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Estimation and out-of-sample Prediction of Sudden Stops: Do Regions of Emerging Markets Behave Differently from Each Other?

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Estimation and out-of-sample Prediction of Sudden Stops: Do Regions of Emerging Markets Behave Differently From Each Other?

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Abstract

We identify episodes of sudden stops in emerging economies and estimate the probability to observe them. Sudden stops are more likely when global growth falters, risk aversion in financial markets rises, and vulnerabilities in the external and financial sectors increase. However, the significance of the explanatory variables vary across regions. In Latin America and Eastern Europe, gross capital inflows are more responsive to changes in global growth than in Asia. Trade linkages tend to be more important than financial linkages in Eastern Europe, while in Asia and Latin America the opposite is true. The model captures only a third of sudden stops outside the estimation sample, but issues reliable sudden stop signals.

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Contents

I. Introduction

International capital flows have been playing an increasingly important role in the business cycles of emerging market economies since 1990s and during financial crises. After a series of financial crises hitting emerging market economies in the 1990s and at the beginning of the 2000 decade, capital flows to emerging market economies increased dramatically until the global financial crisis (GFC) of 2008-2009. Capital flows to emerging market economies rebounded sharply following the GFC, but became volatile again in 2013 in correspondence of the May announcement on tapering of U.S. monetary stimulus.[2] As a consequence, understanding what causes sudden contractions in capital flows to emerging market economies constitutes an important challenge for policymakers and researchers alike.

In this context, the goal of this paper is to estimate the probability of observing sudden stops in selected emerging market economies. What makes this paper interesting is that it contributes to the existing literature on sudden stops in four ways. First, we show how the role played by the explanatory variables, including the measures of contagion, may vary across different groupings of emerging market economies. Second, we propose a measure of financial linkages to capture contagion effects. Third, as a robustness check, we ask whether the coefficient estimates of the explanatory variables change when we restrict our analysis to extreme episodes of sudden stops. We define extreme sudden stops as those episodes when the change in four-quarter gross capital inflows is below its five-year moving average by at least three standard deviations, during at least one quarter.[3] Fourth, we assess the out-of-sample performance of the model in anticipating sudden stops.

Some of the findings of this paper are standard in the literature on sudden stops. As in Forbes and Warnock (2012), we find that sudden stop episodes become more likely in emerging market economies when global economic growth is weak and when risk aversion in financial markets, as measured by the VIX index, rises. We also find that emerging market economies with a large stock of foreign exchange reserves relative to their short-term external debt are unlikely to experience sudden stops, which is in line with the findings of Durdu et al. (2009) and Gourinchas and Obstfeld (2011). Moreover, as in Forbes and Warnock (2012), reducing financial openness, as measured by the Chinn-Ito (2008) measure of financial openness, is unlikely to shield emerging market economies from sudden stops. Domestic

[2] See IMF (2014).

[3] In Forbes and Warnock (2012), episodes of sudden stops were defined as those episodes when the change in four-quarter gross capital inflows is below its five-year moving average by at least two standard deviations, during at least one quarter.

financial vulnerabilities also matter for sudden stops: elevated levels of credit to the private sector and of banking liabilities to non-residents increase the likelihood of sudden stops. This finding is in line with the notion that sudden stops, banking crises and currency crises often follow credit booms (see Calvo et al. (2006); Mendoza (2010); Mendoza and Terrones (2012)). Finally, as in Forbes and Warnock (2012), we find evidence of contagion effects through the trade and financial channels.

We also obtain results which are less common in the literature. When we perform a sensitivity analysis to check the robustness of the baseline estimates, we find that regions of emerging market economies tend to behave differently from each other. Specifically, we obtain two main results. First, the impact of global real GDP growth on the probability of sudden stops changes across regions of emerging market economies. Higher global real GDP growth reduces the probability of sudden stops in Latin America and in the grouping that includes Eastern European and Central Asian emerging market economies, and South Africa (EECAA). By contrast, in emerging Asia global real GDP growth is not significantly associated with the probability of sudden stops. Hence, gross capital inflows in Latin America and EECAA are more responsive to changes in global economic growth than in emerging Asia, where a number of economies have capital controls in place. Second, trade contagion appears to be more important than financial contagion in EECAA, while the opposite is true for Asia and Latin America. The limited importance of financial contagion in EECAA may reflect the commitment of large European banking groups with systemic presence in Emerging Europe to maintain their exposure and keep their subsidiaries well capitalized in the aftermath of the GFC.[4]

Finally, while the model captures only a third of the sudden stop episodes outside the estimation sample, it nevertheless issues reliable out-of-sample sudden stop signals, because the conditional probability of observing a sudden stop episode given a signal issued outside the estimation sample is nearly 70%. In addition, the model correctly identifies nearly all the tranquil periods outside the estimation sample. By region, the model tends to have a superior out-of-sample performance if the panel includes only the EECAA emerging market economies.

This paper is structured as follows. Section II reviews the relevant literature, while sections III and IV describe the data and the methodology, respectively. The results are discussed in section V while concluding remarks are in section VI.

[4]See "Statement at the end of the European Bank Co-ordination Initiative's Second Full Forum Meeting," Press Release No. 10/106, March 22, 2010, `http://www.imf.org/external/np/sec/pr/2010/pr10106.htm`.

II. Related Literature

International capital flows have been playing an increasingly important role in the business cycles of emerging market economies since 1990s. As a consequence, the literature has been analyzing the cyclical behavior of international capital flows, mostly in emerging market economies. Initially, this literature was mostly interested in the analysis of net capital flows, defined as the difference between net purchases of domestic assets by foreign residents and net purchases of foreign assets by domestic residents (Dornbusch et al. (1995); Kamisnky et al. (1998); Levchenko and Mauro (2007); Mendoza (2010)). This literature shows that net capital flows are pro-cyclical and contract abruptly during periods of financial turmoil. In this context, an episode of sudden stop is defined as a sharp contraction in capital flows relative to their past trajectory (Calvo, 1998). Other studies focus on the probability of observing an episode of sudden stop in emerging market economies (Calvo et al. (2004); Calvo (2006); Gourinchas and Obstfeld (2011)). The main findings of these studies are that the probability of observing a sudden stop episode in emerging market economies depends on the presence of domestic financial vulnerabilities, such as liability dollarization, and on the level of official foreign exchange reserves. Finally, Hur and Kondo (2013) develop a theoretical model where reserves endogenously prevent sudden stops.

More recently, several studies proposed identifying episodes of sudden stops by looking at sharp declines in *gross* rather than in *net* capital inflows. For instance, Forbes and Warnock (2012) argue that the size and volatility of gross capital flows increased substantially during the past decade, while net capital flows have been more stable. As a consequence the differentiation between gross and net capital inflows has become more important. Basing the analysis only on net capital flows would miss the change in size and volatility in gross capital flows. Cowan et al. (2007) look at the behavior of gross capital inflows and outflows in emerging and developed economies, Milesi-Ferretti and Tille (2011) study international capital flows during the global financial crisis, while Broner et al. (2013) analyze the behavior of gross capital flows over the business cycle and during financial crises. Finally, Cavallo et al. (2013) propose a methodology to classify episodes of sudden stops depending on the behavior of gross and net capital flows.

