The Channels for Financial Contagion

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Abstract

The seriousness of the Asian financial crises and difficulties in explaining its spread have led to fears of irrational contagion. This paper studies rational channels through which contagion might have spread and highlights those factors which make a country susceptible to contagion. The rational channels studied in the paper are contagion via real sector linkages, financial market linkages, financial institution linkages, and through the interaction of financial institutions and financial markets. The latter channel is suggested as a possible factor in the reductions in financial market liquidity and the flight to quality following news of significant losses at the hedge fund Long Term Capital Management.

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1 Introduction

The seriousness of the recent Asian financial crises, and difficulties in finding macroeconomic explanations for its spread, have led to fears of irrational contagion, and to calls for additional regulation of financial markets. The message of this paper is that it is premature to address contagion through new regulations until we have a better theoretical understanding of the mechanisms through which shocks are transmitted among markets, and knowledge of which theoretical channels are empirically relevant. To back up my claim that more and better theory is needed to understand contagion, it is useful to consider an example in which contagion is defined as a shock in one market or country, that is transmitted to another market or country, but is not related to fundamentals. Similar definitions often appear in the literature on contagion.[1] Based on this definition, one method for detecting contagion is to hypothesize that the return on the i'th country's stock market index, r_i, depends on a set of common macroeconomic factors f and an idiosyncratic residual component u_i:

$$r_i = \alpha_i + \beta_i f + u_i \tag{1}$$

If the residuals from estimating equation (1) are correlated across countries, then this residual correlation might be interpretable as contagion because it is comovement that is unexplained after controlling for fundamentals. An extreme interpretation of results from this regression is that residual correlation that cannot be explained based on fundamentals is proof that markets are irrational, and more regulation is needed.

There are two problems with this interpretation. The first is that the finding of contagion can always be questioned on the basis that the correct set of fundamentals was not controlled for. The second problem is similar but more subtle and is related to the possibility that contagion is occurring through a channel that Kodres and Pritsker (1999), hereafter KP, refer to as cross-market hedging.[2] To describe this channel, suppose the long run value of the national stock indices for each of several countries can be decomposed into components that depends on common macroeconomic risk factors, and on country specific components that are distributed independently of the macroeconomic factors. Further suppose that in the short-run market participants *cannot* learn about the realizations of the macroeconomic risk factors, but that some participants receive information, which I will refer to as an information shock, about the country-specific components. Participants that receive the information will optimally alter their portfolios for the country where the shock occurred. But, because this changes their exposures to the shared macroeconomic risks, they will also hedge the change in their macroeconomic risk exposures by rebalancing in other countries. The rebalancing transmits the idiosyncratic shock across markets, generating correlation in short-run stock returns.

The cross-market hedging example has three interesting properties. The first is that an

[1] One example of a fundamentals-based contagion definition is from Karolyi and Stulz (1996). They state that "Contagion effects result when enthusiasm for stocks in one market brings about enthusiasm for stocks in other markets, regardless of the evolution of market fundamentals."

[2] In early versions of KP, the channel is referred to as cross-market hedging and in latest version it is referred to as cross-market rebalancing. I have chosen to use the earlier term in this paper because cross-market rebalancing can occur for several reasons, only one of which is cross-market hedging.

idiosyncratic, or country-specific, shock generates return comovement across countries. The second is that the pattern of short-run price responses to the shock must be orthogonal to the future realizations of the macroeconomic fundamentals. This orthogonality occurs because the shock is transmitted by market participants before they have any knowledge of the realizations of the macroeconomic fundamentals; therefore the price movements due to the shock are independent and hence orthogonal to the eventual realizations of the macroeconomic factors.[3] Because the information shock is orthogonal to the realizations of the macroeconomic fundamentals, the information shock will only affect the residuals of equation (1), and will induce residual cross-correlation. The third and final interesting feature of this example is that the price response to the shock, although orthogonal to the realizations of the macroeconomic fundamentals, is inextricably related to the fundamentals because it is generated by participants' hedging against changes in the fundamentals. Therefore, this example establishes that the interpretation that residual cross-correlation in equation (1) must be evidence of irrational contagion that is unrelated to the fundamentals is incorrect.

The difficulty with the earlier interpretation of residual correlation in equation (1) is that regressing returns on fundamentals in a statistical model is not the same thing as properly controlling for fundamentals in an economic model. To properly control for fundamentals, one has to know all the ways that they might economically matter. In the case of KP's cross-market hedging example, when considering short-run returns, the realizations of the macro-fundamentals don't matter, but their risk-factor structure, which can sometimes be summarized by the variance covariance matrix of long-run returns, does matter. Because the risk-factor structure was not properly controlled for in equation (1), the regression results were misinterpreted.

Whether cross-market hedging is actually important in explaining contagion, and how to test for it, are open empirical questions. However, the example makes the important point that just because we cannot explain residual asset price comovement does not necessarily mean it is irrational, and does not mean it is necessarily unrelated to fundamentals. The example also shows that there is a serious need for more careful consideration regarding the potential theoretical channels through which shocks might be transmitted when examining questions of contagion. The remainder of the paper will be principally devoted to a broad discussion of the channels through which shocks might be transmitted from one country to another. In addition to highlighting the potential dangers of interpreting regressions like equation (1), the paper makes two contributions to the existing literature on contagion. First, it presents a broad framework through which shocks are transmitted, and explains where the existing theories of contagion through financial markets or through financial intermediaries such as banks fit within the framework. Second, it discusses some potential channels for contagion that have yet to appear in the literature. These potential channels are used to discuss contagion following the emergence of problems at the Long Term Capital Management hedge fund.

[3]Formally, by the definition of statistical independence of a country specific shock s and the macroeconomic fundamentals f, $\mathrm{Cov}[h(s), g(f)] = 0$, for any functions h and g. Because some market participants learn s but not f, and know they that s is independent of the future realizations of f, the price response to their change in demands is a function only of s, and hence must be uncorrelated with f by the definition of independence of s and f.

Before proceeding further, it is important to formally define contagion. For the purposes of this paper I will use the following definition of contagion:

Definition 1 *Contagion occurs when a shock to one or a group of markets, countries, or institutions, spread to other markets, or countries, or institutions.*

This definition of contagion is definitely broader than those which define contagion as comovement that cannot be explained based on fundamentals. I prefer my broader definition because empirical findings of contagion based on the narrower definition will always be subject to questions of interpretation because the economics profession will probably never reach agreement on the appropriate set of fundamentals. My approach is to instead suggest some of the possible channels for contagion. If these channels are empirically testable, then it may be possible to reach agreement on how shocks are transmitted across countries, even if agreement is never reached on fundamentals. That said, I am sensitive to the policy concerns that motivate the use of a narrower definition. Therefore, in parts of the text, and in the conclusion, I discuss whether the contagion channels are rational, whether they are consistent with fundamentals, and most importantly, whether the pattern of contagion and market performance could be improved through changes in public or private institutions and laws.[4] The remainder of the paper consists of five sections: the first presents the broad economic framework, or system of inter-linkages through which shocks might propagate, the second presents the channels for contagion implied by the inter-linkages, the third discusses the resilience of the economic system to propagation along the channels, the fourth revisits the LTCM episode in light of the linkages. The final section concludes.

[4]The notion of whether contagion is rational is difficult to define. I define contagion to be individually rational if given the policies and procedures that an economic unit has been instructed to follow, they pursue policies that are individually rational, and contagion occurs as a result of their actions. For example, if a shock in one country affects the capital position of an investment fund whose charter restricts its finanical leverage and only allows it to invest in emerging markets, then the fund may rationally sell in several emerging markets after experiencing a loss and/or margin calls in one emerging market. Although this behavior is individually rational given the funds charter, it might be argued that the fund's institutional arrangement is irrational or could at least be improved upon by allowing the fund to hold more liquid instruments that it can sell when it needs to raise cash.

