The Liquidity Service of Sovereign Bonds

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Abstract

This study explains why sovereign securities are desirable in improving liquidity for securities markets in emerging-market economies. When systematic risk is high and information is costly, there is an information externality for a firm to issue public securities. As a result, either the number of firms entering securities markets is too low or the amount each firm issues is insufficient for security prices to convey information. By contrast, sovereign securities stimulate information production and thus liquidity by making informed trading more profitable. Specifically this study examines the liquidity service of sovereign bonds on corporate bonds for nine emerging-market economies. The findings indicate that new sovereign issues lower the bid-ask spread of corporate bonds by 36.8 basis points, from a mean level of 159 basis points, increase corporate bond offer prices by 1.56, from the mean level of 97.4, and reduce the correlation between returns on corporate bonds and the corporate return index by 0.09, from a mean level of 0.43. (JEL D5, D62, D82, F34, G14, G15)

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1 Introduction

Governments may issue securities for a number of reasons. They may issue bonds to finance fiscal deficits, to refinance the existing debt at better terms, or to establish a benchmark. For example, the Chilean government returned to the international bond market after an eight-year absence by issuing a dollar denominated sovereign bond on April 20, 1999. The issuance, a US$500 million ten-year global bond, was priced at a spread of 175 basis points over the ten-year U.S. Treasury note. In this case, the Chilean government was enjoying a budget surplus.[1] The risk premium for emerging market securities was also high.[2] However, the Chilean government issued the bond to establish a benchmark with an objective of facilitating the access and financing of Chilean corporations in the international capital markets.[3]

At first glance, the Chilean government's rationale appears plausible, as introducing a tradable security to an incomplete or imperfect financial market normally is a pareto-improvement. However, under closer scrutiny, it is not clear why a well-traded benchmark would increase the price for each security in the financial market. For example, benchmarks such as sovereign bonds can potentially crowd out the market, and thus dry up the liquidity of individual securities. Sovereign issues are more attractive to international investors, as such issues normally have a higher credit rating than their corporate counterparts. Moreover, a sovereign issuance increases the total indebtedness of a country, leading to higher perceived default risk and consequently higher premia for all securities. Finally, issuing sovereign bonds is extremely costly. Considering this high cost, issuing benchmark securities may not be the optimal method for facilitating access and financing of domestic corporations in the international capital markets.

To understand the rationale behind using sovereign issues as benchmarks, this study investigates the effect of sovereign benchmarking in the context of emerging-market economies by formalizing the cost and the spill-over effect

[1]The Chilean government had a fiscal surplus of 131.2 billions of Pesos in 1998, 623.2 billions of Pesos in 1997. Exchange rates were 891.19 in 1999, 791.61 in 1998, and 817.94 in 1997.

[2]The J.P. Morgan emerging market bond index (EMBI) was priced at an average of 618 basis points over comparable treasuries from 1997 to 1998, but was priced at an average of 1130 for the first four months of 1999.

[3]This is drawn from the remarks made by the Chilean Minister of Finance, Dr. Eduardo Aninat, reported by *Financial Times* on April 21, 1999.

of sovereign securities on corporate securities, focusing on the role of information and liquidity. It first presents a model to identify conditions when sovereign securities may stimulate the provision of liquidity for individual securities. It then tests the theoretical predictions of the model by using corporate bond pricing data from nine emerging-market countries.

To study the spill-over effect of sovereign bonds, we use the standard definition of liquidity as the price elasticities of demands for risky securities (Kyle 1989). In the context of asymmetric information, the price elasticity is synonym for the amount of information content in the prices of securities given the level of noise trading. For the same level of noise trading, a liquid security market will have a highly informative price about the intrinsic value of the underlying asset. Thus, the capacity of a liquid market to absorb non-informational trades is large. On the other hand, when high information asymmetry exists between informed and uninformed investors, uninformed investors will participate in the market only when compensated by a high price (liquidity) premium (Yuan 1999). As a result, prices in an illiquid markets convey little information and small shocks cannot be absorbed without affecting prices.

Given the above definition of liquidity, we analyze a situation where all firms in a given economy decide whether to issue a publicly-traded security. Going public in a liquid securities market provides insurance for firms against future liquidity shocks. When hit by a liquidity shock,[4] a firm often needs to raise capital quickly from less-informed investors.[5] These uninformed investors demand a high premium, as they are unsure about the firm's future profitability and hence credibility. However, in a liquid market, security prices indicate the firm's intrinsic value of the firm to uninformed investors. Therefore, liquid instruments help borrowers, in this case, firms, transfer future wealth to the needy present at a lower cost.[6] To isolate the liquidity

[4]Liquidity shocks are sudden needs for capital, which can be either favorable ones, such as new investment opportunities so that firms have to get out of the old line of business, or unfavorable ones, such as terms of trade shocks.

[5]Shleifer and Vishny (1992) argue that when a firm in financial distress needs to sell assets, its industry peers, who are the investors informed about the intrinsic value of the distressed assets, are likely to be experiencing problems themselves, leading to asset sales to uninformed investors at fire-sale prices below value in best use. Such illiquidity makes assets cheap in bad times.

[6]In reality, a firm may use other mechanisms to insure against such liquidity shocks, such as securing a credit line in advance, or holding government or even other firms' claims. However, these mechanisms either are more costly or hedge less perfectly than a liquid

effect of the securities market, the model assumes that, when firms decide on the amount of security to be offered, the sole consideration is the amount of insurance benefit against liquidity shocks, rather than the amount of capital required.

Other researchers have also studied the information role of securities markets. For example, Holmström and Tirole (1993) and Faure-Grimaud and Gromb (1999) find that trading generates information which improves the incentive contracts of employed managers in public firms. Boot and Thakor (1997) also note the valuable information that security prices provide to real decisions of firms, in their study of the differences between bank-versus-market-dominated financial systems.[7]

Despite the information benefits of a liquid market, liquidity, comes at a cost. To characterize and measure the cost of liquidity provision, our model assumes that investors acquire information at a fixed cost. Since asset prices become more informative and asset markets become more liquid when informed speculators trade, the cost of liquidity is equivalent to the cost of enticing informed speculators to trade. However, since acquiring information is costly, informed speculators will enter only those markets in which they can make positive revenues through trading with uninformed investors. On the other hand, uninformed investors will trade if they can break even on average, even though they do not generally make any profits. To attract these uninformed investors, and in turn attract more informed investors, firms have to underprice their initial offerings. Hence, the cost of liquidity provision is equivalent to the amount of the IPO underpricing. Since this cost is borne by the firms, the decision regarding the amount to offer to the public represents a tradeoff between the insurance benefit and the underpricing cost.

Given this framework of market liquidity and security insurance, if firms share a common risk component, but each firm makes its own decision about the optimal level of liquidity, coordination failure in producing economy-wide liquidity may occur. To understand this phenomenon, suppose that the security claim of each firm has two risk components: firm specific and country specific. Every firm has a weak incentive to compensate informed investors for the cost incurred in acquiring information on the country-specific risk component because it cannot internalize all of the benefits. Hence, every

instrument.

[7]Refer to the literature on security design under asymmetric information for discussions of the information content of security prices (Myers and Majluf 1984) (Stein 1992) (DeMarzo and Duffie 1999) (Boot and Thakor 1993) (Chemmanur and Fulghieri 1999)

firm decides on a less-than-optimal amount of liquidity by issuing a smaller number of securities and hoping to free-ride on the information production provided by other firms. This externality is especially severe when the common risk component (country/systematic risk) is highly volatile and thus information about the common risk component is extremely asymmetrical.

Therefore, when systematic risk is relatively high, the government can stimulate liquidity by issuing securities to absorb the cost of acquiring country-specific information and hence internalizing all information externalities. The government is also in a better position than private firms to issue aggregate risk securities because it can audit the income of all firms in the economy and has better information about the country-specific risk component.

The government's role as liquidity facilitator is seen clearly in securities markets in emerging-market economies. In such cases, the information asymmetry problem is most severe when emerging-market firms attempt to obtain financing from the international capital market, as international investors know little about the economic prospects of developing countries or firms within those countries. As a consequence of the high degree of information asymmetry, the securities markets in the emerging economies are plagued with problems such as insider trading, price volatility, and illiquidity. Moreover, emerging-economy firms suffer more from liquidity shocks due to the fast-changing investment environment and thus have more contingency needs to transfer future wealth to the present. Since establishing a liquid securities market is especially important to such firms, sovereign securities in emerging-market countries generate large spill-over effects on corporate securities.

In exploring the spill-over effect of sovereign securities, this paper extends the study of Holmström and Tirole (1998). First, Holmström and Tirole (1998) define liquidity as "the availability of instruments (market and nonmarket) that can be used to transfer wealth across periods." This paper focuses on the market instruments, in particular quantifying their availability to transfer wealth across periods. Furthermore, instead of the moral hazard problem of borrowers who cannot credibly commit their future income, the illiquidity that borrowers face in this study is due to the uncertainty of future investment opportunities and the fixed cost of insuring against this uncertainty. Holmström and Tirole (1998) focus on how intermediaries (in an economy without aggregate uncertainty) or government (in an economy with aggregate uncertainties) pool or commit liquid assets to redistribute them as insurance against liquidity shocks. In their study, coordination failure arises because agency problems limit the amount of available funds and the total amount of liquidity remains constant. This study presents an alternative reason for coordination failure. Here, coordination failure arises when an issuing firm cannot internalize all of the benefits of entering into the securities market. In this case, the amount of liquidity is an endogenous variable chosen jointly by the firms and the government.

The focus of this study on emerging markets also relates to the macroeconomic literature on information externalities in development (Acemoglu and Zilibotti 1998) and recent literature on the development of financial markets (Subrahmanyam and Titman 1999). As in Acemoglu and Zilibotti (1998) and Subrahmanyam and Titiman (1999), this study finds path dependency in market development as a result of information externalities. In particular, there can be multiple equilibria: an information-efficient equilibrium, where prices convey information efficiently, or an information-deficient equilibrium, where there is little information production and prices thus contain little information about a firm's intrinsic value. In addition to characterizing these endogenous information development paths, this study suggests that issuing sovereign securities at a discount creates incentives for investors to acquire information. Sovereign issues lower the public offering cost for firms, encourage more firms to go public, and in turn, make it more profitable for investors to become informed. This snowball effect can move an economy from an "information deficient" stage to an "information efficient" stage.

In an information-efficient market, securities prices are more informative about firms' idiosyncratic risk than in an "information deficient" equilibrium. This theoretical finding is consistent with both Morck, Yeung, and Yu's (1999) and Campbell, Lettau, Malkiel, and Xu's (2001) empirical results. Morck, Yeung, and Yu (1999) find that most emerging markets have synchronous stock price movements. Campbell, Lettau, Malkiel, and Xu (2001) find a noticeable increase in firm-level volatility relative to market volatility over the period 1962-1997 in the U.S. market. This increase in firm volatility may reflect the information efficiency of the current U.S. securities markets compared to those of emerging markets or the U.S. securities market in the early years.