Another branch of research looks at cross-country allocation of investment and contagion through capital flows. A major theme that runs through much of this research is whether the factors driving capital flows are external to the country (push factors) or domestic (pull factors). The seminal papers in this literature —Calvo et al. (1993), Fernandez-Arias (1996),

and Chuhan et al. (1998) —find that push factors are more important than pull factors in driving capital flows. However, some studies find that also domestic factors matter; Calvo et al. (1996) argue that the surge of capital inflows into emerging markets in the early 1990s was initially attributed to domestic developments (such as better policies and economic performance). Another factor which is outside a country's control is contagion. The transmission mechanisms for contagion can be broadly broken into contagion through trade channels (which include direct trade, competition in third markets, and changes in import prices), financial channels (including through cross-border bank lending and portfolio flows), and country similarities (such as a shared regional location or similar economic characteristics). Glick and Rose (1999), Forbes (2002), and Abeysinghe and Forbes (2005) focus on contagion through trade, while Peek and Rosengreen (1997), Van Rijckeghem and Weder (2001), and Broner et al. (2006) focus on the role of financial linkages.

III. Data

Our panel comprises 25 emerging market economies and covers the period March 1990-December 2013.[5] We use quarterly data from the following databases: International Financial Statistics (IFS), Joint BIS-IMF-OECD-WB External Debt Hub (JEDH), IMF World Economic Outlook (WEO), IMF Direction of Trade Statistics (DOTS), Bloomberg and BIS Consolidated Banking Statistics.[6].

The panel includes global macroeconomic indicators, country-specific external and financial sector indicators, as well as measures of trade linkages, financial linkages and geographical proximity to capture possible contagion effects. Global macroeconomic indicators include global real GDP growth (calculated as the simple average of quarterly real GDP growth in the United States, selected European Union countries, and Japan), global liquidity (year-on-year growth rate in the global money supply, calculated as the sum of M2 in the United States, euro area and Japan, and M4 in the United Kingdom, all converted in U.S. dollars), global long-term interest rates (simple average rate on 10-year government bonds of the United States, selected European Union countries, and Japan), and the VIX Index (which is often used in the literature to express the degree of risk aversion of financial market participants).

[5]The emerging market economies are Argentina, Brazil, Bulgaria, Chile, China, Colombia, Hungary, India, Indonesia, Kazakhstan, Korea, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, Romania, Russia, South Africa, Thailand, Turkey, Ukraine, Uruguay and Vietnam.

[6]Foreign claims by nationality of reporting banks, immediate borrow basis, `http://www.bis.org/statistics/consstats.htm?m=6%7C31%7C70`

We use the following country-specific external and financial sector indicators: the ratio between the stocks of foreign exchange reserves and short-term external debt (JEDH database), the ratio between liabilities to non-residents of other depository corporations and nominal GDP (IFS and WEO databases), the ratio between credit to the private sector and nominal GDP (IFS and WEO databases), the ratio between the stock of short-term external debt and nominal GDP (JEDH and WEO databases), and the ratio between the stock of short-term international liabilities to banks that report the BIS Consolidated Banking Statistics and nominal GDP (JEDH and WEO databases).[7]

As regards the measures of trade and financial linkages, we use exports data from the IMF Directions of Trade Statistics (DOTS) database, and foreign claims data from the BIS Consolidated Banking Statistics database, respectively.[8] . In addition, we use the Chinn-Ito Financial Openness Index (see Chinn and Ito, 2006) to control for a country's degree of capital account openness.[9]

IV. Methodology

This section on the methodology is divided into three subsections. In the first subsection, we show how we identify episodes of sudden stop in gross capital inflows and episodes of retrenchment in gross capital outflows. The second subsection illustrates the measures of international linkages used to capture contagion effects. The final subsection is dedicated to the choice of the econometric strategy.

A. Identifying Sudden Stop and Retrenchment Episodes

In order to build indicators of international trade and financial linkages, we first need to define and identify episodes of sudden stops in gross capital inflows and episodes of retrenchment in gross capital outflows. We begin with with sudden stops. For each emerging market economy we use gross capital inflows data taken from the financial account of the balance of payments, (IFS database). Gross capital inflows have been calculated as the sum of direct investment liabilities, portfolio investment liabilities and other investment liabilities. We identify two different types of sudden stops: standard and extreme sudden stop episodes.[10]

[7] See also the Appendix for a description of the indicators.

[8] Section IV shows in greater detail how the indicators of contagion are built.

[9] Since the Chinn-Ito dataset used in this study encompasses the period 1970-2011, we do not have data for the Chinn-Ito Financial Openness Index for the period January 2012-December 2013.

[10] Since we are interested in modeling contagion effects from the trading partners of the emerging market

To identify standard sudden stop episodes in emerging market economies, we follow Forbes and Warnock (2012). First, for each emerging market economy, we aggregate quarterly gross capital inflows:

$$CI_t = \sum_{i=0}^{3} GI_{t-i}, \tag{1}$$

where GI_{t-i} denotes total gross capital inflows recorded in quarter $t-i$ in the financial account of the balance of payments.
As a next step, we calculate the four-quarter changes in gross capital inflows:

$$\Delta CI_t = CI_t - CI_{t-4}. \tag{2}$$

For each country we calculate the rolling mean and standard deviation of ΔCI_t over the last 5 years. An episode of sudden stop occurs each time when the change in four-quarter gross capital inflows is below its five-year rolling mean by at least *two* standard deviations, during at least one quarter:

$$\Delta CI_t \leq \mu^i_{5y} - 2\sigma^i_{5y}, \tag{3}$$

where μ^i_{5y} and σ^i_{5y} denote the five-year rolling mean and standard deviation, respectively, of the four-quarter change in gross capital inflows.

Sudden stop episodes last for all the quarters when the four-quarter change in gross capital inflows is below its five-year rolling mean by at least one standard deviation, that is, when:

$$\Delta CI_t < \mu^i_{5y} - \sigma^i_{5y}, \tag{4}$$

and terminate when the four-quarter change in gross capital inflows is no longer below its five year moving average by at least one standard deviation.

$$\Delta CI_t \geq \mu^i_{5y} - \sigma^i_{5y}. \tag{5}$$

At this stage we introduce the definition of extreme episodes of sudden stops, as we are interested to capture those episodes of sharper contractions in gross capital inflows compared to the definition of sudden stops in Forbes and Warnock (2012). While conditions (1)-(2)

economies included in the sample, we also identify episodes of sudden stop in gross capital inflows in selected advanced economies: Australia, Canada, Denmark, Euro area, Hong Kong, Japan, New Zealand, Norway, Singapore, Sweden, Switzerland, United Kingdom and United States.

and (4)-(5) continue to hold, to identify extreme sudden stops, we modify (3) as follows:

$$\Delta CI_t \leq \mu^i_{5y} - 3\sigma^i_{5y}, \tag{6}$$

where the terminology is unchanged. While Forbes and Warnock (2012) define a sudden stop episode as a *two-standard-deviation move* of the four-quarter change in gross capital inflows below its five-year rolling mean, we define an extreme sudden stop episode as a *three-standard deviation move* of the four-quarter change in gross capital inflows below its five-year rolling mean. As standard sudden stops, extreme sudden stops last for all the quarters when the four-quarter change in gross capital inflows is below its five-year rolling mean by at least one standard deviation and terminate when the four-quarter change in gross capital inflows is no longer below its five year moving average by at least one standard deviation. We identify episodes of extreme sudden stops because in our sensitivity analysis we are interested to check how the coefficient estimates change when we estimate the probability of extreme sudden stops.