In contrast to rational contagion, irrational contagion occurs if a shock is transmitted across countries as a result of market participants following portfolio strategies that are not ex-ante individually rational. In other words, if contagion occurs as a result of some market participants not maximizing their utility given their environment, and given the behavior of other market participants, then the contagion is a result of irrationality.

Irrational contagion, as it is used here, should be distinguished from multiple equilibria. The simplest environment in which multiple equilibria arise is in models of bank runs. Usually, one equilibrium of such models is that investors, fearing a bank run and bank collapse, withdraw their funds, causing the bank to collapse. A second equilibrium is investors believe in the soundness of the bank, so they don't withdraw their funds, so the bank does not collapse. Unlike irrational contagion, investors in the multiple equilibrium example are individually rational within each equilibrium, i.e. it is rational to withdraw your funds from the bank when everyone else is doing so, and it is rational to keep your funds in the bank if there is no bank run.

2 Framework for Contagion

The purpose of this section is to review and discuss many of the potential inter-linkages that could cause a shock from one country to propagate to others.

2.1 The Economy

The economy that I consider consists of N countries indexed by $i = 1, \ldots N$. Each is assumed to have a real sector, RS_i, where goods and services are produced by firms and consumed by consumers. Each country also has a financial market, FM_i, where claims on the cashflows of firms in country i are traded, and where firms in country i can raise capital for future investments. For simplicity I assume that the financial market in country i is the only place where claims on the profits of the firms of country i are traded.[5] Not all firms are financed through the financial market, in addition, firms can acquire financing through the banking sector. Rather than associating a banking sector with each country, I assume that there are a set of K banks for the global economy. In order to allow for the largest set of financial interconnections, I assume each bank can take deposits and lend to firms and banks in all countries. Banks can also, if they choose, directly participate in the financial markets, and can act as securities dealers and underwriters. Finally, I assume there are M non-bank financial market participants, labelled NBFMP. These participants include small investors, hedge funds, mutual funds, etc. I assume that NBFMP's can borrow money from banks, and can participate in the financial markets. For most of the paper, NBFMP's are not a prominent part of the analysis, but they are a prominent part of the analysis in section 4, which deals with the aftermath of the difficulties at Long Term Capital Management.

2.2 The Linkages

The real sectors, the banks, the financial markets, and the non-bank financial market participants are the economic units in the model. The purpose of this section is to model the linkages among the economic units. The approach that I will follow is to use an equation to express an outcome for each of the economic units as a function of the outcomes of some of the other economic units. Although the linkages are modelled using equations, the relationships are strictly reduced form, and should not be thought of as a formal model but rather as a compact way of summarizing the linkages in order to derive the contagion channels.

The Real Sector

Ideally, the real sector linkages should be derived from an open economy model of the world macroeconomy. My goals are less ambitious. Instead of beginning with a macroeconomic model, I will assume a reduced form function which represents linkages from the economic units to the real sector. I will then appeal to a prototypical Keynesian open economy model to justify my choices. I should add that the use of a Keynesian model to justify my choices is made purely for convenience, and is not an endorsement of a particular class of

[5] The loss of generality from this assumption is small because I assume that all potential financial market participants can trade in all markets.

macroeconomic models. With this proviso, I will assume that RS_n represents the GDP of country n, and that RS_n depends on conditions in the financial market of country n, denoted by FM_n, and on conditions at banks 1 through K, $Bank_{k=1}^{K}$, and by GDP in all countries other than country n, $RS_{j\neq n}^{N}$, and by country-specific influences ϵ_{RS_n}:

$$RS_n = g1(\, FM_n,\, Bank_{k=1}^{K},\, RS_{j\neq n}^{N}\,) + \epsilon_{RS_n}, \tag{2}$$

where $g1(.)$ is a reduced form function that should depend on the underlying macroeconomic structure of the economy. FM_n in equation (2), does not just represent financial market n, but represents a vector of attributes of the financial market. These include the actual prices of the assets in market n, the liquidity of the market, and the extent to which the prices reflect the true values of the assets. Conditions in financial markets affect real sector GDP for three potential reasons. First, the price of assets affects national wealth, and hence aggregate demand. Second, the liquidity of financial markets and the price of the assets affect businesses desire and ability to raise money for investment. This has implications for aggregate demand today, and for aggregate supply in the future. $Bank_k$ represents a vector of attributes of bank k that are relevant for the bank's ability and willingness to finance investments in the economy. Therefore, the justification for including each bank in equation (2) is similar to the rationale for including FM_n. The GDP of the real sectors of the other countries enters because of the effect that other countries GDP has on net exports for country n. Finally, ϵ_{RS_n}, denotes country n-specific influences on GDP. These include the monetary, fiscal, and exchange rate policies of country n. These policies influence GDP through their effect on aggregate demand in country n.

The Financial Markets

The assets that trade on the market of country n are claims on the cashflows of the real sector. In a world with complete and perfect markets, the price of the assets should depend only on how the cash flows covary with consumption, and there should be no need for financial intermediaries. However, because there are market imperfections, intermediaries play an important role in lending funds (banks), underwriting security issues (investment banks), providing liquidity in markets (securities broker/dealers and market markets), and in spreading risks towards those investors most willing to bear them (NBFMPs such as hedge funds and mutual funds). I assume that the prices and liquidity of financial markets are potentially affected by the capital position of these intermediaries relative to their risks. For example, banks with low capital relative to risk may be less willing to purchase risky securities or extend credit to others for doing so, potentially impairing market liquidity. The financial position of NBFMP's relative to their risks may also affect securities prices. Specifically, if NBFMP's are unable to assume risks that securities broker/dealers can only hold temporarily, then broker/dealers may be less willing to take on risk, reducing liquidity. NBFMPs may affect markets for a different reason: If they hit hard constraints on borrowing, they may be unable to provide further liquidity, and may become liquidity demanders if they are forced to sell a large amount of securities over a short amount of time. This framework suggests that FM_n, which represents the price and liquidity of country n's stock market index, is determined by the financial position of the banks, the NBFMPs, and expected and

future cashflows for the real sector, as proxied for by RS_n:

$$FM_n = g2(Bank_{k=1}^{K}, NBFMP_{m=1}^{M}, RS_n) + \epsilon_{FM_n}, \tag{3}$$

where $g2(.)$ is a function based on the economic structure of financial markets, and ϵ_{FM_n} is a catchall term to account for factors such as changes in household preferences that are not accounted for by the other economic units in the equation.

The Banks

Banks take deposits and extend loans to financial and non-financial firms. Let $Bank_k$ represent a set of attributes of the k'th bank including the value of the bank's assets and liabilities, and the liquidity and market risk of the bank's portfolio.[6] The value of the bank's assets potentially depends directly on the real sector of each country because whether the country is in recession or not affects the likelihood of defaults by its debtors. The bank's liability base depends on the financial health of other banks who have deposits with it because these deposits might be withdrawn when those banks face financial distress. The value of the bank's assets and liabilities also depend on the prices and liquidity in financial markets becasue the value of banks' assets and liabilities fluctuate with market prices, and because banks are brokers and dealers in many markets. To the extent that banks also make deals with NBFMPs, the value of the bank's financial position and its risk is also tied to the financial performance of NBFMPs. This suggests that $Bank_k$, can be expressed as:

$$Bank_k = g3(\, Bank_{j\neq k}^{K}\,, FM_{n=1}^{N},\, RS_{n=1}^{N},\, NBFMP_{m=1}^{M}) + \epsilon_{Bank_k}, \tag{4}$$

where $g3(.)$ is a function that depends on linkages with the banking sector and ϵ_{Bank_k} represents influences that are specific to bank k such as an internal failure in the bank's management.[7]

Non-Bank Financial Market Participants

Non-bank financial market participants (NBFMPs) take funds from the general public, and borrow from banks, in order to invest in financial markets. Let $NBFMP_m$ denote the net worth and risk of the m'th nonbank financial market participant. Its ability to attract funds for investment depends on their own financial position as determined by the assets they hold, and financial market prices. Their ability to borrow also depends on the willingness of banks and the general public to extend credit, or to place funds under management with an NBFMP. The bank's willingness to extend credit is a function of the bank's own financial position, as measured by $Bank_k$, and the public's willingness to provide funds depends on national income as proxied for by RS_n. Finally, the NBFMPs financial position also depends on NBFMP-specific influences such as the skill of the management team, and the NBFMP's

[6] The banks portfolio consists of its on- and off- balance sheet positions. The bank's liquidity risk is a function of the liquidity of the bank's assets, the stability of its deposit base, and its ability to issue new liabilities when needed. The bank's market risk is the risk that the value of its net worth will change due to changes in market prices, or due to defaults by borrowers.

