Complexity, Concentration and Contagion: A Comment[*]

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1 Introduction

Although the precise origins of the term "complex adaptive system" are unclear, neverthe-less, the hackneyed phrase is now firmly ensconced in the lexicon of biologists, physicists, mathematicians, and, most recently, economists. However, as with many important ideas that become clichés, the original meaning is often obscured and diluted by popular usage. But thanks to the fascinating article by Gai, Haldane, and Kapadia (hereafter GHK), we have a concrete and practical instantiation of a complex adaptive system in economics, one that has real relevance to current policy debates regarding financial reform.

Since there is very little to criticize in GHK's compelling article, I will seek to amplify their results and place them in a broader context in my comments below.

2 Complexity

GHK motivate their analysis by illustrating the growth in complexity of various financial networks in their Figures 1 and 2. While network analysis is a well-studied branch of mathematics and has long been used with great effect in engineering, ecology, anthropology, and sociology, it has had relatively little mainstream exposure in economics and finance until recently.[1] Traditional economic analysis has favored analytical methods such as calculus and optimal control theory over geometric techniques such as graph theory and topology. While it is true that analytical models can reproduce many of the features of network models, the latter are often more direct and parsimonious ways of capturing nonlinearity, heterogeneity, linkages, and complexity in practical economic contexts. Therefore, GHK's current and past efforts are important steps in bringing this new quantitative framework to bear on traditional economic challenges.

While these tools may be directly applied to economic settings, there are some important differences between economics and the other domains of complex adaptive systems that should be kept in mind. Perhaps the most significant difference is the origins of complexity: in the physical and natural sciences, complexity is often a fact of life and exogenous, whereas in economic systems, complexity is usually a demon of our own design. A simple illustration

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[1]See, for example, Jackson (2010) and the references therein.

of this distinction is given by the following expression:

$$
S[L] = \begin{cases} L & \text{if } L \leq K_{\text{IRB}} \\[2mm] K_{\text{IRB}} + K[L] - K[K_{\text{IRB}}] + \\ \quad (d \cdot K_{\text{IRB}}/\omega)(1 - \exp(\omega(K_{\text{IRB}} - L)/K_{\text{IRB}})) & \text{if } L > K_{\text{IRB}} \end{cases}
$$

where

$$
\begin{aligned}
h &= (1 - K_{\text{IRB}}/\text{LGD})^N \\
c &= K_{\text{IRB}}/(1 - h) \\
v &= \frac{(\text{LGD} - K_{\text{IRB}})K_{\text{IRB}} + 0.25(1 - \text{LGD})K_{\text{IRB}}}{N} \\
f &= \left(\frac{v + K_{\text{IRB}}^2}{1 - h} - c^2\right) + \frac{(1 - K_{\text{IRB}})K_{\text{IRB}} - v}{(1 - h)\tau} \\
g &= \frac{(1 - c)c}{f} - 1 \\
a &= g \cdot c \\
b &= g \cdot (1 - c) \\
d &= 1 - (1 - h) \cdot (1 - \text{Beta}[K_{\text{IRB}}; a, b]) \\
K[L] &= (1 - h) \cdot \Big((1 - \text{Beta}[L; a, b])L + \text{Beta}[L; a + 1, b]c\Big) .
\end{aligned}
$$

When asked to identify the meaning and source of these equations, even seasoned banking professionals do not always realize it is the supervisory formula proposed by the Bank of International Settlements for determining whether a bank is sufficiently well capitalized with respect to its securitized debt holdings, and is taken from Paragraph 624 of the Basel II Accord (2004, p. 132). This framework will soon be replaced by the even more complex Basel III Accord (2011), in which capital requirements have been raised, but nothing has been done to address the issue of complexity.

Unlike the complexity of celestial mechanics and global weather patterns, we are the authors of the complexity of our financial system and regulatory infrastructure, but we can also develop new technologies to better manage it as GHK is proposing to do.

3   The Impact of Financial Innovation

One explanation for the complexity in today's financial system is given by GHK's Figure 11, which depicts a stylized balance sheet for a typical bank. Banking used to be a considerably

simpler, almost boring business: accept deposits, pay interest, and make loans. The primary economic purpose of banking was liquidity provision, effectively a market-making service not unlike the services provided by a New York Stock Exchange specialist. The key aspects of such a business involved maintaining the trust and confidence of one's clients, managing one's reserves so as to be able to meet clients' liquidity demands, and managing the credit risk of the bank's portfolio of loans (see, for example, Diamond and Dybvig, 1983). And because the integrity of the banking system was deemed to be so vital to the public interest, the industry has become one of the most highly regulated in the economy. With government guarantees to protect depositors, capital requirements to limit leverage, periodic bank examinations, and the Federal Reserve Bank as the lender of last resort, the bank runs that were all too common in the U.S. in the early 1900's were largely eliminated in modern times.