For each definition of sudden stops, table 1 reports the number of identified sudden stop episodes and their average length (measured in quarters) for each emerging market economy included in the panel. We identify a total of 56 episodes of standard sudden stops across emerging market economies between March 1990 and December 2013: 20 episodes were identified in Asia, 23 in Eastern Europe, Central Asia and South Africa, and 13 in Latin America. Four emerging market economies experienced standard sudden stop episodes whose average length is higher than 5 quarters: Argentina (5.3), Korea (6.5), Thailand (5.3) and Turkey (5.7). On the other hand, four economies experienced standard sudden stop episodes with an average length inferior to four quarters: Brazil (3.3), Chile (3.5), China (3) and Indonesia (2.7). Colombia and Vietnam are the only emerging market economies without any sudden stop episode during the sample period. By region, episodes of standard sudden stops in Asia are on average shorter (4 quarters) than those in EECAA (4.5) and Latin America (4.2). These findings imply that if we use the sudden stop definition adopted by Forbes and Warnock (2012), Asia is the most resilient region of emerging market economies, as it is the region where episodes of sudden stop last less than elsewhere.

Compared to the standard episodes of sudden stops, extreme episodes of sudden stops tend to be fewer (20 in total, as opposed to 56), but with longer average length (4.8 quarters against 4.3). By region, we identified seven episodes of extreme sudden stops in Asia (average length of 4.9 quarters), nine episodes in EECAA (average length of 5 quarters) and

Table 1: Sudden stop episodes and average length (in quarters)

	Standard sudden stops		Extreme sudden stops	
	No. of SSE	Average length	No. of SSE	Average length
Country				
Argentina	3	5.3	–	–
Brazil	3	3.3	–	–
Bulgaria	3	4.3	2	5
Chile	2	3.5	1	4
China	1	3	–	–
Colombia	–	–	–	–
Hungary	2	4.5	2	4.5
India	3	4	1	4
Indonesia	3	2.7	1	4
Kazakhstan	2	4.5	–	–
Korea	2	6.5	2	6.5
Malaysia	2	4	1	4
Mexico	2	4.5	1	5
Pakistan	3	4.3	–	–
Peru	2	4	–	–
Philippines	3	4	1	5
Poland	1	4	1	4
Romania	3	4	1	6
Russia	3	4.7	1	5
South Africa	2	4	–	–
Thailand	3	5.3	1	4
Turkey	3	5.7	1	5
Ukraine	2	5	1	6
Uruguay	1	5	1	5
Vietnam	–	–	–	–
Asia	20	4.0	7	4.9
EECAA	23	4.5	9	5.0
Latin America	13	4.2	3	4.7
All EMEs in the panel	56	4.3	19	4.8

SSE: Sudden Stop Episodes

only three in Latin America (average length of 4.7 quarters). All the episodes of extreme sudden stops lasted for at least four quarters. Korea (average length of 6.5 quarters), Romania (6) and Ukraine (6) were the economies which experienced the longest episodes of extreme sudden stop, while in Chile, India, Indonesia, Malaysia, Poland and Thailand, the average length of extreme sudden stops was four quarters. We did not identify any extreme sudden stop episode in Argentina, Brazil, China, Colombia, Kazakhstan, Pakistan, Peru, South Africa and Vietnam.

In order to build the indicator of international financial linkages, we also define and identify episodes of retrenchment in gross capital outflows in advanced economies. The methodology to identify episodes of retrenchment is very similar to the methodology employed to identify sudden stops. We use gross capital outflows data from the financial account of the balance of payments (IFS database). First, for each advanced economy, we aggregate quarterly gross capital outflows:

$$CO_t = \sum_{i=0}^{3} GO_{t-i}, \tag{7}$$

where GO_{t-i} denotes total gross capital outflows recorded in quarter $t-i$ in the financial account of the balance of payments.

As a next step, we calculate the four-quarter changes in gross capital outflows:

$$\Delta CO_t = CO_t - CO_{t-4}. \tag{8}$$

We then calculate the rolling mean and standard deviation of ΔCO_t over the last 5 years. An episode of retrenchment occurs each time when the change in four-quarter gross capital outflows is below its five-year rolling mean by at least *two* standard deviations, during at least one quarter:

$$\Delta CO_t \leq \mu^o_{5y} - 2\sigma^o_{5y}, \tag{9}$$

where μ^o_{5y} and σ^o_{5y} denote the five-year rolling mean and standard deviation, respectively, of the four-quarter change in gross capital outflows.

Retrenchment episodes last for all the quarters when the four-quarter change in gross capital outflows is below its five-year rolling mean by at least one standard deviation, that is, when:

$$\Delta CO_t < \mu^o_{5y} - \sigma^o_{5y}, \tag{10}$$

and terminate when the four-quarter change in gross capital outflows is no longer below its five year moving average by at least one standard deviation:

$$\Delta CO_t \geq \mu^o_{5y} - \sigma^o_{5y}. \tag{11}$$

Finally, as already done for sudden stops, we also define extreme episodes of retrenchment:

$$\Delta CO_t \leq \mu^o_{5y} - 3\sigma^o_{5y}, \tag{12}$$

where the four-quarter change in gross capital outflows is below its five-year rolling mean by at least three standard deviations.

B. International Linkages

Next, we define the measures of international linkages to capture possible contagion effects across countries.

We define trade linkages as in Forbes and Warnock (2012). Let $TL_{x,t}$ denote country x trade linkages at time t:

$$TL_{x,t} = \frac{\sum_{i=1}^{n} \left(EX_{x,i,t} * E^{ss}_{i,t}\right)}{\sum_{i=1}^{n} EX_{x,i,t}} * \frac{EX_{x,t}}{Y_{x,t}} \tag{13}$$

where $EX_{x,i,t}$ denote the amount of exports of country x toward country i in quarter t, $E^{ss}_{i,t}$ denotes an episode of sudden stop experienced by country i, while the last term is the ratio between total exports and nominal GDP for country x in quarter t.[11] Intuitively, condition (13) implies that if there is an episode of sudden stop in at least one of the trading partners of country x, then that particular episode of sudden stop can be transmitted to country x through the trade linkages between the latter and its partners. Trading partners include all the emerging market economies in the panel and the following selected advanced economies: Australia, Canada, Denmark, Euro area, Hong Kong, Japan, New Zealand, Norway, Singapore, Sweden, Switzerland, United Kingdom and United States.[12]

As a next step, we define the indicator of financial linkages. The indicator is based on banking statistics provided by the Bank for International Settlements.[13] Keeping in mind

[11] Bilateral exports data from country x to country i are taken from the IMF's *Direction of Trade Statistics* database.

[12] For alternative indicators of trade contagion, see Glick and Rose (1999).

