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Determining underlying macroeconomic fundamentals during emerging market crises: Are conditions as bad as they seem?☆

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Abstract

Emerging market crises are characterized by large swings in both macroeconomic fundamentals and asset prices. The economic significance of observed movements in macroeconomic variables is obscured by the brief and extreme nature of crises. In this paper we propose to study the macroeconomic consequences of crises by studying the behavior of "effective" fundamentals, constructed by studying the relative movements of stock prices during crises. We find that these effective fundamentals provide a different picture than that implied by observed fundamentals. First, asset prices often reflect expectations of improvement in fundamentals after the initial devaluations; specifically, effective depreciations are positive but not as large as the observed ones. Second, crises vary in their effect on credit market conditions, with investors expecting tightening of credit in some

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cases (Mexico 1994, Philippines 1997), but loosening of credit in others (Sweden 1992, Korea 1997, Brazil 1999).

Keywords: Emerging market crises; Macroeconomic fundamentals; Asset returns; Exchange-rate overshooting; Credit market conditions; Sudden stops

1. Introduction

Balance of payment crises in emerging markets have been a prevalent phenomenon during the last 10 years. In all cases, these crises were associated with large movements in both asset prices and macroeconomic fundamentals in the affected countries. For example, between December 1994 and March 1995, Mexico's stock market fell 26% in peso terms, the Mexican peso depreciated by 50%, and peso interest rates rose to 70% in annualized terms. These patterns were repeated, to a varying extent, during the Asian crisis in 1997, the Russian crisis in 1998, and the Brazilian crisis in 1999.

In this paper, we assess the economic significance of these shocks by studying the cross-sectional behavior of stock returns during crises. In particular, we estimate the set of macroeconomic innovations that best explain the relative returns of stocks in each country. We denote these implied macroeconomic variables as "effective" fundamentals.

We propose this alternative measure of macroeconomic variables because directly observed fundamentals are difficult to interpret given the brief and extreme nature of crises. For example, consider the behavior of interest rates and exchange rates during crises, illustrated in Fig. 1 for the cases of Mexico 1994 and Korea 1997. Balance of payments crises are characterized by a dramatic rise in interest rates to deter speculation and to reduce excessive depreciation and inflationary pass-through. However, these interest rate shocks are less persistent than during non-crisis times, as they are often reversed after a few months. In Mexico 1994 a large part of the shock was reversed in 3 months, while in Korea 1997 interest rates 9 months after the devaluation were below those observed one year prior to it. An even more extreme example occurred in Sweden 1992 when the Central Bank's lending rate reached 500% in mid-September, but reverted to historical levels over the following 2 months. This suggests that observed interest rate shocks during crises might *overestimate* their actual impact on credit market conditions. On the other hand, if there exist credit constraints that become binding during crises, observed interest rate shocks might *underestimate* the effect of crises. As a result, it is difficult to assess the effect of crises on credit market conditions by looking at the evolution of interest rates. Instead, in this paper we look at the behavior of *effective* interest rates to factor in the persistence of the shock and possible non-linearities in the impact of crises on credit markets.

Interpreting exchange rate movements during crises also presents difficulties, since the size of depreciations during crises is much larger than those observed during non-crisis times. While exchange rates have traditionally been modelled as random walks, it is not obvious how the market regards the persistence of these unprecedented shocks. A casual look at the subsequent appreciation of the Korean won in 1998 suggests that the won may have exhibited "overshooting," while the same cannot be said of the Mexican peso. However, such statements cannot be made with any confidence as the behavior of

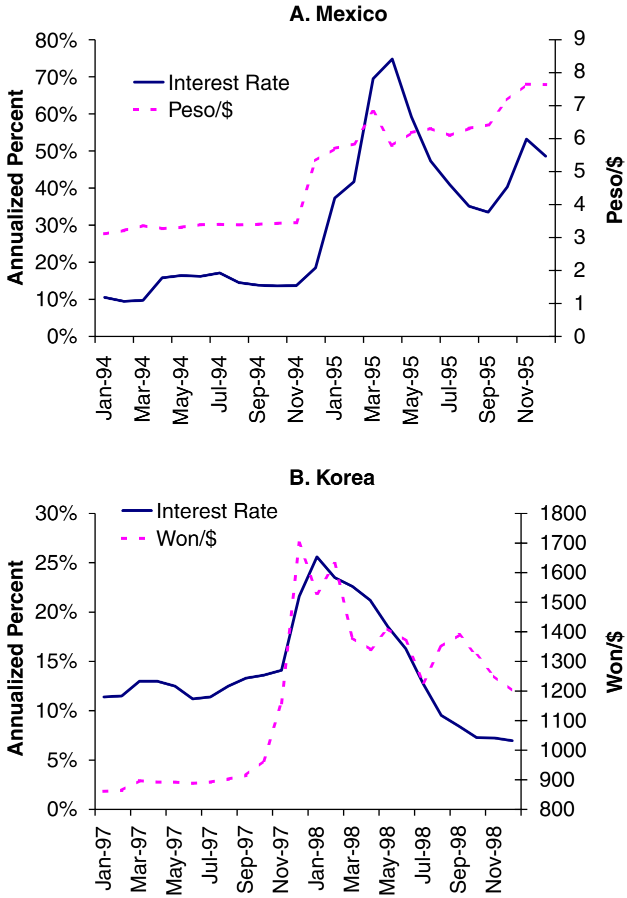

Fig. 1. Interest rates and exchange rates. Panel A plots the annualized nominal 28-day Mexican T-Bill peso interest rate (solid line, left axis) and the peso per dollar exchange rate (dotted line, right axis). Panel B plots the annualized Korean money market won interest rate (solid line, left axis) and the won per dollar exchange rate (dotted line, right axis). Source: IFS.

exchange rates after the crises could be due to subsequent shocks unknown to investors at the time of the devaluation. By looking at the effective exchange rate during the crisis, we are able to determine whether investors anticipated a future reversal of the initial devaluation.

In this paper, we estimate the impact of macroeconomic fundamentals through the lens of asset prices. In particular, we focus on the information provided by the cross-sectional behavior of equity returns within a given country.[1] This is motivated in part by the

[1]Previous studies have usually used information from cross-sections of countries. For example, Frankel and Andrew (1995), Sachs et al. (1996), Kaminsky et al. (1998), and Kaminsky and Reinhart (1999) study the factors that make countries vulnerable to crises, while Milesi-Ferretti and Razin (1998), Kaminsky and Reinhart (1999), Barro (2001), and Hutchison and Noy (2002) study the effects of crises. While such studies provide valuable

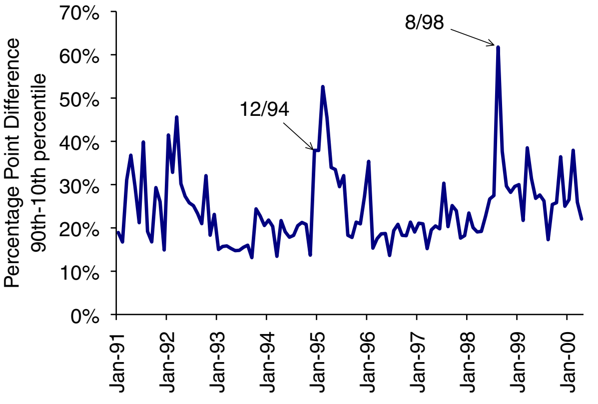

Fig. 2. Cross-sectional dispersion of returns in Mexico. Difference between 90th and 10th percentile in individual stock (monthly) returns in Mexico.

observation that the cross-sectional variance of stock returns is large during crises, which suggests that investors discriminate between different firms during these episodes. Fig. 2 illustrates this point for the case of Mexico during the peso devaluation in December 1994 and Russia's default in August 1998.

We pursue a two stage methodology. First, we measure the sensitivity of individual stock returns to innovations in macroeconomic variables during non-crisis months using a standard multi-factor model. This provides us with a collection of factor loadings or "betas" that describe how each stock responds to non-crisis macroeconomic innovations. Second, we use the betas as independent variables in a cross-sectional regression of crisis returns. We interpret the coefficients estimated in the second-stage regression as effective or normal-period equivalent macroeconomic fundamentals. In particular, they are the fundamentals that, had they occurred during a tranquil period, would best explain the cross section of observed crisis returns.[2]

We study the crises in Mexico 1994, Korea 1997, Thailand 1997, Malaysia 1997, the Philippines 1997, Indonesia 1997, and Brazil 1999. We also include Sweden 1992 as a reference case. We chose as the macroeconomic fundamentals the short-term interest rate to assess credit market conditions and the exchange rate to explore issues of overshooting.[3]

The results indicate that all crises were associated with effective depreciations. However, the depreciations were in general significantly smaller than the observed ones. We test

(*footnote continued*)
information regarding the general characteristics of crises, they are constrained by the fact that crises might have different characteristics in different countries and at different times. Two recent papers on the Mexican crisis that also use disaggregated stock return data are Becker et al. (2002), which estimates devaluation expectations prior to the crisis and Wilson et al. (2000) which studies the transmission channel from devaluation to credit markets.

