Title:
Selective Swap Arrangements and the Global Financial Crisis: Analysis and Interpretation*

Author:
Aizenman, Joshua, University of California, Santa Cruz
Pasricha, Gurnain

Publication Date:
03-01-2009

Series:
Working Paper Series

Publication Info:
Department of Economics, UCSC

Permalink:
http://escholarship.org/uc/item/2vw7s14s

Keywords:
swap-lines, deleveraging, trade and financial exposure

Abstract:
The onset of the US credit crisis in 2008, and its rapid globalization induced the FED to extend unprecedented swap-lines of 30 billion dollars to four emerging markets, and the proliferation of other cross-countries selective swap arrangements. This paper explores the logic for these arrangements, focusing on the degree to which financial and trade linkages, financial openness and credit risk history account for discerning the formation of swap arrangements to EMs. We also study the impact of the formation of these credit lines on the exchange rate and the financial spreads of the relevant countries. We find that exposure of US banks to EMs is the most important selection criterion for explaining the “selected four” swap-lines. This result is consistent with the outlined model, where we show that in circumstances of unanticipated deleveraging, emergency swap-lines may prevent or mitigate costly liquidation today, allowing investment projects to reach maturity and providing positive option value to both the source and the recipient countries. The FED swap-lines had relatively large short-run impact on the exchange rates of the selected EMs, but much smaller effect on the spreads (measured relative to that of other EMs that were not the recipients of swap-lines). Specifically, non-swap countries saw an average depreciation of 0.15% on the day after swap announcement, but swap countries saw their exchange rate appreciate on average, by about 4%. Yet, all the swap countries saw their exchange rate subsequently depreciate to a level lower than pre-swap rate, calling into question the long-run impact of the arrangements.

Selective Swap Arrangements and the Global Financial Crisis: Analysis and Interpretation*

Joshua Aizenman and Gurnain Kaur Pasricha

Joshua Aizenman
Department of Economics
UCSC and the NBER
jaizen@ucsc.edu

Gurnain Kaur Pasricha
Department of Economics
UCSC
gpasrich@ucsc.edu

Abstract

The onset of the US credit crisis in 2008, and its rapid globalization induced the FED to extend unprecedented swap-lines of 30 billion dollars to four emerging markets, and the proliferation of other cross-countries selective swap arrangements. This paper explores the logic for these arrangements, focusing on the degree to which financial and trade linkages, financial openness and credit risk history account for discerning the formation of swap arrangements to EMs. We also study the impact of the formation of these credit lines on the exchange rate and the financial spreads of the relevant countries. We find that exposure of US banks to EMs is the most important selection criterion for explaining the "selected four" swap-lines. This result is consistent with the outlined model, where we show that in circumstances of unanticipated deleveraging, emergency swap-lines may prevent or mitigate costly liquidation today, allowing investment projects to reach maturity and providing positive option value to both the source and the recipient countries. The FED swap-lines had relatively large short-run impact on the exchange rates of the selected EMs, but much smaller effect on the spreads (measured relative to that of other EMs that were not the recipients of swap-lines). Specifically, non-swap countries saw an average depreciation of 0.15% on the day after swap announcement, but swap countries saw their exchange rate appreciate on average, by about 4%. Yet, all the swap countries saw their exchange rate subsequently depreciate to a level lower than pre-swap rate, calling into question the long-run impact of the arrangements.

Keywords: swap-lines, deleveraging, trade and financial exposure

JEL classification: F15, F21, F32, F36, G15

* We are grateful to Yin-Wong Cheung for his useful comments and suggestions.

Board of Governors of the Federal Reserve System Press release, 10/29/2008:

"Today, the Federal Reserve, the Banco Central do Brasil, the Banco de Mexico, the Bank of Korea, and the Monetary Authority of Singapore are announcing the establishment of temporary reciprocal currency arrangements (swap-lines). These facilities, like those already established with other central banks, are designed to help improve liquidity conditions in global financial markets and to mitigate the spread of difficulties in obtaining U.S. dollar funding in fundamentally sound and well managed economies.

Federal Reserve Actions

In response to the heightened stress associated with the global financial turmoil, which has broadened to emerging market economies, the Federal Reserve has authorized the establishment of temporary liquidity swap facilities with the central banks of these four large and systemically important economies. These new facilities will support the provision of U.S. dollar liquidity in amounts of up to $30 billion each by the Banco Central do Brasil, the Banco de Mexico, the Bank of Korea, and the Monetary Authority of Singapore.

These reciprocal currency arrangements have been authorized through April 30, 2009.

The FOMC previously authorized temporary reciprocal currency arrangements with ten other central banks: the Reserve Bank of Australia, the Bank of Canada, Danmarks Nationalbank, the Bank of England, the European Central Bank, the Bank of Japan, the Reserve Bank of New Zealand, the Norges Bank, the Sveriges Riksbank, and the Swiss National Bank."

I. **Introduction and summary**

The unfolding global liquidity crisis provides ample case studies of the assertion that "extraordinary times call for extraordinary action." Our case study focuses on the unprecedented provision by the FED of swap-lines to four emerging markets. While the FED extended such swaps lines to numerous OECD countries (described above), these arrangements were extended (so far) to only four emerging markets. This begs the questions what are the selection criteria explaining the "chosen four," and the degree to which these selective swaps accomplished the goals spelled out in the FED's press release.

While final evaluation of the impact of these swap-lines require much more data and longer time horizon, our preliminary results suggests that the exposure of US banks to EMs is the most important selection criterion. Adding US trade exposure, capital account openness and credit history of countries to the US banks exposure provides statistically accurate interpretation of the selected four swap-lines. This result is consistent with the model outlined in the Appendix

-- in circumstances of unanticipated deleveraging, emergency swap-lines prevent or mitigate costly liquidation today, thereby allowing investment projects to reach maturity. Emergency swap-lines may provide valuable services in circumstances where the realized liquidity shock turns out to be much larger than the one expected ex-ante. The impetus for "a larger than anticipated" liquidity shock may come from 'financial contagion,' or from an adverse real shock reducing the expected productivity of the investment. The first scenario is exemplified by de-leveraging shocks due to credit crunch and 'flight to quality,' affecting creditors that co-financed investment in EMs. The second scenario may correspond to news about the unfolding deep global recession, a recession that may cause further deterioration of EMs terms of trade. The recent challenges facing various EMs reflect a mixture of both scenarios. An emergency swap-line prevents or mitigates the depth of costly liquidation today, allowing the investment project to reach maturity. Swap-lines may also provide valuable positive option value – by averting massive liquidation today, if things improve by the end of the investment gestation period, the higher surplus would support higher profits and will reduce the ultimate cost of the capital flight, possibly enhancing the welfare of both the source and the recipient countries [i.e., the US and the four EMs].

Our analysis suggests that swap-lines had relatively large short-run impact on the exchange rates of the selected EMs, but much smaller effect on the spreads (measured relative to that of other EMs that were not the recipients of swap-lines). Specifically, Non-swap countries saw an average depreciation of 0.15% on the day after swap announcement, but swap countries saw their exchange rate appreciate on average, by about 4%. Yet, all the swap countries saw their exchange rate subsequently depreciate to a level lower than pre-swap rate, calling into question the long-run impact of the arrangements. A note of caution is in order: as the selective swap-lines targeted countries with large US exposure, it potentially prevented even a deeper exchange rate deprecation of the four. Furthermore, only with the benefit of time we would be able to appreciate the fuller welfare implications of these arrangements.