[13] We use Foreign Claims data based on the BIS Consolidated Banking Statistics on an immediate borrower

that no measure of financial linkages is perfect, we follow Forbes and Warnock (2012) and assume that the financial linkages between emerging market economy x and an advanced economy j are claims that country j financial institutions hold on residents in country x.[14]

We let $FL_{x,t}$ denote the measure of the emerging market economy x financial linkages in quarter t, which is defined as follows:

$$FL_{x,t} = \frac{\sum_{j=1}^{m} \left(BC_{x,j,t} * E^{r}_{j,t}\right)}{\sum_{j=1}^{m} BC_{x,j,t}} * \frac{BC_{x,t}}{Y_{x,t}}, \tag{14}$$

where $BC_{x,j,t}$ denote the amount of bank claims that reporting banks in an advanced economy j $(j = 1, \cdots, m)$ have on residents in an emerging market economy x in quarter t, $E^{r}_{j,t}$ denotes an episode of retrenchment in capital outflows observed in j, while the last term in (14) is the ratio between total foreign bank claims on residents in country x and country x nominal GDP in quarter t. The intuition behind (14) is that if there is an episode of retrenchment in gross capital outflows in an advanced economy, for instance when its residents decide to repatriate their foreign investments, an emerging market economy may experience an episode of sudden contraction in external finance.

Finally, following Forbes and Warnock (2012), the measure for regional contagion consists in assigning the value of one to a given emerging market economy during quarter t if a neighboring economy experienced an episode of sudden stop during the previous quarter $t-1$, and zero otherwise.

C. Econometric Strategy

To estimate the conditional probability of observing an episode of sudden stop, we use a panel discrete-choice model with country fixed effects. We use discrete-choice models as these are commonly used in the "early warning" literature on crisis prediction.[15] Among discrete-choice models, we chose to use panel logit models as opposed to panel probit models.

basis (CBS-IB). We could have also used Foreign Claims based on the BIS Consolidated Banking Statistics on an ultimate risk basis (CBS-UR), which takes risk transfers into account. However, the CBS-UR dataset has a shorter time series dimension and is reported by a smaller number of countries than the CBS-IB data, see Avdjiev et al. (2011).

[14] The advanced economies are: Australia, Canada, Denmark, Euro area, Hong Kong, Japan, New Zealand, Norway, Singapore, Sweden, Switzerland, United Kingdom and United States.

[15] See, among others, Eichengreen et al. (1995), Frankel and Rose (1996), Bussière and Fratzscher (2006), and Gourinchas and Obstfeld (2011).

This decision is motivated by the fact that for all the specifications, we were able to reject the hypothesis that the profit estimator is efficient and consistent, after having run the Hausman's specification test. In addition, we chose to use panel logit models with fixed effects, as opposed to random effects. The reason is that with traditional random effects probit models, it is assumed that unobservable country effects are independent on the vector of explanatory variables x, and that they are normally distributed. By contrast, the benefit of using a panel logit model with fixed effects is that we can obtain consistent coefficient estimates without any assumption about how the unobservable country effects are related to the vector of explanatory variables.[16]

Consider an underlying latent response variable y^*:

$$y^* = x\beta + u,$$

where x is a vector of explanatory variables, β is a vector of coefficients and u is an vector of iid disturbance terms. Instead of observing y^*, we observe only a binary variable y which can assume either 0 or 1 depending on whether the latent variable lies above or below a certain threshold:

$$\begin{aligned} y &= 1 \quad \text{if} \quad y^* > 0 \\ y &= 0 \quad \text{otherwise.} \end{aligned}$$

The probability that the latent variable is bigger than the threshold is modeled as follows:

$$\begin{aligned} Pr\left(y^* > 0|\mathbf{x}\right) &= \\ Pr\left(x\beta + u > 0|\mathbf{x}\right) &= \\ Pr\left(u > -x\beta|\mathbf{x}\right) &= \\ Pr\left(y = 1|\mathbf{x}\right) &= \Psi(y^*), \end{aligned}$$

where $\Psi(y^*)$ denotes the cumulative distribution function (CDF).[17] For the logit model, $\Psi(y^*)$ is the CDF of the logistic distribution:

$$Pr\left(y = 1|\mathbf{x}\right) = \frac{\exp\left(x\beta\right)}{1 + \exp\left(x\beta\right)}. \tag{15}$$

[16] See Wooldridge, 2002.
[17] See Baum, 2006.

We use (15) to estimate the probability that a given emerging market economy experiences an episode of sudden stop, conditionally on a vector $\mathbf{x}$ of explanatory variables, which are lagged by one quarter.

V. Results

We regress standard sudden stop episodes on a set of global macroeconomic indicators, country-specific external and financial sector indicators, and measures of trade and financial linkages, using a fixed-effects panel logit model. All the explanatory variables are lagged by one quarter. Baseline estimates of the probability of sudden stops in emerging market economies are reported in the second column of table 2.

A. Baseline Results

We begin by running regressions when the panel includes all the 25 emerging market economies considered in this study. Among the global macroeconomic indicators, global real GDP growth and volatile risk perceptions of financial market participants, as measured by the VIX index, are statistically significant for the probability of sudden stops and have the expected sign. Sudden stops become more likely in periods when global economic growth is sluggish and/or when risk aversion in financial markets rises. By contrast, global liquidity and long term interest rates are not significant. This pattern is not entirely surprising, as it is in line with the notion that historically, most of the gross capital inflows into emerging market economies were direct investment inflows, which tend to be less sensitive than portfolio and other inflows to global monetary and financing conditions. As a result, not all the global macroeconomic indicators are statistically significant: only global real GDP growth and the VIX index are. This result is in line with the findings in Forbes and Warnock (2012).

The ratio between the stocks of foreign exchange reserves and short-term external debt securities (i.e., maturing within one year), is the external sector indicator which is systematically significant. A higher ratio between the stocks of foreign exchange reserves and short-term external debt is associated with a lower probability of sudden stops. Countries with a large stock of foreign exchange reserves relative to their short-term external debt are unlikely to experience sudden stops. This finding is in line with several studies. Durdu et al. (2009) found that the risk of a sudden stop is a plausible explanation behind the process of accumulation of foreign exchange reserves in emerging market economies, following the

several sudden stop episodes in emerging market economies observed between 1994 and 2002. Gourinchas and Obstfeld (2011) found that official reserves can play an important role in financial crisis prevention, while Hur and Kondo (2013) develop a theory where foreign exchange reserves prevent financial crises. High banking liabilities to non-residents contribute to increase the likelihood of observing sudden stops in emerging market economies. This result is in line with the work of Calvo et al. (2006), who show that the probability of sudden stops depends on domestic financial vulnerabilities, including the denomination of debt in foreign currency.

The degree of financial openness tends to be negatively associated with the probability of sudden stops.[18] As a consequence, reducing the degree of financial openness, through for instance the imposition of capital controls, may not shield emerging market economies from sudden stops in gross capital inflows. Indeed, if international investors do not expect the imposition of capital controls in a financially open economy, it is unlikely that they would suddenly cease to invest in that particular economy. Finally, real exchange rate misalignment does not affect the probability of sudden stops.

