Policy decisions preparing for FX intervention

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Abstract

The use of FX intervention (FXI) is preceded by policymakers' institutional decisions. We show that FXI activity increases with the choice of more rigid exchange rate regimes, larger official reserve assets (relative to GDP), and reserves held in a form easing their use for FXI, which we demonstrate by developing an FXI "readiness" index. These institutional decisions well explain but cannot predict FXI. Despite their costs, our findings show that policymakers have expanded FXI preparations over the last two decades and that less democratic countries tend to be more prepared.

JEL-Classification: F31 (foreign exchange), F33 (international monetary arrangements), E58 (central banks and their policies)

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1 Introduction

When it comes to stabilizing open economies, policymakers employ a wide range of tools. These span from broad-based monetary and fiscal policies to more targeted instruments such as foreign exchange intervention (FXI), i.e., the buying and selling of foreign currency to influence the exchange rate (Bruno and Shin, 2015; Hnatkovska et al., 2016; Cavallino, 2019; Hassan et al., 2023).). FXI has always been popular among policymakers, as evidenced by surveys with central bankers (e.g., Neely, 2008). However, these surveys focus on broad FXI motives and statistics about current or past FXI use are incomplete (Fratzscher et al., 2019; Adler et al., 2021). Thus, there is a gap in the empirical literature about the practice of FXI, in particular regarding the ex-ante willingness to use FXI. Consequently, we analyze the institutional decisions made by policymakers regarding preparations for using FXI.

The expectations about such decisions seem to be ambiguous. On the one hand, the gradual slowdown in globalization (e.g., Goldberg and Reed, 2023), as indicated by the slightly falling trade-to-GDP ratio, might indicate a decreasing relevance of open economy issues and, thus, FXI. On the other hand, the comeback of geopolitical tensions may motivate policymakers to increase their arsenal of instruments to manipulate the exchange rate, increasing their interest in FXI. In any case, these are institutional decisions with far-reaching implications for the stability of an open economy. Our analysis reveals increasing preparedness for FXI.

An obvious measure in this respect is policymakers' choice of the exchange rate regime. For example, opting for a floating exchange rate regime relegates FXI to a marginal role. Conversely, suppose a country chooses to peg its currency to another one (or a basket of other currencies). In that case, this peg has to be actively defended at times, implying the willingness to use appropriate instruments, such as FXI. Another critical institutional decision linked to the potential use of FXI is maintaining a sufficient stock of official reserve assets. Such a stock is essential when foreign currency sales stabilize the domestic currency. More generally, the credibility of an intervention policy depends on sufficient reserves to be increased or decreased. Finally, reserves can be held in very different forms, and the form makes a crucial difference when it comes to being ready for FXI (so that we develop an index of "FXI readiness"). That is most obvious when official reserve assets are not held in foreign currency, so intervention in support of the domestic currency may be limited by a lack of immediately available intervention currency. Thus, we develop the concept of preparedness to intervene, which means longer-term strategies and planning, while the measure of FXI readiness is part of this concept and focuses on the immediate capacity to intervene if needed.

While there are clearly defined data on exchange rate regimes and official reserve assets, there is not yet a concept of FXI "readiness," i.e., considering the degree to which official reserve assets are available for FXI purposes. We derive the concept of "readiness" to intervene in FX markets from conventional asset management considerations. Suppose asset managers aim to be able to buy or sell assets, such as reserve assets, at short notice and in unknown amounts. In

that case, the liquidity and safety of respective assets are crucial concerns. That implies that the return on assets is relatively less critical. Indeed, reserve holdings tend to be costly because returns in these safe assets are low (e.g., Adler and Mano, 2021), and readiness is particularly costly in fiscal terms because funds are invested in easily tradable assets so that neither a term nor an illiquidity premium can be earned. From this perspective, we develop a readiness index that relies on: (i) the share of reserves held in the form of foreign currency rather than, for example, gold, and (ii) the share of reserves held in liquid deposits rather than in securities. For the empirical analysis, we use the International Reserves and Foreign Currency Liquidity (IRFCL), published by the International Monetary Fund, which has recently much improved its coverage. To the best of our knowledge, this research is the first to systematically analyze the patterns of official reserves over two decades covering many countries.

Then, we examine the explanatory power of the institutions of interest for FXI in two datasets. Data about *actual* FXI published by the respective central banks (see Adler et al., 2021) are reliable, but due to limited data availability, this sample covers just 28 countries. Thus, we also use the FXI *proxy* developed by Adler et al. (2021), which informs about estimated FXI volume; however, with the disadvantage of overestimating FXI incidence, these data generate a sample of 75 countries.

When assessing correlations among the three institutional variables, the coefficient sizes show that each variable addresses somewhat different aspects. Thus, we consider all of them in the subsequent examinations, where we explain FXI primarily by a Logit model based on our small sample (with 28 countries). We prefer the noise-to-signal ratio for model selection, which balances the ratio between "wrong" and "correct" signals in identifying actual interventions. This criterion leads to a regression encompassing all three institutional variables, i.e., exchange rate regime, reserves to GDP, and FXI readiness. Each of these variables has explanatory power beyond country and time fixed effects. The regime variable performs best. Then, we use the analogous variables in the large sample. The linear panel regressions with fixed effect show that considering all three explanatory variables performs best in this case. In general, we find that all three institutional variables contribute explanatory power and that the exact rankings among the three variables may depend on the specific data universe. Thus, considering all three variables will avoid (good or bad) outliers in explanatory power. We also use the institutional variables to predict actual FXI in a subsequent month. Still, even a random forest model cannot generally outperform a naïve prediction, where we assume that the incidence of FXI or not does continue in the prediction period.

Finally, we document the development over the period 2001-2020 for the four measures of interest, i.e., the share of rigid relative to more flexible exchange rate regimes, the ratio of official reserve assets over GDP, the degree of the readiness indicator, and the FXI activity. As we are interested in decision-making at the country level, we calculate averages across countries by equally weighting these countries. To achieve robust evidence, we refer here to the large sample of 75 countries (instead to the small sample). We find that exchange rate regime

rigidity and official reserves to GDP are increasing, while FXI readiness remains high. Not unexpectedly, these findings are stronger among emerging market economies (EMs) than among advanced economies (AEs). Finally, the level of preparedness for FXI (across countries) is related to higher trade openness, lower GDP p.c., and lower democracy scores. This latter result underlines that increasing geopolitical tensions may contribute to the decisions towards higher FXI preparedness.

Literature. Our research contributes to three major strands of literature in the broad field of designing financial institutions for open economies: (i) the decision about the exchange rate regime, (ii) the role of official reserves, and (iii) the use of FX interventions, while we are not aware of an academic literature about readiness for FXI. We will discuss these areas sequentially.

There has always been some effort to bring the international financial system's governance under the control of official authorities (Eichengreen, 2019). These attempts have become more assertive, particularly after the Global Financial Crisis of 2008/09. Even capital controls, often regarded as a source of allocation distortion, receive renewed attention (Erten et al., 2021). Thus, it is not surprising that also FX has gained recognition as a potentially useful instrument (Basu et al., 2020; IMF, 2022).

(i) The arguably most important decision in designing the institutions for a stable open economy is the choice of exchange rate regime. Every country must weigh the advantages of a flexible exchange rate as a shock absorber against the stability offered by a fixed exchange rate. While the literature provides some guidance in this respect, ultimately, this choice remains a policy decision. For empirical analysis, it is relevant to identify the de facto exchange rate regime, which may differ from the de jure regime (e.g., Reinhart and Rogoff, 2004). This is usually done by analyzing capital flow restrictions and exchange rate volatility (e.g., Frankel and Xie, 2010). We show for a large group of countries that FXI activity holds as another characteristic of exchange rate regimes.

(ii) Regarding the motives for reserve holdings, the earlier literature has shown that mercantilist motives may play a role, but precautionary motives have dominated since the late 1990s (Aizenman and Lee, 2007). Precautionary motives have been fueled by the sequence of financial crises, which were often linked to emerging countries and the volatile capital flows they are confronted with (Kaminsky et al., 2004; Aguiar and Gopinath, 2007; see also Dominguez et al., 2012). While the view that reserve holdings are useful is widely shared (Jeanne, 2016; Bianchi et al., 2018; Arce et al., 2019), their optimal volume is subject to debate (Jeanne and Rancière, 2011). Reserves are costly, mainly if intended for FXI, and thus held in liquid assets. If the latter is the case, reserves, which are preferably held in US-Dollar assets, are for most countries like an inverse carry trade, i.e., the foregone interest rate income is larger than gains in exchange rate appreciation (Fratzscher et al., 2019; Adler and Mano, 2021). These costs call for limiting reserve volumes and may motivate conscious restructuring of the patterns of reserve holdings away from relatively costly holdings that readiness implies. Given this trade-off, it is not clear what authorities actually do. Our paper contributes to the debate by

documenting patterns in behavior.

(iii) The theoretical justifications for FXI, which emphasize the need to hold FX reserves, are explored in recent literature, including works by Gabaix and Maggiori (2015), Cavallino (2019), Fanelli and Straub (2021), and Hassan et al. (2023). These studies argue that FXI can help mitigate market-driven volatility, which improves economic welfare. These theoretical motivations for FXI are complemented by recent empirical studies demonstrating FXI's effectiveness. This includes multi-country studies by Blanchard et al. (2015) and Daude et al. (2016), Fratzscher et al. (2019), Adler et al. (2021), Gelos et al. (2022), the meta-study by Arango-Lozano et al. (2024), and innovative studies on single countries (Chamon et al., 2017; Kuersteiner et al., 2018) or small groups of countries (Menkhoff et al., 2021). Thus, the case for FXI seems to have become stronger over the last few years (compare the earlier account by Sarno and Taylor, 2001). This aligns with our paper's result that there is a systematic pattern that institutions have increasingly prepared for FXI over time.

Our paper is structured into five more sections. Section 2 contains the data description. Section 3 introduces the concept of FXI readiness. Section 4 analyzes the role of exchange rate regimes, reserve holdings, and readiness in explaining and predicting FXI, while Section 5 shows the development of these variables over time and cross-country heterogeneity. Section 6 concludes.

2 Data

Our study relies on general macro data, such as GDP, from the World Bank's World Development Indicator database and specific databases. The latter cover exchange rate regimes, official reserves, and actual FX interventions. We introduce these data sets in the following and provide an overview of time variation in key indicators.

Exchange rate regimes. The standard classification of de facto exchange rate regimes in the literature is provided by Ilzetzki et al. (2019). We use their so-called "coarse grid" classification with five categories: (1) hard pegs (covering the fine categories 1 to 4 out of 15), (2) mainly crawling pegs (5 to 8), (3) somewhat wider bands (9 to 12), (4) freely floating regimes (13), and (5) others, i.e., freely falling (14) and duals markets (15).

We also run our core regressions for robustness with a modified classification following Hassan et al. (2023). These authors slightly reorganize the coarse grid classification by orientating themselves more strictly towards the width of bands. In their 4-regime classification, they put former categories 2 and 3 together in one "soft peg" category and shift the fine category 3 (also a band up to +/- 2%) into this group. In an alternative finer 6-regime classification, Hassan et al. (2023) differentiate this broad soft peg group into three groups.

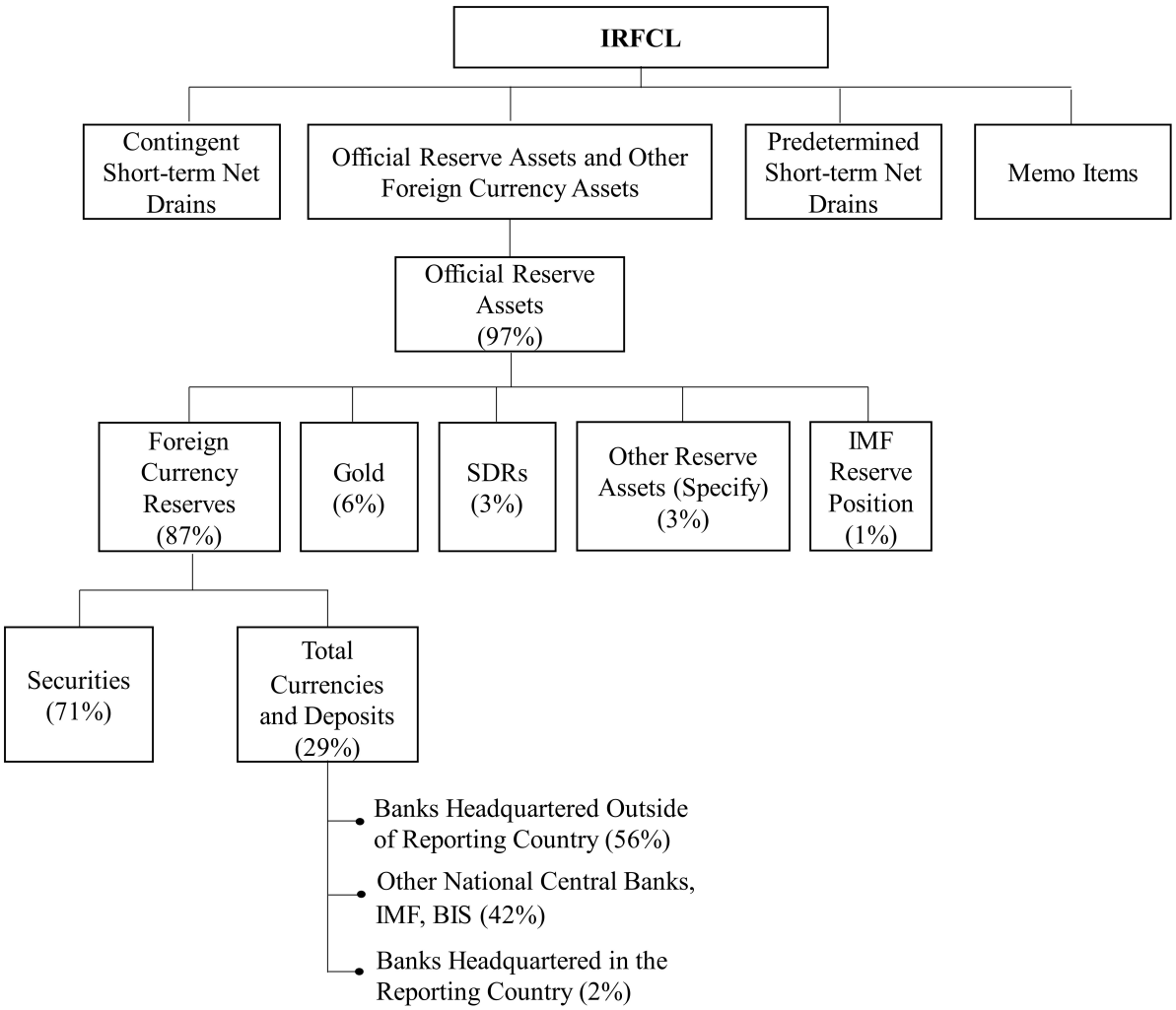
Official reserve assets. Regarding reserves, our data source is the International Reserves and Foreign Currency Liquidity (IRFCL) data template from the IMF. The IRFCL dataset became a prescribed element of the IMF's Special Data Dissemination Standard (SDDS) in

June 1999. While the IRFCL started with a few reporting economies, it currently covers 89 economies that account for 93 percent of the world's GDP. In 2001, 49 economies covering 80% of world GDP joined, and the remaining 38 countries (13 percent of world GDP) joined at later stages (see also Cady and Gonzalez-Garcia, 2007) (see Appendix A Table A.1). However, the European Monetary Union (EMU) countries are counted each, which does not reflect the unified decision-making in the EMU with regard to FXI. Thus, we consider the reserves and GDP of the EMU as one observation only and adjust the sample whenever a new member joins the EMU between 2001 and 2020. That reduces the number of countries to 75 overall, 36 at the start of the sample period and 69 at its end.

How representative are the IRFCL data of global official reserve assets? While aggregate data on official reserve assets have been part of the International Financial Statistics (IFS) for a long time, detailed data from the IRFCL has only been recently made available (see Appendix Figure A.1 for a graphical comparison). Even when restricting the IFRCL to the 49 economies that were part of the IFRCL right from the start, the 49 economies clearly follow the aggregate trends of the 188 economies covered by the IFS data. While the sample's composition does not seem to be crucial in general, there was a significant upward shift in reserves when China joined the IFRCL in 2015. In the remainder of this paper, we work with all 75 economies if possible.

What are the prevalent assets to store official reserve assets? Figure 1 outlines the IRFCL dataset structure and the distribution of official reserve asset holdings across different types of assets from 2001 to 2020 and equally weighting countries. Official reserve assets (ORA) are mainly held in foreign currency reserves (FCR, 87%) or gold (6%). Foreign currency reserves can be further dissected into securities (71%) and total currencies and deposits (TCD, 29%). All securities are held outside of the respective reporting country. Deposits are primarily held at banks headquartered outside the respective reporting country (HQout, 56%), and only 2% are held at banks headquartered in the reporting country. 42% of total currencies and deposits are held at other national central banks, the IMF, or the BIS.

Figure 1: Composition and allocation of international reserves and foreign currency liquidity (2001-2020)



Notes: This diagram illustrates the structure of the International Reserves and Foreign Currency Liquidity (IRFCL) based on data averaged from 2001 to 2020. It specifically highlights the distribution of assets within "*Official Reserve Assets*" across 75 economies. Notably, 3% of the assets under "*Official Reserve Assets and Other Foreign Currency Assets*" are designated to "*Other Foreign Currency Assets*," a category not explicitly shown in the diagram.

FX interventions (FXI). To empirically analyze FXI preparedness, we work with two FXI datasets: *actual* FXI data for a small sample of 28 countries and estimated (*proxy*) data for a large sample of 75 countries. As we are primarily interested in FXI activity, we work with a binary indicator to determine whether a country intervenes in a given month. We use the dataset of Adler et al. (2021), the largest publicly available recent dataset on actual interventions, which covers public monthly FXI as reported by 33 countries for up to 20 years. At the time of our main empirical work, these data were available for 2001 to 2020, determining our examination period. Since we want to use the cleanest possible dataset, a smaller sample of actual interventions is more appropriate than relying on a larger sample of estimated interventions, such as those provided by Adler et al. (2021) or Fratzscher et al. (2023). Matching the actual FXI data

(available for up to 33 countries) with the data on the structure of reserves yields an unbalanced sample of 28 advanced and emerging economies. In 2020, this sample covers about 57% of world GDP and 29% of world reserves. The descriptive statistics for this small sample are shown in Panel A of Table 1. There are up to 4,026 monthly observations. For example, the median annual GDP of all countries over 20 years is 260 billion USD. Taking an example from the ratios provided, the median ratio of official reserves to GDP is 16.2%.

Table 1: Summary statistics.

