

Contagion and Firms' Internationalization in Latin America: Evidence from Mexico, Brazil, and Chile

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Abstract

We investigate whether contagion matters when emerging market firms cross-list their stocks in a developed capital market. We develop a rational expectations model where financial markets are segmented along emerging markets' borders and contagion spreads from one emerging market to another through the actions of international investors rebalancing their portfolio using stocks cross-listed in the developed market. We find that contagion is a cost of internationalization as cross-listed stocks are more affected by contagion than pure domestic stocks. Furthermore, a welfare analysis of international cross-listing versus financial autarky suggests that the benefits of internationalization in terms of less information asymmetry and better market efficiency offset the costs of contagion. The model is able to explain some transmission of the 1998 Brazilian crisis to Mexico and Chile.

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1 Introduction

The paper analyzes whether financial contagion affects differently international stocks in contrast to pure domestic stocks when there is an emerging market crisis, all other stock characteristics being controlled for. We define contagion as the transmission of a shock in one country to the stock price in another country. We define international stocks as emerging market stocks that are listed in both their local market and an international capital market through cross-listing, and pure domestic stocks as stocks only traded in their domestic market.

We develop a rational expectations model that provides a measure of the cost of contagion when emerging market firms cross-list their stocks in a common developed market exchange. In that context, contagion occurs through the action of investors buying and selling cross-listed stocks when they are faced with a liquidity, information, or country specific shock. In that purpose, our model makes the distinction between emerging markets and developed markets; and, in each market, between international stocks and pure domestic stocks. We depart from the common assumption that all financial markets are perfectly integrated. Instead, we argue that markets are segmented along emerging markets' borders. Specifically, emerging market investors mostly invest in their domestic market, whereas developed market investors aka international investors invest in the cross-listed stocks.

As an application, we calibrate our model using a unique dataset of cross-listed stocks and pure domestic stocks in Brazil, Chile, and Mexico. The calibration exercise allows us to investigate whether our model can explain the transmission of the 1998 Brazilian crisis to Mexico and Chile through the action of international investors buying and selling stocks cross-listed in the U.S. And in that context, the model reveals what type of shocks were mostly transmitted.

Finally, we assess whether the benefits of internationalization offset the costs of contagion in our model by performing a welfare-comparison of financial cross-listing versus financial autarky for all investors.

We find that international cross-listing is costly because of contagion: the price response in one emerging country to a shock in another emerging country is significantly stronger for cross-listed stocks than for pure domestic stocks, all other characteristics being controlled for. However, we find a magnitude of contagion that is smaller than reported in other models of contagion that assume perfectly integrated financial markets, which suggests that the magnitude of contagion may have been overestimated in previous studies. Furthermore, shocks in one emerging market are transmitted to all the emerging markets

that have cross-listed stocks in the same developed market even if the emerging markets do not share common economic factors.

The calibration exercise suggests that our model can explain the transmission of the Brazilian crisis to Mexico and Chile through the action of international investors rebalancing stocks cross-listed in the U.S. We find that negative liquidity and country specific shocks were the most important determinants of contagion.

The welfare analysis of international cross-listing versus financial autarky suggests that investors are better off internationally cross-listing their stock versus autarky. Indeed, the benefits of internationalization in terms of reduced information asymmetry and improved market efficiency in all the markets (as highlighted in the literature) offset the costs of contagion in terms of an increase in volatility and a drop in stock prices.

Overall, the findings of the paper confirm that internationalization increases firms' exposure to contagion. And international investors play a role in spreading contagion to pure domestic firms in emerging markets. But most importantly, the welfare analysis emphasizes that the benefits of internationalization are greater than the costs of contagion. Our model is able to explain some cases of contagion and pinpoint which type of shocks were mostly transmitted for the 1998 Brazilian crisis to Mexico and Chile.

The rest of the paper is organized as follows: Section 2 presents a brief literature review of cross-listing and contagion to motivate the model; Section 3 develops the model and interprets contagion within the model and presents the results, in this section we also perform robustness tests to determine how results are affected by the choice of parameters; Section 4, the calibrated model is used to derive the determinants of contagion to Mexico and Chile during the 1998 Brazilian crisis. Section 5 presents, using the model, a welfare analysis of financial internationalization through cross-listings versus financial autarky; Section 6 concludes and suggests policy implications and avenues for future research.

2 Literature Review

International cross-listing boomed in the last decade as a mechanism to circumvent market segmentation in emerging markets and to allow emerging market firms to access international capital markets. Indeed, internationalization enables emerging market firms to raise capital at a lower cost and to increase their shareholder base. In the same vein, internationalization allows investors in developed countries to achieve emerging market's diversification benefits and higher returns right at home¹. Indeed, investment barriers through taxes, ownership

¹For instance, in 2002, there were 470 foreign listings in the New York Stock Exchange, and their market capitalization represented 30% of the total exchange.

restrictions, and information asymmetry create market segmentation in emerging markets. This segmentation is reflected in the existence of a price premium between shares accessible to foreign investors and shares restricted to local investors. Domowitz, Glen and Madhavan (1999) show evidence of significant price premia for unrestricted stocks from Mexico, reflecting market segmentation due to foreign ownership restrictions. Thus, international investors have reduced incentives to directly invest in a domestic market. In that context, internationalization through cross-listing becomes a mechanism for emerging market firms to circumvent market segmentation and access global securities markets.

The literature on cross-listing provides mixed results on whether internationalization (cross-listing) is beneficial or detrimental to the development of the domestic market. Alexander and al (1987) show that cross-listing produces an externality effect by indirectly integrating the market for pure domestic securities with the foreign market. Levine and Schmukler (2002) show that cross-listings result in a drop of liquidity in the domestic market. Hargis (2002) investigates different types of liberalizations including direct listing of securities in U.S. exchanges, and finds that volatility decreases in Latin America after liberalization. Karolyi (2003) claims that the growth of ADRs neither facilitate nor hinders the development of the local stock market. Domowitz et al (1998) highlight that the ultimate effect on the local market depends on the inter-market transparency.

The literature on contagion provides some insight on why internationalization may spread contagion to emerging markets, however there is little evidence why international (cross-listed) firms should be differently affected by contagion than purely domestic firms. International investors, who hold international assets may spread financial crises to emerging markets through several channels. For instance, a crisis in one country may cause investors to revise their expectations for another country, and sell off the country's assets regardless of fundamentals (Masson (1998)).

In this paper, we consider the portfolio rebalancing channel of contagion, which advocates that liquidity calls cause some investors to rebalance their portfolios. International assets being more liquid than pure domestic ones, they might be liquidated first. When information is asymmetric, uninformed market participants may mistakenly interpret the actions of informed investors as a signal of low expected returns, liquidate those assets, and trigger contagion (Calvo and Mendoza (1998), Calvo(1999), and Kodres and Pritsker (2002)). Indeed, the globalization of capital markets reduces incentives for uninformed investors to gather costly information and herding proves to be a profitable strategy which exacerbates contagion (see Calvo and Mendoza (1999)).

Pritsker (2000) shows that negative wealth shocks cause investors with decreasing risk aversion to reallocate part of their portfolios towards less risky assets, thereby spreading contagion to countries in the same region. Allen and

Gale(2001) show that contagion occurs when banks hold interregional claims as insurance against liquidity shocks. Actions of banks or non bank financial market participants (mutual funds, hedge funds) may trigger financial market contagion when there is correlated information.

If international investors help spread contagion, we should expect contagion to affect more international firms than pure domestic firms. Boyer, Kumagai and Yuan (2002) find empirical evidence supporting that there is more contagion to "investable" stocks that are open to foreign investors than to "non-investables". Similarly, Sakho (2003) finds empirical evidence that contagion from the 1998 Brazilian crisis affected more international firms than pure domestic firms in Chile and Mexico.

In this paper, we bridge the literatures on international cross-listings and on contagion to investigate whether international firms in contrast to pure domestic firms are more affected by financial contagion when there is a crisis in another emerging market. To our knowledge the question, of essence for both emerging and developed markets, has received little attention, if any, in the literature. Bekaert et al (2002) empirically document the overall effect of contagion on market integration, however their study focuses on the change in market betas during crisis period. They do not distinguish between international firms and pure domestic firms.

3 A Rational Expectations Model of Contagion and Cross-listing

We extend Kodres and Pritsker (2002) in two directions. First, we make the distinction between developed market and emerging market. In each market, we distinguish between international stocks, traded in both the local and the international capital market, and pure domestic stocks, only traded in the local market. Second, we assume that markets are segmented along emerging markets borders. That is emerging market investors can only invest in the own stock, which are either cross-listed stocks and pure domestic stocks². Internationalization (cross-listing) is in the model the only way for international investors to buy emerging market stocks and hence diversify and earn higher returns; and for emerging market investors to access developed capital markets and hence raise capital at a lower cost and increase their shareholder base.

We assume an early stage of market integration, where firms from emerging countries do cross-list some of their assets in the developed market, but firms from the developed market do not cross-list their assets in emerging markets. For the sake of simplicity, we can assume that we have two emerging countries

² Alexander et al (1987) points that emerging market firms have resorted to cross-listing to circumvent the negative effects of market segmentation as an investment barrier.

and a developed country. In each emerging country, we have two assets, an international asset and a domestic asset. The international asset in emerging market 1 represents an equally weighted portfolio of all the international assets in emerging market 1, and the domestic asset represents an equally weighted portfolio of all pure domestic assets. Indeed, firms that internationalize are usually the biggest firms in terms of market capitalization and value traded. Hence, by taking equally weighted portfolios, we eliminate size and industry effects and focus on contagion.

We use the same indices for countries and investors: 0 represents the developed country, 1 represents emerging country 1, 2 represents emerging country 2. We use the following indices for assets: 0 is only traded in country 0, 01 is traded in countries 0 and 1, 02 in countries 0 and 2, 1 only in country 1, and 2 only in country 2.

Overall there are five assets. Let's define the 5 by 1 vector of risky assets X such that

$$X = [X_0, X_{01}, X_{02}, X_1, X_2]'$$

We make the following additional assumptions:

A1: Investors have Constant Absolute Risk Aversion (CARA) preferences.

A2: Short Sales with use of proceeds are permitted in all countries.

A3: Domestic and Foreign securities returns are joint-normally distributed.

A4: In all countries, there is the same risk free asset with the same gross rate of return normalized to 1.

A5: All assets are in fixed net supply $\bar{X}$.

We assume a two-period endowment economy. Investors trade assets in the first period, and they consume the liquidation values of assets in the second period. Investors behave competitively, in that they take prices as given.

Let P, V, θ be 5 by 1 vectors such that:

P is the price at which trade takes place at first period, V is the random liquidation value of the asset at second period, and θ represents the information of informed traders, it is such that

$$V = \theta + U,$$

where U is a residual uncorrelated to θ .

The unconditional distribution (θ, U) is a bivariate normal.

$$(\theta, U) \sim N \left(\begin{pmatrix} \bar{\theta} \\ 0 \end{pmatrix}, \begin{pmatrix} Var(\theta) & 0 \\ 0 & Var(U) \end{pmatrix} \right)$$

Informed investors differ from uninformed investors in that informed investors know θ , (the information shock) whereas uninformed investors do not know θ . However, uninformed investors can make rational decisions about their portfolio choices, based on their knowledge of the unconditional distribution of (θ, U) , and on the prices they observe at first period P , which reveal some information about θ . We assume that informed investors in the developed country have the same information than informed investors in the emerging country regarding the international stock and that informed investors in the two markets are sufficiently small not to reveal all their private information at equilibrium. The number of informed investors in each country is μ_I , whereas the number of uninformed investors is μ_{UI} .

We assume that investors in each country are identical in terms of risk aversion and first period endowment. They all have CARA utility functions with the same risk tolerance parameter τ , and same first period wealth W_1 .

We also assume that markets are segmented along emerging markets borders, or that investors can only invest in assets that are traded in their domestic market. Investors in the developed market can invest into its pure domestic asset X_0 , and in the international stocks from emerging country 1 and emerging country 2, (X_{01}, X_{02}) . In contrast, investors in emerging market $i = 1, 2$, can only invest in the international asset X_{0i} , and in the pure domestic asset X_i .

Let's define the following matrices R_i selecting the assets that investor $i = 0, 1, 2$ is not allowed to trade

$$R'_0 = \begin{bmatrix} 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$R'_1 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$R'_2 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{bmatrix}$$

Therefore, the constraint that investor i can only trade certain assets is:

$$R'_i X = 0$$

3.1 Investors' Demand Functions

Informed investor i chooses his positions X_i^I in the risky assets X to maximize his end of period wealth W_2 , conditional on information, θ .

X_i^I is a function of (P, θ) , and it is a 5 by 1 vector that solves

$$\text{Max } E(-\exp(-W_2/\tau) | \theta)$$

subject to a budget constraint

$$W_2 = W_1 + X'(V - P)$$

And a market segmentation constraint:

$$R_i' X = 0$$

Let's define the five by five matrices N_i such that

$$N_i = [I_5 - R_i(R_i' R_i)^{-1} R_i']$$

Where I_5 represents the 5 by 5 identity matrix.

The optimal choice is

$$X_i^I = \tau(\text{Var}(U))^{-1} N_i(\theta - P) \quad (1)$$

Similarly, uninformed investors choose their positions X_{UI} in the risky assets X , to maximize their end of period wealth W_2 conditional on prices P .

