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Abstract

We evaluate the change in international reserves in the aftermath of significant external shocks. We examine the response of international reserves to shocks by using a quasi-experimental setup and focusing on earthquakes. The estimation is done on a panel of 103 countries over the period 1979–2016. We find that in the five years following a large earthquake (i) countries exposed accumulate reserves, for precautionary reasons, (ii) trade openness is positively associated with the post-earthquake reserves accumulation, (iii) episodes of reserves depletion are observed in countries under the fixed exchange rate and/or inflation targeting regimes, and (iv) the patterns of reserves holding post-earthquake vary with a country's income level.

JEL-Codes: F310, F410, Q540.

Keywords: disasters, earthquakes, international reserves, foreign exchange holding.

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1. INTRODUCTION

Since 1995, more than 10,000 catastrophic events have affected some 5.2 billion people. These events have caused hundreds of thousands of deaths and a damage to assets valued more than three trillion US dollars (EM-DAT, 2020). Among those disasters, earthquakes are impossible to forecast or predict their timing nor their intensity. The average damage caused by an earthquake is much larger than that from other types of disasters[2]. There were more than a thousand earthquakes and landslides that affected about 143 million people and caused damages to assets worth over 700 billion dollars during this time. Recent examples of major earthquakes include the 1999 Izmit earthquake in Turkey, the 2001 Gujarat earthquake in India, the 2005 Kashmir earthquake in Pakistan, the 2008 Wenchuan earthquake in China, the 2010 earthquake in Haiti, the 2011 Sendai earthquake/tsunami in Japan, the 2015 earthquake in Nepal, and hundreds of other seismic events which have wrought economic pain. A better quantification of some of the macroeconomic impacts of disaster shocks (such as earthquakes) is the objective of this paper.

Recent studies have examined the effect of disasters on income growth, inflation, and trade. Evidence suggests that disasters worsen economic growth (Raddatz, 2007; Toya and Skidmore, 2007; Hochrainer, 2009; Noy, 2009; Raddatz, 2009; Strobl, 2011; Cavallo et al., 2013; Felbermayr and Gröschl, 2014); and distort inflation over the short-to-medium run (Fomby et al., 2013; Cavallo et al., 2014; Parker, 2018; Heinen et al., 2019). A very limited number of empirical works, however, have addressed questions of monetary policy responses when such catastrophic events happen. Among very few studies, Klomp (2020) estimated a dynamic panel of 85 countries from 1960 and 2015, finding that, on average, the short-run policy interest rate falls in the first year after the earthquake to favour short-run economic recovery over price stability. Most relevant to our study is Strobl et al. (2020) on the evaluation of the impact of hurricanes on international reserves in the Caribbean. Their evidence suggests that an increase in foreign reserves a month after the hurricane strike was followed by a decrease two months later.

[2] We use data from EM-DAT (2020).

In this paper, we examine reserves holding in the aftermath of disaster shocks. Since the Asian financial crisis of 1997–1998, many developing and emerging market economies have accumulated large sums of international reserves in hard currency assets. Two motivations for accumulating large foreign exchange reserves are typically cited: First, from a mercantilist perspective, such accumulation helps nations promote exports by preventing or slowing domestic currency appreciation (Aizenman and Lee, 2007). Second, reserves accumulation can arise from a “self-insurance” or “precautionary” motive. While formally disentangling the two motives of reserves holding is a challenge, the precautionary approach has gained more attention.

Allegret and Allegret (2018) point out that countries holding sufficient stock of foreign exchange reserves strengthen their ability to resist disturbances resulting from boom-bust cycles in capital inflows. Using a sample of 134 countries over the period 1993–2004, Obstfeld, Shambaugh, and Taylor (2010) examine the financial motives behind reserves holding. They find that reserves holding is associated with the size of the banking system; i.e., countries with larger banking sectors tend to accumulate more reserves, as well as that holding reserves also help shield domestic economies from the “double-drain” crisis scenarios in which banking and currency problems interact in ways likely to cause sharp and disruptive external currency depreciation. Indeed, crises of this type are very costly over the 2-4 year period, as shown in Hutchison and Noy (2005). Third, reserves holding may be related to the trade-offs between monetary independence, financial openness, and exchange rate stability, i.e. the impossible trinity (Aizenman, Chinn and Ito, 2013; Aizenman and Ito, 2014). Aizenman and Hutchison (2012) find that the positive correlation between output volatility and the degree of capital account openness does not hold in countries with high levels of international reserves.

The empirical links between reserves holding and financial crises are most relevant to our analysis of the macroeconomic aftermath of disaster shocks across countries. The evidence along this line include Catão and Milesi-Ferretti (2014) that higher international reserves reduce the likelihood of external crises, Dominguez (2014) that higher reserves accumulation prior to the global financial crisis was associated with higher post-crisis GDP growth, and Noy (2009) that countries with more reserves appear more robust and better able to endure disasters, with less adverse spill-over into domestic production in the short term.

More recent evidence related to disasters is Strobl et al. (2020) based on a panel VAR with high-frequency (monthly) data on reserves and information on when a Caribbean island hit by a hurricane. Focusing on the short-term impact of hurricanes on reserves, they find an immediate increase in foreign reserves (in the month after the hurricane strike), followed by a decline (observable over the next two months) in the reserves holding. Given the relatively homogenous composition of their sample, they are only able to differentiate between high-income Caribbean Island countries (who mostly rely on income from services, especially financial services) and middle-income Island countries who rely more on tourism and agriculture). In contrast, our estimation on international reserves in the aftermath of disasters uses a sample that covers a larger group of countries and a longer time horizon, thus allowing for a broader and more diverse set of conclusions.

We contribute to the literature by analysing the response of reserve holdings to disaster shocks, controlling for country fundamentals, including the levels of trade and financial openness, the nature of their exchange rate or monetary regimes, and whether they are targeting inflation. Similar to Strobl et al. (2020), we use a quasi-experimental setup in which the timing and Richter-scale intensity of earthquakes are taken as measures of exogenous shocks impacting the economy. We use earthquakes as our indicator for disasters because the earthquake occurrence has a spatial distribution that is wider than hurricanes or droughts. Predicting earthquakes is also impossible with our current geo-seismic knowledge so that one cannot expect less anticipatory behaviour compared to other types of disasters.

Our findings suggest that countries hit by earthquakes tend to follow the precautionary motive for accumulating reserves. An increase in the quake index by one standard deviation is positively associated with a five-year accumulation in the reserves-to-GDP ratio of 2 percent in the baseline estimation. We examine possible channels through which affected countries raise foreign exchange reserves, including increasing broad money, reducing demand for imported goods, and receiving international assistance. The patterns of holding reserves after quakes are also dependent on a country’s income level and other characteristics of the affected countries. Reserves holding of middle-income countries tends to experience the largest impact. Additionally, after a one standard-deviation earthquake shock, high trade openness economies tend to accumulate additional reserves of 0.76% of GDP over a five-year horizon compared to low trade openness economies.[3]

We also find that exchange-rate peg regime countries in the middle-income group appear to have some episode of reserves depletion after earthquakes. Following a standard-deviation quake over five-year time span, those countries decrease reserves holding by 0.84% of GDP. Inflation targeting (IT) economies also deplete part of their reserves following a quake. In particular, high-income IT countries de-accumulate reserves immediately in the first two years since the quake hits while middle-income IT economies only undergo some episodes of reserves depletion three years after the quake hits and in the following year. After all, countries adopting IT tend to hold less reserves following a quake relative to non-IT countries.