Variables	Obs.	Missing	Mean	Std. Dev.	Median	Min.	Max.
Panel A: 28 economies							
Volumes							
GDP (current US$)	4026	0	2169.127	4434.055	260.517	3.163	21372.572
Spot FXI published	4026	0	0.145	2.266	0	-75.061	20.589
Official reserve assets (ORA)	4026	0	123.038	184.176	47.001	0.633	1093.544
Foreign currency reserves (FCR)	4026	0	85.082	111.783	40.683	0.633	542.157
Total currency and deposits (TCD)	3982	44	19.522	30.785	5.663	0.012	200.309
HQ Out	3825	201	6.998	13.123	1.269	0	83.684
Short-term net drains (PSND)	3994	32	-10.525	29.387	-2.757	-552.728	39.324
Shares							
Spot FXI published/GDP	4026	0	0.06	0.495	0	-5.32	10.36
Spot FXI incidence	4026	0	0.568	0.495	1	0	1
ORA/GDP	4026	0	0.17	0.109	0.162	0.005	0.697
FCR/ORA	4026	0	0.832	0.204	0.919	0.045	1
TCD/FCR	3982	44	0.306	0.239	0.263	0	1
HQout/TCD	3787	239	0.478	0.372	0.5	0	3.727
PSND/FCR	3994	32	-0.256	0.793	-0.106	-14	0.121
Panel B: 75 economies							
Volumes							
GDP (current US$)	13124	0	1008.101	2814.331	179.475	0.978	21372.572
Spot FXI proxy	11835	1289	0.16	4.079	0.021	-125.944	80.016
Official reserve assets (ORA)	13124	0	115.959	298.213	30.423	0.26	3771.347
Foreign currency reserves (FCR)	13124	0	99.339	277.406	26.451	0.248	3693.838
Total currency and deposits (TCD)	12961	163	13.956	26.908	4.211	0.003	209.648
HQout	12701	423	7.146	18.1	1.654	0	209.283
Short-term net drains (PSND)	12893	231	-4.309	21.49	-1.926	-552.728	125.849
Shares							
Spot FXI proxy/GDP	11835	1289	0.096	0.996	0.03	-10.13	13.1
Spot FXI incidence	11835	1289	0.989	0.106	1	0	1
ORA/GDP	13124	0	0.224	0.197	0.177	0.005	1.44
FCR/ORA	13124	0	0.868	0.154	0.923	0.045	1.029
TCD/FCR	12961	163	0.294	0.259	0.21	0	1.002
HQ Out/TCD	12614	510	0.568	0.366	0.658	0	4.783
PSND/FCR	12893	231	-0.272	0.686	-0.126	-14	0.763

Notes: This table presents detailed summary statistics for different economic indicators across two unbalanced samples (28 and 75 economies) from 2001-2020. All volumes are expressed in billions of USD. The variables include Gross Domestic Product (GDP) in current US dollars, Spot Foreign Exchange Intervention (FXI) published and proxied figures, Official Reserve Assets (ORA), Foreign Currency Reserves (FCR), Total Currency and Deposits (TCD), and the holdings at banks headquartered outside the reporting country (HQout), among others. Predetermined short-term net drains (PSND) are also analyzed. 'Shares' refer to the proportions and ratios of interest, such as the Spot FXI published/GDP, indicating the economic significance of FXI relative to the economy's size.

While we prefer to work with the precise actual FXI data, for some purposes, we also use the FXI-proxy developed by Adler et al. (2021) because this covers almost all countries of interest, i.e., 75 countries (the news-based classification approach of Fratzscher et al. (2023) may provide less noise, however, for an even smaller sample). Table 1, Panel B shows summary statistics for our large sample, which are qualitatively not that different from the small sample. For example,

the median GDP is 180 billion USD, and ORA/GDP is 17.7%. A disadvantage of this dataset is that it states FXI almost every month, so an FXI dummy cannot be usefully constructed. Thus, we use the ratio of FXI-volume relative to GDP as our measure of FXI-activity.

Both datasets seem somewhat biased regarding FXI in the world economy. The large dataset states FXI almost every month, so an FXI dummy cannot be usefully constructed. Thus, we use the ratio of FXI-volume relative to GDP as our measure of FXI-activity. The small dataset still states FXI in about 60% of the reported months. This share is much larger than the one by Fratzscher et al. (2023), who report 30% in their sample (Fratzscher et al. (2019), report 20% in a larger sample) covering spot FXI from about 30 countries over the period 1995-2011. Thus, there seems to be some bias that countries actively using FXI show up more often in the Adler et al. (2021) database of actual FXI we use here.

3 FX intervention readiness

In this section, we derive readiness indicators based on the structure of reserve holdings (Section 3.1). After that, we discuss the development of readiness indicators over time and across country groups for the sample of 75 economies (Section 3.2), and finally, we develop a readiness index based on the above-introduced indicators (Section 3.3).

3.1 The concept of FX intervention readiness

The readiness of a country to intervene in FX markets can be discussed at each level of disaggregation of the IRFCL data. While the volume of official reserve assets (ORA) to GDP informs about the potential intervention volume as a signal to markets, we focus now on further disaggregation. At the next level (see Figure 1), gold, IMF reserves, et cetera, are not immediately available for FX interventions, but foreign currency reserves are so. Thus, the ratio of foreign currency reserves (FCR) to ORA (FCR/ORA) may provide a first source of information about the degree of readiness.

The FCR is held either as securities or as deposits (including currency). Deposits typically provide stable values but limited expected returns, whereas securities have higher expected returns in the longer run, which explains their dominance in volume over deposits. Most securities can, in principle, be sold at very short-term notice. Still, their prices fluctuate, so they are not preferred as a medium of storage for short-term purposes, such as unexpected interventions. That is why we argue that authorities being ready to intervene will tend to have a higher share of "total currency and deposits" (TCD) in their foreign currency reserves. Accordingly, the ratio of TCD/FC could provide a second source of relevant information.

Deposits are held roughly equal parts at other central banks or at banks with headquarters outside the reporting country (HQout). Banks headquartered in the reporting country have a share of much below 10 percent. If the authority wants to prepare for unexpected FX interventions,

there may be a tendency to hold reserves at international banks. That means the ratio of HQout/TCD provides a third source of information.

Finally, the IRFCL statistics inform about "predetermined short-term net drains" (PSND), i.e., known or scheduled contractual obligations in foreign currencies that will contribute to reducing reserves. These drains lessen the ability to conduct FX interventions. Thus, we expect that authorities being prepared for FX intervention will have a relatively low volume of PSND. Accordingly, the ratio of PSND/FCR gives a fourth possible hint. Here, readiness is indicated by a small ratio, different from the earlier readiness indicators. That is because PSND often has a value of zero, so the reverse ratio of FCR/PSND cannot be used without making further assumptions.

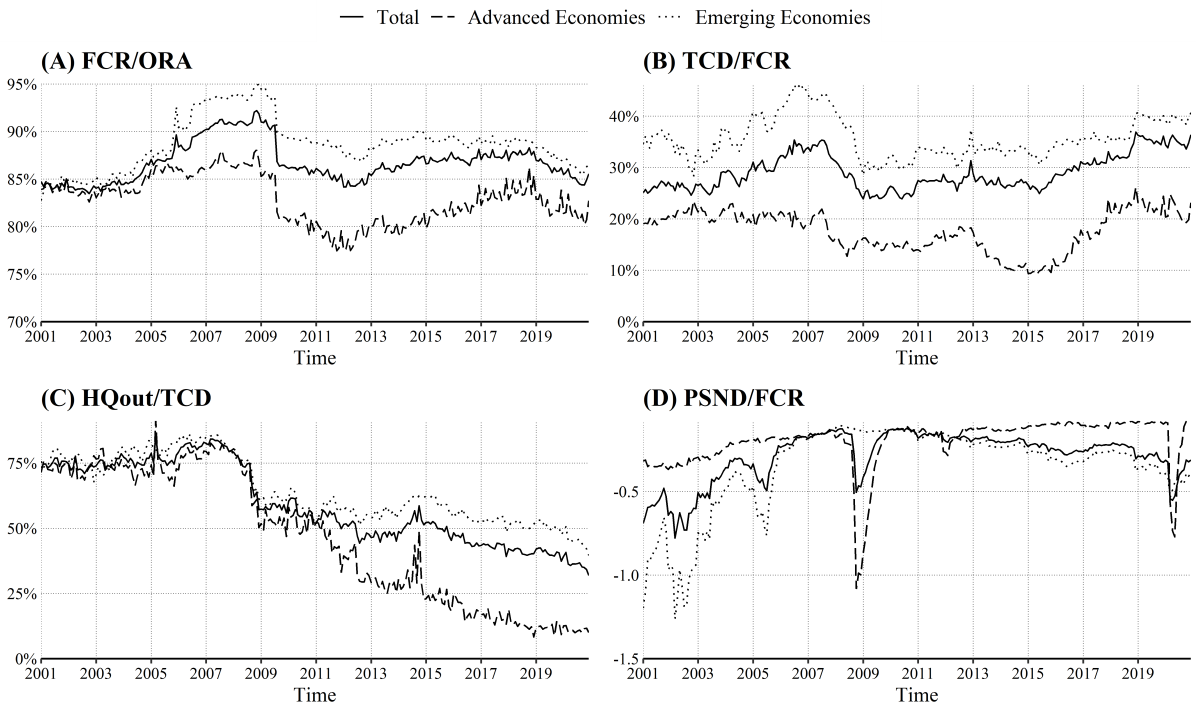
Overall, these four ratios inform about the share of foreign currency reserves (to total), the form of foreign currency reserves, their location, and the drain on them. Ratios are defined in a way that higher ratios indicate a higher degree of FXI readiness, except for the last one, where fewer short-term drains seem preferable from the perspective of readiness.

3.2 Patterns of readiness indicators over time and across country groups

We analyze the development of the four indicators of FX intervention readiness introduced above for the 75 countries that form our large sample between 2001 and 2020. Moreover, we cover the two sub-groups of advanced economies (AEs) and emerging and developing economies (EMs). EMs are, on average, expected to rely more on intervention because they have more rigid exchange rate regimes. They are also expected to be dependent on reserves because they depend more on the reputational effects reserves and greater readiness provide. When aggregating country data to the total ("world" level), we use the unweighted average of all countries' ratios because this is informative about each country's independent policy decision; at the aggregate level, this informs about the typical country.

(i) The average share of foreign currency holdings to official reserve assets (FCR/ORA) across all countries remains at about the same level of about 85% through the two decades (Panel A). Still, there was a marked decline in 2009, which was mainly reversed over the subsequent years (see Figure 2). (ii) According to the IMF classification, FX reserves are held either as securities or deposits. The deposit share is below 50%, as Figure 2, Panel B shows. However, the deposit share increased from about 26% in the earlier years to about 36% at the end of the covered period. (iii) As a third indication of FX readiness, we calculate the share of deposits held with banks headquartered outside the reporting country. This share decreased from more than 70% in 2000 to 30% in 2021 (see Panel C); however, this deposit shift does not go to domestic banks but to international institutions. (iv) Finally, predetermined short-term net drains should be small from the perspective of FX readiness. Indeed, their ratio to FCR is relatively small on average, rarely going beyond 1% (see Panel D), indicating that this position is largely irrelevant.

Figure 2: Evolution of the readiness indicators in advanced and emerging economies (2001-2020)



Notes: This figure shows the evolution of four indicators of FX intervention readiness from 2001 to 2020 across 75 economies, distinguishing between advanced and emerging economies. It comprises four panels: (A) the ratio of foreign currency reserves (FCR) to official reserve assets (ORA), (B) the share of total currency and deposits (TCD) to FCR, (C) the ratio of deposits held at other central banks or banks with headquarters outside the reporting country (HQOut) to TCD, and (D) the ratio of predetermined short-term net drains (PSND) to FCR. *Data source:* International Reserves and Foreign Currency Liquidity (IRFCL)

Overall, we get a quite clear result about the pattern of reserve holding, indicating that FXI readiness has not decreased over time: FCR/ORA remains stable, TCD/FCR increases, while only HQOut/TCD decreases, although at the disadvantage of domestic banks. PSND/FCR does not generally matter. As expected, EMs have higher average readiness than AEs in three out of four measures (see Figure 2).

3.3 Towards a readiness index

As handling the four above-discussed readiness indicators separately is laborious and their information partly overlaps, we condense their main information into a uni-dimensional readiness index. The main benchmark for the usefulness of this index is whether it is closely related to actual FXI. Thus, we first analyze which contribution the individual constituent parts of the readiness indicator provide in explaining FXI and then assess their contribution when combining these indicators into the joint index.

First, we consider correlations within a small sample of 28 countries where reliable FXI information is available. We see in Table 2 that all four readiness indicators are positively related to FXI incidence (for PSND/FCR, the negative coefficient signals this relation), three of them

in a highly significant way. Only the correlation coefficient on PSND/FCR indicates that this variable is hardly related to actual FXI. Regarding relations among the four readiness indicators, FCR/ORA is positively related to the others; however, the correlation coefficient of TCD/FCR to FCR/ORA is close to zero, potentially indicating that these two readiness indicators provide complementary information.

Table 2: Correlation analysis of foreign exchange interventions and readiness indicators (2001-2020)

	Spot FXI (dummy)	FCR/ORA	TCD/FCR	HQout/TCD
Spot FXI (dummy)				
FCR/ORA	0.38***			
TCD/FCR	0.23***	0.02		
HQout/TCD	0.16***	0.29***	-0.14***	
PSND/FCR	-0.01	0.31***	-0.20***	0.13***

Notes: This table shows the correlation matrices between foreign exchange interventions (FXI) and four indicators of FXI readiness. FXI is coded either "1" indicating an intervention has taken place or "0" signifying no intervention. The indicators include the ratio of Foreign Currency to Official Reserve Assets (FCR/ORA), the ratio of Deposits to Foreign Currency Reserves (TCDT/FCR), the ratio of deposits at foreign banks to Total Currency and Deposits (HQout/TCD), and the ratio of predetermined short-term net drains to Foreign Currency Reserves (PSND/FCR). The table is obtained from monthly data on an unbalanced sample of 28 economies from 2001-2020.

Next, we estimate the contribution of readiness indicators in explaining the incidence of FXI with Logit regressions. Table 3 documents the results: while FCR/ORA in column (1) is the base variable in these regressions (due to its high correlation with FXI), the contribution of adding further variables, as measured by a declining Akaike Information Criterion (AIC), is clearly the highest by also considering TCD/FCR (see column 2). The AIC decreases by 240, indicating a better fit, while no other change can reduce the AIC by more than another 17. FCR/ORA and TDC/FCR thus provide the greatest benefit in terms of a parsimonious model that explains the outcome well. A further decrease in AIC is possible by adding HQOut/TCD, but considering that this minimal improvement leads to a 5% loss of observations due to unavailable data, we decide to use the more parsimonious version of readiness index that depends only on the former two variables (an extended discussion on building the readiness index is provided in Appendix B).

Table 3: Logistic regression analysis on the impact of different types of asset holdings on spot Foreign Exchange Interventions (FXI)

	Spot FXI (dummy)					
	(1)	(2)	(3)	(4)	(5)	(6)
FCR/ORA	2.422***	2.408***	2.260***	2.347***	2.469***	2.248***
	(0.089)	(0.085)	(0.081)	(0.089)	(0.096)	(0.080)
TCD/FCR		1.970***	2.000***			2.017***
		(0.100)	(0.098)			(0.102)
HQout/TCD			1.187***	1.088*	1.101*	1.187***
			(0.048)	(0.042)	(0.043)	(0.048)
PSND/FCR					0.734**	1.045
					(0.076)	(0.079)
Observations	3782	3782	3782	3782	3782	3782
AIC	4503.583	4263.742	4246.855	4500.617	4478.955	4248.571
BIC	4516.059	4282.456	4271.807	4519.331	4503.907	4279.761

Notes: All models undergo estimation using logistic regression showing in the table odds ratios. Standard errors are enclosed in parentheses. The dependent variable, Spot FXI (dummy), indicates whether a foreign exchange intervention occurred. Independent variables include the ratio of Foreign Currency to Official Reserve Assets (FRC/ORA), the ratio of Deposits to Foreign Currency Reserves (TCD/FCR), the ratio of deposits at foreign banks to Total Currency and Deposits (HQout/TCD), and the ratio of predetermined short-term net drains to Foreign Currency Reserves (PSND/FCR). Odds ratios are denoted as significant at 0.1% (***), 1% (**), or 5% (*) levels. All regressors are standardized and normalized.

4 Relations between the institutional characteristics

In this section, we document and analyze relations between those institutional characteristics contributing to the concept of FXI preparedness, i.e., the rigidity of exchange rate regimes, the level of official reserve assets, intervention readiness, and FX interventions.

4.1 Description of procedure

To examine the relation between institutional variables and FXI, we prepare the analysis by taking three steps, i.e., examining the correlations among these variables, introducing the empirical models used for explaining FXI, and discussing various success measures.

Correlations. Preparing further analyses, we first document the correlation coefficients between the three institutional variables of interest to each other and actual FXI. Results in Table 4 show that coefficients have the expected positive signs. The three institutional variables positively correlate with FXI to a statistically highly significant degree; moreover, the institutional variables are also positively correlated with each other. Thus, there is no clear ex-ante hypothesis about which variable or combination may work best (this also holds in the large sample, Appendix Table A.2).

Table 4: Correlation analysis of foreign exchange interventions and institutional variables (2001-2020)

	Spot FXI (dummy)	Regime (Coarse)	ORA/GDP
Spot FXI (dummy)			
Regime (Coarse)	0.32***		
ORA/GDP	0.30***	0.53***	
Readiness	0.49***	0.33***	0.40***

Notes: This table shows correlation matrices between Foreign Exchange Interventions (FXI) and three institutional variables of interest. The analysis focuses on the relationship of FXI with the exchange rate regime (categorized as "*Regime (Coarse)*"), the ratio of Official Reserve Assets to GDP (ORA/GDP), and a measure of economic readiness to intervene in the FX market. The coarse regime is based on Ilzetzki et al. (2019) and comprises five categories: (1) hard pegs, which include fine categories 1 to 4 out of 15, (2) mainly crawling pegs (categories 5 to 8), (3) somewhat wider bands (categories 9 to 12), (4) freely floating regimes (category 13), and (5) others, including freely falling (category 14) and dual markets (category 15). The table is obtained from monthly data on an unbalanced sample of 28 economies from 2001-2020.

Empirical models. We use two empirical models to explain the incidence of an FX intervention in a given month and country. First, our benchmark approach is the Logit model, which explains the incidence of FXI by considering different sets of institutional variables. Second, we optimize the information contained in the institutional variables by applying a Random Forest Model, i.e., a widely used machine learning approach. Due to its construction, we expect the random forest approach to deliver a better performance, whereas the Logit model can be more easily interpreted economically.