However, thanks to the confluence of several trends over the past two decades—competition, deregulation, globalization, population growth, and technological and financial innovation—banking today is considerably more "interesting", spanning more markets, businesses, countries, and financial instruments than ever before. These changes have generally been beneficial prior to 2007, supporting broad economic growth across many industries and countries during the unprecedented bull market of the late twentieth century. But the financial regulatory infrastructure that was designed to guard against irrational exuberance did not anticipate the financial innovations of the 1990's, such as asset-backed securities, collateralized debt obligations, credit default swaps, repos and reverse repos, and the rise of hedge funds, money market funds, and the so-called "shadow banking system" (see, for example, Pozsar et al., 2010, and Figure 1 below, which is reproduced from their paper).

In particular, banks are no longer the only entities capable of issuing "high-powered money"; for example, as we saw from the LTCM debacle in 1998, hedge funds are able to obtain vast amounts of leverage from their prime brokers, allowing them to grow their balance sheets to many times greater than their capital base. This allows such entities to wield economic forces far greater than their assets under management might suggest. Moreover, the practice of "rehypothecation", in which financial institutions are able to earn additional fees by re-deploying collateral via securities lending, has added to the "multiplier/accelerator" effect of the shadow banking sector, contributing more leverage to the financial system, leverage than is currently invisible to regulators.

In fact, a critical unintended consequence of the financial innovations of the last two

decades is that regulators now see and control a much smaller fraction of the financial system than before, and the controls at their disposal are no match for the more adaptive strategies employed by private financial institutions. For example, the elaborate rules and regulations that have been developed over the last several decades by U.S. state insurance regulators to prevent insurance companies from taking on too much risk were easily sidestepped during the last 10 years through credit default swaps and other over-the-counter derivatives contracts. As a result, credit default risk became too highly concentrated among a handful of apparently inadequately capitalized insurers such as AIG, AMBAC, MBIA, FGIC, and FSA, ending in a series of defaults. Concentration is the second theme of GHK's analysis, and their Figures 5–7 document similar increases in concentration in the U.S. and U.K. banking industries. This is another manifestation of financial innovation outpacing and outmaneuvering slower-moving regulatory oversight.

During normal market conditions, these innovations provide important sources of additional capital that fuel global economic expansion. However, during periods of market distress, the usual mechanisms for maintaining financial stability—capital requirements, haircuts on short-term collateral, bank examinations, and central banks as lenders of last resort—are no longer as effective because of the size, speed, and complexity of the interactions between the traditional and shadow banking systems.

4   Solvency vs. Liquidity

Perhaps the most significant impact of financial innovation on the banking industry is the new dynamics of liquidity created by dizzying array of financial instruments and vehicles that populate today's markets. While the basic functions of banks still involve liquidity provision, banks now provide a much broader range of liquidity to a more heterogeneous pool of clients over a greater range of horizons. Yet the basic structure of banking regulation— including the accounting framework in which capital adequacy is determined—is largely unchanged and focused more on maintaining bank solvency rather than bank liquidity. This is understandable given that bank regulations were developed decades ago, when liquidity provision was considerably less dynamic.