[7] A striking example of internal management failure is the failure of Baring's to adequately supervise the activity of Nick Leeson, an employee of the investment bank.

reputation and track record, all of which are captured by ϵ_{NBFMP}. This suggests that NBFMPs are linked to the other economic units by the equation:

$$NBFMP_m = g4(\, Bank_{k=1}^{K},\, FM_{n=1}^{N},\, RS_{n=1}^{N}\,) + \epsilon_{NBFMP} \tag{5}$$

2.3 Transmission Pathways

The framework of potential interlinkages in the previous section provide for a large number of channels through which a shock in one place, or to one type of economic unit can be transmitted to others. I will model transmission of shocks as proceeding along chains, i.e. the shock begins with one economic unit. It then spreads to a first set of economic units that are linked with it, and then to a second set of economic units that are linked to the first set, and so on. In all of the analysis attention will be restricted to transmission chains that involve only a small number of links. This is with little loss of generality because longer chains will mostly contain repetition of the connections that I will explore in the shorter chains.[8] There are two types of shocks that can be transmitted among economic units. The first type is intermediary-specific shocks. By this I mean a shock that hits a bank or non-bank financial market participant, but which is specific in its origin to that bank or financial market participant. Intermediary-specific shocks should be viewed as idiosyncratic to that intermediary. The second type of shocks are real shocks. A real shock is a shock to the real sector of the economy. Real shocks include but are not limited to "innovations" in technology, or a flow of information on the performance of real or financial assets.[9] I also view shocks that originate in the financial sector, but are not intermediary-specific as real shocks to the financial sector.[10]

Real Shocks

The Thai financial crisis was a real shock in Thailand that led to the devaluation of the Thai baht, and apparently spread to other South East Asian economies. But, through what channels could the crisis have spread? There are three possibilities of how a shock can appear to spread between countries. The first is coincidence—countries i and j both get hit with independent shocks at the same time. The second is a common global shock—both countries were exposed to the same global shock such as a change in the price of oil, and the third

[8] An alternative justification for focusing on short chains is that the effect of shocks propagating along long chains may be dampened or cut off entirely at each link in the chain. Thus, short chains are likely to be more important for studying economically significant contagion.

[9] Innovation is meant in two senses. The first is innovation as the emergence of a new technology which supplements existing technologies. The second is "innovation" in the sense of a shock which provides information on the relative costs of different types of technologies. For example, the 1973 OPEC Oil embargo was a change in the terms of trade which represented an innovation in the relative value of oil-intensive and non-oil intensive technologies. Other terms of trade shocks can also be understood as innovations in this sense.

[10] If it is announced that the central bank will no longer insure deposits, then I view this as a real shock for the purposes of this framework.

Table 1: Channels for Real Shock Transmission

Channel	Transmission Pathway	Type
1	$RS_i \rightarrow RS_j$	Real
2	$RS_i \rightarrow Bank_k \rightarrow RS_j$	Common FI
3	$RS_i \rightarrow Bank_k \rightarrow Bank_l \rightarrow RS_j$	FI Contagion
4	$RS_i \rightarrow Bank_k \rightarrow FM_j \rightarrow RS_j$	FI & FM interaction
5	$RS_i \rightarrow FM_i \rightarrow Bank_k \rightarrow RS_j$	FM & FI interaction
6	$RS_i \rightarrow FM_i \rightarrow NBFMP_l \rightarrow FM_j \rightarrow RS_j$	FM Contagion via NBFMP
7	$RS_i \rightarrow FM_i \rightarrow Bank_k \rightarrow FM_j \rightarrow RS_j$	FM Contagion via Bank

is through contagion between countries i and j.[11] This paper only focuses on the third of these possibilities.

A list of some of the channels through which a real shock from country i can be transmitted to country j is shown in Table 1. An arrow from one economic unit to another under the column labelled "Transmission Pathway" denotes that along that pathway a shock transmits from the economic unit at one end of the arrow towards the economic unit where the arrow is pointing.

The simplest way in which a shock to one country is transmitted to others is through direct real linkages such as through trade in goods and services (Table 1, Channel 1). One example of how real shocks can spread through trade linkages is through a chain of speculative attacks on exchange rate pegs. For example, if countries i and j peg their currencies, and country i experiences a real shock that makes its current exchange rate peg less desirable, then it may choose to devalue, or it may be forced to devalue due to a speculative attack. Because country i's devaluation affects the competiveness of country j, it may be more desirable for it to devalue, or it may become more vulnerable to speculative attack.[12]

Although direct real trade linkages may explain the contagion between economies that are closely integrated, it does not explain the contagion between countries such as Brazil and Russia, or between Brazil and the economies of South East Asia that emerged after the Asian crisis. An alternative channel for contagion is that a real shock in country i negatively affected the capital position of one of the international banks, say $Bank_k$, that lends to the companies in country i. If $Bank_k$ also has positions in country j, then it may be optimal for $Bank_k$ to alter the amount of lending in country j, and/or alter the composition of its loans in country j.[13] This alteration of the bank's loan portfolio effectively transmits the

[11] Masson (1998) referred to the second possibility as a monsoon, and the third possibility as a spillover. Masson's spillover effects is what I refer to as contagion.

[12] It is unclear whether recent episodes of speculative attacks such as in the Asian crisis, were associated with trade channels or financial channels. Using data from 5 episodes of currency crises after 1971, Glick and Rose (1998) find evidence showing that the pattern of speculative attacks is correlated with trade linkages. Kaminsky and Rheinhart (1998), using a different dataset and methodology, find that the pattern of speculative attacks is also closely correlated with financial linkages such as the presence of a common lender.

[13] If $Bank_k$ experiences a negative shock to the value of its loans in country i, without more information on the overall position of the bank, it is not clear how the bank will alter the composition of its loan portfolio in country j or in other countries. For example, in some situations it may be optimal for $Bank_k$ to reduce the risk of its loan book in country j in order to preserve the bank's charter value, but, if the bank is in a particularly poor capital situation, it might instead be optimal for the bank to follow a go for broke strategy

real shock from country i to country j. I refer to this channel for contagion as the common financial institution channel, or common FI (Table 1, channel 2). The common FI channel is explored in Kaminsky and Rheinhart (1999) and Van Rijckeghem and Weder (1999).

A third possible channel for contagion (Table 1, channel 3) is that a real shock in country i causes $Bank_k$ to lose money on its loans in country i. If $Bank_k$ has deposits with some other $Bank_l$ that has loans in country j, then the problems with $Bank_k$ can cause it to withdraw its deposits from $Bank_l$, which then causes problems at $Bank_l$. As a result $Bank_l$ alters its loan portfolio in country j. This results in the real shock being transmitted from country i to country j through a chain of interconnected lenders.[14] I refer to contagion via interconnected lenders as financial institutions contagion.[15]

The fourth and fifth channels through which a real shock in country i can be transmitted to country j is through the interaction of financial institutions with financial markets.[16] In Table 1, I have labelled these channels as FI & FM interaction and as FM & FI interaction. The different ordering denotes the direction in which the shocks get transmitted. For example, a real shock in country i can affect $Bank_k$ because it has investments there. If $Bank_k$ is an important participant in the financial market of country j, then the shock to $Bank_k$ can cause it to reduce credit provision or liquidity in financial market j, which can affect the real sector in country j. Because the shock goes from bank to financial market, this is labelled as the FI & FM channel. Alternatively, the shock could have gone from the real sector of country i to the financial market of country i. Then, if $Bank_k$ lost money in country i's financial market, then it might alter its loan portfolio in country j as a result. Thus, the contagion is transmitted between countries via the FM & FI channel.