[2]We will discuss in detail how the results can be interpreted in a model in which crises can induce changes in factor sensitivities or risk premia.

[3]In a previous draft we included inflation and industrial production as additional factors. Due to the limited variation in these variables, their corresponding betas and, consequently, their effective innovations were estimated very imprecisely. The addition of these factors, or replacing nominal interest rates with a measure of real interest rates, did not affect any of the results.

whether the smaller effective depreciations at the time of the crises could be due to markets' anticipation of the crises. We find that during the preceding months, only in Thailand did markets reflect anticipation. Moreover, stock prices during and after the crises in Korea, the Philippines, and Brazil suggest that the market anticipated a partial reversal of the initial depreciations (overshooting). The rebound of the exchange rates in Korea and Brazil in the quarter after the devaluations, while seemingly a surprise to many analysts at the time, was apparently priced into stocks early on in the crisis.[4]

The behavior of effective interest rates suggests that crises differ in their effect on credit market conditions. This heterogeneity is not apparent in directly observed interest rates, as these usually indicate worsening conditions. Perhaps the most surprising result is that in the cases of Sweden 1992, Korea 1997, and Brazil 1999 the effective increase in interest rates is *negative*. Namely, the relative movement in stock returns indicates that investors associated these crises with an easing of monetary policy and no serious effects on the countries' financial markets.[5]

On the other hand, in the case of Mexico the effective increase in interest rates is positive and very large. In fact, it is actually larger than the observed one of 22 percentage points, even though interest rate shocks during crises are short-lived. In the Philippines, the effective increase in interest rates is also positive and not statistically different from the observed one. This is consistent with investors expecting credit crunches in both Mexico and the Philippines. Malaysia is a special case in terms of observed fundamentals in that the money market rate actually fell during the crisis of 1997. However, the effective change in the interest rate is zero, implying that credit conditions did not ease despite the observed drop in interest rates.

The results thus show that directly observed fundamentals can provide a misleading picture of the effects of crises. First, while observed interest rates suggest a deterioration in credit market conditions in almost all cases, effective interest rates show that some countries actually experience improvement. In addition, markets consistently discount the observed large depreciations suggesting exchange rate overshooting.

The paper is organized as follows. Section 2 outlines the theoretical framework for relating stock returns to macroeconomic fundamentals; Section 3 describes the empirical methodology; Section 4 contains the empirical results; and Section 5 concludes.

2. Theoretical framework

As noted in the introduction, interpreting directly-observed macroeconomic variables during crises as if they occurred during tranquil periods is likely to provide an incomplete, and possibly misleading, description of the economic impact of these fundamentals. As a result, we propose to calculate a set of effective innovations to fundamentals by estimating the market's assessment of those fundamentals implicit in the cross-sectional behavior of stock prices. The essence of our approach is outlined in the diagram below. During normal periods, we estimate a mapping β from macroeconomic shocks F into stock returns Z,

[4]Note that the smaller movement in the effective exchange rate during crises is *not* a forecast underpredicting an extreme realization. The effective exchange rate is a summary of information implied by the contemporaneous movements in asset prices, not a standard forecast.

[5]Our results may reflect that firms mitigated whatever credit crunch there was by tapping into alternative avenues of finance, such as merging with foreign firms. See for example Aguiar and Gopinath (2005). For additional evidence on Korea, see Borensztein and Lee (2002).

determined by the sensitivity of each stock to each macroeconomic fundamental. During crisis periods, we take the inverse of this mapping and estimate the effective or "implied" fundamentals F^* based on observed returns.

$$\text{Normal periods: } F \xrightarrow{\beta} Z,$$

$$\text{Crisis periods: } F^* \xleftarrow{\beta^{-1}} Z.$$

In the rest of the section, we describe the normal period mapping and discuss how to interpret the reverse mapping during crises.

2.1. A multi-factor model of asset returns

Define the one-period log return on a stock as

$$Z_{t+1} = \log(P_{t+1} + D_{t+1}) - \log(P_t), \tag{1}$$

where P and D represent price and dividend, respectively. Following Campbell and Shiller (1988), a Taylor expansion yields

$$Z_{t+1} \approx k + \rho p_{t+1} + (1-\rho)d_{t+1} - p_t, \tag{2}$$

where lower-case letters represent logs, and ρ and k are constants.[6] By imposing the terminal condition $\lim_{i\to\infty} \mathrm{E}_t \rho^i p_{t+i} = 0$, Campbell and Shiller solve the difference equation (2) to yield an expression for the price of a stock as the discounted sum of log dividends and future expected returns,

$$p_t = \frac{k}{1-\rho} + (1-\rho)\mathrm{E}_t \sum_{s=0}^{\infty} \rho^s d_{t+1+s} - \mathrm{E}_t \sum_{s=0}^{\infty} \rho^s Z_{t+1+s}. \tag{3}$$

Following Campbell (1991), we can use this expression to write the realized return as the sum of the expected return and innovations to expected future log dividends and future expected returns,

$$Z_{t+1} = \mathrm{E}_t Z_{t+1} + (\mathrm{E}_{t+1} - \mathrm{E}_t) \sum_{s=0}^{\infty} \rho^s \Delta d_{t+1+s} - (\mathrm{E}_{t+1} - \mathrm{E}_t) \sum_{s=1}^{\infty} \rho^s Z_{t+1+s}, \tag{4}$$

where $\Delta d_{t+1}$is the dividend growth rate between period t and $t+1$ and $(\mathrm{E}_{t+1} - \mathrm{E}_t)x$ represents the revision in the expectation of x due to information obtained between periods t and $t+1$. In this framework, unexpected returns are attributed to a combination of revisions to expected dividend growth and changes in future expected returns.

Expression (4) is an approximation of an identity, not a particular model of returns. Our first restrictive assumption is to assume that the revision to expected future dividend growth for a given stock is a linear function of macroeconomic and idiosyncratic innovations realized at time t. Namely, for stock j between times t and $t+1$,

$$(\mathrm{E}_{t+1} - \mathrm{E}_t) \sum_{s=0}^{\infty} \rho^s \Delta d_{j,t+1+s} = \beta_{j,1} F^*_{1,t+1} + \cdots + \beta_{j,k} F^*_{K,t+1} + u_{j,t+1}, \tag{5}$$

[6] The expansion is done around the long-run dividend-price ratio, and $\rho = 1/1 + \overline{(D/P)} \in (0, 1)$.

where $F^*_{k,t+1} : k = 1, \ldots, K$ represent *effective* innovations to macroeconomic variables, $\beta_{j,k} : k = 1, \ldots, K$ represent sensitivities to innovations in fundamentals, and $u_{j,t+1}$ represents the idiosyncratic component of shocks to dividends. The important assumption behind Eq. (5) is the existence of a stable, linear relationship between innovations to effective macroeconomic fundamentals and expected dividend growth. We further assume that during non-crisis periods, observed and effective innovations to fundamentals are equal.

In addition, we assume that expected returns (i.e. risk premia) are constant during tranquil periods, and that the timing of a crisis is not known in advance. This latter assumption ensures that crises are "news" and will therefore be reflected by changes in asset prices. In particular, we have $(\mathrm{E}_{t+1} - \mathrm{E}_t)\sum_{s=1}^{\infty}\rho^s Z_{j,t+1+s} = 0$, and $\mathrm{E}_t Z_{j,t+1} \equiv \beta_{j,0}$.

We can therefore represent *tranquil-period* returns on stock j at time t as a linear function of innovations to macroeconomic variables plus an idiosyncratic noise term,

$$Z_{j,t} = \beta_{j,0} + \sum_{k=1}^{K} \beta_{j,k} F_{k,t} + u_{j,t}, \tag{6}$$

where $F_{k,t+1} : k = 1, \ldots, K$, represent *observed* innovations to macroeconomic variables. Eq. (6) is a multi-factor model of asset returns. Many asset pricing theories impose restrictions on this expression; however, we do not impose any in our empirical implementation, since our main interest is in using asset prices as a source of information about the fundamentals F rather than testing a specific model of asset pricing.