II. Explaining the Selectivity of the Arrangements

Out of the 27 markets classified as emerging markets in either the FTSE Global Equity index or the Morgan Stanley Emerging Market index or by the Economist, only four countries received emergency swap-lines from the Federal Reserve. We considered four variables that may

determine the inclusion of an emerging market into the swap arrangements. These are US bank exposure to these markets, measured by the share of the individual market in the consolidated foreign claims of US banks in December 2007, the share of a country in total US goods imports and exports in 2007, the capital account openness of the country as of 2004 (Edwards, 2006 index) and the years since independence or 1800 that the country spent in default or restructuring (Reinhart and Rogoff, 2008).

Table 1 presents the means of each of these variables for countries that received the swap-lines and those that did not. Countries that did not receive the swap-lines had a lower share in total US bank foreign claims (0.6 percent compared to 3 percent for swap recipients), and the difference in the two means is significant. All the swap recipient countries had the higher shares in US bank exposures than all the non-swap countries, with the exception of India which had a 3 percent share. The mean values of share in total US goods trade are also statistically significantly different between swap recipients and other EMs, but mean values of capital account openness and credit history are not.

Tables 2 and 3 present results of the probit regressions that estimate the probability of inclusion into a swap arrangement with the Federal Reserve. Since we have a small sample of 27 EMs out of which only four got the swap-lines, we run probit regressions sequentially, starting with a single explanatory variable and then adding more variables. US bank exposure to these countries, measured by the share of the individual country in the consolidated foreign claims of US banks in December 2007 alone explains 64% of the variation in the dependent variable. A higher US bank exposure to a country increases its probability of getting a swap arrangement by 10.44% (evaluated at average values of regressors). If we interpret a predicted probability of inclusion of 50% or more as an inclusion prediction, then this variable alone correctly predicts 2 out of 4 swap arrangements and 22 out of 23 cases where such arrangements were not made. Each of the other explanatory variables individually have low predictive power – the pseudo R-squares are low and the coefficients of each of the variables in columns 2-4 of Table 2 are insignificant. The high percentage of correctly predicted observations is due to correct predictions of no-swap-lines, which are relatively abundant in our sample. The regressions using only capital account openness or only sovereign default history do not predict a higher than 50% chance of getting a

swap-line for any country. This table suggests that US bank exposure is the most important variable explaining inclusion in a swap arrangement. In Table 3, we sequentially add other regressors to a regression with US bank exposure as an explanatory variable. In two out of the three cases with exactly two regressors, the coefficient of US bank exposure remains significant (columns 2 and 3). In the case in which it loses significance (column 1), the explanatory power of the regression rises – the US bank exposure and capital account openness together correctly predict over 92 percent of the cases (3 out of 4 swap arrangements correctly predicted and 20 out of 21 exclusions from swap arrangements).[1] The insignificance of the estimated coefficients may be due to the small sample size and non-linear relationships between explanatory variables[2]. Adding US trade exposure to the regression with US bank exposure and capital account openness, does not increase the predictive power of the regression beyond 92%. By adding the fourth variable - the years since 1800 or independence that the country spent in sovereign default or restructuring (Reinhart and Rogoff, 2008) - we are able to predict fully the assignment of swap arrangements. This result is driven by the high predictive power of US bank exposure.

III. Announcement Effects of the Swap Arrangements

The Federal Reserve's swap arrangements with the central banks of Brazil, Korea, Mexico and Singapore were announced on October 29, 2008. Figure 1 plots the CDS spreads of the countries that received swap arrangements[3] and figures 2 and 3 plot the CDS spreads of all other emerging markets. The black vertical line separates the pre-swap announcement period from the post swap announcement period. From figure 1, it is clear that the CDS spreads of the countries that received the swap arrangements fell when these arrangements were announced. However, it is also clear from the figures that on the announcement, CDS spreads of other emerging markets fell too. Swap-recipient countries saw on average, a 19.5% drop in their CDS spreads between October 29, 2009 and October 30, 2009. The average drop was lower for non-swap countries (15.81% for the entire sample and 16.23% after excluding Argentina and Pakistan). In neither

[1] The number of observations in the various regressions varies due to constraints on data availability.
[2] The correlations between the explanatory variables are not high –a maximum of 0.6.
[3] See Appendix for data sources and definitions. Data on CDS spreads of Singapore's sovereign bonds was not available.

case does the average change in swap countries differ significantly from that in non-swap countries (p-values = 0.6).

Moreover, the spreads for most emerging markets had already started declining before the swap arrangements were announced. Table 4 presents the peak CDS rates and the dates on which these peaks were reached, for each of the emerging markets. In 20 out of the 25 countries, the 2008 peak of the CDS spreads occurred before October 29, 2008. While CDS spreads remained lower than their pre-swap arrangement peaks in the emerging markets that received the swap-lines, in 4 emerging markets that did not receive swap-lines, CDS spreads subsequently rose to higher than their 2008 peak (Hong Kong, Poland, Czech Republic and Saudi Arabia) .

To further test whether the CDS spreads in Brazil, Korea and Mexico changed more than those in other emerging markets, we look at the pre and post announcement average CDS levels. Table 5 presents the results of dummy variable regressions to test for difference in means[4]. The sample period is truncated to August 6, 2008 to Jan 21 2009, in order to have the same number of days (84) before and after announcement. Pre-swap, non-swap countries' average spread equaled 332.17 basis points but rose significantly to 630.24 basis points in the period after the swap announcements. In countries that received the swap arrangements, the average spread was 215.52 basis points in the 84 days before the arrangements were announced, but rose to 338.30 basis points in the post-swap period. The post-swap period average is higher because although the spreads fell after the announcement date, they remained higher than the pre-Lehman brothers bankruptcy era spreads. Lehman brothers filed for bankruptcy on September 15th, 2008 and our 84-day window begins on August 6, 2008. In the second column of Table 5, we exclude the two obvious outliers, Argentina and Pakistan, and then the differences between markets that received the swap arrangements and those that did not are no longer significant. The pre and post swap

[4] The regression takes the form:
$CDS\_spread = \beta_0 + \beta_1 SwapDate + \beta_2 FedSwap + \beta_3 FedSwap * SwapDate$, so that β_0 = mean CDS spread for non-swap countries in pre-swap period, $\beta_0 + \beta_1$ = mean CDS spread for non-swap countries in post-swap period, $\beta_0 + \beta_1 + \beta_2$ = mean CDS spread for swap-recipients in the pre-swap period and $\beta_0 + \beta_1 + \beta_2 + \beta_3$ = mean CDS spread for swap recipients in the post-swap period.

averages of non-swap countries are significantly different from each other but not significantly different from swap country averages.