The rest of the paper is organized as follows. Section 2 presents the data and variable description. Section 3 illustrates the empirical specification. Section 4 discusses the estimation results. Section 5 concludes.

2. DATA

2.1. International reserves and control variables

We use the reserves-to-GDP ratio as the main dependent variable.[4] Besides, as far as the precautionary-insurance motive is concerned, the demand for reserves holding may also relate to capital outflows to GDP. Obstfeld et al. (2010) also point to the role of financial depth (measured by the broad money to GDP ratio) in driving the demand for foreign exchange reserves. Our estimation investigates these variables of interest.

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[3] Trade openness is defined as a binary variable using either the mean or median of trade/GDP as the cut-off. Trade/GDP ratio which is higher than the cut-off represents high openness.

[4] Related studies in macroeconomics normalized international reserves with the economy's size, measured by GDP. See Aizenman and Lee (2007; 2008), Obstfeld et al. (2009), Obstfeld et al. (2010), Aizenman and Hutchison (2012), Aizenman et al. (2013); Aizenman and Ito (2014), Catão and Milesi-Ferretti (2014), Allegret and Allegret (2018), etc. We also use real reserves in logged terms as another measure for further robustness tests.

We obtain data on macroeconomic variables from the World Development Indicators of the World Bank. The data include income per capita growth rate, trade-to-GDP ratio, broad money to GDP, and population growth rate. Capital account openness data are from Chinn and Ito (2006).[5] To mitigate endogeneity concerns, we construct binary variables for trade and capital account openness using the means and median as the cut-offs; the sample statistics suggest that the binary variables using either cut--off are interchangeable.[6]

Exchange rate regime data are from Shambaugh (2004) and Klein and Shambaugh (2008). A country–year observation classified as being in a “peg” regime (as opposed to a non-peg) if its currency is within a band against the base currency, or zero volatility in all months except for a one-off devaluation.[7] We follow the identification of inflation targeting regime countries of the International Monetary Fund (more details on exchange rate and IT regimes from Table 3 in the Appendix). Finally, we use financial crisis episodes from Laeven and Valencia (2018).

Our final sample covers 1979 to 2016 for all countries for which data are available: for the benchmark specifications, we have data for 103 countries. The variable description and sources are in the Appendix (Tables 1 to 4).

2.2. Earthquakes

To quantify earthquakes, we use the Significant Earthquake Database collected by the National Oceanic and Atmospheric Administration (NOAA).[8] The NOAA database has worldwide coverage and information for each event on the physical magnitude, date and time of occurrence, latitude and longitude, focal depth, magnitude, maximum Modified Mercalli intensity, and socio-economic data such as the total number of casualties, injuries, houses destroyed, houses damaged, and dollar-damage

[5] The data are updated to 2018 by the authors.
[6] The estimated results shown in this paper use the mean as the cut-off. The results using the median as the cut-off are robust and provided upon request.
[7] Data are updated to 2016 by the authors. There are 1,389 pegs in this sample.
[8] Measuring disasters in terms of the number of people affected or physical damage depends on the socio-economic factors or government choices made in the past (Felbermayr and Gröschl, 2014; Klomp, 2020). For instance, the total damage caused by a disaster is often positively correlated with the income level, while the number of people affected is negatively associated with income.

estimates. A significant earthquake from NOAA meets at least one of the following criteria: caused deaths, caused moderate damage (approximately one million US dollars or more), magnitude 7.5 or greater, Modified Mercalli Intensity X or greater, or the earthquake generated a tsunami.

In comparison to other data sources (i.e., the EM-DAT database from the Centre for Research on the Epidemiology of Disasters), the NOAA data record a larger number of earthquake events for almost all countries worldwide and more specific information about each one, especially their physical features. NOAA records every single significant earthquake and classifies it into a five-level scale based on both actual figures and the estimates[9]. For instance, a five-level scale was used to classify monetary damage, which includes: 0 (no damage), 1 (limited), 2 (moderate), 3 (severe) and 4 (extreme). Although the NOAA database includes only 'significant' earthquakes, many of them may cause only minor physical damage and are likely to have only a negligible impact on the economy. For this reason, we filter the observations to only include events with scales 3 and 4 according to any one of the following criteria: number of deaths, number of injuries, monetary damage, and number of destroyed or damaged houses.

After combining with macroeconomic series, we have 356 large events (from 1,180 events) in the final sample of 103 countries spanning 38 years. The average magnitude of these earthquakes is 6.2 on the Richter scale. There are 85 events in the high-income group of 34 countries, 258 events in the middle-income group of 51 countries, and 13 events in 18 low-income economies. For the benchmark specifications, we construct for each country-year an earthquake count variable that takes the timing of the event in a year into account (using the month when the particular event happened)[10]. This configuration allows an event happening earlier in the year to have a different impact than the one happening later.

For robustness, we normalize the earthquake index by land areas of the affected countries[11], as well as use the magnitude of the earthquake (the Richter scale) as an alternative measure. For further

[9] The estimated data are only for some earthquakes with missing monetary damages. The figures for physical features are actual data.
[10] A quake is weighted as the following: $quake_{it} = (12 – M_{it})/12 + M_{it-1}/12$, where M_{it} is the month when the particular quake happened in the country i in year t.
[11] Dividing the baseline index by land area in 1,000 km^2.

comparison among the earthquake indices, we rescale the two alternative measures so that they have the same mean statistics with the benchmark earthquake index[12], following measures in related disaster studies (e.g., Raddatz, 2007; Ramcharan, 2007; Gassebner et al., 2010; Cuaresma et al., 2010; Oh and Reuveny, 2010; Felbermayr and Gröschl, 2014; Oh, 2017; Klomp, 2020).

3. EMPIRICAL SPECIFICATION

We apply the approach in Obstfeld et al. (2010) to examine the motives and channels of reserves holding, focusing our estimations on the disasters (earthquakes). We also incorporate the specifications of Ramcharan (2007) and Bettin and Zazzaro (2018) to analyse the pattern of reserves management over a five-year horizon after the shock. The estimating equation is used to examine the time path of reserves holding after the onset of real shocks as follows:

$$\text{Reserves/GDP}_{i,t} = \sum_{j=0}^{4}\left(\alpha_j \text{quake}_{i,t-j}\right) + \mu \text{Z}_{i,t-1} + v_t + \varepsilon_i + u_{it} \quad (1)$$

where $\text{quake}_{i,t\text{-}j}$ denote the earthquake index and its four lags; $Z_{it\text{-}1}$ denote the set of control variables with one lag, including income per capita growth, exchange rate regime, trade and capital account openness, population growth and financial crises. We also include v_t (year fixed effects) to capture the global trend of increasing reserves in recent decades, and ε_i (country fixed effects) to account for the time-invariant factors determining reserve holdings within countries.[13] Finally, u_{it} are the residual error terms clustered at the country level.[14].Bertrand et al. (2004) and Obstfeld et al. (2010) argue that clustering standard errors by country allows for heteroskedasticity across countries, and more importantly, allows for an unstructured serial correlation in the error terms within countries.

[12] The baseline quake index has the mean of 0.09 and the standard deviation of 0.39. Among the three indices, the one scaled by land area has the smallest standard deviation of 0.37 while the other two have similarly close standard deviation of 0.39. Three measures are strongly correlated with the correlation coefficients of more than 0.96.