X_i^{UI} is a function of P , it is a 5 by 1 vector that solves

$$\text{Max } E(-\exp(-W_2/\tau) | P)$$

subject to subject to a budget constraint

$$W_2 = W_1 + X'(V - P)$$

and the market segmentation constraint

$$R_i' X = 0$$

The optimal choice is

$$X_i^{UI} = \tau \text{Var}(V|P)^{-1} N_i (E(V|P) - P) \quad (2)$$

Noise traders sell and buy assets based on their own idiosyncratic need for liquidity. Let ε be the demand of risky assets by noise traders, ε follows a normal distribution. It is uncorrelated with the demands of other investors, and with the fundamental value of the assets.

$$\varepsilon \sim N(0, \text{Var}(\varepsilon)) \quad (3)$$

3.2 Market Clearing Conditions

At equilibrium, the market clearing conditions equate the demand and the supply of each asset across markets to find equilibrium prices. However, because cross-listed assets are traded in two markets, their demand has two components: the demand of the domestic market and the demand from the market where the asset is cross-listed. The rationality condition for investors requires an additional condition on the consistency of the beliefs of uninformed investors about the information revealed by prices at equilibrium. These two conditions represent the market clearing equations

3.2.1 Market clearing equation

The fixed supply of the asset, represented by the 5 by 1 vector $\overline{X}$, is equal to the sum of the demand of liquidity traders, the demand of all informed investors and the demand of uninformed investors across the three markets.

$$\overline{X} = \varepsilon + \mu_I \sum_{i=0}^2 X_i^I + \mu_{UI} \sum_{i=0}^2 X_i^{UI}$$

In order to get a more concise notation, we can define the 5 by 5 matrices A and A_V such that

Let N be a 5 by 5 matrix

$$N = \sum_{i=0}^2 N_i$$

$$A = \text{Var}(U)^{-1} N$$

$$A_V = \text{Var}(V|P)^{-1} N$$

The market clearing condition becomes:

$$\overline{X} = \varepsilon + \mu_I \tau A (\theta - P) + \mu_{UI} \tau A_V [E(V|P) - P] \quad (4)$$

3.2.2 Consistency Conditions and Expressions of $E(V|P)$ and $Var(V|P)$

In the market clearing equation (4), all the terms depending on P can be regrouped on the left hand side in a term we call $S(P)$.

$$\begin{aligned} S(P) &= (\mu_I \tau A)^{-1} \overline{X} + P - (\mu_I \tau A)^{-1} * \mu_{UI} \tau A_V [E(V|P) - P] \\ &= (\mu_I \tau A)^{-1} \varepsilon + \theta \end{aligned} \quad (5)$$

This equation illustrates the fact that in equilibrium, prices do not fully reveal the information of informed agents. Indeed, they reveal θ , but with a noise that is function of ε .

We assume that investors are rational, hence their choices at equilibrium reflect the information they learn about θ through equation (5). This is equivalent to the following consistency conditions:

$$E(V|P) = E(V|S(P)) \quad (6)$$

$$Var(V|P) = Var(V|S(P)) \quad (7)$$

Using the normality of θ and ε , we can infer that $S(P)$ is also normal, and the previous equations yield the expressions of $E(V|P)$ and $Var(V|P)$. See Model Appendix.

From Equation (6), we can write $E(V|P)$ as a linear function of θ and ε .

$$E(V|P) = \alpha_1 + \alpha_2 * \theta + \alpha_3 * \varepsilon$$

Where the α_i for $i = 1, 2, 3$ are defined in the Model Appendix.

3.2.3 Equilibrium Prices

By rearranging equation (6) we can express prices P as a function of $E(V|P)$ (which is a linear function of θ , and ε), θ , and ε .

$$P = M_0 + M_1 E(V|P) + M_2 \theta + M_3 \varepsilon$$

Then P can be expressed as a function of the shocks θ and ε by replacing $E(V|P)$ as a function of θ and ε .

$$P = M_0 + M_1 \alpha_1 + (M_2 + M_1 \alpha_2) \theta + (M_3 + M_1 \alpha_3) \varepsilon \quad (8)$$

In equilibrium prices can be expressed as a linear function of information and liquidity shocks. In the context of our model, this allows us to clearly see that shocks to any asset in one country have repercussions in the prices of assets in all the other country. Hence, the decomposition of price as a function of shocks allows us to define contagion and provide two methods to actually measure contagion.

3.3 Contagion: Transmission of Information and Liquidity Shocks across Markets

In this section, we define contagion in the context of a baseline case of the model and we provide two methods of measuring contagion in the model. We adopt the definition of contagion as price movements across-markets in excess of what economic fundamentals would predict. More specifically, we consider in our model the channel of contagion that is due to the action of investors rebalancing their portfolio in the developed country. Indeed, Equation (8) shows that contagion can occur in the model through three channels: through correlated liquidity shocks (through ε), through correlated information shocks (through θ), and finally through investors cross-market rebalancing. One sufficient condition to exclude contagion through correlated liquidity shocks and correlated information shocks is to assume that the covariance matrix of θ , and the covariance matrix of ε are diagonal. In this case, it is not possible for investors to infer information on one asset based on information on another asset. Moreover, it is not possible, to predict a liquidity shock for one asset based on liquidity shocks to another asset. We impose the constraint that the covariance matrices of θ and ε are diagonal, so that contagion occurs only from investors cross-market rebalancing.³

3.4 Baseline Model

This part develops a baseline case of the model that considers the extreme case where the two emerging countries do not share any macroeconomic relations. However, they have cross-listed assets in the same developed country. We solve the baseline case for a set of parameters. We show that in the context of our model, information and liquidity shocks (θ and ε) are transmitted from one emerging country to the other through the action of investors rebalancing cross-listed assets in the developed country. In the context of the baseline case of the model, we define by contagion the transmission of shocks to assets prices from one country to another country that do not share economic fundamentals.

There cannot be cross-country transmission of shocks if countries are small island economies. Technically, in order to generate cross-market rebalancing in our model, we need to have correlated residual shocks or a non diagonal covariance matrix for U ⁴. This condition reflects the fact that for shocks to be transmitted across countries, the countries need to be somewhat linked. Hence, the specification of the baseline case of the model consists of decomposing the

³If we assume that the covariance matrices of θ and ε are non diagonal, we allow for two other channels of contagion : one through correlated information shocks and another through correlated liquidity shocks. Therefore, we cannot guarantee that the contagion we observe is only due to the action of investors rebalancing assets cross-listed in the developed exchange.

⁴We have earlier defined the residuals u_i as
 $v_i = \theta_i + u_i$ for $i = 0, 01, 02, 1, 2$

residuals U_i in terms of global/regional risk factors and country specific risk factors. This further ensures that the variance matrix of U_i is non diagonal.

Let f_i represent a vector of common risk factors that affect asset values in more than one country. They can be interpreted as movements in the oil price, or in the world interest rate.

Let η be a vector of country specific factors. They can be interpreted as shocks to the domestic macroeconomic policy or export shocks specific to the country.

Let β_i be the factors loadings, they can be interpreted as the risk exposure of the asset to the global factor. For instance, we should expect cross-listed stocks to have a bigger risk exposure to the global factor than pure domestic stocks. Similarly, stocks of exporting companies should have a greater risk exposure to the world as compared to stocks of non exporting firms.

All investors know the distributions of U and the values of the β_i .

The residuals U_i can be decomposed as follows:

$$U_i = \beta_i f_1 + \eta_1 \quad \text{for } i = 01, 1$$

$$U_i = \beta_i f_2 + \eta_2 \quad \text{for } i = 02, 2$$

$$U_0 = \beta_0^1 f_1 + \beta_0^2 f_2 + \eta_0$$

The decomposition of the U_i reflects the fact that the two emerging countries do not share any common factor. However, each of them shares a common factor with the developed country, and they both have cross-listed stocks in the developed country.

3.5 Measuring Contagion from Emerging Market 1

3.6 to Emerging Market 2 in the Baseline Case

In this section, we derive two methods to measure contagion, one consists of measuring the price response of assets in emerging market 1 to an information or a liquidity shock in emerging market 2. The second approach consists of a variance decomposition analysis to investigate which part of the variance of prices in emerging market 2 is due to shocks in emerging market 1.

3.6.1 Measuring Contagion through Price Responses

3.6.2 to External Shocks

We use our model to derive the price response of each asset in emerging market 2 to information and liquidity shocks from another asset in emerging market 1. We are able to decompose the price response into a component that is due the revisions of expectations of uninformed investors and another component that accounts for investors portfolio rebalancing actions.

The expression of equilibrium prices in equation (8) allows us to compute the price response of assets by taking the derivative of P with respect to θ and ε .

$$\frac{\partial P}{\partial \theta} = M_1 \cdot \alpha_2 + M_2$$

Where α_2 is the derivative of $E(V|P)$ with respect to θ , defined from equation (7). Therefore, the price response with respect to θ can also be written as:

$$\frac{\partial P}{\partial \theta} = M_1 \cdot \frac{\partial(E(V|P))}{\partial \theta} + M_2 \quad (9)$$

Similarly,

$$\begin{aligned} \frac{\partial P}{\partial \varepsilon} &= M_3 + M_1 \alpha_3 \\ &= M_1 \cdot \frac{\partial(E(V|P))}{\partial \varepsilon} + M_3 \end{aligned} \quad (10)^5$$

In each equation (9) and (10) the price response is in two terms, the first term represents an expectation component, and the second term a portfolio balance component. The expectation component of the price change reflects the part of the price that is due to revisions in the expectations of uninformed investors. The portfolio balance component measures how prices would respond to the shift in the excess demand curve for assets caused by the shocks if the uninformed investors believed that the shock contained no information.

3.6.3 Measuring Contagion through Variance Decomposition

The unconditional variance of prices $Var(P)$ enables us to perform a variance decomposition exercise. Indeed, we are able to measure the proportion of the variance of an asset that is caused by shocks from another asset. This provides us with another measure of how shocks are propagated from one emerging market to another through the action of international investors trading cross-listed stocks.

⁵The expressions of $\frac{\partial P}{\partial \varepsilon}$ and $\frac{\partial P}{\partial \theta}$ show that they are uniquely function of the variances of the shocks θ and ε . Therefore, they can be directly computed once we make assumptions about their distributions.

The 5 by 5 matrix $Var(P)$ can be determined using the decomposition of P in equation (8).

$$Var(P) = M(C\Sigma_\theta C' + D\Sigma_\varepsilon D')M' \quad (11)$$

Where C and D are defined in the Model Appendix.

$Var(P)$ is a function of the variances of the shocks θ, ε .

3.7 Results of the Baseline Case

In this section, we solve the baseline case of our model for a set of the most simple parameters and distributional assumptions. We present the results of contagion in terms of transmission of information and liquidity shocks from assets in emerging country 1 to assets in emerging country 2 and in developed country 0. We present both the price response and the variance decomposition analysis.

3.7.1 Parameters' Value and Distributional Assumptions

We set the risk exposure parameters values as summarized in Table 1.

The intuition for the choice of parameters values is that in the emerging country the risk exposure to the common factor is greater for the international asset than for the pure domestic asset, $\beta_{01} = 1$, whereas $\beta_1 = 0.5$.

In the developed country, the common factors have the same risk exposure $\beta_0^2 = \beta_0^1 = 1$, or the two emerging countries are symmetric for the developed country.⁶

The supply of risky asset $\bar{X}$ is set equal to the 5 by 1 vector of ones.

Besides, one investor is informed for every 100 uninformed investors, that is $\mu_I = 1$, and $\mu_{UI} = 100$. This ensures that prices do not fully reveal information in equilibrium.

Investors' risk tolerance parameter, τ is set equal to 1.

For the sake of simplicity, the risk factors f_i , the country specific factors η_i , the information shocks θ_i , and the liquidity shocks ε_i are all independent standard normal distributions, hence with variance 1.

We consider the price response of all assets to a one standard deviation negative information shock and a one standard deviation negative liquidity shock

⁶We check how the results are affected by changes in the values of the β_i in the robustness section.

from asset 01. The results are presented in Figures 1 and 2. We can summarize the results in three main points:

- A crisis in emerging country 1 affects more the international asset than to the pure domestic asset in country 2.

- A crisis in emerging country 1 that is caused by a shock to the international asset has a greater repercussions in country 2 than a crisis that is caused by a shock to the pure domestic asset.

- Finally, most of the price change in response to a shock comes from the expectation component rather than the portfolio balance component. Therefore, asymmetric information plays an important role in determining the magnitude of contagion.

3.7.2 Shock to international Asset 01 from Emerging Market 1

In this section, we specifically trace back the effect of a one standard deviation negative information/liquidity shock to the international asset in country 1 to all other assets. We give the intuition of the sign of the price response, and the intuition for the results summarized earlier in the context of our baseline case.

Negative Information Shock Let's assume that we start at equilibrium for all portfolios. Then informed investors receive some additional negative information about asset 01. As a consequence, they decrease their expectation of asset 01 liquidation value by $d\theta_{01}$. Their optimal response is to sell some of asset 01 regardless of whether the investor is from developed market 0 or from emerging market 1. The sale decreases the price of asset 01. Uninformed investors infer from the price decrease that informed investors have received a negative signal for asset 01 and they also sell some asset 01, which reinforces the initial price decrease.