In sum, this paper develops a model that identifies conditions when sovereign issue enhances overall market liquidity. After developing the model, it then tests the model's predictions by examining data from nine emerging-market countries. The most salient prediction of the model is that, after sovereign issuances, securities markets become more liquid and information-efficient. In particular, a more liquid market exhibits a smaller bid-ask spread, a lower liquidity premium and hence a higher price; a more information-efficient securities market exhibits security prices that reflect relatively more firm-specific risk than aggregate risk. This risk differential reflects firms' willingness to compensate informed investors more to speculate on firm-specific risks when the government absorbs aggregate risk speculation costs. In short, sovereign issues result in a less-correlated securities market.

The remainder of the paper is organized as follows. Section 2 presents the theoretical model and illustrates the liquidity difference between a decentralized-economy regime and a sovereign regime. Testable predictions are highlighted. Section 3 presents empirical specifications, reports the results, and conducts various robustness checks. Section 4 concludes by discussing implications of the empirical results and future works.

2 The Model

This section presents a theoretical model of liquidity provision for an economy with N firms. It first introduces agents in this economy: firms with their liquidity needs, informed traders, liquidity traders, and private investors. It then solves for the equilibrium liquidity provision for an economy without government securities and for an economy with government securities. The amount of liquidity provision between these two economies is then compared.

2.1 Firms

Suppose that there are N firms in an economy. Each firm is owned by a risk-neutral entrepreneur.[8] For each firm, there are four crucial dates (date 0, 1, 2, and 3). Date 3 is the completion date, when firm i's random output $(\widetilde{v}_i)$ is realized. However, at date 2, before the random output is realized, firm i may suffer an unobserved liquidity shock with a probability (π), which requires the firm to sell the business to private investors,[9] who are uninformed mean-variance preference investors with a risk-aversion coefficient of α.[10]

[8] "Firm" is used as a synonym of "entrepreneur" in this paper. Hence, maximizing an entrepreneur's utility is equivalent to maximizing a firm's profit in this paper.

[9] This sellout assumption is purely for simplicity of illustration. Assuming that only a certain amount of money is to be raised will not change the results of the model.

[10] Note that all agents in the model are risk neutral except private investors. This assumption reflects the liquidity needs and hence measures the liquidity cost. If all agents

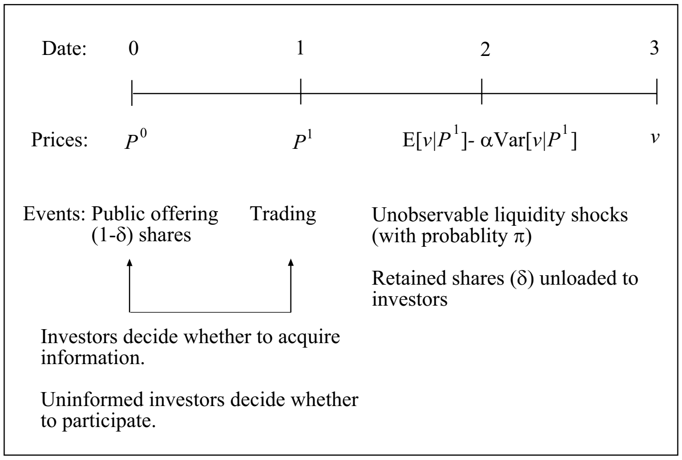

Figure 1: Time Line of Firm i's Events

This liquidity shock can be interpreted in several ways. It can be represented as an adverse balance sheet shock, such as a terms of trade shock or an exchange rate shock, for which firm i needs to raise money to cover the working capital. Or it may be seen as a new investment opportunity, for which firm i needs to raise funding by selling out its existing business.

In the above illustration, private investors estimate the value of firm i's asset based only on his prior knowledge about the intrinsic value of the firm; in this case, asset price at date 2 will be $P^2 = E\left[\widetilde{v}_i\right] - \alpha Var\left[\widetilde{v}_i\right]$. In other words, if the firm has to sell the existing business earlier than date 3, it has to pay private investors a price concession in the amount of $\alpha Var\left[\widetilde{v}_i\right]$.

To insure against a liquidity shock and reduce the price concession paid to private investors, a firm may signal private investors about the value of the existing business to help these investors infer the value of the output more precisely. This model incorporates the following signal: the price of a security claim on the future output of the firm. The security claim has to be issued on date 0 and traded on date 1 so that liquidity providers can infer the asset value by conditioning on the security's price on date 1 (P_i^1).

In the above timeline, firm i decides how much $(1 - \delta_i)$ to issue (or how

are risk neutral in this economy, there will be no cost in transferring future resources and liquidity is free. The empirical justification for this assumption is that private investors have to absorb all liquidity selling at a short notice when firm i is hit by the liquidity shock. The author wishes to thank Jeremy Stein for pointing out this intuition.

much δ_i to retain) at date 0 to insure against a shock at date 2. It also may decide not to issue at all (that is $\delta_i = 1$). Thus, the maximization problem for firm i is:

$$\max \left\{ V_{\delta_i=1}, \max_{0 \leq \delta_i < 1} E\left[P_i^0 \left(1-\delta_i\right) + \left(\left(1-\pi\right)\widetilde{v}_i + \pi \left(E\left[\widetilde{v}_i | P_i^1\right] - \alpha Var\left[\widetilde{v}_i | P_i^1\right] \right)\right) \delta_i \right] \right\},$$

where $V_{\delta_i=1}$ is the value firm i receives if it decides not to enter the securities market.

For simplicity, assume that each of these N firms faces the four crucial dates at the same time, and that the stochastic properties of outputs and liquidity shocks are the same across firms. In this model, firm i has to decide first whether to issue a publicly-traded security and second how much to issue, if it chooses to issue. Firm i's decision on whether to issue the security at date 0 (and how much to issue) or to face a possible liquidity shock at date 1 can be regarded as a decision about entering a public security market at date 0. If firm i decides to issue securities at date 0 to alleviate the severity of a possible liquidity shock at date 1, it has to pay the cost of issuing a publicly-traded security.[11] If firm i decides not to enter the public market until a later date, it faces the challenge of raising money from uninformed risk averse private investors. The difference between issuing at date 0 or issuing at a later date is the difference between the information acquisition cost at date 0 and the risk premium demanded by private investors at date 1.

Ultimately, firm i's decision on whether to issue securities hinges on the stochastic property of its final output, the informativeness (liquidity) and the cost of issuing a publicly-traded security. Assume that the future output of each firm has two risk components: systematic and security-specific. In particular,

$$\widetilde{v}_i = \overline{v}_i + \beta_i \widetilde{\gamma} + \widetilde{\varepsilon}_i,$$

where $\widetilde{\gamma}$ is the systematic (macroeconomic) and $\widetilde{\varepsilon}_i$ is the firm-specific (idiosyncratic) component of firm value innovation. β_i is the macro factor loading. $\overline{v}_i$ is firm i's mean output at the final date.

[11] The cost of issuing a publicly-traded security will be addressed in Section 2.3.2. This cost is the amount that firm i has to pay for informed traders to enter the market to make the security price informative.

2.2 Securities Markets

In our model, the securities market consists of two types of risk-neutral informed traders: traders who acquire information only on the macro factor and traders who acquire information only on the security-specific factor. The information acquisition cost for each type of signal is a fixed cost, c. The number of each type of trader is determined by the zero profit condition.[12]

Both types of informed traders receive imperfect signals about the underlying random output. In particular, macro-factor speculators receive the same signal about the macro factor ($\widetilde{\gamma}$),

$$\widetilde{s}_m = \widetilde{\gamma} + \widetilde{\xi}_i$$

and security-specific speculators receive the same $\widetilde{s}_i$ about firm i's firm-specific risk,

$$\widetilde{s}_i = \widetilde{\varepsilon}_i + \widetilde{\eta}_i.$$

In addition to risk-neutral informed traders, liquidity traders also exist in this economy. Hence, informed traders can use the profit from trading with liquidity traders to cover the information acquisition cost. Prices are thus insufficient statistics of the signals and the no-trade theorem will not apply (Milgrom and Stokey 1982). Note that, although liquidity traders in this economy trade for non-informational motivations, they expect to earn zero profit before participating in any market and are thus discretionary liquidity traders. In essence, these discretionary liquidity traders act as uninformed traders and, on average, do not lose money. We use uninformed traders and discretionary liquidity traders interchangeably for the rest of the paper.[13] In our model, we assume for each security that the discretionary liquidity

[12]Here we assume that macro-informed traders are constrained from investing in learning about the firm-specific risk component to make the derivation easier. In fact, the assumptions can be less restrictive. Assuming that a trader cannot learn about firm-specific risk components for all firms at the same time allows some traders to have signals that are noisier with respect to the security they can invest in under the no-sovereign regime than under the sovereign regime. In another words, signals are more aligned with securities under the sovereign regime.

[13]Note that this definition of discretionary liquidity traders is different from that in classical models such as Kyle (1985) and Admati and Pfleiderer (1988). As in classical models, liquidity traders here contribute directly to the market liquidity. However, in most previous models, the existence of liquidity traders is exogenously specified and therefore there is no cost to provide liquidity. However, in this model, liquidity traders are similar

demand $(1-\delta)\widetilde{y}$ is proportional to the size of the outstanding asset $(1-\delta)$ and is normally distributed as $N\left(0,(1-\delta)^2\sigma_y^2\right)$.

In addition, we assume that $\left(\widetilde{\varepsilon}_i,\widetilde{\eta}_i,\widetilde{\gamma}_i,\widetilde{\xi}_i,\widetilde{y}\right)$ are mutually independent, jointly normally distributed with mean 0, and with variances $\left(\sigma_v^2,\sigma_\eta^2,\sigma_\gamma^2,\sigma_\xi^2,\sigma_y^2\right)$, respectively. For simplicity, the precisions are defined as follows:

$$(\tau_v,\tau_\eta,\tau_\gamma,\tau_\xi,\tau_y,\tau_s,\tau_m)\equiv\left(\sigma_v^{-2},\sigma_\eta^{-2},\sigma_\gamma^{-2},\sigma_\xi^{-2},\sigma_y^{-2},1/(\sigma_v^2+\sigma_\eta^2),1/(\sigma_\gamma^2+\sigma_\xi^2)\right)$$

We next identify the equilibrium price for firm i's asset at date 1 using Kyle's framework (Kyle 1989). Here both informed and liquidity traders submit their demands to a market maker, not knowing the market clearing price when they do so. The security price is set by an uninformed market maker who observes only the total net order flow for one security: q_i. Market making is competitive and the market maker is expected to break even. That is: $P_i^1=E\left(\widetilde{v}_i|q_i\right)$.

Informed traders are strategic: they know that their order will affect the price and thus camouflage their information when submitting the order. This is an important assumption of the model since each informed trader acts like a monopolist. However, they are not cooperative. The more informed investors, the more they erode the monopoly rent and make the price more informative.

Finally, the equilibrium price for firm i's asset at date 0 can be found by solving the discretionary liquidity traders' zero-profit condition, as they expect to break even, on average.

2.3 An Economy without Government Securities

In this economy, each firm individually decides the amount of security to be issued to insure against the liquidity risk. The maximum possible number of securities issued by firms is N.

2.3.1 Asset Prices

Suppose firm i decides to issue $(1-\delta_i)$ of security (retaining δ_i). We first solve for the security's initial price (P_i^0) at date 0 and the public trading

to the discretionary liquidity traders in Subrahmanyam (1991) in that they do not lose money in trading and are merely uninformed. The size of uninformed participation in this model is an endogenous choice variable.

price (P_i^1) at date 1. We then solve for the optimal offering $(1-\delta_i)$.