[13] Some countries are more exposed to seismic risks than others, thought that might not manifest itself in the actual experience of earthquakes in the seismically short time period we base our estimates on. The country fixed effects account for any differences in reserve holding policy that arises out of these differences in exposure.

[14] Our fixed effects model allows for arbitrary dependence between the unobserved effect ε_i and the quake index or other explanatory variables. It is unlikely that the unobserved factors in our sample are uncorrelated with the quake index and other control variables.

The occurrence of earthquakes, in general, is assumed to be exogenous, unaffected by the level of reserves. Also, we assume that the occurrence of quakes does not systematically alter the exchange rate regime or inflation targeting regime.[15]

Equation (2) further examines the role of country macroeconomic fundamentals in explaining the patterns of reserves holding after the shocks.

$$\text{Reserves/GDP}_{i,t} = \sum_{j=0}^{4}\left(\alpha_j \text{quake}_{i,t-j} + \beta_j \text{quake}_{i,t-j} * \text{X}_{i,t-1}\right) + \pi \text{X}_{i,t-1} + \mu \text{Y}_{i,t-1} + \nu_t + \varepsilon_i + u_{it} \quad (2)$$

where $\text{quake}_{i,t-j}$ denote the earthquake index and its four lags; X_{it-1} denote explanatory variables with one lag, including trade openness, or exchange rate regime or IT regime; Y_{it-1} denote another set of control variables with one lag, including income per capita growth, exchange rate regime, trade and capital account openness, population growth and financial crises without repetitions in any explanatory variables X_{it-1}.

4. RESULTS

4.1. Reserves holding in the aftermath of earthquakes

Table 1 reports the average increase in international reserves over a five-year horizon following earthquakes.[16] Earthquakes generally have both contemporary and medium-term impact on international reserves across countries. All other things being equal, in column 1 of Table 1, an increase in the quake index by one standard deviation (0.391) is associated with an increase in a five-year accumulation in the reserves-to-GDP ratio by 2.01 percent.[17] The impact of earthquakes on international reserves appears

[15] To interpret the estimated coefficients β_j as the causal effect, as discussed in Ramcharan (2007), requires controls for other potential country features that could affect both explanatory variable X_{it} (exchange rate or monetary regimes) and the response to the shock.

[16] We also estimate leads of quake index in the regression to examine if vulnerable countries accumulate more reserves before the events. This alternative specification may serve as a falsification test whether the quake-affected countries and others were on a different trajectory of reserves accumulation. There are no significant coefficients on these leads of the quake index.

[17] The five-year accumulated impact of a standard-deviation quake on reserves is the summation of the statistically significant coefficients on the quake index and its lags multiplied by the standard deviation of the quake index, in particular, it is (1.276 + 0.932 + 0.875 + 0.928 +1.128)*0.391 = 2.01%.

both statistically and economically significant. Likewise, when the alternative measures for earthquakes are used, the impact remains close to the baseline estimation. Specifically, a same-sized quake shock is associated with an increase in reserves/GDP by 1.93% for the model with the weighted quake index (column 2) and 2.05% for the one with Richter measure (column 3).

Table 1: Five-year impact of earthquakes on international reserves

Dependent variable	**IR/GDP**			**M2/GDP**	**IM/GDP**
Quake Index	**Baseline**	**Weighted**	**Richter**	**Baseline**	
	(1)	(2)	(3)	(4)	(5)
quake	1.276***	1.227**	1.426***	3.479**	.027
	(.432)	(.476)	(.475)	(1.689)	(.309)
quakeL1	.932**	.874*	.969**	1.995*	-.526**
	(.416)	(.446)	(.418)	(1.152)	(.216)
quakeL2	.875**	.837*	.896**	2.78*	-.196
	(.44)	(.468)	(.45)	(1.544)	(.253)
quakeL3	.928**	.93**	.965**	2.204*	-.367
	(.406)	(.441)	(.47)	(1.188)	(.279)
quakeL4	1.128**	1.078*	.997**	2.837	-.072
	(.506)	(.546)	(.483)	(1.977)	(.432)
_cons	7.587***	7.615***	7.605***	33.229***	36.41***
	(1.792)	(1.795)	(1.781)	(2.65)	(1.678)
Country number	103	103	103	103	103
Observations	2866	2866	2866	2662	2737
R-squared	0.231	0.229	0.231	0.382	0.187
Zit-1 controls	Yes	Yes	Yes	Yes	Yes

Notes: All columns add time and country fixed effects. Standard errors in parenthesis are clustered by country. quakeL1, quakeL2, quakeL3, quakeL4 are lagged 1-4 year earthquake index. Columns (1)-(4) control the per capita GDP growth rate, trade, capital account openness, exchange rate regime, population growth, and financial crises. Column (5) controls the per capita GDP growth rate, exchange rate regime, capital account openness, population growth, and financial crises (one lag for all controls).
**** p<0.01, ** p<0.05, * p<0.1*

4.2. Macroeconomic channels of reserves accumulation after the earthquakes

The main incentive of reserves build-up in countries vulnerable to quakes is the precautionary and self-insurance motive. Earthquakes are not randomly distributed around the world, but tend to occur along the fault lines between tectonic plates. By controlling for country fixed-effects, we account for these differences. However it might be the case that the occurance of an earthquake makes this continuing risk more salient, and therefore leans to additional holding of international reserves as self-insurance to preempt destabilizing capital outflows. Our baseline findings in Table 1 are largely supportive of this possibility.

What could be the potential channels for building up reserves immediately after the quakes hit? Following large disasters, the affected countries need to mobilize their resources to rebuild. Column 4 of Table 1 suggests that a standard-deviation quake shock is associated with an accumulated increase in broad money by 4.08 percent of GDP over the five-year horizon. The model given by Obstfeld et al. (2010) explains that the potential need for reserves is proportional to the size of broad money as authorities typically prefer some degree of exchange rate stability.[18] We find that reserves accumulation after the quakes is consistent with the increase in broad money level relative to its economic size.

An additional channel for reserves build-up in countries hit by quakes is the reduction in demand for imports. Column 5 of Table 1 shows that imports decrease by 0.21 percent of GDP after a standard-deviation quake shock. Interestingly, we do not observe any significant impact of quakes on exports of the affected economy. Osberghaus (2019) summarizes the effects of disasters on trade from 16 relevant studies based on different samples, research questions, and methodologies. Compared to these studies, our estimates are consistent with the findings of Cuaresma et al. (2008), Gassebner et al. (2010), Oh and Reuveny (2010), and Oh (2017), which show that the impact of disasters tends to fall mostly on imports. Due to the expected fall in income following a catastrophe, the demand for costly foreign goods drops after the event. Also, Gassebner et al. (2010) argue that disasters would reduce demand for imports in affected countries as households anticipate an increase in the probability of future disasters and increase their precautionary savings as a result.[19]

Countries could also increase their reserves holding aided by the financial liquidity available from international assistance in response to the quake shocks. Evidence suggests that inflows of official development assistance (ODA) and remittances to vulnerable countries increase over short-to-medium term immediately after the shocks (Osberghaus, 2019). Using an event-study approach, Becerra et al.

