3 Month
	(1.3424)	(17.8073)	(−17.1234)		
Mongolia	0.1668	0.1534***	−53.6519***	0.3203	Prolonged 3 Month
	(1.3319)	(8.8022)	(−203.6819)		
Morocco	0.1942***	0.4429***	−8.4985***	0.6372	Prolonged 6 Month

(*continued on next page*)

Table 3 (*continued*)

Country and Region	α	β	Intervention Item	α + β	Types of intervention Item
	(305.4342)	(11,821.8086)	(−5373.9078)		
New Zealand	0.1107***	0.7840***	−34.2626***	0.8947	Prolonged 3 Month
	(3.0845)	(4.0205)	(−3.8929)		
Nigeria	0.2125***	0.7874	0.0000	1.0000	Prolonged 6 Month
	(8.6431)	NA	(0.0000)		
Pakistan	0.0000	0.9999	0.0136	1.0000	Pure Jump
	(0.0000)	NA	(1.4871)		
Qatar	0.0511	0.9452***	0.2688***	0.9963	Prolonged 6 Month
	(0.9537)	(48.6288)	(5.9113)		
Russia	0.4668***	0.5331	0.0000	1.0000	Prolonged 12 Month
	(4.6335)	NA	(0.0000)		
Serbia	0.3335***	0.6223***	−0.4702***	0.9559	Pure Jump
	(4.4015)	(9.5830)	(−2.9460)		
Singapore	0.0000	0.9999	0.0000	1.0000	Prolonged 3 Month
	(0.0000)	NA	(0.0000)		
South Africa	0.1557*	0.8215***	0.3887	0.9773	Pure Jump
	(1.9148)	(9.7533)	(1.0246)		
Sri Lanka	0.0329	0.1050***	−38.2945***	0.1380	Pulse
	(0.2410)	(2.9236)	(−17.1190)		
Suriname	0.5708***	0.4291	3.5313	1.0000	Prolonged 12 Month
	(8.1417)	NA	(1.6352)		
Switzerland	0.2126**	0.7385***	1.5986	0.9512	Pulse
	(2.0579)	(5.6600)	(0.5904)		
Tajikistan	0.4787***	0.0839***	−25.0778***	0.5627	Pulse
	(4.4403)	(3.7804)	(−17.3894)		
Thailand	0.0155***	0.8778***	−39.6064***	0.8934	Prolonged 3 Month
	(213.6435)	(493.5404)	(−208.2311)		
Turkey	0.4695**	0.4371***	0.0000	0.9067	Pure Jump
	(2.5469)	(3.0722)	(0.0000)		
Ukraine	0.4886***	0.5113	0.0000	1.0000	Pure Jump
	(9.6141)	NA	(0.0000)		
UAE	0.3043***	0.6473***	0.0984***	0.9516	Pure Jump
	(3.3400)	(9.1068)	(2.5950)		
UK	0.0000	0.9961***	0.0000	0.9961	Prolonged 12 Month
	(0.0000)	(127,626.3532)	(0.0000)		

Notes: This table reports the results of the intervention analysis. The estimation results of the mean equations are not reported here for brevity. The reported result for each country or region was selected from the results under five different impacting scenarios, with the last column of this table demonstrating the selected impacting types. ***, **, and * denote the significant at 1%, 5%, and 10% level, respectively.

connections with China. The reason for the existence of an asymmetric effect might be that their imports and exports trade with China raise the leverage effect, as proximity is a dominating factor in determining bilateral trade flow (Feenstra et al., 2001). Third, the conditional volatility is quite persistent (i.e., IGARCH (1,1)) for the countries (and regions) that have experienced economic or political instability during the sample period, including Ukraine, Egypt, Argentina, and Pakistan, among others. Finally, we only find three relatively small-sized countries (Armenia, Belarus, and Sri Lanka) whose bilateral exchange rate volatilities are best fitted by the GARCH-M process. This fact implies that almost the return series is independent of its volatility.

The second step is to re-estimate the selected model using the full-sample observations with an introduced intervention item (Enders, 1990; Enders, 2015; Enders and Sandler, 1993). Table 3 summarizes the best results for each country's bilateral exchange rates chosen from the five different impact scenarios proposed in the previous section.[9] Our result sheds several new lights on the impact of BSAs.

First, we find certain volatility depressing effects of the BSAs, although the effects vary across countries (and regions) and sometimes can even be reversed. Among the 37 countries (and regions) under investigation, 21 out of 37 samples present significant effects of BSAs on bilateral exchange rate volatility as the coefficient of the intervention item is statistically significant. In addition, among these 21 significant cases, there are 16 return series that appear significantly negative effects. This result is consistent with the conclusions in previous studies that the central bank swap lines conducted by the U.S. Federal Reserve during the 2007–2009 global financial crisis had substantially relieved the panic in out-of-American financial markets and smoothed the exchange market turmoil in other countries like Korea (Aizenman et al., 2011; Aizenman and Pasricha, 2010; Andrieș et al., 2017; Fleming, 2012; Goldberg et al., 2010; Obstfeld et al., 2009; Rose and Spiegel, 2012). The main purpose of bilateral currency swap conducted by the PBOC, as demonstrated in its annual report, is "[to]…improve and play an active role in facilitating bilateral trade and investment and

[9] Table A-3 in the Appendix reports the detailed re-estimated results under the five impacting scenarios, including the impact of BSAs might last one month (i.e., pulse), one quarter (i.e., prolonged three months), half a year (i.e., prolonged six months), one year (i.e., prolonged 12 months), and forever (i.e., pure jump).

Table 4
Results of the approach using the EWMA volatility model and R-square.

	Prolonged 1 Month		Prolonged 3 Month		Prolonged 6 Month		Prolonged 12 Month		Pure Jump	
Country/region	estimated	Adj-R^2	estimated	Adj-R^2	estimated	Adj-R^2	estimated	Adj-R^2	estimated	Adj-R^2
Panel A: Results of using monthly exchange rates data										
Albania	−0.2658	−0.0029	−0.3061	0.0055	−0.3340**	0.0204	−0.4326***	0.0755	−0.5496***	**0.2641**
	(0.3763)		(0.2190)		(0.1565)		(0.1118)		(0.0696)	
Argentina	0.0662	−0.0059	0.0400	−0.0059	−0.0406	−0.0058	−0.1278	−0.0051	0.2536	−0.0022
	(1.0592)		(0.6227)		(0.4530)		(0.3407)		(0.3196)	
Armenia	0.1868	−0.0051	0.1645	−0.0040	0.1214	−0.0038	0.0686	−0.0046	−0.5438***	**0.2665**
	(0.4981)		(0.2891)		(0.2063)		(0.1486)		(0.0684)	
Australia	−0.0346	−0.0058	−0.0558	−0.0055	−0.0725	−0.0048	−0.1662	0.0043	−0.5706***	**0.1741**
	(0.3934)		(0.2313)		(0.1682)		(0.1260)		(0.0937)	
Belarus	−0.1263	−0.0058	−0.2082	−0.0054	−0.3185	−0.0036	−0.5873	0.0081	1.9405***	**0.1638**
	(1.1890)		(0.6988)		(0.5079)		(0.3800)		(0.3303)	
Brazil	−0.2227	−0.0040	−0.2810	0.0028	−0.2908*	0.0125	−0.3193***	0.0368	0.1762***	**0.0441**
	(0.3979)		(0.2303)		(0.1635)		(0.1163)		(0.0591)	
Canada	−0.3742	0.0029	−0.4115**	0.0253	−0.3354***	0.0340	−0.3111***	0.0576	−0.4772***	**0.2808**
	(0.3057)		(0.1766)		(0.1266)		(0.0919)		(0.0580)	
Chile	−0.4893	0.0025	−0.5194**	0.0217	−0.4829***	0.0401	−0.4861***	0.0804	−0.7282***	**0.3482**
	(0.4097)		(0.2371)		(0.1691)		(0.1217)		(0.0758)	
Hong Kong, SAR	−0.0748	−0.0037	−0.0839	0.0019	−0.0760	0.0060	−0.0493	0.0025	−0.0284	−0.0034
	(0.1234)		(0.0728)		(0.0534)		(0.0413)		(0.0440)	
Egypt	7.6789**	0.0312	7.5942***	0.1015	7.7320***	0.2129	7.6404***	0.4059	6.8223***	**0.8482**
	(3.0120)		(1.6845)		(1.1249)		(0.7039))		(0.2206))	
EUR	0.0863	−0.0055	0.0456	−0.0056	−0.0112	−0.0058	−0.1111	0.0003	−0.4021***	**0.1601**
	(0.3512)		(0.2052)		(0.1478)		(0.1083)		(0.0694)	
Hungary	−0.0763	−0.0058	−0.1330	−0.0053	−0.2087	−0.0032	−0.3750*	0.0102	−1.3260***	**0.4063**
	(0.7359)		(0.4299)		(0.3093)		(0.2259)		(0.1221)	
Iceland	0.0651	−0.0058	0.0173	−0.0059	0.0263	−0.0058	−0.0372	−0.0057	−1.1728***	**0.2429**
	(0.6504)		(0.3824)		(0.2781)		(0.2093)		(0.1569)	
Indonesia	0.2376	−0.0029	0.3250*	0.0103	0.3658***	0.0329	0.3550***	**0.0586**	0.2043**	0.0179
	(0.3338)		(0.1950)		(0.1402)		(0.1041)		(0.1007)	
Japan	−0.2745	0.0022	−0.3054**	0.0237	−0.3560***	0.0730	−0.3986***	0.1849	−0.3923***	**0.2208**
	(0.2343)		(0.1346)		(0.0936)		(0.0632)		(0.0558)	
Kazakhstan	0.0008	−0.0059	−0.0476	−0.0057	−0.1117	−0.0041	−0.0497	−0.0053	0.3290***	**0.0330**
	(0.4808)		(0.2826)		(0.2054)		(0.1547)		(0.1259)	
Korea	0.5770	0.0032	0.5987**	0.0222	0.5974***	0.0458	0.5624***	**0.0708**	0.4225***	0.0345
	(0.4627)		(0.2711)		(0.1969)		(0.1501)		(0.1585)	
Malaysia	0.1022	−0.0036	0.1064	0.0012	0.1179*	0.0102	0.1425***	0.0334	0.4298***	**0.3171**
	(0.1643)		(0.0970)		(0.0710)		(0.0542)		(0.0479)	
Mongolia	0.3048*	0.0105	0.3145***	0.0440	0.2959***	0.0757	0.2675***	0.1030	0.2994***	**0.1605**
	(0.1817)		(0.1056)		(0.0764)		(0.0589)		(0.0516)	
Morocco	−0.0631	−0.0058	−0.0967	−0.0051	−0.1466	−0.0022	−0.2484*	0.0146	−0.6230***	**0.3723**
	(0.4472)		(0.2596)		(0.1850)		(0.1321)		(0.0616)	
New Zealand	−0.0377	−0.0058	−0.0727	−0.0049	−0.1107	−0.0014	−0.0250	−0.0055	−0.2743***	**0.0639**
	(0.2975)		(0.1748)		(0.1269)		(0.0957)		(0.0770)	
Nigeria	2.0119	0.0067	1.9608**	0.0296	1.9108***	0.0603	1.7791***	0.1047	1.5801***	**0.1381**
	(1.3706)		(0.7868)		(0.5524)		(0.3883)		(0.2965)	
Pakistan	0.0398	−0.0056	0.0349	−0.0053	0.0053	−0.0059	0.0297	−0.0045	−0.0496	−0.0002
	(0.1907)		(0.1121)		(0.0816)		(0.0613)		(0.0502)	