Informed investors in emerging 1 have only access to asset 01 and asset 1, so when they liquidate asset 01 their only option is to buy more of asset 1. Thus, the demand for asset 1 should increase and the price of asset 1 should increase.

Informed investors in the developed country 0 have access to three assets: 0, 01, and 02. So when they sell some of asset 01, this lowers their exposure to f_1 below optimal level, they adjust their portfolio by buying some of asset 0, but this increase their exposure to f_2 above optimal level, which they adjust by selling some of asset 02.

Informed sales of asset 02 are partially absorbed by investors from 2. They do so by selling off some of the pure domestic asset 2, whose price decreases. As

a consequence, informed sales from the developed country depreciate the price of asset 01, asset 02, and asset 2, and increase the price of asset 1, and asset 0.

Figure 1 presents the price response of all the assets to a shock to asset 01, the results are obtained using the parametrization described above. Panel A. presents the price response to a one standard deviation negative information shock to asset 01. Panel B. presents the price response to a one standard deviation negative liquidity shock to asset 01. The liquidity shocks are independent from the information shocks.

Results presented in Figure 1, Panel A , confirm this intuition in terms of the sign of the price response of each asset. The table presents the effect of a one standard deviation negative information shock to the international asset 01 to all the assets. The price response is decomposed into an expectation component and a portfolio balance component. Indeed, uninformed traders believe that the action of informed traders might be motivated by negative expected revenues for asset 01 rather than portfolio rebalancing needs. Thus, the expectation component reflects the price change due to the revision of expectations from uninformed traders, whereas the portfolio balance component represent the change in prices due to adjustments to maintain the optimal risk exposure.

Figure 1, Panel A shows that shocks from the international asset 01 are transmitted to both the international and the pure domestic asset in 2, even though the two countries do not share common factors. The most important result from the table is that contagion affects more international stock 02 than the pure domestic stock 2. For instance, the total price response for asset 02 is -0.073, whereas the one for its pure domestic asset 2 it is -0.046. Nevertheless, the asset that experiences the shock, asset 01 is the most affected with a total price response of -0.628. The developed country stock is affected with a price response of 0.132. Finally, the shock is transmitted to the pure domestic asset 1, with a price response of 0.112. The price response of assets in country 2 are of a lesser magnitude.

Figure 1, Panel A further highlights that for all assets, the expectation component of the price response is greater than the portfolio balance component. For instance, for the effect on the domestic asset 1, the expectation component is 0.33, whereas the portfolio balance is a mere 0.0005. Which suggests that most of the price response comes from the actions of uninformed investors trying to determine whether informed investors actions are motivated by expected low profits or portfolio rebalancing.

However, compared to the case where there is no market segmentation, and there is no cross-listing, contagion is much less severe. Indeed, Kodres and Pritsker (2002) assume that there is complete market integration, and investors can freely invest in any assets from any country. They find that the price response for the market index in emerging country 2 is -0.39, which is much

more than the -0.073 price change for asset 02, and the -0.046 price change for asset 2. This suggests that in our model the market segmentation hypothesis reduces the magnitude of contagion.⁷

Negative Liquidity Shock The effect of a negative liquidity shock from asset 01 to all other assets is presented in Figure 1 Panel B.

Indeed, if we suppose that liquidity traders suddenly sell an amount $d\varepsilon_1$ of asset 01. Then informed traders absorb some of the sales but not all, which causes the price of 01 to decrease. Informed traders from emerging market 1 who bought asset 01, sell off some of asset 1, which decreases the price of 1. Investors from the developed market who bought asset 01 sell off some of asset 0 to adjust their exposure to risk factor f_1 .⁸

The sale of asset 0 in the developed market lowers informed investors' exposure to risk factor f_2 below optimal level, so they buy some asset 02 to compensate. This increases the demand of asset 02, so the price of asset 02 increases by 0.035. Uninformed investors in country 2 expect that the value of asset 02 increases also buy asset 02. For those investors, an increase in the acquisition of asset 02 is accompanied by a sale of domestic asset 2, which decreases the price of 2 by -0.09.

Overall, the price effect of a negative liquidity shock from asset 1 is a decrease in the price of assets 01, 2, and an increase in the price of asset 0, 02, and 1.

3.7.3 Shocks to the Pure Domestic Asset 1

3.7.4 from Emerging Market 1

In this section, we investigate in the context of our baseline model, how shocks from the pure domestic asset in emerging country 1 are transmitted to all assets. We consider independent one standard deviation negative information and liquidity shocks. More specifically, we investigate how shocks from the pure domestic asset are differently transmitted to other assets than shocks from the international asset. We find similar direction in the price responses of the assets; however, the magnitude is smaller for shocks originating from the pure domestic asset 1 than for shocks originating from the international asset 01.

⁷Kodres and Pritsker (2002) use a similar parametrization, however they do not make the distinction between developed countries and emerging countries. Moreover, they do not have emerging market assets cross-listed in a developed market. Because emerging markets are segmented.

⁸This explains the fact that the portfolio balance component of the price response for asset 0 is negative (-0.0087). Nevertheless the expectation component is positive (0.0776), and overall the price of asset 0 increases by 0.069.

Negative Information Shock Figure 2 presents the price response to shocks on the pure domestic asset 1, Panel A presents the price response of all assets to a one standard deviation negative information shocks, while Panel B presents price response of all assets to a one standard deviation negative liquidity shocks.

The main result of the table is that shocks from pure domestic asset have smaller repercussions than shocks from international assets.

A negative information shock to asset 01 changes the price of asset 02 by -0.073 whereas the same shock from asset 1 creates a change of price of asset 02 by -0.046, or a 40% smaller price change.

A negative information shock first causes informed investors to sell asset 1, which results in a drop in the price of asset 1. However, uninformed investor infer from the drop of the price that informed investor may have some negative information about the asset. Hence, they sell asset 1 too, reinforcing the initial price decrease of asset 1 to -0.44.

Informed investors from emerging 1 readjust their portfolio exposure to the common factor f_1 by buying asset 01, which increases the price of asset 01 by 0.11. Informed investors from the developed country readjust their portfolio in two steps. They first buy asset 0, then they sell asset 02 to maintain an optimal risk factor exposure relative to factors f_1 and f_2 . The price of asset 02, therefore decreases by -0.046.

The sales of asset 02 are partially absorbed by informed investors in country 2, who buy asset 02 and sell asset 2. Uninformed investors from country 2 observe the sale of asset 2 by informed investors. They infer that informed investors sales are motivated by negative information on the valuation of asset 2. Some uninformed investors follow the signal and sell asset 2, increasing the initial effect to -0.029

Finally, the effect of an information shock to asset 1 is a decrease in the price of asset 1, asset 02, and asset 2; and an increase in the price of asset 01, and asset 0.

Negative Liquidity Shock Liquidity traders sell an amount $d\varepsilon_1$ of asset 1. Informed investors absorb some of the sales but not all, which still causes the price to decrease. Uninformed investors infer that they should sell too, which further decrease the price of asset 1. Hence, the portfolio balance and the expectation components of the price change are respectively -0.026 and -0.457. However, informed investors in country 1 readjust their portfolios by selling asset 01, which decreases the price of the asset by -0.023. Informed investors in country 0 absorb some of the sales of asset 01 but not all, hence the price

of asset 01 still decreases. Informed investors readjust their portfolio by selling asset 0. As a consequence, uninformed investors in 0 also sell asset 01 and buy asset 0 to rebalance their portfolio. This explain in Figure 2 Panel B the positive expectation component for asset 0 of 0.049, and the negative portfolio balance component of -0.0042. Overall the price of asset 0 increases by 0.045.

Informed investors from country 0 sell asset 02 to adjust their portfolio exposure to f_2 . The sales are partially absorbed by informed investors from country 2, who sell asset 2 and buy asset 02. Uninformed investors from country 2 mimic informed investors and also sell asset 2 and buy asset 02. Which results in the positive price change for asset 02 by 0.022, and the negative price change for asset 2 by -0.006.

3.8 Variance Decomposition

In this part, we use another measure of contagion by considering the proportion of the variance of an asset that is caused by shocks from another asset. We consider independent one standard deviation negative information and liquidity shocks. More precisely, we investigate how shocks from asset 01 and asset 1 are propagated to the international asset 02 and to the pure domestic asset 2. This allow us to compare the impact of contagion to international stocks versus pure domestic stocks. We find that shocks to the international asset are transmitted across countries with greater impact than shocks from the pure domestic asset.

Figure 2.3 presents the variance decomposition of prices as a function of shocks to each asset.

The decomposition shows that shocks from the international asset have a greater impact than shocks from purely domestic asset. Indeed, shocks from asset 01 represent 8% of the variance of asset 02 and 7% of the variance of asset 2. In contrast, shocks from asset 1 represent 5% of the variance of asset 02 and 5% of the variance of asset 2.

Shocks from international asset represent 31% of the variance of asset 0, whereas shocks from purely domestic asset represent only 19% of the variance of asset 0.

Not surprisingly, the table also confirms the fact that shocks to a particular asset predominantly affects that stock. Indeed, shocks to international asset 01 represent 74% of its variance, shock to asset 1 represent 13% of the variance of asset 01, whereas shocks to asset 02 and 2 represent respectively 8% and 5% of the variance of asset 01. However, shocks to domestic asset 1 represent around 71% of their own variance, shocks to asset 01 represent 17% of the variance of asset 1, while shocks to asset 02 and asset 2 represent respectively 7% and 5% of the variance of asset 1.

We notice that the portion of variance of country 1 asset due to shock in country 2 is relatively modest (between 5% and 8%), which suggests a more modest contagion, when markets are segmented by barriers to investment, as opposed to the case of perfect market integration described in Kodres and Pritsker (2002).

Overall, our results show that information and liquidity shocks to assets in country 1 will affect both the international and the domestic stock in country 2, with a relative lesser impact on the domestic stock than on the international stock. More importantly, shocks to the international asset are transmitted across countries with greater impact than shocks from the pure domestic asset. Moreover, if investors in the developed market transmits shocks across the two emerging countries through portfolio hedging and cross-market rebalancing. Uninformed investors herding in all countries exacerbates contagion.

The findings in this section support those of Calvo (1998) and Calvo and Mendoza (1999), that international capital markets act as carrier of emerging market crises. Moreover, when information is asymmetric, herding is a profitable strategy for uninformed investors, associated with a higher risk of contagion. Indeed, our results show that most of the price response to shocks comes from the expectation component, which reflects price changes due to the actions of uninformed investors trying to interpret whether the actions of informed investors are motivated by expected low returns or portfolio rebalancing.

Contributions in the literature that focus on the role of international firms in spreading contagion across emerging markets also support our findings. Indeed Frankel and Schmukler (1996) show empirical evidence of contagion from Mexican country funds. They highlight a pattern of contagion where domestic investors react first to shocks, then transmit them to other emerging countries through New York. Boyer, Kumagai, and Yuan (2002) use data on investable stocks, whose shares are open to foreigners, versus non-investable stocks to investigate contagion. They find that there is more transmission of crises in investable stocks that are open to foreigners as compared to non-investable stocks.

3.9 Robustness

In order to better understand our results, we investigate how they are affected by changes in the degree of information asymmetry in all three countries, the exposure to common risk factors through the βs , and the exposure to country specific risk through $Var(\eta)$.

3.9.1 No Asymmetric Information in the Developed Market

In this section, we relax the previous assumption that the proportion of informed investors versus uninformed investors is the same in all three countries. Instead, we assume that all investors are uninformed in the developed market. The assumption is consistent with the findings of Frankel and Schmukler (1996) that investors in emerging markets may be better informed about assets in their country than international investors. One explanation might be that local investors are on site and hence are more able to monitor the firm as well as the economic environment of the country. Using country-funds data, Frankel and Schmukler (1996) show that during the 1994 Peso crisis, local investors lost confidence in the market before investors in New York.

In order to illustrate the importance of the differential in market transparency between emerging countries and developed countries, we solve the simplified case where there is no asymmetric information in the developed country. The results are presented in Figure 4. They are similar to those related to the case of asymmetric information. We do not find that information asymmetry reduces the sensitivity of the developed market prices to order flow, and therefore reduces their exposure to contagion. This suggests that investors in the developed market are less affected by contagion, as suggested by Kodres and Pritsker (2002), only if they are all informed as opposed to a situation where they are all uninformed.

3.9.2 More Information Asymmetry in Emerging Markets

In this section, we investigate the impact of relaxing the assumption the variance of all information shocks is set to one on our results. Indeed, the amount of information asymmetry for asset 02 can be measured by the variance of the information shock to the international asset in country 2, $Var(\theta_{02})$.

More specifically, we consider the effect on the price responses of an increase in the amount of information asymmetry for asset 02, when $Var(\theta_{02})$ take any value in the interval $[0, 5]$.

Figure 5 presents the graph of the price response of international asset 02 and pure domestic asset 2 to an information shock and a liquidity shock from international asset 01, as a function of $Var(\theta_{02})$, which varies from 0 to 5

The graph illustrates that the price response of asset 02 to an information shock from asset 01 increases with the information asymmetry in stock 02. However the price response of asset 2 is not much affected by information asymmetry for stock 02. The price response to liquidity shock follows the same pattern. Indeed, uninformed investors in country 2 first think that the order flow is due to expected low values for the asset rather than investors' portfolio rebalancing, and they increase the price response. The graph suggests that information asymmetry for stock 02 increases transmission of information and

liquidity shocks to stock 02. Therefore we would have obtained greater price response for asset 02 than what we obtained for the baseline model. However, the amount of information asymmetry for asset 02 does not really affect the price response of stock 2. Hence, we can assume that the price response of asset 2 would not have changed. Overall our results are robust to changes in the amount of information asymmetry for asset 02, as measured by $Var(\theta_{02})$.