2.2. *Crisis fundamentals*

In this subsection we use the linear model just presented to illustrate the difference between observed and effective innovations to fundamentals. For simplicity, suppose that there is only one fundamental, for example, short-term interest rates. Also, suppose that at time t_c an unexpected crisis starts and interest rates rise sharply (i.e. F_{r,t_c}, where r stands for interest rates, is positive and large). If investors responded to movements in observed interest rates during crises *as if* they occurred during a non-crisis period, we would expect stock returns to equal

$$Z_{j,t_c} = \beta_{j,0} + \beta_{j,r} F_{r,t_c} + u_{j,t_c}. \tag{7}$$

However, there are three reasons why the relationship between observed interest rate movements and stock returns may be different during crisis and non-crisis times. First, the time series properties of interest rates may change during crises. For example, the interest rate might become more mean reverting during crises if high interest rates are expected to last for a short period of time. Second, there may be a non-linear relationship between stock returns and interest rates that is reflected in a change in the sensitivity of stock returns to movements in interest rates during crises. For example, if credit constraints that do not bind in normal times become binding during crises. Third, there may be changes to the risk premia associated with interest rates. Although these possibilities are not mutually exclusive, we argue next that they can all be interpreted as stock returns responding to an effective innovation to interest rates that may be different from the observed innovation.

Suppose that during crises, stock returns are characterized by

$$Z_{j,t_c} = \beta_{j,0} + \delta_0 + \beta_{j,r} F^*_{r,t_c} + u_{j,t_c}, \tag{8}$$

where F^*_{r,t_c} is the effective innovation to the interest rate, and δ_0 is a constant that captures the possibility of an aggregate shock. How would F^*_{r,t_c} reflect the three channels mentioned above? First, if the interest rate becomes more mean reverting during crises, then the effective innovation would be smaller and $F^*_{r,t_c} = \Phi F_{r,t_c}$, where $\Phi < 1$. Second, if stocks become more sensitive to interest rate movements during crises, then $F^*_{r,t_c} = \Phi F_{r,t_c}$ where $\Phi > 1$.[7]

Third, to show that changes in risk premia may also be captured by our effective fundamentals we assume that risk is priced according to the arbitrage pricing theory (APT). Namely, we assume that expected returns satisfy

$$\beta_{j,0} = \lambda_0 + \sum_{k=1}^{K} \beta_{j,k}\lambda_k, \tag{9}$$

where λ_k is the risk premium associated with factor k and λ_0 is the return on the "zero-beta" portfolio.

For example, suppose that at time t_c an unexpected crisis starts which lasts for one period. After the crisis, risk premia revert to their pre-crisis levels. The change in expected future returns is given by

$$(\mathrm{E}_{t_c} - \mathrm{E}_{t_c-1}) \sum_{s=1}^{\infty} \rho^s Z_{j,t_c+s} = \rho\Delta\beta_{j,0} = \rho\Delta\lambda_0 + \rho\sum_k \beta_{j,k}\Delta\lambda_k, \tag{10}$$

and the stock return at time t_c is then given by

$$\begin{aligned} Z_{j,t_c} &= \mathrm{E}_{t_c-1} Z_{j,t_c} + (\mathrm{E}_{t_c} - \mathrm{E}_{t_c-1}) \sum_{s=0}^{\infty} \rho^s \Delta d_{j,t_c+s} - (\mathrm{E}_{t_c} - \mathrm{E}_{t_c-1}) \sum_{s=1}^{\infty} \rho^s Z_{j,t_c+s} \\ &= \beta_{j,0} + \sum_k \beta_{j,k}\Phi_{k,t_c}F_{k,t_c} + u_{j,t_c} - \rho\left(\Delta\lambda_0 + \sum_k \beta_{j,k}\Delta\lambda_k\right) \\ &= \beta_{j,0} - \rho\Delta\lambda_0 + \sum_k \beta_{j,k}\left(\Phi_{k,t_c}F_{k,t_c} - \rho\Delta\lambda_k\right) + u_{j,t_c}. \end{aligned} \tag{11}$$

Eq. (11) can be reconciled with Eq. (8) by identifying the constant δ_0 with the change in the country risk premium $\rho\Delta\lambda_0$, and by defining effective fundamentals as

$$F^*_{k,t_c} = \Phi_{k,t_c}F_{k,t_c} - \rho\Delta\lambda_k. \tag{12}$$

In our empirical analysis, we estimate F^*_{k,t_c} by regressing crisis returns on non-crisis factor sensitives. Although given the brief nature of crises we cannot separately identify the three reasons why effective and observed fundamentals differ, this is not crucial for the overall interpretation of the results. However, one should keep in mind that when referring to effective fundamentals we are using this broad definition.[8]

[7]One can think of $\beta_{j,r}$ as reflecting a stable, linear relationship between stock returns and changes in some intermediate unobserved variable, say credit conditions; and a time varying Φ (normalized to 1 in non-crisis times) as reflecting a non-linear relationship between this variable and interest rates. We thank our referee for suggesting this interpretation.

[8]Broner et al. (2005) show that risk permia on emerging market assets do increase during crises. Although the evidence in that paper is on sovereign bonds, it seems reasonable that the same will be true for stocks.

3. Empirical methodology

The previous section motivates the following simple model of stock returns,

$$Z_{j,t} = \beta_{j,0} + \sum_{k=1}^{K} \beta_{j,k} F_{k,t} + u_{j,t} \quad \text{if } t \in T_{\mathrm{N}},$$

$$Z_{j,t} = \beta_{j,0} + \delta_0 + \sum_{k=1}^{K} \beta_{j,k} F^{*}_{k,t} + u_{j,t} \quad \text{if } t \in T_{\mathrm{C}}, \tag{13}$$

where $T_{\mathrm{N}}, T_{\mathrm{C}}$ represent normal periods and crisis periods, respectively. For a given country, there are K macroeconomic fundamentals and J stocks spanning months $T = T_{\mathrm{N}} \cup T_{\mathrm{C}}$.[9]

3.1. Estimation of effective fundamentals

We assume that the idiosyncratic shocks $u_{j,t}$ are normally distributed and independent across time and stocks. We allow the within-period variance to vary across stocks and between normal and crisis periods. Specifically, let $u_{\mathrm{N}}, u_{\mathrm{C}}$ represent the $JT_{\mathrm{N}} \times 1$ and $JT_{\mathrm{C}} \times 1$ vectors of residuals, respectively. That is $u_{\mathrm{N}} = (u_1, \ldots, u_J)'$ where $u_j = (u_{j,1}, \ldots u_{j,T_{\mathrm{N}}})'$ and similarly for u_{C}. Then,

$$\mathrm{E}(u_{\mathrm{N}} u'_{\mathrm{N}}) = \sigma^2_{\mathrm{N}}(\Omega \otimes I_{T_{\mathrm{N}}}), \tag{14}$$

$$\mathrm{E}(u_{\mathrm{C}} u'_{\mathrm{C}}) = \sigma^2_{\mathrm{C}}(\Omega \otimes I_{T_{\mathrm{C}}}),$$

where Ω is the $J \times J$ matrix

$$\Omega = \begin{bmatrix} \omega_1 & & 0 \\ & \ddots & \\ 0 & & \omega_J \end{bmatrix}$$

and I_T is a $T \times T$ identity matrix. Note that we allow the scale factors σ^2_{N} and σ^2_{C} to differ between crisis and normal periods. The relative heteroscedasticity between stocks is captured by the matrix Ω.[10]

The log likelihood function is therefore

$$\ln L = \ln L_{\mathrm{N}} + \ln L_{\mathrm{C}}, \tag{16}$$

where

$$\ln L_m = -\frac{T_m J}{2} \ln(2\pi) - \frac{1}{2} \ln |\sigma^2_m \Omega| - \frac{1}{2} u'_m \left(\sigma^2_m \Omega\right)^{-1} u_m, \quad m = N, C. \tag{17}$$

Our estimation strategy begins by defining the normal and crisis periods. Suppose that the crisis begins at time τ.[11] The normal period is then $t \in [1, \tau - 4] \cup [\tau + 6, T]$. The crisis

[9] In practice, T_{N} will vary across stocks.

[10] We do not have enough data to estimate cross-correlations among stocks. As we will see below, this does not matter for the estimation of β. For the crisis, we account for an aggregate component to the residuals by including a constant.