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Table 4 (*continued*)

	Prolonged 1 Month		Prolonged 3 Month		Prolonged 6 Month		Prolonged 12 Month		Pure Jump	
Country/region	estimated	Adj-R^2	estimated	Adj-R^2	estimated	Adj-R^2	estimated	Adj-R^2	estimated	Adj-R^2
Qatar	−0.0709	−0.0049	−0.0749	−0.0025	−0.0404	−0.0040	0.0505	−0.0005	0.2983***	**0.3558**
	(0.1708)		(0.0997)		(0.0718)		(0.0527)		(0.0305)	
Russia	0.1203	−0.0057	0.2425	−0.0039	0.7101**	0.0273	1.1750***	0.1623	1.6633***	**0.6457**
	(0.7123)		(0.4158)		(0.2948)		(0.2011)		(0.0941)	
Serbia	−0.3532	−0.0050	−0.4098	−0.0023	−0.4923	0.0043	−0.6545**	0.0289	−1.3997***	**0.4531**
	(0.9048)		(0.5247)		(0.3731)		(0.2654)		(0.1172)	
Singapore	0.1369	−0.0006	0.1499*	0.0126	0.1575**	0.0326	0.1329***	0.0426	0.1608***	**0.0899**
	(0.1439)		(0.0841)		(0.0605)		(0.0453)		(0.0380)	
South Africa	−0.5373	0.0070	−0.5860***	0.0389	−0.5676***	0.0750	−0.5018***	0.1111	−0.6532***	**0.3599**
	(0.3624)		(0.2083)		(0.1472)		(0.1061)		(0.0663)	
Sri Lanka	−0.0111	−0.0059	−0.0315	−0.0054	−0.0616	−0.0025	−0.1215**	0.0197	0.0898***	**0.0445**
	(0.1958)		(0.1137)		(0.0810)		(0.0577)		(0.0300)	
Suriname	−0.0333	−0.0059	−0.0811	−0.0058	−0.1521	−0.0051	−0.0034	−0.0059	2.1786***	**0.5177**
	(1.0213)		(0.5967)		(0.4296)		(0.3217)		(0.1604)	
Switzerland	−0.3613	0.0001	−0.3953*	0.0150	−0.4082***	0.0369	−0.4143***	0.0757	−0.6044***	**0.3362**
	(0.3595)		(0.2085)		(0.1485)		(0.1069)		(0.0646)	
Tajikistan	0.3882	−0.0014	0.4083	0.0088	0.5131***	0.0396	0.7286***	0.1709	0.6781***	**0.4917**
	(0.4457)		(0.2575)		(0.1808)		(0.1210)		(0.0526)	
Thailand	0.0096	−0.0058	0.0102	−0.0056	−0.0058	−0.0057	−0.0037	−0.0057	0.0119	−0.0038
	(0.0759)		(0.0446)		(0.0325)		(0.0244)		(0.0200)	
Turkey	−0.3182	−0.0038	−0.3367	0.0010	−0.4048*	0.0133	−0.5809***	0.0672	−0.5339***	**0.1212**
	(0.5338)		(0.3111)		(0.2227)		(0.1592)		(0.1077)	
Ukraine	1.4136	0.0012	1.3621*	0.0133	1.2928**	0.0267	1.1666***	0.0410	1.9736***	**0.1961**
	(1.2833)		(0.7499)		(0.5418)		(0.4047)		(0.3020)	
UAE	−0.0357	−0.0056	−0.0290	−0.0054	−0.0297	−0.0049	−0.0330	−0.0036	0.0973***	**0.0353**
	(0.1709)		(0.0998)		(0.0719)		(0.0528)		(0.0361)	
UK	−0.1808	−0.0005	−0.2187**	0.0168	−0.2521***	0.0512	−0.3092***	0.1457	−0.4039***	**0.3824**
	(0.1893)		(0.1103)		(0.0788)		(0.0563)		(0.0391)	
Panel B: Results of using daily official exchange rates reported by the PBOC										
EUR	−0.2876**	0.0009	−0.2770***	0.0031	−0.2882***	0.0067	−0.3392***	0.0178	−0.3756***	**0.0451**
	(0.1406)		(0.0804)		(0.0581)		(0.0422)		(0.0291)	
Hong Kong, SAR	−0.0354***	0.0017	−0.0337***	0.0046	−0.0327***	**0.0083**	−0.0163***	0.0034	−0.0121**	0.0016
	(0.0135)		(0.0081)		(0.0059)		(0.0045)		(0.0047)	
Japan	−0.2774*	0.0006	−0.2432***	0.0018	−0.2765***	0.0048	−0.2863***	0.0103	−0.3042***	**0.0138**
	(0.1544)		(0.0903)		(0.0654)		(0.0467)		(0.0429)	
UK	−0.1826	0.0002	−0.2021**	0.0016	−0.2038***	0.0031	−0.2075***	0.0060	−0.3574***	**0.0265**
	(0.1400)		(0.0819)		(0.0607)		(0.0457)		(0.0377)	
Canada	−0.1777	0.0001	−0.1570*	0.0009	−0.1140	0.0008	−0.1303**	0.0024	−0.4067***	**0.0354**
	(0.1610)		(0.0954)		(0.0715)		(0.0540)		(0.0476)	
Russia	−0.3328	0.0004	0.3508**	0.0021	0.6056***	**0.0134**	0.3963***	0.0101	−0.1802***	0.0027
	(0.2433)		(0.1481)		(0.1085)		(0.0818)		(0.0686)	

Notes: Panel A reports the impact of swap on volatility. The volatility is calculated by EWMA and the same dummy variables are employed as mentioned in Section 2. Panel B reports the impact of swaps on volatility by using the daily exchange rates collected from the website of PBOC. The daily volatility is also calculated using the EWMA approach. But for the daily data, we transform the valid periods of dummy variables into prolonged 30, 90, 180, and 360 days for the corresponding prolonged 1, 3, 6, and 12 months, respectively. The bold number indicates the best-fitted (highest adjusted-R^2) dummy for a country. ***, **, and * indicate significance level of 1%, 5%, and 10%, respectively.

maintaining financial stability…" (The People's Bank of China, 2019). As exchange rate volatility (i.e., risk) always plays an important role in transnational economic activities, and the exchange rate risk is one of the major potential triggers of the financial crisis in China (Allen et al., 2017; Allen et al., 2008; Allen et al., 2012), our second result of 16 samples with significantly negative effects out of 37 cases demonstrates that PBOC has, at least to a certain extent, achieved its policy goals.