While the announcement effects in the CDS spreads of emerging markets are not strong, the same is not true for their exchange rates. Table 6 presents the results from dummy variable regressions on the change in exchange rates on the day before the swap-line announcements and the day after. Non-swap countries saw an average depreciation of 0.15% on the day after swap announcement, but swap countries saw their exchange rate appreciate on average, by about 4%. The two changes are statistically significantly different from each other, and the non-swap countries' depreciation is not significantly different from 0. Between the day before the announcement and the day of the announcement, the average exchange rate depreciation for non-swap countries was 1.1% and the average depreciation for swap countries at 1.7% was not significantly different. Moreover, all the swap countries saw their exchange rate subsequently depreciate to a level lower than pre-swap rate (Table 7), calling into question the long-run impact of the arrangements.

Explaining CDS Spreads

We model the CDS spreads of a country as a function of its country risk rating (from EIU), its reserves-GDP ratio and three global variables that represent the level of liquidity in the world economy. These include the yield on 5-year US treasuries, the Center for Board Options Exchange (CBOE) VIX index of stock market volatility and the price-earnings ratio on S&P 100 index. Tables 8 and 9 report the results of unit root and co-integration tests on a balanced panel of 19 countries and 37 months (October 2004 to October 2007). We did three panel unit root tests –Levin-Lin –Chu test, Sarno and Taylor (1998)'s multivariate ADF tests and Hadri (2000) panel unit root tests. There is evidence of unit root in all the variable series in at least one time series in the panel. The ADF test is unable to reject the null of a unit root for the three global series. The Nyblom Harvery test for no common trends in the CDS spreads series rejects the null, indicating that there may be co-integrating relationships.

The results of the regressions are presented in Tables 10 and 11. Table 10 presents the regressions with the full sample of countries, whereas Table 11 presents results with the balanced

panel. The risk rating is included contemporaneously in some specifications and with a lead in others, to account for the fact that risk ratings are often backward looking. In all the specifications, reserves/GDP ratio enter with a negative sign, indicating that reserves accumulation lowers the CDS spreads of countries. This is consistent with our model in the appendix where the additional reserves may allow a country to avoid costly liquidation and therefore lower the cost of the probability of default. In Table 10, the full sample regressions without time effects, every additional percentage point increase in reserves-GDP ratio reduces the CDS spread by 0.64 basis points on average. In the balanced panel (Table 11), the effect of additional reserves is smaller, but still significant (Columns 3 and 4 with robust standard errors). Higher risk rating of the country and greater expected volatility in global markets also implies higher spreads.

IV. Concluding remarks

This paper studied the unprecedented provision of swaps lines by the FED to four emerging markets. The evidence suggests selectivity criteria where EMs with large US banks exposure, sizable US trade exposure, capital account openness and solid credit history are prime targets of swap-lines. These results are in line with the view that it's in the self interest of source countries to engage in bilateral credit arrangements with EMs as long as they have had a strong track-record in good times. Countries with lukewarm economic track-record in good times would find that the International Financial Institutions may be the main possible sources of help in bad times. This is also consistent with the recent willingness of key OECD countries to expand rapidly the size and the role of the IMF, and with the lukewarm attitude of Germany and other countries in the core of Europe towards the provision of deep swaps-lines to Eastern European countries.

Appendix

International reserves and emergency swap-lines

This Appendix outlines a framework explaining the rationale for swap-line arrangements. The model is extension of the one used in Aizenman and Lee (2007), explaining self insurance offered by international reserves in mitigating the output effects of liquidity shocks affecting banks in developing countries. The framework is akin to Diamond and Dybvig (1983) -- investment in a long term project should be undertaken prior to the realization of liquidity shocks. Hence, the liquidity shock may force costly liquidation of the earlier investment, reducing second period output. International reserves provide valuable self insurance in circumstances when foreign financial inflows deposited in domestic banks of a developing country are intermediated into longer term investment. The maturity mismatch exposes the banking system to the possibility that capital flight would induce costly premature liquidation. This appendix shows that emergency swap-lines may enhance the expected utility of the source and the recipient countries following an unanticipated large deleveraging shock.

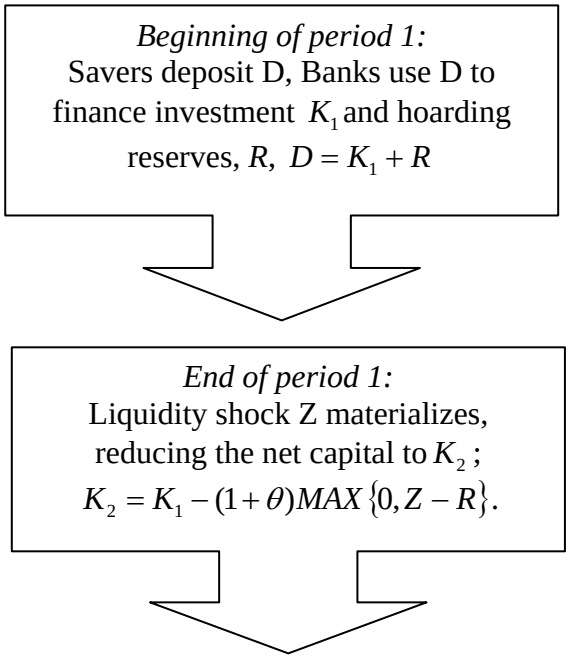
As our focus is on developing countries, we assume that all financial intermediation is done by banks, relying on a debt contract. We simplify further by assuming that there is no separation between the bank and the entrepreneur – the entrepreneur is the bank owner, using it to finance the investment. The time line is summarized in the figure below.

At the beginning of period 1, risk neutral agents deposit D in banks, which in turn use D to finance long term investment, K_1, and hoarding reserves, R.[5] We assume that a sizable share of depositors was funded by foreign parties seeking to diversify their portfolio by means of foreign financial investment. A liquidity shock, with the aggregate value of Z for the borrowing economy, materializes at the end of period 1, after the commitment of capital. A liquidity shock exceeding reserves induces a pre-mature liquidation of Z - R. Output increases with the capital invested at the beginning of period one, K_1, and declines with liquidation at a rate that depends

[5] Our model follows the tradition of Bryant (1980) or Diamond and Dybvig (1993) in that the source of liquidity shock lies with the lender, rather than the borrower (Holmstrom and Tirole, 1998). However, our model assumes away the market equilibrium among lenders (be it the risk of runs or the difficulty of the decentralized provision of liquidity). Abstracting from the question whether market-based liquidity insurance is available, we focus on the implication of large adjustment cost—including but not restricted to the liquidation cost—on the demand for reserves as self-insurance. In a similar vein, no distinction is made between the private sector and the monetary authorities which maintain the stock of international reserves.

on the adjustment cost, θ. The liquidity shock is realized from a known distribution. The new aspect of our Appendix is that, after the realization of the liquidity shock, we add the possibility of 'black-swan' news – an unanticipated adverse shock (with probability *p*, the future output will decline at a rate of δ).[6] Such a shock may reflect rapid deterioration of the global economy, reducing the expected future demand for the project.

Figure A1: **The time line**



"Black-swan" news: with probability *p*, productivity in period 2 will decline at a rate δ

	Period 2:	
	No black-swan	***Black-swan***
Output Y_2 materializes,	$Y_2 = (K_2)^{\alpha}$;	$Y_2 = (1-\delta)(K_2)^{\alpha}$
Depositors are paid	$(D-Z)(1+r_D)$;	Min$[(D-Z)(1+r_D); Y_2 = (1-\delta)(K_2)^{\alpha}]$

[6] The "Black-swan" concept was coined by Nassim Nicholas Taleb -- an unlikely but not impossible catastrophe that no one seems to plan for.