This is well illustrated by GHK's stylized balance sheet in Figure 1, which is the starting point for their analysis. The interaction between various balance sheet items and external
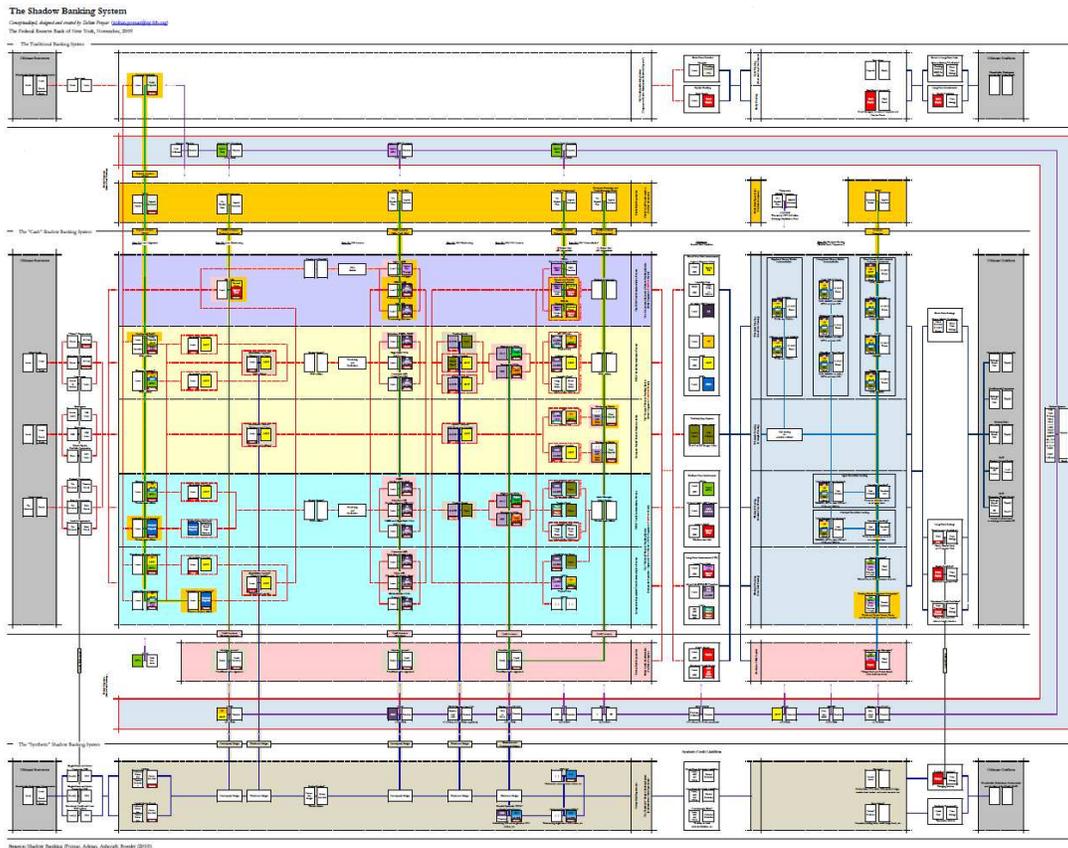
Figure 1: A flowchart of the shadow banking system, from Pozsar et al. (2010).

liquidity shocks gives rise to the following liquidity condition at each node of their network:

$$A_i^L \;+\; (1-h-h_i)A_i^C \;+\; \frac{(1-h-h_i)}{(1-h)}A_i^{RR} \;+\; L_i^N \;-\; L_i^R \;-\; \lambda\mu_i L_i^{IB} \;-\; \epsilon_i \;>\; 0 \;.$$

This expression is the main focal point of GHK's analytic framework. It states that bank i is liquid if the bank's liquid assets, A_i^L, plus the amount raised from pledging collateral assets, $(1-h-h_i)A_i^C$, plus the amount raised from rehypothecating collateral received in reverse repo operations, $[(1-h-h_i)/(1-h)]A_i^{RR}$, plus new unsecured interbank borrowing, L_i^N, less its repo liabilities, L_i^R, and outflows of capital due to the liquidity hording of counterparties, $\lambda\mu_i L_i^{IB}$, minus a random liquidity shock, ϵ_i, is positive.

Implicit in this condition is the assumption that bank i must maintain a positive liquidity condition, hence if the sum of these terms becomes negative, it is assumed that the bank will act immediately to restore its liquidity condition by: (1) raising interest rates (which has negative signalling implications for bank i); (2) liquidating fixed assets (which can be costly, especially over short time periods); and (3) reducing interbank lending. This last response imposes externalities on the entire banking system, and is the channel by which GHK captures network effects or contagion, the third major theme of their model.

5 Valuation Uncertainty and Accounting Practices

By focusing on liquidity instead of solvency, we are implicitly assuming some form of capital-market imperfection. If not for such imperfections, a solvent bank should always be able to address short-term liquidity needs either through the private sector or various central-banking facilities. GHK do not address this issue explicitly in their framework, but simply assume that the liquidity condition (1) must be satisfied. However, from a policy perspective, the specific frictions that give rise to liquidity problems is key.