[18] Because the scope of the run out of domestic-currency deposits is proportional to the domestic banking system's liabilities. Deposits are perfectly liquid while bank assets are almost illiquid. Just in case of an adverse event, demand for foreign exchange goes up and the central bank needs to act as a lender of last resort.
[19] See also Skidmore (2001) and Gassebner et al. (2010) for more details.

(2014) find that the median increase in ODA to low-income countries is 18 percent compared to the pre-disaster level of ODA flows, but covers only 3 percent of the total estimated economic loss caused by the adverse events. Studies also show the positive association between disasters and remittances (Bluedorn, 2005; Yang, 2008; Amuedo-Dorantes et al., 2010; David, 2011; Mohapatra et al., 2012; Bettin and Zazzaro, 2018). Our estimates in Table 2 below are in line with the findings in the literature. Because those financial flows are only applied for middle-income and low-income countries, we provide more relevant discussion in the next section evaluating the impact of quakes across counties with different per capita income levels.

Countries might also accumulate foreign exchange from international reinsurance, but reinsurance flows are typically surprisingly low. Ito and McCauley (2019) quantify these flows and find empirical evidence that losses from disasters are shared internationally to a very limited extent. Particularly, they find that the average portion of economic damage offset by reinsurance is less than 5%. They also show that the international reinsurance share is positively associated with international reserves and the degree of global financial integration.[20]

[20] This method identifies for the first time the cross-border flow of reinsurance payments to 88 economies that experienced insured disasters in the 1985–2017 period. Economic losses are physical damages to tangible assets following a disaster. They decompose international risk-sharing into the portion of losses insured and the portion of insurance that is internationally re-insured.

Table 2: Five-year impact of earthquakes by income level (baseline)

Dependent variable	IR/GDP	IR/GDP	M2/GDP	Remittance	ODA	IR/GDP	Remittance	ODA
Sample	HIC	MIC				LIC		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
quake	.605	1.179**	4.526***	.209**	-0.046	6.985***	0.035	1.993
	(.554)	(.448)	(1.596)	(0.080)	(0.161)	(1.844)	(0.332)	(2.094)
quakeL1	.422	.854**	2.612***	0.093	0.120	-2.515	0.217	1.432
	(.566)	(.416)	(0.895)	(0.067)	(0.127)	(3.272)	(0.301)	(1.542)
quakeL2	.506	.46	3.155*	0.097*	0.152*	-1.019	0.172	1.549
	(.732)	(.524)	(1.705)	(0.056)	(0.089)	(2.506)	(0.209)	(1.750)
quakeL3	1.186	.471	2.396*	0.008	0.210*	1.407	0.826***	4.147***
	(.843)	(.495)	(1.390)	(0.057)	(0.114)	(3.035)	(0.263)	(1.131)
quakeL4	1.33	.731	2.889	0.140*	0.021	-4.68***	0.024	-3.133
	(.878)	(.68)	(2.334)	(0.072)	(0.104)	(1.404)	0.780	(1.848)
_cons	10.70***	3.339	33.52***	19.72***	8.39***	.95	17.39***	16.68***
	(1.451)	(3.444)	(5.473)	(0.786)	(2.036)	(1.95)	(0.478)	(2.268)
Country number	34	51	51	51	48	18	18	18
Observations	1044	1458	1451	1413	1381	406	413	504
R-squared	0.136	0.365	0.445	0.083	0.220	0.315	0.428	0.259
Zit-1 controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: All columns add time and country fixed effects. Standard errors in parenthesis are clustered by country. quakeL1, quakeL2, quakeL3, quakeL4 are lagged 1-4 year earthquake index. Columns (1)-(3) and (6) control the per capita GDP growth rate, trade, capital account openness, exchange rate regime, population growth and financial crises. Column (4)-(5) and (7)-(8) control the exchange rate regime, trade and capital account openness, population growth and financial crises (one lag for all controls).
*** p<0.01, ** p<0.05, * p<0.1

4.3. Impact of earthquakes on reserves accumulation by income level

Table 2 presents the five-year impact of earthquakes by income group (using the World Bank's classification). To make the results comparable, we standardize the impact by one standard deviation of the quake index across sub-samples. The baseline estimation results in Table 2 show different patterns across the income groups (results using the other two quake indices are available upon request).

In Table 2, we can see the five-year accumulated impact of a standard-deviation earthquake on reserves/GDP is significant across low- and middle-income countries (columns 2 and 6) while there is no observable impact for the high-income group (column 1). Reserves accumulation of the middle-income countries is the most responsive in our sample. Given that many emerging market and developing economies have significantly increased their reserves holding since the Asian financial crisis shock, our estimates of the significant increase in reserves after the earthquake shocks for middle-income countries are supportive of the precautionary motives of reserves accumulation observed during the past two decades.

We also find a significant increase in broad money in the middle-income countries (column 3 of Table 2). Both middle-income and low-income groups registered a significant increase in remittances and ODA following the quakes (the data on remittances and ODA are only applicable and available for middle-income and low-income countries). While the middle-income group is more dependent on remittance inflows, the low-income group is more dependent on foreign aid. Columns 4 and 7 of Table 2 present the increases in remittances for a standard-deviation quake shock are 0.22% and 0.10% of GDP, respectively, in middle-income and low-income countries. Columns 5 and 8 of Table 2 report the increases in ODA for a standard-deviation shock are 0.18% and 0.52% of GDP, respectively, in middle-income and low-income countries.[21]

4.4. Impact of earthquakes on reserves accumulation by trade openness

Trade openness may influence reserves holding patterns across countries in the aftermath of quakes. Our findings indicate the degree of trade openness is positively associated with reserves accumulation (Table 3).[22] The estimates are robust for the whole sample and the sample of middle-income countries, using any earthquake index.[23] In the baseline estimation, high trade openness economies accumulate more reserves by 0.76% of GDP over a five-year horizon compared to low trade openness counterparts once a one standard-deviation earthquake shock happens (Column 1). To be more specific, in such circumstance, high trade openness countries accumulate more reserves by 1.71% of GDP while low trade openness countries accumulate more reserves by 0.95% of GDP.[24] Compared to the whole sample, these estimates for the middle-income countries are largely consistent. High-income countries, however,

[21] The five-year accumulated impact is (0.152 + 0.210)*0.499 = 0.18% for the MIC (column 5) and is 4.147*0.126 = 0.52% for the LIC (column 8).

[22] Trade openness is defined as a binary variable using the mean of trade/GDP as the cut-off. Trade/GDP ratio which is higher than the cut-off represents high trade openness; otherwise, it is low trade openness.

[23] Due to data availability of some of the macroeconomic variables, especially the reserves/GDP, our sample includes only 18 low-income countries. In those countries, the number of events is insufficient to continue with this investigation separately.