So far, we have not involved non-bank financial market participants in the chain of contagion. To show, how their actions may transmit contagion. Consider a shock to the real sector of country i which affects the financial market of country i. If a nonbank financial market participant has a position in country i, then he may optimally alter his position in country i in response to the shock. It may also be optimal to alter his position in other countries financial markets following the shock, including the market of country j. Thus the real shock in country i gets transmitted to country j by nonbank financial market participants through the financial markets of countries i and j. This channel of shock transmission is Financial Market (FM) Contagion via a nonbank financial market participant (NBFMP), (Table 1, channel 6). If instead contagion was transmitted from financial market i to j through the actions of a $bank_k$ which has positions in both markets, then, then, in Table 1 the pattern of contagion is labelled as Financial Market contagion via a Bank.

Intermediary-Specific Shocks

All of the contagion channels that I have presented so far involve the transmission of a shock to the real sector of a country. Of course, there is no reason that a shock needs to begin

in which it substantially increases the riskiness of its loan portfolio.

[14] Although the number of lenders in the chain that we discuss is only 2, Allen and Gale (1998) show that it is possible to generate contagion through chains of interconnected lenders with arbitrary length.

[15] Contagion via lenders that are directly linked to each other was modelled by Allen and Gale (1998). Contagion via financiers that are linked to each other through common investment projects was modelled by Lagunoff and Schreft (1998).

[16] Allen and Gale (1997) model the role of financial institutions in markets.

in the real sector of a country to propogate to other countries. Instead it could begin with a shock to a bank or nonbank financial market participant, and then spread. Rather than providing a detailed list of paths as I have in Table 1, here I just provide a few paths for illustrative purposes. One possible path is that a shock begins with an international bank or perhaps with the banking sector of a large country (say Japan) and then spills over to the real sectors of other countries through decreased lending by the bank as in Figure 1. A different scenario is that a shock could begin with a large nonbank financial market participant. If this large participant is in turn linked to a number of banks and investment banks that are important for providing liquidity provision in markets, then the shock to the nonbank participant can potentially percolate through the financial sector from banks, to markets, and then to the real sectors of economies that depend on those markets, as in the pyramidal diagram provided in Figure 2.

Whether the pathways that shocks follow in Table 1 and in Figures 1 and 2 are plausible depends on the financial and economic structure of the economies in each country, and on the fragility of the real economy and of the financial system. This topic will be pursued in the next major section of this paper. But, before discussing fragility, it is useful to relate the channels for contagion in Table 1 and Figures 1 and 2 to the theoretical literature on contagion.

2.4 Relation to Pathways in the Theoretical Literature

The literature on real contagion via trade-links, and the literature on financial institution contagion has already been alluded to earlier in the text. The purpose of this section is to expand on the literature on financial market contagion. This literature examines how shocks in one financial market, or to the participants in one market, are transmitted to others. In the parlance of Kodres and Pritsker (1999), there are four separate channels of financial market contagion. The first, and most intuitive, is the correlated information channel. The idea behind this channel is that if there are common macroeconomic influences that determine assets values in more than one country because of real linkages, then the real linkage causes financial markets to be linked. More specifically, if there is a publicly observable negative real shock in country i and through real linkages, this shock is transmitted to the real sector of country j, then the stock markets of countries i and j will respond to the real shocks (Figure 3, panel A). Of course, country i can experience many types of real shocks; some publicly observable real shocks will affect country i and its stock market, but will not be transmitted to the real sector of country j or j's stock market. This possibility is illustrated in panel B. The failure of the real shock from country i to be transmitted to the real sector of country j and then to the financial market of country j is represented by the crossed out lines in panel B.

It is important to emphasize that the pattern of shock propagation in panels A and B was worked out for a case when the real sector shocks are publicly observable. Because of this observability, shocks in the real sector of country i that directly affect the real sector of country j, will be fully reflected in the financial markets of both countries, and shocks in i that have no implications for the real sector j will not be reflected in the prices of financial

market j.[17] In a world with imperfect public information, the picture is different. Suppose, for example, that real shocks in i are not publicly observable, but are privately observable to some financial market participants in country i. Then a negative real shock in country i will lower prices in i's financial market, but financial market participants in market j will not be able to discern whether the price decline in market i reflects information that is relevant for market j, but because of the possibility that it is relevant, a price decline in market i will cause a price decline in market j.[18]

The channel for contagion in the example in panel C of Figure 3 is "correlated information." I have given it this name because the information that market participants are trading on in country i might be relevant for country j; i.e. the information participants trade on in country i is unconditionally correlated with the value of real assets in country j. The correlated information channel has been explored in King and Wadhani (1990) and others. A key feature of financial market contagion via correlated information when there is information asymmetry is that a real shock in country i that would have no effect on country j if the shock was publicly observable, can have a real effect on j's financial markets and real sector if the shock is not publicly observable (Figure 3, panel C). In other words, when there is information asymmetry a shock in country i may have real effects in country j that are excessive relative to country j's full information macroeconomic fundamentals. Thus, the contagion from the correlated information channel is consistent with notions of contagion based on price movements that are excessive relative to *full-information* fundamentals. However, market participants are rational in this channel. Furthermore, the most direct institutional change that would be suggested from this channel is better public information on the assets in countries i and j, and attempts to reduce information asymmetries, perhaps with insider trading restrictions.

Although correlated information, as used here, represents shocks transmitted across financial markets because of the possibility of real linkages, it should also be emphasized that government polices can inadvertently potentially introduce real linkages where none may have existed. For example, Nouriel Roubini has suggested that the international community's failure to bail out Russia during its debt and balance of payments difficulties in the fall of 1998 may have been interpreted by market participants as implying that Brazil would not be bailed out from its balance of payments problems either. Thus, a speculative attack on Russia was followed by one on Brazil even though the two countries are not tightly linked through their real sectors.

In the correlated information channel, financial market contagion occurs because of the real linkages between countries. The other channels for contagion involve a financial market participant (such as a bank or NBFMP) responding to a shock that affects them by rebalancing across markets, thus transmitting the shock. There are many different reasons why financial market participants might rebalance across markets. Kodres and Pritsker (1999) present a model in which contagion can occur through the correlated information channel,

[17] I am abstracting from all other channels for contagion in panels A and B other than direct linkages between the real sectors.

[18] The size of the price decline in market j with private information (Figure 3 panel C) is likely to be an average of the price movements one would observe in the two cases with public information (panels A and B).

but can also occur through market participants rebalancing. They associate the different motivations for rebalancing with different types of financial market contagion.

If a financial market participant experiences an idiosyncratic shock that forces her to liquidate her portfolio, and she does so in a number of markets, then KP refer to this as a correlated liquidity shock because it is a liquidity shock that is correlated across markets.[19] Correlated liquidity shocks is the channel for contagion considered in Calvo (1999). In addition to liquidity shocks, participants might rebalance their portfolio across markets because they follow portfolio strategies that either implicitly or explicitly involve the chasing of price trends, regardless of beliefs about market fundamentals. This investment style is referred to as feedback trading. Considered in a single market, feedback trading would occur if a participant makes his buy/sell decisions based on past price movements, for example buying after prices rise, or selling after they fall.[20] In a multiple market setting, participants can possibly engage in cross-market feedback trading in which participants respond to a price change in one market by altering their positions in other markets, causing contagion.[21]

The next to last channel for financial market contagion is cross-market rebalancing, which KP referred to in early versions of their paper as cross-market hedging. Cross-market hedging is the channel of contagion was used to explain the problem with empirical contagion tests in the introduction. Contagion occurs through the cross-market hedging channel because investors respond to shocks by readjusting their hedges to macroeconomic risks. KP show that cross-market hedging can transmit shocks between two countries whose macroeconomies share no macroeconomic risk factors in common provided, that both countries share risk factors with a third country.