While the Logit model is well-known, the Random Forest Model may deserve some explanation about the approach in general and how we implement it here. First, note that random forest is an ensemble machine-learning algorithm that can be used for classification and regression tasks. It consists of a collection of decision trees and generates predictions by averaging the results of individual trees. It works by randomly splitting the dataset into subsets, building decision trees on these subsets, and combining the results of these trees to produce the final prediction. Random forest is a popular algorithm in machine learning because it performs well for classification and regression problems, handles missing values and outliers well, and can handle large datasets and high-dimensional feature spaces. It also improves accuracy compared to a single decision tree and is resistant to overfitting when compared to a single decision tree. However, it can be slow for real-time prediction due to a large number of trees, biased towards features with many categories or high cardinality, and prone to overfitting if the number of trees is too large.

Success measures. Most of our results are based on Logit models, and we display the strength of the relationship of interest as an odds ratio to ease interpretation. We standard-normalize the underlying data to make these ratios more comparable across exogenous variables and settings. Hence, the resulting odds ratio informs about its change when there is a one standard deviation change in the exogenous variable.

However, odds ratios are of limited value if one thinks of a more practical implementation. Thus, we also use standard interpretations of the four cases of outcomes that can occur in our setting: if an actual intervention takes place and is correctly identified as such, i.e., the "true positive" case (A); if it is not identified this is "false negative" (C); if there is no actual intervention, but it is falsely classified as such, this is "false positive" (B); finally, the case of no intervention and no classification as such is "true negative" (D). The first prominent success measure is "accuracy," the share of all correct classifications (A+D) to all cases, which should be large. Our second success measure is the ratio of the "probability of false alarm" (B/(B+D)) relative to the "probability of detection" (A/(A+C)), called the "noise-to-signal ratio," which should be small. While accuracy is also informative, we prefer the latter measure because it balances different forecasting mistakes.

4.2 Main results in explaining FX intervention

We present the main results in two steps, i.e., using the preferred Logit model approach on a small sample with precise FXI information and using a large country sample with proxied FXI data.

Small sample with precise FXI. We start with the results of the Logit models explaining actual FXI iWe start with the results of the Logit models explaining actual FXI in the sample of up to 28 countries. The first regressions consider the three institutional variables one by one. After that, we combine them in increasingly comprehensive multiple regressions. We estimate a Logit model of the form:

$$\log\left(\frac{P(Y_{it}=1)}{1-P(Y_{it}=1)}\right)=\beta_0+\beta_1 X_{1t}+\beta_2 X_{2t}+\cdots+\beta_k X_{kt}+\sum_t \delta_t D_{\text{year}_t}+\sum_i \gamma_i D_{\text{country}_i}$$

where $\log\left(\frac{P(Y_{it}=1)}{1-P(Y_{it}=1)}\right)$ is the log odds of foreign exchange intervention, Y_{it} is a binary index indicating the occurrence of a foreign exchange intervention for a country i in a month t and $X_{1t}, X_{2t}, \cdots, X_{kt}$ the vector of explanatory variables. We add country $D_{\text{country}_1}, D_{\text{country}_2}, \cdots, D_{\text{country}_m}$ and time $D_{\text{year}_1}, D_{\text{year}_2}, \cdots, D_{\text{year}_t}$ dummy variables to absorb the respective heterogeneity in the main specifications. Time-invariant country-level heterogeneity may come from a potentially higher likelihood of intervening due to specific country or central bank characteristics. As some countries always or never intervene when public intervention data are available, country fixed-effects reduce the sample to 5 AEs and 14 EMs. Furthermore, we include time-fixed effects for each year, which absorb general differences at a specific point in time, which can be the case during a crisis or in particularly calm times.

Table 5 provides the results of this exercise in Panel A for the small sample and in Panel B for the large sample. Panel A, column (1) shows the result for the exchange regime classification according to the coarse grid. Relative to the hard peg regime, all others are characterized by

fewer FXI; a tendency of less FXI with increasingly flexible regimes, i.e. from hard peg to peg to wider band etc., is only weak. The realization of success measures, such as an accuracy of 0.888 (to be large in a range of 0 to 1) and a noise-to-signal ratio (NSR) of 0.235 (to be small in a range of 0 to 1), are reasonable, indicating that regimes are related to FXI, and more rigid regimes tend to intervene more often. Columns (2) and (3) show coefficients on reserves and readiness, respectively, being largely around two, highly significant, and generating reasonable but slightly worse success measures.

Column (4) shows the result when combining the variable regime with the one on reserves, column (5) combines regime with readiness, column (6) does this with reserves and readiness, and in column (7), all three institutional variables are used to explain the incidence of FXI. Relying on two or three variables very slightly improves the explanatory power of the regressions relative to relying on reserves or readiness only. However, these regressions with two or more RHS variables do not outperform the information provided by the exchange rate regime alone. The least important variable of the three is official reserves (when combined with others).

Large sample with proxied FXI. In Panel B of Table 5, we repeat the analysis shown in Panel A but now use the FXI proxy as the dependent variable (FXI volume to GDP) to be able to rely on the large sample with 75 countries (qualitatively similar results for this approach in the small sample are shown in Appendix Table A.3). The results indicate similar adjusted R-squares across the seven specifications shown in columns 1 to 7. Thus, each indicator or combination provides information about FXI (volume) to a similar degree. Compared to before, reserves (relative to GDP) are relatively more important, while readiness seems more informative for the incidence of FXI.

Interim summary. We show in Panel A of Table 5 that all three institutional variables provide useful information about FXI (incidence), where FXI is measured precisely. When comparing these three variables to each other, the exchange rate regime appears to be relatively better at explaining FXI. These results are qualitatively confirmed by the information shown in Panel B for a larger sample, a different FXI measure, and a different method.

Table 5: Analysis of institutional variable on spot Foreign Exchange Interventions (FXI) across economies (with country and time dummies)

Panel A: 28 economies

	Spot FXI (Dummy)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Coarse: Hard pegs							
Coarse: Crawling pegs	0.238***			0.238***	0.118***		0.084***
	(0.078)			(0.086)	(0.047)		(0.036)
Coarse: Wider bands	0.777			0.776	1.183		0.764
	(0.172)			(0.267)	(0.294)		(0.277)
Coarse: Freely floating	0.154***			0.154***	0.294***		0.181***
	(0.039)			(0.060)	(0.080)		(0.074)
Coarse: Others	0.089***			0.089***	0.059***		0.038***
	(0.034)			(0.040)	(0.029)		(0.021)
Official Reserves/GDP		1.834***		0.998		1.289	0.671
		(0.281)		(0.225)		(0.212)	(0.160)
Readiness Index (Continuous)			2.428***		2.826***	2.325***	2.908***
			(0.269)		(0.331)	(0.272)	(0.346)
Observations	3687	3687	3643	3687	3643	3643	3643
AIC	3059.688	3142.009	3065.761	3061.688	2965.227	3064.925	2964.431
BIC	3333.041	3396.725	3319.984	3341.254	3244.253	3325.348	3249.656
Accuracy (AUC)	0.888	0.881	0.886	0.888	0.894	0.886	0.894
Probability of detection (TPR)	0.786	0.854	0.874	0.786	0.829	0.852	0.834
Probability of false alarm (FPR)	0.185	0.263	0.264	0.185	0.213	0.251	0.216
Noise-to-signal ratio (NSR)	0.235	0.308	0.303	0.235	0.257	0.294	0.259
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: 75 economies

	Spot FXI proxy/GDP						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Coarse: Hard pegs							
Coarse: Crawling pegs	-0.252***			-0.223***	-0.224***		-0.202***
	(0.049)			(0.049)	(0.050)		(0.050)
Coarse: Wider bands	-0.412***			-0.350***	-0.378***		-0.331***
	(0.063)			(0.062)	(0.063)		(0.063)
Coarse: Freely floating	-0.373***			-0.316***	-0.343***		-0.299***
	(0.063)			(0.063)	(0.064)		(0.064)
Coarse: Others	-0.206***			-0.131*	-0.147*		-0.090
	(0.056)			(0.056)	(0.058)		(0.057)
Official Reserves/GDP		0.198***		0.180***		0.186***	0.173***
		(0.024)		(0.023)		(0.024)	(0.024)
Readiness Index (Continuous)			0.077***		0.058***	0.036*	0.022
			(0.016)		(0.016)	(0.016)	(0.016)
Observations	12516	12571	12408	12516	12353	12408	12353
AIC	28381.211	28411.820	28279.852	28258.802	28118.189	28156.636	28012.834
BIC	29065.209	29073.904	28940.774	28950.235	28808.402	28824.985	28710.469
R-squared	0.442	0.444	0.439	0.447	0.443	0.445	0.448
Adjusted R-squared	0.438	0.440	0.435	0.443	0.439	0.441	0.443
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table consolidates findings from both logistic and linear regression analyses, examining the impact of three institutional variables on the likelihood and intensity of foreign exchange interventions (FXI) across different economies from 2001-2020. The three institutional variables include the coarse exchange rate regimes, based on Ilzetzki et al. (2019), the Official Reserves to GDP ratio, and a continuous Readiness Index as an economic indicator to assert countries readiness to intervene on the FX market. The analysis spans two panels: Panel A focuses on 28 economies using logistic regression to model the probability of FXI occurrences. Odds Ratios are presented in panel A, with standard errors enclosed in parentheses. Panel B extends the inquiry to 75 economies using linear regression to assess the influence of the same factors on the FXI proxy normalized by GDP. In FXI proxy/GDP, we compute the absolute values of the Spot FXI proxy divided by GDP to measure the total volume of FXI without considering whether it is a purchase or sale transaction. Coefficients in panel A are presented with robust standard errors in parentheses.

4.3 Robustness checks in explaining FX intervention

We conduct four robustness checks regarding the main results from above Section 4.2. As these checks largely confirm findings, we report them in detail in Appendix C and just mention a few results here.

(i) We neglect fixed effects in the estimations and see that these indeed capture much of the explanatory power, particularly in the small sample. This is to be expected, and the main structures hold in the estimations. (ii) We use two alternative definitions of exchange rate regimes, following the proposal by Hassan et al. (2023), who build on Ilzetzki et al. (2019). While their 6-regime classification sometimes provides even better results than our standard classification of exchange rate regimes, overall, there is not that much difference. (iii) We replicate the regressions by applying a Random Forest model, which can be quite powerful in detecting systematic relations. However, compared to the benchmark results shown in Table 5, there is no real improvement, probably because we apply fixed effects in the regression reported in Table 5 and these capture useful time-invariant information about country level differences that the RF model misses. (iv) Finally, we separately analyze the sub-samples of advanced economies (AEs) and emerging and developing economies (EMs). Main results largely hold for both sub-samples, and we do not find systematic differences across these groups when we consider both the small and the large country samples.

4.4 Predicting FX Intervention via Preparedness

As the institutional policy decisions regarding the intended degree of preparedness are done ahead of FXI, it may be possible that the degree preparedness can forecast later FXI. However, actual FXI are often determined by recent developments in foreign exchange markets and, thus, may be too noisy to be forecasted by longer ranging institutional decisions. We will test in this Section 4.4 which of these hypotheses gets more support from the data.

To assess the forecasting ability of the three elements of FXI preparedness we rely on three analyses: first, we calculate a naïve benchmark by assuming that the incidence of FXI in the forecasting period will be identical to last observation considered. We take for all three models a lag of three months, assuming that this may be the delay between decision about FXI and data availability, so that the forecast for January 2016 uses data until October 2015. Second, we rely on the preferred Logit model for FXI (see Table 5), and third we use the same input of for the Logit model but analyze it via a machine-learning Randon Forest model. In each case, we split the total sample period into a longer support period on which the model is calibrated and a one-year out-of-sample estimation period. We start with 2001 to 2015 as the support period and then predict the intervention months for all countries during 2016. Subsequently, the support period is from 2001 to 2016, and the estimation period is 2017. Thus, we get predictions for five years, i.e., 2016 until 2020. We do this for the small sample of 28 countries, because this represents actual FXI data and because the FXI incidence is the basic decision, being even more

relevant than deciding about the FXI amount (which would be available for the large sample).

The in-sample explanatory power of the model with all three institutional variables covering the entire sample period provides a reference point, which is documented in Table 5, Panel A, column (7). There, the accuracy of the Logit model is 0.894, and the NSR is 0.259. We expect that in-sample predictive performance will be better than when predicting out-of-sample. Table 6 shows the outcomes of the respective forecasting, year by year, from 2015 to 2020. The average accuracy of the naïve forecast model is 0.878 and the NSR is 0.155. Numbers for the Logit model are 0.821 and 0.281, those for the Random Forest model are 0.875 and 0.292, indicating that the Random Forest does not really improve forecasting here. Overall, there seems to be relatively small decline relative to the in-sample performance and also a decline relative to a naïve forecasting model. Thus, the models do not really deliver a considerable forecasting performance. This is even more true considering that many countries do not change their intervention behavior over time, so that they either intervene always or never. Taking this into account and reducing the sample to countries that vary FXI incidence within the considered time period, results get much worse, and underline the difficulty to forecast at a monthly frequency (Appendix Table A.6).

Table 6: Year-by-year performance comparison of logit, random forest, and GLM models for predicting foreign exchange interventions using 3-months lags

Panel A: 28 economies

Spot FXI (dummy) Coarse, Official Reserves/GDP, and Readiness Index (Continuous)						
	2016	2017	2018	2019	2020	Average
Naïve benchmark						
Accuracy (AUC)	0.902	0.861	0.906	0.902	0.942	0.903
Probability of detection (TPR)	0.915	0.869	0.911	0.916	0.944	0.911
Probability of false alarm (FPR)	0.114	0.146	0.099	0.116	0.062	0.107
Noise-to-signal ratio (NSR)	0.124	0.168	0.109	0.127	0.066	0.119
Logit						
Accuracy (AUC)	0.906	0.787	0.766	0.785	0.86	0.821
Probability of detection (TPR)	0.929	0.784	0.703	0.781	0.78	0.796
Probability of false alarm (FPR)	0.106	0.25	0.234	0.312	0.204	0.221
Noise-to-signal ratio (NSR)	0.114	0.319	0.333	0.399	0.261	0.285
Random forest						
Accuracy (AUC)	0.954	0.856	0.857	0.866	0.867	0.88
Probability of detection (TPR)	0.986	0.95	0.756	0.944	0.927	0.912
Probability of false alarm (FPR)	0.13	0.333	0.177	0.377	0.31	0.265
Noise-to-signal ratio (NSR)	0.132	0.351	0.235	0.399	0.334	0.29
Observations	264	283	313	316	277	290.6

Notes: The table presents a year-over-year evaluation of different forecasting models - the Logistic, Random Forest, and GLM models - for predicting spot Foreign Exchange Interventions (FXI) using 3-months lags. Starting with 2015 data, each model forecasts the following year's FXI by using the 3-months lags value of Coarse exchange rate regime, Official Reserves/GDP ratio, and Readiness index as input variables. The forecasted FXIs are then matched against the actual market interventions for that particular year. This annual prediction sequence updates the input data set progressively, meaning the forecast for 2016 is based on data up to 2015, while the forecast for 2019 uses information available until 2018. The Coarse exchange rate regime, as described by Ilzetzki et al. (2019), categorizes exchange rates into five classes: (1) hard pegs, (2) predominantly crawling pegs, (3) broader bands, (4) fully floating rates, and (5) all other types.

In summary, results on the larger sample (Panel B) seem to be tentatively weaker than for the smaller sample (Panel A), although they cannot be compared directly due to the different methods applied. A reason may be that the institutional characteristics used here as RHS variables are chosen to indicate preparedness, which is closer to predicting the incidence of FXI in the small sample than to predicting the volume of FXI.

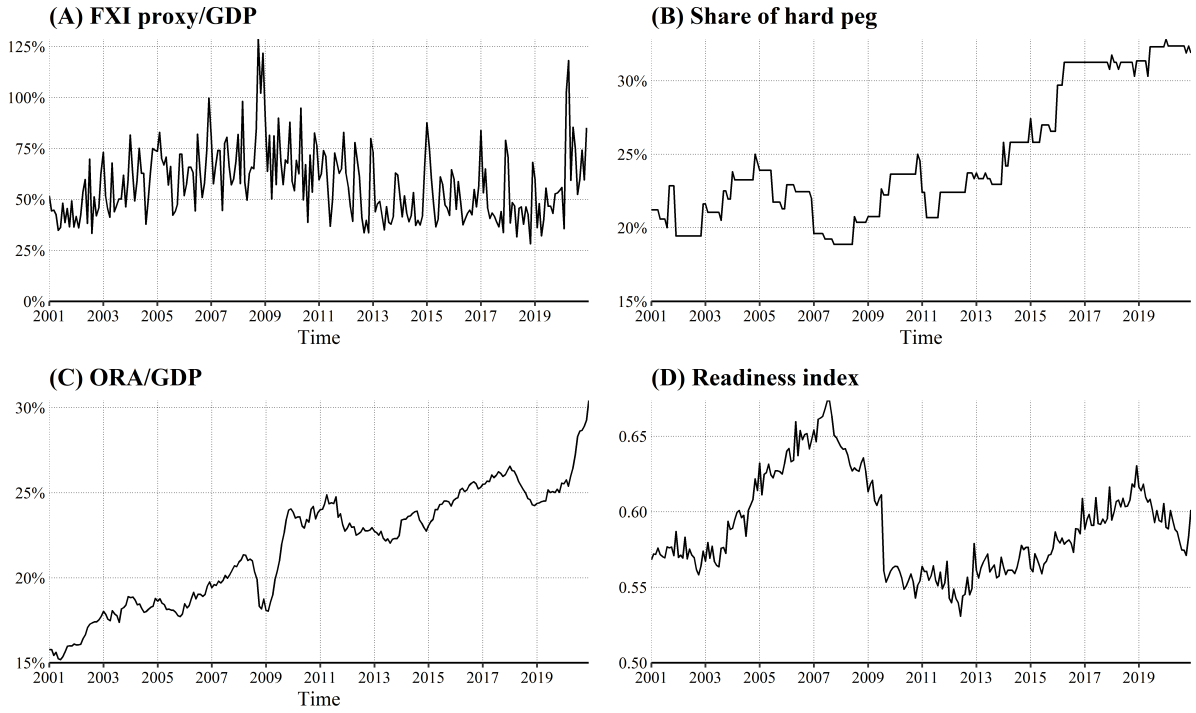
5 Development of FXI preparedness

This section analyses the development of those three institutions that capture FXI preparedness, according to our argument. We use the large sample for better coverage of the world economy. In the first part, we describe their development over time, and in the second part of this section we aim for explaining the cross-country heterogeneity in the level of preparedness for FXI.

