CONTAGION IN EMERGING MARKETS: when *Wall Street* is a carrier

Guillermo A. Calvo*
University of Maryland
www.bsos.umd.edu/econ/ciecalvo.htm
First Draft: December 30, 1998
This Draft: May 2, 1999

Abstract. The paper examines the case in which the capital market is populated by informed and uninformed investors. The uninformed try to extract information from informed investors' trades. This opens up the possibility that if informed investors are forced to sell emerging market securities to meet margin calls, for example, this action may be misread by the uninformed investors as signaling low returns in emerging markets. The paper presents a simple model in which this type of *Wall Street* confusion may result in a collapse in emerging markets' output.

* A rough version of these notes was presented at the AEA 1999 New York Meetings, and at the Winter Camp in International Finance, organized by the Center for International Economics (University of Maryland) and the Faculty of Economics (Universidad de los Andes, Bogota, Colombia) in Cartagena, Colombia, January 7-11, 1999. I would like to acknowledge with thanks useful comments by Enrique Mendoza, Maury Obstfeld, and other seminar participants.

I. Introduction

Prior to the Tequila crisis of 1994/5 in Mexico, balance-of-payments crises in emerging-market economies were quickly attributed to macroeconomic mismanagement, the first and foremost suspect always being an 'unsustainable' fiscal deficit. The Mexican crisis questioned this conventional view because the country was coming from a long stability period in which important structural reform projects were undertaken and, on the whole, fiscal deficit had been brought under control. After a little while, however, the conventional wisdom started to change, and consensus began to shift in the direction of focusing not just on the fiscal deficit, but on the current account deficit–undoubtedly a more encompassing measure of a country's deficit. Mexico showed some weaknesses in that respect, because its current account deficit was about 8 percent in 1994 and was programmed to rise to 9 percent in 1995. This was considered 'unsustainable' for Mexico, given its poor growth record.[1]

The new crisis paradigm had hardly begun to fly when Asia fell into disarray. The unsustainability flag could not easily be raised in this instance, especially for countries like Korea and Indonesia. It was then that, for the first time, the conventional wisdom started to pay serious attention to what is likely to be central to all recent crises, namely, financial sector weaknesses.

Looking at the financial sector, one begins to find threads that are common to all emerging markets. A salient aspect was the existence of short-term debt which, in most cases, was denominated in foreign exchange (and, thus, could not be liquidated through devaluation) and, in several instances, a weak and poorly supervised domestic financial system. However,

[1] In Calvo (1998 a) I have argued that the analysis underlying the sustainability of current account deficits leaves much to be desired, but the topic will not be discussed because it is not central for our purposes here.

before the pieces of the puzzle could be put together, Russia announced (in August 1998) a surprise partial repudiation of its public debt. Russia's trade with most emerging markets is insignificant (particularly with those located in Latin America), and its GDP represents a scant 1 percent of world's output. However, the shock wave spread all over emerging markets, and even hit financial centers. What happened?

The dominant theory is that–due to market incompleteness and financial vulnerabilities–many economies around the globe, and especially emerging-market economies, exhibit multiple equilibria. No one has yet provided a good theory about equilibrium selection, but multiple-equilibrium models allow to make statements like 'upon seeing Russia default, investors thought that other emerging-markets countries would follow suit, tried to pulled out and drove those economies into a crisis equilibrium.' Moreover, in a formal model exhibiting multiple equilibria, the crisis can be made consistent with rationality (models that can be adapted to provide that kind of explanation are, for instance, Obstfeld (1994), Calvo (1998 b), Cole and Kehoe (1996)).

In this note I will take a different tack, and explore the underpinnings of a model in which a key factor behind the spread of the Russian shock lies at the heart of the capital market. So I will not shift the focus away from the financial sector, but I will explore the possibility that Wall Street could help spread the virus. The basic ideas have been summarized in Calvo (1998 c and d) in an informal way. The present note continues the analysis by providing a more formal discussion of the central insights.