Assuming a Cobb-Douglas production function, the second period output in the absence of "black-swan" news is

(A1) $Y_2 = [K_1 - (1+\theta)MAX\{Z - R, 0\}]^{\alpha}$; where $0 \le \theta < 1$, and $\alpha < 1$.

Recalling that $K_1 = D - R$, the net capital after liquidation is:

$$\text{(A2)} \quad K_2 = \begin{cases} D - R - (1+\theta)(Z - R) = D - Z - \theta(Z - R) & \text{if } Z > R \\ D - R & \text{if } Z \le R \end{cases}$$

It is convenient to normalize the liquidity shock by the level of deposits, denoting the normalized shock by z:

(A3) $Z = zD$; $0 \le z < \tau \le 1$, and density $f(z)$.

Depositors are entitled to a real return of r_D on the loan that remains deposited for the duration of investment.[7] Assuming agents' subjective discount rate is ρ, competitive intermediation implies that

$$\text{(A4)} \quad \int_0^{\tau} (1-z) f(z) dz = \frac{(1+r_D)\int_0^{\tau} (1-z) f(z) dz}{1+\rho} \quad \Rightarrow \quad r_D = \rho .$$

Net reserves held until period 2 are assumed to yield a return of r_f. We denote the marginal liquidity shock associated with liquidation by z^*, $z^* = R/D$. The FOC determining the optimal demand for international reserves can be reduced to [see Aizenman and Lee (2007)]:

(A5) $[MP_{K_1} - (1+r_f)] \cdot \Pr[Z < R] = \theta E\left[MP_K \mid Z > R\right]$,

[7] The possibility that the outcome of investment is not large enough to meet the promised rate of return is discussed in Aizenman and Lee (2007). To simplify, we ignore it in the present set up.

where MP_{K_1} is the marginal productivity of capital, and $\Pr[Z < R]$ is the probability that the liquidity shock is below the level of reserves. The expected opportunity cost of holding reserves is equalized to the expected precautionary benefit of holding reserves.

To illustrate, we consider the case with small shocks to gain the basic insight for the welfare gains associated with reserves. In the absence of uncertainty, the optimal level of deposits (D_0^*), and the resultant surplus (Π_0) are:

$$\text{(A6)} \qquad D_0^* = \left[\frac{\alpha}{1+\rho}\right]^{1/(1-\alpha)}; \qquad \Pi_0 = (1+\rho)D_0^* \frac{1-\alpha}{\alpha}.$$

Suppose that the liquidity shocks are either zero or z_0, with probability half each, and $\rho = r_f$. If reserves are set to zero, and deposits at D_0^*, the expected surplus is

$$\text{(A7)} \qquad E[\Pi]_{|R=0} = \frac{\left[D_0^*\right]^{\alpha} - (1+\rho)D_0^*}{2} + \frac{\left[D_0^*(1-(1+\theta)z_0)\right]^{\alpha} - (1+\rho)D_0^*(1-z_0)}{2}.$$

The first order approximation of the expected surplus can be reduced to

$$\text{(A8)} \qquad E[\Pi]_{|R=0} \cong \Pi_0 - \theta\frac{z_0(1+\rho)D_0^*}{2}.$$

Liquidity shocks have a first order adverse effect on expected surplus. In the absence of the insurance provided by reserves, liquidation induces a deadweight loss equal to the adjustment cost, θ, times the expected liquidation. In a two states of nature case, perfect stabilization can be achieved by hoarding reserves equal to the liquidity shock: $R = z_0 D_0^*$; adjusting deposits to $D = (1+z_0)D_0^*$, thereby setting the stock of capital at $K_1 = D_0^*$. If the liquidity shock materializes, R would provide the needed liquidity, preventing costly output adjust. If the shock

is nil, there would no need to use R. The assumption that $\rho = r_f$ implies that the cost of this insurance is zero. Consequently, [8]

$$(A9) \quad E[\Pi]_{|R=z_0 D_0^*} = \Pi_0$$

This simple example suggests that liquidity shocks have a first order welfare effects in the absence of reserves, and that hoarding reserves can reduce the cost of liquidity shocks from first to second order magnitude.

Black-swan news and emergency swap-lines

We apply the above model to understand the provisions of emergency swap-lines. To simplify, we focus first on the last example, assuming that z_0 is zero, hence the optimal demand for international reserves is zero, and the level of borrowing is given by (A6), $D_0^* = \left[\frac{\alpha}{1+\rho}\right]^{1/(1-\alpha)}$. Suppose that at the end of period 1, after the commitment of capital, an exogenous and unanticipated "black-swan" shock reduces the expected productivity of investment. Specially, the news is that with probability *p*, the future output will decline at a rate of δ:

$$(A1') \quad Y_2 = \begin{cases} [K_1 - (1+\theta)MAX\{Z-R,\ 0\}]^{\alpha} & probability \quad 1-p \\ (1-\delta)[K_1 - (1+\theta)MAX\{Z-R,\ 0\}]^{\alpha} & probability \quad p \end{cases};$$

where $0 \le \delta,\ p \le 1$. Thus, the expected future output drops to

$$(A10) \quad (1-\delta p)\left[\frac{\alpha}{1+\rho}\right]^{\alpha/(1-\alpha)}.$$

[8] With more than two states of nature, R would be preset at the ex-ante efficient level, providing full insurance for liquidity shocks below z*, and partial insurance above. While there is no way to insure complete stabilization, one expects large welfare gain from setting R at the ex-ante efficient level relative to the case of R = 0.

The expected output falls short of the second period liabilities iff

(A11) $(1-\delta p)[D_0^*]^{\alpha} < (1+\rho)D_0^*$

Applying (A6) and (A11), the expected output falls short of the second period liabilities iff

(A11') $1-\delta p < \alpha$

If (A11') holds, depositors expecting that the first to be "in line" will get higher share of their deposit back will "run on the bank." The premature liquidation implies that each depositor will get only $1-\theta$ pre dollar deposited. In these circumstances, the run on the bank would impact the depositors' source country utility by

(A12) $-D_0^* + D_0^*(1-\theta) = -\theta D_0^*$

Suppose that the depositors' source country, in order to prevent the bank-run in the emerging market, would extend a swap-line of D_0^*, at a contractual cost of $1+\rho$. In these circumstances, the expected utility of the source country following the "black-swan" news will be:[9]

(A13) $-D_0^* + \frac{(1-p)D_0^*(1+\rho) + p(1-\delta)[D_0^*]^{\alpha}}{1+\rho} = -pD_0^* + \frac{p(1-\delta)[D_0^*]^{\alpha}}{1+\rho}$

The swap-line improves the source country expected utility iff

(A14) $-pD_0^* + \frac{p(1-\delta)[D_0^*]^{\alpha}}{1+\rho} > -\theta D_0^*$.

Applying (A6) and (A14), the swap-lines is beneficial iff

[9] We assume that in case of partial default, the realized output is fully paid to depositors.

(A15) $\frac{p(\alpha+\delta-1)}{\alpha}<\theta$.