3.9.3 Risk Exposure of the International Asset

3.9.4 to the Common Factor f_2

In the baseline model, we set the value of β_{02} to one. In this section, we investigate how our results are affected by changes in the value of β_{02} , for any value of β_{02} in the interval $[0, 5]$. Intuitively, β_{02} can be interpreted as the risk exposure of the international asset 02 to the common factor f_2 , as β_{02} increases we should expect greater transmission of shocks to both the international asset 02 and the domestic asset 2. Indeed, the more open the international stock is to the common factor the more useful it is to rebalance portfolio.

Figure 6 presents the price response of international asset 02 and pure domestic asset 2 to an information shock and a liquidity shock from international asset 01 as a function of β_{02} , for values of β_{02} between 0 and 5. The price response of the domestic asset 2 to an information shock from asset 01 increases with β_{02} . In contrast, the price response of the international asset 02 to an information shock from asset 01 increases with the risk exposure of the international asset β_{02} for values of β_{02} between 0 and 2. Then it decreases for values of β_{02} greater than 2. Indeed, as β_{02} increases, the international asset 02 become more useful for hedging the risk exposure to f_2 . Hence, the transmission of information shocks increases with the risk exposure of the international asset in country 2. We should expect more important price responses for both the international asset 02 and the domestic asset 2. However, for values of β_{02} above 2, the asset loses its diversification properties as it is "too" open to the common factor. As investors from country 2 use less the international asset 02 for diversification, the price response of asset 02 should decrease as compared to the baseline case.⁹

3.9.5 Country Risk in Country 2

The country risk is measured by the variance of the country specific factor η_2 , $Var(\eta_2)$. In the baseline model, we assumed that $Var(\eta_2)$ was equal to one.

⁹When the shock from asset 01 is a liquidity shock we observe a similar pattern but with a lower threshold value. The price response of asset 02 increases for values of β_{02} between 0 and 1. Then it decreases with β_{02} for values of β_{02} greater than 1. The price response of asset 2 decreases for values of β_{02} between 0 and 2. Then it increases for values of β_{02} greater than 2.

In this part, we investigate the implication for our results if we assume that $Var(\eta_2)$ can take any value in the interval $[0, 5]$. The intuition is that the greater the country risk in country 2, the less useful the international asset 02 is to rebalance international investors portfolio. Therefore we should expect smaller price responses as compared to the baseline results.

Figure 7 presents the price response of international asset 02 and pure domestic asset 2 to an information shock and a liquidity shock from international asset 01 as a function of the country risk in country 2 measured by $Var(\eta_2)$, for values of $Var(\eta_2)$ in the interval $[0, 5]$.

The price response to an information shock from asset 01 increases with the country factor for both the domestic and the international asset in country 2.

Indeed, we find that when the shock is a liquidity shock, the price response of asset 02 decreases when the country risk increases. However, the price response for asset 2 decreases for values of $Var(\eta_2)$ lower than 1, and increases for values of $Var(\eta_2)$ greater than 1.

Overall, the main results of the baseline model are maintained when we depart from the parametrization set for β_{02} , $Var(\eta_2)$, and $Var(\theta_2)$.

4 Calibration

In this section, we investigate whether the channels of contagion highlighted in our model through the portfolio rebalancing actions of international investors with stocks cross-listed in the U.S. can explain part or the whole of the transmission of the Brazilian crisis to Mexico and Chile. We define the Brazilian crisis as a combination of information, liquidity, and country specific shocks. We calibrate the model using a dataset that distinguishes international firms from purely domestic firms in Brazil, Mexico, and Chile. Given our calibrated model, we determine which combination of shocks generates some transmission of Brazil's shocks to Chile and Mexico. We compare the prediction of our model to what happened in Chile and Mexico as shown in our data. More specifically, our data predicts that the Brazilian crisis had negative repercussions in both the international and the pure domestic asset in Chile and Mexico. Furthermore, international assets were slightly more affected than pure domestic stocks. We find that our calibrated model can produce some modest transmission of the Brazilian crisis to Chile and Mexico that is consistent with the data (and the result of the baseline case of the model). The calibration highlights the role of important liquidity shocks are a determinant of contagion through portfolio rebalancing of cross-listed assets during the Brazilian crisis.

4.1 Expression of Assets Returns in the Model

From our model, we use the valuation of assets at second period and the price at first period to model returns for the assets as a function of the common factors, the country specific shocks, the liquidity shocks and the information shocks.

We decompose the valuations of assets as:

$$V = \theta + \beta f + \eta \quad (12)$$

We can express returns R in the model as the difference between the second period valuation V and the first period price P , from equation (8).

$$\begin{aligned} R &= V - P \\ &= \theta + \beta f + \eta - [(M_0 + M_1\alpha_1) + (M_1\alpha_2 + M_2)\theta + (M_1\alpha_3 + M_3)\varepsilon] \\ &= -(M_0 + M_1\alpha_1) + (I_5 - M_1\alpha_2 - M_2)\theta + \beta f - (M_1\alpha_3 + M_3)\varepsilon + \eta \end{aligned}$$

The M_i and the α_i depend on $Var(U)$, $Var(\theta)$, and $Var(\varepsilon)$ as seen in the Model Appendix. The expression can be rewritten as:

$$R = \alpha + \beta f + \gamma\theta + \delta\varepsilon + \eta \quad (13)$$

Where

f is the vector of common factors

θ is the vector of information shocks

ε is the vector of liquidity shocks

η is the vector of country specific factors

Let's define

$$Res = \gamma\theta + \delta\varepsilon + \eta.$$

We can rewrite the returns equation as:

$$R = \alpha + \beta f + Res \quad (14)^{10}$$

¹⁰ $\alpha = \bar{R} - \beta\bar{f}$

Where $\bar{R}$ and $\bar{f}$ respectively represent the mean of R and f .

4.2 Matching the Model to the Data

The reduced form of equation (14) allows us to use our data to set the parameters βs so that the covariance of the returns in the model are equal to the covariances of returns in the data sample. In order, to get the βs from the data, we need to construct the analog of the assets in our model using the data. The following paragraph briefly presents the data and describes how we match the model to the data.

We use a unique firm-level dataset we constructed by individually matching parent stocks to ADRs¹¹ and cross-listed stocks using Bloomberg and the International Finance Corporation Emerging Market Database (IFC EMDb). Overall, we have weekly data from 01/14/1994 to 12/30/2000 on 344 stocks from Chile, Mexico, and Brazil. The data includes price as well as ADRs programs effective dates in a U.S. exchange (if any) for each stock in our sample. Hence we are able for each stock to determine whether its issuing firm has or has not issued and American Depositary Receipts (ADR) or listed in the NYSE before the Brazilian crisis¹². With that information, we are able to distinguish international stocks from pure domestic stocks before the crisis. We construct for each country, Brazil, Chile, and Mexico an international index based on a portfolio of equally weighted international stocks and a domestic index based on portfolio of equally weighted pure domestic stocks. We also use the Morgan Stanley Capital Index (MSCI World Index) as a proxy for the world common factor, and the S&P500 index as a proxy of the pure domestic stock in the U.S. Hence, the returns of asset 0 from the developed country in our model are represented by the sample returns of the S&P500 index, the returns of the common factor in our model are represented by the returns of the MSCI World Index from the data.

Moreover, Brazil represents emerging market 1 (and the crisis country too). The returns of the international asset in Brazil, asset 01 are represented in the data by the sample returns of the international index that we constructed using stocks of Brazilian firms that issued ADRs or cross-listed in the U.S. before the crisis. The returns of the pure domestic asset in Brazil, asset 1 are represented by the sample returns of the domestic index that we constructed with stocks of firms in Brazil that did not issue American Depositary Receipts (ADR) or list in the U.S. prior to the Brazilian crisis. Emerging market 2, is either Mexico or Chile and the international asset 02 can be similarly obtained in our sample using the index of Mexican or Chilean firms that issued American Depositary Receipts (ADR) or listed in the U.S. prior to The Brazilian crisis. The pure domestic

¹¹For each ADR traded in a foreign exchange, there is an underlying domestic stock from the same company that is traded in the domestic stock. The ADR is redeemable for a given number of shares of the parent stock. Therefore, we consider for the "international stock", the parent stock of the ADR, which is traded in the domestic market. And the firm that issues and ADR is considered an international firm.

¹²We use for the cut off date for the Brazilian crisis December 1998.

asset 2 is represented by the returns of the pure domestic index of Mexican or Chilean firms that never issued American Depository Receipts (ADR) or listed in a U.S. exchange before the crisis.

We use our sample to run the regression implied by our model in equation (14) during the period preceding the crisis from 1/14/1994 to 6/19/1998 as follows.

$$R = \alpha + \beta f_{World} + Res$$

First, from the regression, we are able to identify the parameters β so that the covariance of the returns in the model are equal to the covariances of returns in the sample.

Second, from equation (14), we infer that the variance of the information shock, the liquidity shock, and the country specific shock ($Var(\theta)$, $Var(\varepsilon)$, and $Var(\eta)$) are not separately identified (and not separately identifiable from γ and δ). Only the variance of the sum is identified, $Var(Res)$.

Also, we can identify one parameter γ or δ if we define the crisis in Brazil by a shock (be it an information shock, a liquidity shock, or a country specific shock only), and the magnitude of the shock can be defined as such as it equates the variance of residuals $Var(Res)$ during the pre-crisis period to the variance of residuals during the crisis period.

However, when we do so, the calibrated model does not yield any transmission of shocks to other assets, which suggests that in order to get some cross-market transmission of shock we need to define the crisis in Brazil as a combination of different shocks. Then, even if we assume that the magnitude of the shock matches pre-crisis variance to post-crisis variance, the parameters γ and δ remain separately unidentifiable from $Var(\theta)$, and $Var(\varepsilon)$. Therefore, we need to set some values for the parameters γ and δ . For each set of parameters, we need to consider several scenario where we vary the different contributions of the variance of each shock to the variance of the residuals.

More specifically we consider different weights represented by the triplet (x, y, z) , such that :

$$Var(Res) = \gamma^2 Var(\theta) + \delta^2 Var(\varepsilon) + Var(\eta)$$

$$\gamma^2 Var(\theta) = (x\%) Var(Res)$$

$$\delta^2 Var(\varepsilon) = (y\%) Var(Res)$$

$$Var(\eta) = (z\%) Var(Res)$$

We are specially interested in determining which combinations of shocks (x, y, z) can yield a price response of the Brazilian crisis to Mexico and Chile that is similar to what we observe in the data. That is such that the crisis in Brazil has negative repercussions in both the international and the pure domestic asset in Chile and Mexico. Furthermore, international assets are slightly more affected by the crisis than pure domestic stocks.

However, we need to make some additional assumptions about the other unidentified parameters of the model. Specifically, the numbers of informed investors μ_I and the number of uninformed investors μ_{UI} always appears multiplied by the risk tolerance parameter τ , which suggests that μ_I , μ_{UI} , and τ are not separately identified in our model. We set investors risk tolerance τ to 1 and assume that for one informed investor there is a hundred uninformed investors, that is $\mu_I = 1$ and $\mu_{UI} = 100$. The 5 by 1 vector of supply of risky asset $\bar{X}$ is not identified, we set it to the 5 by 1 vector of one for simplicity.

4.3 Results

Figure 9 presents the sample regression coefficients β for Brazil, Mexico, and Chile during the crisis, and the sample estimate of the variance of the residuals. Figure 2.10 presents the price response in Chile and Mexico to a one standard deviation information shock from Brazil as a function of the relative size of all shocks. The set of parameter considered is $\gamma = 0.001$ and $\delta = 0.0001$.¹³

We find three main results:

-Liquidity shocks seem to be the most important determinant for the Brazilian crisis to be transmitted to Mexico and Chile. Indeed, information shocks alone, or country specific shocks alone cannot explain any transmission of the crisis in Chile and Mexico. For instance, a scenario of (1, 98,1) for both Chile and Mexico, where the variance of the information shocks represent 98% of the total variance of residuals does not yield any transmission of the crisis. Similarly, a scenario where the variance of the country specific shocks represent 98% of the total variance of residuals does not yield any transmission of the crisis for Both Chile and Mexico (See Figure 10). In contrast, a scenario where the variance of liquidity shocks represent 98% of the total variance of residuals yields contagion. Interestingly, a scenario where liquidity shocks and country specific shocks have similar weight (respectively 40% and 60%) and information shocks are negligible also yields contagion.

However, the price response are quite modest in comparison to what the data predicts, we get a mere 0.3% negative price response for the international

¹³The price response change as a function of the values set for the parameters γ and δ . For this set of value presented we obtain some transmission of the crisis to Mexico and Chile.

asset in Chile (for the (60,0.1,39.9%) scenario), which suggest that our model can explain part of the transmission of the Brazilian crisis to Chile and Mexico.

-Whenever, the liquidity shocks and the country specific shocks are important enough to generate contagion, there is more transmission of shocks to international firms than to pure domestic firms. For instance (for the (60,0.1,39.9%) scenario), for Mexico, we get a price response of 1% to the international stock 02, and a mere price response of 0.04% for the pure domestic stock 2. Similarly, the same scenario for Chile yields a price response of 0.3% for the international asset versus 0.2% for the response for the international asset (see Figure 10).