The key notion underlying the models is that knowing about emerging-market economies involves large fixed costs relative to the size of investment projects. Learning about an individual country is costly. One has to learn about its economy and politics, which requires a team of experts constantly monitoring those variables. Economies change at a rapid pace, especially in emerging-market economies with incipient political systems. Thus, monitoring has to be frequent and in depth. However, there is no great cost differential between learning about macro variables in the U.S. and, say, a small country like Paraguay. In fact, a large country like the U.S. may exhibit more stability in its macro variables, making frequent monitoring less necessary. Therefore, fixed learning costs may be especially relevant for small emerging-market economies.

Fixed costs generate economies of scale and, hence, the financial industry is likely to organize itself around *clusters of specialists*. This makes it plausible to assume that there exists a set of informed and a set of uninformed investors. The former likely leverage their portfolios (those who know better about a given project have incentives to borrow to finance it) and, thus, are potentially liable to margin calls.[2] In fact, to all accounts, important specialists invested in Russian debt and were subject to margin calls as its value plunged after repudiation. Section II starts from this observation and presents two models for explaining the behavior of the uninformed. In both models, the problem faced by the uninformed is that they can only observe price and, occasionally, some details of the investment strategy followed by specialists. However, if they see the latter selling emerging-market securities, or, more simply, staying out of auctions of new bonds, for example, they could not tell exactly whether it reflects negative information about those securities or that the specialists were subject to margin calls. Thus, they

[2] The economics of margin calls or, more generally, of collaterals will not be discussed in this paper.

face a “signal extraction” problem. The first model in Section II will show an example in which if the volatility of emerging-markets returns is high relative to, say, margin calls, then it will be rational to attach high probability that the signal received by the uninformed reflects conditions in emerging markets. The second model in Section II gets essentially the same result in terms of a more elementary setup. Thus, these models help to rationalize a situation in which the capital market (the uninformed part of it) took the events surrounding the Russian shock as indication that there were fundamental problems with emerging markets in general, and tried to pull their funds from all of them. The Appendix shows that these phenomena can be captured in terms of a general equilibrium model, patterned after Grossman and Stiglitz (1980). The main difference with the latter is that I assume that the uninformed can observe informed investors’ trades, albeit imprecisely.

Section III explores “multiplier” effects that magnify the initial shock. It pursues some ideas developed in Calvo (1998 d) according to which a sudden stop in capital inflows (provoked by the Russian shock, for example) can wreak havoc on financial systems, unless financial contracts are indexed to the sudden-stop state of nature (which is unlikely when the shock comes via Russia and margin calls in Wall Street). It will be argued that this channel may give rise to multiple equilibria, but the relatively novel insight is that, even under equilibrium uniqueness, the sudden-stop channel may produce multiplier effects that help to magnify the initial shock. Section IV concludes, and discusses possible extensions.

II. Signal Extraction. Two Simple Models

This section will discuss two simple models in which rational but imperfectly informed individuals may take a signal emitted by informed investors as a good indicator of prospects in emerging markets. The signal is imperfect and sometimes reflects conditions inherent to informed investors–like the margin calls that reportedly took place after Russia decided to repudiate some of its debt–and provide no information on emerging markets. Thus, these models show that emerging markets could be innocent victims of shocks that lie completely outside their realm and control. This insight is further explored in the Appendix in terms of a complete general equilibrium framework.

Model 1. Informed investors take an observable (for the uninformed investors) action *y* (e.g., buy emerging markets bonds). This action is motivated by a combination of the following two variables: *s* and *m*. Variable *s* is an accurate signal of returns on emerging market securities: the larger is *s*, the larger is the return. This is the variable that uninformed investors would like to know (not *y*). In turn, variable *m* reflects factors that are relevant only for the informed (e.g., margin calls, profitability of investment projects available to informed investors only, see Wang (1994)). For simplicity, we assume that

$$y = s - m. \tag{1}$$

Uninformed individuals are able to observe *y*, and are assumed to know the unconditional distribution of *s* and *m*. Informed individuals know the exact value of the two variables.