Second, we find that among the 21 significant cases, the pattern of the 16 negative effects is quite different from that of the 5 positive ones: the positive effects are generally much more persistent than that of the negative ones. Among the five countries or regions that have shown the positive effect of BSAs on exchange rate volatility, three cases show an influential pattern of a pure jump. At the same time, the other two cases are prolonged for six months (see Fig. 1 for the patterns of intervention items). Meanwhile, for the 16 cases of negative effects, 12 cases show an influential pattern of no more than six months, and four exceptions show a pattern of a pure jump. The relatively short-term negative effects of BSAs are also consistent with the findings in earlier literature based on the currency swap lines of the U.S. Federal Reserve (Moessner and Allen, 2013). Again, the disparity between with and without significant effects and between the significantly positive and negative groups validates the necessity of considering various volatility modeling approaches and different intervention items for the analysis in this study.

Since its inception in 1981, currency swap has been widely used by global firms to hedge for exchange risk exposure (Allayannis and Ofek, 2001; Géczy et al., 1997; Goswami et al., 2004), implying volatility depressing effect of currency swap for conventional end-users. Similar volatility depression effects also have been observed for the central bank swap lines by the U.S. Federal Reserve (Aizenman and Pasricha, 2010; Rose and Spiegel, 2012), although the market player is different and mainly serves as an effective international lender of last resort (Bahaj and Reis, 2022a, 2022b; Carré and Le Maux, 2020). The much more complicated influential effects of the PBOC's BSAs, especially presenting some positive effect cases, suggest the complicated role of China as an emerging global economic giant. For instance, the persistent positive effect of BSAs on the exchange rate volatility of Hong Kong SAR might be caused by its role as a principal offshore settlement center of the China RMB. The positive effects of the other four countries might reflect their close economic relationship with China, for the international trade of primary commodities (e.g., crude oil in Qatar).[10] Signing a BSA with PBOC, along with their close economic relationship with mainland China, might induce more speculative activities on the exchange markets and thus increase the bilateral exchange volatility.

On the other hand, we observe that the BSAs of PBOC exert a certain global influence beyond the East-Asian area. For instance, besides Asian countries like Japan, Korea, and Malaysia, there is also a significant influence on Australia, New Zealand, Brazil, South Africa, and the European Currency Union Area. Such results confirm the argument in earlier literature that alongside the growing importance of the Chinese economy in the world, RMB will play an increasingly important role both in Asia and in the world (Ito, 2017; Subramanian and Kessler, 2013).

In summary, we find certain volatility depressing effects of the PBOC's BSAs. However, the results vary across countries (or regions) and sometimes can even be reversed. The disparities of such influential patterns suggest the complicated role of China as an emerging economic giant with an increasing global influence. Nevertheless, these results are obtained from a model-selection approach using information criteria and monthly exchange rate data. In what follows, we will further discuss this issue based on the approach using the EWMA volatility model and R-square.

3.2. EWMA method

As discussed in the methodology section, the proposed intervention analysis based on the model selection approach depends heavily on the statistical value (i.e., information criteria) or statistical significance (i.e., p-value), thus might introduce selection bias. In the following examination, we use the exchange rate volatility series calculated from EWMA and model selection based on the R^2 of regression of the calculated volatility series on intervention items as a robustness check. Panel A of Table 4 reports the reexamination results for all 37 countries (or regions).

Panel A shows that among the 37 countries (and regions) under investigation, 33 out of 37 present significant effects of BSAs on bilateral exchange rate volatility; and among the 33 significant cases, there are a comparable number of countries show positive effects versus that of negative effects (17 versus 16). The number of significant (and positive effect) cases is much higher than that using the proposed modeling selection approach based on information criteria. But similar to the previous results, Panel A shows that the countries with positive effects are almost the emerging market countries or China's neighbor countries, while the ones with significant negative effects are mostly the developed countries (e.g., Canada, Japan, and UK). Although we shall interpret such results with a caveat because of the two intrinsic defects in the approach used here—restricting all the 37 bilateral exchange rates volatility into the same data generating process and tending to select the effects of longer time-span due to shock persistence—Panel A confirms two key findings from our previously proposed model selection approach: (1) PBOC's BSAs do affect its bilateral exchange rates volatility; (2) the effects vary across countries (or regions).

We also re-conduct the examination for the six available daily official exchange rates of the countries or regions that signed a BSA with PBOC (i.e., EUR, Hong Kong SAR, Japan, UK, Canada, and Russia). The key variables for financial risk management like the value at risk (VaR) are generally calculated at a daily frequency and the EWMA volatility model is widely used in the financial sector in practice (Boucher et al., 2014; Jorion, 2007, 2011; Nieto and Ruiz, 2016). Thus, the reexamination using daily official exchange rate data will carry important implications besides as a robustness check for the potential selection bias.

[10] More specifically, UAE's Dubai crude oil and Upper Zakum crude oil, and Qatar Marine crude oil are among the eight delivered crudes for matured futures contacts in China's Shanghai International Energy Exchange (INE) crude oil futures markets. See Yu et al. (2023) for the details.

Panel B of Table 4 reports the related results showing a similar pattern that has been revealed from the monthly data. Panel B shows that a BSA exerts a significantly negative effect on the exchange rate volatility for all the sample countries (or regions) except Russia. In the case of Russia, it has a significantly positive effect. The results, again, show that BSAs may depress bilateral exchange rate volatility, but the effects vary across countries (or regions). Therefore, the possible model selection bias in the proposed intervention analysis approach does not affect our key conclusions.

4. Driving forces behind the pattern of BSAs

This section uses logistic regression to analyze further what factors affect the influential pattern of the BSAs on bilateral exchange rate volatility. The basic regression described in Section 2 is given by: $\text{Prob}(Y_i = 1) = \alpha_0 + \beta X_i + \varepsilon_i$, where $\text{Prob}(Y_i = 1)$ is the dependent variable indicating whether the intervention item is estimated significantly at 5% level for the whole sample or whether the intervention item is estimated significantly negative shown in Table 3. The vector X_i is the specific factor(s) that may affect the value of Y, including gravity model factors, international trade factors, financial development factors, macroeconomic factors, institutional factors, and bilateral diplomatic relationship factors. The term α_0 is the constant intercept, and as usual ε_i is the error term.

To avoid the possible correlation between X_i and ε_i and obtain a consistent estimation, all the variables in X_i are proxied by the five-year average value before signing the first BSA with PBOC for each sample country (or region).[11] Thus, X_i will be the predetermined variables in later regression analysis. Table A-2 in the appendix summarizes the detailed information about the variables used for later regression analysis. Following Yang and Zhou (2013) and Yang et al. (2021), we first run a simple regression to investigate the statistically significant factors, and then conduct a multiple regression, as the detected significant variables may highly correlate with each other (see Table A-4 in the appendix).

First, we examine the impact of two gravity model factors on the BSAs' influential pattern, because promoting the usage of RMB in bilateral trade and investment is the major motivation for PBOC's BSAs. In this analysis, we consider GDP and bilateral distance as two key factors used in the gravity model which is the most successful in explaining bilateral trade flows (Feenstra et al., 2001). We use the distance between Beijing and the capital city of a specific country as a proxy for measuring the distance between China and its counterpart. The logistic regression results show that the coefficient of GDP is estimated significantly positive and distance is significantly negative for whether BSAs can be effective (column 2 in Panel A of Table 5). Nevertheless, none of the two variables is estimated significantly for whether the effect is negative (column 2 in Panel B of Table 5).

Second, we examine the impact of trading flow and FTA (i.e., Free Trade Agreement) on the influential pattern, which provides further direct evidence of the effects of bilateral trade. Interestingly, the results illustrate that the bilateral trade flow significantly affects whether a BSA will be effective (column 3 of Panel A of Table 5). In contrast, FTA significantly affects whether an effective BSA can decrease the exchange rate volatility (column 3 of Panel B of Table 5).