In this model macro-factor informed traders will invest in all available securities, while firm-specific informed traders will participate only in the security market they know best. We denote the number of macro-factor informed traders as g, and the number of firm-specific informed traders as k_i. The net amount of liquidity traders' demand is $(1-\delta_i)\,\widetilde{y}$. As in Kyle (1989), the market maker sets the price by a linear pricing rule,[14]

$$P_i^1 = \overline{v}_i + \lambda_i q_i.$$

Lemma 1 *For firm i's security, each macro-factor informed trader submits an order x_i^m, and each firm-specific informed trader submits an order of x_i^s:*

$$x_i^m = \frac{1}{(g+1)\,\lambda_i}\frac{\beta_i\sigma_\gamma^2}{\sigma_\gamma^2+\sigma_\xi^2}\widetilde{s}^m,\ x_i^s = \frac{1}{(k_i+1)\,\lambda_i}\frac{\sigma_v^2}{\sigma_v^2+\sigma_\eta^2}\widetilde{s}_i$$

$$\lambda_i = \frac{\left(\frac{k_i}{(k_i+1)^2}\frac{\sigma_v^2}{\sigma_v^2+\sigma_\eta^2}+\frac{g}{(g+1)^2}\frac{\beta_i^2\sigma 4}{\sigma_\gamma^2+\sigma_\xi^2}\right)^{1/2}}{(1-\delta_i)\,\sigma_y}$$

The expected revenue for macro-factor informed traders is:

$$E\left[revenue\_macro\right] = \frac{1}{(g+1)^2\,\lambda_i}\frac{\left(\beta_i\sigma_\gamma^2\right)^2}{\sigma_\gamma^2+\sigma_\xi^2}$$

The expected revenue for firm-specific risk informed traders is:

$$E\left[revenue\_firm\right] = \frac{1}{(k_i+1)^2\,\lambda_i}\frac{\sigma_v^4}{\sigma_v^2+\sigma_\eta^2}$$

The comparative statics here are fairly intuitive. First, market liquidity increases with the number of informed traders, regardless of the type of information. Second, the larger the initial issuance $(1-\delta_i)$, the more liquid the market is. This effect is seen through three channels: the first one is through the large number of discretionary liquidity traders (uninformed traders), the second is through the high variance of their trading, and the third is through the number of informed traders.

[14] Note that, in the literature, $1/\lambda_i$ is often used as a measure for market liquidity as this expression is the price elasticity of the demand for the asset i.

Corollary 1 *Market liquidity* $(1/\lambda_i)$ *increases with the number of both firm-specific and macro-factor informed traders.*

In this scenario, as more traders decide to become informed, the monopoly rent advantage disappears and the information premium decreases.

Corollary 2 *The security price increases (decreases) with the number of informed traders given the order flow* $q > 0$ $(q < 0)$.

Since informed traders are competitive, the equilibrium numbers of firm-specific informed traders (k_i) and macro-factor informed traders (g) are obtained by setting $E\left[revenue\right] = c$, assuming w is equal to the number of firms deciding to enter the security market.

$$c = \frac{w}{\left(g+1\right)^2 \lambda_i} \frac{\left(\beta_i \sigma_\gamma^2\right)^2}{\sigma_\gamma^2 + \sigma_\xi^2} = \frac{1}{\left(k_i+1\right)^2 \lambda_i} \frac{\sigma_v^2}{\sigma_v^2 + \sigma_\eta^2}$$

Therefore, the revenue of informed traders decreases with the number of informed traders ($\frac{\partial E[\text{Revenue}|s_i]}{\partial k_i} < 0, \frac{\partial E[\text{Revenue}|s^m]}{\partial g} < 0$). In addition, the number of informed traders increases with signal precision, underlying fundamental variance, and initial offering size. More importantly,

Corollary 3 *A more liquid market is also a market that is more informative about the fundamental's payoff.*

Proof. The sufficient statistics (z_m, z_i) for the underlying signals $(\widetilde{s}_m, \widetilde{s}_i)$ have variances $(1/\tau_{z_m}, 1/\tau_{z_i})$ that decrease with the number of informed traders, but are independent of discretionary liquidity trading. This independence reflects the tendency of informed traders to disguise information by scaling investments in the same proportion as liquidity trading. ■

We thus write the expression for the measure of liquidity as:

$$\frac{1}{\lambda_i} = \frac{\left(1-\delta_i\right)^2 \sigma_y^2}{(k_i + g/w)c}$$

Corollary 4 *Market liquidity increases with the IPO size:* $\frac{\partial(1/\lambda_i)}{\partial(1-\delta_i)} > 0$.

Following this relationship, firm i can determine the level of liquidity (informativeness) by choosing how much to issue to the public securities market.

The equilibrium initial offering price, P_i^0, is determined by the discretionary liquidity traders' break-even condition:

$$P_i^0 = \overline{v}_i - (k_i c + gc/w)/(1-\delta_i)$$

Note that the initial underpricing exists even when all active traders are risk-neutral. However, it is less pronounced when a large number of firms are already in the security market. This decrease in underpricing occurs because firm i can free-ride on the macro-factor information already generated by the other firms' securities trading.

Lemma 2 *The initial underpricing increases with offering size, and decreases with the number of firms that have issued securities.*

2.3.2 Firm i's Initial Offering Decision

In deciding whether to issue a security, a firm trades off the initial underpricing with the risk of liquidation. The initial underpricing creates a more informative and liquid market, which may bring favorable terms in the event of liquidation.

Suppose there are w number of firms in the economy that have issued securities. The total revenue to a marginal firm i if it chooses to retain (δ_i) is

$$\begin{aligned}
& V\left(0 \le \delta_i < 1\right) \\
= \; & P_i^0 \left(1-\delta_i\right) + \\
& \delta_i E^0 \left[\left(1-\pi\right)\widetilde{v}_i + \pi\left(E^1\left[\widetilde{v}_i | P_1^1, ..., P_w^1, P_i^1\right] - \alpha Var^1\left[\widetilde{v}_i | P_1^1, ..., P_w^1, P_i^1\right]\right)\right] \\
= \; & \overline{v}_i - k_i c - \frac{gc}{w} - \frac{\pi\delta_i\alpha\beta_i^2}{\tau_\gamma + \left(w+1\right)\tau_{z_m}} - \frac{\pi\delta_i\alpha}{\tau_v + \tau_{z_i}}
\end{aligned}$$

Firm i chooses $\delta_i^* = argmax_{\delta_i} V(0 \le \delta_i \le 1)$ to maximize total revenue. In the above specification, the initial offering size $(1-\delta_i)$ decreases $Var\left[\widetilde{v}_i | P_1^1, ..., P_w^1, P_i^1\right]$. Therefore, it lowers the risk premium that liquidity investors require in the event of liquidity shock and increases the total expected value firm i receives. However, a large initial offering also has a cost; that is, the more firm i offers to the public, the less it has at the final date $(\overline{v}_i\delta_i)$. Moreover, a large initial offering results in a larger underpricing.

Proposition 1 *If the underlying stochastic variables (e.g.,* $\sigma_v^2, \sigma_\eta^2, \sigma_\gamma^2, \sigma_\xi^2, \sigma_y^2$*) are such that the market is highly liquid (i.e.* $1/\lambda_i$ *is high), firms can issue smaller amounts of securities to achieve a smaller IPO underpricing and a more informative* P^1*.*

Proof. Suppose the number of informed traders in the liquid market is the same as in an illiquid market. From Lemma 1, we know that informed traders earn strictly positive profits. Therefore, firm i can decrease its initial offering size and still retain informed traders. The rest of the proposition follows from Lemma 2. ■

However, firm i may choose to stay out of the market. If securities for w firms are already traded in the markets, a liquidity shock to firm i at date 3 allows it to sell for a price that is better than $\overline{v}_i - \alpha(\beta_i^2(\sigma_\gamma^2 + \sigma_\xi^2) + \sigma_v^2)$. This is because the trading of other firms' securities reveals information about the macro factor.

$$
\begin{aligned}
V(\delta_i = 1; w) &= E^0\left[(1-\pi)\widetilde{v}_i + \pi\left(E^1\left[\widetilde{v}_i | P_1^1, ..., P_w^1\right] - \alpha Var^1\left[\widetilde{v}_i | P_1^1, ..., P_w^1\right]\right)\right] \\
&= \overline{v}_i - \pi\alpha\left(\frac{\beta_i^2}{\tau_\gamma + w\tau'_{z_m}} + \frac{1}{\tau_v}\right)
\end{aligned}
$$

Lemma 3 *The option value of free-riding on other* w *firms is,*

$$
\begin{aligned}
&V(\delta_i = 1; w) - V(0 \leq \delta_i^* < 1; w) \\
&= k_i c + \frac{gc}{w} - \pi\alpha\beta_i^2\left(\frac{1}{\tau_\gamma + w\tau'_{z_m}} - \frac{\delta_i^*}{\tau_\gamma + (w+1)\tau_{z_m}}\right) - \pi\alpha\left(\frac{1}{\tau_v} - \frac{\delta_i^*}{\tau_v + \tau_{z_i}}\right)
\end{aligned}
$$

This value increases with both the information acquisition cost, c*, the number of informed traders in the markets (*k_i *and* g*), and the level of information asymmetry on the macro factor (*$1/\tau_{z_m}$*) or on the firm-specific factor (*$1/\tau_{z_i}$*), but is a non-linear function of* w*: it is a decreasing function of* w *when* w *is small, could be an increasing function of* w *when* w *is large.*

Proof. It is immediate that $w \to 0$, $\frac{\partial OptionValue}{\partial w} < 0$. ■

The equilibrium number of firms in securities markets (w) is found by setting the option value of free-ride of the marginal firm i to zero, that is, $V(\delta_i = 1; w) = V(0 \leq \delta_i < 1; w)$. Within a certain range of w, the expected revenue for firm i of entering the securities market is an increasing function of the number of firms in the market. That is, firms' decisions to enter the security market may complement each other. The more firms that enter, the lower the cost of "paying" for the liquidity service of macro-informed investors. However, for a large enough w, firms' decisions to enter the security market may also be substitutes since the more firms that enter, the stronger the incentive to stay out of security market and free-ride.

Following Lemma 3, there are three possible types of equilibria in this economy. [15]

Proposition 2 *Depending on parameter values, any of the following three equilibria could occur:*

1. *Each firm issues* $1-\overline{\delta}$*;*
2. *A fraction of the* N *firms issue* $1-\overline{\overline{\delta}}$*, and the rest stay out of the securities market;*
3. *None of the firms enters the securities market.*

In this decentralized economy, firms must entice speculators. They do so by setting the initial underpricing too high and the trading price too low, compared to output risk. Thus, firms overpay for liquidity to satisfy macro informed traders who do not know about the firm-specific risk. The same is true for firm-specific informed traders.

In addition, each firm has an incentive to avoid paying for liquidity provision by staying outside the securities market and free-riding on other firms' information production. Consequently, coordination fails.