Let $s \sim n(\bar{s}, \sigma^2)$, and $m \sim n(0, \tau^2)$, where function *n* denotes normal distribution and, as usual, the first argument denotes the mean and the second the variance of the associated random variable. These are the *unconditional* distributions of *s* and *m*. Upon observing *y*, however, the uninformed can compute the *conditional* distribution of *s* and *m* (conditional on *y*, of course). In particular, it can be shown that if *m* and *s* are stochastically independent, the conditional distribution for *s* is $n(\theta y + (1-\theta)\bar{s}, \theta\tau^2)$, where $\theta = \dfrac{\sigma^2}{\sigma^2 + \tau^2}$. The intuitive plausibility of the result can be appreciated in limiting cases.[3] Thus, for example, if τ is very close to zero, the idiosyncratic variable *m* would be nearly a constant and, hence, it is plausible to attribute most of the change in *y* to changes in *s*. That is precisely what the formula implies since in that case $\tau^2 \simeq 0$ and $\theta \simeq 1$. Notice that while the conditional mean of *s* is a function of the observed variable *y*, its conditional variance is not.

The case $\theta \simeq 1$ is very interesting because it shows the possibility that uninformed investors will react very strongly even though the change in *y* is provoked, say, by margin calls. Our formal results imply that one can get $\theta \simeq 1$ even though τ^2 is 'large'. For, what is actually required is that τ^2 be small *relative to* σ^2. A characteristic of emerging-markets economies is the relatively high volatility of variables like terms of trade (see Hausmann and Rojas-Suarez (1996)), which will be reflected in large σ^2. On the other hand, margin calls and serious liquidity problems in Wall Street are likely to be more the exception than the rule. Consequently, the case for σ^2/τ^2 large is not hard to make. In this context, the Russian shock can be interpreted as the outcome of a large positive shock to *m*, e.g., large margin calls, which resulted in a sizable cut in observed *y*.

<u>Model 2</u>. In contrast with previous model, we assume that *s* and *m* can take two values indicated by $x^L < x^H$, $x = s,m$. Observable variable *y* also takes two values $y^L < y^H$, as follows:

---

[3] The model is isomorphic to that underlying the Lucas Supply Function in Lucas (1976).

$$
\begin{aligned}
&y = y^H \; if \;\; s = s^H \; and \; m = m^L, \\
&y = y^L, otherwise.
\end{aligned}
\quad \textbf{(2)}
$$

This captures a situation in which the informed send a negative signal (i.e., $y = y^L$) if either they get negative information about the profitability of emerging-markets securities (i.e., $s = s^L$), or they are subject to, say, margin calls (i.e., $m = m^H$). Otherwise, they send a positive signal (i.e., $y = y^H$). Again, we assume that variables m and s are stochastically independent.

Hence, the set of possible events $\Omega = \{(s^L,m^L),(s^L,m^H),(s^H,m^L),(s^H,m^H)\}$, and

$$
P(s^L / y^L) = \frac{P(s^L)}{1 - P(s^H)P(m^L)}, \quad \textbf{(3)}
$$

where P is the probability measure on Ω. As a result, as $P(m^L) \rightarrow 1$, we have $P(s^L/y^L) \rightarrow 1$. Therefore, again, uninformed investors are going to attach a large probability to the "bad" outcome (i.e., $s = s^L$) after observing $y = y^L$ if the "bad" idiosyncratic shock (i.e., m^H) has low probability.

III. Sudden Stop. Multiplier Effect

Extensions to a dynamic setting could rationalize positive and negative shocks to emerging markets coming from Wall Street but, unless one introduces serial correlation, there will be a quick reversion to the mean. Serial correlation could be introduced through random variables s and/or m, but this is not a satisfactory modeling strategy. Much better would be to obtain serial correlation from fundamental economic considerations. Moreover, if the analysis rested there, large shocks to emerging markets would be predicated on the existence of equivalently large Wall Street shocks. This is possible, but more interesting would be to identify mechanisms that *magnify* Wall Street shocks. The present section will identify 'multiplier' effects, and channels that might contribute to serial correlation in dynamic settings.