Third, we examine the impact of financial development on the influential pattern of BSAs. A previous study on the BSAs of the U.S. Federal Reserve finds that capital account openness highly correlates with the central bank swap arrangements (Aizenman and Pasricha, 2010). Domestic financial markets development and capital account openness are also highly correlated with RMB internationalization (Prasad, 2017); Subacchi, 2016). We use the Chinn-Ito index (Chinn and Ito, 2008) and the 2019 Financial Center Index from the "Long Time" as two proxies of financial development factors.[12] The regression results reveal that both variables significantly affect whether BSAs can be effective and whether the effect is negative.

Fourth, we examine the impact of macroeconomic factors, including sovereign default history, inflation rate, and whether the country is a developed country. These three variables significantly affect whether a BSA will be effective, yet only inflation is less significant at 10% for whether the effect is negative.

Fifth, we examine the impact of the institutional factor—measured by the World Bank's rule of law indicator (*Rule of Law*). The results show that institutional factors significantly affect both whether a BSA can be effective and whether the effect is negative.

Sixth, we examine the impact of bilateral political relationships. We consider two variables here: (1) variable US_Miltary indicates whether a U.S. military base exists in that country, which is a proxy for the close diplomatic relationship with the U.S. (Chey et al., 2019). A solid bilateral political connection with the U.S. might depress the effect of BSAs conducted by China's PBOC; (2) variable *BeltRoad* indicates whether a country participated in China's 'Belt and Road Initiative' during the sample period. Recent studies show that the "Belt and Road Initiative" has significantly affected China's firm-level exporting behaviors, and thus might also potentially affect the trade flow and financial factors, including exchange rate volatility (Tong et al., 2020; Yu and Tong, 2020). Interestingly, *US_Miltary* significantly only affects whether a BSA can be effective while *BeltRoad* only significantly affects whether the effect is negative, as shown in column 7 in each panel of Table 5.

[11] The data used for later regression analysis are in fact compressed into the cross-sectional form. We also estimated all the results using the commonly used panel data following related literature (e.g., Yang and Zhou, 2013; Yang, Tong, and Yu, 2021; Yu et al., 2023). The detected significant variables using the panel data are more than that using the compressed data. But the conclusions using both data are quite similar. The results are available on request.

[12] Accessed at https://www.longfinance.net/programmes/financial-centre-futures/global-financial-centres-index. The index includes 104 cities from different countries and rank these cities through an algorithm which considers education, infrastructure, regulation, among others. We generate a categorical variable to evaluate the financial development of a country by the rank of its cities. If a country has more than one city listed in the index, we only consider the city with highest rank in a country. As there are 104 cities in the index, we assign 6 to the top 17 cities, 5 to the cities ranked between 18 and 34, so on and so forth, till we assign value 1 to the cities ranked below 86 (included).

Table 5
Regression analysis for the determinants.

Panel A: Determinants of whether a BSA can be effective							
log(GDP)	0.0849**						−0.1896***
	(2.4367)						(−2.6524)
Proximity with China	−0.7521***						−0.9433***
	(−6.7836)						(−6.8759)
log(Trade Flow)		0.1738***					0.2267***
		(5.8374)					(4.1089)
FTA		−0.0077					
		(−0.0527)					
Chinn − Ito Index			0.2969***				0.3363***
			(4.6860)				(3.5315)
Financial Center Index			0.0763**				0.2718***
			(2.1574)				(3.6989)
Sovereign Default				−1.5782***			−1.8117***
				(−6.4423)			(−6.4720)
Inflation				−18.1925***			−5.2173
				(−7.3338)			(−1.5957)
Developed				−1.2096***			−4.1097***
				(−6.0910)			(−9.3431)
Rule of Law					0.1512**		0.5141***
					(2.3143)		(3.9598)
US_Miltary						0.4277***	0.4869**
						(2.7234)	(2.0775)
BeltRoad						−0.1194	
						(−0.7408)	
Constant	4.6679***	−2.2018***	−0.0390	1.9425***	0.2338***	0.2397	10.9045***
	(3.5854)	(−5.2749)	(−0.3744)	(9.9061)	(3.4065)	(1.5275)	(6.0865)
Observations	37	37	37	37	37	37	37
McFadden R Square	0.0557	0.0353	0.0666	0.2037	0.0027	0.0075	0.3334
Panel B: Determinants of whether a significant effect is negative							
log(GDP)	0.0056						
	(0.1071)						
Proximity with China	−0.0247						
	(−0.1997)						
log(Trade Flow)		0.0112					
		(0.3976)					
FTA		0.9002***					−3.8669***
		(3.7128)					(−6.4406)
Chinn − Ito Index			0.2180**				−3.5477***
			(2.3270)				(−8.3540)
Financial Center Index			−0.3501***				−2.5420***
			(−5.9086)				(−8.8301)
Sovereign Default				−17.5003			
				(−0.0300)			
Inflation				−8.2790*			
				(−1.7754)			
Developed				0.1401			
				(0.4724)			
Rule of Law					0.5368***		10.8580***
					(4.6132)		(8.9644)
US_Miltary						0.0359	
						(0.1527)	
BeltRoad						0.5894**	3.4914***
						(2.4881)	(7.3619)
Constant	1.2225	0.7315*	2.2413***	1.6936***	1.0023***	0.7543***	7.5145***
	(0.7370)	(1.7138)	(9.6986)	(6.0254)	(9.6236)	(3.2687)	(8.3346)
Observations	21	21	21	21	21	21	21
McFadden R Square	0.0002	0.0244	0.0570	0.1636	0.0360	0.0204	0.4666

Notes: This table reports the results of logistic regression with robust standard errors. The *t*-statistics are in the parenthesis. ***, **, and * denote significant at 1%, 5%, and 10% level, respectively.

Finally, we conduct two multiple regressions to explore the relatively more important factors further, as the detected significant variables might correlate highly with each other (see Appendix Table A-4). For the detected significant variables on whether a BSA can be effective (Panel A of Table 5), the multiple regression results show that only the estimated coefficient of GDP changes its sign into negative, and the estimated coefficient of inflation loses its significance. The other variables are still estimated significant at the conventional 5% level with the same sign as before, and only some estimated significance might slightly change for a few variables. This result implies that whether a PBOC's BSA can be effective is highly fundamental-based. For whether the significant effect is negative (Panel B of Table 5), the estimated coefficients of FTA and Chinn-Ito index change from positive to negative. The coefficient of Financial Market development, the rule of law, and the *BeltRoad* are still estimated significantly with the same sign as before. This result indicates that financial market development, institution, and participation in the "Belt and Road Initiative" are the three most important determinants in whether a significant effect is negative.

In summary, we find that the impact of BSAs on bilateral exchange rate volatility is fundamental-based. Financial market development, domestic institutional factors, bilateral political relationship, and other factors appear to be the most significant determinants for the influential pattern of PBOC's BSAs.

5. Conclusions

In the past decade, central bank bilateral currency swap arrangements have profoundly reshaped the architecture of the international financial system, yet the consequences of such behavior have rarely been explored. This study examines how central bank currency swap behaviors affect the bilateral exchange rate volatility with evidence from China. Specifically, we examine the impact of bilateral currency swap arrangements (BSAs) conducted by the People's Bank of China on bilateral exchange rate volatility from 2009 to 2019. Applying an intervention analysis based on a model-selection approach, we find that such an arrangement significantly affects 21 bilateral exchange rate series' volatility out of the 37 cases under consideration and that there are 16 series among the above 21 significant cases affecting the volatility negatively. The negative effects, on average, last a shorter period than the positive ones. The results imply that BSAs might temporarily depress bilateral exchange rate volatility in general, but the effects vary across countries (or regions) and sometimes can even be reversed. Further regression analysis reveals that financial market development, domestic institutional factors, and bilateral political relationships, among other factors, appear to be significant determinants for the influential pattern of BSAs. These findings extend the existing literature on central bank swap lines and Renminbi internationalization, and also highlight the importance of considering BSAs in any discussion of international financial issues for the past decade. Future research on the impact of BSAs on bilateral trade and investment will be fruitful.

Author agreement

The authors warrant that the article is the original work, hasn't received prior publication and isn't under consideration for publication elsewhere.

Declaration of Competing Interest

None.

Data availability

We have shared the link to our data/code at the Attached File step.

Data&Codes for "Central Bank Currency Swap Arrangements Central Bank Swap Arrangements and Exchange Rate Volatility: Evidence from China" (Original data) (Mendeley Data)

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Appendix A

Table A-1
BSAs signed by PBOC, 2009/01–2019/06.