As in Forbes and Warnock (2012), we find evidence of contagion effects through trade and financial channels. An emerging market economy is more likely to experience a sudden stop in the current quarter if in the last quarter one or more of its trading partners experienced a sudden stop. Similarly, an emerging market economy is more likely to experience an episode of sudden stop in the current quarter if in the last quarter one or more of its financial partners experienced retrenchment in gross capital outflows.

B. Sensitivity Analysis

The goal of the the sensitivity analysis is to assess whether the coefficient estimates change compared to those obtained in the baseline regression. We proceed in three ways. First, we run again the baseline regression using three regional panels. Second, we run alternative specifications using additional explanatory variables. Third, we focus on extreme episodes of sudden stops.[19]

[18] The Chinn-Ito financial openness index takes on higher values the more open the country is to cross-border capital transactions, see Chinn and Ito (2008), and `http://web.pdx.edu/~ito/kaopen_Chinn-Ito_hi0523.pdf`. A negative coefficient associated to the Chinn-Ito Index of financial openness means that more financial openness is associated with a lower probability of sudden stops.

[19] See section III for the definition of extreme sudden stops.

Table 2: Panel logit regressions: baseline and regional estimates

Dependent variable: $P(y_{it} = 1 \mid \mathbf{x}_{it-1})$				
	Baseline	Asia	EECAA	Latin America
Global indicators				
Global real GDP growth	-0.242^{***}	0.157	-0.622^{***}	-0.347^{**}
	(0.067)	(0.121)	(0.130)	(0.144)
Global liquidity	0.556	-3.304	3.296^{*}	2.970
	(1.090)	(2.171)	(1.870)	(2.223)
Global LT interest rates	0.021	0.227^{**}	0.082	0.029
	(0.053)	(0.089)	(0.117)	(0.121)
VIX Index	0.056^{***}	0.056^{***}	0.058^{***}	0.057^{**}
	(0.011)	(0.018)	(0.021)	(0.022)
Country-specific indicators				
FX reserves/ST ext. debt	-0.342^{***}	-0.091	-0.938^{***}	-0.075
	(0.072)	(0.090)	(0.202)	(0.242)
REER misalignment	0.016	0.221^{**}	-0.013	-0.016
	(0.050)	(0.099)	(0.099)	(0.101)
Bank liabilities to non-residents	0.017^{**}	5.674^{**}	0.074	13.876^{***}
	(0.007)	(2.476)	(0.807)	(3.399)
Chinn-Ito index of financial openness	-1.465^{***}	-4.667^{***}	-1.129	-0.927
	(0.471)	(1.321)	(0.875)	(0.835)
Contagion				
Trade	16.039^{***}	7.321	27.012^{***}	11.353
	(5.135)	(8.789)	(9.759)	(16.757)
Financial	5.116^{***}	15.984^{***}	1.803	7.773^{***}
	(1.032)	(3.568)	(1.533)	(3.012)
Observations	2092	760	762	570

*** Significant at the 1% level
** Significant at the 5% level
* Significant at the 10% level
Standard errors in parenthesis

i. Global vs. Regional Panels

We begin the sensitivity analysis by dividing the overall panel of emerging market economies into three smaller panels, each of which represents a region of emerging market economies. We group the emerging market economies into three regions: i) Asia, ii) Eastern Europe, Central Asia and South Africa (EECAA), and iii) Latin America.[20]

For each of the three regional panels, in table 2 we compare the estimates with the baseline ones. Three differences among the regions of emerging market economies emerge. First, while in EECAA and Latin America stronger global real GDP growth reduces the likelihood of sudden stops, in Asia stronger global growth turns out not to be significant. Gross capital inflows in emerging Asia are less responsive to changes in global economic growth than in Latin America and EECAA. In turn, this may partly reflect the presence of capital controls in a number of Asian emerging market economies.

Second, we find evidence of contagion effects through financial linkages in Asia and Latin America, but not in EECAA. By contrast, we find evidence of contagion effects from trade linkages in the EECAA region but not in Asia or Latin America. Why are contagion effects from financial linkages absent in EECAA? Cerutti et al. (2010) argue that during the global financial crisis of 2008-09, many subsidiaries of large European banking groups had to rely on their parent banks for capital and liquidity support. There is evidence that large European banking groups with systemic presence in Emerging Europe committed to maintain their exposure and keep their subsidiaries well capitalized.[21] As a consequence, cross-border transfers from parent to subsidiaries have not dried up and this may have shielded emerging market economies in the EECAA region from contagion effects through financial linkages.

The third difference is captured by the impact of financial openness on the probability of sudden stops. In Latin America and EECAA, the degree of financial openness is not significantly related with the probability of sudden stops, which is in line with the result of Forbes and Warnock (2012). As a consequence, sudden stops do not become less likely by reducing the degree of financial openness. In Asia, by contrast, the relationship between the degree of financial openness and the probability of sudden stops is negative: more financial

[20]The Asia panel includes the following countries: China, India, Indonesia, Korea, Malaysia, Pakistan, Philippines, Thailand and Vietnam. The EECAA panel includes the following countries: Bulgaria, Hungary, Kazakhstan, Poland, Romania, Russia, South Africa, Turkey and Ukraine. The Latin America panel includes the following countries: Argentina, Brazil, Chile, Colombia, Mexico, Peru and Uruguay.

[21]See "Statement at the end of the European Bank Co-ordination Initiative's Second Full Forum Meeting," Press Release No. 10/106, March 22, 2010, http://www.imf.org/external/np/sec/pr/2010/pr10106.htm. See also the Mission Statement of the Vienna Initiative (2012) http://www.imf.org/external/np/sec/pr/2012/pdf/pr12265b.pdf

openness would reduce the probability of sudden stops.

ii. Additional Control Variables

We now turn to perform a series of robustness checks by introducing one control variable at a time in the baseline regression using the panel of 25 emerging market economies. We run a number of specifications where we include the following control variables: the ratio between the level of credit to the private sector and nominal GDP, the ratio between short-term liabilities to BIS reporting banks and nominal GDP, the ratio between short-term external debt and nominal GDP, and a measure of regional contagion to check whether geographical proximity plays a role in explaining the probability of sudden stops.

Table 3 contains four different specifications which are compared with the baseline. Credit to the private sector as a percentage of nominal GDP is statistically significant and positively related with the probability of sudden stops. The result is in line with the notion that credit growth, if excessive, may trigger a sudden stop in capital inflows (see Mendoza, 2010 and Mendoza and Terrones, 2012). High short-term external debt and short-term international banking liabilities to banks may also increase the likelihood of a sudden stop episode.

Finally, in the last column of table 4 we show that geographical proximity also contributes to transmit sudden stops across emerging market economies. As in the baseline regression, we still find evidence of contagion effects through financial and trade linkages.

iii. Extreme Sudden Stop Episodes

At this stage, we focus our sensitivity analysis on extreme episodes of sudden stops. Table 4 reports the coefficient estimates obtained when we use the definition of extreme sudden stops. The estimates suggest that extreme episodes of sudden stops are usually preceded by sluggish global economic growth, rising risk aversion, as well as the build-up of vulnerabilities in the financial and external sectors. Finally, the estimates suggest that trade and financial linkages may also contribute to provoke extreme sudden stop episodes.