[24] The five-year accumulated impact of a standard-deviation quake on reserves is the summation of statistically significant coefficients on the quake index, its lags and the interaction terms with the explanatory variable multiplied by one standard deviation of the quake index. For instance, in the column (1) of Table 3, the accumulated impact for high trade-openness countries is (1.498 + 0.94 + 1.949)*0.391 = 1.71%.

do not exhibit any significant difference in the impact of quakes on reserves build-up across the different degrees of trade openness.[25]

Table 3: Impact of earthquakes on international reserves leveraged by trade openness

Dependent variable	**IR/GDP**						**EX/GDP**	**IM/GDP**	**EX/GDP**	**IM/GDP**
Sample	**All**	**HIC**	**MIC**	**All**	**HIC**	**MIC**	**MIC**			
Quake Index	**Baseline**			**Quake_weighted**			**Baseline**		**Quake weighted**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
quake	1.498***	.827*	1.495***	1.390***	0.900**	1.453**	.02	-.016	-.013	-.021
	(.449)	(.481)	(.505)	(0.522)	(0.414)	(0.571)	(.324)	(.25)	(.377)	(.279)
quakeL1	.94**	.598	.883**	0.733	0.575	0.703	-.112	-.554**	-.364	-.777***
	(.419)	(.508)	(.384)	(0.513)	(0.488)	(0.487)	(.371)	(.276)	(.421)	(.258)
quakeL2	.684	.636	.26	0.614	0.656	0.178	-.556	-.478	-.852	-.699
	(.526)	(.707)	(.605)	(0.574)	(0.677)	(0.686)	(.536)	(.325)	(.605)	(.429)
quakeL3	.737	1.236	.303	0.855*	1.212	0.377	-.615	-.547	-.549	-.51
	(.476)	(.863)	(.584)	(0.508)	(0.814)	(0.631)	(.491)	(.345)	(.511)	(.351)
quakeL4	.886	1.221	.514	0.687	1.201	0.258	-.346	-.508	-.715	-.847
	(.603)	(.902)	(.859)	(0.700)	(0.882)	(0.990)	(.49)	(.477)	(.589)	(.553)
quake*trade	-.564	-4.789	-1.249	-0.132	-3.775	-0.628	2.623*	2.335	2.173**	1.993
	(1.04)	(4.337)	(1.372)	(0.643)	(3.002)	(0.746)	(1.409)	(2.162)	(1.035)	(1.741)
quakeL1*trade	.68	-3.419	.316	1.141*	-2.575	0.960*	2.646***	1.796*	2.994***	2.419***
	(.518)	(4.434)	(.576)	(0.620)	(2.977)	(0.558)	(.9)	(.911)	(.663)	(.893)
quakeL2*trade	1.949**	-2.965	1.557**	1.789*	-2.380	1.823*	2.371**	1.439	3.229***	2.529**
	(.876)	(3.794)	(.723)	(0.981)	(2.639)	(0.978)	(1.114)	(1.276)	(.962)	(1.04)
quakeL3*trade	2.131	-1.065	1.566	0.847	-1.095	0.805	1.541*	2.631*	1	1.944*
	(1.325)	(2.444)	(1.129)	(1.121)	(1.785)	(0.996)	(.84)	(1.386)	(.782)	(1.087)
quakeL4*trade	2.481	1.441	1.795	2.468	1.020	1.989	1.697	3.333	2.204**	3.904**
	(2.946)	(2.445)	(2.898)	(2.264)	(1.746)	(2.390)	(1.129)	(2.052)	(1.021)	(1.718)
_cons	7.764***	10.642***	3.508	7.806***	10.558***	3.503	25.7***	35.981***	26.247***	36.317***
	(1.777)	(1.427)	(3.447)	(1.781)	(1.415)	(3.456)	(5.663)	(4.907)	(5.649)	(4.92)
Country number	103	34	51	103	34	51	51	51	51	51
Observations	2962	1044	1458	2958	1042	1458	1474	1424	1476	1425
R-squared	0.234	0.139	0.367	0.233	0.139	0.367	0.273	0.171	0.276	0.176
Zit-1 controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: All columns add time and country fixed effects. Standard errors in parenthesis are clustered by country. quakeL1, quakeL2, quakeL3, quakeL4 are lagged 1-4 year earthquake index. Columns (1)-(6) control the per capita GDP growth rate, trade and capital account openness, exchange rate regime, population growth and financial crises. Columns (7)-(10) control the per capita GDP growth rate, exchange rate regime, capital account openness, population growth, political IV and financial crises. Columns (4)-(6), (9), (10) use quake index weighted by land area.
*** *p<0.01*, ** *p<0.05*, * *p<0.1.*

We delve further into the impact of earthquakes on imports and exports for the middle-income countries. We observe the positive effects of quakes on both exports and imports in high trade openness

[25] Previous studies (Cuaresma, 2008; Noy, 2009; Gassebner et al., 2010; Parker, 2018; Felbermayr and Gröschl, 2014) suggest that high-income economies experience a smaller macro-economic cost of disasters relative to the middle- and low-income economies. We also estimate the impact of quakes on imports in high-income countries and find no significant fall in imports following quakes.

economies and the reduction in imports for low trade openness countries. Following a standard-deviation quake shock over a five-year period, exports increase by 4.56 percent of GDP and imports by 2.2 percent of GDP in high trade openness countries relative to low trade openness countries (columns 7 and 8). Using the quake index weighted by land area, we also find that the marginal effects of quakes on exports are higher than those on imports for high trade openness economies (columns 9 and 10). The positive effect of quake shocks on the trade balance of high trade openness countries might be a result of exchange rate depreciation given the middle-income countries are the most vulnerable group.

Our results are generally in line with the previous findings in the literature. Countries that are more open to trade are more likely to get trade credit and financial assistance from other countries and international organisations. Gassebner et al. (2010) find that disasters reduce imports in the short run though the impacts are dependent on the level of democracy and geographical size of the affected countries. In addition, Noy (2009) finds that a higher level of exports is associated with a lower macro-cost of a disaster; a country that is more open to trade would experience a smaller negative shock to the demand for its products and is more likely to receive a larger international capital inflow to aid in the reconstruction effort. Pelli & Tschopp (2017) argue that hurricanes may increase exports of very competitive industries; by destroying the capital of partly non-competitive industries, the disasters induce firms to invest in new technologies in the reconstruction process after hurricanes, reducing thereby the costs of technological transformation. El Hadri et al. (2018) show that disasters only affect agricultural exports negatively if they hit rural areas and occur during their respective growing seasons. Moreover, they suggest that exports to trade partners with cultural ties do not decline but even increase after disasters hit the exporting countries. As the deconstruction caused by earthquakes requires new capital for the rebuilding process, countries that are highly open to trade accumulate more reserves than countries with a lower degree of trade openness.

4.5. Impact of earthquakes on reserves accumulation by exchange rate and monetary regimes

We control for exchange rate regime and find its coefficient positive and statistically significant in the main regressions, supporting the role of exchange-rate stability in reserves hoarding (Obstfeld et al.,

2010) after the earthquakes. The negative and significant coefficient of the interaction terms, quakeL3*peg, in column 3 of Table 4 suggests that the middle-income countries with peg regimes tend to deplete their reserves following a quake, three years after the shock[26] (similar results are the case with using any of the two alternative quake measures; see Appendix Tables 5 and 6 for further comparison). Holding other variables constant, the middle-income-pegged-exchange-rate countries tend to deplete reserves by 0.84 percent of GDP (-1.686*0.499) following a standard deviation quake shock. The estimates for the interaction terms of high-income countries are insignificant possibly because the economies in this group generally do not experience severe quake shocks.

[26] To be precise, the estimated coefficients of the interaction terms quakeL3*peg are negative and statistically significant while the coefficients of the quakeL3 are not significant.