-The bigger the size of the liquidity shocks, the more transmission of the shock. For instance in Mexico, a scenario where the variance of liquidity shocks is 60% of the total variance of residuals yields a price response of the international stock of 1%, while a scenario where the variance of liquidity shocks is less than 40% yields a price response of the international stock in Chile of 0.7%.

-In all scenario, the developed country is unaffected by the crisis, which is consistent with the fact that U.S. market were unaffected by the Brazilian crisis.

Our model highlights a new channel of contagion of the Brazilian crisis to Mexico and Chile through the portfolio rebalancing of cross-listed stocks in the U.S. The direction of the price response in Chile and Mexico to the Brazilian crisis is consistent with the data (and the result of the baseline case of the model) for important liquidity shocks. Indeed, we get a negative price response for both the international and the pure domestic asset in Mexico and Chile, and the international asset is slightly more affected than the pure domestic asset. However, the magnitude of contagion is quite modest. This could mean that our model can only partially explain the transmission of the Brazilian crisis to Mexico and Chile. Or that the role of investors induced contagion was overestimated during the Brazilian crisis. An alternative explanation is that we get a modest transmission of the crisis in the model because of the assumption of market segmentation in emerging markets, which reduces the magnitude of contagion. And this explanation would support other theories in the literature that argue that the magnitude of contagion has been overestimated in the Asian crisis and the Brazilian crisis. Forbes and Rigobon (2002), for instance, argue that most countries in emerging markets did not experience contagion, but rather a continuation of pre-existing macroeconomic interdependence.

The results confirm that the model can at least partially explain the fact that the Brazilian crisis was transmitted to international firms in Chile and Mexico through the action of international investors trading stocks cross-listed in the U.S.. However, this requires certain assumptions for the relative size of the variance of liquidity, information, and country specific shocks. Interestingly, we find that liquidity shocks are the main component to achieve contagion in our model, country specific shocks do play a role too when combined with liquidity

shocks of a certain size. Information shocks however, cannot generate transmission of the Brazilian crisis, even if they are paired with sizeable country specific shocks.

These results are consistent with the "facts" of the 1998 Brazilian crisis: it was seen as an aftermath of the Russian Default, the Brazilian macroeconomic environment was weak and vulnerable. For international investors it was predictable that Brazil would be hit by the crisis next. As for self fulfilling prophecies, liquidity fled out of the country and the economic conditions worsened. In that context, it is plausible that liquidity and country specific shocks seemed to have been the determinants of the transmission of the Brazilian crisis to Mexico and Chile rather than information shocks.

5 Welfare Analysis

By cross-listing in a developed exchange, emerging market firms are able to raise capital at a lower cost and diversify their shareholder base. However, the succession of crises in the nineties proved that contagion could be a cost of cross-listing. Our model confirms that when there is a crisis, international firms are more affected by contagion than pure domestic firms. It is of interest to assess whether contagion jeopardizes the benefits for emerging markets firms to cross-list their assets in developed exchanges. In this section, we address this issue by investigating whether from a welfare standpoint, investors are better off in autarky or in cross-listing. We use in this section, the same parametrization that we used to solve the baseline case of the model, described in Table 1.

5.1 Financial Autarky

In the financial autarky scenario, all markets are separated like small island economies. Thus, there is no distinction between the developed country and the emerging countries, all countries are the same. In each economy, there is a single type of domestic asset, as cross-listing is not an option. Hence, when faced with a shock, investors cannot diversify as all assets are identical and there are no outside opportunities.

We assume that investors in each country can only trade assets in their own market. Let's assume that there is a single risky asset denoted X and a riskless asset that pay a gross return normalized to 1.

5.1.1 Informed Investors

The informed investor chooses his position X^I in the risky assets X to maximize his end of period wealth W_2 , conditional on information, θ .

We compute the expected utility levels over the probabilities distributions for all shocks (θ, ε, U) for informed investors in the autarky case

$$E_I = E_{\theta, \varepsilon, U} (-\exp(-W_2/\tau))$$

$$= \frac{-1}{(1+c^2\Sigma_U^{-1}\Sigma_\varepsilon+b^2\Sigma_U^{-1}\Sigma_\theta)^{1/2}} * \exp[-\frac{W_1}{\tau} + \frac{\Sigma_U^{-1}\bar{U}^2}{2} - \frac{(a+b\bar{\theta}+\bar{U})^2\Sigma_U^{-1}}{2(1+c^2\Sigma_U^{-1}\Sigma_\varepsilon+b^2\Sigma_U^{-1}\Sigma_\theta)}]$$

(See Welfare Appendix)

5.1.2 Uninformed Investors

The expected utility of the uninformed investor in the autarky case can be written as

$$E_{UI} = E_{\theta, \varepsilon, U} (-\exp(-W_2/\tau))$$

$$= \frac{-1}{(1+2V^{-1}B\Sigma_\varepsilon)^{1/2}(1+2V^{-1}D\Sigma_\theta)^{1/2}} \exp\{-\frac{W_1}{\tau} - V^{-1}[da + d\bar{U} - V^{-1}\frac{\Sigma_U d^2}{2} - \frac{\alpha^2}{2}\frac{V^{-1}\Sigma_\varepsilon}{1+2V^{-1}B\Sigma_\varepsilon} - \frac{C^2}{4D} + \frac{(\bar{\theta}+\frac{C}{2D})^2 D}{1+2V^{-1}D\Sigma_\theta}]\}$$

(See Welfare Appendix)

5.2 Cross-listing

In the cross-listing case, we consider the financial internationalization through cross-listings scenario. There are two main differences with the autarky case: first, in the autarky case there is a single risky asset, and second there is no distinction between developed and emerging economies. Now, cross-listings allow us to consider two different types of assets in each country: an international asset and a pure domestic asset and two different types of economies: a developed market and emerging market. More importantly, investors now differ not only with regards to information access, but also in their access to different types of assets. Investors in the emerging country have access to international and pure domestic stocks from their country, which allows them to rebalance their portfolio when faced with a shock. This rebalancing was not available to them in the autarky case. Investors in the developed country can now diversify their portfolio. They have access to three types of stocks from three countries. Hence, cross-country contagion, which was impossible in the autarky case is now possible.

Another technical difference from autarky is that now θ, P, ε , and U are 5 by 1 vectors instead of scalars. The matrices $\acute{M}_i$ (*for* $i = 0, 1, 2, 3$) are also 5 by 5 matrices.

5.2.1 Informed Investor i from Country i

We use the derivation of the utility for informed investors in the autarky case to infer the utility E_I^i of the informed investor in country i in the cross-listing case. Besides, the difference in dimension, in the cross-listing case investors have access to several assets, and the 5 by 5 matrices N_i represent the assets each investor i can invest in. Whereas, in the autarky case, there was a single asset and investor could only invest in that one asset.

The expected utility levels over the probabilities distributions for all shocks (θ, ε, U) for informed investors in the cross-listing case is as follows:

$$\begin{aligned} E_I^i &= E_{\theta, \varepsilon, U}(-\exp(-W_2/\tau)) \\ &= -\{A_i'(2I - \Sigma_U A_i)c'\Sigma_\varepsilon c + A_i'(2I - \Sigma_U A_i)b'\Sigma_\theta b + I\}^{-1/2} \exp\{-W_1/\tau + \\ &\quad \bar{U}' A_i(2I - \Sigma_U A_i)^{-1} \bar{U} - (a + b\bar{\theta} + (2I - \Sigma_U A_i)^{-1} \bar{U})' \frac{(b'\Sigma_\theta b)^{-1}}{2} [I - \{(c'\Sigma_\varepsilon c)^{-1} [I - \\ &\quad (A_i'(2I - \Sigma_U A_i)c'\Sigma_\varepsilon c + I)^{-1}] b'\Sigma_\theta b + I\}^{-1}] (a + b\bar{\theta} + (2I - \Sigma_U A_i)^{-1} \bar{U})\} \end{aligned}$$

(see Welfare Appendix)

5.2.2 Uninformed Investor i from Country i

We also use the derivation of the utility for uninformed investors in the autarky case to infer the utility E_{UI}^i of uninformed investors in country i in the cross-listing case. Again, besides the difference in dimension, in the cross-listing case investors can invest in different assets.

The expected utility of the uninformed investor in the cross-listing case can be written as

$$E_{UI}^i = E_{\theta, \varepsilon, U}(-\exp(-W_2/\tau))$$

To simplify the notation let's define $AV_i = \text{Var}(V|P)^{-1} N_i$

$$\begin{aligned} E_{UI}^i &= \exp(-W_1/\tau) * E_{\theta, \varepsilon, U} \exp[-(E(V|P) - P)' AV_i' (V - P)] \\ &= -((2k + \Sigma_\varepsilon^{-1})\Sigma_\varepsilon + I)^{-1/2} ((2Q + \Sigma_\theta^{-1})\Sigma_\theta + I)^{-1/2} \exp\{-\frac{W_1}{\tau} + n + \\ &\quad m_1' K l_1 + P'(2Q + \Sigma_\theta^{-1})^{-1} \frac{\Sigma_\theta^{-1}}{2} [I - ((2Q + \Sigma_\theta^{-1})\Sigma_\theta + I)^{-1}] (2Q + \Sigma_\theta^{-1})^{-1} O\} \end{aligned}$$

(See Welfare Appendix)

5.3 Change in Consumption Level from Autarky

5.4 to Cross-listing.

In this section, we express the change in utility levels for investors from autarky to cross-listing in terms of change in consumption levels. Specifically, we measure the increase or decrease in the autarky consumption level necessary for each type of investor to enjoy the same level of utility than in the cross-listing scenario. The end of period wealth, W_2 determines the consumption level.

$$E_1 = -exp - \frac{W_2^1}{\tau} \quad (15)$$

$$E_2 = -exp - \frac{W_2^2}{\tau} \quad (16)$$

Where, W_2^1 and W_2^2 are respectively, the end of period wealth in autarky and the end of period wealth with cross-listing.

We would like to determine C , the change in the final period wealth when we move from autarky to cross-listing, C is such that:

$$E_2 = -exp - \frac{C * W_1^2}{\tau}$$

$$C * W_1^2 = -\tau LN(-E_2)$$

$$\text{From (15) } W_1^2 = -\tau LN(-E_1)$$

Hence,

$$C = \frac{LN(-E_2)}{LN(-E_1)}$$

If C is greater than 1, then we need to increase the autarky consumption to enjoy the utility level achieved with cross-listing, which means that investors are worse off in the autarky scenario as they consume less and better off in the cross-listing scenario as they consume more.

If C is smaller than 1, then we need to decrease the autarky consumption to enjoy the same utility level than in cross-listing, which means that investors are better off in the autarky scenario as they consume more and worse off in the cross-listing scenario which is associated to less consumption.

Figure 8 presents the results of the welfare analysis suggests. The main implications of the table are that when we move from a situation of financial autarky to one of cross-listing:

-Informed investors in all country are worse off ($C_0 = 0.56, C_1 = 0.69, C_2 = 0.64$) because they move from a situation where they have the monopoly of private information and they can extract all the rent associated to it to a situation where the informed investors from the developed country has the same information than him on the cross-listed stock. In fact, cross-listing and ADRs issuance are associated with an increase in the quality and the quantity of information publicly available on the stocks that cross-list. Indeed, emerging market firms that cross-list must comply with the accounting standards of the exchange where they cross-list (see Miller (1999)). Hence, informed investors get less rent from being informed when we move from autarky to cross-listing.

-Uninformed investors are better off in all countries with cross-listing because it is associated with more informed investors. Thus, prices reveal more private information from informed investors. In a sense, the market is more efficient as price reflect better the fundamentals of the assets.

-As uninformed investors represent over 99% of all investors, overall cross-listing is associated with more consumption than autarky. Thus, cross-listing is preferable to autarky.

-The information benefits associated with cross-listing change the original costs of contagion versus benefit of diversification analysis. Indeed, investors from the developed country are the only ones in our model to fully appreciate the benefits of diversification, they hold three assets from three countries. In contrast, investors from the emerging countries hold two assets from their own country. However, Figure 8 shows that investors from the developed country have the same experience than investors from emerging countries: informed investors are better off in autarky, uninformed investors are better off with cross-listing. This suggests that the information benefits associated with cross-listing outweigh the costs of contagion. This holds even though diversification comes with an increased exposure to contagion. Figure 2.8 shows that informed investor from the developed country have their consumption reduced by more when they move from autarky to cross-listing ($C_0 = 0.56$ versus $C_1 = 0.69$ and $C_2 = 0.64$). And uninformed investors from the developed country have their consumption increased by less (than for uninformed investors in emerging countries) when they move from autarky to cross-listing ($C_0 = 1.66$ versus $C_1 = 1.69$).

A priori, the values of the consumption cost or gain of moving from autarky to cross-listing seem quite high, however they can be explained by the fact that we choose an arbitrary parametrization (that of the baseline case), that might not exactly predict "reasonable" values. Furthermore, there are several shocks in our model, that make prices quite volatile. Finally, the assumption of asymmetric information among investors is another source of distortion that can explain the big values of the consumption cost/gains. More importantly, the welfare comparison emphasizes that when an economy moves from autarky

to cross-listing some individuals have a lower utility, while others experience and increase in their utility level.