Table 3: Panel logit regressions: additional control variables

Dependent variable: $P(y_{it} = 1 \mid \mathbf{x}_{it-1})$					
	Baseline	1	2	3	4
Global indicators					
Global real GDP growth	−0.242***	−0.184*	−0.237***	−0.251***	−0.198***
	(0.067)	(0.095)	(0.067)	(0.068)	(0.068)
Global liquidity	0.556	1.868	0.681	0.453	0.071
	(1.090)	(1.932)	(1.087)	(1.099)	(1.075)
Global LT interest rates	0.021	0.481**	0.024	0.047	0.014
	(0.053)	(0.197)	(0.053)	(0.054)	(0.052)
VIX Index	0.056***	0.081***	0.056***	0.056***	0.053***
	(0.011)	(0.015)	(0.011)	(0.011)	(0.011)
Country-specific indicators					
FX reserves/ST ext. debt	−0.342***	−0.217**	−0.325***	−0.319***	−0.324***
	(0.072)	(0.100)	(0.073)	(0.072)	(0.071)
REER misalignment	0.016	0.057	0.014	0.016	0.019
	(0.050)	(0.082)	(0.050)	(0.050)	(0.051)
Chinn-Ito index of financial openness	−1.465***	−3.683***	−1.542***	−1.476***	−1.522***
	(0.471)	(0.877)	(0.470)	(0.474)	(0.467)
Bank liabilities to non-res./Nom. GDP	0.017**	–	–	0.017**	0.013*
	(0.007)	–	–	(0.007)	(0.007)
Credit to the private sector/Nom. GDP	–	0.047***	–	–	–
	–	(0.011)	–	–	–
ST comm. bank liabilities/Nom. GDP	–	–	3.170**	–	–
	–	–	(1.329)	–	–
ST ext. debt/Nom. GDP	–	–	–	7.539**	–
	–	–	–	(3.437)	–
Contagion					
Trade	16.039***	22.848**	16.979***	15.743***	11.606**
	(5.135)	(8.007)	(5.123)	(5.149)	(5.201)
Financial	5.116***	6.342***	5.154***	5.285***	5.144***
	(1.032)	(1.767)	(1.035)	(1.039)	(1.026)
Regional	–	–	–	–	0.680***
	–	–	–	–	(0.192)
Observations	2092	1279	2092	2029	2029

*** Significant at the 1% confidence level
** Significant at the 5% confidence level
* Significant at the 10% confidence level
Standard errors in parenthesis

Table 4: Panel logit regressions: extreme sudden stops.

Dependent variable: $P(y_{it}=1\|\mathbf{x}_{it-1})$					
	Baseline	1	2	3	4
Global indicators					
Global real GDP growth	-0.294^{**}	-1.000^{***}	-0.304^{***}	-0.282^{**}	-0.240^{**}
	(0.106)	(0.269)	(0.106)	(0.107)	(0.107)
Global liquidity	-3.469^{*}	-0.729	-3.293^{*}	-4130^{*}	-2.827
	(1.967)	(4.529)	(1.928)	(2.068)	(2.007)
Global LT interest rates	0.015	0.327	-0.014	0.077	-0.020
	(0.094)	(0.464)	(0.094)	(0.097)	(0.094)
VIX Index	0.060^{***}	0.142^{***}	0.061^{***}	0.057^{***}	0.052^{***}
	(0.018)	(0.037)	(0.018)	(0.018)	(0.018)
Country-specific indicators					
FX reserves/ST ext. debt	-1.489^{***}	-4.415^{***}	-1.591^{***}	-1.393^{***}	-1.466^{***}
	(0.257)	(0.955)	(0.266)	(0.255)	(0.252)
REER misalignment	0.027	-0.093	0.001	-0.000	0.012
	(0.077)	(0.184)	(0.071)	(0.091)	(0.085)
Chinn-Ito index of financial openness	-0.019	0.643	-0.280	-0.081	-0.048
	(0.000)	(2.071)	(0.718)	(0.748)	(0.744)
Bank liabilities to non-res./Nom. GDP	0.014^{*}	–	–	0.016^{**}	0.013
	(0.008)	–	–	(0.008)	(0.008)
Credit to the private sector/Nom. GDP	–	0.049^{**}	–	–	–
	–	(0.021)	–	–	–
ST comm. bank liabilities/Nom. GDP	–	–	0.392	–	–
	–	–	(1.358)	–	–
ST ext. debt/Nom. GDP	–	–	–	11.886^{**}	–
	–	–	–	(4.699)	–
Contagion					
Trade	20.542^{*}	33.783	22.504	20.129^{*}	9.142
	(11.767)	(32.965)	(11.721)	(11.844)	(12.220)
Financial	2.844^{*}	-2.695	2.604^{*}	3.470^{**}	3.487^{***}
	(1.594)	(4.027)	(1.590)	(1.633)	(1.602)
Regional	–	–	–	–	1.110^{***}
	–	–	–	–	(0.314)
Observations	1479	495	1479	1479	1479

*** Significant at the 1% confidence level
** Significant at the 5% confidence level
* Significant at the 10% confidence level
Standard errors in parenthesis

C. Out-of-sample performance

The goal of this exercise is to check how the model performs in predicting the episodes of sudden stops observed across emerging market economies during the Global Financial Crisis (GFC) of 2008-2009, conditionally on the information available until December 2007. In other words, we assess the out-of-sample performance of the model. We study the out-of-sample performance of four different econometric specifications. In the first specification, we run the baseline regression using the panel which includes all the 25 emerging market economies considered in this study. In the remaining three specifications, we run the baseline regression using the three regional panels, each of which represents an aggregate of emerging market economies: i) Asia, ii) Eastern Europe, Central Asia and South Africa (EECAA), and iii) Latin America.

From a methodological point of view, we proceed as follows. We partition the original sample period (March 1990-December 2013) into two subsamples: the estimation sample (March 1990-December 2007) and the forecasting sample (March 2008-December 2013). Then, we obtain the coefficient estimates for each specification, which are reported in table 5.[22] The estimates show that there is considerable parameter instability. If the GFC and subsequent years are excluded from the sample period, there are at least two important changes compared to the full-sample baseline estimates. First, the likelihood of sudden stops no longer depends on the VIX. This result is in line with the notion that in correspondence of the GFC, there has been a reassessment of risk among financial market participants, which is likely to have reduced the appetite of international investors for emerging market economies assets. Second, when the panel includes all the 25 emerging market economies, there is no longer evidence of contagion effects through trade or financial linkages. This result is motivated by the fact that most of the retrenchment episodes identified in advanced economies took place during the global financial crisis.

Once obtained the coefficient estimates, we calculate the probability of sudden stops, and choose its optimal cut-off value. In turn, the optimal cut-off value is chosen such that the total misclassification error (TME) is minimized. The TME is calculated as the sum between the percentage of missed sudden stops, or Type 1 error (the ratio between missed sudden stops over the total number of sudden stops) and the percentage of false alarms, or Type 2 error (the ratio between the number of false alarms and the total number of tranquil periods,

[22]For each specification, the full sample coefficient estimates are identical to the ones reported in table 3.