Development over time. Figure 3 shows, for the sample of 75 countries, the development of FXI and the three institutional variables discussed above over the 20 years 2001-2020. The figure indicates that the topic of FXI and the underlying institutional decisions have remained relevant over the last 20 years. FXI is measured as FXI/GDP (based on the Adler et al., 2021, proxy) to get a larger country sample than by relying on the actual FXI data. The development of exchange rate regimes needs some simplification to condense the information from the six regimes; thus, we indicate the status by the ratio of hard pegs to other kinds of regimes. Reserves are measured straightforwardly, i.e., ORA/GDP, and readiness is indicated by the readiness index.

Panel A, representing FXI (precisely: the absolute volume of FXI relative to GDP), shows an increase until the end of 2008, followed by some decline and increase in 2019/2020. Panel B on the share of hard pegs shows an increase during the 2010s from about 20% to more than 30%. Panel C on reserves to GDP documents a quite continuous trend of a remarkably increasing ratio over most of the years, while Panel D on readiness reminds more of Panel A, with a strong increase over the first years followed by a decline and some increase after that. Overall, we note that FXI and readiness kept their level over the 20 years and that rigid regimes and reserves clearly increased. These patterns are confirmed when using GDP-weights, instead of equal weight, for the aggregation of countries (see Appendix Figure A.2), and they are also confirmed for our small sample of 28 countries (see Appendix Figure A.3). Overall, these developments document that the preparedness for FXI has increased over time.

Figure 3: Trends in Foreign Exchange Interventions and Economic Indicators (2001-2020)



*Notes:*This figure shows the evolution of four economic indicators from 2001 to 2020, each measured as average of 75 economies (equally weighted). It includes: (A) the Foreign Exchange Intervention (FXI) proxy as a percentage of GDP, (B) the share of economies adhering to a hard peg exchange rate regime, (C) the ratio of official foreign exchange reserves (ORA) to GDP, and (D) the readiness index to intervene in the FX market. In (A), we compute the absolute values of the Spot FXI proxy divided by GDP to measure the total volume of FXI without considering whether it's a purchase or sale transaction. *Data source:* Data for the FXI proxy are sourced from Adler et al. (2021), exchange rate regime classifications are taken from Ilzetzki et al. (2019), official reserve assets are compiled by International Reserves and Foreign Currency Liquidity (IRFCL) provided by the IMF, and GDP figures are obtained from the World Bank Development Indicators.

Cross-country heterogeneity in preparedness. As FXI preparedness appears to have increased over the twenty years from 2001 to 2020, we analyze potential cross-country differences in the level of preparedness. Ex-ante reasoning may hypothesize that preparedness is higher for countries being more exposed to and thus more depending on trade flows, while a higher level of GDP per capita may indicate generally stronger institutions and thus a lower level of preparedness. Finally, we are interested in a potential influence from geopolitics and test whether a higher degree of democratic institutions goes along with more openness to the world economy and, thus, less FXI preparedness.

These relations are empirically best investigated using a one-dimensional measure of preparedness. To reduce the three institutional dimensions of preparedness into one, we run a Principal Component Analysis (PCA). The first component of the PCA analysis explains around 50% of the variation and loads heavily on regimes and reserves and less on readiness. We run fixed effect regressions, the same approach as applied above, first explaining monthly preparedness by trade openness, i.e., the sum of exports and imports divided by GDP, and GDP per capita. Table 7, column (1) shows that both variables are highly significant with expected

signs (the same signs as in bivariate correlations). Thereafter we use two indices measuring a higher degree of democracy. One index is the "voice and accountability" index provided by the World Bank, and the other index is the "polity score," which is provided by the Polity5 dataset of the Center for Systemic Peace (from Virginia, USA). We do not favor one of them conceptually, but both indices are established and widespread. Both contribute to the regressions with a negative coefficient without qualitatively changing the coefficients of trade openness and GDP per capita. Column (4) shows that when putting both democracy indices into one regression, the World Bank measure, which is also broadly available, is more strongly related, so we prefer it. We learn that preparedness is higher in countries with more trade openness and lower GDP per capita, as expected. Interestingly, preparedness is higher in countries with a lower degree of democracy. This brings us back to the issue of increasing geopolitical tensions in the world economy, partially motivating our research. Our result is consistent with the view, that such tensions contribute to increasing the level of preparedness for FXI.

Table 7: Preparedness and socio-economic indicators

	Preparedness			
	(1)	(2)	(3)	(4)
Trade openness	5.646***	5.157***	7.068***	6.620***
	(0.457)	(0.464)	(0.571)	(0.581)
GDP per capita (log)	-0.228***	-0.209***	-0.209***	-0.202***
	(0.003)	(0.004)	(0.004)	(0.004)
Voice and Accountability		-0.147***		-0.156***
		(0.024)		(0.041)
Polity score			-0.013***	0.000
			(0.002)	(0.004)
Observations	12906	12520	10720	10358
AIC	17294.641	16627.647	13399.963	12879.938
BIC	18003.859	17333.980	14047.871	13524.789
R-squared	0.844	0.846	0.829	0.831
Year dummy	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes

Notes: : This table uses Ordinary Least Squares (OLS) regression models to examine the influence of four socio-economic indicators on countries' preparedness for FXI across an unbalanced sample of 75 economies from 2001-2020. Preparedness is measured through a Principal Component Analysis (PCA) incorporating the presence of hard peg exchange rate regimes (binary), countries' official reserves to GDP ratios, and levels of the readiness index related to countries' ability to intervene in the foreign exchange market based on their reserves structure. Coefficients are denoted as significant at 0.1% (***), 1% (**), or 5% (*) levels. Robust standard errors are in parentheses.

In robustness analyses we also look at measures of financial development. In line with the World Bank project on measuring financial development (see Cihak et al., 2012) we take "private credit by deposit money banks to GDP in %" as measure of financial depth; and we take the average "bank Z-score" in the economy as measure of financial efficiency. Both measures indicate a better quality of the financial system and these better institutions would allow ceteris paribus a lower degree of FXI preparedness. Indeed, this is what direct relations show (Table A.7, in columns 1 and 3). When adding these two variables to the three ones from Table 7, overall results remain qualitatively the same, except that signs of the two financial development

variables switch (Table A.7). This switch occurs probably because of the high correlation of financial development with GDP per capita so that the financial variables capture something minor beyond general economic development. As their coefficient sizes are very small and do not qualitatively change the other coefficients, we think that these smaller influences can be neglected for our purpose.

6 Conclusion

Interventions in foreign exchange markets (FXI) occur in an institutional environment shaped by policymakers to maintain or achieve stability in their open economies. Despite the apparent relationship between such institutional frameworks and FXI, the existence, strength, and nature of such relations have, to the best of our knowledge, not been systematically analyzed. To address this gap, we compile data on the rigidity of the exchange rate regime, the size of official reserve assets relative to GDP, and analyze the various forms of reserve holdings by using new data from the IMF's IRFCL statistics (the latter leads to a new index of FXI readiness). With these we can proxy how prepared countries are for FXI.

We examine the relations between the three institutional variables of interest to each other and FXI; in general, we document significantly positive relations. Next, we combine the three institutional variables that best explain FXI behavior. This approach shows that all three variables contribute, that the exchange rate regime sometimes dominates, but that reliance on all three variables always provides – under various circumstances – good explanatory power. Overall, we find that institutional variables are informative in explaining, but not in predicting, FXI for both emerging and advanced economies, implying that the authorities predetermine their capacity for FXI activity by deciding on some institutional characteristics of the open economy design.

Finally, we analyze whether the policy stance on preparedness towards FXI has changed over time. Relying on the large sample with 75 countries, we find that the exchange rate regimes become more rigid, the ratio of reserves to GDP increases further, and FXI readiness does not decline (which would be expected if reserves are just used as an investment vehicle). When we combine the information from the three institutional variables into a single indicator of FXI-preparedness, the degree of preparedness follows some economic rationale: countries with more trade openness and lower GDP p.c. are more prepared; this also holds for less democratic countries.

Our analysis highlights that policymakers remain prepared to intervene in FX markets amidst a period characterized by a slightly declining trade-to-GDP ratio, which can be interpreted as a sign of stagnating or even decreasing globalization. This preparedness is revealed by looking at institutional decisions, such as increasing rigidity of exchange rate regimes, increasing levels of reserves to GDP, and a continuously high readiness to conduct FXI. These policy decisions go along with increasing geopolitical tensions. Central banks and governments expect more volatile development of the world economy as well as higher economic and non-economic tensions that

make it important to be prepared to defend the exchange rate with foreign exchange intervention if needed.

References

Adler, G., Chang, S., Mano, R. C., and Shao, Y. (2021). Foreign exchange intervention: A dataset of public data and proxies. *IMF Working Paper, 2021/047*, forthcoming in Journal of Money, Credit, and Banking.

Adler, G. and Mano, R. C. (2021). The cost of foreign exchange intervention: Concepts and measurement. *Journal of Macroeconomics*, 67:103045.

Aguiar, M. and Gopinath, G. (2007). Emerging market business cycles: The cycle is the trend. *Journal of Political Economy*, 115(1):69–102.

Aizenman, J. and Lee, J. (2007). International reserves: Precautionary versus mercantilist views, theory and evidence. *Open Economies Review*, 18(2):191–214.

Arango-Lozano, L., Menkhoff, L., Rodríguez-Novoa, D., and Villamizar-Villegas, M. (2024). The effectiveness of FX interventions: A meta-analysis. *Journal of Financial Stability*, 100794, forthcoming.

Arce, F., Bengui, J., and Bianchi, J. (2019). A macroprudential theory of foreign reserve accumulation. *NBER Working Papers*, 26236.

Basu, S., Boz, E., Gopinath, G., Roch, F., and Unsal, F. (2020). A conceptual model for the integrated policy framework. *IMF Working Papers*, 20/121.

Bianchi, J., Hatchondo, J. C., and Martinez, L. (2018). International reserves and rollover risk. *American Economic Review*, 108(9):2629–2670.

Blanchard, O., Adler, G., and de Carvalho Filho, I. (2015). Can foreign exchange intervention stem exchange rate pressures from global capital flow shocks? *NBER Working Papers*, 21427.

Bruno, V. and Shin, H. S. (2015). Cross-border banking and global liquidity. *The Review of Economic Studies*, 82(2):535–564.

Cady, J. and Gonzalez-Garcia, J. (2007). Exchange rate volatility and reserves transparency. *IMF Staff Papers*, 54(4):741–754.

Cavallino, P. (2019). Capital flows and foreign exchange intervention. *American Economic Journal: Macroeconomics*, 11(2):127–170.

Chamon, M., Garcia, M., and Souza, L. (2017). FX interventions in Brazil: A synthetic control approach. *Journal of International Economics*, 108:157–168.

Cihak, M., Demirgüç-Kunt, A., Levine, E. F. H., and Ross, E. (2012). Benchmarking financial systems around the world. *World Bank Policy Research WP*, 6175.

Daude, C., Levy Yeyati, E., and Nagengast, A. J. (2016). On the effectiveness of exchange rate interventions in emerging markets. *Journal of International Money and Finance*, 64:239–261.

Dominguez, K. M., Hashimoto, Y., and Ito, T. (2012). International reserves and the global financial crisis. *Journal of International Economics*, 88(2):388–406.

Eichengreen, B. (2019). *Globalizing Capital: A History of the International Monetary System*. Third edition, Princeton University Press.

Erten, B., Korinek, A., and Ocampo, J. A. (2021). Capital controls: Theory and evidence. *Journal of Economic Literature*, 59(1):45–89.

Fanelli, S. and Straub, L. (2021). A theory of foreign exchange interventions. *Review of Economic Studies*, 88(6):2857–2885.

Frankel, J. and Xie, D. (2010). Estimation of de facto flexibility parameter and basket weights in evolving exchange rate regimes. *American Economic Review*, 100(2):568–572.

Fratzscher, M., Gloede, O., Menkhoff, L., Sarno, L., and Stöhr, T. (2019). When is foreign exchange intervention effective? Evidence from 33 countries. *American Economic Journal: Macroeconomics*, 11(1):132–156.

Fratzscher, M., Heidland, T., Menkhoff, L., Sarno, L., and Schmeling, M. (2023). Foreign exchange intervention: A new database. *IMF Economic Review*, 71:852–884.

Gabaix, X. and Maggiori, M. (2015). International liquidity and exchange rate dynamics. *Quarterly Journal of Economics*, 130(3):1369–1420.

Gelos, G., Gornicka, L., Koepke, R., Sahay, R., and Sgherri, S. (2022). Capital flows at risk: Taming the ebbs and flows. *Journal of International Economics*, 134(103555).

Goldberg, P. and Reed, T. (2023). Is the global economy deglobalizing? And if so, why? And what is next? *Brookings Papers on Economic Activity*, forthcoming.

Hassan, T. A., Mertens, T. M., and Zhang, T. (2023). A risk-based theory of exchange rate stabilization. *Review of Economic Studies*, 90(2):879–911.

Hnatkovska, V., Lahiri, A., and Vegh, C. A. (2016). The exchange rate response to monetary policy innovations. *American Economic Journal: Macroeconomics*, 8(2):137–81.

Ilzetzki, E., Reinhart, C. M., and Rogoff, K. S. (2019). Exchange arrangements entering the 21st century: which anchor will hold? *Quarterly Journal of Economics*, 134(2):599–646.

IMF (2022). Review of the institutional view on the liberalization and management of capital flows. *International Monetary Fund Policy Papers, Washington, DC*.

Jeanne, O. (2016). The macroprudential role of international reserves. *American Economic Review*, 106(5):570–573.

Jeanne, O. and Rancière, R. (2011). The optimal level of international reserves for emerging market countries: A new formula and some applications. *Economic Journal*, 121(555):905–930.

Kaminsky, G. L., Reinhart, C. M., and Végh, C. A. (2004). When it rains, it pours: Procyclical capital flows and macroeconomic policies. *NBER Macroeconomics Annual*, 19:11–53.

Kuersteiner, G. M., Phillips, D. C., and Villamizar-Villegas, M. (2018). Effective sterilized foreign exchange intervention? Evidence from a rule-based policy. *Journal of International Economics*, 113:118–138.

Menkhoff, L., Rieth, M., and Stöhr, T. (2021). The dynamic impact of FX interventions on financial markets. *Review of Economics and Statistics*, 103(5):939–953.

Neely, C. J. (2008). Central bank authorities' beliefs about foreign exchange intervention. *Journal of International Money and Finance*, 27(1):1–25.

Reinhart, C. and Rogoff, K. (2004). The modern history of exchange rate arrangements: A reinterpretation. *The Quarterly Journal of Economics*, 119(1):1–48.

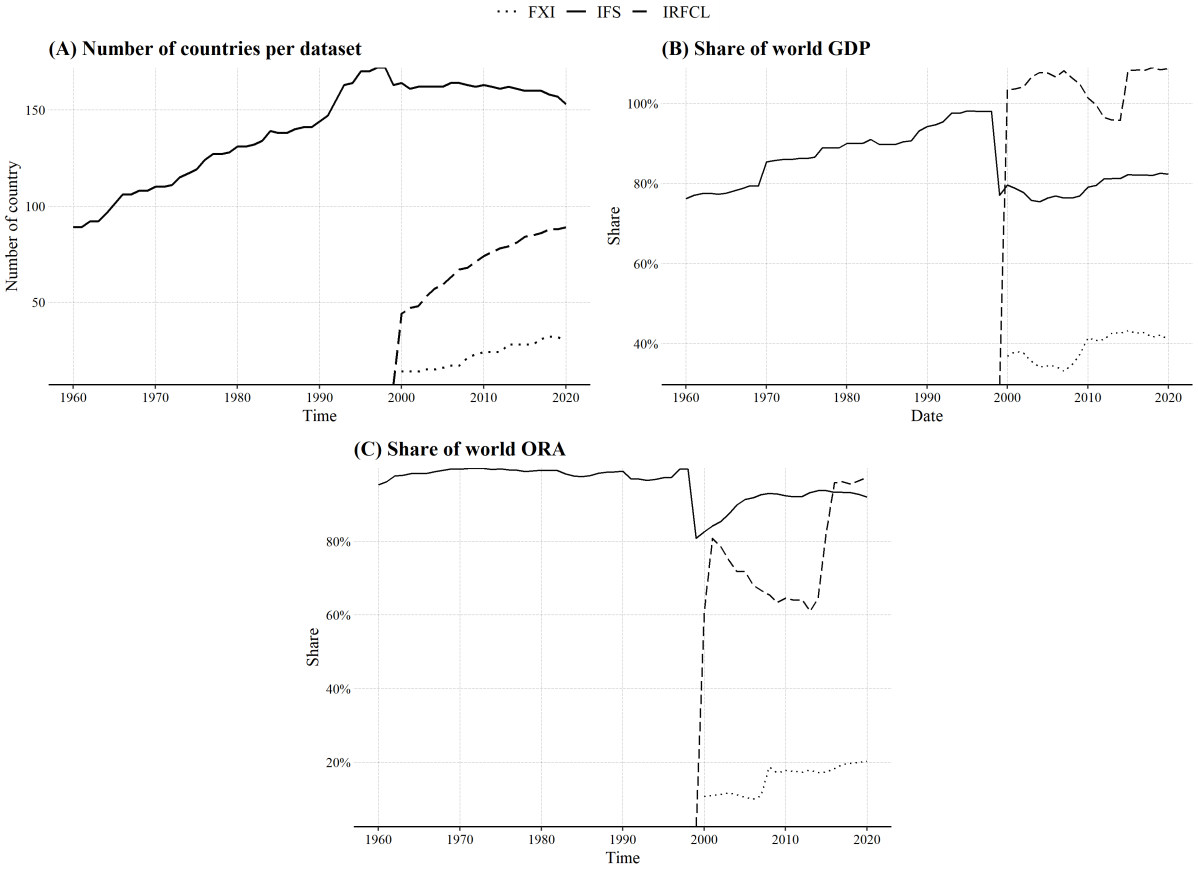
Sarno, L. and Taylor, M. P. (2001). Official intervention in the foreign exchange market: Is it effective and, if so, how does it work? *Journal of Economic Literature*, 39(3):839–868.