[11] Usually, we take the start of the crisis as the month of the devaluation or the beginning of massive capital outflows.

period is divided into three 3-month sub-periods: Pre-crisis $= t \in [\tau-3, \tau-1]$, Crisis $= t \in [\tau, \tau+2]$, and Post-crisis $= t \in [\tau+3, \tau+5]$. The reason for including the immediate pre- and post-crisis months separately is to allow for tests of anticipation and overshooting, to be described below. Also, reporting results from the borders of the event window makes explicit how the results would change if we altered the choice of starting and ending dates for the crises. The following diagram illustrates

$$t = \overbrace{1, 2, \ldots, \tau-4}^{T_{\mathrm{N}_1}} \overbrace{\overbrace{\tau-3, \ldots, \tau-1}^{\text{Pre-crisis}} \overbrace{\tau, \ldots, \tau+2}^{\text{Crisis}} \overbrace{\tau+3, \ldots, \tau+5}^{\text{Post-crisis}}}^{T_{\mathrm{C}}} \overbrace{\tau+6, \ldots, T}^{T_{\mathrm{N}_2}}.$$

To ensure that the estimate of the vector β reflects the normal relationship between fundamentals and returns, we do not include the crisis periods in its estimation. That is, we do not minimize $\ln L$ over the entire period, but instead choose estimates of β, denoted b, that minimize the log-likelihood restricted to normal periods $\ln L_{\mathrm{N}}$. This is asymptotically equivalent to using the entire sample given that we are simply dropping nine observations, although we are sacrificing finite-sample efficiency. Given the i.i.d. assumption regarding the behavior of returns, the ML estimate of β is simply equation by equation least squares.[12]

The second step is to estimate the effective fundamentals, F^*, which is the $3(K+1) \times 1$ vector of coefficients, corresponding to K fundamentals and one constant for the pre-crisis, crisis, and post-crisis periods. We use the normal period residuals to form a consistent estimate of the covariance matrix Ω as well as σ_{N}^2. To find the maximum likelihood estimates of F^*, we minimize $\ln L_{\mathrm{C}}$ with respect to F^*, given the estimates b and $\hat{\Omega}$. The solution to this is equivalent to a (GLS) regression of returns $Z - b_0$ on the estimates b and a constant, where b_0 is the $J \times 1$ vector of constants from the first stage regression. We sum the returns over the months of each of the three sub-periods, leaving one observation per stock in each of the three second-stage regressions. The residuals from the second stage provide an estimate of σ_{C}^2, the common scaling factor for the residual covariance matrix during crises.[13]

Given that we are using the estimated b instead of the true β, we need to adjust the standard error of the second stage regression.[14] We do this as outlined by Murphy and Topel (1985). Specifically, let V_0 be the uncorrected covariance matrix from the GLS estimates of F^*, and V_b be the covariance matrix for the first stage estimates of β. Then the corrected covariance matrix V_{F^*} is

$$V_{F^*} = V_0 + V_0 C V_b C' V_0, \tag{18}$$

[12] Our assumption that stocks are independent within periods is not important in the first stage of the estimation. GLS in this set up is Zellner's seemingly unrelated regression (SUR). A feature of SUR is that it collapses to equation by equation least squares when all equations have identical regressors, which is the case here. Note also that since we are excluding crisis periods in the estimation of b, there is no need to iterate between the estimates of b and F^*.

[13] We estimate a single σ_{C}^2 for the 9-month period covering pre-crisis, crisis, and post-crisis. Specifically, $\sigma_{\mathrm{C}}^2 = (1/3J)\sum_{\tau=\mathrm{pre}}^{\mathrm{post}} \sum_{j=1}^{J} \hat{e}_{j,\tau}^2$, where $\hat{e}_{j,\tau}$ is the jth stock's residual in the $\tau \in \{\text{pre, crisis, post}\}$ sub-period.

[14] Our estimate of F^* is consistent, given that the first stage estimation error goes to zero as T approaches infinity.

where

$$C = \sigma_C^2 (B \otimes I_3)' \Omega (I_J \otimes F^*) \tag{19}$$

and I_M is a $M \times M$ identity matrix, B is a $J \times K$ matrix of the estimated factor sensitivities and F^* is the $K \times 3$ matrix containing the estimated effective fundamentals.

3.2. Interpretation of effective fundamentals

At a very mechanical level, the effective fundamentals are the macroeconomic shocks that "best" explain the observed cross-section of returns during a crisis, given the vector of factor sensitivities. A significant F^* indicates that the factor sensitivity has power in explaining the cross-section of returns; for example, a positive effective interest rate implies that interest rate sensitive stocks decline more than average. The value of the estimated fundamental is interpreted as the crisis fundamental's normal-period equivalent—that is, the fundamental that best explains observed crisis returns using the normal period mapping from macro variables to stock returns.

In addition, we use the estimates of F^* to determine whether the observed fundamentals accurately reflect market perceptions. Let us define δ_k as the difference between the kth effective fundamental and its observed counterpart,

$$\delta_k \equiv F_k^* - F_k.$$

As an example, suppose the fundamental consists of changes in the log exchange rate (where a positive movement is an appreciation). Using the methodology proposed above, we can estimate the effective depreciation that best explains the cross section of stock returns. If the market considered that conditions were worse than observed, δ would be negative, while if the market discounted the impact of the drop in the exchange rate, δ would be positive.

One reason why δ may be different from zero is that the news regarding the fundamental was already incorporated into stock prices. For example, suppose that in the month prior to the devaluation the market correctly anticipated the change in currency regime. When the devaluation occurs, stocks do not respond and the implied δ is positive and equal to minus the observed fundamental, i.e. $F^* = F + \delta = 0$. To explore this possibility, we estimate the pre-crisis effective fundamentals; if the market had anticipated the devaluation, it would be reflected in a negative pre-crisis δ. Similarly, we estimate the post-crisis effective fundamentals to analyze the possibility of expected reversals or "overshooting." If the market expected the devaluation to be partially reversed, the crisis period δ would be positive, while the post-crisis δ would be negative. The following diagram summarizes:

Pre-crisis	Crisis	Post-crisis	Interpretation
$\delta_{\text{pre}} < 0$	$\delta_{\text{crisis}} > 0$		$\Longrightarrow$ Anticipation
	$\delta_{\text{crisis}} > 0$	$\delta_{\text{post}} < 0$	$\Longrightarrow$ Overshooting

In interpreting the effective fundamentals it is important to note a few caveats. First, the analysis is sensitive to the assumption that the crisis overshadows anything else taking place during the pre-crisis and post-crisis windows. For example, a negative pre-crisis δ is interpreted as anticipation of the crisis and not driven by reaction to events preceding the pre-crisis months. This is a plausible assumption given that crises tend to stand out in terms of stock returns and movements of fundamentals.

Second, as mentioned in Section 2.2, we cannot determine whether an effective fundamental differs from the observed fundamental during crises due to a change in the stochastic properties of the fundamental, a change in the sensitivity of stock returns to the fundamental, or a change in the risk premium associated with the fundamental. However, this does not pose a serious problem for the overall interpretation of our results. For example, whether a shock to interest rates is effectively more serious than the observed shock due to market participants expecting interest rates to remain high for a long time, due to stocks becoming more sensitive to interest rate shocks due to non-linear credit frictions, or due to an increase in the risk premium associated with interest rates due to higher uncertainty in credit markets, it is still the case that credit market conditions deteriorated more than captured in observed interest rates changes. In other words, although we cannot identify empirically the three reasons why effective and observed fundamentals might differ during crises, we believe this is not a serious problem since they are quite close conceptually.

Third, we assume that the mapping β between fundamentals and returns is stable, both between crisis and non-crisis times and between different non-crisis periods. Given the brevity of crises, we cannot test for stability of the β's during crises. For our results to be valid qualitatively, the important assumption is that the relative sensitivities of stocks remain stable during crises. For example, stocks that are usually more sensitive to movements in interest rates during tranquil times should remain so during crises. This does not seem to be a strong assumption. However, the quantitative results rely explicitly on a stable mapping, and thus must be interpreted "conditional" on a given vector of β's; that is, "as if" the macroeconomic shocks occurred during non-crisis periods. To account for the possibility that the β's are not stable during non-crisis times, we estimated the non-crisis β's using different normal-period subsamples. Our results were stable across alternative first stage subsamples. In Appendix A.1 we report the results using as our non-crisis sample the immediate 24 months after the crisis event window.

4. Empirical results

In this section, we apply the methodology described above to study a number of emerging market crises that took place during the 1990s. We present results on crises in Mexico in 1994, Korea, Thailand, Malaysia, Indonesia, and the Philippines in 1997, and Brazil in 1999. For comparison, we also include Sweden's crisis of 1992.[15] Table 1 illustrates the impact of these episodes, and summarizes their effects on macroeconomic variables. The table makes clear that the crises were periods of large drops in stock markets and large swings in macroeconomic variables.

[15]Specifically, the Mexican crisis begins in December 1994, Korea in October 1997, Southeast Asia in July 1997, Brazil in December 1998 and Sweden in October 1992. While the timing usually coincides with the devaluation, the results are robust to alternative starting points given that we study a 9 month window. We did not include Argentina 1994 and Russia 1998 due to the small number of stocks for which we have data.