2.4 An Economy with Government Securities

We now suppose that the government issues a security with a pure macro risk:

$$\widetilde{Y}_m = \widetilde{\gamma}$$

This sovereign security is a basket security:

$$\widetilde{Y}_m = \sum_{i=1}^{N} w_i \overline{S}_i + \sum_{i=1}^{N} w_i \beta_i \widetilde{\gamma} + \sum_{i=1}^{N} w_i \widetilde{\varepsilon}_i$$

[15] Only symmetric equilibria are considered in this paper.

where

$$\sum_{i=1}^{N} w_i \widetilde{\varepsilon}_i \rightarrow 0, \ \sum_{i=1}^{N} w_i \beta_i \rightarrow 1$$

Note that this basket security is a claim issued against the outputs of all firms in this economy regardless of their securities market participation. The government can issue this security more easily than private firms, as it can use audit and tax information to obtain economy-wide information and thus greater credibility.

Once a new market opens, macro-factor informed traders will invest in the sovereign security market, while firm-specific informed traders will invest in synthesized securities, $\widetilde{v}_i - \beta_i \, \widetilde{Y}_m$, hedging away the macro risk and focusing on what they know best, i.e. firm-specific risks.[16]

Lemma 4 *For a synthesized firm i's security, each macro-factor informed trader submits an order, y^m, for the sovereign security, and each firm-specific informed trader submits an order, y_i^s:*

$$y^m = \frac{1}{\left(g^{sov}+1\right)\lambda_m^{sov}} \frac{\sigma_\gamma^2}{\sigma_\gamma^2+\sigma_\xi^2} \widetilde{s}^m, y_i^s = \frac{1}{\left(k_i^{sov}+1\right)\lambda_i^{sov}} \frac{\sigma_v^2}{\sigma_v^2+\sigma_\eta^2} \widetilde{s}_i$$

and

$$\lambda_m^{sov} = \frac{1}{\sigma_y} \left(\frac{g^{sov}}{\left(g^{sov}+1\right)^2} \frac{\sigma_\gamma^4}{\sigma_\gamma^2+\sigma_\xi^2} \right)^{1/2}$$

$$\lambda_i^{sov} = \frac{1}{\left(1-\delta_i^{sov}\right)\sigma_y} \left(\frac{k_i^{sov}}{\left(k_i^{sov}+1\right)^2} \frac{\sigma_v^4}{\sigma_v^2+\sigma_\eta^2} \right)^{1/2}$$

The expected revenue for macro-factor informed investors is:

$$E\left[revenue\_macro\right] = \frac{1}{\left(g^{sov}+1\right)^2 \lambda_m^{sov}} \frac{\sigma_\gamma^4}{\sigma_\gamma^2+\sigma_\xi^2}$$

[16]Macro-factor informed investors receive a signal that is orthogonal to the synthetic securities, $\widetilde{v}_i - \beta_i \, \widetilde{Y}_m$, hence, they are like discretionary liquidity traders in the synthetic firm-specific securities markets, who on average do not lose money. Their demands for the synthetic securities are not explicitly modelled other than the zero profit condition. Firm-specific informed informed investors' demands for the sovereign security are modelled similarly.

The expected revenue for firm-specific risk informed investors is:

$$E\left[revenue\_firm\right] = \frac{1}{\left(k_i^{sov}+1\right)^2 \lambda_i^{sov}} \frac{\sigma_v^4}{\sigma_v^2+\sigma_\eta^2}$$

Hence,

Lemma 5 *When the sovereign security is introduced, prices are more informative and markets are more liquid.*

Moreover, in this economy, the covariances among returns on different firms' securities will reflect only covariances of their intrinsic values (instead of noises) and will be smaller as securities prices are more informative. Let $\widetilde{r}_i$ denote the return on firm i's asset and $\widetilde{r}_M$ the return on the aggregate market, we have

Corollary 5 $Cov[\widetilde{r}_M^{sov}, \widetilde{r}_i^{sov}] < Cov[\widetilde{r}_M, \widetilde{r}_i]$. *That is, individual securities are less correlated in the sovereign regime than in the regime without sovereign securities.*

Proposition 3 *Total welfare is improved with the introduction of a basket security such as a sovereign security.*

Proof. The proof is similar to the one for Proposition 1. Since $\lambda_i^{sov} < \lambda_i, \lambda_m^{sov} < \lambda_i$, by Proposition 1, welfare is greater in the sovereign regime than in the decentralized regime. ■

Corollary 6 *The secondary market prices for corporate bonds are higher when a sovereign security is introduced.*

Intuitively, a macro-factor informed trader demands a smaller price concession with a sovereign security option because she has a sharper signal regarding this security. Thus, the equilibrium price is closer to the true realization in the sovereign regime, and the firm can achieve better insurance at a lower cost (a lower initial underpricing). Hence, the total expected revenue in the economy rises when sovereign securities are introduced for information purposes. By extension, borrowers should split securities into parts that are aligned with different investors' signals to obtain the lowest required price discounts and the maximum revenues. In our model, we have two types of market information, and therefore, it is an pareto-improvement for the economy to have two types of security claims: macro and firm-specific. Hence, the government can internalize the externality of information production of each firm by issuing the macro security. The benefit of the macro security is larger when the option value of free-riding is higher.

One may argue against the necessary role of the government in facilitating market liquidity. Investors could issue a new security claim by pooling the existing set of securities.[17] This composite security would embody mostly macro risk. However, this indexed security is pooled on an incomplete set of individual securities, which may not be a perfect hedging instrument for macro risk, as some firms may choose to stay out of the securities markets.[18] Thus, a demand-side initiated security design is suboptimal.

2.5 Testable Hypotheses

The above theoretical model is a general one in the sense that in reality we do not observe securities that fully embody the macro risk in every contingency. Since the equity shareholders essentially own a call option on the firm, an equity market index reflects the upside risk of the macro factor. Similarly, since bondholders wrote a put option on the firm to the equity-holders, sovereign bonds represent the downside risk of the macro factor.

In our empirical work below, we limit the scope of this study to the dollar-denominated bond market and test three specific hypotheses that are implied by the theoretical model: after dollar-denominated sovereign issues and especially when the option value of the freeriding is high,

1. bid-ask spreads of corporate bonds will become smaller;

2. prices of corporate bonds will increase;

3. correlations of corporate bonds will decrease.

[17] For example, due to investor demand, the Chicago Board of Trade (CBOT) and Chicago Mercantile Exchange (CME) launched an index on Mexican peso futures and options in April 25, 1995 and IPC, an index of the Mexican stock market, in May 30, 1995.

[18] It is possible that an initial incomplete securities index will attract some firms entering the securities market and hence start a snowball effect. However, this solution may not be possible in the emerging-market setting, as information asymmetry is severe and the cost threshold for firms to enter the securities market is high.

The first hypothesis follows directly from Lemma 6, as bid-ask spread is a measurement for liquidity, the second from Propositions 1, 3 and Corollary 6, and the third from Corollary 5.

3 Empirical Estimation of Sovereign Bonds' Liquidity Service

In the following sections, we present the results of our empirical tests of the hypotheses. The empirical study focuses on dollar-denominated emerging market bond markets in the United States. The dollar-denominated bonds include three categories: Eurodollar (Euro-144A), Global, and Yankee. Eurodollar bonds are underwritten by an international syndicate and traded outside of any one domestic market. Yankee bonds are SEC registered and trade like any other U.S. domestic bonds. Global bonds are hybrid, designed to trade and settle in both the Euro and Yankee markets. Since Eurodollar bonds are not registered with the SEC, underwriters are legally prohibited from selling to the U.S public until the issue has "come to rest" and a seasoning period has expired. European retailers, who have the dominant presence in the Eurodollar markets, tend to buy and hold to maturity. Hence, liquidity in the secondary Eurodollar markets is somewhat constrained.[19] Yankee and Global bonds face sophisticated U.S. investor base and the secondary markets in Yankee and Global bonds are more liquid. (Fabozzi 2000) We are interested in the liquidity variation of dollar-denominated bonds from emerging-market countries. More specifically, we estimate the magnitude of the liquidity service of benchmark sovereign bonds on corporate bonds from each of these nine emerging-market countries.

3.1 Data

This section outlines the data set used in the subsequent analysis. The analysis requires three types of data: bid-ask spread, price(return), and benchmark sovereign issue date. The principal source of data is from a major

[19]Regulation 144A provided foreign borrowers with greater access to institutional investors by allowing issuers to provide only the documentation required by their home-market regulators rather than undergo the more cumbersome SEC registration process, which makes the Euromarkets and the U.S. domestic bond markets more fungible.

emerging-market bond dealer on Wall Street. The data set contains daily information on prices (returns), and bid-ask spreads from 1996 to 2000 for each of 357 dollar-denominated bonds issued by nine emerging-market countries and traded in the Wall Street. The nine countries are: Argentina, Brazil, Chile, Indonesia, Korea, Mexico, Philippines, Russia, and Venezuela. The data set also provides detailed descriptive information on each bond, including issuer, announcement date, auction date, issue date, issue type, maturity, and coupon rate. Among the 357 bonds, 248 are corporate instruments. We also searched Lexis*Nexis for news stories on each sovereign issuance to check the announcement date and determine the benchmark status. To control for general market conditions, we also include daily data on the emerging-market bond index (EMBI) from J.P. Morgan, exchange rates, Lehman Brother's US high yield bond index, S&P500 index, and three-month Treasury bill returns from DataStream.

The summary statistics for the sample appear in Table 1, 2 and 3. These sample statistics show that bonds from emerging-market countries are extremely volatile over the sample period: January 1996 to November 2000. Average bid-ask spreads of corporate bonds in all nine countries except Venezuela are higher than those of respective sovereign bonds. Average sovereign bond returns exceed average corporate bond returns in four countries: Indonesia, Korea, Mexico, and Russia. Sovereign issues also dominate this market from the number of issues.

To test the effect of new benchmark sovereign issues on corporate bonds, we first construct a time window around each benchmark sovereign issue date. Then we estimate the change in the corporate bonds' price, bid-ask spread, and return correlation in response to a new sovereign issue within the time window. A dummy variable called trade#m is introduced, where # is the number of months after a new sovereign issue is announced in the time window. The variable, trade#m, takes a value of 1 after a new sovereign issue is announced; otherwise, takes a value of 0. Therefore, the coefficient on trade#m measures the liquidity service of sovereign bonds: a negative (positive) coefficient indicates that sovereign bonds have a liquidity service and the magnitude of the liquidity service is measured by the absolute value of the coefficient when the dependent variable is bid-ask spread (offer price) of corporate bonds. The results are robust for time windows ranging from 1 month to 1 year before and from 1 month to 3 months after the introduction of a sovereign bond.

To test the hypothesis that corporate issue correlations will decrease after sovereign issues, we need to construct a corporate bond return index (RI_c)

Table 1: Summary Statistics
This table displays a number of sample summary statistics. All average returns are expressed in percentage terms. Average bid-ask spreads are in basis points/100. Average bid and offer prices are effective average dirty prices. All sample periods start on January 3, 1996 and end on November 20, 2000. The missing number of bid-ask observations is in the parentheses under the column: Obs Num. Standard deviations are also in parentheses.