Appendix to

Policy Decisions Preparing for FX Intervention

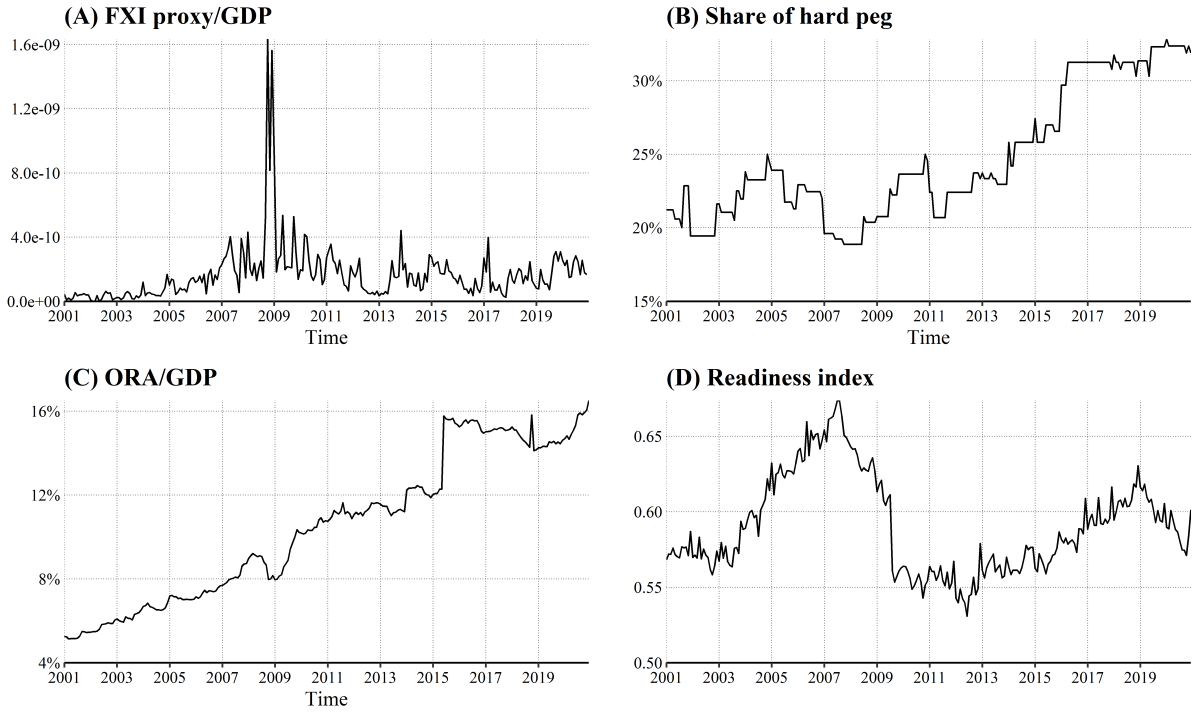
Appendix A: Additional Tables and Figures

Figure A.1: Comparative trends in country participation, global GDP share, and world official reserves across datasets



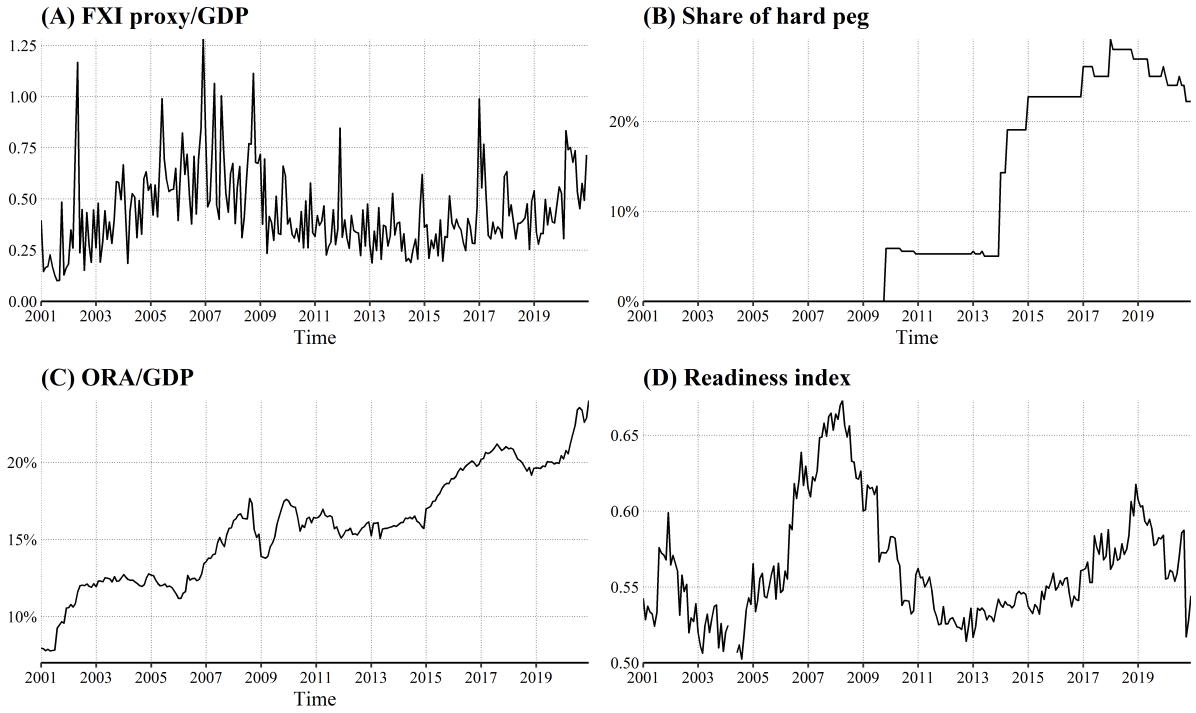
Notes: This figure illustrates the evolution over time across three key dimensions using the International Financial Statistics (IFS), the International Reserves and Foreign Currency Liquidity (IRFCL), and the Foreign Exchange Interventions (FXI) datasets (Adler et al., 2021). (A) tracks the number of countries included in each dataset from 1960 to 2020, (B) depicts the share of world GDP represented within each dataset and (C) focuses on the share of world Official Reserve Assets (ORA) documented by each dataset.

Figure A.2: Trends in FXI and economic indicators (2001-2020) for a set of 75 economies



Notes: This figure compares the evolution of four economic indicators from 2001 to 2022 across 75 economies. It includes (A) the Foreign Exchange Intervention (FXI) proxy as a percentage of GDP, (B) the evolution of economies adhering to a hard peg exchange rate regime, (C) the ratio of official foreign exchange reserves to GDP, and (D) the readiness index. GDP weights are used to aggregate countries. *Data Source:* Data for the FXI proxy are sourced from Adler et al. (2021), exchange rate regime classifications are taken from Ilzetzki et al. (2019), and official reserve assets are compiled by the International Reserves and Foreign Currency Liquidity (IRFCL)), and GDP figures are obtained from the World Bank Development Indicators.

Figure A.3: Trends in FXI and economic indicators (2001-2020) for a set of 28 economies



Notes: This figure compares the evolution of four economic indicators from 2001 to 2022 across 28 economies. It includes (A) the Foreign Exchange Intervention (FXI) proxy as a percentage of GDP, (B) the evolution of economies adhering to a hard peg exchange rate regime, (C) the ratio of official foreign exchange reserves to GDP, and (D) the readiness index. Equal weights are used to aggregate countries. *Data Source:* Data for the FXI proxy are sourced from Adler et al. (2021), exchange rate regime classifications are taken from Ilzetzki et al. (2019), and official reserve assets are compiled by the International Reserves and Foreign Currency Liquidity (IRFCL)), and GDP figures are obtained from the World Bank Development Indicators.

Table A.1: Global overview of IMF's SDDS adherence, official reserves, and FXI in 2020.

N.	Country	Date joined the IMF's SDDS	ORA (2020)	GDP (2020)	ORA/GDP (2020)	Spot FXI (2020)
1	Albania	January 2014	52.182	15.163	3.441	0.029
2	Angola	October 2020	44.787	48.502	0.923	4.296
3	Argentina	September 2000	508.17	385.741	1.317	8.565
4	Armenia, Rep. of	November 2003	30.69	12.642	2.428	0.263
5	Australia	March 2000	544.657	1330.382	0.409	0
6	Austria	December 1999	334.57	435.049	0.769	Not available
7	Belarus, Rep. of	November 2004	96.359	61.372	1.57	0
8	Belgium	July 2000	379.204	526.264	0.721	Not available
9	Bolivia	January 2015	73.735	36.63	2.013	2.973
10	Brazil	December 2000	4232.354	1476.107	2.867	24.768
11	Bulgaria	September 2003	385.057	70.369	5.472	0
12	Cambodia	January 2016	237.431	25.873	9.177	0
13	Canada	April 2000	1065.605	1647.598	0.647	0
14	Chile	August 2000	449.201	254.258	1.767	0
15	China, P.R.: Hong Kong	April 2000	5464.18	344.943	15.841	0
16	China, PR: Mainland	June 2015	39152.128	14687.744	2.666	0
17	Colombia	April 2000	665.364	270.151	2.463	0
18	Costa Rica	November 2009	97.206	62.396	1.558	1.194
19	Croatia, Rep. of	March 2000	245.786	57.76	4.255	0
20	Cyprus	January 2010	14.067	25.227	0.558	Not available
21	Czech Rep.	March 2000	1849.345	245.975	7.518	0
22	Denmark	December 1999	827.744	354.763	2.333	0
23	Dominican Rep.	December 2012	108.24	78.845	1.373	0

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Table A.1 – *Continued from the previous page*

N.	Country	Date joined the IMF's SDDS	ORA (2020)	GDP (2020)	ORA/GDP (2020)	Spot FXI (2020)
24	Ecuador	December 2018	42.608	99.291	0.429	0
25	Egypt, Arab Rep. of	August 2009	464.925	383.818	1.211	0
26	El Salvador	December 1999	46.868	24.93	1.88	0
27	Estonia, Rep. of	January 2000	22.504	31.37	0.717	Not available
28	Euro Area	December 1999	12263.844	13097.222	0.936	0
29	European Central Bank	December 1999	1038.561			Not available
30	Finland	January 2000	152.141	271.886	0.56	Not available
31	France	August 2000	2555.93	2647.419	0.965	Not available
32	Georgia	January 2007	43.987	15.843	2.776	0.45
33	Germany	December 1999	3058.216	3887.727	0.787	Not available
34	Greece	January 2003	123.522	188.48	0.655	Not available
35	Guatemala	August 2008	203.294	77.715	2.616	0
36	Honduras	November 2010	83.768	23.828	3.516	0
37	Hungary	April 2000	407.259	157.227	2.59	0
38	Iceland	October 2000	81.386	21.566	3.774	0
39	India	October 2007	6253.619	2671.595	2.341	98.127
40	Indonesia	June 2000	1583.646	1059.055	1.495	0
41	Ireland	April 2001	70.548	428.609	0.165	Not available
42	Israel	December 2001	1820.443	413.268	4.405	21.238
43	Italy	August 2000	2381.104	1897.462	1.255	Not available
44	Jamaica	August 2013	45.247	13.812	3.276	0.04
45	Japan	April 2000	16551.887	5048.79	3.278	Not available
46	Jordan	January 2006	197.139	43.7	4.511	0
47	Kazakhstan, Rep. of	February 2003	390.285	171.082	2.281	1.582
48	Korea, Rep. of	January 2005	5003.092	1644.313	3.043	0
49	Kyrgyz Rep.	February 2004	31.175	8.27	3.769	Not available
50	Latvia	April 2000	58.56	34.391	1.703	Not available
51	Lithuania	January 2004	58.514	56.965	1.027	Not available
52	Luxembourg	January 2006	13.165	73.699	0.179	Not available
53	Malaysia	April 2000	1249.275	337.456	3.702	0
54	Malta	December 2009	10.629	15.253	0.697	Not available
55	Mauritius	June 2007	86.292	11.408	7.564	0.964
56	Mexico	January 2000	2353.353	1120.741	2.1	0
57	Moldova, Rep. of	May 2006	39.606	11.532	3.434	0.322
58	Mongolia	December 2017	46.528	13.313	3.495	0
59	Morocco	November 2005	362.981	121.354	2.991	0
60	Namibia	January 2020	24.02	10.584	2.27	0
61	Netherlands, The	April 2000	599.989	909.793	0.659	Not available
62	New Zealand	March 2000	214.479	212.57	1.009	0
63	Nicaragua	December 2010	33.153	12.678	2.615	0.015
64	North Macedonia, Republic of	January 2011	45.6	12.364	3.688	0
65	Norway	April 2000	872.529	367.633	2.373	0
66	Paraguay	October 2018	103.374	35.432	2.918	1.08
67	Peru	August 2001	798.621	201.948	3.955	13.944
68	Philippines	April 2000	1053.536	361.751	2.912	0
69	Poland, Rep. of	April 2000	1612.729	599.443	2.69	0
70	Portugal	April 2000	316.121	229.032	1.38	Not available
71	Romania	January 2007	551.577	251.363	2.194	0
72	Russian Federation	December 2004	6928.074	1493.076	4.64	20.103
73	Saudi Arabia	January 2014	5524.146	734.271	7.523	0
74	Seychelles	January 2011	6.988	1.184	5.904	Not available
75	Singapore	August 2000	3785.912	348.392	10.867	0
76	Slovak Rep.	December 1999	103.79	106.731	0.972	Not available
77	Slovenia, Rep. of	March 2000	13.945	53.735	0.26	Not available
78	South Africa	July 2000	650.317	338.291	1.922	0
79	Spain	August 2000	936.801	1278.129	0.733	Not available
80	Sri Lanka	October 2015	81.656	84.441	0.967	0
81	Sweden	August 2000	682.399	547.054	1.247	0
82	Switzerland	September 2000	11488.501	741.999	15.483	0
83	Thailand	April 2000	2916.838	500.457	5.828	0
84	Turkey, Rep of	August 2000	1080.431	720.338	1.5	5.985
85	Ukraine	December 2002	323.631	156.618	2.066	5.098
86	United Kingdom	April 2000	2503.322	2697.807	0.928	0
87	United States	October 2000	1623.974	21060.474	0.077	0
88	Uruguay	August 2003	191.92	53.667	3.576	0
89	West Bank and Gaza	September 2012	8.17	15.532	0.526	0

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Table A.1 – *Continued from the previous page*

N.	Country	Date joined the IMF's SDDS	ORA (2020)	GDP (2020)	ORA/GDP (2020)	Spot FXI (2020)

Notes: This table shows a list of economies in the International Reserves and Foreign Currency Liquidity (IRFCL) database and their participation in the International Monetary Fund's Special Data Dissemination Standard (SDDS), their official reserve assets (ORA) in 2020, Gross Domestic Product (GDP) for the same year, the ratio of ORA to GDP, and spot Foreign Exchange Interventions (FXI) activities in 2020. ORA (2020), GDP (2020), and FXI (2020) are in billion USD.

Table A.2: Data availability across countries for IRFCL, FXI, and sample sizes.

N	Country	IRFCL (Raw data)	IRFCL (Cleaned data)	FXI (Actual)	FXI (Proxy)	Final data (Big sample)	Final data (Small sample)
1	Albania	2014-2023	2014-2022	2013-2020	2000-2021	2014-2020	2014-2020
2	Angola	2020-2023	2020-2022	2000-2020	2000-2021	2020-2020	2020-2020
3	Argentina	2000-2023	2001-2022	2003-2020	2000-2021	2001-2020	2003-2020
4	Armenia	2003-2023	2003-2022	2017-2020	2000-2021	2003-2020	2017-2020
5	Australia	2000-2023	2001-2022		2000-2021	2001-2020	
6	Austria	1999-2023					
7	Belarus	2004-2023	2004-2022		2000-2021	2004-2020	
8	Belgium	2000-2023					
9	Bolivia	2015-2021	2015-2021	2008-2020	2000-2021	2015-2020	2015-2020
10	Bosnia & Herzegovina			2000-2020	2002-2021		
11	Botswana	2022-2023	2022-2022		2000-2021		
12	Brazil	2000-2023	2001-2022	2000-2020	2000-2021	2001-2020	2001-2020
13	Bulgaria	2003-2023	2003-2022		2000-2021	2003-2020	
14	Cambodia	2016-2023	2016-2022		2000-2021	2016-2020	
15	Canada	2000-2023	2001-2022	2009-2020	2000-2021	2001-2020	2009-2020
16	Chile	2000-2023	2001-2022		2000-2021	2001-2020	
17	China	2015-2023	2015-2022		2000-2021	2015-2020	
18	Colombia	2000-2023	2001-2022	2000-2020	2000-2021	2001-2020	2001-2020
19	Costa Rica	2009-2023	2009-2022	2006-2020	2000-2021	2009-2020	2009-2020
20	Croatia	2000-2022	2001-2022		2000-2021	2001-2020	
21	Cyprus	2010-2023			2000-2007		
22	Czechia	2000-2023	2001-2022	2000-2020	2000-2021	2001-2020	2001-2020
23	Denmark	1999-2023	2001-2022		2000-2021	2001-2020	
24	Dominican Republic	2012-2023	2012-2022		2000-2021	2012-2020	
25	Ecuador	2018-2023	2018-2022		2000-2021	2018-2020	
26	Egypt	2009-2023	2009-2022		2000-2021	2009-2020	
27	El Salvador	1999-2023	2001-2022		2000-2021	2001-2020	
28	Estonia	2000-2023	2001-2010		2000-2010	2001-2010	
29	Euro Area	1999-2023	2001-2022	2000-2020		2001-2020	2001-2020
30	European Central Bank	1999-2023					
31	Finland	2000-2023					
32	France	2000-2023					
33	Georgia	2007-2023	2007-2022	2009-2020	2000-2021	2007-2020	2009-2020
34	Germany	1999-2023					
35	Greece	2003-2023			2000-2000		
36	Guatemala	2008-2023	2008-2022		2000-2021	2008-2020	
37	Guyana			2008-2020	2000-2021		
38	Honduras	2010-2023	2010-2022		2000-2020	2010-2020	
39	Hong Kong SAR China	2000-2023	2001-2022		2000-2021	2001-2020	
40	Hungary	2000-2023	2001-2022		2000-2021	2001-2020	
41	Iceland	2000-2023	2001-2022		2000-2021	2001-2020	
42	India	2007-2023	2007-2022	2000-2020	2000-2021	2007-2020	2007-2020
43	Indonesia	2000-2023	2006-2022		2000-2021	2006-2020	
44	Ireland	2001-2023					
45	Israel	2001-2023	2001-2022	2000-2020	2000-2021	2001-2020	2001-2020
46	Italy	2000-2023					
47	Jamaica	2013-2023	2013-2022	2017-2020	2000-2021	2013-2020	2017-2020
48	Japan	2000-2023	2001-2022			2001-2020	
49	Jordan	2006-2023	2006-2022		2000-2021	2006-2020	
50	Kazakhstan	2003-2023	2003-2022	2000-2020	2000-2021	2003-2020	2003-2020
51	Kyrgyzstan	2004-2023	2004-2022			2004-2020	
52	Latvia	2000-2023	2001-2013		2000-2013	2001-2013	
53	Lithuania	2004-2023	2004-2014		2000-2014	2004-2014	

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Table A.2 – *Continued from the previous page*