Table 1
Summary statistics

Cumulative totals	Δe	Δr	Market
Mexico 1994	−0.55	0.21	−0.42
Korea 1997	−0.65	0.09	−0.53
Thailand 1997	−0.34	0.13	−0.17
Malaysia 1997	−0.16	−0.01	−0.37
Philippines 1997	−0.18	0.05	−0.44
Indonesia 1997	−0.30	0.32	−0.11
Brazil 1999	−0.56	0.15	0.16
Sweden 1992	−0.04	0.00	0.002

Source: IFS, DataStream. Market is DataStream total market return index. Δr is change in log monthly interest rate (change in $\log(1+r)$, where r is annualized rate). Interest rate is IFS T-Bill for Mexico and the Philippines, otherwise IFS money market. Δe is log change in either nominal exchange rate (expressed as dollars/local currency) or nominal effective exchange rate index (Malaysia, Philippines, Indonesia, and Sweden) provided by IFS (increase is an appreciation). All values are cumulative sums over pre-crisis and crisis sub-periods: Mexico 9/94-2/95, South East Asia: 4/97-9/97, Korea: 7/97-12/97, Brazil: 9/98-2/99, Sweden: 8/92-11/92.

4.1. Data and first stage regressions

For stock returns, we use monthly log changes in the return index from DataStream. The data range from December 1990 through April 2000, although not all stocks span this entire period. The number of stocks per country ranges from 62 in Mexico to 330 in Malaysia. (See Table 3.)

We concentrate on two macroeconomic fundamentals, short-term interest rates and exchange rates. In a previous version of the paper, we also included industrial production and inflation, but these factors were rarely significant if we included the two primary factors.[16] Neither did we include many common factors from the finance literature, such as the market return or company characteristics (size, book-to-market, etc.). These are usually of interest to prove or disprove a particular model of asset pricing, which is not our focus.

For the exchange rate, we use the nominal effective exchange rate index as calculated by the IMFs *International Financial Statistics*. An increase in this index is an appreciation of the local currency. If this series was unavailable, we used the dollar exchange rate expressed as dollars/local currency to preserve the sign convention of the IFS index. For interest rates we use money market rates reported by the IFS when available (Thailand, Indonesia, Korea, Brazil and Sweden) and otherwise T-Bill rates (Mexico, Malaysia, and the Philippines). The short maturities of these debt instruments justify the use of nominal interest rates rather than trying to construct real interest rates.[17]

Table 2 summarizes the macro fundamentals for normal and crisis periods. For exchange rate innovations, we use the monthly change in the log exchange rate. Given

[16]As mentioned in the introduction, the effective innovations for industrial production and inflation were estimated very imprecisely. The addition of these factors, or replacing nominal interest rates with a measure of real interest rates, did not affect the conclusions regarding the two primary fundamentals.

[17]We also found that cross-sectional variation in sensitivities to ex post real interest rates are driven by sensitivities to nominal interest rates and not inflation. The results from the second stage regressions are therefore not sensitive to the choice between nominal and ex post real interest rates.

Table 2
Macroeconomic fundamentals

Country	Fundamental	Normal	Pre-crisis	Crisis	Post-crisis
Mexico	Mean Δe	−0.005	−0.007	−0.175	−0.019
	Standard deviation Δe	0.024	0.002	0.226	0.164
	Mean Δr	−0.004	−0.002	0.073	0.039
	Standard deviation Δr	0.026	0.004	0.064	0.136
Korea	Mean Δe	−0.000	−0.010	−0.206	0.070
	Standard deviation Δe	0.022	0.005	0.166	0.119
	Mean Δr	−0.002	0.006	0.024	0.003
	Standard deviation Δr	0.011	0.004	0.035	0.026
Thailand	Mean Δe	0.002	0.003	−0.116	−0.086
	Standard deviation Δe	0.035	0.008	0.089	0.077
	Mean Δr	−0.001	0.020	0.025	−0.044
	Standard deviation Δr	0.022	0.014	0.050	0.056
Malaysia	Mean Δe	0.002	−0.009	−0.045	−0.055
	Standard deviation Δe	0.023	0.009	0.040	0.036
	Mean Δr	−0.001	0.002	−0.005	0.008
	Standard deviation Δr	0.004	0.027	0.043	0.002
Philippines	Mean Δe	0.002	−0.003	−0.057	−0.028
	Standard deviation Δe	0.024	0.011	0.033	0.037
	MeanΔr	−0.002	0.001	0.014	0.007
	Standard deviation Δr	0.010	0.006	0.004	0.011
Indonesia	Mean Δe	−0.007	−0.004	−0.097	−0.116
	Standard deviation Δe	0.110	0.000	0.052	0.124
	Mean Δr	−0.003	0.008	0.098	−0.027
	Standard deviation Δr	0.036	0.014	0.226	0.051
Brazil	Mean Δe	−0.096	−0.006	−0.180	0.060
	Standard deviation Δe	0.126	0.005	0.271	0.110
	Mean Δr	−0.023	0.051	0.001	−0.030
	Standard deviation Δr	0.456	0.070	0.057	0.053
Sweden	Mean Δe	−0.001	0.002	−0.024	−0.066
	Standard deviation Δe	0.013	0.000	0.032	0.051
	Mean Δr	−0.000	0.244	−0.242	−0.006
	Standard deviation Δr	0.008	0.331	0.290	0.001

Summary of macroeconomic fundamentals used in first stage regressions. Δe refers to monthly change in log exchange rate expressed as dollars/local currency for Mexico, Korea, Brazil, Indonesia, and Thailand. For Malaysia, the Philippines and Sweden, Δe refers to monthly change in log nominal effective exchange rate as calculated by IFS. In both cases, a positive number indicates an appreciation of the local currency. Δr refers to log change in annualized gross interest rate. The interest rate is the money market rate, except for Mexico and the Philippines, for which we use the T-Bill rate. All data from IFS.

a large literature that fails to out-predict this model at monthly frequencies, this seems a reasonable assumption. Similarly, for the interest rate we take monthly changes in the log of the gross (annualized) interest rate, i.e. $F_r = \ln(1 + r_{t+1}) - \ln(1 + r_t)$. The random walk assumption behind the choice of innovations for interest rates is less grounded in the

Table 3
Summary of first stage regressions

Country	Regressors	Δe	Δr	Median R^2	Median obs	Firms
Mexico	median β	1.46	−0.14	0.11	91	62
	Standard deviation of β	0.92	0.66			
	Median |t-stat|	2.58	0.92			
Korea	Median β	1.91	−0.48	0.08	101	292
	Standard deviation of β	1.19	1.65			
	Median |t-stat|	2.57	0.72			
Thailand	Median β	0.21	0.16	0.02	99	225
	Standard deviation of β	0.96	1.27			
	Median |t-stat|	0.83	0.72			
Malaysia	Median β	1.68	−2.64	0.07	101	330
	Standard deviation of β	1.06	3.63			
	Median |t-stat|	2.21	0.77			
Philippines	Median β	0.63	−0.98	0.03	101	104
	Standard deviation of β	1.17	2.75			
	Median |t-stat|	0.94	0.54			
Indonesia	Median β	0.30	−0.24	0.06	102	135
	Standard deviation of β	0.39	0.73			
	Median |t-stat|	2.00	0.80			
Brazil	Medianβ	−0.85	−0.08	0.11	69	73
	Standard deviation of β	1.59	0.77			
	Median |t-stat|	2.47	0.74			
Sweden	Median β	0.15	−1.97	0.02	128	114
	Standard deviation of β	0.79	3.49			
	Median |t-stat|	0.58	1.34			

Summary results of first stage (time series) regression of stock return on macroeconomic factors. Macroeconomic factors are monthly changes in log exchange rate and log (gross) annualized interest rate, plus a constant. For each country, the first row corresponds to the median estimated β_k across stocks within the country, the second to the cross-sectional standard deviation of estimated β_k, and the third to the median absolute value of t-stats across stocks. Units are such that a coefficient of 1 indicates that a 0.01 monthly change in the log exchange rate or (gross) annualized interest rate is associated with a 0.01 monthly change in that stock's log return index.

empirical literature, but the absence of a long time series to accurately estimate an alternative process for the interest rate makes monthly changes the best available choice. To verify the robustness of the results to the random walk assumption, we also estimated an AR(1) for both the exchange rate and the interest rate and used the residuals as innovations. We report the results using this alternative model in Appendix A.2.[18]

In the first stage, we estimate the vector b of factor sensitivities for each stock as in Eq. (13). Table 3 reports summary statistics by country for the first-stage regressions.

[18]Appendix A.2 indicates the main results are robust to this alternative model of fundamental innovations. The one exception is Brazil, particularly the results regarding the implied exchange rate. This may be due to the instability in Brazil's exchange rate regime during the 1990s.