I have argued elsewhere that a sudden stop (i.e., a sizable and largely unanticipated stop) in capital inflows could result in a collapse of marginal productivity of capital in emerging-markets economies (Calvo (1998 c)). One can formalize this situation by postulating that the unconditional mean of *s*, $\bar{s}$, is decreasing function of the (relative) size of the sudden stop. Let production in emerging-market economies be proportional to their capital stock, *k*, and the factor of proportionality be given by *s*. Consider Model 1 above. Suppose that the return on projects outside emerging-market economies is normally-distributed. Thus, in the context of a one-period portfolio choice model, one could write the demand for *k* as a function of the conditional expectation of *s* only (recall that the variance of the conditional distribution for *s* is constant with respect to *y* and $\bar{s}$). The higher is *y* or $\bar{s}$, the larger will be the demand for emerging-markets securities. More specifically,

$$k = K\left(\theta y + (1-\theta)\bar{s}\right),\ K' > 0, \tag{4}$$

for some differentiable function *K*.

The sudden-stop effect can be captured by postulating that the unconditional expectation of *s* is a positive function of the difference between *k* and, say, its expected value from previous period's perspective. Taking the latter as given, one can thus simply write

$$\bar{s} = \Phi(k),\ \Phi'(k) > 0, \tag{5}$$

for some differentiable function Φ. Function Φ is likely to be concave as a drop in *k* is likely to have a larger impact than an equivalent rise.

By equations (4) and (5),

$$k = K\big(\theta y + (1-\theta)\Phi(k)\big). \qquad \textbf{(6)}$$

The expression on the right-hand side of equation (6) is an increasing function of *k*. Therefore, the sudden-stop effect is capable of giving rise to *multiplicity of equilibria*. This is possible because, for example, a smaller *k* lowers the expected marginal productivity of capital (i.e., lowers $\bar{s}$), which induces a lower demand for *k*. But even in cases where equilibrium is unique, the sudden-stop component implies interesting results. Thus, for instance, assuming $(1-\theta)K'\Phi' < 1$, we get, by totally differentiating expression (6) with respect to *y*,

$$\frac{dk}{dy} = \frac{\theta K'}{1-(1-\theta)K'\Phi'} > \theta K' > 0. \qquad \textbf{(7)}$$

The direct impact of *y* on *k* is $\theta K'$ but, by (7), the impact is magnified by multiplier $1/[1-(1-\theta)K'\Phi'] > 1$.

Interestingly, the direct impact of *y* on *k* increases with θ–which, by last section's analysis is attributed to a larger relative variance of the marginal productivity of capital–while the multiplier is lower as θ rises. The net effect of a rise in θ is ambiguous. To show it, differentiate (7) with respect to θ; thus,

$$\frac{\partial}{\partial\theta}\left(\frac{dk}{dy}\right) = \frac{K'(1-K'\Phi')}{\left[1-(1-\theta)K'\Phi'\right]^2}. \qquad \textbf{(8)}$$

The bracketed expression in the numerator of the right-hand side of expression (8) can be of either sign.

Modeling the Demand for Emerging Markets Securities, *K*.

Calvo (1998 b) and Calvo and Mendoza (1998) show that as the capital market gets more globalized, the response of investors to news about expected returns (as a proportion of a country's investment) may increase without bound.

It is worth noting that *K'/K* will also be large if *K* is 'small' (one way of characterizing emerging markets), and *K'* is somewhat invariant to *K* (i.e., total investment in emerging markets). Thus, for example, this property would hold in a portfolio model in which returns are normally distributed and the utility function exhibits constant absolute risk aversion, because *K* is linear in the rate of return (= *s*, in this paper's notation) and, hence, *K'* is totally invariant with respect to *K* (see the Appendix).

These examples illustrate the possibility that being small in a globalized capital market may make *K'/K* large, magnifying the damage caused by a negative signal coming from the capital market. (For further discussion, see the Appendix.)

IV. Final Words

- The key insight of the above analysis is that under asymmetric information, rational but imperfectly informed investors could react very strongly to signals emitted by informed individuals. Those signals, in turn, may be due to factors that are relevant to informed individuals (e.g., margin calls) but that bear no relationship to fundamentals in emerging-markets economies. Moreover, sudden-stop effects contribute to the existence of multiple equilibria, and may give rise to multiplier effects. These elements help to explain why the Russian shock so virulently spread beyond Russia and still lingers on after a long period in which it has become apparent that much of the global turmoil was caused by problems in the capital market itself (e.g., margin calls), and little or nothing to new problems in emerging-market economies (except Russia).