N	Country	IRFCL (Raw data)	IRFCL (Cleaned data)	FXI (Actual)	FXI (Proxy)	Final data (Big sample)	Final data (Small sample)
54	Luxembourg	2006-2023					
55	Malaysia	2000-2023	2001-2022		2000-2021	2001-2020	
56	Malta	2009-2023			2000-2007		
57	Mauritius	2007-2023	2007-2022	2000-2020	2000-2021	2007-2020	2007-2020
58	Mexico	2000-2023	2001-2022	2000-2020	2000-2021	2001-2020	2001-2020
59	Moldova	2006-2023	2006-2022	2005-2020	2000-2021	2006-2020	2006-2020
60	Mongolia	2017-2023	2017-2022		2000-2021	2017-2020	
61	Morocco	2005-2023	2005-2022	2018-2019	2001-2021	2005-2020	2018-2019
62	Namibia	2020-2023	2020-2022		2000-2021	2020-2020	
63	Netherlands	2000-2022					
64	New Zealand	2000-2023	2001-2022		2000-2021	2001-2020	
65	Nicaragua	2010-2023	2010-2022	2000-2020	2000-2021	2010-2020	2010-2020
66	Nigeria			2008-2017	2000-2021		
67	North Macedonia	2011-2023	2011-2022		2001-2021	2011-2020	
68	Norway	2000-2023	2001-2022		2000-2021	2001-2020	
69	Palestinian Territories	2012-2023	2012-2022		2006-2021	2012-2020	
70	Panama	2021-2023	2021-2022		2000-2021		
71	Paraguay	2018-2023	2018-2022	2013-2020	2000-2021	2018-2020	2018-2020
72	Peru	2001-2023	2001-2022	2000-2020	2000-2021	2001-2020	2001-2020
73	Philippines	2000-2023	2001-2022		2000-2021	2001-2020	
74	Poland	2000-2023	2001-2022		2000-2021	2001-2020	
75	Portugal	2000-2023					
76	Romania	2007-2023	2007-2022		2000-2021	2007-2020	
77	Russia	2004-2023	2004-2022	2008-2020	2000-2021	2004-2020	2008-2020
78	Saudi Arabia	2014-2023	2014-2022		2005-2021	2014-2020	
79	Seychelles	2011-2023	2011-2022			2011-2020	
80	Singapore	2000-2023	2001-2022		2000-2021	2001-2020	
81	Slovakia	1999-2023	2001-2008		2000-2008	2001-2008	
82	Slovenia	2000-2023	2001-2006		2000-2006	2001-2006	
83	South Africa	2000-2023	2001-2022		2000-2021	2001-2020	
84	South Korea	2005-2023	2005-2022		2000-2021	2005-2020	
85	Spain	2000-2023					
86	Sri Lanka	2015-2023	2015-2022		2000-2021	2015-2020	
87	Sweden	2000-2023	2001-2022		2000-2021	2001-2020	
88	Switzerland	2000-2023	2001-2022		2000-2021	2001-2020	
89	Thailand	2000-2023	2001-2022		2000-2021	2001-2020	
90	Tunisia	2001-2019	2001-2019		2000-2021	2001-2019	
91	Turkey	2000-2023	2001-2022	2013-2020	2000-2021	2001-2020	2013-2020
92	Ukraine	2002-2023	2002-2022	2018-2020	2000-2021	2002-2020	2018-2020
93	United Kingdom	2000-2023	2001-2022	2010-2020		2001-2020	2010-2020
94	United States	2000-2023	2001-2022	2000-2020		2001-2020	2001-2020
95	Uruguay	2003-2023	2003-2022		2000-2021	2003-2020	
96	Uzbekistan			2017-2020	2000-2021		
97	Zambia			2013-2019	2000-2021		
	Total	92	77	33	79	75	28

Notes: "*IRFCL (Raw data)*" is the raw data directly provided by the International Reserves and Foreign Currency Liquidity (IRFCL). In the "*IRFCL (Cleaned data)*", some countries are removed based on the year they joined the Euro Area. The European Central Bank has also been removed from the data. "*FXI (Actual)*" is the raw Foreign Exchange Interventions (FXI) data that is publicly available, and "FXI (PROXY)" is the proxy intervention. "*Final data (Big sample)*" is our final sample of 75 economies, and "*Final data (Small sample)*" is our sample of 28 economies.

Table A.3: Analysis of regime, reserves, and readiness on spot FXI: OLS models (small sample)

28 economies							
	Spot FXI proxy/GDP						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Coarse: Hard pegs							
Coarse: Crawling pegs	-0.435***			-0.030	-0.481***		-0.076
	(0.084)			(0.082)	(0.088)		(0.082)
Coarse: Wider bands	-0.513***			-0.013	-0.518***		-0.038
	(0.102)			(0.097)	(0.102)		(0.096)
Coarse: Freely floating	-0.380***			0.162	-0.386***		0.132
	(0.083)			(0.095)	(0.084)		(0.094)
Coarse: Others	-0.368***			0.181	-0.390***		0.138
	(0.096)			(0.104)	(0.098)		(0.102)
Official Reserves/GDP		0.401***		0.443***		0.396***	0.423***
		(0.069)		(0.084)		(0.069)	(0.082)
Readiness Index (Continuous)			0.083*		0.099**	0.061*	0.062
			(0.033)		(0.034)	(0.031)	(0.032)
Observations	3389	3420	3376	3389	3345	3376	3345
AIC	5924.342	5894.235	5986.412	5841.297	5861.488	5841.542	5789.242
BIC	6212.371	6164.281	6255.888	6135.455	6155.019	6117.142	6088.888
R-squared	0.451	0.462	0.437	0.465	0.452	0.461	0.464
Adjusted R-squared	0.443	0.455	0.430	0.457	0.444	0.454	0.456
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table uses Ordinary Least Squares (OLS) regression models to examine the influence of exchange rate regimes, the Official Reserves to GDP ratio, and a continuous Readiness Index on the magnitude of foreign exchange interventions (FXI proxy) across an unbalanced sample of 28 economies from 2001-2020. The coarse regime is based on Ilzetzki et al. (2019) and comprises five categories: (1) hard pegs, which include fine categories 1 to 4 out of 15, (2) mainly crawling pegs (categories 5 to 8), (3) somewhat wider bands (categories 9 to 12), (4) freely floating regimes (category 13), and (5) others, including freely falling (category 14) and dual markets (category 15). In FXI proxy/GDP, we compute the absolute values of the Spot FXI proxy divided by GDP to measure the total volume of FXI without considering whether it is a purchase or sale transaction. Robust standard errors are in parentheses. Coefficients are denoted as significant at 0.1% (***), 1% (**), or 5% (*) levels.

Table A.4: Analysis of coarse regime classification, reserves, and readiness on spot FXI: Logit (small sample)

Panel A: 28 economies

	Spot FXI (dummy)													
	AEs	EMs	AEs	EMs	AEs	EMs	AEs	EMs	AEs	EMs	AEs	EMs	AEs	EMs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Coarse: Hard pegs														
Coarse: Crawling pegs		0.119***						0.060***		0.010***				0.004***
		(0.051)						(0.030)		(0.005)				(0.002)
Coarse: Wider bands	579.100***	0.297*					557.282***	0.136**	535.178***	0.015***			426.080***	0.006***
	(362.666)	(0.170)					(410.924)	(0.089)	(331.699)	(0.010)			(320.676)	(0.004)
Coarse: Freely floating	0.000***	0.094***					0.000***	0.039***	0.000***	0.003***			0.000***	0.001***
	(0.000)	(0.057)					(0.000)	(0.028)	(0.000)	(0.002)			(0.000)	(0.001)
Coarse: Others		0.057***						0.024***		0.004***				0.001***
		(0.028)						(0.015)		(0.002)				(0.001)
Official Reserves/GDP			0.577	2.285*			0.960	0.436*			0.134***	4.267***	0.790	0.347*
			(0.197)	(0.733)			(0.386)	(0.162)			(0.050)	(1.516)	(0.331)	(0.148)
Readiness Index (Continuous)					6.955***	2.142***			2.003	6.107***	17.656***	2.650***	2.090	6.098***
					(2.475)	(0.343)			(0.843)	(1.117)	(7.734)	(0.396)	(0.909)	(1.111)
Observations	1171	2468	1171	2468	1168	2427	1171	2468	1168	2427	1168	2427	1168	2427
AIC	460.040	2281.145	677.676	2334.694	625.986	2307.651	462.033	2278.760	458.415	2177.982	588.215	2290.246	460.219	2173.961
BIC	586.680	2507.781	799.251	2543.896	747.499	2516.249	593.739	2511.207	590.054	2409.758	714.791	2504.639	596.921	2411.532
Accuracy (AUC)	0.888	0.888	0.881	0.881	0.886	0.886	0.888	0.888	0.894	0.894	0.886	0.886	0.894	0.894
Probability of detection (TPR)	0.786	0.786	0.854	0.854	0.874	0.874	0.786	0.786	0.829	0.829	0.852	0.852	0.834	0.834
Probability of false alarm (FPR)	0.185	0.185	0.263	0.263	0.264	0.264	0.185	0.185	0.213	0.213	0.251	0.251	0.216	0.216
Noise-to-signal ratio (NSR)	0.235	0.235	0.308	0.308	0.303	0.303	0.235	0.235	0.257	0.257	0.294	0.294	0.259	0.259
Year Fixed-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table uses Logit regression models to examine the influence of coarse regime classifications, the Official Reserves to GDP ratio, and the continuous Readiness Index on the likelihood of foreign exchange interventions (FXI) across an unbalanced sample of 28 economies from 2001-2020. Each part divides the sample into advanced (AEs) and emerging (EMs) economies. Odds ratios are presented as significant at 0.1% (***), 1% (**), or 5% (*) levels. The coarse regime is based on Ilzetzki et al. (2019). It comprises five categories: (1) hard pegs, which include fine categories 1 to 4 out of 15, (2) mainly crawling pegs (categories 5 to 8), (3) somewhat wider bands (categories 9 to 12), (4) freely floating regimes (category 13), and (5) others. Standard errors are in parentheses.

Table A.5: Analysis of coarse regime classification, reserves, and readiness on spot FXI: OLS models (big sample)

Panel B: 75 economies

	Spot FXI proxy/GDP													
	AEs	EMs	AEs	EMs	AEs	EMs	AEs	EMs	AEs	EMs	AEs	EMs	AEs	EMs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Coarse: Hard pegs														
Coarse: Crawling pegs	-0.215	-0.083*					-0.209	-0.033	-0.193	-0.082*			-0.200	-0.029
	(0.123)	(0.041)					(0.124)	(0.042)	(0.122)	(0.042)			(0.124)	(0.043)
Coarse: Wider bands	-0.358**	-0.157***					-0.324**	-0.057	-0.333**	-0.167***			-0.317**	-0.065
	(0.111)	(0.043)					(0.110)	(0.047)	(0.110)	(0.044)			(0.110)	(0.048)
Coarse: Freely floating	-0.797***	-0.046					-0.751***	0.066	-0.733***	-0.062			-0.729***	0.051
	(0.142)	(0.045)					(0.145)	(0.049)	(0.141)	(0.046)			(0.144)	(0.049)
Coarse: Others		0.018						0.119*		0.030				0.134**
		(0.048)						(0.051)		(0.048)				(0.052)
Official Reserves/GDP			0.154***	0.214***			0.143***	0.221***			0.138***	0.220***	0.132***	0.225***
			(0.029)	(0.031)			(0.029)	(0.033)			(0.032)	(0.031)	(0.032)	(0.034)
Readiness Index (Continuous)					0.101**	0.008			0.084**	-0.004	0.045	0.004	0.032	-0.003
					(0.031)	(0.017)			(0.030)	(0.018)	(0.035)	(0.017)	(0.034)	(0.017)
Observations	3792	8724	3792	8779	3753	8655	3792	8724	3753	8600	3753	8655	3753	8600
R-squared	0.411	0.478	0.412	0.480	0.407	0.477	0.416	0.481	0.412	0.478	0.412	0.480	0.416	0.482
Adjusted R-squared	0.404	0.473	0.406	0.476	0.401	0.472	0.410	0.477	0.405	0.473	0.406	0.476	0.409	0.477
Year Fixed-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed-effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table uses Ordinary Least Squares (OLS) regression models to examine the influence of coarse regime classifications, the Official Reserves to GDP ratio, and the continuous Readiness Index on the magnitude of foreign exchange interventions (Spot FXI proxy/GDP) across an unbalanced sample of 75 economies from 2001-2020. Each part divides the sample into advanced (AEs) and emerging (EMs) economies. Coefficients are denoted as significant at 0.1% (***), 1% (**), or 5% (*) levels. The coarse regime is based on Ilzetzki et al. (2019). It comprises five categories: (1) hard pegs, which include fine categories 1 to 4 out of 15, (2) mainly crawling pegs (categories 5 to 8), (3) somewhat wider bands (categories 9 to 12), (4) freely floating regimes (category 13), and (5) others. In FXI proxy/GDP, we compute the absolute values of the Spot FXI proxy divided by GDP to measure the total volume of FXI without considering whether it is a purchase or sale transaction. Robust standard errors are in parentheses.

Table A.6: Year-by-year performance comparison of logit, random forest, and GLM models for predicting foreign exchange interventions using 3-months lags

Panel A: 28 economies

Spot FXI (dummy) Coarse, Official Reserves/GDP, and Readiness Index (Continuous)						
	2016	2017	2018	2019	2020	Average
Naïve benchmark						
Accuracy (AUC)	0.769	0.606	0.657	0.667	0.615	0.663
Probability of detection (TPR)	0.901	0.627	0.712	0.718	0.652	0.722
Probability of false alarm (FPR)	0.63	0.414	0.413	0.432	0.438	0.465
Noise-to-signal ratio (NSR)	0.699	0.659	0.58	0.602	0.671	0.642
Logit						
Accuracy (AUC)	0.641	0.452	0.56	0.398	0.597	0.53
Probability of detection (TPR)	0.975	0.855	0.516	0.972	0.891	0.842
Probability of false alarm (FPR)	0.889	0.717	0.326	0.946	0.594	0.694
Noise-to-signal ratio (NSR)	0.911	0.839	0.632	0.973	0.666	0.804
Random forest						
Accuracy (AUC)	0.507	0.529	0.706	0.59	0.434	0.553
Probability of detection (TPR)	1	0.691	0.871	0.915	0.978	0.891
Probability of false alarm (FPR)	0.963	0.533	0.587	0.73	0.875	0.738
Noise-to-signal ratio (NSR)	0.963	0.772	0.674	0.797	0.894	0.82
Observations	108	115	108	108	78	103.4

Notes: The table presents a year-over-year evaluation of different forecasting models - the Logistic Regression, Random Forest, and GLM models - for predicting spot foreign exchange interventions (FXI) using 3-months lags. Starting with 2015 data, each model forecasts the following year's FXI by using the 3-months lags value of Coarse exchange rate regime, Official Reserves/GDP ratio, and Readiness index as input variables. The forecasted FXIs are then matched against the actual market interventions for that particular year. This annual prediction sequence updates the input data set progressively, meaning the forecast for 2016 is based on data up to 2015, while the forecast for 2019 uses information available until 2018. Countries that consistently intervene, as well as those that refrain from any intervention within a particular year, are excluded from the data set for that year.The Coarse exchange rate regime, as described by Ilzetzki et al. (2019), categorizes exchange rates into five classes: (1) hard pegs, (2) predominantly crawling pegs, (3) broader bands, (4) fully floating rates, and (5) all other types.

Table A.7: Preparedness and socio-economic indicators

	Preparedness				
	(1)	(2)	(3)	(4)	(5)
Private credit by deposit money banks to GDP (%)	-0.001**	0.004***			0.009***
	(0.000)	(0.000)			(0.000)
Trade openness		4.479***		5.033***	4.400***
		(0.431)		(0.476)	(0.426)
GDP per capita (log)		-0.226***		-0.233***	-0.262***
		(0.004)		(0.007)	(0.006)
Voice and Accountability		-0.132***		-0.136***	-0.151***
		(0.022)		(0.024)	(0.022)
Bank Z-score			-0.041***	0.009***	0.008***
			(0.001)	(0.002)	(0.002)
Observations	12532	12146	12458	12096	11722
AIC	18818.440	14266.343	18882.569	16180.702	13478.426
BIC	19517.428	14977.200	19573.570	16883.762	14185.872
R-squared	0.812	0.865	0.816	0.847	0.870
Year dummy	Yes	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes	Yes

Notes: This table uses Ordinary Least Squares (OLS) regression models to examine the influence of four socio-economic indicators on countries' preparedness for economic fluctuation across an unbalanced sample of 75 economies from 2001-2020. Preparedness is measured through a Principal Component Analysis (PCA) incorporating countries' official reserves to GDP ratios, the presence of hard peg exchange regimes (binary), and readiness indexes related to countries' ability to intervene in the foreign exchange market based on their reserves structure. Coefficients are denoted as significant at 0.1% (***), 1% (**), or 5% (*) levels. Robust standard errors are in parentheses.

Appendix B: More Information about the Construction of the Readiness Index

Section 3 in the paper describes the construction of the readiness index. Here we show additional empirical results in five directions which further substantiate our procedure. First, we show that the patterns of readiness indicators over time are robust to some modifications: (i) we calculate the ratios for the readiness indicators not by equally weighting countries (as in Figure 3 in the main text), but by calculating the sum of all numerator and denominator amounts, so that we get ratios weighted by size (Figure B.1); moreover, we show the development of the four ratios for our small sample of 28 countries (Figure B.2), as well as for the sample of all countries until 2022 (Figure B.3).

Second, we complement the correlation matrix between the readiness indicators for 28 economies, i.e. Table 2 in the paper, with a correlation matrix based on the large sample of 75 economies. However, this implies that we must rely on a less precise measure of FXI, i.e., Adler et al. (2021)-proxy data, which we relate to GDP, to get a measure that can be better compared across countries. The resulting Table 1 shows generally much smaller coefficients than Table 2 in the main paper. This indicates that readiness may be a measure more related to the incidence of FXI than to the extent of FXI. Moreover, we see again that FCR/ORA has the closest relation to FXI; the significant coefficient of PSND/FCR is not very relevant, given the small size of this variable. Finally, FCR/ORA is significantly related to the three other readiness indicators, further supporting its crucial role in understanding FXI. Thus, Table 1 is not a perfect match with Table 2 but it also does not contradict it, and the other message is the probably better fit of readiness with the dummy variable based on actual FXI data.