Table 4
Results for Mexico 1994

	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental
Panel A: Effective fundamentals (F^*)						
Δe (b_e)	−0.020	−0.020	−0.242***	−0.526	−0.026	−0.057
	(0.037)		(0.043)		(0.037)	
Δr (b_r)	0.009	−0.007	0.265***	0.220	0.039	0.116
	(0.053)		(0.061)		(0.053)	
Constant	−0.033		−0.123*		0.138**	
	(0.061)		(0.071)		(0.061)	
Firms	62		62		62	
R^2	0.01		0.37		0.01	

Fundamental	Pre-crisis	Crisis	Post-crisis
Panel B: Difference between effective and observed fundamentals (δ)			
Δe	0.001	0.284***	0.031
Δr	0.016	0.045	−0.077

Panel A: GLS regression of the *sum* over each sub-period of excess returns ($Z - b_0$) on factor sensitivities b plus a constant, producing estimates of F_k^* (cumulative over each 3-month sub-period). Standard errors are calculated as described in Section 3. Observed fundamental is the sum of observed monthly changes in log exchange rates and log interest rates over the 3 months for each sub-period. Pre-crisis, crisis, and post-crisis cover 9/94-11/94, 12/94-2/95, 3/95-5/95, respectively. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.
Panel B: Presents the difference between the effective fundamental (summed over the 3 month sub-period) reported in panel A and the observed fundamental (also reported in panel A). Standard errors are not reported as they are the same as those reported in panel A. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.

4.2. *Estimates of effective fundamentals*

The effective fundamentals are estimated, as described in Section 3, by regressing the crisis returns on the factor sensitivities. Specifically, we calculate excess returns for each stock, $Z_{t,j} - b_{j,0}$, and sum these returns over each sub-period. We then regress the sub-period excess returns on the estimated interest rate and exchange rate sensitivities, including a constant and using the $\hat{\Omega}$ as a weighting matrix. This produces estimates of the two (cumulative) effective fundamentals for each sub-period. The deviations δ are constructed by subtracting observed fundamentals from these estimates.

Tables 4–11 contain the results of the second stage regressions. Panel A of each table contains the estimates of the cumulative implied fundamentals F^* for the three crisis sub-periods. For comparison, panel A also includes the observed fundamentals. Panel B compares the estimated effective fundamentals to the observed fundamentals.

In order to focus the discussion, we begin with a description of Sweden 1992, which is the reference case (Table 11). For Sweden, we limit the sub-periods to 2 months to ensure that the 1-month interest rate spike remains observable, with the entire period ranging from August 1992 through January 1993. From the observed fundamentals reported in panel A, we see that during the 2 months of the pre-crisis period, money market interest

Table 5
Results for Korea 1997

	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental
Panel A: Effective fundamentals (F^*)						
Δe (b_e)	−0.015	−0.030	−0.060***	−0.619	−0.081***	0.209
	(0.019)		(0.020)		(0.020)	
Δr (b_r)	−0.007	0.019	−0.026*	0.071	0.001	0.008
	(0.015)		(0.015)		(0.015)	
Constant	−0.109***		−0.670***		0.421***	
	(0.041)		(0.042)		(0.042)	
Firms	292		292		292	
R^2	0.01		0.03		0.07	

Fundamental	Pre-crisis	Crisis	Post-crisis
Panel B: Difference between effective and observed fundamentals (δ)			
Δe	0.015	0.559***	−0.289***
Δr	−0.026*	−0.097***	−0.008

Panel A: GLS regression of the *sum* over each sub-period of excess returns ($Z - b_0$) on factor sensitivities b plus a constant, producing estimates of F_k^* (cumulative over each 3-month sub-period). Standard errors are calculated as described in Section 3. Observed fundamental is the sum of observed monthly changes in log exchange rates and log interest rates over the 3 months for each sub-period. Pre-crisis, crisis, and post-crisis cover 7/97-9/97, 10/97-12/97, 1/98-3/98, respectively. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.
Panel B: Presents the difference between the effective fundamental (summed over the 3 months sub-period) reported in panel A and the observed fundamental (also reported in panel A). Standard errors are not reported as they are the same as those reported in panel A. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.

rates increased by 48% in log terms. Over the months of October and November, the central bank completely reversed the interest rate hike and devalued the currency by roughly 5%. In 2 months immediately after this period, the currency fell another 13%. Panels A and B of Table 11 report that the entire interest rate hike was discounted by the market. Panel A reports that the effective increase in the interest rate was basically zero. On the way back down, the effective fundamental is significantly below zero at the 10% level, but much smaller in magnitude than the observed fundamental. The point estimate for the pre-crisis implied exchange rate indicates an anticipated devaluation of roughly 3.4% (although with a relatively large standard error). The crisis and post-crisis columns indicate that investors discounted the observed devaluation once it occurred. In short, the Swedish results are consistent with the story that on the eve of the devaluation the market ignored the large increase in interest rates and partially priced in a devaluation, and were not surprised when they were vindicated by actual events.

At first glance, the ease with which Europe dealt with the 1992 currency crisis differs markedly from the drama witnessed in Asia and Latin America. We now ask whether investors' assessment of fundamentals in emerging markets follows the relatively orderly process found in Sweden.

Table 6
Results for Thailand 1997

	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental
Panel A: Effective fundamentals (F^*)						
Δe (b_e)	−0.123***	0.008	−0.046	−0.347	−0.206***	−0.257
	(0.040)		(0.040)		(0.043)	
Δr (b_r)	−0.023	0.061	−0.038	0.074	−0.145***	−0.133
	(0.035)		(0.035)		(0.038)	
Constant	−0.042***		−0.009		−0.055***	
	(0.016)		(0.016)		(0.017)	
Firms	225		225		225	
R^2	0.13		0.01		0.23	

Fundamental	Pre-crisis	Crisis	Post-crisis
Panel B: Difference between effective and observed fundamentals (δ)			
Δe	−0.130***	0.301***	0.051
Δr	−0.084**	−0.111***	−0.012

Panel A: GLS regression of the *sum* over each sub-period of excess returns ($Z - b_0$) on factor sensitivities b plus a constant, producing estimates of F_k^* (cumulative over each 3-month sub-period). Standard errors are calculated as described in Section 3. Observed fundamental is the sum of observed monthly changes in log exchange rates and log interest rates over the 3 months for each sub-period. Pre-crisis, crisis, and post-crisis cover 4/97-6/97, 7/97-9/97, 10/97-12/97, respectively. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.
Panel B: Presents the difference between the effective fundamental (summed over the 3 month sub-period) reported in panel A and the observed fundamental (also reported in panel A). Standard errors are not reported as they are the same as those reported in panel A. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.

Tables 4–10 contain the results for Mexico, Korea, Thailand, Malaysia, the Philippines, Indonesia, and Brazil, respectively. First, note the difference between the implied and observed exchange rate movements during the crisis sub-periods reported in panels B. In general, effective devaluations are not as large as observed devaluations. That is, the estimated δ for the exchange rate is significantly positive, exceeding 50 percentage points in some cases. This is true across all crises except Indonesia. However, the implied fundamental is still significantly negative, indicating that stocks responded to the devaluation, only less severely than it would appear from the observed drop in the exchange rate.

As noted in the previous section, this could be due to anticipation; namely, the devaluation may already be priced into stocks. Looking at the pre-crisis sub-period, we see that there is evidence of this in Thailand. In particular, Thai stocks reveal that a 12% devaluation was anticipated, while the crisis saw the baht fall 35%. This may not be surprising; while we start the crisis in July 1997 for Thailand, the weakness of the banking system was evident by June. However, although the anticipated devaluation was much smaller than the one realized during the crisis, the crisis δ of *positive* 30% indicates that the market largely discounted the entire devaluation when it occurred. Brazil and Malaysia

Table 7
Results for Malaysia 1997

	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental
Panel A: *Effective fundamentals* (F^*)						
Δe (b_e)	−0.054*** (0.019)	−0.028	−0.097*** (0.019)	−0.136	−0.152*** (0.019)	−0.166
Δr (b_r)	−0.003 (0.006)	0.007	0.006 (0.006)	−0.014	−0.006 (0.006)	0.024
Constant	−0.119*** (0.030)		−0.174*** (0.031)		−0.551*** (0.032)	
Firms	330		330		330	
R^2	0.09		0.21		0.10	

Fundamental	Pre-crisis	Crisis	Post-crisis
Panel B: *Difference between effective and observed fundamentals* (δ)			
Δe	−0.026	0.039**	0.015
Δr	−0.010*	0.020***	−0.030***

Panel A: GLS regression of the *sum* over each sub-period of excess returns ($Z - b_0$) on factor sensitivities b plus a constant, producing estimates of F_k^* (cumulative over each 3-month sub-period). Standard errors are calculated as described in Section 3. Observed fundamental is the sum of observed monthly changes in log exchange rates and log interest rates over the 3 months for each sub-period. Pre-crisis, crisis, and post-crisis cover 4/97-6/97, 7/97-9/97, 10/97-12/97, respectively. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.
Panel B: Presents the difference between the effective fundamental (summed over the 3 month sub-period) reported in panel A and the observed fundamental (also reported in panel A). Standard errors are not reported as they are the same as those reported in panel A. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.

also have significantly negative implied exchange rates in the pre-crisis period. However, these currencies were classified as managed floats in the pre-crisis period and the implied depreciations do not differ significantly from those observed. We therefore do not interpret the negative implied fundamental in the pre-crisis period as evidence that the market anticipated the imminent collapse of the currencies.