Table 4: Impact of earthquakes on international reserves leveraged by exchange rate and IT regimes (Baseline)

Dependent variable: IR/GDP									
Sample	**All**	**HIC**	**MIC**	**All**	**HIC**	**MIC**	**All**	**HIC**	**MIC**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
quake	.983	.783	.937	1.34***	.877	1.115***	.901	1.067	.665
	(.611)	(.65)	(.797)	(.405)	(.723)	(.412)	(.624)	(.758)	(.747)
quakeL1	.685	.807	.424	1.099***	.708	1.026***	1.069**	1.138*	.958
	(.433)	(.593)	(.594)	(.385)	(.684)	(.369)	(.455)	(.633)	(.602)
quakeL2	1.034**	.611	.545	1.098***	.676	.738*	1.283***	.763	.845
	(.487)	(.827)	(.649)	(.401)	(.691)	(.399)	(.467)	(.672)	(.518)
quakeL3	1.052*	1.152	.759	1.053***	1.128*	.644*	1.451***	1.227*	1.29**
	(.617)	(.767)	(.756)	(.271)	(.614)	(.334)	(.514)	(.624)	(.585)
quakeL4	1.112*	1.475*	.601	1.442***	1.316*	1.15*	1.468***	1.316*	1.16*
	(.575)	(.788)	(.68)	(.431)	(.729)	(.576)	(.521)	(.776)	(.691)
quake*peg	.136	-.625	-.045				.473	-.808	.614
	(.801)	(1.177)	(1.086)				(.773)	(1.205)	(1.032)
quakeL1*peg	1.092	-.444	.986				.755	-.71	.495
	(.867)	(1.316)	(1.006)				(.864)	(1.278)	(.992)
quakeL2*peg	-.303	-.764	.153				-.449	-.808	-.013
	(.378)	(1.275)	(.702)				(.425)	(1.225)	(.641)
quakeL3*peg	-1.072	-.88	-1.686**				-1.38*	-.78	-2.065***
	(.827)	(1.246)	(.654)				(.765)	(1.213)	(.578)
quakeL4*peg	.605	.078	.973				.313	.357	.386
	(.64)	(1.643)	(.833)				(.673)	(1.643)	(1)
quake*IT				-.848	-1.306*	-.268	.06	-1.592*	.605
				(.871)	(.77)	(.784)	(1.049)	(.885)	(1.094)
quakeL1*IT				-.752	-1.858*	-.279	-.616	-2.513**	-.192
				(.638)	(.942)	(.519)	(.696)	(1.104)	(.736)
quakeL2*IT				-.871*	-.876	-.806	-.645	-.419	-.639
				(.466)	(1.111)	(.55)	(.795)	(1.799)	(.849)
quakeL3*IT				-.567	1.248	-1.224**	-2.066**	-.938	-2.775***
				(.867)	(3.054)	(.562)	(.811)	(2.165)	(.954)
quakeL4*IT				-1.778***	-1.17	-2.536***	-1.846**	1.225	-2.354***
				(.653)	(1.516)	(.789)	(.768)	(3.05)	(.873)
_cons	7.655***	10.637***	3.562	7.609***	10.987***	3.273	7.634***	10.881***	3.383
	(1.828)	(1.429)	(3.478)	(1.794)	(1.367)	(3.476)	(1.83)	(1.373)	(3.517)
Country number	103	34	51	103	34	51	103	34	51
Observations	2866	1011	1408	2962	1044	1458	2866	1011	1408
R-squared	0.237	0.15	0.371	0.234	0.148	0.371	0.241	0.159	0.379
Zit-1 controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: All columns add time and country fixed effects. Standard errors in parenthesis are clustered by country. quakeL1, quakeL2, quakeL3, quakeL4 are lagged 1-4 year earthquake index. All columns control the per capita GDP growth rate, trade and capital account openness, exchange rate regime, population growth and financial crises (one lag for control variables). Columns (4)-(9) add IT.
**** p<0.01, ** p<0.05, * p<0.1*

Regarding the role of the monetary regime, our findings show similar patterns across high-income and middle-income countries. Countries with inflation targeting (IT) regimes tend to accumulate less reserves relative to non-IT countries after the earthquakes (Table 4). Column 4 shows inflation targeters appear to hold less reserves by 1.04 percent of GDP [(-0.871 – 1.778) *0.391] over a five-year period after a standard deviation quake shock. Column 5 shows high-income inflation targeters appear to deplete reserves by 0.87 percent of GDP [(-1.306 – 1.858) *0.276] in the year of the quake and the following year. For the middle-income countries, in response to a one standard-deviation quake shock, inflation targeters appear to deplete reserves by 1.88 percent of GDP three years following a quake and the year after (column 6).[27] Our findings are consistent across the two alternative quake measures (see Appendix Tables 5 and 6 for more details). Figure 1 summarizes the impacts of a one-standard deviation quake shock across the country groupings.

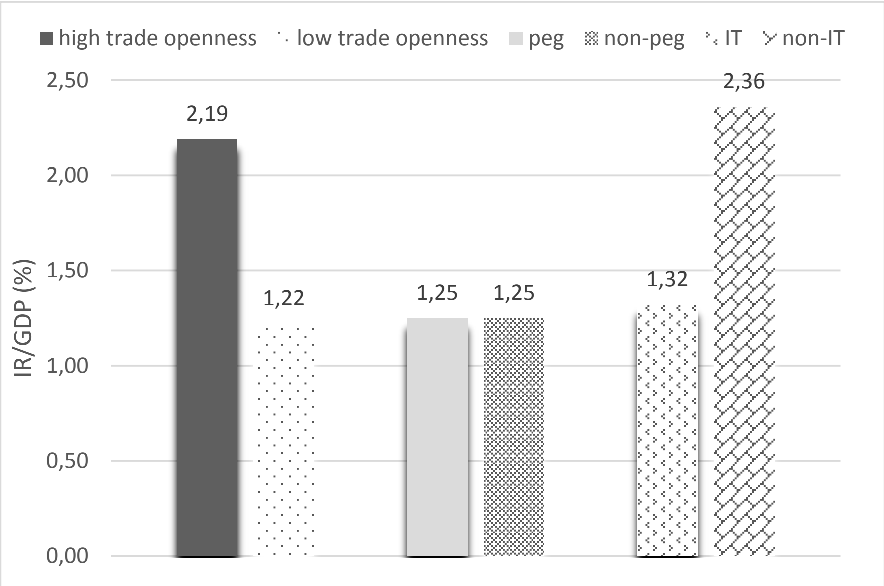

Figure 1: Five-year impact of earthquakes (baseline) on international reserves by country features.

We further combine these above-mentioned variables and their interactions with the quake index to reaffirm the findings. The results remain robust for the estimates of interactions of exchange rate regime and IT regime with the quake index (columns 7 to 9 of Table 4, and Appendix Tables 5 and 6).