The final channel for contagion is contagion due to wealth shocks. If an investor experiences a shock to their wealth, it may be optimal to alter their portfolio holdings.[22] For example, investors with decreasing relative risk aversion may optimally choose to move their portfolios toward lessy risky assets as their wealth declines. This behavior can cause contagion that is analogous to a correlated liquidity shock. The main difference is that investors responding to the wealth shock choose to liquidate, whereas investors responding to the correlated liquidity shock are forced to liquidate.

Before continuing, it is useful to take stock of the contagion channels that I have covered so far, and to note those that have not been covered. the correlated information channel of financial market contagion pertains to the correlation between real sectors of the economy and is related to channel 1 of Table 1. Channel 2, common FI, has been examined empirically by

[19] A liquidity shock requires a market participant to generate additional cash, or to invest additional funds. Examples of liquidity shocks are margin calls, redemptions from mutual funds, or unanticipated inflows into mutual funds.

[20] Buying after prices rise, or selling after prices sell is referred to as positive feedback trading because it tends to push prices in the direction that they were already moving. Negative feedback trading involves selling after prices rise, or buying after they fall.

[21] Market participants may follow feedback trading strategies because they irrationally chase price trends, or they may engage in feedback trading as part of dynamically hedging a portfolio of derivative securities exposures. For example, if firms that are derivatives dealers have written options whose value depends on the value of securities in more than one market, then their hedging strategy will involve cross-market feedback trading.

[22] In the KP model changes in investors wealth do not generate contagion because the investors in the model all have CARA utility functions. For this utility function, if there are no restrictions on investors borrowing and lending, then asset demands do not depend on wealth.

Peek and Rosengren (1999), Van Rijckeghem and Weder (1999), and Kaminsky and Reinhart (1998). Channel 3 is financial institutions contagion which has been examined by Allen and Gale (1998). Channels 6 and 7 are financial market contagion, which has been theoretically examined by King and Wadhani (1990), Calvo (1999), and Kodres and Pritsker (1999). The channels that are missing are 4 and 5, which deal with how the interaction between financial markets and financial institutions can cause contagion. The only theoretical model that I know of that deals with both is by Backus, Foresi, and Wu (1999), hereafter BFW. They modify the Diamond-Dybvig bank run model in a way that allows banks to sell assets into securities markets when they face a run, or liquidity crises. The effect of the selling is to depress asset prices, and thus provides a mechanism for financial markets to transmit the crises from healthy to unhealthy banks through financial markets. I will mention this channel again when I discuss areas for further research.

3 Resilience/Vulnerability

As alluded to in the previous section, the mere fact that there is potential for a shock to be transmitted from one country to another, does not mean it will be. Whether a shock is transmitted, and whether it has a large effect on the real sector, depends on the resilience of the real sector and the resilience of the financial system to the shock. It is to this topic that I now turn.

It is useful to begin by considering the resilience of the real sector of one country to real shocks emanating from another country. The real sector of country i is relatively more resilient to real shocks from abroad the greater is i's ability to substitute away from any particular shock. For example, if country j produces inputs that are used for production in country i, then i is relatively more insulated to supply disruptions from j if i can easily substitute towards alternative suppliers, or alternative inputs. Similarly, if country i experiences a demand shock in an output market, it will be relatively resilient to the output shock if there are alternative markets to sell the output. The real sector of country i will also be relatively resilient to a shock from another country the less its economy depends on that of any other country. In other words, if the real sector is diversified, this may help to dampen the effects of shocks from abroad.[23]

The same principles of substitution and diversification that explain the resilience of the real sector of a country to direct transmission of real shocks from abroad also applies to shocks that are indirectly transmitted through the financial sector.

The linkages in Table 1 motivate the types of resilience that need to be examined. For example, based on channel 2, the areas of resilience that matter are the resilience of a bank or the banking sector to a shock from the real sector, and the resilience of the real sector to a shock from the banking sector. More generally, if one groups the actors from section 2.1 into three groups, Real Sectors (RS), Financial Markets(FM), and Financial Intermediaries(FI), which consist of banks and NBFMPs, then resilience depends on the ability of members of each group to withstand stocks transmitted from members of one's own group, as well as

[23]If shocks have permanent effects, and a country pegs its exchange rate, the pressures to devalue will build-up over time until the government is forced to devalue. Greater substitutability and diversification are unlikely to prevent the eventual need to devalue, although they may postpone its timing.

members of each other group. This suggests considering the resilience to shock transmission from one economic unit to the other among the pairings (RS,RS), (RS,FI), (RS,FM), (FI,FI), (FI,FM), and (FM,FM). Because the resilience of real sectors to direct shocks from other real sectors was discussed above, I will only discuss the latter five pairings in what follows.

3.1 Resilience of Real Sector and Financial Market

The financial market would be "resilient" to shocks from the real sector if changes in real sector conditions did not affect financial markets. This type of resilience is undesirable because the price of financial assets need to reflect real conditions so that financial markets can help direct funds towards those those positive net present value investments that earn the highest returns. The more interesting question is what determines whether the real sector is resilient to shocks to financial markets, where resilience means that shocks to financial markets do not harm the real sector.

I will assume that the real sector is harmed if financial market prices are interpreted in a way such that the wrong set of projects is financed, i.e. that some projects that deserve funding don't get it, and some that don't deserve it, do get it. We will operationalize the resilience of the real sector to financial market shocks by examining how this could happen. To begin, suppose that the prices of assets in financial markets have two components. The first is the fundamental value of the firms that trade in the stock market while the second is a noise term that is unrelated to fundamental value. Then, when the stock price goes up, even if the full increase in the price is due to fundamentals, the increase will be partially attributed to noise, and hence investment in the firm will increase by less than it should have if it was known that the stock price fully reflected fundamentals. Similarly, suppose the stock price increased due to noise, then market participants will partially attribute the increase to fundamentals, and hence will invest more in the project than it deserves. These two examples show that the presence of noise in asset prices has the effect of causing underinvestment in good projects and overinvestment in bad projects relative to a situation where the stock market has less noise.

Given that noise in stock prices may harm the real sector, the question is how does the noise get into prices in the first place? There are many potential explanations that one could give based on irrational behavior by market participants. A very simple rational explanation is based on information asymmetry. If there are significant information asymmetries among participants in the financial markets, then the orderflow of uninformed market participants can be misinterpreted as order flow that is partially based on information. This causes market prices to over-react to uninformed trading, and hence injects noise into prices.[24] This suggests that economies in which there is little publicly available information on firms, and in which private information about firms is closely held, may have real sectors that are less resilient to stock market shocks than in economies where information about the economy and about firms is more widely available. The other determinant of resilience to stock market shocks is the extent to which the real sector relies on financing through equity and bond

[24] Calvo (1999) and Kodres and Pritsker (1999) suggest that the high price volatility in emerging markets during the Asian financial crises may have occurred because emerging markets may have more information asymmetry than other markets. Calvo(1999) and Subrahmanyam and Titman (1999) also suggests why financial market shocks may have persistent effects on the real economy.

markets. In countries where market financing is insignificant and bank finance is dominant, the real sector should be more resilient to shocks to financial markets.[25] This leads to the next topic, which is resilience of the real sector and financial institutions to shocks from each other.