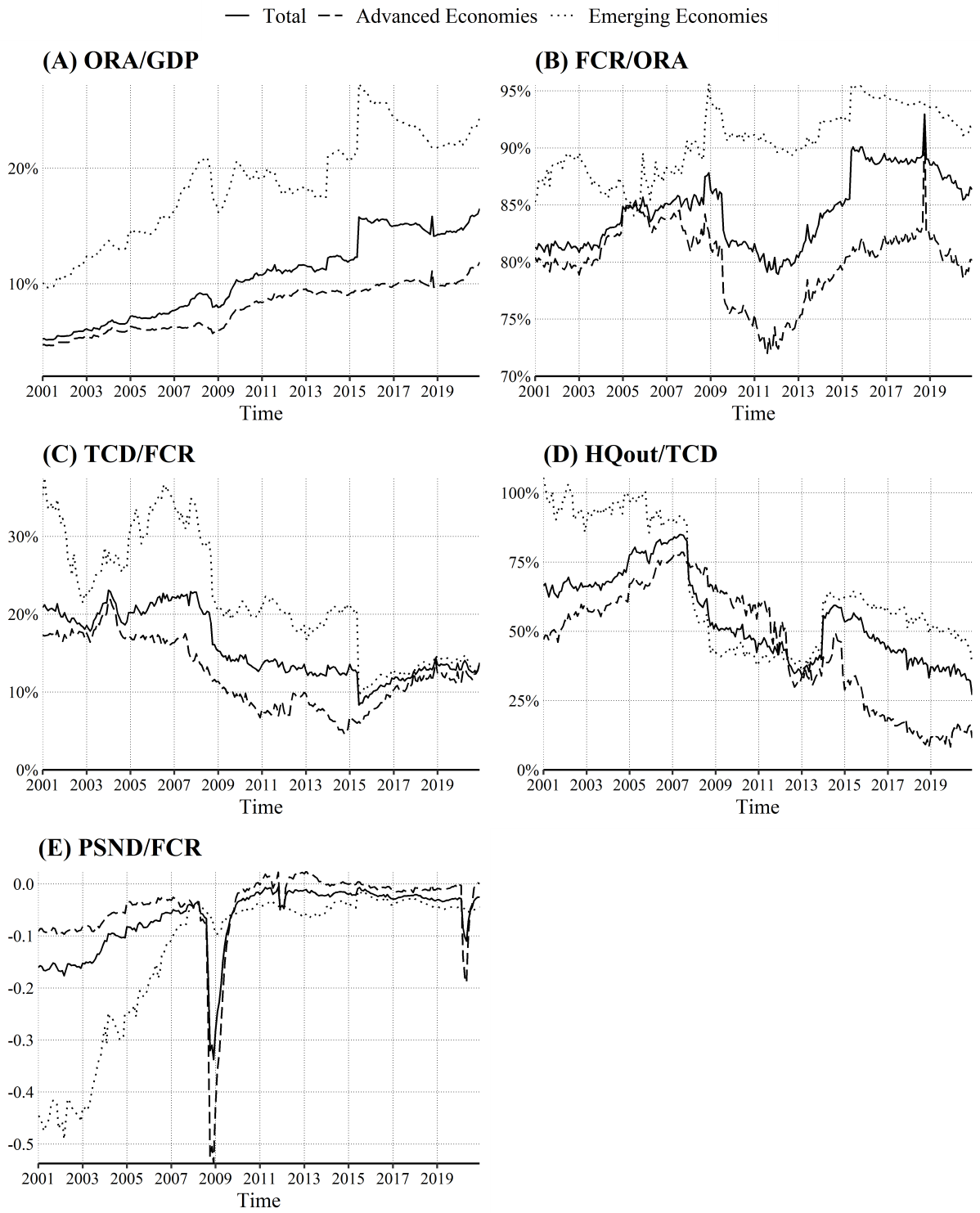
As a third related robustness check, we recalculate the above-described correlation matrix, but for the small sample of 28 countries only. The resulting Table B.2 shows again very small and insignificant coefficients of correlation with FXI. Thus, it confirms that the weaker results in Table B.1 are not because of the sample but because of the FXI measure.

Fourth, Table 3 of the paper is complemented by Table B.3, which documents the contribution of the four single readiness indicators in explaining the incidence of FXI in the small sample. Accordingly, column (1) of Table B.3 repeats column (1) of Table 3, whereas the following columns (2) to (4) show results for the further indicators. Overall, three of them (i.e., FCR/ORA, DEP/FCR, and Bank HQ outside/DEP) have a considerable and statistically highly significant relation to FXI, while the coefficient of PSND/FCR is smaller and insignificant. Assessed by the coefficient size or the noise-to-signal ratio, either FCR/ORA or DEP/FCR seem to be most closely related to FXI (incidence).

In the fifth analysis, we present in Table B.4 more quality measures to assess the regressions formerly shown in Table 3. In particular, we add the information leading to noise-to-signal ratios which cannot be presented in Section 3 yet, because these measures will be introduced in Section 4 only. The best combined readiness index, and better than all single readiness indicators, is

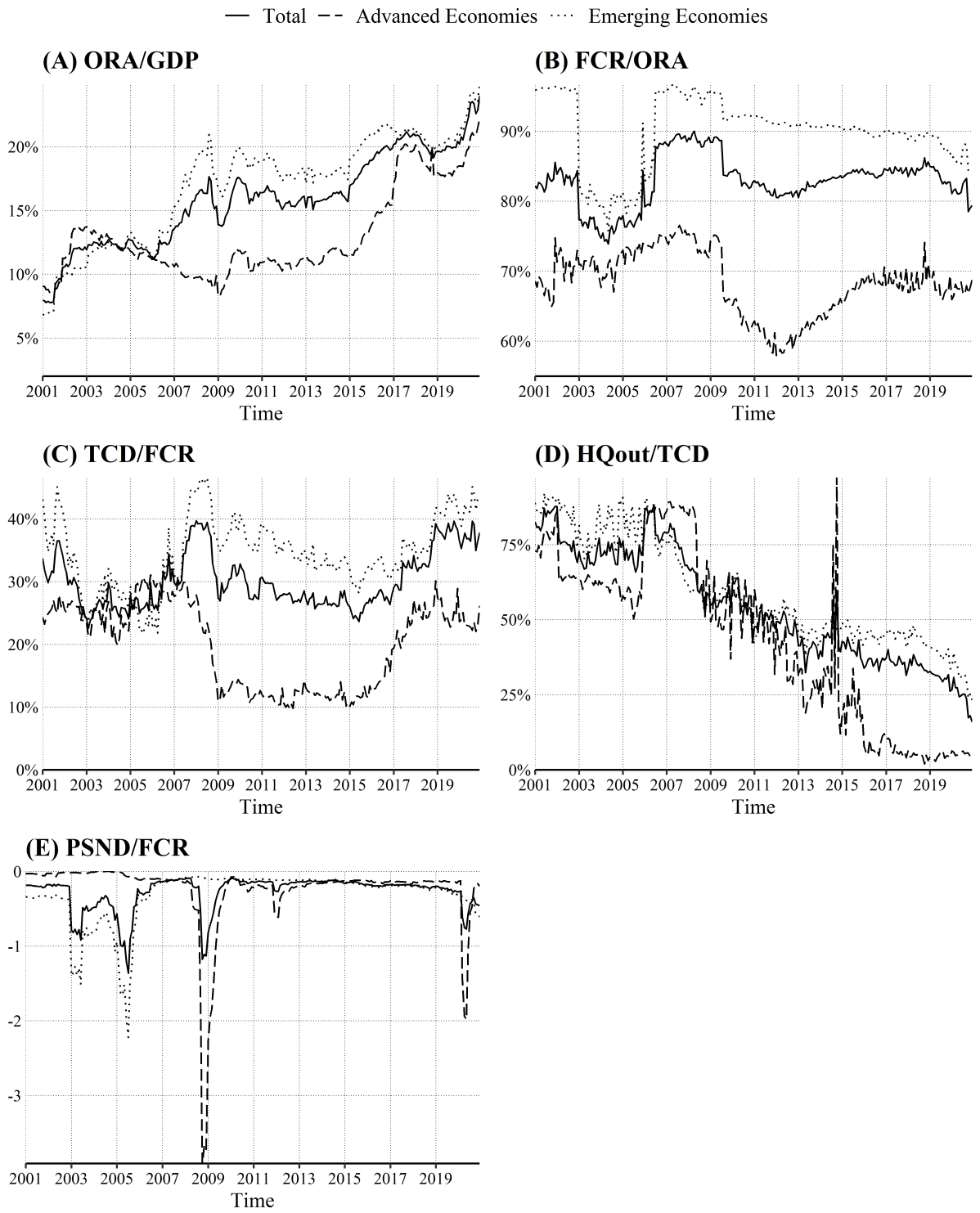
shown in column (2), i.e. the index relying on FCR/ORA and DEP/FCR with a NSR in the specific specification of 0.426. This is exactly the readiness index we use in the remaining part of the paper.

Figure B.1: Evolution of readiness indicators over time (ratios weighted by size)



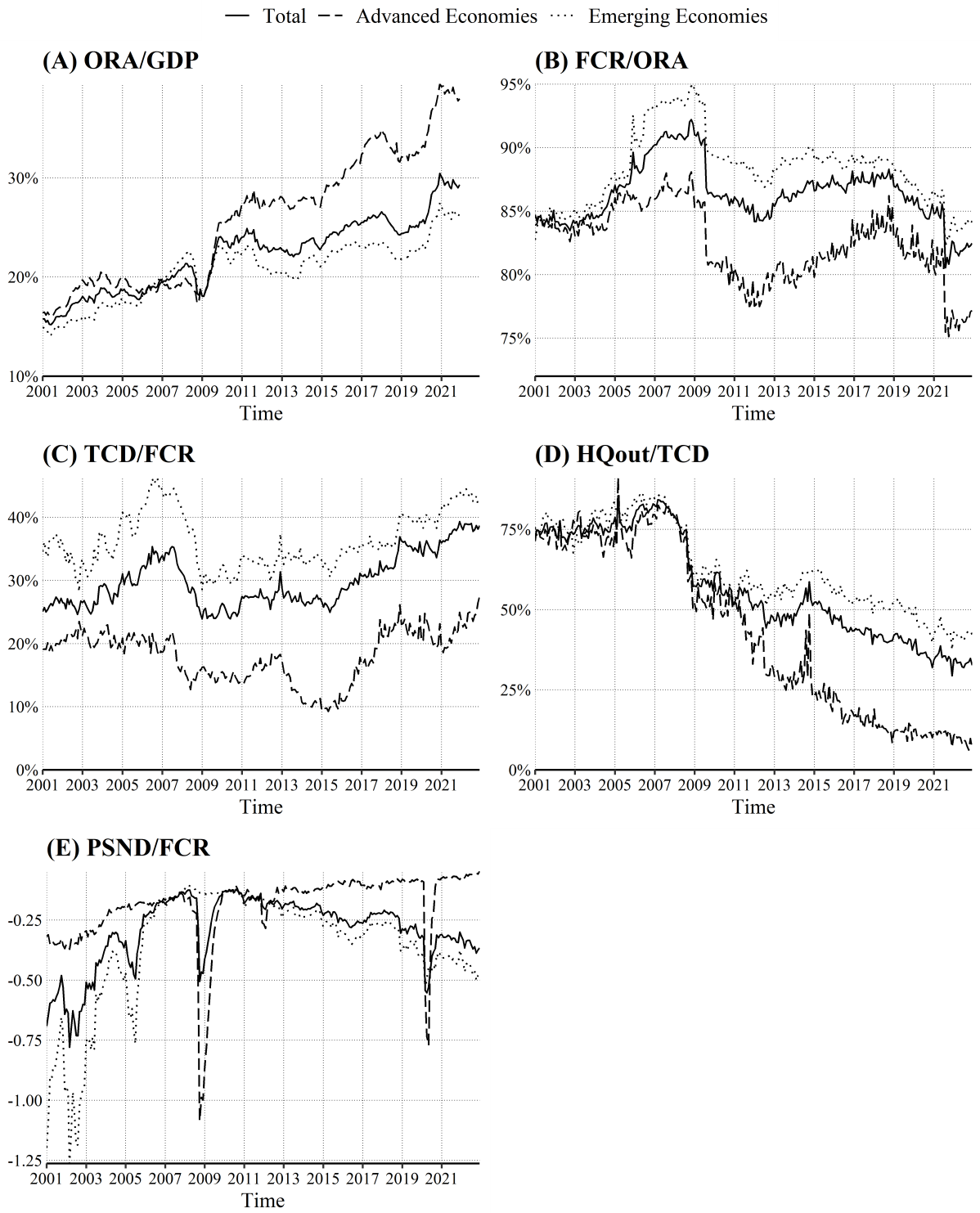
Notes: Panels A, B, C, D and E show official reserve assets (ORA) as a percentage of GDP, foreign currency reserves (FCR) as a percentage of ORA, the share of total currency and deposits (TCR) to FCR, the ratio of deposits held in roughly equal parts, either at other central banks or banks with headquarters outside the reporting country (HQout) to FCR and the ratio of predetermined short-term net drains (PSND) to FCR, across 75 economies, *Data Source:* Reserve assets are compiled by International Reserves and Foreign Currency Liquidity (IRFCL), and GDP figures are obtained from the World Development Indicator database.

Figure B.2: Evolution of readiness indicators over time (28 economies)



Notes: Panels A, B, C, D and E show official reserve assets (ORA) as a percentage of GDP, foreign currency reserves (FCR) as a percentage of ORA, the share of total currency and deposits (TCR) to FCR, the ratio of deposits held in roughly equal parts, either at other central banks or banks with headquarters outside the reporting country (HQout) to FCR and the ratio of predetermined short-term net drains (PSND) to FCR, across 75 economies, *Data Source:* Reserve assets are compiled by International Reserves and Foreign Currency Liquidity (IRFCL), and GDP figures are obtained from the World Development Indicator database.)

Figure B.3: Evolution of readiness indicators over time (75 economies)



Notes: Panels A, B, C, D and E show official reserve assets (ORA) as a percentage of GDP, foreign currency reserves (FCR) as a percentage of ORA, the share of total currency and deposits (TCR) to FCR, the ratio of deposits held in roughly equal parts, either at other central banks or banks with headquarters outside the reporting country (HQout) to FCR and the ratio of predetermined short-term net drains (PSND) to FCR, across 75 economies, *Data Source:* Reserve assets are compiled by International Reserves and Foreign Currency Liquidity (IRFCL), and GDP figures are obtained from the World Development Indicator database.

Table B.1: Correlation analysis of volume of foreign exchange interventions to GDP and asset holdings (2001-2020)

	Spot FXI proxy/GDP	FCR/ORA	TCD/FCR	HQ Out/TCD
Spot FXI proxy/GDP				
FCR/ORA	0.03**			
TCD/FCR	0.01	-0.09***		
HQ Out/TCD	-0.01	0.17***	0.12***	
PSND/FCR	0.05***	0.37***	-0.29***	0.03**

Notes: This table shows the correlation matrices between the volume of foreign exchange interventions to GDP (FXI proxy/GDP) and different types of asset holdings. FXI is coded either "1" indicating an intervention has taken place or 0 signifying no intervention. The assets holdings include the ratio of Foreign Currency to Official Reserve Assets (Foreign Currency/ORA), the ratio of Deposits to Foreign Currency Reserves (Deposits/FCR), the ratio of deposits at foreign banks to Total Currency and Deposits (HQout/TCD), and the ratio of predetermined short-term net drains to Foreign Currency Reserves (PSND/FCR). In FXI proxy/GDP, we compute the absolute values of the Spot FXI proxy divided by GDP to measure the total volume of FXI without considering whether it is a purchase or sale transaction. The table is obtained from monthly data on an unbalanced sample of 75 economies from 2001-2020.

Table B.2: Correlation analysis of volume of foreign exchange interventions to GDP and asset holdings (2001-2020)

	Spot FXI proxy/GDP	FCR/ORA	TCD/FCR	HQ Out/TCD
Spot FXI proxy/GDP				
FCR/ORA	-0.01			
TCD/FCR	0.03	0.02		
HQ Out/TCD	0	0.29***	-0.14***	
PSND/FCR	0.01	0.31***	-0.20***	0.13***

Notes: This table shows the correlation matrices between the volume of foreign exchange interventions to GDP (FXI proxy/GDP) and different types of asset holdings. FXI is coded either "1" indicating an intervention has taken place or 0 signifying no intervention. The assets holdings include the ratio of Foreign Currency to Official Reserve Assets (Foreign Currency/ORA), the ratio of Deposits to Foreign Currency Reserves (Deposits/FCR), the ratio of deposits at foreign banks to Total Currency and Deposits (HQout/TCD), and the ratio of predetermined short-term net drains to Foreign Currency Reserves (PSND/FCR). In FXI proxy/GDP, we compute the absolute values of the Spot FXI proxy divided by GDP to measure the total volume of FXI without considering whether it is a purchase or sale transaction. The table is obtained from monthly data on an unbalanced sample of 28 economies from 2001-2020.

Table B.3: Logistic regression analysis on the impact of different types of asset holdings on spot Foreign Exchange Interventions (FXI)

	Spot FXI (dummy)			
	(1)	(2)	(3)	(4)
Foreign Currency/ORA	2.422***			
	(0.089)			
Deposits/FCR		1.974***		
		(0.094)		
HQ Out/TCD			1.392***	
			(0.047)	
PSND/FCR				1.077
				(0.053)
Observations	3782	3782	3782	3782
AIC	4503.583	4865.699	5045.864	5141.075
BIC	4516.059	4878.175	5058.340	5153.551
Accuracy (AUC)	0.675	0.666	0.599	0.528
Probability of detection (TPR)	0.979	0.616	0.495	0.466
Probability of false alarm (FPR)	0.690	0.356	0.306	0.355
Noise-to-signal ratio (NSR)	0.705	0.578	0.618	0.761
Year dummy	No	No	No	No
Country dummy	No	No	No	No

Notes: All models undergo estimation using logistic regression showing odds ratios. Standard errors are enclosed in parentheses. The dependent variable, Spot FXI (dummy), indicates whether a foreign exchange intervention occurred. Independent variables include the ratio of Foreign Currency to Official Reserve Assets (Foreign Currency/ORA), the ratio of Deposits to Foreign Currency Reserves (Deposits/FCR), the ratio of deposits at foreign banks to Total Currency and Deposits (HQOut/TCD), and the ratio of predetermined short-term net drains to Foreign Currency Reserves (PSND/FCR). Odds Ratios are denoted as significant at 0.1% (***), 1% (**), or 5% (*) levels. All regressors are standardized and normalized.