6 Conclusion

We investigate whether contagion is a cost of international cross-listing for emerging market firms. We develop a rational expectations model of contagion where some emerging market firms cross-list their stocks in a developed exchange. We model the fact that markets are segmented along emerging market borders, so that cross-listing is the only way for foreign investors to invest in emerging market stocks and for emerging market firms to access developed capital markets.

We find that contagion is a cost of internationalization as the price response in one emerging country to a shock in another emerging country is significantly greater for cross-listed stocks than for pure domestic stocks. Furthermore, we find that a shock in one emerging market affects the stocks of all the other emerging markets that have cross-listed stocks in the same developed market. These findings support Calvo (1998) and Calvo and Mendoza (1999), that international capital markets act as carrier of emerging market crises. However, the magnitude of contagion that we find is more modest than reported in papers on contagion like Kodres and Pritsker (2002) that assume that all markets are perfectly integrated. The discrepancy in the magnitude of contagion found suggests that market segmentation in emerging markets may reduce the transmission of shocks from other markets and that some previous studies may have overestimated the magnitude of contagion.

As an application of our model, we investigate whether the contagion of the 1998 Brazilian crisis to Mexico and Chile could be spread by the action of international buying and selling stocks cross-listed in the U.S. We calibrate our model using stock price data of Brazil, Mexico, Chile, and the U.S.. We find that our model can indeed explain some of the transmission of the Brazilian crisis to Mexico and Chile and the model further indicates the crucial determinants of contagion in that case, were negative liquidity shocks and country specific shocks.

Our initial results suggested that emerging markets firms should cautiously consider internationalization to developed exchanges as cross-listing is associated with more exposure to cross-market contagion. Against this backdrop, the welfare analysis of internationalization versus autarky concludes that the benefits of internationalization in terms of reducing information asymmetry and increasing market efficiency are greater than the costs of contagion.

7 Appendix

7.1 Model Appendix

7.1.1 Expression of $E(V|P)$

$$\begin{aligned} E(V|P) &= E(V|S(P)) \\ &= \bar{V} + Cov(V, S(P)) * [Var(S(P))]^{-1} * [S(P) - E(S(P))] \end{aligned}$$

We use the fact that

$$V = \theta + U$$

$$S(P) = (\mu_I \tau A)^{-1} \varepsilon + \theta$$

ε and θ are normal therefore $S(P)$ is normal too.

Finally,

$$E(V|P) = \bar{\theta} + \Sigma_{\theta} \left[\Sigma_{\theta} + \frac{A^{-1} \Sigma_{\varepsilon} A^{-1'}}{(\tau \mu_I)^2} \right]^{-1} \left[\theta + \frac{A^{-1} \varepsilon}{\tau \mu_I} - \bar{\theta} \right]$$

$E(V|P)$ can be expressed as a linear function of shocks

$$E(V|P) = \alpha_1 + \alpha_2 * \theta + \alpha_3 * \varepsilon$$

Where

$$\alpha_1 = \bar{\theta} \left(1 - \Sigma_{\theta} \left[\Sigma_{\theta} + \frac{\Sigma_U \Sigma_{\varepsilon} \Sigma_U}{(\tau \mu_I)^2} \right]^{-1} \right)$$

$$\alpha_2 = \Sigma_{\theta} \left[\Sigma_{\theta} + \frac{\Sigma_U \Sigma_{\varepsilon} \Sigma_U}{(\tau \mu_I)^2} \right]^{-1}$$

$$\alpha_3 = \Sigma_{\theta} \left[\Sigma_{\theta} + \frac{\Sigma_U \Sigma_{\varepsilon} \Sigma_U}{(\tau \mu_I)^2} \right]^{-1} \frac{\Sigma_U}{\tau \mu_I}$$

7.1.2 Expression of $Var(V|P)$

$$\begin{aligned} Var(V|P) &= Var(V|S(P)) \\ &= Var(V) - Cov(V, S(P)) * [Var(S(P))]^{-1} * Cov(V, S(P))' \end{aligned}$$

We use the fact that

$$V = \theta + U$$

$$S(P) = (\mu_I \tau A)^{-1} \varepsilon + \theta$$

ε and θ are normal therefore $S(P)$ is normal too.

We get

$$Var(V|P) = (\Sigma_\theta + \Sigma_U) - \Sigma_\theta \left[\Sigma_\theta + \frac{A^{-1} \Sigma_\varepsilon A^{-1'}}{(\tau \mu_I)^2} \right]^{-1} \Sigma_\theta'$$

7.1.3 Expressions of the M_i in the Equilibrium Price

Let $M = (\tau \mu_I A + \tau \mu_{UI} A_V)^{-1}$

$$M_0 = -M \bar{X}$$

$$M_1 = \tau \mu_{UI} A_V^{-1} M$$

$$M_2 = \tau \mu_I A^{-1} M$$

$$M_3 = M$$

7.1.4 Variance of P

$$\begin{aligned} Var(P) &= Var(M_0 + M_1 \alpha_1 + (M_2 + M_1 \alpha_2) \theta + (M_3 + M_1 \alpha_3) \varepsilon) \\ &= M * I * M' \end{aligned}$$

$$\begin{aligned} I &= Var \left\{ \left[\tau \mu_{UI} A_V \Sigma_\theta \left(\Sigma_\theta + \frac{A^{-1} \Sigma_\varepsilon A^{-1'}}{(\tau \mu_I)^2} \right)^{-1} + \tau \mu_I A \right] \theta \right\} + \\ &\quad Var \left[\tau \mu_{UI} A_V \Sigma_\theta \left(\Sigma_\theta + \frac{A^{-1} \Sigma_\varepsilon A^{-1'}}{(\tau \mu_I)^2} \right)^{-1} \frac{A^{-1}}{\tau \mu_I} \right] \varepsilon \end{aligned}$$

If we call $C = \tau\mu_{UI}A_V\Sigma_\theta \left(\Sigma_\theta + \frac{A^{-1}\Sigma_\varepsilon A^{-1'}}{(\tau\mu_I)^2} \right)^{-1} + \tau\mu_I A$,

and $D = C \frac{A^{-1}}{\tau\mu_I}$,

Then

$$Var(P) = M(C\Sigma_\theta C' + D\Sigma_\varepsilon D')M'$$

8 Welfare analysis Appendix

We compute the expected utility levels over the probabilities distributions for all shocks for informed and uninformed investors. We compare the levels for autarky to the levels for financial cross-listing. We extensively present the computation for the autarky case, then we present the result for the cross-listing case, which is a generalization of the autarky under some conditions that we expose.

8.1 Autarky case

We assume that investors in each country can only trade assets in their own market, they cannot cross-list them in a developed exchange. Let's assume that there is a single risky asset denoted X and a riskless asset that pay a gross return normalized to 1. Thus there is no distinction between the developed country and the emerging countries.

8.1.1 Informed investors

The informed investor chooses his position X^I in the risky assets X to maximize his end of period wealth W_2 , conditional on information, θ .

The expected utility of the informed investor in the autarky case is

$$E = E_{\theta,\varepsilon,U}(-\exp(-W_2/\tau))$$

$$\text{where } W_2 = W_1 + X_I'(V - P)$$

$$\text{And } X_I = \tau\Sigma_U^{-1}(\theta - P).$$

Hence, the informed investor's end of period wealth can be written as

$$\begin{aligned} W_2 &= W_1 + \tau\Sigma_U^{-1}(\theta - P)(V - P) \\ &= W_1 + \tau\Sigma_U^{-1}[(\theta - P)^2 + (\theta - P)U] \end{aligned}$$

The expected utility becomes:

$$E_I = E_{\theta,\varepsilon,U}(-\exp(-\frac{W_2}{\tau}))$$

$$= \left(-\exp -\frac{W_1}{\tau}\right) * E_{\theta, \varepsilon, U} \left(\exp -\Sigma_U^{-1}[(\theta - P)^2 + (\theta - P)U]\right)$$

$(\theta - P)$ does not depend on U , hence E_I can be written as:

$$E_I = - \left(-\exp -\frac{W_1}{\tau}\right) * E_{\varepsilon, \theta} [\exp(-\Sigma_U^{-1}(\theta - P)^2) * E_U(\exp(-\Sigma_U^{-1}(\theta - P)U) | \varepsilon, \theta)]$$

U follows a normal distribution with mean $\bar{U}$, and variance Σ_U . The distribution of U is independent from the distributions of ε , and θ .

$$-\Sigma_U^{-1}(\theta - P)U \sim N(-\Sigma_U^{-1}(\theta - P)\bar{U}, \Sigma_U^{-1}(\theta - P)^2)$$

$$y = \exp(-\Sigma_U^{-1}(\theta - P)U) \sim \text{LogNormal}(-\Sigma_U^{-1}(\theta - P)\bar{U}, \Sigma_U^{-1}(\theta - P)^2)$$

$$E(y) = \exp(-\Sigma_U^{-1}(\theta - P)\bar{U} + \frac{\Sigma_U^{-1}}{2}(\theta - P)^2)$$

$$E_I = \left(-\exp -\frac{W_1}{\tau}\right) * E_{\varepsilon, \theta} [\exp(-\Sigma_U^{-1}(\theta - P)^2) * \exp(-\Sigma_U^{-1}(\theta - P)\bar{U} + \frac{\Sigma_U^{-1}}{2}(\theta - P)^2)]$$

$$= \left(-\exp -\frac{W_1}{\tau} + \frac{\Sigma_U^{-1}}{2}\bar{U}^2\right) * E_{\theta} [E_{\varepsilon} \exp\left(\frac{-\Sigma_U^{-1}}{2}(\theta - P + \bar{U})^2\right) | \theta]$$

P is a function of θ , ε , and we can express $\theta - P + \bar{U}$ as a function of θ , and ε . and the M_i .

Let's define the terms a, b, c such that:

$$a = -M_0 - M_1\alpha_1$$

$$b = 1 - M_2 - M_1\alpha_2$$

$$c = -M_3 - M_1\alpha_3$$

Where the α_i and the M_i were defined earlier.

Then

$$\theta - P + \bar{U} = a + b\theta + c\varepsilon + \bar{U}$$

ε and θ follow independent normal distributions,

Hence, conditional on the information shock θ , $(\theta - P + \bar{U})$ follows a normal distribution such that:

$$(\theta - P + \bar{U}) \sim N((a + b\theta + \bar{U}), c^2\Sigma_{\varepsilon}),$$

Proposition 1 *If a random variable x follows normal distribution with mean m and variance s^2 , then for any positive number α ,*

$$E(\exp -\alpha x^2) = \frac{1}{\sqrt{1+2\alpha s^2}} \exp\left(-\frac{m^2\alpha}{1+2\alpha s^2}\right)$$

Proof:

$$E(\exp -\alpha x^2) = \int_{-\infty}^{+\infty} \frac{1}{\sqrt{2\pi s^2}} \exp(-\alpha x^2) * \exp -\frac{(x-m)^2}{2s^2} dx$$

$$E(\exp -\alpha x^2) = \int_{-\infty}^{+\infty} \frac{1}{\sqrt{2\pi s^2}} \exp\left(-\frac{m^2\alpha}{1+2\alpha s^2}\right) * \exp -\frac{\left(x-\frac{m}{1+2\alpha s^2}\right)^2}{2s^2/(1+2\alpha s^2)} dx$$

$$\text{Let's perform the change of variable } y = \frac{x - \frac{m}{1+2\alpha s^2}}{s/\sqrt{1+2\alpha s^2}}$$

$$E(\exp -\alpha x^2) = \int_{-\infty}^{+\infty} \frac{1}{\sqrt{2\pi s^2}} \exp\left(-\frac{m^2\alpha}{1+2\alpha s^2}\right) * \exp\left(-\frac{y^2}{2}\right) \frac{s}{\sqrt{1+2\alpha s^2}} dy$$

$$\text{We use the well established result } \int_{-\infty}^{+\infty} \exp\left(-\frac{y^2}{2}\right) dy = \sqrt{2\pi}$$

$$E(\exp -\alpha x^2) = \frac{1}{\sqrt{1+2\alpha s^2}} \exp\left(-\frac{m^2\alpha}{1+2\alpha s^2}\right)$$

We apply proposition 1 to get

$$E_\varepsilon[\exp\left(\frac{-\Sigma_U^{-1}}{2}(\theta - P + \bar{U})^2\right) | \theta] = \frac{1}{(1+c^2\Sigma_U^{-1}\Sigma_\varepsilon)^{1/2}} * \exp -\frac{(a+b\theta+\bar{U})^2\Sigma_U^{-1}}{2(1+c^2\Sigma_U^{-1}\Sigma_\varepsilon)}$$

$$E_I = \left(-\exp -\frac{W_1}{\tau} + \Sigma_U^{-1}\frac{\bar{U}^2}{2}\right) * \frac{1}{(1+c^2\Sigma_U^{-1}\Sigma_\varepsilon)^{1/2}} * E_\theta - \exp \frac{(a+b\theta+\bar{U})^2\Sigma_U^{-1}}{2(1+c^2\Sigma_U^{-1}\Sigma_\varepsilon)}$$