Country		Bonds Num.	Obs. Num.	Bid-ask Spread	Bid Price	Offer Price	Annual Return
Argentina	Corporate	47	30766	1.437	98.236	99.671	10.529
			(0)	(1.915)	(11.092)	(9.959)	(771.209)
	Sovereign	22	11055	0.670	96.927	97.597	8.849
			(4)	(0.973)	(11.063)	(10.894)	(945.496)
Brazil	Corporate	34	22491	1.579	93.580	95.138	14.835
			(0)	(1.930)	(13.488)	(13.651)	(557.246)
	Sovereign	11	4821	0.893	91.254	92.145	10.342
			(1)	(0.861)	(11.849)	(11.511)	(535.601)
Chile	Corporate	25	11792	1.407	91.759	93.191	15.853
			(515)	(1.605)	(10.863)	(9.709)	(264.406)
	Sovereign	1	375	0.821	94.443	95.264	3.855
			(0)	(0.354)	(2.101)	(2.021)	(181.843)
Indonesia	Corporate	8	3270	1.929	81.391	83.316	-1.929
			(145)	(1.350)	(24.993)	(24.068)	(900.200)
	Sovereign	1	1079	1.914	84.550	86.455	6.904
			(27)	(1.579)	(13.971)	(12.987)	(742.191)
Korea	Corporate	17	7418	1.674	93.961	95.448	8.754
			(2729)	(3.213)	(13.420)	(11.605)	(689.047)
	Sovereign	18	13835	0.716	97.794	98.538	11.015
			(1277)	(0.675)	(7.500)	(7.033)	(310.177)
Mexico	Corporate	82	51835	1.412	98.141	99.552	13.468
			(1)	(4.468)	(12.038)	(11.803)	(513.409)
	Sovereign	31	21480	0.857	102.771	103.627	17.128
			(0)	(0.840)	(8.419)	(8.284)	(284.299)
Philippines	Corporate	17	10538	1.694	93.584	95.278	4.059
			(0)	(2.416)	(16.869)	(15.779)	(1134.822)
	Sovereign	8	3219	0.754	95.847	96.601	-3.906
			(1)	(0.584)	(7.465)	(7.134)	(472.639)
Russia	Corporate	5	3405	4.487	53.418	57.905	-10.144
			(0)	(4.112)	(36.709)	(35.339)	(2835.174)
	Sovereign	10	4571	0.928	64.319	65.247	15.765
			(0)	(0.583)	(26.510)	(26.239)	(1406.783)
Venezuela	Corporate	13	5074	1.465	91.591	93.058	11.662
			(0)	(1.796)	(12.855)	(12.052)	(324.741)
	Sovereign	7	5074	1.767	86.507	88.275	11.358
			(0)	(1.826)	(16.185)	(15.807)	(632.217)

Table 2: Number of Instruments in Trading

This table displays for each country from January 3, 1996 to November 20, 2000 the numbers of dollar-denominated bond instruments in trading in each of these four categories: Yankee, Global, Euro, and Euro144A.

Country		Yankee	Global	Euro144A	Euro
Argentina	Corporate	10	6	25	96
	Sovereign		20	2	
Brazil	Corporate		6	23	5
	Sovereign		9	2	
Chile	Corporate	17	2	3	1
	Sovereign		1		
Indonesia	Corporate		1	5	2
	Sovereign	1			
Korea	Corporate	4	4	4	4
	Sovereign	2	10	1	5
Mexico	Corporate	14	18	46	4
	Sovereign	3	15	12	1
Philippines	Corporate	2	9	4	2
	Sovereign		6	1	1
Russia	Corporate			2	3
	Sovereign			8	2
Venezuela	Corporate	1		10	
	Sovereign	1	2	3	1

Table 3: Number of Instruments Issued

This table displays for each country from January 3, 1996 to November 20, 2000 the numbers of dollar-denominated bond instruments issued in each of these four categories: Yankee, Global, Euro, and Euro144A.

Country		Yankee	Global	Euro144A	Euro
Argentina	Corporate	1	5	19	4
	Sovereign		16		
Brazil	Corporate			18	5
	Sovereign		9	2	
Chile	Corporate	15		3	1
	Sovereign		1		
Indonesia	Corporate			4	2
	Sovereign	1			
Korea	Corporate	1	3	4	4
	Sovereign	1	8	1	2
Mexico	Corporate	11		41	3
	Sovereign	1	11	3	
Philippines	Corporate	2	4	4	2
	Sovereign		6	1	1
Russia	Corporate			2	3
	Sovereign			8	2
Venezuela	Corporate	1		7	
	Sovereign		2	1	

within each country. We use a price-weighed index as it weighs the impact on each bond equally regardless of differences in market capitalization across bonds. We also need to calculate the correlations between the excess return on each corporate bond (R_i) and the excess return on the corporate index (RI_c) for the sub-periods (before and after a sovereign issue) in the specified time window.

A further examination of the data in Table 1 shows a large variation in the mean value of prices of bonds within a country. To be certain that our results are not driven by extreme values in the data set, we use fixed-effect estimations while the fixed effect is specific with respect to each window.

3.2 Methodology and Evidence

This section describes the results of our test whether sovereign issues improve liquidity. Our first set of results concerns simple specifications estimated by country. We then perform joint tests that employ the entire panel of nine countries to increase the power of our tests. Finally, we examine the economic significance of the liquidity effect of sovereign bonds with traditional measures similar to R^2.

The decision to issue sovereign bonds may be endogenous. That is, the government may time sovereign issuances, and therefore, a sovereign issue, by itself, may signal "good news." Prices of existing corporate are often adjusted to the news of a new sovereign issue immediately upon the announcement. In country-by-country studies, endogeneity may result in upward-biased estimates of the mean liquidity effect of sovereign bonds (which is the coefficient on trade#m). Hence, we need to be cautious in interpreting the country-by-country regression results. However, with cross-country, individual corporate bond specific data, this bias should be picked up by the country fixed effects in the panel regressions.

3.2.1 Country Tests

We now estimate a set of simple regressions for each country. Specifically, we estimate the parameters of the following equations:

$$
\begin{aligned}
BA_i &= \alpha + \beta_1 trade\#m + \gamma controls + \epsilon_i \\
P_i &= \alpha + \beta_2 trade\#m + \gamma controls + \epsilon_i \\
Corr(R_i, RI_c) &= \alpha + \beta_3 trade\#m + \gamma controls + \epsilon_i,
\end{aligned}
$$

Table 4: Corporate Bonds' Bid-Ask Spreads

This table displays country-specific and panel results of estimating changes in daily corporate bond bid-ask spreads in response to a new sovereign issue. A time window of 5 months is chosen for the estimation. The dependent variable is corporate bond daily bid-ask spread in basis points/100. The independent variables include control variables, country dummy variables, and a dummy variable, trade#m, where # is the number of months after a new sovereign issue is announced in the time window. The variable, trade#m, takes a value of 1 after a new sovereign issue is announced; otherwise, takes a value of 0. Estimations are done using fixed effect. Standard errors are in parentheses.

		Month[-3, +2] Window		
Country	Obs.	Dependent Mean	β	R^2
Argentina	45667	1.756	-0.406	0.027
		(2.359)	(0.012)	
Brazil	21590	1.238	-0.348	0.053
		(1.500)	(0.011)	
Chile	1925	2.094	-0.802	0.217
		(2.015)	(0.037)	
Indonesia	208	0.906	-	-
		(0.196)	-	
Korea	3211	1.679	-	-
		(3.319)	-	
Mexico	56493	1.400	-0.299	0.004
		(4.423)	(0.037)	
Philippines	8021	2.038	-0.277	0.034
		(2.672)	(0.054)	
Russia	3709	3.207	-	-
		(3.068)	-	
Venezuela	291	1.263	-	-
		(2.190)	-	
All countries	141115	1.590	-0.368	0.013
		(3.324)	(0.017)	

Table 5: Corporate Bond Prices

This table displays country-specific and panel results of estimating changes in daily corporate bond offer prices in response to a new sovereign issue. A time window of 5 months is chosen for the estimation. The dependent variable is corporate bond daily offer price. The independent variables include control variables, country dummy variables, and a dummy variable, trade#m, where # is the number of months after a new sovereign issue is announced in the time window. The variable, trade#m, takes a value of 1 after a new sovereign issue is announced; otherwise, takes a value of 0. Estimations are done using fixed effect. Standard errors are in parentheses.

		Month[-3, +2] Window		
Country	Obs.	Dependent Mean	β	R^2
Argentina	45667	97.624	1.060	0.027
		(9.956)	(0.026)	
Brazil	21590	96.567	2.339	0.183
		(12.323)	(0.040)	
Chile	1925	91.114	5.439	0.431
		(9.592)	(0.141)	
Indonesia	208	101.925	-	-
		(4.492)	-	
Korea	3211	97.700	-	-
		(10.903)	-	
Mexico	56493	99.279	1.255	0.026
		(11.148)	(0.041)	
Philippines	8021	93.272	1.635	0.345
		(15.496)	(0.067)	
Russia	3709	81.951	-	-
		(16.175)	-	
Venezuela	291	103.673	-	-
		(10.049)	-	
All countries	141115	97.400	1.560	0.051
		(12.231)	(0.050)	

Table 6: Corporate Bonds Return Correlations

This table displays country-specific and panel results of estimating changes in correlation of daily corporate bond returns in response to a new sovereign issue. A time window of 10 months is chosen for the estimation. The independent variables include country dummy variables, and a dummy variable, trade#m, where # is the number of months after a new sovereign issue is announced in the time window. The variable, trade#m, takes a value of 1 after a new sovereign issue is announced; otherwise, takes a value of 0. The independent variables also include a control variable, average exchange rate before month 0 and after month 0. The dependent variable is correlation of each corporate bond daily return with a price-weighted corporate return index before and after the announcement date. Estimations are done using fixed effect. Standard errors are in parentheses.

		Month[-3, +2] Window		
Country	Obs.	Dependent Mean	β	R^2
Argentina	1349	0.392	-0.084	0.043
		(0.289)	(0.002)	
Brazil	588	0.352	-0.071	0.054
		(0.315)	(0.002)	
Chile	20	0.623	-	-
		(0.135)	-	
Indonesia	2	1	-	-
		(0.000)	-	
Korea	195	0.659	-0.113	0.133
		(0.304)	(0.004)	
Mexico	1734	0.435	-0.109	0.098
		(0.291)	(0.002)	
Philippines	220	0.404	-0.021	0.023
		(0.326)	(0.005)	
Russia	111	0.777	0.010	0.004
		(0.229)	(0.005)	
Venezuela	9	0.841	-0.035	0.046
		(0.172)	(0.013)	
All countries	4228	0.429	-0.090	0.163
		(0.301)	(0.001)	

where i represents corporate; BA_i and P_i denote bid-ask spread and spread, respectively; R_i and RI_c, denote excess return on corporate bond i, and corporate bond index, respectively. Control variables include nominal exchange rate, S&P500 index level, and three-month Treasury bill returns.

The regression coefficients presented in Table 4 and 5 on country-specific regressions already give us an idea of the significance of sovereign bonds' liquidity effect. All of the five negatively estimated coefficients for the country bid-ask spread regressions are significantly different from zero using a two-tailed, two-percent test. Similarly, all of the five positively estimated coefficients for the country offer price regressions are also significantly different from zero using a two-tailed, two-percent test. For Indonesia, Korea, Russia, and Venezuela, each has too few observations on bid-ask spreads and offer prices for us to estimate the effects.

Table 6 reports the estimation results on changes in corporate return correlation after a new sovereign issue. The estimated coefficients for all country return correlation regressions except the case of Russia are negative and significantly different from zero using a two-tailed, two-percent test. The average correlation among all corporate bonds except those in Russia goes down after a sovereign issue. For Chile and Indonesia, there are two few observations to perform the estimation.