3.2 Resilience of Real Sector and Financial Institutions

The real sector is vulnerable to financial institution losses, or in the extreme, to collapse of the financial institution, if the consequent cut back in lending cannot be substituted for by other financial institutions. Because money is fungible, it would seem that one financial instition should be easily able to step in when another succumbs. However, the services that financial institutions provide are not so easily substitutable because financial institutions solve problems of moral hazard and asymmetric information by gathering information about borrowers, monitoring their activities, and by establishing long-term borrower/lender relationships.[26] If these long-term relationships get broken, they are difficult to quickly replace. As a result, it is difficult for the real sector to insulate itself to the failure of a financial institution. However, although it is difficult to rapidly replace the lending that disappears when an FI fails, it is possible to insulate the real sector from an FI's failing by diversifying the real sector's borrowing across financial institutions, and by taking steps to reduce the likelihood that major financial institutions fail. These steps include solid bank supervision regimes, which includes encouraging banks to diversify, hedge, and hold adequate amounts of risk capital. These steps should also be taken to make the banking system resilient to real shocks from a particular country.

3.3 Resilience of Financial Institutions

Contagion can be transmitted through financial institutions when the failure of one financial institution triggers problems or failures at institutions to which it is linked. The main lesson in Allen and Gale (1998) is that the pattern of linkages among FIs is very important in shock transmission. One might at first think that a large number of linkages between FIs creates many channels for contagion among them, perhaps exacerbating contagion. Allen and Gale show that this reasoning is not necessarily true, and that in fact a small number of significant linkages among banks can be more financially fragile than a larger number of less significant linkages.[27] Here I will attempt to highlight a few of the ideas from Allen

[25] If international lenders use a country's stock market index as an indicator of whether to lend, then the size of the stock market may not be as important an indicator of the real sectors resilience to shocks as will be the noisiness of stock prices.

[26] Both borrower and lender can earn rents from the long-term relationship provided the bank gives the borrower worse lending terms than it deserves given its risk, but better than it could get from other lenders that do not have knowledge of the borrowers characteristics. See Peterson and Rajan (1995 and 1994) and the references they cite.

[27] A similar point was made in an entirely different context by Horvath (1998, 1999). Horvath showed in the context of a real business cycle model that if sectors of the economy are linked to each other by a small number of links then shocks to one sector transmit more readily through the economy than if each sector is linked to many other sectors. The reason for Horvath's finding is that more linkages provide more opportunities for firms to substitute away from the effect of shocks in input and output markets. This substitutability dampens the shocks propagation.

and Gale's paper. Consider five banks that are labelled, a, b, c, d, and e. If the banks face liquidity shocks (depositor withdrawals) that are not perfectly correlated, then each bank may benefit by depositing a part of its funds with another bank. This deposit arrangement allows banks to hold a mininimum of assets in the form of cash while still being able to cover liquidity shocks by withdrawing part of their deposits from banks that were not hit by a shock. Figure 4 presents two different possible configurations of deposits among the banks. In Panel A, bank a has deposits with b, b with c, c with d, d with e, and e with a. The arrangement in A is clearly a small number of significant links because each bank only has deposits with one other. By contrast, in panel B, each bank splits the deposits it would have made in Panel A evenly among all the other banks. Therefore, each bank deposits the same amount as in panel A, but there are more linkages among the banks, and each is smaller in size when measured by amount of deposits.[28] To see which configuration is potentially more fragile, suppose bank a fails. For the deposit configuration in panel A, this will cause problems at bank e because it will not be able to recover the full value of its deposits from a. If e's losses are large enough, it can trigger a bank run on e causing it to collapse, this can generate similar problems for bank d. Allen and Gale establish conditions in which all of the banks collapse if the losses for e from $a's$ collapse are large enough. By contrast, consider the configuration in panel B. There when a collapses, each bank loses a portion of its deposits with a, but because the overall exposure to a is small, each banks ability to pay its other depositors is not in question, hence bank runs don't emerge, and the financial institutions don't collapse like dominoes as they did in panel A.

The other factor that matters for financial fragility among the FIs, other than the number and size of the linkages between them, is the strength of the banks in the chain to withstand a shock. If one of the banks has a significant enough cushion of capital and a strong enough balance sheet, then it would not experience a bank run, and the domino effect in panel A would not have occurred. Therefore, it is both the configuration of the linkages among FIs, and their capital that determines whether the financial stucture of banking institutions is fragile.

3.4 Resilience of Financial Markets.

As noted in section 2.4, shocks can be transmitted directly from financial market i to financial market j through the correlated information channel described in section 2.4, or through the actions of financial intermediaries who transmit the shock across markets. This subsection is concerned with the first of these possibilities while the next subsection is concerned with the second. Recall that financial markets are linked through the correlated information channel when the real sectors of countries i and j are correlated, and when there is asymmetric information in financial markets. Because the real sectors are actually correlated, and financial markets should reflect the value of assets in the real sector, it is not necessarily undesirable for the financial markets to be correlated. However, as noted earlier, the information asymmetry has the additional effect of causing shocks in the financial market of one country to cause price movements in the other country that are excessive relative to the

[28] The arrows denote the direction of the deposits. For example in panel A, an arrow leading from a to b denotes that a has deposits with b, whereas in panel B, the arrow from a to b points in both directions, showing that a has deposits with b and b has deposits with a.

other country's full information fundamentals. The most straightforward way for a country to reduce its own vulnerability to this form of contagion from other financial markets is to improve the quality of information about the assets in its own market.

3.5 Resilience of Financial Markets and Financial Institutions

Financial institutions are inherently vulnerable to shocks from financial markets as part of their regular business risk as brokers, dealers, and proprietary traders. Although FI's are vulnerable to shocks from financial markets, there is no single straightforward method to quantify an FI's vulnerability. Three indicators appear to be useful. The first is the distribution of returns on the FI's portfolio over some fixed time horizon given the FI's current positions and hedges in all markets. This distribution summarizes the FI's market risk over the given time horizon assuming that its portfolio holdings and hedges remain fixed. The Bank for International Standards capital charge for market risk is based on the 1% quantile of this distribution at a 10-day time horizon. A deficiency of the distribution of returns measure is it does not account for an FI's ability to withstand one or a series of shocks by altering its portfolio through selling or hedging. Thus, the liquidity of an FI's portfolio, and the availability of hedging instruments, are also indicators of an FI's ability to withstand financial market shocks. The final relevant measure of vulnerability is the FI's capital position. If an FI's capital relative to risk is large, then the market risk may not be so severe that the FI experiences financial distress or bankruptcy, thus potentially harming the real sector.[29]

Financial markets are vulnerable to shocks transmitted from FI's through FI's own proprietary trading and through FI's roles as broker/dealers in markets. A financial markets vulnerability to an FI's rebalancing across markets in its proprietary-trading role depends on many factors. If vulnerability is defined in terms of price movements that are inconsistent with fundamentals, then the magnitude of information asyummetry in the market matters. The other factors that matter are any factors that will influence an FI's choice of whether and in which markets to rebalance. These factors include the FI's level of capital, the liquidity of *all* the markets in which the FI might rebalance, the risk factor structure of returns in all markets in which the FI might rebalance, and the FI's objective function and portfolio.[30] A markets vulnerability to shocks from FI's proprietary trading activities also depend on the proportion of FI's with similar positions and strategies in the markets, and the size of FI's demand relative to the liquidity of the market. Illiquid markets in which FIs

[29]Recall that in this section I grouped banks and NBFMPs together. If the former go bankrupt, it may have implications for the real sector.

[30]Some of the same factors that influence the rebalancing behavior of FIs influence whether the informed and uninformed investors in KP (1999) rebalance across markets. The influences that don't appear in KP are market capital and market liquidity.The analog of capital in the KP model is investors wealth, but asset demands don't depend on wealth because investors in the KP model have Constant Absolute Risk Aversion utility. The liquidity of markets also does not affect rebalancing in KP because all market participants in the model are price takers. In models where FIs are not price takers, liquidity and perceived future liquidity will both affect rebalancing. For example, if a liquidity shock requires a firm to convert some or all of its portfolio to cash, the firm may sell its most liquid assets to avoid the losses from having to sell into an illiquid market. But, if the FI believes it may experience more liquidity shocks in the future, then it might optimally choose to liquidate in relatively illiquid markets today to avoid having to do so under even worse conditions in the future.

follow similar strategies might be more vulnerable to shocks from FIs than markets where FIs follow a multiplicity of strategies.[31]

The analysis in the preceding paragraph was based on FI's roles as proprietary traders. Backus, Wu, and Foresi's (1999) model used banks proprietary trading to generate the collapse of asset prices in their model. A separate and I believe interesting question is whether markets are vulnerable to FIs because of FI's roles as dealers. My answer is maybe. The reason is that many of the world's most important markets, are not perfectly competitive in the sense of consisting of a large number of very small participants. Instead, in many OTC markets such as foreign exchange, corporate bonds, and many derivative securities, the market is dominated by a relatively small number of large dealer firms, who are typically banks or investment banks. Because most of the liquidity in many markets is provided by a small number of large dealers, shocks experienced by these firms can significantly affect the liquidity of markets provided that others cannot enter and provide liquidity when dealers cut back.