Aside from anticipation, the failure of the market to fully react to the devaluation may be due to anticipated "overshooting." That is, the large drop in the value of the currency is not expected to persist (as the normal-period random walk process would imply), but instead bounce back as the classic overshooting model would predict. In this case, we would see a positive δ for the exchange rate in the crisis sub-period, but a negative value in the post-crisis sub-period. We should note that a positive post-crisis δ does not imply that the exchange rate actually appreciates, but that, whatever the realized movement, the market reacts as if the exchange rate moved by δ less than observed. There is evidence consistent with overshooting in Korea, the Philippines, and Brazil. For example, in Korea the effective depreciation during the crisis sub-period is significant but, at 6%, is much smaller than the observed fall of 62%. During the post-crisis sub-period, the Korean won did in fact *appreciate* by 21%. However, we estimate an effective *depreciation* of 8% in the

Table 8
Results for Philippines 1997

	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental
Panel A: Effective fundamentals (F^*)						
Δe (b_e)	−0.024	−0.009	−0.046	−0.170	−0.127***	−0.084
	(0.028)		(0.030)		(0.029)	
Δr (b_r)	−0.013	0.004	0.041**	0.043	0.009	0.021
	(0.014)		(0.016)		(0.015)	
Constant	−0.226***		−0.245***		−0.121***	
	(0.032)		(0.033)		(0.033)	
Firms	104		104		104	
R^2	0.04		0.11		0.17	

Fundamental	Pre-crisis	Crisis	Post-crisis
Panel B: Difference between effective and observed fundamentals (δ)			
Δe	−0.014	0.124***	−0.043
Δr	−0.017	−0.002	−0.012

Panel A: GLS regression of the *sum* over each sub-period of excess returns ($Z - b_0$) on factor sensitivities b plus a constant, producing estimates of F_k^* (cumulative over each 3-month sub-period). Standard errors are calculated as described in Section 3. Observed fundamental is the sum of observed monthly changes in log exchange rates and log interest rates over the 3 months for each sub-period. Pre-crisis, crisis, and post-crisis cover 4/97-6/97, 7/97-9/97, 10/97-12/97, respectively. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.
Panel B: Presents the difference between the effective fundamental (summed over the 3 months sub-period) reported in panel A and the observed fundamental (also reported in panel A). Standard errors are not reported as they are the same as those reported in panel A. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.

post-crisis sub-period, suggesting that investors expected an even larger appreciation. This is noteworthy given that the rally of early 1998 appeared to have been a surprise to many observers. For example, shortly before this "disappointing" appreciation, the January 6, 1998, issue of the *Wall Street Journal* carried a headline, "Asian Currencies Tumble Against Dollar—Downward Spiral Appears Unlikely to End Soon."

The results on exchange rates show regularity across crises. Effective devaluations are significant, but substantially smaller than observed movements. Moreover, the market seems to have expected a partial reversal of the initial devaluations in many of the crises, suggesting overshooting.

The results on interest rates, on the other hand, show important differences across crises. In the case of Sweden, as discussed before, the spike in interest rates as the currency came under attack was completely discounted by the market. In the introduction, we noted a similar rapid increase in Mexican interest rates. In the case of Mexico, however, the effective increase in the interest rate was more than 26 percentage points, even larger than the observed increase of 22%.[19] This implies that investors treated the peso crisis as a

[19]The difference is not statistically significant at traditional confidence levels. However, when we isolate December 1994 in Mexico on its own (not reported), the implied δ is significant.

Table 9
Results for Indonesia 1997

	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental
Panel A: Effective fundamentals (F^*)						
Δe (b_e)	0.066	−0.012	−0.467***	−0.292	−0.667***	−0.349
	(0.078)		(0.080)		(0.082)	
Δr (b_r)	−0.005	0.025	0.009	0.294	0.028	−0.081
	(0.046)		(0.047)		(0.048)	
Constant	0.056*		−0.150***		−0.289***	
	(0.033)		(0.034)		(0.034)	
Firms	135		135		135	
R^2	0.02		0.24		0.23	
Fundamental		Pre-crisis		Crisis		Post-crisis
Panel B: Difference between effective and observed fundamentals (δ)						
Δe		0.078		−0.176**		−0.318***
Δr		−0.030		−0.285***		0.109**

Panel A: GLS regression of the *sum* over each sub-period of excess returns ($Z - b_0$) on factor sensitivities b plus a constant, producing estimates of F_k^* (cumulative over each 3-month sub-period). Standard errors are calculated as described in Section 3. Observed fundamental is the sum of observed monthly changes in log exchange rates and log interest rates over the 3 months for each sub-period. Pre-crisis, crisis, and post-crisis cover 4/97-6/97, 7/97-9/97, 10/97-12/97, respectively. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.
Panel B: Presents the difference between the effective fundamental (summed over the 3 months sub-period) reported in panel A and the observed fundamental (also reported in panel A). Standard errors are not reported as they are the same as those reported in panel A. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.

significant tightening in credit market conditions. Consistent with this, Aguiar (2005) documents that the combination of dollar-denominated debt and devaluation in Mexico exerted a negative impact on a firms ability to invest. In the case of Malaysia, the effective change in interest rates was zero, even though observed interest rates decreased during the crisis sub-period. The (statistically significant) difference between effective and observed interest rates suggest the market did not anticipate a loosening of credit as a result of the devaluation. In fact, Malaysia did increase interest rates in the post-crisis sub-period, a move which the market appears to have anticipated given the negative post-crisis δ. In the Philippines, the effective increase in interest rates was 4%, very close to the observed value, also suggesting tightening of credit conditions.

The story is markedly different regarding interest rates in the other countries in our sample. During the crises in Thailand and Indonesia, the market apparently ignored the increase in the interest rates observed during the crises. Interestingly, in Korea and Brazil the effective change in interest rates is in fact *negative*. This indicates that rather than credit markets tightening, investors in these countries viewed the currency crises as heralding an easing of monetary policy. While this is consistent with the classic view linking weak

Table 10
Results for Brazil 1999

	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental
Panel A: Effective fundamentals (F^*)						
$\Delta e(b_e)$	−0.044**	−0.017	0.004	−0.540	−0.024	0.180
	(0.021)		(0.024)		(0.024)	
$\Delta r(b_r)$	−0.010	0.152	−0.119**	0.002	−0.121**	−0.089
	(0.041)		(0.058)		(0.058)	
Constant	−0.018*		−0.020*		0.007	
	(0.010)		(0.012)		(0.012)	
Firms	73		73		73	
R^2	0.03		0.03		0.06	

Fundamental	Pre-crisis	Crisis	Post-crisis
Panel B: Difference between effective and observed fundamentals (δ)			
Δe	−0.027	0.545***	−0.204***
Δr	−0.161***	−0.121**	−0.031

Panel A: GLS regression of the *sum* over each sub-period of excess returns $(Z - b_0)$ on factor sensitivities b plus a constant, producing estimates of F_k^* (cumulative over each 2-month sub-period). Standard errors are calculated as described in Section 3. Observed fundamental is the sum of observed monthly changes in log exchange rates and log interest rates over the 3 months for each sub-period. Pre-crisis, crisis, and post-crisis cover 9/98-11/98, 12/98-2/99, 3/99-5/99, respectively. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.
Panel B: Presents the difference between the effective fundamental (summed over the 3 months sub-period) reported in panel A and the observed fundamental (also reported in panel A). Standard errors are not reported as they are the same as those reported in panel A. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.

currencies with easy money, it stands in contrast to the modern view that combines high interest rates and weak banks to produce a credit crunch. This latter scenario finds more support in the results for Mexico and, to a lesser extent, the Philippines. It may be the case that the spike in interest rates is accompanied by alternative methods of financing that mitigate the net effect of the credit crunch. For example, Aguiar and Gopinath (2005) document a marked increase in foreign acquisitions of cash-poor firms during and after the Asian crisis of 1997.