In fact, we can estimate the differential liquidity service of sovereign bonds because theory predicts that sovereign externality is larger when the value of the free-riding option is higher. To proxy for the value of the free-riding option, we use the volatility level of the bond market index (σ_m^2) before the new sovereign issue following from Lemma 3. Specifically, we estimate the parameters of the following equations:

$$\begin{aligned} BA_{i,j} &= \alpha + \beta_4 \sigma_{m_j}^2 trade\#m + \gamma controls + \epsilon_i \\ P_{i,j} &= \alpha + \beta_5 \sigma_{m_j}^2 trade\#m + \gamma controls + \epsilon_i \\ Corr(R_{i,j}, RI_{c,j}) &= \alpha + \beta_6 \sigma_{m_j}^2 trade\#m + \gamma controls + \epsilon_i, \end{aligned}$$

where j indexes the country.

The option set of regressions mostly preserves the signs and the significance levels of the previous set of regressions. The panel test of correlation is no longer significant, however. This is has to do with the way how the market variance is estimated – it is estimated to be orthogonal to the variance of each corporate bond.

Table 7: Corporate Bonds' Bid-Ask Spreads and the Free-riding Option

This table presents country-specific and panel results of estimating changes in daily corporate bond bid-ask spreads in response to a new sovereign issue accounting for the free-riding option value. A time window of 5 months is chosen for the estimation. The dependent variable is corporate bond daily bid-ask spread in basis points/100. The independent variables include control variables, country dummy variables, and an interaction variable between $\sigma^2_{m,j}$ and the dummy variable, trade#m, where # is the number of months after a new sovereign issue is announced in the time window. The variable, trade#m, takes a value of 1 after a new sovereign issue is announced; otherwise, takes a value of 0. σ^2_m is the variance of the corresponding country bond market index. Estimations are done using fixed effect. Standard errors are in parentheses.

		Month[-3, +2] Window			
Country	Obs.	Dependent Mean	Average σ^2_m	β	R^2
Argentina	45667	1.756	0.0001117	-2955.583	0.0318
		(2.359)	(0.0001703)	(77.75984)	
Brazil	21590	1.238	0.0000704	-2883.601	0.0224
		(1.500)	(0.0001393)	(85.32648)	
Chile	1925	2.094	-	-	-
		(2.015)	-	-	
Indonesia	208	0.906	-	-	-
		(0.196)	-	-	
Korea	3211	1.679	0.0000304	2279.468	0.0260
		(3.319)	(0.0000516)	(1440.601)	
Mexico	56493	1.400	0.0000207	-6519.314	0.3436
		(4.423)	(0.0000235)	(256.2598)	
Philippines	8021	2.038	0.0001201	-3428.498	0.0299
		(2.672)	(0.0000937)	(597.1232)	
Russia	3709	3.207	0.0000808	21399.95	0.1917
		(3.068)	(0.0000567)	(1043.019)	
Venezuela	291	1.263	.000014	-44973.81	0.4884
		(2.190)	(.0000121)	(10850.03)	
All countries	141115	1.590	0.0000583	-1301.505	0.1545
		(3.324)	(0.0001151)	(64.76362)	

Table 8: Corporate Bond Prices and the Free-riding Option

This table displays country-specific and panel results of estimating changes in daily corporate bond offer prices in response to a new sovereign issue accounting for the free-riding option value. A time window of 5 months is chosen for the estimation. The dependent variable is corporate bond daily offer price. The independent variables include control variables, country dummy variables, and an interaction variable between $\sigma^2_{m,j}$ and the dummy variable, trade#m, where # is the number of months after a new sovereign issue is announced in the time window. The variable, trade#m, takes a value of 1 after a new sovereign issue is announced; otherwise, takes a value of 0. σ^2_m is the variance of the corresponding country bond market index. Estimations are done using fixed effect. Standard errors are in parentheses.

		Month[-3, +2] Window			
Country	Obs.	Dependent Mean	Average σ^2_m	β	R^2
Argentina	45667	97.624	0.0001117	5264.493	0.1111
		(9.956)	(0.0001703)	(176.1324)	
Brazil	21590	96.567	0.0000704	18209.78	0.0943
		(12.323)	(0.0001393)	(281.2177)	
Chile	1925	91.114	-	-	-
		(9.592)	-	-	
Indonesia	208	101.925	-	-	-
		(4.492)	-	-	
Korea	3211	97.700	0.0000304	4058.842	0.1612
		(10.903)	(0.0000516)	(1443.731)	
Mexico	56493	99.279	0.0000207	5781.129	0.0718
		(11.148)	(0.0000235)	(638.2138)	
Philippines	8021	93.272	0.0001201	-48995.71	0.5106
		(15.496)	(0.0000937)	(2642.253)	
Russia	3709	81.951	0.0000808	-48995.71	0.5106
		(16.175)	(0.0000567)	(2642.253)	
Venezuela	291	103.673	-	-48173.37	0.7310
		(10.049)	-	(29075.7)	
All countries	141115	97.400	0.0000583	3498.839	0.1901
		(12.231)	(0.0001151)	(341.6706)	

Table 9: Corporate Bonds Return Correlations and the Free-riding Option

This table displays country-specific and panel results of estimating changes in correlation of daily corporate bond returns in response to a new sovereign issue accounting for the free-riding option value. A time window of 5 months is chosen for the estimation. The independent variables include country dummy variables, and an interaction variable between $\sigma^2_{m,j}$ and the dummy variable, trade#m, where # is the number of months after a new sovereign issue is announced in the time window. The variable, trade#m, takes a value of 1 after a new sovereign issue is announced; otherwise, takes a value of 0. The independent variables also include a control variable, average exchange rate before month 0 and after month 0. The dependent variable is correlation of each corporate bond daily return with a price-weighted corporate return index before and after the announcement date. σ^2_m is the variance of the corresponding country bond market index. Estimations are done using fixed effect. Standard errors are in parentheses.

			Month[-3, +2] Window		
Country	Obs.	Dependent Mean	Average σ^2_m	β	R^2
Argentina	1349	0.392	0.0001117	-1264.196	0.0096
		(0.289)	(0.0001703)	(806.2503)	
Brazil	588	0.352	0.0000704	-3754.224	0.0000
		(0.315)	(0.0001393)	(196.8591)	
Chile	20	0.623	-	-	-
		(0.135)	-	-	
Indonesia	2	1	-	-	-
		(0.000)	-	-	
Korea	195	0.659	0.0000304	-14204.93	0.0660
		(0.304)	(0.0000516)	(1660.316)	
Mexico	1734	0.435	0.0000207	-9201.789	0.0129
		(0.291)	(0.0000235)	(788.5865)	
Philippines	220	0.404	0.0001201	-21896.18	0.0344
		(0.326)	(0.0000937)	(27469.66)	
Russia	111	0.777	0.0000808	2185184	0.0107
		(0.229)	(0.0000567)	(489513.7)	
Venezuela	9	0.841	-	-	-
		(0.172)	-	-	-
All countries	4228	0.429	0.0000583	-349.6069	0.0627
		(0.301)	(0.0001151)	(1146.774)	

3.2.2 Joint Tests

While the above country results strongly support our hypotheses, we now use the entire data set to verify the liquidity service effect of sovereign bonds. We estimate one set of regressions with the simple specification with all of the data from each country of the following forms:

$$
\begin{aligned}
BA_{i,j} &= \alpha + \beta_1 trade\#m + \gamma controls + \delta country + \epsilon_{i,j} \\
P_{i,j} &= \alpha + \beta_2 trade\#m + \gamma controls + \delta country + \epsilon_{i,j} \\
Corr(R_{i,j}, RI_{c,j}) &= \alpha + \beta_3 trade\#m + \gamma controls + \delta country + \epsilon_{i,j} \\
BA_i &= \alpha + \beta_4 \sigma_m^2 trade\#m + \gamma controls + \delta country + \epsilon_i \\
P_i &= \alpha + \beta_5 \sigma_m^2 trade\#m + \gamma controls + \delta country + \epsilon_i \\
Corr(R_i, RI_c) &= \alpha + \beta_6 \sigma_m^2 trade\#m + \delta country + \gamma controls + \epsilon_i,
\end{aligned}
$$

where j which indexes the country, ranges from 1 to 9 and the parameters α and $\beta_l (l = 1, 2, 3, 4, 5, 6)$ are constrained to be the same across firms and countries. The coefficients on country dummy variables (country) should pick up the endogenous timing effect of sovereign issues.

The panel regressions are estimated using fixed effects on each sovereign issue window. The standard regression procedures assume that error terms are random and uncorrelated across firms. This is a reasonable assumption if there is no clustering, that is, if the event windows of the included securities do not overlap in calendar time. However, as all corporate bonds share the same sovereign issuing dates, the standard assumption that errors are uncorrelated across firms cannot be maintained. We adjust the variance-covariance matrix to account for clustering.

The results on pooled regressions are reported as the last rows in Tables of country regressions. The findings indicate that new sovereign issues lower the bid-ask spread of corporate bonds by 36.8 basis points, from a mean level of 159 basis points, increase corporate bond offer prices by 1.56, from the mean level of 97.4, and reduce the correlation between returns on corporate bonds and the corporate return index by 0.09, from a mean level of 0.43.

3.2.3 Economic Significance

With the above parameter estimates reported, we now discuss the economic significance of the liquidity effect of sovereign bonds. To assess this effect, we use the coefficient of the panel regression on corporate bid-ask spreads, -36.8

basis points, as our estimate of the bid-ask impact of the liquidity service of sovereign bonds. The mean daily spread is 159 basis points, with a standard deviation of 332.4. The bid-ask spread impact of the liquidity service of the sovereign bonds is about 11.1% of the standard deviation of the daily bid-ask spread. The R^2 of the panel regression reported is 1.3%, a low number. Alternatively, we use the coefficient of the panel regression on the corporate offer prices, 1.56, as our estimate of the price impact of the liquidity service of sovereign bonds. The mean daily price is 97.4, with a standard deviation of 122. The price impact of the liquidity service of the sovereign bonds is now about 13.7% of the standard deviation of the daily offer price. The R^2 of the panel regression reported is 0.5%.

Although 11.1% or 13.7% may not be seen as enormous, it is not reasonable to expect the price impact of sovereign bonds on corporate bonds to be extremely large. Many fundamental shocks affect daily bond prices, including global news and local credit events. Consequently, the price or bid-ask spread impact may not be the most effective gauge of the economic significance of the liquidity effect of the sovereign bonds.

To examine the effect of sovereign issues on liquidity, we can look alternatively at the change in corporate bond return correlations. The sovereign impact on corporate correlations is extremely stronger. The coefficient in the panel regression is -0.09 while the average correlation is 0.429 and the standard deviation is 0.301. The liquidity service of the sovereign bonds is about 30%, a fairly large number. The R^2 in this case is also higher, 16.3%.

Overall, the evidence shown in this paper implies that sovereign bonds perform an economically significant liquidity service.

4 Conclusion

This paper considers and estimates the liquidity service of one benchmark security such as a sovereign bond in emerging market economies. Controlling for market conditions, a sovereign bond introduction is estimated to have a significant impact on corporate bonds' liquidity. Therefore, the government has a role in facilitating the development of financial markets. Future work will focus on more detailed analysis of the bond market. It may yield interesting implications about the optimal term structure of sovereign bonds as a benchmarking mechanism.