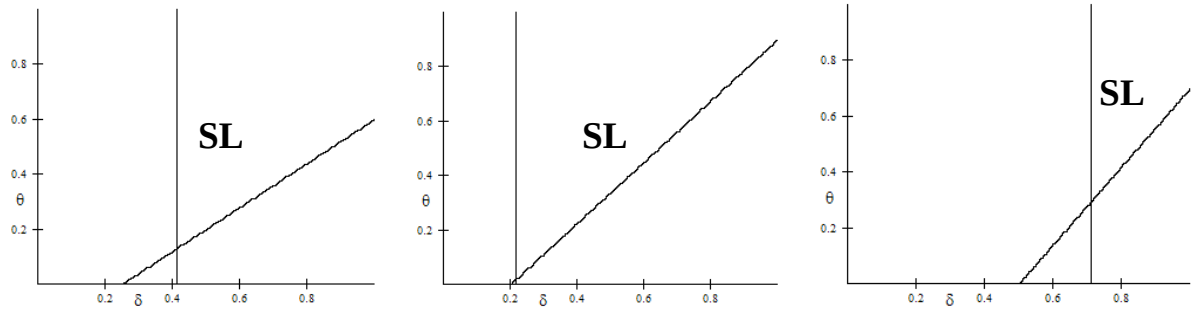
It is easy to verify that, conditional of the black-swan news, the recipient country is better off -- its surplus following the black-swan news and the bank-run would be zero. Yet, its the expected surplus with the swap-line is $(1-p)(1-\alpha)D_0^*>0$. Consequently, the emergency swap-line is a win-win (i.e., increases the expected utility of both countries) if

(A16) $\frac{p(\alpha+\delta-1)}{\alpha}<\theta \quad and \quad 1-\delta p<\alpha$.

Figure (A2), area SL traces configurations of the adverse output shock (δ) and costly liquidation (θ) where the swap-lines would increase the expected welfare, for three (α, p) pairs. This is the area above the upward sloping line and to the left of the vertical line [tracing $p(\alpha+\delta-1)/\alpha=\theta$ and $1-\delta p=\alpha$, respectively].

Figure A2

Shocks, costly deleveraging and optimal provision of swap-lines (region SL)



α = 0.75 and p = 0.6 α = 0.8 and p = 0.9 α = 0.5 and p = 0.7

To conclude, the swap-line provided by the source country bails out its depositors, sparing them the penalty associated with the liquidation costs. The swap-lines provide the creditors' source country with the option value that, if the adverse shock would not materialize, the source country would be fully paid. If the adverse shock would take place, the source country would be paid $(1-\delta)[D_0^*]^{\alpha}$. In both cases, the swap-line saved the source country the liquidation costs. If

liquidation costs (θ) are high enough, and if the size of the coming "black-swan" shock (δ) is high enough, large exposure implies that these swap arrangements are a win-win to both the source and the recipient countries. Our analysis can be extended in several ways, adding the possibility of 'self insurance' provided by international reserves, costly bankruptcies, and other relevant dimensions.

Table A1. Data Definitions

Variable Name	Source	Description
USBankExpShare07	BIS Quarterly Review, Dec 2008, Table 9B	Consolidated claims of US banks on individual countries divided by the consolidated claims of US banks on all countries in December 2007.
USTradeShare2007	UN Comtrade	Total US goods trade with the individual country as a share of US goods trade with the world in 2007.
Edwards2004	Edwards (2005)	Edwards index of de-jure capital account openness of the country in the year 2004.
CDS5yr	Datastream	Credit default swap spread on sovereign senior 5-year bond.
RiskEIU	Datastream	Economist Intelligence Unit's country risk rating
VIX	Datastream	CBOE's Volatility Index
SP100_PE	Datastream	Price-Earnings ratio of S&P 100 index.
Reserves/GDP	IFS	Ratio of total reserves minus to GDP. This variable has monthly granularity. The quarterly GDP series available from IFS were converted into monthly series using linear interpolation.
USTreasury5y	Datastream	Yield on 5-year Treasury bills.

References

Aizenman, Joshua and Jaewoo Lee (2007) "International Reserves: Precautionary Versus Mercantilist Views, Theory and Evidence" *Open Economies Review*, 18, pp. 191-214.

Bryant, Ralph (1980) "A Model of Reserves, Bank Runs, and Deposit Insurance," *Journal of Banking and Finance* 4, pp. 335-344.

Diamond, Douglas and Philip Dybvig (1983) "Bank Runs, Liquidity and Deposit Insurance," *Journal of Political Economy* 91, pp. 401-419.

Edwards, S. (2005) "Capital Controls, Sudden Stops and Current Account Reversals", *NBER Working Paper* No. 11170, Cambridge, March 2005.

Hadri, K. (2000) "Testing for Stationarity in Heterogeneous Panels with Multiple Regressors", *Oxford Bulletin of Economics and Statistics*, 61, 653-70.

Holmstrom, Bengt and Jean Tirole (1998) "Private and Public Supply of Liquidity," *Journal of Political Economy*, 106, pp.1-40.

Levin, A., Lin, C.F., Chu, C. (2002) "Unit Root Tests in Panel Data: Asymptotic & Finite Sample Properties", *Journal of Econometrics*, 108, 1-24.

Nyblom, Jukka & Harvey, Andrew (2000) "Tests Of Common Stochastic Trends," *Econometric Theory*, Cambridge University Press, 16(2), 176-199, April.

Reinhart, Carmen M., and Kenneth S. Rogoff (2008) "Is the 2007 U.S. Subprime Crisis So Different? An International Historical Comparison." *American Economic Review* Vol. 98 No. 2: 339–344.

Taylor, M. P. & Sarno, L. 1998. "The behavior of real Exchange rates during the post-Bretton Woods period" *Journal of International Economics*, 46, 281–312.

Table 1: Mean values and tests of difference in means

	US Bank Exposure Share, 2007	Capital Account Openness 2004 (Edwards, 2006)	US Trade Share 2007	Years in Default since 1800
Non-Swap Recipients	0.007	56.25	0.012	17.98
Swap Recipients	0.034	65.63	0.042	17.5
(p-value)	0	0.25	0.08	0.96

Table 2: Univariate Probit Regressions for explaining inclusion in Fed Swap Arrangements

	(1)	(2)	(3)	(4)
USBankExpShare2007	116.9**			
	(50.73)			
KOpen2004		0.024		
		(0.020)		
years_default_c1800			-0.001	
			(0.0195)	
ustrd_share2007				13.27
				(8.393)
Constant	-2.962***	-2.455*	-0.920**	-1.297***
	(1.06)	(1.28)	(0.46)	(0.38)
Observations	27	26	23	25
Pseudo R-squared	0.64	0.06	0.00	0.11
Percent Correctly Explained	89	85	83	84

*** p<0.01, ** p<0.05, * p<0.1
Standard errors in parentheses

Table 3: Multivariate Probit Regressions for explaining inclusion in Fed Swap Arrangements

	(1)	(2)	(3)	(4)	(5)
USBankExpShare2007	160.1	114.8**	116.2**	154.5	3969
	(108.2)	(51.85)	(47.40)	(106.3)	(0)
KOpen2004	0.039			0.037	1.567
	(0.034)			(0.035)	(324.5)
years_default_c1800		-0.003			2.034
		(0.041)			(1615)
ustrd_share2007			-6.159	-2.671	322.4
			(19.33)	(26.07)	(0)
Constant	-6.185	-2.874**	-2.758***	-5.896	-214.9
	(4.108)	(1.234)	(0.992)	(4.296)	(30314)
Observations	26	23	25	25	21
Pseudo R-squared	0.72	0.61	0.64	0.72	1.00
Percent Explained Correctly	92	87	88	92	100

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Peak CDS Spreads in full sample and 2008.