To see why, consider the experience of the U.S. commercial banking sector with respect to repo transactions during the build-up to the crisis in 2006 and 2007. Repo markets figure prominently in GHK's framework, and has been cited by a number of studies as the epicenter of the recent financial crisis. According to the March 10, 2011 U.S. Flow of Funds Accounts (Table L.109), the aggregate net repo liabilities of the sector were $888.2 and $838.5 billion in these two years, respectively (see Table 1 below, row 30). However, in those same two years, the asset values of agency and GSE-backed securities (row 8 of Table 1) were $1,135.6

and \$1,022.3 billion, respectively, far exceeding repo liabilities. Since such securities are considered good collateral and commonly used in repo transactions, with haircuts of 2% to 3% even during the recent crisis, it is not obvious that liquidity was the problem.

In fact, the largest market for such transactions is the tri-party repo market, and in a New York Fed study, Copeland, Martin, and Walker (2010) find that "...both the level of haircuts and the amount of funding were surprisingly stable in this market" during the crisis period (see, also, the study by the Payments Risk Committee, 2010). Moreover, as documented in a Federal Reserve Bank of New York (2010) study, this market continued to expand throughout 2007 and into the first half of 2008 (see Figure 2).

The availability of the tri-party repo market for borrowing, the existence of unencumbered collateral in the banking sector, and the ability to raise equity directly in public markets strongly suggests that banks had a number of backstops that could have limited the propagation of the type of shocks discussed in this paper. Therefore, if liquidity was truly an issue during this period, we must ask where the particular capital market imperfections are, and address them directly.
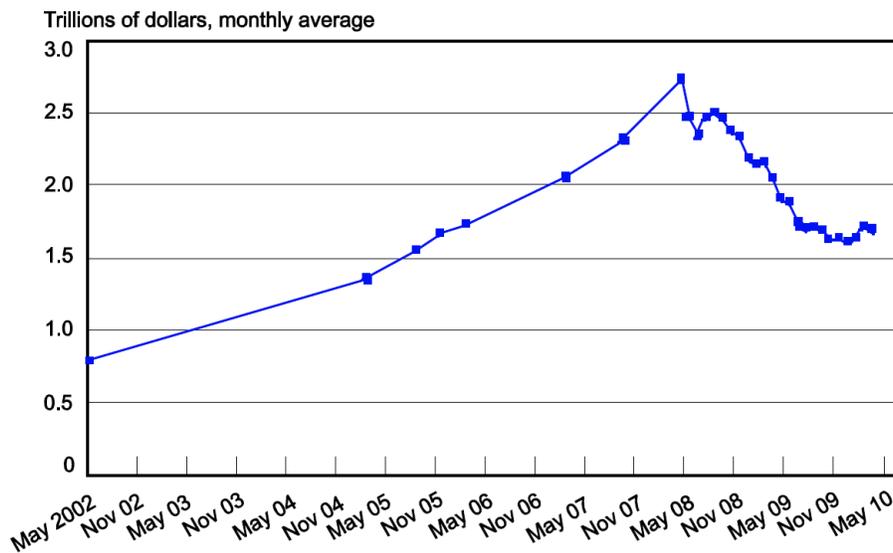

Figure 2: Aggregate size of U.S. tri-party repo market. Source: Federal Reserve Bank of New York (2010, Figure 2).

One conjecture is that uncertainty surrounding the credit quality of individual bank counterparties caused all banks to withdraw short-term liquidity from the interbank and