Country and region	Date	Size (Billion Renminbi)	Country and region	Date	Size (Billion Renminbi)
Albania	9/12/2013	2	Japan	10/26/2018	200
	4/3/2018	2	Mongolia	5/6/2011	5
Argentina	4/2/2009	70		3/20/2012	10
	7/18/2014	70		8/21/2014	15
	7/18/2017	70		7/6/2017	15
Armenia	3/25/2015	1	Morocco	5/11/2016	10
Australia	3/22/2012	200	New Zealand	4/18/2011	25
	3/30/2015	200		4/25/2014	25
	3/30/2018	200		5/19/2017	25
Belarus	3/11/2009	20	Nigeria	4/27/2018	15
	5/10/2015	7	Pakistan	12/23/2011	10
	5/10/2018	7		12/23/2014	10
Brazil	3/26/2013	190		5/23/2018	20
Canada	11/8/2014	200	Qatar	11/3/2014	35
	11/8/2017	200		11/2/2017	35
Chile	5/25/2015	22	Russia	10/13/2014	150
	5/25/2018	22		11/22/2017	150
Egypt	12/6/2016	18	Serbia	6/17/2016	1.5
EUR	10/8/2013	350	Singapore	7/23/2010	150
	9/27/2016	350		3/7/2013	300
Hong Kong, SAR	1/20/2009	200		3/7/2016	300
	11/22/2011	400	South Africa	4/10/2015	30
	11/22/2014	400		4/11/2018	30
	11/22/2017	400	Sri Lanka	9/16/2014	10
Hungary	9/9/2013	10	Surinam	3/18/2015	1
	9/12/2016	10		2/11/2019	1
Iceland	6/9/2010	3.5	Switzerland	7/21/2014	150
	9/11/2013	3.5		7/21/2017	150
	12/21/2016	3.5	Tajikistan	9/3/2015	3
Indonesia	3/23/2009	100	Thailand	12/22/2011	70
	10/1/2013	100		12/22/2014	70
	11/16/2018	200		12/22/2017	70
Kazakhstan	6/13/2011	7	Turkey	2/21/2012	10
	12/14/2014	7		9/26/2015	12
	5/28/2018	7	UAE	1/17/2012	35
Korea	4/20/2009	180		12/14/2015	35
	10/26/2011	360	UK	6/22/2013	200
	10/11/2014	360		10/20/2015	350
	10/11/2017	360		10/13/2018	350
Malaysia	2/8/2009	80	Ukraine	6/26/2012	15
	2/8/2012	180		5/15/2015	15
	4/17/2015	180		12/10/2018	15
	8/20/2018	180	Uzbekistan	4/19/2011	0.7

Notes: All information is collected from PBOC's *2019 RMB Internationalization Report*.

Table A-2
The definition and data source of dependent variables.

Variable	Definition	Source
log(GDP)	Logarithm value of GDP, 2005–2018 average value	world bank
Proximity with China	Logarithm value of the distance from Beijing to the capital of a specific country, km	https://distancecalculator.globefeed.com/
log(Trade Flow)	Logarithm value of bilateral trade, 2005–2018 average value	UN Comtrade Database
FTA	A dummy variable equals 1 when there is an FTA between China and a specific country	http://fta.mofcom.gov.cn
Chinn − Ito index	Chinn-Ito index of indicating the capital account openness	http://web.pdx.edu/~ito/Chinn-Ito_website.htm
Financial Center Index	Long financial center index (2019)	https://www.longfinance.net/programmes/financial-centre-futures
Sovereign Default	A dummy variable equals 1 if a sovereign default happened between 1983 and 2001	The Moody's "Special Comment: Sovereign Default and Recovery Rates
Inflation	Inflation rate, 2005–2018 average value	IMF&National Statistics & Census Institute

(*continued on next page*)

Table A-2 (*continued*)

Variable	Definition	Source
Developed	A dummy variable equals 1 if a country is classified as the developed economic entity	https://www.imf.org
Rule of Law	The rule of law index, 2005–2018 average value	https://databank.worldbank.org/source/worldwide-governance-indicators
US_Miltary	A dummy variable equals 1 if there is a US military base in a specific country	Wikipedia
BeltRoad	A dummy variable equals 1 if the country participants in China's "Belt and Road Initiative"	https://eng.yidaiyilu.gov.cn/i

Table A-3
Estimation results of the intervention analysis under five scenarios.

Panel I: Results of an intervention item as pulse.

Country and Region	Alpha	Beta	D	Alpha+Beta	AIC	SBC
Albania	0.2101**	0.5756***	0.0000	0.7857	4.3079	4.4016
	(2.4855)	(3.7428)	(0.0000)			
Argentina	0.4177***	0.5822	0.0000	1.0000	4.5124	4.6062
	(7.6456)	NA	(0.0000)			
Armenia	0.0000	0.9967***	0.0000	0.9967	4.3123	4.4248
	(0.0000)	(514,158.5943)	(0.0000)			
Australia	0.1028	0.7045***	−0.2109	0.8073	4.6599	4.7911
	(0.9422)	(4.3547)	(−0.2863)			
Belarus	0.0000	0.9970***	0.0000	0.9970	6.1024	6.2149
	(0.0000)	(194,061.249)	(0.0000)			
Brazil	0.3457***	0.0984	−2.0951**	0.4442	5.1096	5.2408
	(2.6310)	(0.4800)	(−2.0471)			
Canada	0.2792	0.7207	0.0000	1.0000	4.1304	4.2241
	(1.0995)	NA	(0.0000)			
Chile	0.2778**	0.4261	−0.6757	0.7039	4.6153	4.7466
	(2.5051)	(1.5089)	(−0.7658)			
Hong Kong, SAR	0.1649***	0.8016***	1.5900**	0.9665	1.8582	1.9707
	(3.9164)	(21.7918)	(2.3717)			
Egypt	0.2090***	0.7909	0.0000	1.0000	5.7270	5.8207
	(10.0132)	NA	(0.0000)			
EUR	0.1817**	0.7206***	0.0000	0.9023	4.3101	4.4039
	(2.4760)	(7.9246)	(0.0000)			
Hungary	0.0751*	0.9172***	0.0000	0.9924	5.0961	5.2274
	(1.7958)	(19.6978)	(0.0000)			
Iceland	0.4734***	0.4122***	0.0000	0.8857	4.9755	5.0693
	(3.0299)	(3.4813)	(0.0000)			
Indonesia	0.7564***	0.2435	0.0000	1.0000	3.9939	4.0876
	(6.6081)	NA	(0.0000)			
Japan	0.0184	0.0039	−31.9295***	0.0224	4.3557	4.4869
	(0.1569)	(0.0795)	(−9.2581)			
Kazakhstan	0.0000	0.9999***	0.0000	0.9999	5.0575	5.1512
	(0.0000)	(3776.5769)	(0.0000)			
Korea	0.2181***	0.7260***	0.0000	0.9441	4.1846	4.3158
	(2.6754)	(7.2475)	(0.0000)			
Malaysia	0.2465**	0.4410***	1.5428	0.6876	3.7205	3.8330
	(2.5225)	(2.6779)	(0.8294)			
Mongolia	0.0595	0.7551***	−1.8232***	0.8146	3.9311	4.0436
	(0.5152)	(10.6151)	(−2.8342)			
Morocco	0.1346**	0.8087***	0.0000	0.9434	3.9229	4.0542
	(2.1905)	(12.9443)	(0.0000)			
New Zealand	0.0802	0.8922***	−0.3950	0.9724	4.7605	4.8917
	(1.3768)	(6.0052)	(−0.6939)			
Nigeria	0.2125***	0.7874	0.0000	1.0000	4.3404	4.4342
	(8.8707)	NA	(0.0000)			
Pakistan	0.0000	0.9999	0.0000	1.0000	3.4842	3.5779
	(0.0000)	NA	(0.0000)			
Qatar	0.0181	0.9609***	4.2510***	0.9791	1.6424	1.7736
	(0.5165)	(68.0020)	(5.6345)			
Russia	0.4668***	0.5331	0.0000	1.0000	5.0059	5.0997
	(6.2136)	NA	(0.0000)			
Serbia	0.2820***	0.7020***	−5.5027**	0.9841	4.6644	4.7956
	(2.9797)	(5.2054)	(−2.0162)			
Singapore	0.0000	0.9999	0.0000	1.0000	2.9645	3.0583
	(0.0000)	NA	(0.0000)			
South Africa	0.1223	0.8342***	0.0000	0.9565	5.3908	5.5033

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Table A-3 (*continued*)