I believe that entry into liquidity provision is limited for some of the same reasons that financial intermediaries exist in the first place, i.e. to solve problems of information asymmetry and borrower monitoring. In the case of financial markets, problems of information asymmetry can cause the market mechanism to break down completely in some cases. A potential solution to some of the problems of perfectly competitive markets is oligopolistic markets dominated by large dealer financial intermediaries. Just as financial institutions long-term implicit contracts with borrowers solve particular contracting problems when there are not markets, when there are markets FIs can improve market function by gathering information on securities, and then incorporate this information into prices in their roles as dealers. While the information asymmetries associated with well informed large players could cause a perfectly competitive market to collapse, because the dealer FIs in these markets are large and are long-term market participants, they can be punished in the future for attempting to exploit their information (or otherwise cheat their customers) through damage to their reputation (Allen and Gale, 1997), or perhaps by other market participants refusing to trade with them for some period of time.[32]

If many financial markets are ologopolistic and liquidity in markets is maintained by financial institutions with established reputations, then the loss of a dealer financial institution can be very costly to the market if a dealer with similar experience and reputation cannot for some reason step in and take the collapsed dealers place. Perhaps the best example of this is the failure of Drexel, Burnham, and Lambert (Brewer and Jackson, 1997). Drexel was the largest dealer in the junk bond market. When Drexel collapsed, the junk bond market essentially collapsed with it, and did not recover for several years.

Drexel's collapse was significant because of the very high concentration of the junk bond market and of Drexel's dominant role in that market. Most of the major OTC markets are less concentrated than the junk bond market was in the late 1980s. Thus, one would expect that a shock to a single dealer FI would not necessarily have a major effect on prices and

[31] If FIs are following similar or the same strategies, their demands are positively correlated, and if they all try to buy or sell at the same time it may be disruptive to markets.

[32] The view that dealers are better informed than customers is the opposite of the assumption that is typically made in the market microstructure literature. The truth is probably somewhere in between, where dealers and customers each have information that the other does not have.

liquidity because other dealers could step in. However, if the market is concentrated enough, and most of the large FIs experience a common shock, then it may be possible to have the shock spread from FIs to markets. I claim this may have happened during the troubles with LTCM in the Fall of 1998.

4 LTCM Revisited

To analyze the effect that the losses and eventual bailout of the hedge fund Long Term Capital Management (LTCM) might have had on market liquidity, it is instructive to revisit Figure 2. The figure shows a Nonbank Financial Market Participant such as LTCM at the the top of the pyramid getting hit with a shock and the shock then filtering down to banks and investment banks that are dealers in financial markets. LTCM had positions at some of the largest dealer firms in OTC markets in several different classes of securities.[33] When the heads of these firms learned about the troubles at LTCM and the dollar losses, they also learned, a second, perhaps more surprising fact, the credit riskiness of their exposures at LTCM were much greater than they had believed because of the high leverage that LTCM had employed.

When the Chief Executive Officer (CEO) of each dealer financial institution learned about his firms higher than expected credit exposures to LTCM, there were two possible interpretations of what he learned. The first was that LTCM was an outlier, and although the credit riskiness of the firms exposures with LTCM were higher than anticipated, the firm's assessments of its credit risk with respect to its other counterparties were probably accurate. The second interpretation was that the mistakes that caused the firm to take on too much credit risk in its LTCM exposures were likely to be systematic mistakes which caused the firm to also understate the credit riskiness of its exposures with other counterparties. For each CEO, the possibility that the mistakes were systematic might cause him to curtail further credit extension—including a cut-back in liquidity provision to markets—pending more information about the firms overall credit risk. If one dealer firm reacted this way to the events at LTCM, other dealers might have been able to step in and provide additional liquidity to markets to make up for the loss of a single dealer. But, in fact, many of the largest dealer firms were exposed to LTCM. If all of these firms responded in the same way to the news on leverage and credit, then all might have cut back on dealing, and liquidity would have dried up in a number of markets. In my opinion, this may have been part of what happened following the announcement of problems at LTCM. It is indisputable in any case that lending was cut off to hedge funds. The benefits that hedge funds had been providing towards liquidity provision through risk sharing may have been cut off with their credit.

The drying up of liquidity in some markets may have been accompanied by knock-on effects that were transmitted to other markets. The knock on effects from the drying up of liquidity in some markets is that participants with particular liquidity objectives have to rebalance their portfolio towards more liquid instruments. Since this will typically involve

[33]The consortium of lenders that met to bail out LTCM included Goldman Sachs, Merrill Lynch, J.P. Morgan, Morgan Stanley, Dean Witter, the Travelers Group, Union Bank of Switzerland, Barclays, Bankers Trust, Chase Manhattan, Credit Suisse First Boston, Deutsche Bank, Lehman Brothers, Paribas, and Societe General (Edwards, 1999).

selling the illiquid instruments and buying liquid instruments, this would be accompanied by a flight to quality (because high quality instruments are more liquid) and a higher premium for liquid instruments because the supply of liquidity dropped. This roughly corresponds to what happened in markets once the difficulties at LTCM become known; i.e. liquidity dried up in a number of markets, and there was a flight to quality. Moreover, because of the flight to quality, all markets with illiquid instruments, not just those that became illiquid first would suffer. So, for example, although the problems at LTCM had nothing to do with emerging markets, in the scramble to dump illiquid assets, emerging markets could potentially have suffered.

5 Summary and Conclusions

The channels through which a shock in one country or market spreads to other countries or markets are not well understood. Some might interpret the difficulties in explaining shock propagation as evidence that markets are irrational. While financial market irrationality is one possibility, I interpret our failure to explain propagation as evidence that more channels for propagation need to be theoretically modelled and empirically tested. In this paper I have discussed at least five separate channels through which real shocks are transmitted from one country to another. They involve contagion via real linkages, contagion via a common lender, contagion via financial markets, contagion via financial institutions, and contagion via the interaction of financial institutions and markets.

None of these contagion channels require irrationality for shocks to be transmitted. Nevertheless, due to market imperfections involving information asymmetries, the price movements that occur in one market or country as a result of contagion from elsewhere can sometimes be excessive relative to full-information fundamentals. This suggests that more public information production and insider trading laws may improve market function and reduce unnecessary contagion.

Although I have identified several channels for shock propagation, this paper has barely scratched the surface in terms of modelling the propagation. One promising research area that deserves a closer look is the interaction between large financial institutions which are dealers in financial markets, and the financial markets. In markets which are highly concentrated, problems at dealer firms may spill over to markets, potentially impairing liquidity. This may be part of what happened to markets after news of large losses at LTCM, but whether this happened with LTCM, and whether it could happen again are subjects for further theoretical and empirical research.