The information shock θ follow a normal distribution with mean $\bar{\theta}$, and variance Σ_θ , by linearity of the normal distribution

$$a + b\theta + \bar{U} \sim N(a + b\bar{\theta} + \bar{U}, b^2\Sigma_\theta)$$

We can apply Proposition 1 to get

$$E_\theta \exp -\frac{(a+b\theta+\bar{U})^2\Sigma_U^{-1}}{2(1+c^2\Sigma_U^{-1}\Sigma_\varepsilon)} = \frac{1}{\left(1+\frac{\Sigma_U^{-1}}{1+c^2\Sigma_U^{-1}\Sigma_\varepsilon}b^2\Sigma_\theta\right)^{1/2}} * \exp -\frac{(a+b\bar{\theta}+\bar{U})^2\Sigma_U^{-1}}{2(1+c^2\Sigma_U^{-1}\Sigma_\varepsilon)(1+\frac{\Sigma_U^{-1}}{1+c^2\Sigma_U^{-1}\Sigma_\varepsilon}b^2\Sigma_\theta)}$$

Finally,

$$E_I = \frac{-1}{(1+c^2\Sigma_U^{-1}\Sigma_\varepsilon+b^2\Sigma_U^{-1}\Sigma_\theta)^{1/2}} * \exp\left[-\frac{W_1}{\tau} + \frac{\Sigma_U^{-1}\bar{U}^2}{2} - \frac{(a+b\bar{\theta}+\bar{U})^2\Sigma_U^{-1}}{2(1+c^2\Sigma_U^{-1}\Sigma_\varepsilon+b^2\Sigma_U^{-1}\Sigma_\theta)}\right]$$

8.1.2 Uninformed investors

The expected utility of the uninformed investor in the autarky case can be written as

$$E_{UI} = E_{\theta, \varepsilon, U} (-\exp(-W_2/\tau))$$

$$\text{where } W_2 = W_1 + X'_{UI}(V - P)$$

$$\text{And } X_{UI} = \tau \text{Var}(V|P)^{-1}(E(V|P) - P).$$

Hence, uninformed investor's end of period wealth can be written as

$$W_2 = W_1 + \tau \text{Var}(V|P)^{-1}(E(V|P) - P)(V - P)$$

To simplify the notation let's define $V = \text{Var}(V|P)$

$$E_{UI} = -\exp(-\frac{W_1}{\tau}) * E_{\theta, \varepsilon, U} \exp[-V^{-1}(E(V|P) - P)(V - P)]$$

Let also define the terms d , e , and f using the α_i defined earlier such that

$$d = \alpha_1 - M_0 - M_1\alpha_1$$

$$e = \alpha_2 - M_2 - M_1\alpha_2$$

$$f = \alpha_3 - M_3 - M_1\alpha_3$$

$$E(V|P) - P = d + e\theta + f\varepsilon$$

As in the informed investors case

$$V - P = \theta - P + U = a + b\theta + c\varepsilon + U$$

Where a , b , and c were defined earlier

$$\begin{aligned} (E(V|P) - P)(V - P) &= (d + e\theta + f\varepsilon) * (a + b\theta + c\varepsilon + U) \\ &= (d + e\theta + f\varepsilon) * (a + b\theta + c\varepsilon) + (d + e\theta + f\varepsilon)U \end{aligned}$$

$$E_{UI} = -\exp(-\frac{W_1}{\tau}) * E_{\theta, \varepsilon} \{ \exp[-V^{-1}(d + e\theta + f\varepsilon) * (a + b\theta + c\varepsilon)] * E_U[\exp[-V^{-1}(d + e\theta + f\varepsilon)U | \theta, \varepsilon]] \}$$

U , θ , and ε follow independent normal distributions. Hence the distribution of U conditional on θ and ε is the same as the distribution of U .

$$U \sim (\bar{U}, \Sigma_U)$$

Let's define $x = -V^{-1}(d + e\theta + f\varepsilon)U$

$$x \sim N(-V^{-1}(d + e\theta + f\varepsilon)\overline{U}, V^{-2}(d + e\theta + f\varepsilon)^2 * \Sigma_U)$$

$$y = \exp(x) \sim \text{LogNormal}(-V^{-1}(d + e\theta + f\varepsilon)\overline{U}, V^{-2}(d + e\theta + f\varepsilon)^2 * \Sigma_U)$$

$$E_U[y|\theta, \varepsilon] = \exp[-V^{-1}(d + e\theta + f\varepsilon)\overline{U} + V^{-2}(d + e\theta + f\varepsilon)^2 * \frac{\Sigma_U}{2}]$$

$$E_{UI} = -\exp(-\frac{W_1}{\tau} * E_{\theta, \varepsilon} \exp -V^{-1}[(d + e\theta + f\varepsilon)(a + b\theta + c\varepsilon) + (d + e\theta + f\varepsilon)\overline{U} - V^{-1}(d + e\theta + f\varepsilon)^2 * \frac{\Sigma_U}{2}])$$

$$E_{UI} = -\exp(-\frac{W_1}{\tau}) * E_{\theta}(\exp -V^{-1}[(d + e\theta)(a + b\theta) + (d + e\theta)\overline{U} - V^{-1}(d + e\theta)^2 * \frac{\Sigma_U}{2}]) \\ * E_{\varepsilon}[\exp -V^{-1}(A + B\varepsilon)\varepsilon|\theta]$$

Let A and B such that

$$A = \alpha + \beta\theta$$

Where

$$\alpha = d + c + fa + f\overline{U} - V^{-1}df\Sigma_U$$

$$\beta = ec + fb - V^{-1}ef\Sigma_U$$

And

$$B = fc - V^{-1}f^2 * \Sigma_U/2$$

$$(A + B\varepsilon)\varepsilon = B(\varepsilon + \frac{A}{2B})^2 - \frac{A^2}{4B}$$

$$E_{\varepsilon}[\exp -V^{-1}(A + B\varepsilon)\varepsilon|\theta] = \exp\left(V^{-1}\frac{A^2}{4B}\right) E_{\varepsilon}[\exp -V^{-1}B(\varepsilon + \frac{A}{2B})^2]$$

$$\varepsilon + \frac{A}{2B} \sim N\left(\frac{A}{2B}, \Sigma_{\varepsilon}\right)$$

We need B positive to apply Proposition 1

$$E_{\varepsilon}(\exp -V^{-1}B(\varepsilon + \frac{A}{2B})^2) = \frac{1}{(1+2V^{-1}B\Sigma_{\varepsilon})^{1/2}} \exp -\frac{A^2V^{-1}}{4B(1+2V^{-1}B\Sigma_{\varepsilon})}$$

$$E_{UI} = \frac{-1}{(1+2V^{-1}B\Sigma_{\varepsilon})^{1/2}} \exp(-\frac{W_1}{\tau}) * E_{\theta} \exp\{-V^{-1}(d + e\theta)[(a + b\theta) + \overline{U} - V^{-1}(d + e\theta)\frac{\Sigma_U}{2}] + V^{-1}\frac{A^2}{4B} - \frac{A^2}{4B} \frac{V^{-1}}{1+2V^{-1}B\Sigma_{\varepsilon}}\}$$

$$= \frac{-1}{(1+2V^{-1}B\Sigma_\varepsilon)^{1/2}} \exp\left\{-\frac{W_1}{\tau} - V^{-1}[da + d\bar{U} - V^{-1}\Sigma_U d^2/2 - \frac{\alpha^2}{2} \frac{V^{-1}\Sigma_\varepsilon}{1+2V^{-1}B\Sigma_\varepsilon}]\right\} \\ * E_\theta \exp\{-V^{-1}(C\theta + D\theta^2)\}$$

Where

$$C = db + ea + e\bar{U} - V^{-1}\Sigma_U ed - \alpha\beta \frac{V^{-1}\Sigma_\varepsilon}{1+2V^{-1}B\Sigma_\varepsilon}$$

$$D = eb - \frac{V^{-1}\Sigma_U e^2}{2} - \frac{\beta^2}{2} \frac{V^{-1}\Sigma_\varepsilon}{(1+2V^{-1}B\Sigma_\varepsilon)}$$

$$E_\theta \exp\{-V^{-1}(C\theta + D\theta^2)\} = \exp + \frac{V^{-1}C^2}{4D} * E_\theta \exp\{-V^{-1}D(\theta + \frac{C}{2D})^2\}$$

$$\theta \sim N(\bar{\theta}, \Sigma_\theta)$$

$$\theta + \frac{C}{2D} \sim N(\bar{\theta} + \frac{C}{2D}, \Sigma_\theta)$$

We need D to be positive to apply Proposition 1

$$E_\theta \exp\{-V^{-1}D(\theta + \frac{C}{2D})^2\} = \frac{1}{(1+2V^{-1}D\Sigma_\theta)^{1/2}} \exp - \left\{(\bar{\theta} + \frac{C}{2D})^2 \frac{V^{-1}D}{1+2V^{-1}D\Sigma_\theta}\right\}$$

$$E_{UI} = \frac{-1}{(1+2V^{-1}B\Sigma_\varepsilon)^{1/2}(1+2V^{-1}D\Sigma_\theta)^{1/2}} \exp\left\{-\frac{W_1}{\tau} - V^{-1}[da + d\bar{U} - V^{-1}\frac{\Sigma_U d^2}{2} - \right. \\ \left. \frac{\alpha^2}{2} \frac{V^{-1}\Sigma_\varepsilon}{1+2V^{-1}B\Sigma_\varepsilon} - \frac{C^2}{4D} + \frac{(\bar{\theta} + \frac{C}{2D})^2 D}{1+2V^{-1}D\Sigma_\theta}]\right\}$$

8.2 Cross-listing case

We use the derivation of the utility for informed and uninformed investors in the autarky case to infer the utility E_I^i of the informed investor and E_{UI}^i of uninformed investors in country i in the cross-listing case.

However, in the cross-listing case θ, P, ε , and U are 5 by 1 vectors instead of scalars. The matrices $\hat{M}_i$ (for $i = 0, 1, 2, 3$) are also 5 by 5 matrices. Besides, the difference in dimension, in the cross-listing case investors have access to several assets, and the 5 by 5 matrices N_i represent the assets each investor i can invest in. Whereas, in the autarky case, there was a single asset and investor could only invest in that one asset. Hence the 5 by 5 matrices P, A_i, A, A_v , and M_i are as defined in the model, and a, b, c are such that

$$a = -M_0 - M_1 \bar{\theta} \left(1_{5,1} - \Sigma_\theta \left[\Sigma_\theta + \frac{A^{-1}\Sigma_\varepsilon A^{-1'}}{(\tau\mu_I)^2} \right]^{-1} \right)$$

$$b = 1 - M_2 - M_1 \Sigma_\theta \left[\Sigma_\theta + \frac{A^{-1}\Sigma_\varepsilon A^{-1'}}{(\tau\mu_I)^2} \right]^{-1}$$

$$c = -M_3 - M_1 \Sigma_\theta \left[\Sigma_\theta + \frac{A^{-1}\Sigma_\varepsilon A^{-1'}}{(\tau\mu_I)^2} \right]^{-1} \frac{A^{-1}}{\tau\mu_I}$$

We use the vector formulation of Proposition 1:

If a random vector X follows a multivariate normal distribution with mean M and variance Σ , then, for any positive definite matrix α ,

$$E(\exp -X'\alpha X) = (2\alpha\Sigma + I)^{-1/2} \exp - \left\{ M' \frac{\Sigma^{-1}}{2} [I - (2\alpha\Sigma + I)^{-1}] M \right\}$$

Where I is the identity matrix.

8.2.1 Informed investor i from country i

$$E_i^I = E_{\theta, \varepsilon, U} (-\exp(-W_2/\tau))$$

The expression of E_i^I can be written such that it

$$\begin{aligned} E_i^I = & - \{ A_i'(2I - \Sigma_U A_i) c' \Sigma_\varepsilon c + A_i'(2I - \Sigma_U A_i) b' \Sigma_\theta b + I \}^{-1/2} \\ & * \exp \{ -W_1/\tau + \overline{U}' A_i (2I - \Sigma_U A_i)^{-1} \overline{U} - (a + b\overline{\theta} + (2I - \Sigma_U A_i)^{-1} \overline{U})' \frac{(b' \Sigma_\theta b)^{-1}}{2} \\ & * [I - \{ (c' \Sigma_\varepsilon c)^{-1} [I - (A_i'(2I - \Sigma_U A_i) c' \Sigma_\varepsilon c + I)^{-1}] b' \Sigma_\theta b + I \}'^{-1}] \\ & * (a + b\overline{\theta} + (2I - \Sigma_U A_i)^{-1} \overline{U}) \} \end{aligned}$$

8.2.2 Uninformed investor i from country i

The expected utility of the uninformed investor in the cross-listing case can be obtained the same way we derived the expected utility of the uninformed investor in the autarky case. However, we need to take into account that all the variables and parameters are matrices or vector, and we need to take into account that the investors cannot invest in all the assets. Then E_{UI}^i can be written as

$$E_{UI}^i = E_{\theta, \varepsilon, U} (-\exp(-W_2/\tau))$$

Let's define

$$d = \alpha_1 - M_0 - M_1 \alpha_1$$

$$e = \alpha_2 - M_2 - M_1 \alpha_2$$

$$f = \alpha_3 - M_3 - M_1 \alpha_3$$

Let's also define

$$k = (f' A V_i c + f' A V_i' \frac{\Sigma_U}{2} A V_i f)$$

$$K = (2k + \Sigma_\varepsilon^{-1})^{-1} \frac{\Sigma_\varepsilon^{-1}}{2} [I - ((2k + \Sigma_\varepsilon^{-1}) \Sigma_\varepsilon + I)^{-1}] (2k + \Sigma_\varepsilon^{-1})^{-1}$$