Panel I: Results of an intervention item as pulse.						
Country and Region	Alpha	Beta	D	Alpha+Beta	AIC	SBC
	(1.6448)	(9.1678)	(0.0000)			
Sri Lanka	0.0329	0.1050***	−38.2945***	0.1380	2.8592	2.9717
	(0.2410)	(2.9236)	(−17.1190)			
Suriname	0.5278***	0.4721	0.0000	1.0000	3.8355	3.9292
	(9.3726)	NA	(0.0000)			
Switzerland	0.2126**	0.7385***	1.5986	0.9512	4.4539	4.5663
	(2.0579)	(5.6600)	(0.5904)			
Tajikistan	0.4787***	0.0839***	−25.0778***	0.5627	3.1400	3.2712
	(4.4403)	(3.7804)	(−17.3894)			
Thailand	0.1690***	0.6350***	1.6706	0.8040	3.3034	3.4159
	(2.6256)	(5.8421)	(1.0038)			
Turkey	0.4283**	0.4446***	0.0000	0.8729	5.2437	5.3562
	(2.4716)	(2.9351)	(0.0000)			
Ukraine	0.4886***	0.5113	0.0000	1.0000	4.7800	4.8738
	(9.4460)	NA	(0.0000)			
UAE	0.2857***	0.7105***	0.0000	0.9962	1.9346	2.0283
	(3.7196)	(13.3775)	(0.0000)			
UK	0.0000	0.9961***	0.0000	0.9961	4.4578	4.5891
	(0.0000)	(343,130.8729)	(0.0000)			

Panel II: Results of an intervention item as a prolonged three months.						
Country and Region	Alpha	Beta	D	Alpha+Beta	AIC	SBC
Albania	0.2119**	0.5745***	0.0563	0.7865	4.3078	4.4015
	(2.4807)	(3.7741)	(0.1364)			
Argentina	0.4177***	0.5822	0.0000	1.0000	4.5124	4.6062
	(7.6312)	NA	(0.0000)			
Armenia	0.1155***	0.8189***	−8.9354***	0.9344	4.8517	5.0017
	(11,909.6769)	(126,322.1343)	(−10,385.6508)			
Australia	0.1022	0.7044***	−0.0268	0.8066	4.6601	4.7914
	(0.9312)	(4.3322)	(−0.1812)			
Belarus	0.0000	0.9970***	0.0000	0.9970	6.1024	6.2149
	(0.0000)	(197,786.0925)	(0.0000)			
Brazil	0.3390***	0.1668	0.3764	0.5058	5.1903	5.3027
	(2.8432)	(0.8526)	(0.8074)			
Canada	0.2792	0.7207	0.0000	1.0000	4.1304	4.2241
	(1.1581)	NA	(0.0000)			
Chile	0.2751**	0.4318	−0.0931	0.7070	4.6168	4.7480
	(2.4863)	(1.5013)	(−0.5252)			
Hong Kong, SAR	0.1746***	0.7945***	0.2507**	0.9692	1.8471	1.9596
	(4.0051)	(21.0488)	(2.4499)			
Egypt	0.2090***	0.7909	0.0000	1.0000	5.7270	5.8207
	(10.1470)	NA	(0.0000)			
EUR	0.1633***	0.8145***	−37.7973***	0.9779	5.4637	5.5950
	(112.1412)	(130.4443)	(−72.3019)			
Hungary	0.0773*	0.9144***	0.0000	0.9917	5.0845	5.1970
	(1.8913)	(20.1039)	(0.0000)			
Iceland	0.4703***	0.4223***	0.9594	0.8927	4.9718	5.0656
	(3.1927)	(4.1638)	(0.6108)			
Indonesia	0.7563***	0.2436	0.0000	1.0000	3.9939	4.0876
	(6.7638)	NA	(0.0000)			
Japan	0.1271	0.5483**	−0.1533	0.6755	4.5900	4.7025
	(1.1867)	(2.0595)	(−0.5363)			
Kazakhstan	0.7444***	0.2067*	−0.4589**	0.9512	4.5799	4.6923
	(3.6708)	(1.6607)	(−1.9852)			
Korea	0.2972***	0.6395***	0.0000	0.9368	4.2716	4.3653
	(2.6357)	(5.0802)	(0.0000)			
Malaysia	0.1211	0.6306***	−27.9630***	0.7517	6.2034	6.3346
	(1.3424)	(17.8073)	(−17.1234)			
Mongolia	0.1668	0.1534***	−53.6519***	0.3203	9.2324	9.3824
	(1.3319)	(8.8022)	(−203.6819)			
Morocco	0.1346**	0.8087***	0.0000	0.9434	3.9229	4.0542
	(2.1840)	(12.8797)	(0.0000)			
New Zealand	0.1107***	0.7840***	−34.2626***	0.8947	6.6586	6.7898
	(3.0845)	(4.0205)	(−3.8929)			
Nigeria	0.2125***	0.7874	0.0000	1.0000	4.3404	4.4342
	(8.8341)	NA	(0.0000)			

(*continued on next page*)

Table A-3 (*continued*)

Panel II: Results of an intervention item as a prolonged three months.						
Country and Region	Alpha	Beta	D	Alpha+Beta	AIC	SBC
Pakistan	0.0000	0.9999	0.0000	1.0000	3.4842	3.5779
	(0.0000)	NA	(0.0000)			
Qatar	0.0374	0.9543***	0.8468***	0.9917	1.6055	1.7180
	(0.8148)	(58.0298)	(5.2192)			
Russia	0.4668***	0.5331	0.0000	1.0000	5.0059	5.0997
	(3.8450)	NA	(0.0000)			
Serbia	0.4081***	0.5696***	0.0000	0.9778	4.7316	4.8253
	(3.1593)	(5.9747)	(0.0000)			
Singapore	0.0000	0.9999	0.0000	1.0000	2.9645	3.0583
	(0.0000)	NA	(0.0000)			
South Africa	0.1223	0.8342***	0.0000	0.9565	5.3908	5.5033
	(1.6245)	(8.7386)	(0.0000)			
Sri Lanka	0.1955*	0.7779***	−36.8213***	0.9734	3.6924	3.8236
	(1.7372)	(11.5733)	(−11.3468)			
Suriname	0.5278***	0.4721	0.0000	1.0000	3.8355	3.9292
	(9.5846)	NA	(0.0000)			
Switzerland	0.2133**	0.7302***	0.1821	0.9436	4.4565	4.5690
	(2.0953)	(5.1821)	(0.2839)			
Tajikistan	0.3261***	0.4152***	−16.0944***	0.7413	4.0801	4.1926
	(6.5703)	(18.3856)	(−48.7260)			
Thailand	0.0155***	0.8778***	−39.6064***	0.8934	6.3019	6.4144
	(213.6435)	(493.5404)	(−208.2311)			
Turkey	0.4695***	0.4371***	0.0000	0.9067	5.2970	5.3907
	(2.6019)	(3.4730)	(0.0000)			
Ukraine	0.4886***	0.5113	0.0000	1.0000	4.7800	4.8738
	(9.2215)	NA	(0.0000)			
UAE	0.2857***	0.7105***	0.0000	0.9962	1.9346	2.0283
	(3.1429)	(12.0352)	(0.0000)			
UK	0.0000	0.9961***	0.0000	0.9961	4.4578	4.5891
	(0.0000)	(338,675.4661)	(0.0000)			

Panel III: Results of an intervention item as a prolonged six months.						
Country and Region	Alpha	Beta	D	Alpha+Beta	AIC	SBC
Albania	0.2101**	0.5756***	0.0000	0.7857	4.3079	4.4016
	(2.4132)	(3.7274)	(0.0000)			
Argentina	0.4177***	0.5822	0.0000	1.0000	4.5124	4.6062
	(7.6395)	NA	(0.0000)			
Armenia	0.0000	0.9970***	0.0000	0.9970	4.3761	4.4699
	(0.0000)	(453,478.6280)	(0.0000)			
Australia	0.1678*	0.6019**	−0.0487	0.7697	4.7341	4.8654
	(1.6564)	(2.3810)	(−0.8184)			
Belarus	0.0000	0.9970***	0.0000	0.9970	6.1024	6.2149
	(0.0000)	(219,161.9496)	(0.0000)			
Brazil	0.3403***	0.1414	0.1388	0.4818	5.1903	5.3028
	(2.8448)	(0.6853)	(0.7817)			
Canada	0.4109***	0.5890	0.3780	1.0000	4.1162	4.2099
	(2.8731)	NA	(1.0224)			
Chile	0.4707***	0.1551***	−26.0786***	0.6259	8.3529	8.5029
	(462.8283)	(7.0695)	(−120.5792)			
Hong Kong, SAR	0.0201	0.9508***	0.1220***	0.9709	1.5851	1.7163
	(0.2614)	(46.7948)	(3.7897)			
Egypt	0.2090***	0.7909	0.0000	1.0000	5.7270	5.8207
	(14.9112)	NA	(0.0000)			
EUR	0.3944***	0.0431	−33.1124***	0.4375	8.1397	8.2522
	(16.0226)	(1.1079)	(−153.6420)			
Hungary	0.0773*	0.9144***	0.0000	0.9917	5.0845	5.1970
	(1.9333)	(20.2052)	(0.0000)			
Iceland	0.4961***	0.3968***	0.3888	0.8930	4.9681	5.0618
	(3.1688)	(3.7791)	(0.8664)			
Indonesia	0.7564***	0.2435	0.0000	1.0000	3.9939	4.0876
	(6.8281)	NA	(0.0000)			
Japan	0.1303	0.5496**	−0.0401	0.6799	4.5909	4.7034
	(1.2178)	(2.0410)	(−0.3666)			
Kazakhstan	0.6871***	0.2276**	−0.2997***	0.9147	4.5443	4.6568
	(4.3592)	(2.4304)	(−3.6722)			
Korea	0.2972**	0.6395***	0.0000	0.9368	4.2716	4.3653