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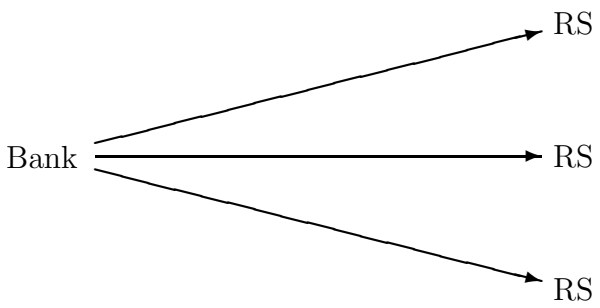
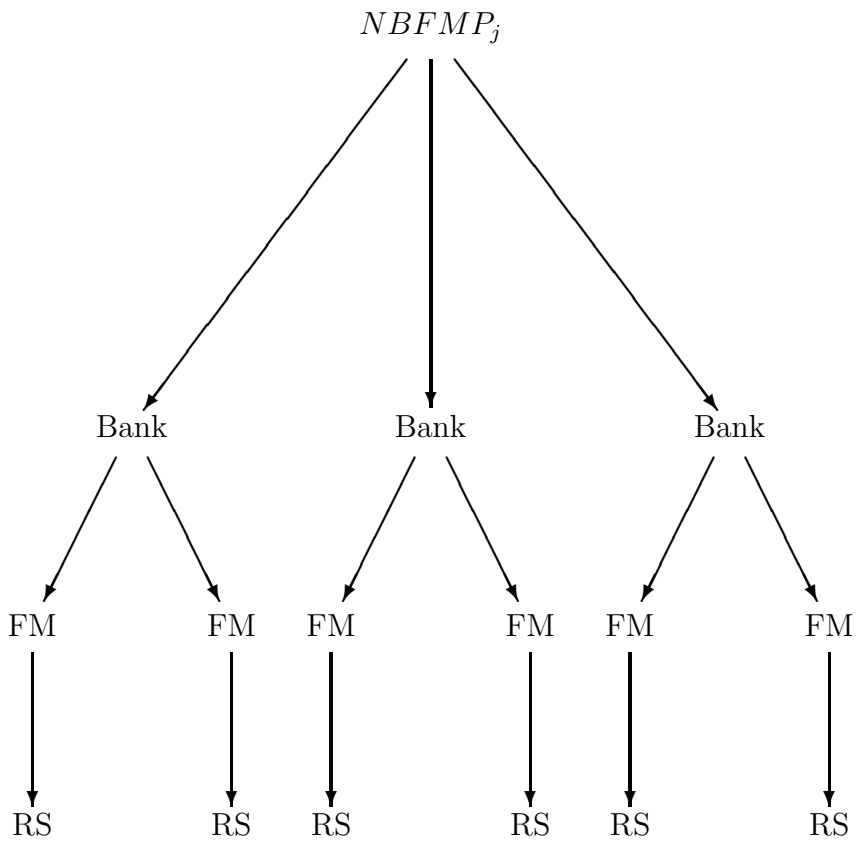
Figure 1: Propagation from Bank to Real Sectors



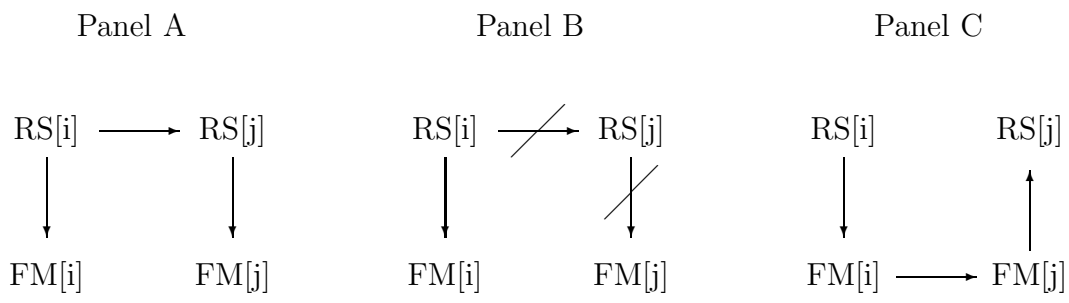
Notes: The figure illustrates how a shock that begins with a bank that has operations in many countries can spread from the bank to the real sector of the economies of each of the countries. The figure is referenced in section 2.3 of the text.

Figure 2: Pyramidal Shock Propagation



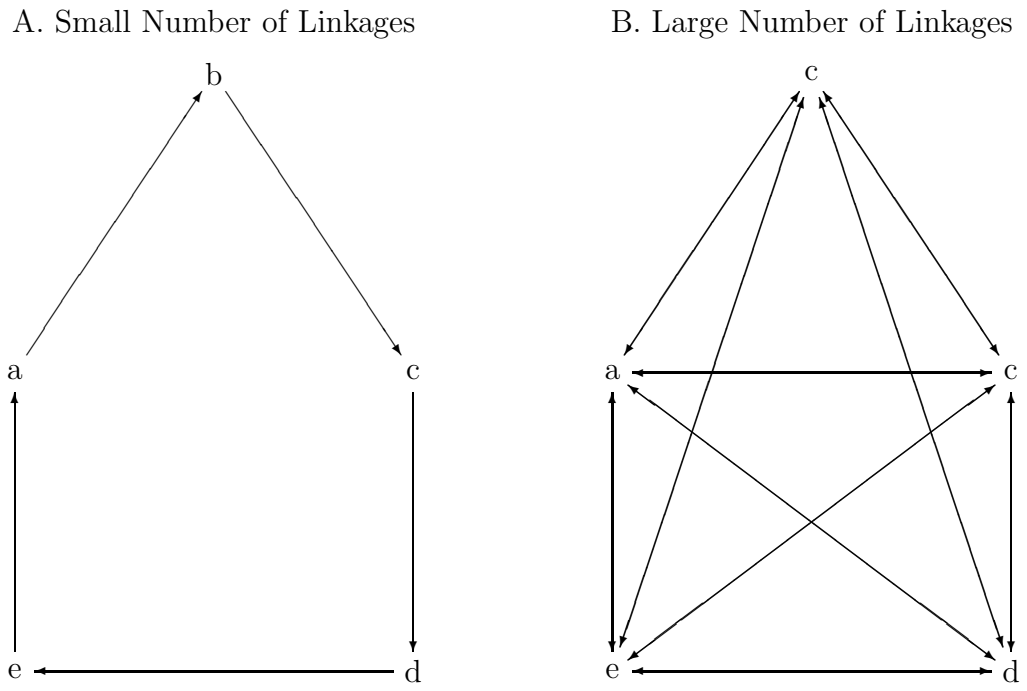
Notes: The figure illustrates how a shock originating with nonbank market participant j ($NBFMP_j$) can spread to the banks that lend to j , and then to the financial markets (FM) in which the banks provide liquidity, and then eventually to the real sectors (RS) that are tied to the financial markets. Details on the figure are provided in section 2.3 and section 4 of the text.

Figure 3: Correlated Information Channel for Contagion



Notes: The figure presents how a shock to the real sector of country i , $RS[i]$, propagates to the real sector of country j, $RS[j]$. In Panel A, the shock is publicly observable and is transmitted to j because it affects a part of the real sector of country i that is correlated with the real sector of country j. In Panel B, the shock is also publicly observable, but affects a part of the real sector of country i that is not correlated with the real sector of country j. Therefore, the shock affects financial markets in country i, but it does not affect the real sector or financial markets of country j. In Panel C, the shock could be of the type in panel A or panel B, but the shock is only privately observable to market participants in country i. As a result, the shock propagates to the financial markets in country i, and then because the price move in i may be relevant to the value of real sector claims in country j, it propagates to the financial markets of country j and then to the real sector of country j. Because the real shock in panel C could be of the type in panel B, the financial market may transmit a shock from one real sector to another although based on public information the shock should be irrelevant. Details on the figure are presented in section 2.4.

Figure 4: Fragile and Less Fragile FI Linkages



Notes: The figure presents the set of possible linkages between five deposit taking institutions, a, b, c, d, and e. The arrows represent deposits between the institutions. In panel A, each institution has deposits with one other institution. Institution a has deposits with b, b with c, and so on. In panel B, each institution has deposits with every other institution. Section 3.3 of the text discusses why the financial system in which there are a large number of linkages among financial institutions is likely to be more resilient to shocks to a single institution.