Looking at the pre-crisis sub-period, we see little evidence that markets anticipated the large interest rate hikes. There is also little evidence of anticipation of reverting interest rates in the post-crisis period. Specifically, the post-crisis δ's on the interest rate sensitivities are not significantly different from zero in Korea, Thailand or Brazil, implying that effective fundamentals equal observed fundamentals in these sub-periods. The one exception in emerging markets is Indonesia, which discounted the crisis jump in interest rates, perhaps expecting a fall in interest rates later (as indicated by the positive post-crisis δ on interest rates). In the case of Mexico, the positive crisis interest rate δ is weakly (in a statistical sense) matched by a negative post-crisis δ, which could be interpreted as the initial overreaction was in anticipation of future interest rate hikes (which did in fact occur).

Table 11
Results for Sweden 1992

	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental	Effective fundamental	Observed fundamental
Panel A: Effective fundamentals (F^*)						
$\Delta e(b_e)$	−0.034	0.004	0.049	−0.048	−0.034	−0.132
	(0.034)		(0.034)		(0.033)	
$\Delta r(b_r)$	0.015	0.488	−0.019*	−0.485	0.001	−0.013
	(0.010)		(0.010)		(0.010)	
Constant	−0.255***		0.032		0.015	
	(0.030)		(0.030)		(0.030)	
Firms	114		114		114	
R^2	0.04		0.07		0.01	

Fundamental	Pre-crisis	Crisis	Post-crisis
Panel B: Difference between effective and observed fundamentals (δ)			
Δe	−0.038	0.097***	0.098***
Δr	−0.473***	0.466***	0.014

Panel A: GLS regression of the *sum* over each sub-period of excess returns ($Z - b_0$) on factor sensitivities b plus a constant, producing estimates of F_k^* (cumulative over each 3-month sub-period). Standard errors are calculated as described in Section 3. Observed fundamental is the sum of observed monthly changes in log exchange rates and log interest rates over the 3 months for each sub-period. Pre-crisis, crisis, and post-crisis cover 8/92-9/92, 10/92-11/92, 12/92-1/93, respectively. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.
Panel B: Presents the difference between the effective fundamental (summed over the 2 months sub-period) reported in panel A and the observed fundamental (also reported in panel A). Standard errors are not reported as they are the same as those reported in panel A. $*$, $**$, $***$ refer to significance at the 10%, 5%, and 1% levels, respectively.

5. Concluding remarks

In this paper we study the relationship between asset prices and macroeconomic fundamentals during currency crises. We show that investors discount the large depreciations that take place during crises. There is evidence that this may be due to exchange-rate overshooting.

Moreover, interest-rate sensitivity is often an important determinant of stock performance during crises, suggesting that credit market conditions play a significant role during these episodes. Interestingly, the sign of the implied interest rate innovation varied across countries. This may be due to two opposite effects on credit markets arising from devaluations. On the one hand, depreciations are traditionally associated with a loosening of monetary policy, especially if the monetary authorities had been trying to defend the peg by raising interest rates. On the other hand, devaluations might entail a worsening in credit market condition through its effect on collateral value and balance sheets. It is noteworthy that the response of implied interest rates varied in sign across apparently similar emerging market countries. In future work we hope to identify which

Table A.1
Effective fundamentals (F^*): Alternative first stage sample

Country		Pre-crisis	Crisis	Post-crisis
Mexico	$\Delta e(b_e)$	−0.016	−0.238***	−0.072
		(0.047)	(0.055)	(0.048)
	$\Delta r(b_r)$	0.052	0.313***	0.041
		(0.068)	(0.079)	(0.069)
Korea	$\Delta e(b_e)$	−0.008	−0.073***	−0.059***
		(0.018)	(0.018)	(0.019)
	$\Delta r(b_r)$	−0.022	−0.013**	−0.030***
		(0.006)	(0.006)	(0.006)
Thailand	$\Delta e(b_e)$	−0.083*	0.006	−0.101**
		(0.042)	(0.040)	(0.045)
	$\Delta r(b_r)$	−0.059***	−0.021	−0.094***
		(0.017)	(0.016)	(0.018)
Malaysia	$\Delta e(b_e)$	−0.061***	−0.093***	−0.168***
		(0.016)	(0.016)	(0.018)
	$\Delta r(b_r)$	−0.008	−0.003	−0.014***
		(0.005)	(0.005)	(0.005)
Philippines	$\Delta e(b_e)$	−0.063***	−0.063***	−0.105***
		(0.023)	(0.022)	(0.023)
	$\Delta r(b_r)$	−0.005	−0.000	0.004
		(0.004)	(0.004)	(0.004)
Indonesia	$\Delta e(b_e)$	−0.029	−0.456***	−0.775***
		(0.082)	(0.086)	(0.094)
	$\Delta r(b_r)$	−0.000	0.016	0.060
		(0.043)	(0.045)	(0.049)
Brazil	$\Delta e(b_e)$	−0.130**	−0.116**	−0.025
		(0.057)	(0.054)	(0.052)
	$\Delta r(b_r)$	−0.062***	−0.046**	−0.039**
		(0.018)	(0.018)	(0.017)

This table recomputes effective fundamentals for each country using an alternative first stage sample. Specifically, the first stage sensitivities (betas) were estimated using a sample restricted to the first 24 months after the crisis window (or less, if data did not span entire period). The estimation used for Panel A of Tables 4–10 was then performed on these alternative betas. The columns "pre-crisis,""crisis," and "post-crisis" have the same meaning as the column headings in the original tables' Panel A. Standard errors are in parantheses.

factors explain this variation and whether the differences in implied fundamentals foreshadow differences in the speed of recovery.

In this paper we focused on crises as distinct form non-crisis periods, under the implicit assumption that crises are the most extreme and therefore the most important episodes to study. The methodology could be used to estimate effective fundamentals for any period

Table A.2
Effective fundamentals (F^*): Alternative fundamental innovation

Country		Pre-crisis	Crisis	Post-crisis
Mexico	$\Delta e(b_e)$	−0.005	−0.238***	−0.014
		(0.037)	(0.043)	(0.038)
	$\Delta r(b_r)$	0.025	0.245***	0.055
		(0.048)	(0.055)	(0.048)
Korea	$\Delta e(b_e)$	−0.012	−0.065***	−0.075***
		(0.020)	(0.020)	(0.020)
	$\Delta r(b_r)$	0.003	−0.013	0.009
		(0.015)	(0.015)	(0.015)
Thailand	$\Delta e(b_e)$	−0.121***	−0.057	−0.223***
		(0.041)	(0.041)	(0.042)
	$\Delta r(b_r)$	0.014	−0.062*	−0.076**
		(0.035)	(0.035)	(0.036)
Malaysia	$\Delta e(b_e)$	−0.060***	−0.102***	−0.156***
		(0.019)	(0.019)	(0.020)
	$\Delta r(b_r)$	−0.001	0.008	−0.004
		(0.006)	(0.006)	(0.006)
Philippines	$\Delta e(b_e)$	−0.026	−0.061**	−0.133***
		(0.028)	(0.028)	(0.030)
	$\Delta r(b_r)$	−0.010	0.006	0.001
		(0.013)	(0.013)	(0.014)
Indonesia	$\Delta e(b_e)$	0.085	−0.451***	−0.648***
		(0.078)	(0.080)	(0.082)
	$\Delta r(b_r)$	0.010	0.007	0.024
		(0.044)	(0.045)	(0.046)
Brazil	$\Delta e(b_e)$	0.089***	0.156***	0.090***
		(0.027)	(0.036)	(0.032)
	$\Delta r(b_r)$	−0.114*	−0.207**	−0.207**
		(0.063)	(0.100)	(0.093)

This table models fundamentals as an AR(1) process. In particular, we estimate an AR(1) for each fundamental and each country and use the residuals as innovations for the first stage regressions. With these new betas, we recompute the effective fundamental during the crisis window. The results reported above are comparable with those reported in Panel A of Tables 4–10. Standard errors are in parantheses. It should be kept in mind that the observed fundamental implied by the AR(1) (not reported) will not necessarily equal the observed fundamental from the random walk model (reported in Tables 4–10). However, there are no major discrepancies between the two alternative series.

for which we observe the cross section of stock returns. We have checked whether effective fundamentals during crises do indeed differ from those implied by the cross-section of returns in other months. Not surprisingly, we found that in most cases effective exchange rate movements during crises are extreme outliers. That is, while effective fundamentals do not move as sharply as the observed exchange rate during crises, they are nevertheless unusual events. Similarly, the movement in the effective interest rate in Mexico, Malaysia, and the Philippines were in the tail end of the sample.[20] We also feel that the methodology used in this paper may be useful in other contexts in which a short time series can be augmented with a rich cross section. One important application that comes to mind are models of exchange rates with regime switches or time varying parameters.[21]

Appendix

The estimated effective fundamentals are robust to alternative first stage samples (Table A.1) and alternative fundamental innovations (Table A.2).

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[20]A previous draft of the paper included both the methodology and results for these tests. It is available from the authors.

[21]We are grateful to our referee for pointing us in this direction.