4.6. Additional robustness checks

Throughout the analysis, we also estimate the impact of quakes on international reserves using the two alternative quake measures: (i) the baseline index scaled by land area and (ii) the Richter scale. Our estimates remain consistent across different specifications with any of the three quake measures. The results are comparable to the baseline estimates, shown in Appendix Tables 5 and 6. Further, we also

[27] [(0.644+1.15)-(1.224+2.536)]*0.499 = 1.88%.

use real reserves in logged terms as the dependent variable, following the approach of Strobl et al. (2020). The main findings remain intact for the whole sample and across sub-samples.[28]

5. CONCLUSION

To better understand what typically happens to international reserves following external shocks, we study the role of disasters, focusing on the case of earthquakes, in a cross-country sample. As the disasters are technically exogenous, our quasi-experiment is well suited to examine the responses of reserves to shocks more broadly (shocks like financial crises). We find evidence suggestive of a strong precautionary motive for accumulating reserves in countries affected by disasters over the past four decades. Our estimation highlights several conditioning factors, including in particular the degree of trade openness and the monetary regimes: (i) countries more open to trade accumulate reserves faster than others following the earthquake shocks; and (ii) countries with pegged exchange rates and those under the inflation targeting regime tend to experience some episodes of reserves depletion following the seismic shocks. While our study provides new evidence on the patterns of reserves accumulation in the aftermath of disasters, in future research we plan to delve into the relationship between disasters, external positions, and resource mobilization (fiscal and monetary), potentially with country case-studies, to shed further lights on the mechanisms linking macroeconomic aggregates and disasters.

[28] The results are available upon request.

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APPENDIX

Appendix Table 1. Data sources

Data	Description	Source
Reserves	Total reserves minus gold in current US dollars (IR)	World Development Indicators (WDI), code FI.RES.XGLD.CD
GDP	Gross domestic products in current US dollars (GDP)	WDI, code NY.GDP.MKTP.CD
deflator	GDP inflator	WDI, code NY.GDP.DEFL.ZS
quake	Frequency/number of large events per year (Baseline quake index)	The Significant Earthquake Database, the National Oceanic and Atmospheric Administration
Richter	Quake measured by Richter scale of large events	
trade	trade openness/volume proxied by (imports+exports)/GDP (%)	WDI, code NE.TRD.GNFS.ZS
exports	Exports of goods and services as % of GDP (%)	WDI, code NE.EXP.GNFS.ZS
imports	Imports of goods and services as % of GDP (%)	WDI, code NE.IMP.GNFS.KD
kao	Capital account openness index	Chinn and Ito (JDE, 2006)
peg	Exchange rate regime (dummy)	Shambaugh (QJE, 2004); Klein and Shambaugh (JIE, 2008)
IT	Adoption of Inflation targeting regime (IT)	Jahan (IMF, 2016)
gdp	Per capita gdp growth (%)	WDI, code NY.GDP.PCAP.KD.ZG
oda	Net official development assistance as % of GNI	WDI, code DT.ODA.ODAT.GN.ZS
remittances	Personal remittances, received in current US dollars	WDI, code BX.TRF.PWKR.CD.DT
M2	Broad money (money and quasi money) as % of GDP	WDI, code FM.LBL.MQMY.GDP.ZS
pop	Population growth (%)	WDI, code SP.POP.GROW
crisis	Financial crisis (dummy)	Laeven and Valencia (IMF, 2018)
area	Land area in square kilometres	WDI, code AG.LND.TOTL.K2

Appendix Table 2. Variable statistics

Variable	Description/Construction	N	Country number	Mean	St.Dev
IR/GDP	IR/GDP (%)	3510	103	12.307	14.528
ln(IRD)	ln(IR/deflator)	3643	103	17.056	2.675
quake	Quake index in number of large events/year (Baseline)	3914	103	.091	.391
quake_w	Baseline quake weighted by land area in ’000 km^2	3914	103	.091	.375
Richter	Quake measured by summation of all large events’ Richter scales	3914	103	.091	.393
trade	=1 if trade volume > its mean, 0 otherwise	3636	103	.49	.5
exports	Exports/GDP (%)	3542	101	34.702	24.327
imports	Imports/GDP (%)	3341	103	37.926	22.563
kao	=1 if capital account openness index > its mean, 0 otherwise	3914	103	.609	.488
peg	=1 for peg exchange rate regime, 0 otherwise	3516	103	.395	.489
IT	=1 for IT regime (from the year of IT adoption onwards), 0 otherwise	3914	103	.112	.316
gdp	Per capita gdp growth (%)	3681	103	1.745	4.818
oda	Net oda as % of GNI	2563	77	5.943	8.223
remitance	Remittances as % of GDP	3,211	102	2.909	5.135
M2	M2/GDP (%)	3291	103	48.789	34.379
pop	Population growth (%)	3909	103	1.633	1.302
crisis	=1 for years with any financial crisis, 0 otherwise	3914	103	.106	.308

Appendix Table 3. De-facto exchange rate classification and IT regime countries

De-factor exchange rate regime classification by Shambaugh (2004) and Klein and Shambaugh (2008)

The authors focus on whether the exchange rate stays within a band. To determine the base country, they examine the exchange rate against the US dollar, all major currencies, and major regional currencies to find any potential fixed exchange rate relationship.

For annual classifications, a peg regime is determined if the exchange rate stayed within 2 percent bands against the base currency or zero volatility in all months except for a one-off devaluation, otherwise, a non-peg is recorded (the United States does not have a "base" country and is assumed to be non-pegged). Countries must be pegged for two consecutive years to be counted as a peg to avoid spuriously classifying observations as pegs due to random lack of volatility.

Technically, it tests whether the max and min of the log of the month-end values of the exchange rate are within. This methodology tests only that they are within 2 percent bands in a given year. In addition, to prevent breaks in the peg status due to one-time realignments, any exchange rate that had a percentage change of zero in eleven out of twelve months is considered fixed[29].

IT countries in our sample, from Jahan (IMF, 2016)

Country	Start year	Country	Start year	Country	Start year
ALB	2009	HUN	2001	PHL	2002
ARM	2006	IDN	2005	POL	1998
AUS	1993	IND	2015	PRY	2011
BRA	1999	ISR	1997	ROU	2005
CAN	1991	JPN	2013	RUS	2015
COL	1999	KOR	2001	SWE	1993
GTM	2005	MEX	2001	THA	2000
CZE	1997	NOR	2001	UGA	2011
DOM	2012	NZL	1991	URY	2007
GBR	1992	PER	2002	ZAF	2000

[29] The decision of 1 percent compared with 2 percent bands and the decision to include single peg breaks do not influence the results substantially. In addition, single year pegs are dropped as they are quite possibly not intentional pegs. When the data are differenced, the first year of a peg is dropped so as not to difference from peg to nonpeg.
The data are extended to 2016 by the authors.

Appendix Table 4. Pairwise correlation between quake measures and country features

Variables	(quake)	(quake_w)	(Richter)	(reserve)	(trade)	(peg)	(IT)
quake	1.000						
quake_w	0.993***	1.000					
Richter	0.970***	0.966***	1.000				
reserve	0.032*	0.026	0.032*	1.000			
trade	-0.182***	-0.180***	-0.174***	0.318***	1.000		
peg	-0.028*	-0.032*	-0.039**	-0.028*	0.149***	1.000	
IT	0.002	0.003	0.010	0.065***	-0.019	-0.239***	1.000

*Note: *** p<0.01, ** p<0.05, * p<0.1*

Appendix Table 5: Impact of Earthquakes on International Reserves leveraged by exchange rate and IT regimes (Weighted index)