This study emphasizes the informational role of the securities market in liquidity provision. It is worth noting that other types of mechanisms (such as banks) could provide liquidity. When are markets preferred to other intermediaries in liquidity provision? This paper suggests that if a group of uninformed traders, who are willing to participate given strong enough incentives, exist, the cost of markets as a channel for liquidity insurance could be lowered. Future theoretical research could explore other reasons why markets may dominate other types of liquidity provision mechanisms. For example, markets offer an insurance not only to borrowers against borrowers' liquidity shocks but also to investors against investors' liquidity shocks.

A key insight of the paper is that when an investor decide to acquire information, she has a positive externality on other investors' information acquisition cost. Without government interventions, multiple equilibria exist which may result in various equilibrium liquidity levels in the securities market. This insight points out that the liquidity cycle in the asset market can be endogenized and future research will set to understand the mechanism that determines the equilibrium liquidity level.

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A Equilibrium Prices

At date $i+1$, the equilibrium price P_i^1 is determined as in Kyle (1985):

$$P_i^1 = E\left[\upsilon_i | q_i = (1-\delta_i)\,\widetilde{y} + k_i x_s(\widetilde{s}) + g x_m\left(\widetilde{s}_m\right)\right]$$

where $(1-\delta_i)\,y$ is discretionary liquidity traders' demand and $x_s(s)$ is firm-specific informed traders' demand, and $x_m\left(\widetilde{s}_m\right)$ is macro-factor informed traders' demand.

Conjecture that in equilibrium:

$$\begin{aligned} x_m(\widetilde{s}_m) &= \beta_m \widetilde{s}_m \\ x_s(\widetilde{s}) &= \beta_s \widetilde{s} \\ P_i^1 &= \lambda_i q + \lambda_0 \end{aligned}$$

Then, the optimal investment problem of a macro-factor informed trader is

$$\begin{aligned} & \max x_m E\left[\widetilde{\upsilon}_i - P_i^1 | \widetilde{s}_m\right] \\ = \;& x_m E\left[\widetilde{\upsilon}_i - \left(\lambda_1\left((1-\delta)\,\widetilde{y} + k_i\beta_s\widetilde{s} + (g-1)\,\beta_m\widetilde{s}_m + x_m(\widetilde{s}_m)\right) + \lambda_0\right)|\widetilde{s}_m\right] \\ = \;& x_m \frac{\beta_i\sigma_\gamma^2}{\sigma_\gamma^2+\sigma_\xi^2}\widetilde{s}_m + x_m\overline{\upsilon}_i - \lambda_1 x_m^2 - \lambda_0 x_m - (g-1)\,x_m\lambda_1\beta_m\widetilde{s}_m \end{aligned}$$

The FOB yields:

$$\begin{aligned} x_m &= \frac{1}{2\lambda}\left(\frac{\beta_i\sigma_\gamma^2}{\sigma_\gamma^2+\sigma_\xi^2}\widetilde{s}_m + \overline{\upsilon}_i - \lambda_0 - (g-1)\,\lambda_i\beta_m\widetilde{s}_m\right) \\ \beta_m &= \frac{1}{(g+1)\,\lambda_i}\frac{\beta_i\sigma_\gamma^2}{\sigma_\gamma^2+\sigma_\xi^2} \end{aligned}$$

For a firm-specific factor informed trader:

$$\begin{aligned} & \max x_s E\left[\widetilde{\upsilon}_i - P_1 | \widetilde{s}_s\right] \\ = \;& x_s E\left[\widetilde{\upsilon}_i - \left(\lambda_1\left((1-\delta)\,\widetilde{y} + (k_i-1)\,\beta_s\widetilde{s}_s + g x_m(\widetilde{s}_m) + x_s(\widetilde{s}_s)\right) + \lambda_0\right)|\widetilde{s}_s\right] \\ = \;& x_s \frac{\sigma_\upsilon^2}{\sigma_\upsilon^2+\sigma_\eta^2}\widetilde{s}_s + x_x\overline{\upsilon}_i - \lambda_1 x_s^2 - \lambda_0 x_s - (k_i-1)\,x_s\lambda_i\beta_s\widetilde{s}_s \end{aligned}$$

FOC yields:

$$x_s = \frac{1}{(k_i+1)\lambda_i}\frac{\sigma_v^2}{\sigma_v^2+\sigma_\eta^2}\widetilde{s}_s$$
$$\beta_s = \frac{1}{(k_i+1)\lambda_i}\frac{\sigma_v^2}{\sigma_v^2+\sigma_\eta^2}$$

It will be shown later that $\overline{v}_i = \lambda_0$.

Given demands, the equilibrium price is set as:

$$\begin{aligned} P_i^1 &= E\left[\widetilde{v}_i | q = (1-\delta_i)\widetilde{y} + k_i\beta_s\widetilde{s}_s + g\beta_m\widetilde{s}_m + \overline{v}_i\right] \\ &= \overline{v}_i + \frac{k_i\beta_s\sigma_v^2 + g\beta_m\beta_i\sigma_\gamma^2}{(1-\delta_i)^2\sigma_y^2 + (k_i\beta_s)^2\left(\sigma_v^2+\sigma_\eta^2\right) + (g\beta_m)^2\left(\sigma_\gamma^2+\sigma_\xi^2\right)}q \end{aligned}$$

and the coefficients are:

$$\begin{aligned} \lambda_0 &= \overline{v}_i \\ \lambda_i &= \frac{\left(\frac{k_i}{(k_i+1)^2}\frac{\sigma_v^4}{\sigma_v^2+\sigma_\eta^2} + \frac{g}{(g+1)^2}\frac{\beta_i^2\sigma_\gamma^4}{\sigma_\gamma^2+\sigma_\xi^2}\right)^{1/2}}{(1-\delta_i)\sigma_y} \\ \beta_m &= \frac{(1-\delta_i)\sigma_y}{(g+1)\left(\frac{k_i}{(k_i+1)^2}\frac{\sigma_v^4}{\sigma_v^2+\sigma_\eta^2} + \frac{g}{(g+1)^2}\frac{\beta_i^2\sigma_\gamma^4}{\sigma_\gamma^2+\sigma_\xi^2}\right)^{1/2}}\frac{\beta_i\sigma_\gamma^2}{\sigma_\gamma^2+\sigma_\xi^2} \\ \beta_s &= \frac{(1-\delta_i)\sigma_y}{(k_i+1)\left(\frac{k_i}{(k_i+1)^2}\frac{\sigma_v^4}{\sigma_v^2+\sigma_\eta^2} + \frac{g}{(g+1)^2}\frac{\beta_i^2\sigma_\gamma^4}{\sigma_\gamma^2+\sigma_\xi^2}\right)^{1/2}}\frac{\sigma_v^2}{\sigma_v^2+\sigma_\eta^2} \end{aligned}$$

$$\begin{aligned} \frac{\partial P_i^1}{\partial k_i} &= \frac{\partial \lambda_i}{\partial k_i}q + \lambda_i\frac{\partial q}{\partial k_i} \\ &= \frac{\partial \lambda_i}{\partial k_i}q + \lambda_i\left(\beta_s + k_i\frac{\partial \beta_s}{\partial k_i}\right)\widetilde{s}_s \\ &= \frac{1}{k_i+1}q\lambda_1 \\ \frac{\partial P_i^1}{\partial k_i} &> 0 \quad \text{if } q > 0 \end{aligned}$$

Similarly,

$$\frac{\partial P_i^1}{\partial g} > 0 \quad \text{if } q > 0$$

B Equilibrium Number of Speculators and Some Comparative Statistics

B.1 Non-sovereign Regime

Macro factor traders' ex ante expected profits are

$$\begin{aligned}
E\left[revenue|s_m\right] &= E\left[x_m\left(\widetilde{v}_i - \lambda_i q - \lambda_0\right)|\widetilde{s}_m\right] \\
&= E\left[\begin{array}{c} \frac{1}{(g+1)\lambda_i}\frac{\beta_i\sigma_\gamma^2}{\sigma_\gamma^2+\sigma_\xi^2}\widetilde{s}_m \\ \left(\widetilde{v}_i - \overline{v}_i - \lambda_i\left(\left(1-\delta_i\right)\widetilde{y} + k_i\beta_s\widetilde{s} + g\beta_m\widetilde{s}_m\right)\right)|\widetilde{s}_m \end{array}\right] \\
&= \frac{1}{\left(g+1\right)\lambda_i}\frac{\beta_i\sigma_\gamma^2}{\sigma_\gamma^2+\sigma_\xi^2}\left(\frac{\beta_i\sigma_\gamma^2}{\sigma_\gamma^2+\sigma_\xi^2} - \lambda_i g\frac{1}{\left(g+1\right)\lambda_i}\frac{\beta_i\sigma_\gamma^2}{\sigma_\gamma^2+\sigma_\xi^2}\right)\widetilde{s}_m^2 \\
E\left[revenue\right] &= \frac{1}{\left(g+1\right)^2\lambda_i}\frac{\left(\beta_i\sigma_\gamma^2\right)^2}{\sigma_\gamma^2+\sigma_\xi^2}
\end{aligned}$$

Firm-specific informed traders' ex ante expected profits are:

$$\begin{aligned}
E\left[revenue|\widetilde{s}_i\right] &= E\left[x_s\left(\widetilde{v}_i - \lambda_i q - \lambda_0\right)|\widetilde{s}_i\right] \\
&= E\left[\begin{array}{c} \frac{1}{(k_i+1)\lambda_i}\frac{\sigma_v^2}{\sigma_v^2+\sigma_\eta^2}\widetilde{s}_i \\ \left(\widetilde{v}_i - \overline{v}_i - \lambda_i\left(\left(1-\delta_i\right)\widetilde{y} + k_i\beta_s\widetilde{s}_i + g\beta_m\widetilde{s}_m\right)\right)|\widetilde{s}_i \end{array}\right] \\
&= \frac{1}{\left(k_i+1\right)\lambda_i}\frac{\sigma_v^2}{\sigma_v^2+\sigma_\eta^2}\widetilde{s}_i^2\left(\frac{\sigma_v^2}{\sigma_v^2+\sigma_\eta^2} - \lambda_i k_i\beta_s\right) \\
E\left[revenue\right] &= \frac{1}{\left(k_i+1\right)^2\lambda_i}\frac{\sigma_v^4}{\sigma_v^2+\sigma_\eta^2}
\end{aligned}$$

The optimal k_i and g are obtained by setting $E\left[revenue\right] = c$:

$$c = \frac{w}{\left(g+1\right)^2\lambda_i}\frac{\left(\beta_i\sigma_\gamma^2\right)^2}{\sigma_\gamma^2+\sigma_\xi^2} = \frac{1}{\left(k_i+1\right)^2\lambda_i}\frac{\sigma_v^4}{\sigma_v^2+\sigma_\eta^2}$$

$$\begin{aligned}
z_i &= \frac{P_i - \overline{v}_i}{\lambda_i}\frac{1}{k_i\beta_s} = \frac{\left(1-\delta_i\right)y}{k_i\beta_s} + \frac{g\beta_m\widetilde{s}_m}{k_i\beta_s} + \widetilde{s}_i \\
\frac{1}{\tau_{z_i}} &= var\left(z_i - \varepsilon_i\right) = \frac{1}{k_i}\left(\sigma_v^2+\sigma_\eta^2\right) + \frac{g(g+1)}{wk_i^2}\left(\sigma_v^2+\sigma_\eta^2\right) + \sigma_\eta^2
\end{aligned}$$