Table 5: Panel logit regressions: changing the sample period

Dependent variable: $P(y_{it}=1\|\mathbf{x}_{it-1})$								
	Baseline		Asia		EECAA		Latin America	
	Full sample	1990-2007	Full sample	1990-2007	Full sample	1990-2007	Full sample	1990-2007
Global indicators								
Global real GDP growth	-0.242^{***}	-0.187^{*}	0.157	0.244	-0.622^{***}	-0.607^{***}	-0.347^{**}	-0.137
	(0.067)	(0.113)	(0.121)	(0.224)	(0.130)	(0.225)	(0.144)	(0.249)
Global liquidity	0.556	-1.031	-3.304^{*}	-7.559^{**}	0.256	0.098	2.970	2.710
	(1.009)	(1.313)	(2.168)	(3.179)	(1.870)	(2.278)	(2.223)	(2.763)
Global LT interest rates	0.021	-0.188^{**}	0.227^{**}	0.049	0.082	-0.116	0.029	-0.279
	(0.053)	(0.272)	(0.089)	(0.153)	(0.117)	(0.183)	(0.121)	(0.161)
VIX Index	0.056^{***}	0.019	0.055^{***}	0.025	$0.058***$	0.023	0.057^{**}	-0.036
	(0.011)	(0.016)	(0.018)	(0.030)	(0.021)	(0.031)	(0.022)	(0.037)
Country-specific indicators								
FX reserves/ST ext. debt	-0.342^{***}	-1.875^{***}	-0.091	-1.163^{***}	-0.938^{***}	-2.453^{***}	-0.075	-3.001^{***}
	(0.072)	(0.272)	(0.090)	(0.376)	(0.202)	(0.631)	(0.242)	(0.903)
REER misalignment	0.016	-0.021	0.221^{**}	-0.004	-0.013	-0.180	-0.016	0.020
	(0.050)	(0.071)	(0.099)	(0.191)	(0.099)	(0.179)	(0.101)	(0.132)
Bank liabilities to non-residents	0.017^{**}	0.008	5.674^{**}	6.047^{*}	0.074	-1.246	13.876^{***}	21.010^{***}
	(0.007)	(0.012)	(2.474)	(3.489)	(0.807)	(1.188)	(3.399)	(5.220)
Chinn-Ito index of financial openness	-1.465^{***}	-2.205^{***}	-4.667^{***}	-9.097^{***}	-1.129	-4.172^{**}	-0.927	-0.749
	(0.471)	(0.635)	(1.321)	(2.216)	(0.875)	(1.743)	(0.835)	(0.948)
Contagion								
Trade	16.039^{***}	-0.079	7.321	-5.448	27.012^{***}	48.129^{***}	11.353	-44.945
	(5.135)	(7.798)	(8.789)	(12.851)	(9.759)	(16.377)	(16.757)	(43.288)
Financial	5.116^{***}	5.884	15.984^{***}	4.708	1.803	0.502	7.773^{***}	10.528
	(1.032)	(2.393)	(3.568)	(5.011)	(1.533)	(3.181)	(3.012)	(6.677)
Observations	2092	1398	760	497	762	475	570	426

*** Significant at the 1% level
** Significant at the 5% level
* Significant at the 10% level
Standard errors in parenthesis

hence without sudden stops). Formally:

$$TME = \text{Type 1 error} + \text{Type 2 error} \tag{16}$$

where

$$\text{Type 1 error} = \frac{\text{Missed Episodes of Sudden Stops}}{\text{Total Episodes of Sudden Stops}}, \tag{17}$$

and

$$\text{Type 2 error} = \frac{\text{False Alarms}}{\text{Total Episodes of Tranquil Periods}}. \tag{18}$$

As a next step, we check whether, for each country in the panel and at any point in time, the estimated probability of sudden stop is higher or lower than the cut-off value. If it is higher, then the model issues a sudden stop signal, while if it is lower, the model predicts a tranquil period. Sudden stop signals can be correct or not. A sudden stop signal issued at time t is correct if, within the following two years, a sudden stop episode is realized. Otherwise, the signal constitutes a false alarm. Similarly, the model correctly predicts a tranquil period signal at time t if, within the following two years, no episode of sudden stop is realized. On the contrary, the model has missed a sudden stop episode.

Table 6 shows the in-sample and out-of sample performances of the four econometric specifications. For each specification, the following measures are calculated: the percentages of sudden stop episodes and tranquil periods correctly called, the percentages of missed sudden stop episodes and false alarms, the TME, the probability of observing a sudden stop within the next two years given a sudden stop signal, and finally the probability of observing a sudden stop episode within the next two years if no prior sudden stop signal has been issued.

The baseline specification correctly calls only 33% of the sudden stop episodes outside the estimation sample. However, an out-of-sample sudden stop signal issued by the baseline specification is highly likely to be followed by an actual episode of sudden stop, as the probability of observing a sudden stop episode given a signal is close to 0.7. Hence, while the model misses most of the sudden stop episodes outside the estimation sample, the sudden stop signals it issues outside the estimation sample tend to be reliable.

Looking at the regional aggregates, the TME of the EECAA specification is lower than those of the Asia and Latin America specifications. In addition, the EECAA specification has the best record across specifications in terms of correct calls of sudden stop episodes outside the estimation sample. The model performs well if the panel includes only EECAA countries,

while it performs poorly if the panel includes only Asian or Latin American emerging market economies.

Table 6: In-sample and out-of-sample performance

	Baseline		Asia		EECAA		LA	
	I	O	I	O	I	O	I	O
Correct calls of SS (%)	51.3	33.1	60.4	23.3	55.4	53.2	34.6	17.1
Correct calls of non-SS (%)	69.9	93.6	58.9	66.6	70.7	97.1	78.0	100.0
Missed SS(%)	48.7	66.8	39.6	76.6	44.5	46.7	65.4	82.8
False alarms (%)	30.1	6.4	41.1	33.3	29.2	2.9	22.0	0.0
TME	78.8	73.7	80.7	110.0	73.8	49.6	87.4	82.8
P (SS|signal)	0.35	0.68	0.32	0.21	0.39	0.91	0.29	1.00
P (SS|no signal)	0.18	0.22	0.18	0.31	0.18	0.21	0.18	0.18
Observations	1398		497		475		426	

I: In-sample
O: Out-of-sample
SS: Sudden stops
TME: Total misclassification error

VI. Conclusions

In this study we were interested in estimating the probability of sudden stops in emerging market economies over the period March 1990-December 2013. We found that selected global and country-specific indicators could be highly relevant to estimate the probability of sudden stops. Among the global indicators, global real GDP growth and the risk perceptions of financial market participants, as measured by the VIX Index, were systematically significant to estimate the probability of sudden stops. Among the country-specific indicators, the ratio between foreign exchange reserves and short-term external debt was always relevant to explain the probability of sudden stops. Additional significant external and financial sector indicators included the ratio between credit to the private sector and nominal GDP, the ratio between short-term international liabilities to banks and nominal GDP, and the ratio between short-term external debt and nominal GDP. We also found evidence of contagion effects through trade linkages, financial linkages and geographical proximity.