Let l and m , two linear functions of θ such that.

$$l = l_1 + l_2\theta$$

$$m = m_1 + m_2\theta$$

Where

$$l_1 = f' AV_i (a + \overline{U}) + f' AV_i \frac{\Sigma_U}{2} AV_i d$$

$$l_2 = f' AV_i b + f' AV_i \frac{\Sigma_U}{2} AV_i e$$

$$m_1 = d' AV_i c + d' AV_i' \Sigma_U AV_i f$$

$$m_2 = e' AV_i c + e' AV_i \Sigma_U AV_i f$$

Let's also define

$$n = [d' AV_i a + d AV_i \overline{U} - \frac{1}{2} d' AV_i' \Sigma_U AV_i d]$$

$$o = [e' AV_i a + e' AV_i \overline{U} - \frac{1}{2} e' AV_i' \Sigma_U AV_i d]$$

$$p = [d' AV_i b - \frac{1}{2} d' AV_i' \Sigma_U AV_i e]$$

$$q = [e' AV_i b - \frac{1}{2} e' AV_i' \Sigma_U AV_i e]$$

$$\text{Let } O = (o + m_2' K l_1)$$

$$P = (p + m_1' K l_2)$$

$$Q = (q + m_2' K l_2)$$

Then, finally,

$$\begin{aligned} E_{UI} = & -((2k + \Sigma_\varepsilon^{-1})\Sigma_\varepsilon + I)^{-1/2}((2Q + \Sigma_\theta^{-1})\Sigma_\theta + I)^{-1/2} \\ & * \exp - \left\{ \frac{W_1}{\tau} + n + m_1' K l_1 + P'(2Q + \Sigma_\theta^{-1})^{-1} \frac{\Sigma_\theta^{-1}}{2} [I - ((2Q + \Sigma_\theta^{-1})\Sigma_\theta + I)'^{-1}] (2Q + \right. \\ & \left. \Sigma_\theta^{-1})^{-1} O \right\} \end{aligned}$$

9 References

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Table 1. Parametrization of the Baseline Case of the Model	
Parameters β	
$\beta_{01} = \beta_{02} = 1$	
$\beta_0^2 = \beta_0^1 = 1$	
$\beta_1 = \beta_2 = 0.5$	
Parameters μ, τ , and $\bar{X}$	
$\bar{X} = 5 \times 1$ vector of 1	
$\mu_I = 1$	
$\mu_{UI} = 100$	
$\tau = 1$	
Shocks $\eta, \theta, \varepsilon$ and common factor f	
$\eta_i \sim N(0, 1)$	
$\theta_i \sim N(0, 1)$	
$\varepsilon_i \sim N(0, 1)$	
$f_i \sim N(0, 1)$	

Figure 1: Price Response of all Assets to Shocks to Asset 01

Panel A. presents the price response to a one standard deviation negative information shock to asset 01. Panel B. presents the price response to a one standard deviation negative liquidity shock to asset 01.

A. Negative Info Shock

	Stock 0	Stock 01	Stock 02	Stock 1	Stock 2
Expectation Component	0.125	-0.607	-0.071	0.106	-0.044
Portfolio Balance	0.007	-0.021	-0.002	0.006	-0.002
Total	0.132	-0.628	-0.073	0.112	-0.046

B. Negative Liquidity Shock

Expectation Component	0.0776	-0.4236	0.0357	0.0473	-0.0085
Portfolio Balance	-0.0087	-0.0178	-0.0003	-0.0004	-0.0004
Total	0.069	-0.441	0.035	0.047	-0.009

Figure 2: Price Response of all Assets to Shocks to Asset 1

Panel A. presents the price response to a one standard deviation negative information shock to the pure domestic asset 1. Panel B. presents the price response to a one standard deviation negative liquidity shock to asset 1.

A. Negative Info Shock

	Stock 0	Stock 01	Stock 02	Stock 1	Stock 2
Expectation Component	0.081	0.109	-0.045	-0.419	-0.028
Portfolio Balance	0.002	0.002	-0.001	-0.023	-0.001
Total	0.083	0.111	-0.046	-0.442	-0.029

B. Negative Liquidity Shock

	Stock 0	Stock 01	Stock 02	Stock 1	Stock 2
Expectation Component	0.0493	-0.0208	0.022	-0.4576	-0.0056
Portfolio Balance	-0.0042	-0.002	-0.0002	-0.0262	-0.0003
Total	0.045	-0.023	0.022	-0.484	-0.006

Figure 3: Variance of Prices as a Function of Shocks

The table presents the variance decomposition analysis for each asset as a function of the contributions of shocks from other assets.

	Stock 0	Stock 01	Stock 02	Stock 1	Stock 2
Shock to Stock 01	0.13	0.64	0.07	0.11	0.05
Shock to Stock 02	0.13	0.07	0.64	0.05	0.11
Shock to Stock 1	0.08	0.11	0.05	0.45	0.03
Shock to Stock 2	0.08	0.05	0.11	0.03	0.45
Total	0.43	0.86	0.86	0.64	0.64
Effect of Shocks on Stock 01	0.31	0.74	0.08	0.17	0.07
Effect of Shocks on Stock 02	0.31	0.08	0.74	0.07	0.17
Effect of Shocks on Stock 1	0.19	0.13	0.05	0.71	0.05
Effect of Shocks on Stock 2	0.19	0.05	0.13	0.05	0.71

Figure 4: Price Response to Shocks to Asset 01 with no Asymmetric Information in Country 0

The table considers the case, where all investors are uninformed in the developed market. However, information remains asymmetric among investors in emerging countries.

A. Negative Info Shock

	Stock 0	Stock 01	Stock 02	Stock 1	Stock 2
Expectation Component	0.157	-0.628	-0.091	0.093	-0.057
Portfolio Balance	0.000	-0.021	-0.002	0.006	-0.002
Total	0.157	-0.649	-0.093	0.099	-0.059

B. Negative Liquidity Shock

Expectation Component	0.1275	-0.4241	0.0352	0.0394	-0.0165
Portfolio Balance	-0.0099	-0.0179	-0.0004	-0.0040	-0.0006
Total	0.118	-0.442	0.035	0.035	-0.017

Figure 5: Price Response to Shocks from Asset 01 as a function of $Var(\theta_{02})$

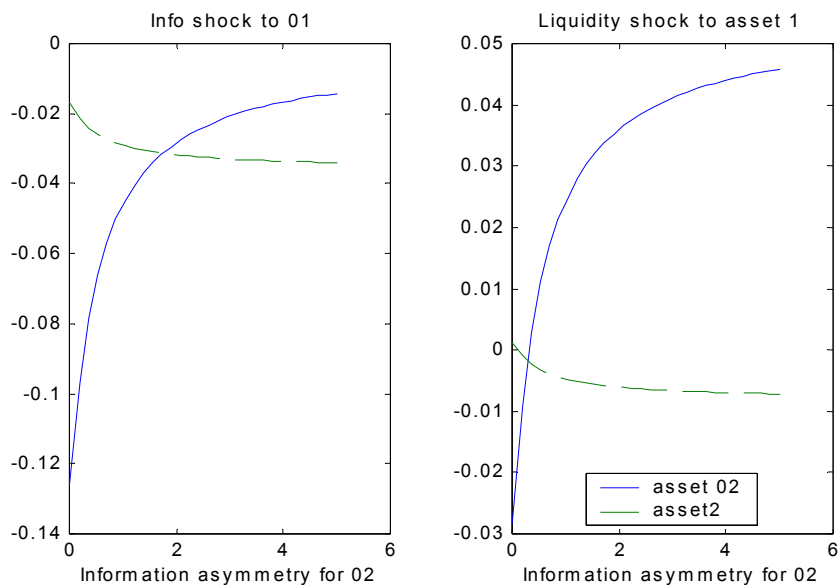


Figure 6: Price Response to Shocks from Asset 01 as a function of β_{02}

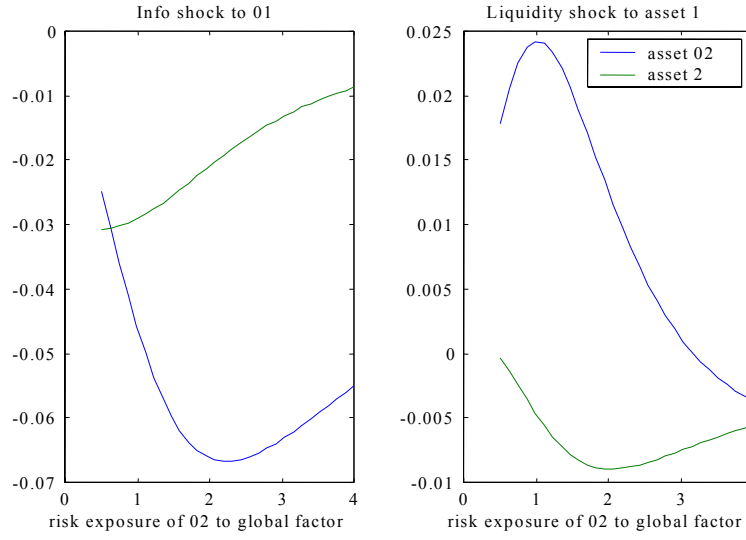


Figure 7: Price Response to Shocks from Asset 01 as a function of $Var(\eta_{02})$

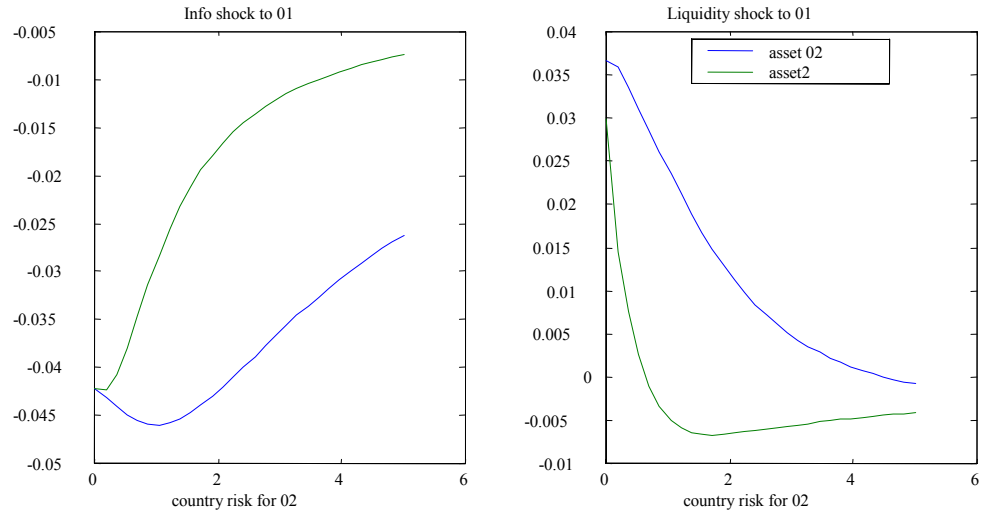


Figure 8: Welfare Analysis: Change in Consumption Level from Autarky to Cross-listing

The table presents the changes in the second period wealth necessary for each type of investor in each country to move from the level of utility associated with autarky to the utility level associated with cross-listing.

A. Informed investors

Country 0 Country 1 Country 2

0.56 0.69 0.64

B. Uninformed Investors

1.66 1.69 1.69

Figure 9: Sample Regression Coefficients before the Brazilian Crisis

The table presents the result of the regression $R = \alpha + \beta \cdot f_{\text{world}} + \text{Res}$ of returns of the international (domestic) index of a country on the global factor, f_{world} , during the period prior to the Brazilian crisis, defined from 1/14/1994 to 10/22/1998.

	α	β	Vres
U.S.			
Stock 0	0.0015	-0.0536	0.0001
Brazil			
Stock 01	-0.0017	0.3992	0.0007
Stock 1	-0.0014	0.4343	0.0006
Chile			
Stock 02	-0.0015	0.6101	0.0001
Stock 2	-0.0012	0.2575	0.0001
Mexico			
Stock 02	-0.0035	1.1660	0.0003
Stock 2	-0.0023	0.2860	0.0002

Figure 10: Price Response in Chile and Mexico to Information Shocks from Brazil

(x, y,z) represents a scenario where the variance of the liquidity shock, the variance of the information shock, and the variance of the country specific shock respectively represent x%, y%, and z% of the total variance of residuals.

A. CHILE

	Stock 0	Stock 01	Stock 02	Stock 1	Stock 2
(98,1,1)	0	-0.991	-0.0001	-0.0011	-0.0001
(1,98,1)	0	-1	0	0	0
(1,1,98)	0	-1	0	0	0
(60,0.1,39.9)	0	-0.9718	-0.0003	-0.0009	-0.0002
(39.9,0.1,60)	0	-0.9867	-0.0002	-0.0004	-0.0001

B. MEXICO

(98,1,1)	0	-0.991	-0.0003	-0.0011	-0.0001
(1,98,1)	0	-1	0	0	0
(1,1,98)	0	-1	0	0	0
(60,0.1,39.9)	0	-0.9718	-0.001	-0.0009	-0.0004
(39.9,0.1,60)	0	-0.9867	-0.0007	-0.0004	-0.0002