- The paper does not discuss how the signal is emitted by the informed. This is an important issue that may be left for another occasion. However, it is worth pointing out that specialists may send a negative signal even if they do not run down their stock of emerging-markets securities. This is so because emerging markets exhibit current account deficits that need financing. Thus, absence (or diminished presence) of specialists in the auctioning of new emerging-markets securities is likely to be noticed and taken as a negative signal.
- This note places special emphasis on *quantity* signals, while much of the traditional finance literature has focused on *price* signals (e.g., Grossman and Stiglitz (1980), Wang (1994)). I feel that price signals are less relevant in emerging markets because those markets have a relatively short life span and have exhibited sizable volatility, largely unrelated to 'fundamentals.'[4] However, assuming that the uniformed pay attention to price signals will not in general eliminate the effects highlighted in this paper. Actually, price signals could aggravate the effects on margin calls (as shown in Genotte and Leland (1990) and, more recently, Kodres and Pritsker (1998)).
- The paper assumes the existence of one homogeneous emerging-markets security. Extensions are straightforward. A simple extension is to assume that there is a variety of

---

[4] However, financial analysts seem to pay a great deal of attention to sovereign bonds prices.

securities, indexed by $i = 1,. . .,I$. Let us assume that (1) the returns on securities are mutually independent random variables, (2) the unconditional distribution for the return on security i is $n(\bar{s}, \sigma^2)$, the same for all i, and (3) there is an observable variable associated with each security $y_i = s_i - m$. Then, if there exists a large number of securities, uninformed investors could closely estimate m and, in that fashion, approximately pinpoint the value of each s_i.

However, the assumption of a common m shock in all the y_i equations is hard to justify in a context where there are sizable fixed information costs. Under those conditions, there will be few investors who are informed about *all* emerging markets. Most of them are likely to specialize on a few of them. Thus, the polar case in which there exists and m-type shock for each y_i, e.g., $y_i = s_i - m_i$, where m_i are mutually stochastically independent could be a better approximation. Clearly, increasing the number of markets in this case yields no informational bonus. Actually, Calvo and Mendoza (1999) show examples where incentives to collect information declines with the number of markets, which would worsen the forecast-error problem.

- The above models are static, while sudden-stop effects are essentially dynamic. An unexpected change in the demand for emerging- markets securities causes disruptions in the financial sector because (in a richer, though straightforward, model) it brings about unexpected changes in relative prices. Thus, in a realistic scenario with incomplete financial contracts (in which, for instance, the loan rate of interest is not made contingent on variables like y), a change in relative prices may cause bankruptcy and, through that channel, bring about a fall in the marginal productivity of capital. However, these effects are likely transitory. As firms are dismantled, new firms will spring to life. Thus, the initial drop in the marginal productivity of capital may be followed by a renaissance in which marginal productivity increases over time and even overshoots its value prior to crisis.

- A deeper analysis, of course, will have to rationalize why loan interest rates are not indexed to observables like y. One answer is that y may be observable but hard to *verify* (Townsend (1976)). Another is that indexation to y is likely to be a function of the indexation rules adopted in other contracts since, for example, a given firm's financial difficulties likely depend on the financial situation of its clients and suppliers (through the interenterprise-credit channel, for example)–the latter, in turn, being a function of the adopted indexation formulas. The complexity of the problem may be so great that one could possibly invoke bounded-rationality considerations for market incompleteness.

Appendix

I will show that the asymmetric-information results discussed in Section II can be obtained in a conventional general equilibrium context in which the uninformed make their forecasts on the basis of *quantity* decisions taken by the informed (extensions to the case in which uninformed investors also look at prices are discussed later in the Appendix).