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Table A-3 (*continued*)

Panel III: Results of an intervention item as a prolonged six months.						
Country and Region	Alpha	Beta	D	Alpha+Beta	AIC	SBC
	(2.5577)	(4.8442)	(0.0000)			
Malaysia	0.2405**	0.4602*	0.0497	0.7008	3.7273	3.8398
	(2.4789)	(1.8863)	(0.3197)			
Mongolia	0.9999***	0.0000	0.0321	0.9999	3.9093	4.0406
	(4.0250)	(0.0000)	(0.1138)			
Morocco	0.1942***	0.4429***	−8.4985***	0.6372	5.2987	5.4112
	(305.4342)	(11,821.8086)	(−5373.9078)			
New Zealand	0.0920	0.8271***	−0.0054	0.9192	4.8005	4.9130
	(1.4363)	(5.8467)	(−0.1282)			
Nigeria	0.2125***	0.7874	0.0000	1.0000	4.3404	4.4342
	(8.6431)	NA	(0.0000)			
Pakistan	0.0000	0.9999	0.0000	1.0000	3.4842	3.5779
	(0.0000)	NA	(0.0002)			
Qatar	0.0511	0.9452***	0.2688***	0.9963	1.5552	1.6677
	(0.9537)	(48.6288)	(5.9113)			
Russia	0.4668***	0.5331	0.0000	1.0000	5.0059	5.0997
	(4.4987)	NA	(0.0000)			
Serbia	0.4081***	0.5696***	0.0000	0.9778	4.7316	4.8253
	(3.1727)	(5.9991)	(0.0000)			
Singapore	0.0000	0.9999	0.0000	1.0000	2.9645	3.0583
	(0.0000)	NA	(0.0000)			
South Africa	0.1223	0.8342***	0.0000	0.9565	5.3908	5.5033
	(1.6240)	(8.6132)	(0.0000)			
Sri Lanka	0.0694	0.2284***	−12.4274***	0.2978	4.1218	4.2530
	(0.5323)	(4.5285)	(−47.8368)			
Suriname	0.5278***	0.4721	0.0000	1.0000	3.8355	3.9292
	(7.2106)	NA	(0.0000)			
Switzerland	0.2131**	0.7272***	0.0403	0.9403	4.4569	4.5694
	(2.0522)	(4.6605)	(0.1540)			
Tajikistan	0.5244***	0.0810	−0.2846	0.6054	3.4309	3.5434
	(4.4065)	(0.7598)	(−1.5041)			
Thailand	0.2041**	0.5328***	0.1113	0.7369	3.2843	3.3968
	(2.4676)	(3.3085)	(1.4029)			
Turkey	0.4695***	0.4371***	0.0000	0.9067	5.2970	5.3907
	(2.6061)	(3.6063)	(0.0000)			
Ukraine	0.4886***	0.5113	0.0000	1.0000	4.7800	4.8738
	(9.4682)	NA	(0.0000)			
UAE	0.2857***	0.7105***	0.0000	0.9962	1.9346	2.0283
	(6.2933)	(33.5363)	(0.0000)			
UK	0.0000	0.9961***	0.0000	0.9961	4.4578	4.5891
	(0.0000)	(57,115.6221)	(0.0000)			

Panel IV: Results of with an intervention item as prolonged 12 months.						
Country and Region	Alpha	Beta	D	Alpha+Beta	AIC	SBC
Albania	0.2101**	0.5756***	0.0000	0.7857	4.3079	4.4016
	(2.4457)	(3.7762)	(0.0000)			
Argentina	0.4177***	0.5822	0.0000	1.0000	4.5124	4.6062
	(7.8231)	NA	(0.0000)			
Armenia	0.0000	0.9934***	0.0000	0.9934	4.2761	4.4073
	(0.0000)	(491,608.5097)	(0.0000)			
Australia	0.1690**	0.5795***	−0.0313	0.7486	4.7279	4.8591
	(2.2336)	(12.8878)	(−1.3254)			
Belarus	0.0000	0.9970***	0.0000	0.9970	6.1024	6.2149
	(0.0000)	(112,561.3857)	(0.0000)			
Brazil	0.3532***	0.2037	0.0500	0.5570	5.1153	5.2465
	(2.9417)	(1.0646)	(0.8808)			
Canada	0.4595***	0.5404	0.1273	1.0000	4.1174	4.2111
	(3.3763)	NA	(1.1125)			
Chile	0.1273***	0.8413***	0.0000	0.9686	4.6066	4.7378
	(2.6702)	(17.6806)	(0.0000)			
Hong Kong, SAR	0.2292***	0.7364***	0.0167***	0.9656	1.7765	1.8889
	(4.0494)	(15.3520)	(3.0302)			
Egypt	0.2090***	0.7909	0.0000	1.0000	5.7270	5.8207
	(10.4151)	NA	(0.0000)			
EUR	0.2058***	0.3291***	−52.5805***	0.5350	11.7486	11.8798
	(942.7765)	(29.2842)	(−29,299.5357)			

(*continued on next page*)

Table A-3 (*continued*)

Panel IV: Results of with an intervention item as prolonged 12 months.

Country and Region	Alpha	Beta	D	Alpha+Beta	AIC	SBC
Hungary	0.0773*	0.9144***	0.0000	0.9917	5.0845	5.1970
	(1.8816)	(20.0220)	(0.0000)			
Iceland	0.4790***	0.4084***	0.0227	0.8875	4.9753	5.0690
	(3.1047)	(3.7684)	(0.2107)			
Indonesia	0.7564***	0.2435	0.0000	1.0000	3.9939	4.0876
	(6.6966)	NA	(0.0000)			
Japan	0.0318***	0.9588***	−5.9193***	0.9907	6.4250	6.5562
	(88.0431)	(14,009.7724)	(−576.9768)			
Kazakhstan	0.0000	0.9999***	0.0000	0.9999	5.0575	5.1512
	(0.0000)	(2779.4732)	(0.0000)			
Korea	0.2972**	0.6395***	0.0000	0.9368	4.2716	4.3653
	(2.4923)	(4.5568)	(0.0000)			
Malaysia	0.1714*	0.6375***	0.0000	0.8089	3.6362	3.7487
	(1.6572)	(4.1344)	(0.0000)			
Mongolia	0.0453	0.7521***	−0.0181	0.7975	3.9598	4.0722
	(0.3978)	(9.8663)	(−0.9124)			
Morocco	0.2074***	0.7261***	−63.6073***	0.9335	8.4639	8.6139
	(38.9652)	(14.1322)	(−410.3447)			
New Zealand	0.0945	0.8335***	−0.0076	0.9281	4.7990	4.9115
	(1.5029)	(5.4892)	(−0.5113)			
Nigeria	0.2125***	0.7874	0.0000	1.0000	4.3404	4.4342
	(8.4234)	NA	(0.0000)			
Pakistan	0.0000	0.9999	0.0044	1.0000	3.4680	3.5617
	(0.0000)	NA	(1.2886)			
Qatar	0.2563***	0.7143***	0.0555**	0.9706	1.2297	1.3609
	(3.4785)	(15.5595)	(2.1098)			
Russia	0.4668***	0.5331	0.0000	1.0000	5.0059	5.0997
	(4.6335)	NA	(0.0000)			
Serbia	0.1984	0.7707***	0.0000	0.9691	4.6643	4.7955
	(1.4049)	(5.4046)	(0.0000)			
Singapore	0.0000	0.9999	0.0000	1.0000	2.9645	3.0583
	(0.0000)	NA	(0.0000)			
South Africa	0.1116	0.8586***	0.0535	0.9702	5.3891	5.5015
	(1.5459)	(8.9551)	(0.5358)			
Sri Lanka	0.0000	0.9999***	0.0059	0.9999	3.1145	3.2457
	(0.0000)	(3513.4644)	(1.1079)			
Suriname	0.5708***	0.4291	3.5313	1.0000	3.1872	3.2809
	(8.1417)	NA	(1.6352)			
Switzerland	0.2100**	0.7355***	0.0237	0.9455	4.4562	4.5687
	(2.1740)	(5.6490)	(0.3872)			
Tajikistan	0.0000	0.9919***	0.0000	0.9919	3.7989	3.9302
	(0.0000)	(178.6312)	(0.0000)			
Thailand	0.2003**	0.5185**	0.0239	0.7188	3.2989	3.4114
	(2.2312)	(2.3933)	(1.0641)			
Turkey	0.4198**	0.4606***	0.0000	0.8804	5.2554	5.3866
	(2.4061)	(3.2007)	(0.0000)			
Ukraine	0.4886***	0.5113	0.0000	1.0000	4.7800	4.8738
	(9.4702)	NA	(0.0000)			
UAE	0.2857***	0.7105***	0.0000	0.9962	1.9346	2.0283
	(3.1838)	(14.0694)	(0.0000)			
UK	0.0000	0.9961***	0.0000	0.9961	4.4578	4.5891
	(0.0000)	(127,626.3532)	(0.0000)			