Table B.4: Logistic regression analysis on the impact of different types of asset holdings on spot Foreign Exchange Interventions (FXI)

	Spot FXI (dummy)					
	(1)	(2)	(3)	(4)	(5)	(6)
Foreign Currency/ORA	2.422***	2.408***	2.260***	2.347***	2.469***	2.248***
	(0.089)	(0.085)	(0.081)	(0.089)	(0.096)	(0.080)
Deposits/FCR		1.970***	2.000***			2.017***
		(0.100)	(0.098)			(0.102)
Bank HQ Outside/TCD			1.187***	1.088*	1.101*	1.187***
			(0.048)	(0.042)	(0.043)	(0.048)
PSND/FCR					0.734**	1.045
					(0.076)	(0.079)
Observations	3782	3782	3782	3782	3782	3782
AIC	4503.583	4263.742	4246.855	4500.617	4478.955	4248.571
BIC	4516.059	4282.456	4271.807	4519.331	4503.907	4279.761
Accuracy (AUC)	0.675	0.74	0.745	0.68	0.683	0.746
Probability of detection (TPR)	0.979	0.647	0.776	0.98	0.906	0.782
Probability of false alarm (FPR)	0.69	0.276	0.399	0.69	0.622	0.403
Noise-to-signal ratio (NSR)	0.705	0.426	0.513	0.704	0.687	0.516
Year dummy	No	No	No	No	No	No
Country dummy	No	No	No	No	No	No

Notes: All models undergo estimation using logistic regression showing odds ratios. Standard errors are enclosed in parentheses. The dependent variable, Spot FXI (dummy), indicates whether a foreign exchange intervention occurred. Independent variables include the ratio of Foreign Currency to Official Reserve Assets (Foreign Currency/ORA), the ratio of Deposits to Foreign Currency Reserves (Deposits/FCR), the ratio of deposits at foreign banks to Total Currency and Deposits (HQout/TCD), and the ratio of predetermined short-term net drains to Foreign Currency Reserves (PSND/FCR). Odds Ratios are denoted as significant at 0.1% (***), 1% (**), or 5% (*) levels. All regressors are standardized and normalized.

Appendix C: Extended results in explaining FX intervention

The extended results cover four different directions: (i) we check the robustness of results by neglecting fixed effects in the estimations, (ii) we use somewhat different definitions of exchange rate regimes, (iii) we analyze the outcome when applying a Random Forest model, and (iv) we separately analyze the sub-samples AEs and EMs.

Estimates without fixed effects. The use of fixed effects is justified by the aim to control for unobserved heterogeneity at the country level or over time so that estimation results are regarded as more precise. However, one may argue that countries purposely decide on exchange rate regimes, et cetera, to address problematic characteristics of their economies, so the regime choice is endogenous in this respect. Then, using fixed effects would eliminate some information in such decisions. In some contrast, time-fixed effects seem to be less problematic because they control for possible time-specific common determinants on FXI; still, this assumption may be too strong, as, for example, freely floating regimes may not intervene at all while a wide band regime does so that the assumption of a common component leads to a distortion of the estimation.

Therefore, we repeat the main analysis from Table 5 but now leave out fixed effects. Results are shown in Table C.1, each column following the ordering of Table 5.

Table C.1: Analysis of institutional variable on spot Foreign Exchange Interventions (FXI) across economies (without country and time dummies)

Panel A: 28 economies

	Spot FXI (Dummy)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Coarse: Hard pegs							
Coarse: Crawling pegs	5.949***			6.016***	4.381***		4.477***
	(0.547)			(0.560)	(0.410)		(0.426)
Coarse: Wider bands	1.695***			1.721***	1.536***		1.583***
	(0.091)			(0.095)	(0.085)		(0.090)
Coarse: Freely floating	0.059***			0.063***	0.123***		0.138***
	(0.009)			(0.011)	(0.020)		(0.025)
Coarse: Others	2.971***			3.067***	2.552***		2.705***
	(0.581)			(0.613)	(0.540)		(0.579)
Official Reserves/GDP		1.967***		1.075		1.284***	1.160
		(0.112)		(0.087)		(0.084)	(0.099)
Readiness Index (Continuous)			2.773***		1.732***	2.725***	1.740***
			(0.099)		(0.086)	(0.103)	(0.087)
Observations	3995	4026	3982	3995	3951	3982	3951
AIC	4029.498	5422.696	4505.466	4030.712	3884.947	4492.615	3883.731
BIC	4054.670	5428.997	4511.755	4062.176	3916.356	4505.194	3921.421
Accuracy (AUC)	0.786	0.715	0.763	0.793	0.816	0.767	0.815
Probability of detection (TPR)	0.978	0.964	0.654	0.977	0.662	0.610	0.675
Probability of false alarm (FPR)	0.523	0.560	0.255	0.521	0.193	0.216	0.216
Noise-to-signal ratio (NSR)	0.535	0.581	0.389	0.534	0.291	0.354	0.319
Year dummy	No	No	No	No	No	No	No
Country dummy	No	No	No	No	No	No	No

Panel B: 75 economies

	Spot FXI proxy/GDP						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Coarse: Hard pegs							
Coarse: Crawling pegs	0.527***			0.593***	0.506***		0.578***
	(0.013)			(0.013)	(0.013)		(0.013)

Coarse: Wider bands	0.484***			0.457***	0.487***		0.459***
	(0.010)			(0.010)	(0.010)		(0.010)
Coarse: Freely floating	0.197***			0.400***	0.209***		0.408***
	(0.008)			(0.012)	(0.009)		(0.012)
Coarse: Others	0.560***			0.672***	0.557***		0.669***
	(0.041)			(0.041)	(0.043)		(0.042)
Official Reserves/GDP		0.227***		0.276***		0.224***	0.272***
		(0.011)		(0.011)		(0.011)	(0.011)
Readiness Index (Continuous)			0.124***		0.086***	0.104***	0.056***
			(0.010)		(0.009)	(0.010)	(0.009)
Observations	12516	12571	12408	12516	12353	12408	12353
AIC	33203.339	34910.473	35135.918	32020.103	32832.092	34461.898	31699.099
BIC	33233.078	34917.912	35143.344	32057.277	32869.200	34476.750	31743.629
R-squared	0.168	0.054	0.011	0.243	0.172	0.064	0.245
Adjusted R-squared	0.168	0.054	0.011	0.243	0.172	0.063	0.245
Year dummy	No	No	No	No	No	No	No
Country dummy	No	No	No	No	No	No	No

Notes: This table consolidates findings from both logistic and linear regression analyses, examining the impact of three institutional variables on the likelihood and intensity of foreign exchange interventions (FXI) across different economies from 2001-2020. The three institutional variables include the coarse exchange rate regimes, based on Ilzetzki et al. (2019), the Official Reserves to GDP ratio, and a continuous Readiness Index as an economic indicator to assert countries readiness to intervene on the FX market. The analysis spans two panels: Panel A focuses on 28 economies using logistic regression to model the probability of FXI occurrences. Odds Ratios are presented in panel A, with standard errors enclosed in parentheses. Panel B extends the inquiry to 75 economies using linear regression to assess the influence of the same factors on the FXI proxy normalized by GDP. In FXI proxy/GDP, we compute the absolute values of the Spot FXI proxy divided by GDP to measure the total volume of FXI without considering whether it is a purchase or sale transaction. Coefficients in panel A are presented with robust standard errors in parentheses.

Regarding Panel A, the results structure is quite similar, but the level of explanatory power goes down, as expected. Interestingly, readiness becomes even more important and is the single most relevant variable. The odds ratios of the regimes "crawling pegs" and "wider bands" are high and thus difficult to explain, but the coefficients of floating regimes are consistently below one and, therefore, make sense. The relatively low noise-to-signal ratios indicate that much information is in the fixed effects, i.e., mainly country-specific behavior, which may also explain the strange coefficients on some regime classifications.

Interestingly, Panel B is less affected by permanently (non-)intervening countries and thus provides the known results structure. The adjusted R-squared confirms what we learn from Table 5, i.e., regimes are most important, reserves matter for the FXI-proxy, and readiness does less so. The coefficients of the regime variables are steadily declining with more regime flexibility, and the use of all three institutional variables provides the highest explanatory power.

Different exchange rate regime classification. The classification of exchange rate regimes remains to some degree arbitrary, depending, among others, on the focus of classification. To assess the robustness of our result, we repeat the main analysis from Table 5 with an alternative exchange rate regime classification. We rely on the definition used by Hassan et al. (2023), who modify the Ilzetzki et al. (2019) classification by giving more weight to the width of allowed exchange rate fluctuations, leading to either 4 or 6 groups of regimes relative to five groups of regimes in the coarse grid.

Table C.2 columns (1) and (2) regression results for the small sample, the 4-regime

classification, and either for regimes only or for all three institutional variables. Coefficients are largely in line with what we know. The same applies for the 6-regimes classification, see columns (3) and (4). Here, the noise-to-signal ratios are the smallest relative to all other approaches. The large sample is the basis of columns (5) and (6). The outcome is very similar to Table 5, i.e., different from the results for the small sample. There is no significant difference in regression quality (proxied mainly by the R-squared).

Table C.2: Analysis of regime, reserves, and readiness on spot Foreign Exchange Interventions (FXI): Logit and OLS models

	Logit			OLS		
	Spot FXI (dummy)			Spot FXI proxy/GDP		
	(1)	(2)	(3)	(4)	(5)	(6)
Fine: Hard peg						
Fine: Soft peg	-0.528*	-1.034**			-0.269***	
	(0.217)	(0.355)			(0.053)	
Fine: Floating	-2.067***	-2.443***			-0.255***	
	(0.245)	(0.395)			(0.059)	
Fine: Others	-1.897***	-2.437***			-0.100	
	(0.331)	(0.462)			(0.058)	
Official Reserves/GDP		-0.622**		-0.719**	0.177***	0.168***
		(0.237)		(0.227)	(0.024)	(0.024)
Readiness Index (Continuous)		0.861***		0.256	0.024	0.012
		(0.117)		(0.143)	(0.016)	(0.016)
Fine category=1						
Fine category=2			17.135***	16.226***		-0.021
			(0.489)	(0.571)		(0.068)
Fine category=3			-0.165	-0.896**		-0.287***
			(0.236)	(0.345)		(0.054)
Fine category=4			-3.402***	-4.062***		-0.442***
			(0.343)	(0.452)		(0.060)
Fine category=5			-4.343***	-5.085***		-0.399***
			(0.337)	(0.464)		(0.062)
Fine category=6			-1.953***	-2.644***		-0.147*
			(0.499)	(0.590)		(0.059)
Observations	3687	3643	3687	3643	12353	12353
AIC	3072.169	3001.378	2814.966	2795.580	28023.608	27986.385
BIC	3339.310	3280.403	3094.531	3087.006	28713.822	28691.442
Year Fixed-effect	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed-effect	Yes	Yes	Yes	Yes	Yes	Yes
Accuracy (AUC)	0.886	0.890	0.909	0.909	-	-
Probability of detection (TPR)	0.820	0.896	0.832	0.812	-	-
Probability of false alarm (FPR)	0.218	0.288	0.159	0.153	-	-
Noise-to-signal ratio (NSR)	0.266	0.321	0.191	0.189	-	-
R-squared	-	-	-	-	0.447	0.449
Adjusted R-squared	-	-	-	-	0.443	0.445

Notes: This table uses Logit and Ordinary Least Squares (OLS) regression models to examine the influence of exchange rate regimes, the Official Reserves to GDP ratio, and a continuous Readiness Index on the likelihood and magnitude of foreign exchange interventions (FXI) across unbalanced samples of economies from 2001-2020. We differentiate in the table two exchange regime classifications: "*Fine: 4 regimes*" (Hard peg, soft peg, floating and others) and "*Fine: 6 regimes*" (category 1 to 6) inspired by Hassan et al. (2023). The analysis is divided into two parts: Columns 1-3 apply Logit regression to predict the binary outcome of FXI occurrences in 28 economies, while columns 4-6 use OLS regression to assess the impact of these variables on the FXI proxy, normalized by GDP, in a broader sample of 75 economies. In FXI proxy/GDP, we compute the absolute values of the Spot FXI proxy divided by GDP to measure the total volume of FXI without considering whether it is a purchase or sale transaction. Robust standard errors are in parentheses. Coefficients are denoted as significant at 0.1% (***), 1% (**), or 5% (*) levels.

Using the Random Forest model. Machine learning approaches, such as Random Forest models, can be powerful in detecting complex relationships between variables, such as interactions. With this capability in mind, we run the Random Forest model using the same variables outlined in the Logit or OLS model presented in Table 5. However, we do not find that the Random Forest model clearly performs better than the Logit or OLS model, probably because the former relies on important fixed effects.

Starting with the small sample explaining FXI incidence, Table C.3, Panel A provides condensed results for the random forest model. The first two columns rely on the coarse regime classification, giving the explanatory power of regime alone in column (1) and the three institutional variables in column (2). Here, it is obviously not sufficient to rely only on the regime. Taking all three institutional variables is crucial. Following this latter model, accuracy is very high at 92.2%, and relative to the Logit model, it can increase the probability of detection but also slightly increases the probability of false alarm so that the noise-to-signal ratio is low at 0.267, and thus almost unchanged relative to the Logit model. Results are slightly better when we use the 4-regimes and, in particular, the 6-regimes classifications, as shown in columns (3) to (6).

Panel B of Table C.3 complements the above results for the small sample with results for the large sample. Columns strictly mirror those of Panel A. Moreover, results in columns (1) and (2) can directly be compared to those in Table 5, Panel B above, where an OLS model is applied. It may be surprising that the R-squared is significantly lower than in the Logit model presented in Table 5. The main reason may be the use of fixed effects in Table 5 because, without these, results (as shown in Table 6) are worse than when using the random forest model.

Table C.3: Analysis of the relationship between reserves, readiness, and different exchange rate regimes on FXI using random forest

Panel A: 28 economies

	Spot FXI (dummy)					
	(1)	(2)	(3)	(4)	(5)	(6)
Coarse regime	Yes	Yes				
Fine: 4 regimes			Yes	Yes		
Fine: 6 regimes					Yes	Yes
Official Reserves/GDP		Yes		Yes		Yes
Readiness Index (Continuous)		Yes		Yes		Yes
Observations	3995	3951	3995	3951	3995	3951
Accuracy (AUC)	0.724	0.922	0.61	0.911	0.792	0.939
Probability of detection (TPR)	0.978	0.934	0.978	0.895	0.752	0.939
Probability of false alarm (FPR)	0.66	0.249	0.66	0.213	0.236	0.204
Noise-to-signal ratio (NSR)	0.675	0.267	0.674	0.238	0.314	0.217

Panel B: 75 economies

	Spot FXI proxy/GDP					
	(1)	(2)	(3)	(4)	(5)	(6)
Coarse regime	Yes	Yes				
Fine: 4 regimes			Yes	Yes		
Fine: 6 regimes					Yes	Yes
Official Reserves/GDP		Yes		Yes		Yes
Readiness Index (Continuous)		Yes		Yes		Yes

Observations	12516	12353	12516	12353	12516	12353
R-squared (R2)	0.052	0.129	0.051	0.118	0.067	0.134
Mean Squared Error (MSE)	0.632	0.586	0.632	0.594	0.622	0.583
Mean Absolute Error (MAE)	0.48	0.451	0.48	0.456	0.473	0.447
Root Mean Squared Error (RMSE)	0.795	0.765	0.795	0.77	0.789	0.763
Root Mean Squared Logarithmic Error (RMSLE)	0.351	0.331	0.351	0.334	0.347	0.329

Notes: This table presents the outcomes of a random forest analysis aimed at understanding the impact of reserves, readiness, and different exchange rate regimes indicators on foreign exchange interventions (FXI) across two distinct samples: Panel A for 28 economies and Panel B for 75 economies, all from 2001 to 2020. The analysis differentiates between "*Coarse regime*" based on Ilzetzki et al. (2019), *"Fine: 4 regimes"*, and "*Fine: 6 regimes*" inspired by Hassan et al. (2023). In the FXI proxy/GDP, we compute the absolute values of the Spot FXI proxy divided by GDP to measure the total volume of FXI without considering whether it is a purchase or sale transaction.

Analysis by country groups. In the last analysis of Section 4.3, we estimate the explanatory power of the Logit and OLS models in explaining the incidence of FXI for AEs and EMs.

Results are shown in Table C.4 in very condensed form. Columns (1) and (2) in Table C.4 show the results of the benchmark Logit model introduced in Table 5 for the small sample, but now separated for AEs and EMs. Our model does reasonably well for both country groups in explaining in which months interventions occur. However, success measures are much better for advanced economies. Accuracy and the noise-to-signal ratio are 0.970 and 0.081, respectively. Columns (3) and (4) show analogous results for the large sample, with adjusted R-squared of 0.409 and 0.477, respectively, showing better results for EMs. Overall, there does not seem to be a consistent advantage for either AEs or EMs.

Table C.4: Analysis of coarse regime classification, reserves, and readiness on spot FXI: Logit and OLS models

	Logit		OLS	
	Spot FXI (dummy)		Spot FXI proxy/GDP	
	(1) AEs	(2) EMs	(3) AEs	(4) EMs
Coarse: Hard pegs				
Coarse: Crawling pegs		-5.595***	-0.200	-0.029
		(0.635)	(0.124)	(0.043)
Coarse: Wider bands	6.055***	-5.184***	-0.317**	-0.065
	(0.753)	(0.770)	(0.110)	(0.048)
Coarse: Freely floating	-8.985***	-6.967***	-0.729***	0.051
	(1.643)	(0.866)	(0.144)	(0.049)
Coarse: Others		-6.747***		0.134**
		(0.751)		(0.052)
Official Reserves/GDP	-0.235	-1.060*	0.132***	0.225***
	(0.419)	(0.428)	(0.032)	(0.034)
Readiness Index (Continuous)	0.737	1.808***	0.032	-0.003
	(0.435)	(0.182)	(0.034)	(0.017)
Observations	1168	2427	3753	8600
AIC	460.219	2173.961	10086.977	17194.727
BIC	596.921	2411.532	10348.650	17731.251
Year Fixed-effect	Yes	Yes	Yes	Yes
Country Fixed-effect	Yes	Yes	Yes	Yes
Accuracy (AUC)	0.970	0.853	-	-
Probability of detection (TPR)	0.944	0.705	-	-
Probability of false alarm (FPR)	0.076	0.172	-	-
Noise-to-signal ratio (NSR)	0.081	0.243	-	-
R-squared	-	-	0.416	0.482
Adjusted R-squared	-	-	0.409	0.477

Notes: This table uses Logit and Ordinary Least Squares (OLS) regression models to examine the influence of coarse regime classifications, the Official Reserves to GDP ratio, and the continuous Readiness Index on the likelihood and magnitude of foreign exchange interventions (FXI) across unbalanced samples of economies from 2001-2020. The analysis is divided into two parts: Columns 1-2 apply Logit regression to analyze the binary outcome of FXI occurrences in 28 economies, while Columns 3-4 use OLS regression to assess the impact of these variables on the FXI proxy, normalized by GDP, in a broader sample of 75 economies. Each part divides the sample into advanced (AEs) and emerging (EMs) economies. Coefficients are denoted as significant at 0.1% (***), 1% (**), or 5% (*) levels. The coarse regime is based on Ilzetzki et al. (2019). In the FXI proxy/GDP, we compute the absolute values of the Spot FXI proxy divided by GDP to measure the total volume of FXI without considering whether it is a purchase or sale transaction. Robust standard errors are in parentheses.