I will borrow the basic framework from Grossman and Stiglitz (1980), GS. There are two periods (*present* and *future*), and two assets: a safe asset (a pure bond, say) yielding ρ units of future output, and a risky asset yielding r units of future output (this asset could be identified as an "emerging-markets assets"). Let us assume

$$r = s + \varepsilon,\ s \sim n(\bar{s}, \sigma^2),\ \varepsilon \sim n(0, \omega^2). \tag{9}$$

Informed investors will be assumed to know s but no ε. Thus, contrary to Section II, information is incomplete, even for informed investors. This is a necessary assumption in the present context–in which, following GS, I allow for unlimited short sales–to ensure a well-defined optimal portfolio. Letting $\overline{b_i}$ and $\overline{x}_i$ denote the initial stock of the safe and risky assets, respectively, held by investor i, his budget constraint satisfies:

$$px_i + b_i = p\overline{x}_i + \overline{b_i}, \tag{10}$$

where x_i , b_i , and p stand for the demand for the risky and safe assets by investor i, and the present output price of the risky asset in terms of the safe asset, respectively. Thus, future wealth of individual i, W_i, satisfies:

$$W_i = \rho b_i + r x_i. \qquad \textbf{(11)}$$

The utility function exhibits constant absolute risk aversion, CARA, and thus can be expressed as follows:

$$-e^{-\alpha W_i},\ \alpha > 0, \qquad \textbf{(12)}$$

where α is the coefficient of absolute risk aversion.

As noted, informed investors know *s* but not ε (only its distribution). On the other hand, uninformed investors know the distribution of both variables, but can directly observe neither. Within each type, investors are identical. Thus, I will use subindex *I* and *U* to indicate the per capita portfolio choices of the informed and uninformed investors, respectively.

I will assume that all the random variables defined here are mutually stochastically independent. Under these assumptions, the informed investors' optimal portfolio can be shown to satisfy (see GS):

$$x_I = \frac{s - \rho p}{\alpha \omega^2}. \qquad \textbf{(13)}$$

Uninformed investors are not totally in the dark about *s*. They do not have a long and stable stock market series from which they can infer something about *s*, but I will assume that they can observe the actions of the informed, subject to some noise *z*. Formally, I assume that the uninformed can observe $\tilde{x}$, where[5]

$$\tilde{x} = x_I - z,\ z \sim n(0, \kappa^2). \tag{14}$$

Thus, by (13) and (14),

$$\tilde{x} = \frac{s - \rho p}{\alpha\omega^2} - z. \tag{15}$$

Hence,

$$y \equiv \tilde{x}\alpha\omega^2 + \rho p = s - m,\ m \equiv \alpha\omega^2 z. \tag{16}$$

Moreover, if we set $\tau^2 = \alpha^2\omega^4\kappa^2$, it follows that $m \sim n(0,\tau^2)$. Uninformed investors observe y and, on that basis, infer the statistical properties of s. This is precisely the problem solved in the first model in Section II. Let us denote by r^e random variable r after observing y. Then, it follows that $r^e \sim n(\theta y + (1-\theta)\bar{s}, \theta\tau^2 + \omega^2)$, where, again, $\theta = \sigma^2/(\sigma^2 + \tau^2)$. Hence, optimal portfolio for the uninformed satisfies:

$$x_U = \frac{\theta y + (1-\theta)\bar{s} - \rho p}{\alpha(\theta\tau^2 + \omega^2)}. \tag{17}$$

Therefore, by (16) and (17), we get,

---

[5] GS assumes that the total supply of the risky asset is random and the uninformed cannot observe it directly. Our results carry over to that case with just minor formal changes. The present assumption, however, will help to draw a sharp distinction between *quantity* and *price* signals.

$$x_U = \frac{\theta(s - \alpha\omega^2 z) + (1-\theta)\bar{s} - \rho p}{\alpha(\theta\tau^2 + \omega^2)}. \tag{18}$$

Notice that, as expected, if informed and uninformed have the same information (i.e., $z = 0$, $\kappa^2 = 0$), we have $\theta = 1$, and equation (18) boils down to (13). In all other cases, however, signaling error, represented by z, is a factor in the portfolio decisions of the uninformed.