Dependent variable: IR/GDP									
Sample	**All**	**HIC**	**MIC**	**All**	**HIC**	**MIC**	**All**	**HIC**	**MIC**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
quake	.888	.699	.834	1.305***	.806	1.102**	.829	.99	.616
	(.622)	(.684)	(.82)	(.46)	(.711)	(.476)	(.65)	(.777)	(.772)
quakeL1	.629	.665	.395	1.042**	.611	1.027**	.989**	1.01	.894
	(.407)	(.639)	(.555)	(.432)	(.692)	(.413)	(.427)	(.673)	(.549)
quakeL2	.985*	.516	.542	1.063**	.616	.758*	1.229**	.674	.85
	(.501)	(.834)	(.68)	(.445)	(.682)	(.435)	(.5)	(.681)	(.567)
quakeL3	1.022	1.152	.728	1.061***	1.067*	.668*	1.423**	1.242**	1.267*
	(.638)	(.711)	(.809)	(.325)	(.549)	(.398)	(.564)	(.546)	(.666)
quakeL4	1.045*	1.473*	.515	1.387***	1.329*	1.059	1.379**	1.295	1.077
	(.593)	(.786)	(.727)	(.49)	(.673)	(.655)	(.544)	(.787)	(.741)
quake*peg	.316	-.496	.222				.581	-.694	.769
	(.74)	(1.053)	(1.074)				(.723)	(1.082)	(.989)
quakeL1*peg	.983	-.156	.955				.688	-.45	.541
	(.876)	(1.191)	(.959)				(.882)	(1.153)	(.951)
quakeL2*peg	-.252	-.554	.156				-.411	-.622	-.049
	(.367)	(1.132)	(.658)				(.418)	(1.065)	(.618)
quakeL3*peg	-.86	-.956	-1.523*				-1.183	-.894	-1.93***
	(.825)	(1.18)	(.781)				(.786)	(1.146)	(.691)
quakeL4*peg	.58	.059	.842				.328	.335	.284
	(.637)	(1.413)	(.907)				(.666)	(1.419)	(1.039)
quake*IT				-.835	-1.19*	-.208	.063	-1.453*	.67
				(.893)	(.686)	(.838)	(1.053)	(.811)	(1.107)
quakeL1*IT				-.757	-1.629*	-.257	-.651	-2.224**	-.156
				(.663)	(.895)	(.542)	(.686)	(1.052)	(.686)
quakeL2*IT				-.892*	-.793	-.847	-.61	-.382	-.644
				(.485)	(1.043)	(.57)	(.824)	(1.569)	(.871)
quakeL3*IT				-.523	1.012	-1.271**	-2.019**	-1.16	-2.827***
				(.909)	(2.688)	(.602)	(.815)	(1.823)	(.967)
quakeL4*IT				-1.726**	-1.185	-2.55***	-1.786**	1.641	-2.361***
				(.678)	(1.489)	(.828)	(.797)	(3.308)	(.862)
_cons	7.693***	10.631***	3.61	7.63***	10.986***	3.291	7.667***	10.864***	3.429
	(1.831)	(1.435)	(3.482)	(1.796)	(1.372)	(3.48)	(1.834)	(1.376)	(3.521)
Country number	103	34	51	103	34	51	103	34	51
Observations	2866	1011	1408	2962	1044	1458	2866	1011	1408
R-squared	0.236	0.15	0.37	0.233	0.148	0.37	0.24	0.159	0.377
Zit-1 controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: All columns add time and country fixed effects. Standard errors in parenthesis are clustered by country. quakeL1, quakeL2, quakeL3, quakeL4 are lagged 1-4 year earthquake index. All columns control the per capita GDP growth rate, trade and capital account openness, exchange rate regime, population growth and financial crises (one lag for control variables). Columns (4)-(9) add IT.
**** p<0.01, ** p<0.05, * p<0.1*

Appendix Table 6: Impact of Earthquakes on International Rreserves leveraged by exchange rate and IT regimes (Richter scale)

Dependent variable: IR/GDP									
Sample	**All**	**HIC**	**MIC**	**All**	**HIC**	**MIC**	**All**	**HIC**	**MIC**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
quake	1.319**	.862	.908	1.544***	.921	1.08**	1.336**	1.135*	.656
	(.634)	(.584)	(.871)	(.431)	(.675)	(.505)	(.64)	(.664)	(.819)
quakeL1	.628	.782	.353	1.217***	.737	1.114**	1.082**	1.089*	1.044
	(.445)	(.531)	(.628)	(.373)	(.634)	(.417)	(.476)	(.557)	(.65)
quakeL2	.926*	.649	.349	1.175***	.753	.669	1.264**	.779	.779
	(.509)	(.778)	(.704)	(.404)	(.649)	(.476)	(.492)	(.632)	(.6)
quakeL3	.936	1.212	.504	1.175***	1.122*	.547	1.417**	1.23**	1.137
	(.686)	(.746)	(.856)	(.318)	(.565)	(.395)	(.577)	(.555)	(.7)
quakeL4	1.019**	1.414**	.375	1.356***	1.366*	1.085*	1.438***	1.298*	1.102
	(.492)	(.69)	(.702)	(.415)	(.681)	(.639)	(.426)	(.711)	(.734)
quake*peg	-.221	-.967	-.008				.077	-1.129	.705
	(.625)	(1.321)	(1.087)				(.66)	(1.327)	(.991)
quakeL1*peg	1.044	-.55	.846				.664	-.788	.214
	(.657)	(1.445)	(1.15)				(.668)	(1.401)	(1.075)
quakeL2*peg	.077	-.959	.444				-.13	-.959	.235
	(.404)	(1.388)	(.624)				(.44)	(1.348)	(.63)
quakeL3*peg	-.227	-1.129	-1.705*				-.607	-.953	-2.152**
	(1.256)	(1.349)	(.948)				(1.192)	(1.307)	(.872)
quakeL4*peg	.228	.407	1.194				-.083	.652	.495
	(.72)	(1.774)	(.82)				(.7)	(1.78)	(.987)
quake*IT				-1.118	-1.302*	-.294	-.468	-1.609*	.434
				(.822)	(.732)	(.667)	(.955)	(.82)	(.941)
quakeL1*IT				-.938	-1.801**	-.557	-.657	-2.417**	-.472
				(.575)	(.879)	(.487)	(.616)	(1.014)	(.7)
quakeL2*IT				-.868**	-1.085	-.71	-.608	-.421	-.608
				(.422)	(.859)	(.532)	(.722)	(1.495)	(.785)
quakeL3*IT				-.557	1.725	-1.039**	-1.7**	-.303	-2.291***
				(.852)	(2.752)	(.456)	(.771)	(2.263)	(.822)
quakeL4*IT				-1.521**	-1.144	-2.249***	-1.765***	.861	-2.137**
				(.608)	(1.409)	(.709)	(.627)	(2.703)	(.822)
_cons	7.705***	10.627***	3.769	7.606***	10.974***	3.414	7.656***	10.881***	3.527
	(1.815)	(1.423)	(3.478)	(1.782)	(1.363)	(3.468)	(1.817)	(1.365)	(3.507)
Country number	103	34	51	103	34	51	103	34	51
Observations	2866	1011	1408	2962	1044	1458	2866	1011	1408
R-squared	0.238	0.151	0.369	0.236	0.149	0.37	0.242	0.16	0.377
Zit-1 controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: All columns add time and country fixed effects. Standard errors in parenthesis are clustered by country. quakeL1, quakeL2, quakeL3, quakeL4 are lagged 1-4 year earthquake index. All columns control the per capita GDP growth rate, trade and capital account openness, exchange rate regime, population growth and financial crises (one lag for control variables). Columns (4)-(9) add IT.
*** *p<0.01, ** p<0.05, * p<0.1*