Country	PeakCDS_2008	PeakCDS_2008_Date	PeakCDS	PeakCDS_Date
Argentina	4570.398	30-Dec-08	4570.398	30-Dec-08
Brazil	600.8	23-Oct-08	900.2	31-May-04
Chile	315	24-Oct-08	315	24-Oct-08
China	296.7	24-Oct-08	296.7	24-Oct-08
Colombia	613.3	24-Oct-08	655.9	12-Apr-04
CzechRepublic	228.3	27-Oct-08	230	21-Jan-09
Egypt	767.8	29-Oct-08	767.8	29-Oct-08
HongKong	108.6	31-Oct-08	118.6	21-Jan-09
Hungary	605	24-Oct-08	605	24-Oct-08
India	215.7	12-Feb-08	215.7	12-Feb-08
Indonesia	1256.7	23-Oct-08	1256.7	23-Oct-08
Israel	275	24-Oct-08	275	24-Oct-08
Korea	700	27-Oct-08	700	27-Oct-08
Malaysia	520.2	24-Oct-08	520.2	24-Oct-08
Mexico	606.7	23-Oct-08	606.7	23-Oct-08
Morocco	350	3-Nov-08	518.407	27-Jun-03
Pakistan	5105.699	27-Oct-08	5105.699	27-Oct-08
Peru	611.2	24-Oct-08	611.2	24-Oct-08
Philippines	870	24-Oct-08	870	24-Oct-08
Poland	288.1	17-Dec-08	290.8	21-Jan-09
Russia	1116.7	24-Oct-08	1116.7	24-Oct-08
SaudiArabia	245	8-Dec-08	265	21-Jan-09
South Africa	683.3	24-Oct-08	683.3	24-Oct-08
Thailand	524.2	24-Oct-08	524.2	24-Oct-08
Turkey	849.2	24-Oct-08	849.2	24-Oct-08

Note: Full sample is the period 1 Jan 2003 to 21 Jan 2009 for most countries. India and Saudi Arabia's data starts in early 2008.

Table 5: Announcement effects on CDS Spreads

Variables	(1)	(2) No Outliers
Swap_Date	298.1***	127.1***
	(27.50)	(6.854)
Fed_swap	-116.6**	2.277
	(55.55)	(13.27)
Fed_swap*Swap_Date	-175.3**	-4.350
	(78.94)	(18.87)
Constant	332.2***	213.2***
	(19.24)	(4.793)
Observations	2993	2751
R-squared	0.047	0.125

Standard errors in parentheses. (2) excludes Argentina and Pakistan. *** p<0.01, ** p<0.05, * p<0.1

Table 6: Announcement effects on Exchange Rates (X)

			No Outliers	
VARIABLES	(1) Δ X _post-swap	(2) Δ X _pre-swap	(3) Δ X _post-swap	(4) Δ X _pre-swap
Fed_swap	-4.147***	-0.639	-4.155***	-0.532
	(1.003)	(0.937)	(1.052)	(0.965)
Constant	0.153	-1.059***	0.161	-1.167***
	(0.386)	(0.361)	(0.421)	(0.386)
Observations	27	27	25	25
R-squared	0.406	0.018	0.404	0.013

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Exchange rate bottoms in 2008 and since 2006.

Country	X_maxdate08	X_maxdate	Δ X _post-swap
Argentina	8-Dec-08	29-Jan-09	-0.22
Chile	21-Nov-08	21-Nov-08	0.81
China	1-Jan-08	18-Jan-06	-0.04
Colombia	28-Oct-08	28-Jun-06	0.75
Czech	20-Nov-08	2-Jan-06	2.58
Egypt	26-Oct-08	20-May-06	-0.13
HongKong	12-Jun-08	3-Aug-07	0.00
Hungary	24-Oct-08	29-Jan-09	1.70
India	20-Nov-08	20-Nov-08	-0.34
Indonesia	25-Nov-08	25-Nov-08	-0.47
Israel	20-Nov-08	22-Feb-06	-1.11
Malaysia	4-Dec-08	2-Jan-06	-1.37
Morocco	14-Nov-08	29-Jan-09	-0.91
Pakistan	17-Oct-08	17-Oct-08	0.37
Peru	26-Dec-08	13-Jan-06	0.00
Philippines	18-Nov-08	29-Jun-06	-0.51
Poland	20-Nov-08	29-Jan-09	1.88
Russia	31-Dec-08	29-Jan-09	0.04
SaudiArabia	16-Oct-08	16-Oct-08	0.01
SouthAfrica	22-Oct-08	22-Oct-08	0.97
Taiwan	27-Oct-08	20-Jan-09	-1.33
Thailand	1-Dec-08	2-Jan-06	0.06
Turkey	19-Nov-08	19-Nov-08	0.80
Brazil	8-Dec-08	8-Dec-08	-1.12
Korea	24-Nov-08	24-Nov-08	-10.85
Mexico	20-Nov-08	27-Jan-09	-2.64
Singapore	1-Dec-08	2-Jan-06	-1.37

Note: X_maxdate08 = date at which the exchange rate was most depreciated during 2008, X_maxdate = date at which the exchange rate wasat its lowest level (most depreciated level) 1 Jan 2006 and 19 Jan 2009. Δ X _postswap is the change in exchange rate between October 29 and October 30, 2008.

Table 8: Panel Unit Root Tests

Levin-Lin-Chu Tests. H0: All time series in the panel are I(1)	t(star)	p-value
CDS Spreads	2.63	0.996
RiskEIU	1.18	0.88
Reserves/GDP	0.25	0.6

Multivariate ADF (Sarno and Taylor, 1998). H0: All time series in the panel are I(1)	MADF	5% Critical Value
CDS Spreads	170.16	25.46
RiskEIU	134.18	25.46
Reserves/GDP	143.43	25.46

Hadri (2000) Panel Unit Root Test. H0: All time series in the panel are I(0).	Z(mu)	p-value	Z(tau)	p-value
CDS Spreads	65.67	0	28.13	0
RiskEIU	81.19	0	25.87	0
Reserves/GDP	56.38	0	20.83	0

ADF Tests for Unit roots in Global Series H0: The series has a unit root.	Z(t)	p-value
US Treasury5y	-1.486	0.54
VIX	0.291	0.98
S&P100_PE	-0.836	0.81

Note: All regression equations allow for a trend and a constant. The markets in the balanced panel are: Argentina, Brazil, Chile, China, Colombia, HongKong, Hungary, Indonesia, Israel, Korea, Mexico, Morocco, Peru, Philippines, Poland, Russia, SouthAfrica, Thailand and Turkey.