Similarly,

$$\begin{aligned}
z_m &= \frac{P_i - \overline{v}_i}{\lambda_i}\frac{1}{g\beta_m} = \frac{(1-\delta)\,y}{g\beta_m} + \frac{k_i\beta_s\widetilde{s}_s}{g\beta_m} + \widetilde{s}_m \\
\frac{1}{\tau_{z_m}} &= var\,(z_m - \gamma) = \frac{1}{g}\left(\sigma_\gamma^2 + \sigma_\xi^2\right) + \frac{wk_i(k_i+1)}{g^2}\left(\sigma_\gamma^2 + \sigma_\xi^2\right) + \sigma_\xi^2
\end{aligned}$$

Also we can re-write the equilibrium λ_i using the condition for the number of informed investors:

$$\lambda_i = \frac{(k_i + g/w)c}{(1-\delta_i)^2\,\sigma_y^2}$$

so that the revenue can be rewritten as:

$$\begin{aligned}
E\left[revenue|s_i\right] &= \frac{1}{(k_i+1)^2\,\frac{k_i+g/w}{(1-\delta_i)^2\sigma_y^2}c}\frac{\sigma_v^2}{\sigma_v^2+\sigma_\eta^2} \\
\frac{\partial E\left[revenue|s_i\right]}{\partial k_i} &< 0 \\
E\left[revenue|s^m\right] &= \frac{1}{(g_i+1)^2\,\frac{k_i+g/w}{(1-\delta_i)^2\sigma_y^2}c}\frac{\left(\beta_i\sigma_\gamma^2\right)^2}{\sigma_\gamma^2+\sigma_\xi^2} \\
\frac{\partial E\left[revenue|s^m\right]}{\partial g_i} &< 0
\end{aligned}$$

We can also rewrite the condition for the number of informed investors as:

$$\begin{aligned}
c\frac{k_i+g}{(1-\delta_i)^2\,\sigma_y^2} &= \frac{w}{(g_i+1)^2}\frac{\left(\beta_i\sigma_\gamma^2\right)^2}{\sigma_\gamma^2+\sigma_\xi^2} \\
c\frac{k_i+g}{(1-\delta_i)^2\,\sigma_y^2} &= \frac{1}{(k_i+1)^2}\frac{\sigma_v^4}{\sigma_v^2+\sigma_\eta^2}
\end{aligned}$$

so that the numbers of macro factor and firm-specific informed investors are the roots of the following third order polynomials:

$$\begin{aligned}
\frac{c^2/w}{(1-\delta_i)^2\,\sigma_y^2}\frac{\sigma_\varepsilon}{\beta_i^3\sigma_\gamma^3}\frac{1}{\tau_m}\sqrt{\frac{\tau_s}{\tau_m}}\,(g+1)^3 - \frac{2}{\beta_i^2\sigma_\gamma^2\tau_m}\,(g+1)^2 - 1 &= 0 \\
\frac{Nc^2}{(1-\delta_i)^2\,\sigma_y^2}\frac{\beta_i\sigma_\gamma}{\sigma_v^3}\frac{1}{\tau_s}\sqrt{\frac{\tau_m}{\tau_s}}\,(k_i+1)^3 - \frac{2}{\sigma_v^2\tau_s}\,(k_i+1)^2 - 1 &= 0
\end{aligned}$$

Where we can get:

$$\begin{aligned}
\left(\frac{1}{k_i+g}+\frac{2}{g+1}\right)\frac{\partial g}{\partial \delta_i} &= -\frac{2}{1-\delta_i} \\
\left(\frac{1}{k_i+g}+\frac{2}{k_i+1}\right)\frac{\partial k_i}{\partial \delta_i} &= -\frac{2}{1-\delta_i}
\end{aligned}$$

Obviously, the number of informed is decreasing in the retaining shares, or increasing in the IPO size. The entry decision to the firm-specific information trading is more sensitive to the initial offering size if there are a lot of macro-factor informed investors or firm-specific factor informed investors. The entry decision to macro-factor information trading is more sensitive to the initial offering size if there are a lot of macro-factor informed investors existing already.

To see how the initial offering size affects the market liquidity,

$$\begin{aligned}
\frac{\partial \lambda_i}{\partial \delta_i} &= \frac{1}{(1-\delta_i)^2\,\sigma_y^2}\left(\frac{\partial k_i}{\partial \delta_i}+\frac{\partial g}{\partial \delta_i}\right)+\frac{2\,(k_i+g)}{(1-\delta_i)^3\,y^2} \\
&= \frac{2}{(1-\delta_i)^3\,\sigma_y^2}\left(-\frac{1}{\frac{1}{k_i+g}+\frac{2}{g+1}}-\frac{1}{\frac{1}{k_i+g}+\frac{2}{k_i+1}}+2\,(k_i+g)\right) \\
&> 0
\end{aligned}$$

Therefore the market liquidity is decreasing in the retaining size, or increasing in the IPO size.

B.2 Sovereign Regime

The equilibrium k_i and g are given by the following conditions;

$$c=\frac{1}{(g^{sov}+1)^2\,\lambda_m^{sov}}\frac{\sigma_\gamma^4}{\sigma_\gamma^2+\sigma_\xi^2}=\frac{1}{(k_i^{sov}+1)^2\,\lambda_i^{sov}}\frac{\sigma_\upsilon^4}{\sigma_\upsilon^2+\sigma_\eta^2}$$

Or,

$$\begin{aligned}
c &= \frac{\sigma_y}{(g^{sov})^{1/2}\,(g^{sov}+1)^2}\frac{\sigma_\gamma^2}{(\sigma_\gamma^2+\sigma_\xi^2)^{1/2}} \\
c &= \frac{(1-\delta)\sigma_y}{(k_i^{sov})^{1/2}\,(k_i^{sov}+1)^2}\frac{\sigma_\upsilon^2}{(\sigma_\upsilon^2+\sigma_\eta^2)^{1/2}}
\end{aligned}$$

C Informativeness of Equilibrium Prices

C.1 Proof of Corollary 3

The sufficient statistics (z_m, z_s) for the underlying signals $(\widetilde{s}_m, \widetilde{s})$ have variances decreasing in the number of informed traders, but independent of the discretionary liquidity trading level. This is because informed traders scale up or down their investment to disguise their information in the same proportion to the liquidity trading.

$$
\begin{aligned}
z_i &= \frac{P_i - \overline{v}_i}{\lambda_i}\frac{1}{k_i\beta_s} = \frac{(1-\delta_i)\,y}{k_i\beta_s} + \frac{g\beta_m\widetilde{s}_m}{k_i\beta_s} + \widetilde{s}_i \\
\frac{1}{\tau_{z_i}} &= var\left(z_i - \varepsilon_i\right) = \frac{1}{k_i}\left(\sigma_v^2 + \sigma_\eta^2\right) + \frac{g(g+1)}{wk_i^2}\left(\sigma_v^2 + \sigma_\eta^2\right) + \sigma_\eta^2
\end{aligned}
$$

$$
\begin{aligned}
z_m &= \frac{P_i - \overline{v}_i}{\lambda_i}\frac{1}{g\beta_m} = \frac{(1-\delta)\,y}{g\beta_m} + \frac{k_i\beta_s\widetilde{s}_s}{g\beta_m} + \widetilde{s}_m \\
\frac{1}{\tau_{z_m}} &= var\left(z_m - \gamma\right) = \frac{1}{g}\left(\sigma_\gamma^2 + \sigma_\xi^2\right) + \frac{wk_i(k_i+1)}{g^2}\left(\sigma_\gamma^2 + \sigma_\xi^2\right) + \sigma_\xi^2 \\
\frac{1}{\lambda_i} &= c(g+1)^2\frac{\sigma_\gamma^2 + \sigma_\xi^2}{w\left(\beta_i\sigma_\gamma^2\right)^2} = c(k+1)^2\frac{\sigma_v^2 + \sigma_\eta^2}{\sigma_v^4}
\end{aligned}
$$

C.2 Proof of Lemma 5

The new sufficient statistics (z_m^{sov}, z_s^{sov}) for the underlying signal $(\widetilde{s}_m, \widetilde{s})$ are much more precise,

$$
\begin{aligned}
z_i^{sov} &= \frac{P_i^{sov} - \overline{v}_i}{\lambda_i^{sov}}\frac{1}{k_i^{sov}\beta_s^{sov}} = \frac{\left(1-\delta_i^{sov}\right)y}{k_i^{sov}\beta_s^{sov}} + \widetilde{s}_i \\
1/\tau_{z_i^{sov}} &= var\left(z_i^{sov} - \varepsilon_i\right) = \left(\sigma_v^2 + \sigma_\eta^2\right)/k_i^{sov} + \sigma_\eta^2 < 1/\tau_{z_i}
\end{aligned}
$$

$$
\begin{aligned}
z_m^{sov} &= \frac{P_i^{sov} - \overline{v}_i}{\lambda_m^{sov}}\frac{1}{g^{sov}\beta_m^{sov}} = \frac{\left(1-\delta_i^{sov}\right)y}{g^{sov}\beta_m^{sov}} + \widetilde{s}_m \\
1/\tau_{z_m^{sov}} &= var\left(z_m^{sov} - \gamma\right) = \left(\sigma_\gamma^2 + \sigma_\xi^2\right)/g^{sov} + \sigma_\xi^2 < 1/\tau_{z_m}
\end{aligned}
$$

C.3 Proof of Corollary 5

Using Stein's Lemma and iterated expectations, we can show the covariance between returns on firm i and firm j is smaller after a new sovereign security is introduced.

C.4 Proof of Corollary 6

The secondary market price for firm i security is

$$\begin{aligned} P_i &= \lambda_i \left(x_i^m = \frac{1}{(g+1)\lambda_i} \frac{\beta_i \sigma_\gamma^2}{\sigma_\gamma^2 + \sigma_\xi^2} \widetilde{s}^m + x_i^s = \frac{1}{(k_i+1)\lambda_i} \frac{\sigma_v^2}{\sigma_v^2 + \sigma_\eta^2} \widetilde{s}_i \right) + \lambda_0 \\ &= \frac{g}{g+1} \frac{\beta_i \sigma_\gamma^2}{\sigma_\gamma^2 + \sigma_\xi^2} \widetilde{s}_m + \frac{k_i}{k_i+1} \frac{\sigma_v^2}{\sigma_v^2 + \sigma_\eta^2} \widetilde{s}_i + \overline{v}_i \end{aligned}$$

When a sovereign is introduced,

$$P_i^{sov} = \frac{g^{sov}}{g^{sov}+1} \frac{\beta_i \sigma_\gamma^2}{\sigma_\gamma^2 + \sigma_\xi^2} \widetilde{s}_m + \frac{k_i^{sov}}{k_i^{sov}+1} \frac{\sigma_v^2}{\sigma_v^2 + \sigma_\eta^2} \widetilde{s}_i + \overline{v}_i$$

It is immediate again that

$$P_i^{sov} > P_i$$