Some of the results were sensitive to the composition of the panel. The impact of global real GDP growth on the probability of sudden stops changed across regions of emerging market economies. Higher global real GDP growth reduced the probability of sudden stops in Latin

America and in the Eastern Europe, Central Asia and Africa (EECAA) aggregate, while in Asia global real GDP growth is not significantly associated with the probability os sudden stops. This finding suggests that gross capital inflows tend to behave pro-cyclically only in EECAA and Latin America. We also found evidence of contagion effects through financial linkages in the Asian and Latin American emerging market economies, but not in EECAA. By contrast, we found evidence of contagion effects through trade linkages in EECAA, but neither in Asia nor Latin America. The absence of contagion effects through financial linkages in EECAA may reflect the commitment of large European banking groups with systemic presence in Emerging Europe to maintain their exposure and keep their subsidiaries well capitalized in the aftermath of the global financial crisis.

Most of the estimates were robust to the definition of extreme sudden stops. Global real GDP growth, the risk perceptions of financial market participants, and the ratio between foreign exchange reserves and short-term external debt remained significantly associated with the probability of sudden stops. Trade and financial linkages also contributed to provoke extreme sudden stop episodes. Finally, while the model captures only a third of the sudden stop episodes outside the estimation sample, it nevertheless issues reliable out-of-sample sudden stop signals, because the conditional probability of observing a sudden stop episode given a signal issued outside the estimation sample is close to 70%. In addition, the model correctly identifies nearly all the tranquil periods outside the estimation sample. By region, the model tends to have a superior performance if the panel includes only the EECAA emerging market economies.

This study offers a number of macroeconomic policy recommendations. First, in presence of contagion effect through trade linkages, financial linkages and geographical proximity, episodes of sudden stops can be easily transmitted from one country to another. It is therefore important that emerging market economies are able to run countercyclical macroeconomic policies should an external shock, such as a sudden stop in gross capital inflows, occur. Second, since the ratio between short-term external debt and nominal GDP is positively associated with the probability of sudden stops, issuing more long-term rather than short-term external debt could be helpful for emerging market economies in the prevention of sudden stop episodes. This underscores the importance of emerging market economies to be able to issue sovereign debt securities with long maturities. In turn, issuing long-term sovereign debt securities requires governments in emerging market economies to run credible macroeconomic policies. Third, preventing the build up of vulnerabilities in the financial sector is key because sudden stops tend to be preceded by elevated levels of credit

to the private sector and banking liabilities to non-residents. Hence, macro-prudential policies with the goal to prevent excessive borrowing could play an important role in preventing sudden stops. Fourth, the VIX index, which expresses the volatile risk perceptions of financial market participants, is systematically significant when estimating the probability of sudden stops. Therefore, it is important for countries to have good macroeconomic policies in place to deal with the volatility of gross capital inflows. Finally, while early warning systems tend to have limited power in anticipating sudden stop episodes outside the estimation sample, they can nonetheless be useful to policymakers because they may issue reliable sudden stop signals outside the estimation sample.

This research could be extended in a number of directions. First, the panel could be extended to include more financially integrated emerging market economies in Eastern Europe and Central Asia. Second, it would be interesting to estimate the probability of sudden stops by focusing only on those episodes of sudden stops which were preceded by episodes of gross capital inflow bonanzas. Third, while this study was concerned with sudden stop episodes in overall gross capital inflows in emerging market economies, it would be interesting to identify and analyze episodes of sudden stops for each kind of gross capital inflows recorded in the balance of payments: direct investment inflows, portfolio investment inflows and other investment inflows. Fourth, it would also be interesting to use alternative methods to identify episodes of sudden stops, such as methods involving distributional criteria.[23]

[23]See Magud and Vesperoni, 2014, and Reinhart and Reinhart, 2008.

Appendix
Description of the indicators.

- Gross capital inflows: sum of direct, portfolio and other investment liabilities, expressed in billions of U.S. dollars. Source: International Financial Statistics (IFS)
- Gross capital outflows: sum of direct, portfolio and other investment assets, expressed in billions of U.S. dollars. Source: IFS.
- GRY: Global real GDP growth: simple average of quarterly real GDP growth rates in the United States, selected European Union (E.U.) countries and Japan. Source: IFS.
- GL: Global liquidity: as in Forbes and Warnock (2012), global liquidity is calculated as the year-on-year growth rate in the global money supply. The global money supply is calculated as the sum of M2 in the United States, euro area and Japan, and M4 in the United Kingdom, all converted into U.S. dollars. Source: IFS.
- GLTIR: Global long-term global interest rate. It is the simple average rate on 10-year government bonds of the United States, selected E.U. countries and Japan. Source: IFS.
- VIX is the Chicago Board Options Exchange Market Volatility Index. It measures the implied volatility of the S&P 500 index options. It represents the market participants expectations of the stock market volatility over the next 30 day period. It is often used to quantify the degree of risk aversion of market participants. Source: Bloomberg.
- BLNR/Y: Ratio between liabilities to non-residents of other depository corporations and nominal GDP. Line 26C of the IFS database. Source: IFS.
- CPRS/Y: Ratio between credit to the private sector and nominal GDP. Data for credit to the private sector is taken from line 22D of the IFS database (claims on private sector held by other depository corporations). Data not available for Bulgaria, Hungary and Poland. Source: IFS.
- REERM: Indicator of real effective exchange rate misalignment. The indicator is calculated as the difference between the real effective exchange rate observed at time t and its moving average calculated during the previous four quarters. Source: IFS.
- FXR/STED: Ratio between the stocks of foreign exchange reserves and short term external debt. The indicator is built as the ratio between the stock of international

reserves (excluding gold, line 26 of the Joint External Debt Hub Database) and short-term international debt securities (line 17 of the Joint External Debt Hub Database). Source: Joint External Debt Hub `http://www.jedh.org`.

- STED/Y: Ratio between short term external debt and nominal GDP. Sources: Joint External Debt Hub `http://www.jedh.org` (line 17) and IMF World Economic Outlook database `http://www.imf.org/external/pubs/ft/weo/2014/02/weodata/weoselgr.aspx`.

- Regional contagion variable: A country is assigned the value of 1 if there is at least one country in the region experiencing either an episode of sudden stop.

- Chinn-Ito FO: Chinn-Ito Financial Openness Index. The Chinn-Ito Financial Openness Index is an index measuring a country's degree of capital account openness. The index was initially introduced in Chinn and Ito (Journal of Development Economics, 2006). KAOPEN is based on the binary dummy variables that codify the tabulation of restrictions on cross-border financial transactions reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER).

- STCBL/Y: Ratio between short-term international liabilities to banks that report the BIS Consolidated Banking Statistics and nominal GDP. Sources Sources: Joint External Debt Hub `http://www.jedh.org` (line 12) and IMF World Economic Outlook database `http://www.imf.org/external/pubs/ft/weo/2014/02/weodata/weoselgr.aspx`.

- Ratio between total international liabilities to banks report the BIS Consolidated Banking Statistics and nominal GDP. Sources: Joint External Debt Hub `http://www.jedh.org` (line 25) and IMF World Economic Outlook database `http://www.imf.org/external/pubs/ft/weo/2014/02/weodata/weoselgr.aspx`.

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