Table 9: Nyblom Harvey Test for Common Trends in the 19 time series of CDS Spreads

H0: No common trends among the 19 series in the panel.			
Test Statistic assuming IID RW errors			5.8
Test Statistic with non-parametric adjustment for long-run variance			2.55
Critical Values		N=20	N=10
	10%	4.18	2.28
	5%	4.5	2.53
	1%	5.11	3.14

Table 10: CDS Spreads in EMEs, 2003-Sept2008

VARIABLES	(1) cds5yr	(2) cds5yr	(3) cds5yr	(4) cds5yr
RiskEIU	2.493***		2.493*	
	(0.829)		(1.410)	
UStreasury5y	-27.34***	-27.19***	-27.34***	-27.19***
	(5.591)	(5.600)	(5.585)	(5.619)
VIX	1.922**	1.914**	1.922**	1.914**
	(0.808)	(0.806)	(0.769)	(0.776)
SP100_PE	6.734***	6.641***	6.734***	6.641***
	(1.156)	(1.158)	(1.828)	(1.825)
Reserves/GDP	-63.15***	-64.03***	-63.15***	-64.03***
	(23.29)	(23.24)	(16.05)	(15.84)
F.RiskEIU		2.621***		2.621*
		(0.828)		(1.423)
Constant	15.57	12.53	15.57	12.53
	(63.91)	(63.41)	(90.96)	(90.86)
Observations	1032	1032	1032	1032
R-squared	0.180	0.181	0.180	0.181
Number of countries	21	21	21	21

Standard errors in parentheses. Fixed effects estimators, no time dummies. Columns 3 and 4 use robust standard errors. Monthly data, with end of the month CDS spreads.
*** p<0.01, ** p<0.05, * p<0.1

Table 11: CDS Spreads in EMEs, Balanced Panel, Oct2004- Oct2007

VARIABLES	(1) cds5yr	(2) cds5yr	(3) cds5yr	(4) cds5yr
RiskEIU	3.512***		3.512***	
	(0.733)		(1.242)	
UStreasury5y	-13.04*	-14.86**	-13.04	-14.86*
	(6.903)	(6.982)	(7.989)	(8.168)
VIX	3.298***	3.318***	3.298***	3.318***
	(0.850)	(0.856)	(0.774)	(0.801)
SP100_PE	15.29***	14.14***	15.29***	14.14***
	(2.906)	(2.958)	(2.952)	(3.042)
Reserves/GDP	-36.56	-34.63	-36.56**	-34.63**
	(25.23)	(25.78)	(17.07)	(17.22)
F.RiskEIU		3.623***		3.623***
		(0.753)		(1.252)
Constant	-284.5***	-261.0***	-284.5***	-261.0***
	(88.47)	(89.08)	(91.59)	(92.14)
Observations	703	684	703	684
R-squared	0.207	0.211	0.207	0.211
Number of countries	19	19	19	19

Standard errors in parentheses. Fixed effects estimators, no time dummies. Columns 3 and 4 use robust standard errors. Monthly data, with end of the month CDS spreads. For list of markets in balanced panel, see notes to Table 7.
*** p<0.01, ** p<0.05, * p<0.1

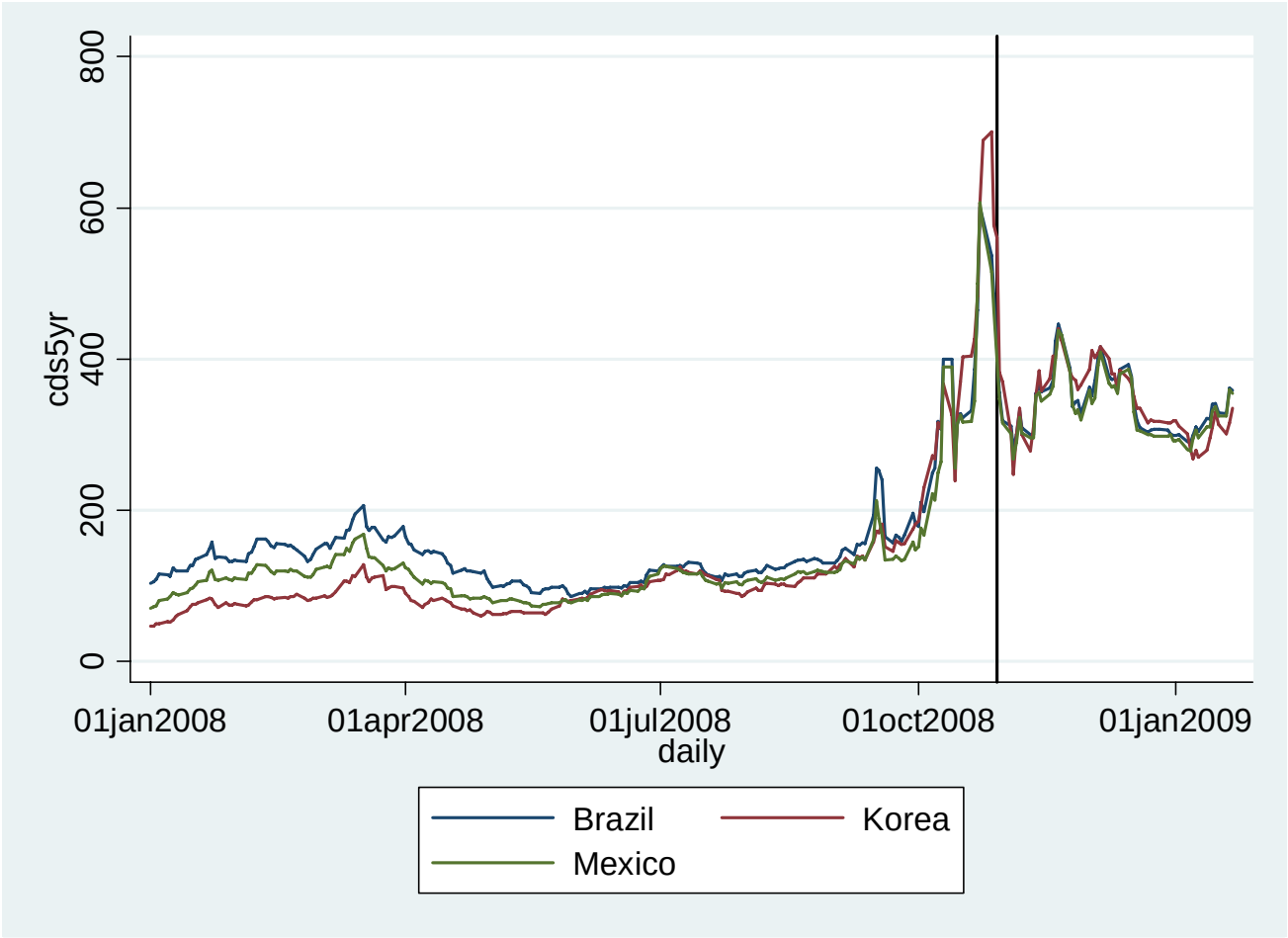


Figure 1: Spreads on Credit default swaps of 5-year senior sovereign debt of countries that received swap-lines from the Federal Reserve in October 2008.