The model is closed by imposing equilibrium conditions. Assuming a fixed net supply of assets, and assuming total supply of the risky asset equals 1, we can state the general equilibrium condition as follows:

$$\lambda x_I + (1-\lambda)x_U = 1, \tag{19}$$

where λ is the share of informed investors in total population, and total population is set equal to unity. A brief look at equations (13) and (18) shows that, given s and z, equation (19) determines p. Moreover, p increases with s and declines with z (or m). The impact of z depends positively on the share of uninformed. Thus, given the motivation behind these notes (where m plays a prominent role), it is useful to examine the extreme case in which the informed investors are of measure zero, i.e., $\lambda = 0$. By (18) and (19), we have $x_U = 1$, which implies

$$p = \frac{\theta(s - \alpha\omega^2 z) + (1-\theta)\bar{s} - \alpha(\theta\tau^2 + \omega^2)}{\rho}. \tag{20}$$

Therefore,

$$\frac{\partial p}{\partial z} = -\frac{\theta\alpha\omega^2}{\rho} = -\frac{\sigma^2}{\sigma^2 + \tau^2}\frac{\alpha}{\rho}\omega^2, \tag{21}$$

which increases in absolute value as κ^2/σ^2 declines. Thus, we have obtained the same type of result that we got in the first model of Section II: misinformation has an increasingly large impact on prices or quantities as the relative volatility of misinformation goes to zero. Notice that, as in the text, the relevant concept is κ^2/σ^2, not just κ^2.

In the present model we also get results about the distribution of prices, which paint a similar picture. Thus, by (20), the unconditional expectation of $p = \bar{s}/\rho$, i.e., it equals (as one would have guessed) the expected return on the risky asset divided by the gross return on the safe asset, while its unconditional variance is

$$\frac{1}{\rho^2}\frac{\sigma^4}{\sigma^2+\tau^2} = \frac{\theta\sigma^2}{\rho^2}, \tag{22}$$

which, once again, increases as κ^2 declines. However, the existence of uninformed investors *reduces* price volatility. Notice, for instance, that if $\lambda = 1$ and, thus, the uninformed investors are nil, we have, by (13) and (19), that the unconditional variance of p would be

$$\frac{\sigma^2}{\rho^2}, \tag{23}$$

which is larger than the expression in (22).

Sudden Stop effects discussed in Section III are easily captured if one assumes that the unconditional expectation of s, i.e., $\bar{s}$, is an increasing function of p. For instance, assuming $\bar{s} = \hat{s} + \beta p$, where $\hat{s}$ is some fixed parameter, expression (20) becomes

$$p = \frac{\theta(s - \alpha\omega^2 z) + (1-\theta)\hat{s} - \alpha(\theta\tau^2 + \omega^2)}{\rho - \beta(1-\theta)}. \tag{24}$$

I will focus on the case in which the denominator is positive, since it (plausibly) implies a positive association between *s* and equilibrium *p*. Armed with this result, it is straightforward to show, for instance, that the variance of equilibrium price becomes

$$\frac{\theta\sigma^2}{[\rho-(1-\theta)\beta]^2}. \tag{25}$$

Thus, the unconditional variance of *p* is larger, the larger is the SS effect, β. Interestingly, the SS effect vanishes as κ^2/σ^2 goes to zero. This is so because for κ^2/σ^2 small, the uninformed respond almost exclusively to informed investors' behavior, and tend to ignore a priori information about *s*. However, SS effects are likely to increase the variance of *s*, σ^2, a channel that is disregarded in this analysis.

Would equilibrium change if the uninformed extracted information from prices? The answer is "no" in the extreme case examined earlier in which the informed are of measure zero. Prices would just reflect what the uninformed learn from the informed investors' *trades*, and nothing else. The information obtained by informed investors does not get reflected in prices because they are insignificant players. However, if $\lambda > 0$, prices will convey additional information. Conceivably, information contained in prices could be so good that the uninformed will altogether stop looking at trades. This would be the case at equilibria in which prices are fully revealing, i.e., *p* reveals *s* (an example is shown below). However, if prices are not fully revealing (see, for instance, the examples discussed in GS), the uninformed investors would still have incentives to use information about informed investors' trades. This implies that the effects highlighted in this paper will still hold in the richer model. It would, however, be interesting to gain a deeper understanding about the interaction between price and quantity signals as the share of the informed investors, and other parameters are varied.