Panel V: Results of with an intervention item as pure jump.

Country and Region	Alpha	Beta	D	Alpha+Beta	AIC	SBC
Albania	0.2101**	0.5756***	0.0000	0.7857	4.3079	4.4016
	(2.4361)	(3.4820)	(0.0000)			
Argentina	0.4455***	0.5544	1.1124***	1.0000	4.4160	4.5098
	(5.5251)	NA	(2.7093)			
Armenia	0.0000	0.9967***	0.0000	0.9967	4.3123	4.4248
	(0.0000)	(345,155.3853)	(0.0000)			
Australia	0.1898*	0.5425***	−0.3147**	0.7324	4.7135	4.8447
	(1.9152)	(4.8485)	(−2.0803)			
Belarus	0.0000	0.9970***	0.0000	0.9970	6.1024	6.2149
	(0.0000)	(299,136.8863)	(0.0000)			
Brazil	0.3479***	0.1263	0.1785	0.4742	5.1911	5.3036

(continued on next page)

Table A-3 (*continued*)

Panel V: Results of with an intervention item as pure jump.						
Country and Region	Alpha	Beta	D	Alpha+Beta	AIC	SBC
	(2.9040)	(0.6375)	(0.7219)			
Canada	0.2792	0.7207	0.0000	1.0000	4.1304	4.2241
	(0.9402)	NA	(0.0000)			
Chile	0.0481	0.9457***	−0.0324*	0.9939	4.5960	4.7460
	(1.2263)	(10.2567)	(−1.7668)			
Hong Kong, SAR	0.0689	0.9120***	0.2136***	0.9809	1.6433	1.7933
	(0.6254)	(33.2699)	(2.7919)			
Egypt	0.2090***	0.7909	0.0000	1.0000	5.7270	5.8207
	(9.7782)	NA	(0.0000)			
EUR	0.1807**	0.7227***	0.0000	0.9034	4.3221	4.4346
	(2.3104)	(7.1848)	(0.0000)			
Hungary	0.2537***	0.7368***	−0.3164**	0.9905	5.0095	5.1220
	(3.4377)	(7.0886)	(−2.1437)			
Iceland	0.4263***	0.4428***	0.0000	0.8691	4.9199	5.0324
	(2.7989)	(3.9049)	(0.0000)			
Indonesia	0.7564***	0.2435	0.0000	1.0000	3.9939	4.0876
	(6.7530)	NA	(0.0000)			
Japan	0.0989	0.7396	0.0386	0.8386	4.5454	4.6953
	(0.8532)	(1.3689)	(0.1685)			
Kazakhstan	0.1119	0.3020***	3.0943***	0.4140	4.1075	4.2200
	(0.7575)	(10.3809)	(17.4970)			
Korea	0.3598***	0.5642***	−0.4295***	0.9240	4.2076	4.3389
	(5.6271)	(11.0567)	(−6.2409)			
Malaysia	0.2517**	0.4760***	0.2916	0.7278	3.7194	3.8319
	(2.4362)	(2.7498)	(1.0631)			
Mongolia	0.1424	0.7689***	0.1105	0.9113	3.8938	4.0438
	(1.2728)	(10.8217)	(0.8839)			
Morocco	0.1859**	0.7573***	0.0000	0.9433	3.9411	4.0348
	(2.2890)	(10.7360)	(0.0000)			
New Zealand	0.2815*	0.5246**	0.0000	0.8062	4.7931	4.8868
	(1.7726)	(2.5375)	(0.0000)			
Nigeria	0.2125***	0.7874	0.0000	1.0000	4.3404	4.4342
	(8.9295)	NA	(0.0000)			
Pakistan	0.0000	0.9999	0.0136	1.0000	3.4589	3.5527
	(0.0000)	NA	(1.4871)			
Qatar	0.4573***	0.4021***	0.5763***	0.8594	1.4244	1.5181
	(3.2536)	(3.8661)	(2.9628)			
Russia	0.4668***	0.5331	0.0000	1.0000	5.0059	5.0997
	(4.9213)	NA	(0.0000)			
Serbia	0.3335***	0.6223***	−0.4702***	0.9559	4.6460	4.7772
	(4.4015)	(9.5830)	(−2.9460)			
Singapore	0.0000	0.9999	0.0000	1.0000	2.9645	3.0583
	(0.0000)	NA	(0.0000)			
South Africa	0.1557*	0.8215***	0.3887	0.9773	5.3712	5.4836
	(1.9148)	(9.7533)	(1.0246)			
Sri Lanka	0.5032***	0.3504**	0.3849**	0.8537	3.0156	3.1280
	(3.2373)	(2.0294)	(2.1309)			
Suriname	0.5278***	0.4721	0.0000	1.0000	3.8355	3.9292
	(6.7848)	NA	(0.0000)			
Switzerland	0.2258***	0.7063***	0.0000	0.9322	4.4459	4.5396
	(19.7760)	(4.4716)	(0.0000)			
Tajikistan	0.3092***	0.3857***	0.0058	0.6949	3.1722	3.3222
	(17.2639)	(14.9292)	(0.0347)			
Thailand	0.1314	0.3746	−0.1422	0.5061	3.2145	3.3645
	(1.3723)	(1.3498)	(−1.0393)			
Turkey	0.4695**	0.4371***	0.0000	0.9067	5.2970	5.3907
	(2.5469)	(3.0722)	(0.0000)			
Ukraine	0.4886***	0.5113	0.0000	1.0000	4.7800	4.8738
	(9.6141)	NA	(0.0000)			
UAE	0.3043***	0.6473***	0.0984***	0.9516	1.4712	1.6024
	(3.3400)	(9.1068)	(2.5950)			
UK	0.0000	0.9961***	0.0000	0.9961	4.4578	4.5891
	(0.0000)	(136,665.9884)	(0.0000)			

Notes: This table reports the results of logistic regression with robust standard errors. The *t*-statistics are in the parenthesis. ***, **, and * denote significant at 1%, 5%, and 10% level, respectively.

Table A-4
Correlation matrix of variables used for further investigation.

	log(GDP)	Proximity with China	*log*(Trade Flow)	FTA	Chinn – Ito index	Financial Center Index	Sovereign Default	Inflation	Developed	Rule of Law	US_Miltary
log(GDP)	1										
Proximity with China	0.051	1									
log(Trade Flow)	0.838	−0.185	1								
FTA	0.051	−0.189	0.352	1							
Chinn – Ito index	0.302	−0.078	0.428	0.193	1						
Financial Center Index	0.541	−0.002	0.711	0.294	0.626	1					
Sovereign Default	0.083	0.028	−0.103	0.009	−0.315	−0.205	1				
Inflation	−0.248	−0.017	−0.454	−0.357	−0.614	−0.755	0.446	1			
Developed	0.327	0.000	0.479	0.434	0.581	0.694	−0.126	−0.659	1		
Rule of Law	0.183	0.208	0.261	0.330	0.447	0.524	−0.144	−0.569	0.681	1	
US_Miltary	0.491	−0.028	0.402	0.055	0.412	0.509	0.035	−0.343	0.483	0.393	1
BeltRoad	−0.411	−0.279	−0.433	−0.098	−0.372	−0.515	−0.063	0.371	−0.669	−0.410	−0.403

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