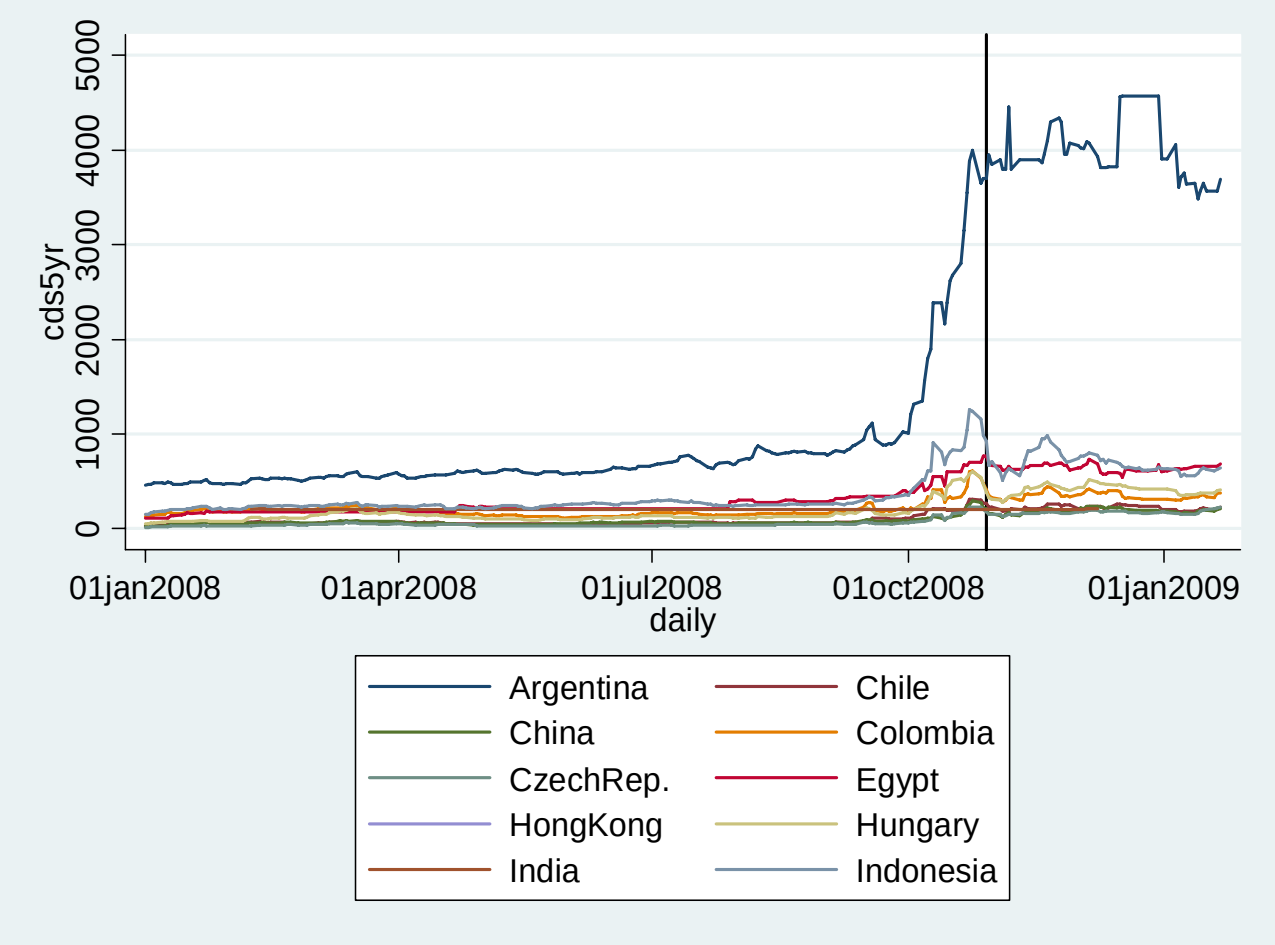


Figure 2.a. Spreads on Credit Default Swaps on 5-year senior sovereign debt of other emerging markets.

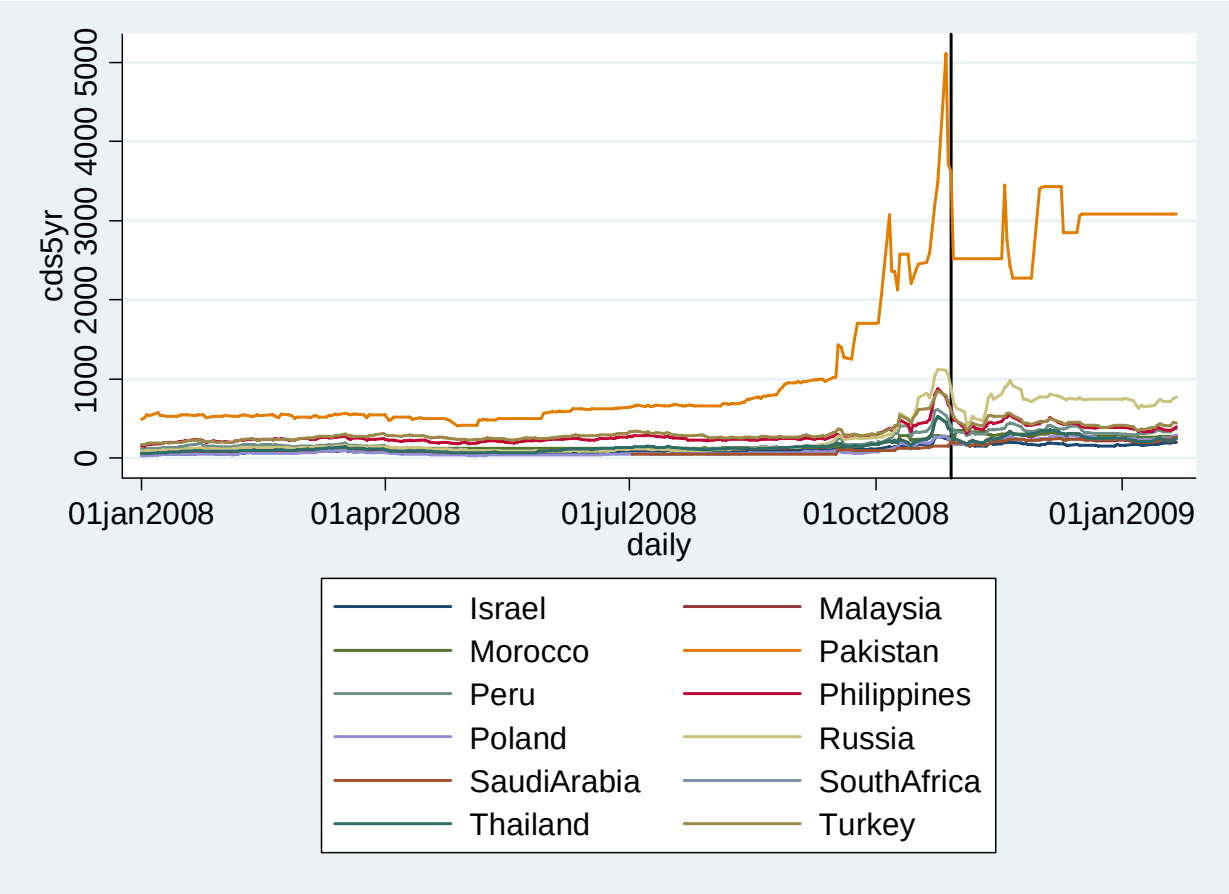


Figure 2.b. Spreads on Credit Default Swaps on 5-year senior sovereign debt of other emerging markets.