It is useful to contrast the equilibrium concept developed above with the one in GS. GS assumes that individuals can observe market prices but not quantities. Interestingly, under the GS assumptions, there exists an equilibrium in which the uninformed would be able have *exactly the same information* as informed investors! To see this, let us assume that the statement holds true. Thus, since both types have the same utility function, the equilibrium condition in the risky-asset market will be, recalling (13) and (19),

$$\frac{s-\rho p}{\alpha\omega^2}=1. \qquad \textbf{(26)}$$

Therefore, in that equilibrium s would be fully revealed by prices (since $s = \alpha\omega^2 + \rho p$).[6] Clearly, as pointed out above, if the economy settles down to this equilibrium, uninformed investors will have no incentive to learn about informed investors' trades.[7]

---

[6] This equilibrium concept makes sense only if $\lambda > 0$. Otherwise, prices cannot convey information about s. When $\lambda = 0$, the uninformed entirely rely on their prior information. This "discontinuity" at $\lambda = 0$, is key to the GS examples displaying nonexistence of equilibrium when λ is endogenously determined.

[7] This is an imprecise statement in a static framework like ours. More precise would be to say that "if investors believe that the other investors believe that equilibrium prices satisfy equation (22), then the uninformed would have no incentive to learn about informed investors' trades, and equation (22) will be satisfied at equilibrium."

References

Calvo, Guillermo A., 1998 a, "The 'Unforgiving' Market and the *Tequilazo*," in *Financial Reform in Developing Countries*, edited by J.M. Fanelli and R. Medhora; London: Macmillan Press Ltd.

Calvo, Guillermo A., 1998 b, "Varieties of Capital Market Crises," in G.A.Calvo and M.King (editors) *The Debt Burden and its Consequences for Monetary Policy*, Chapter 7; London: Macmillan Press Ltd.

Calvo, Guillermo A., 1998 c, "Understanding the Russian Virus–with special reference to Latin America," paper presented at the Deutsche Bank's conference "Emerging Markets: can they be crisis free?," Washington, DC, October 3, 1998.

Calvo, Guillermo A., 1998 d, "Capital Flows and Capital Market Crises: The Simple Economics of Sudden Stops," *Journal of Applied Economics*, vol. 1, nº 1, November, pp. 35-54.

Calvo, Guillermo A., and Enrique G. Mendoza, 1999, "Rational Contagion and the Globalization of Securities Markets," *Journal of International Economics*, forthcoming.

Cole, Harold L., and Timothy J. Kehoe, 1996, "A Self-Fulfilling Model of Mexico's 1994-95 Debt Crisis," *Journal of International Economics*, September.

Gennotte, Gerard, and Hayne Leland, 1990, "Market Liquidity, Hedging, and Crashes," *American Economic Review*, Vol. 80, 5, December, pp. 999-1021.

Grossman, Sanford J., and Joseph E. Stiglitz, 1980, "On the Impossibility of Informationally Efficient Markets," *American Economic Review*, 70, June, pp. 393-408.

Hausmann, Ricardo, and Liliana Rojas-Suarez (editors), 1996, *Volatile Capital Flows: Taming Their Impact on Latin America*, Washington: Inter-American Development Bank.

Kodres, Laura E., and Matthew Pritsker, 1998, "A Rational Expectations Model of Financial Contagion," manuscript, October.

Lucas Jr., Robert E., 1976, "Econometric Policy Evaluation: A Critique," *Carnegie-Rochester Conference Series on Public Policy*, vol. 1.

Obstfeld, Maurice, 1994, "The Logic of Currency Crises,"<u>Cahiers Economiques et Monetarires</u>, No. 43, Banque de France.

Townsend, Robert M., 1976, "Optimal Contracts and Competitive Markets with Costly State Verification," *Journal of Economic Theory*, vol. 21, October, pp. 265-293.

Wang, Jiang, 1994, "A Model of Competitive Stock Trading Volume," *Journal of Political Economy*, vol. 102, nº 1, February, pp. 127-168.