L.109 Commercial Banking (1)
Billions of dollars

		2005	2006	2007	2008	2009	2010	
1	**Total financial assets**	**9843.7**	**10886.1**	**11879.0**	**14056.3**	**14288.2**	**14402.3**	1
2	Vault cash	50.1	51.7	55.0	57.7	54.9	52.8	2
3	Reserves at Federal Reserve	16.3	16.7	18.2	816.3	908.7	886.4	3
4	Checkable deposits and currency	3.0	2.9	2.6	3.2	4.2	3.3	4
5	Total bank credit	7546.6	8402.4	9187.1	9672.8	9298.1	9499.1	5
6	Open market paper	0.0	0.0	0.0	15.7	0.0	0.0	6
7	Treasury securities	97.0	94.9	112.3	93.2	185.4	298.5	7
8	Agency- and GSE-backed securities	1089.6	1135.6	1022.3	1169.4	1276.9	1354.0	8
9	Municipal securities	157.7	180.2	192.9	216.7	218.6	246.1	9
10	Corporate and foreign bonds	687.0	780.3	978.2	979.9	868.3	749.6	10
11	Bank loans n.e.c.	1577.9	1705.2	2027.3	2230.6	1778.9	1776.7	11
12	Mortgages	2958.0	3403.1	3644.4	3841.4	3818.7	3651.2	12
13	Consumer credit	707.0	741.2	804.1	878.6	855.3	1098.7	13
14	Security credit	230.7	302.2	334.5	221.0	219.6	242.3	14
15	Corporate equities	24.1	35.3	41.5	6.7	30.3	37.1	15
16	Mutual fund shares	17.4	24.5	29.6	19.6	46.1	45.0	16
17	Customers' liab. on acceptances (2)	4.0	0.4	0.5	0.0	0.0	0.0	17
18	Miscellaneous assets	2223.7	2411.9	2615.6	3506.3	4022.2	3960.7	18
19	**Total liabilities**	**8685.2**	**9533.1**	**10473.0**	**12534.3**	**12651.2**	**12828.5**	19
20	Net interbank liabilities	128.3	115.7	12.8	972.8	250.7	80.8	20
21	To monetary authority	1.0	-0.3	48.6	558.2	94.5	-1.2	21
22	To domestic banks (3)	21.3	19.3	21.1	51.7	86.1	62.0	22
23	To foreign banks	106.0	96.7	-56.9	362.9	70.1	20.0	23
24	Checkable deposits	610.3	574.4	587.7	729.1	814.0	890.8	24
25	Federal government	33.9	28.0	42.9	3.5	3.8	3.6	25
26	Rest of the world	19.7	28.8	34.1	67.6	44.6	44.4	26
27	Private domestic	556.8	517.6	510.7	658.0	765.7	842.8	27
28	Small time and savings deposits	3527.1	3814.7	4077.7	4619.1	5003.5	5280.6	28
29	Large time deposits	1363.7	1627.7	1925.3	1827.7	1824.8	1619.8	29
30	Federal funds and security RPs (net)	817.7	888.2	838.5	482.8	746.6	583.2	30
31	Credit market instruments	823.9	1001.5	1262.8	1425.3	1665.6	1854.6	31
32	Open market paper	61.2	82.2	117.2	77.7	60.8	177.6	32
33	Corporate bonds	494.1	570.8	690.3	821.3	1202.8	1399.0	33
34	Other loans and advances	268.5	348.5	455.2	526.3	402.0	277.9	34
35	Taxes payable (net)	25.8	24.7	11.1	-74.6	-67.5	-60.8	35
36	Miscellaneous liabilities	1388.5	1486.2	1757.2	2552.1	2413.6	2579.6	36
	Memo:							
37	Credit market funds advanced (4)	7278.4	8040.9	8782.1	9425.5	9002.1	9174.7	37
38	Consumer leases not included above (5)	0.0	0.0	11.2	9.5	6.9	6.2	38

(1) U.S.-chartered commercial banks, foreign banking offices in U.S., bank holding companies, and banks in U.S.-affiliated areas. IBFs are excluded from domestic banking and treated the same as branches in foreign countries.
(2) Included in other loans and advances (table L.216).
(3) Floats and discrepancies in interbank transactions.
(4) Total bank credit (line 5) less security credit (line 14) less corporate equities (line 15) less mutual fund shares (line 16) plus customers' liability on acceptances (line 17).
(5) Receivables from operating leases, such as consumer automobile leases, are booked as current income when payments are received and are not included in financial assets (or household liabilities). The leased automobile is a tangible asset.

Table 1: Aggregate balance sheet of U.S. commercial banks from 2005 to 2010. Source: March 10, 2011 U.S. Flow of Funds Data, Table L.109.

repo markets, i.e., GHK's liquidity hoarding, creating a credit crunch that cascaded into a full-blown crisis. While such uncertainty may have been precipitated by the breakdown in subprime-mortgage-related securities markets, it was undoubtedly magnified by the "valuation uncertainty" created by bank accounting practices and conventions. And even in situations where short-term borrowing was secured by high-quality collateral, the market risk of that collateral may have been overshadowed by the potential legal risks created by a defaulting counterparty, where bankruptcy proceedings may tie up the collateral longer than either borrower or lender can stay in business. If bank i is uncertain about the viability of bank j as a going concern, it is natural for i to reduce its exposure to j. Now let such behavior propagate throughout the network, and contagion and systemic repercussions can emerge quite naturally.

To capture such effects within GHK's framework, a simple but significant modification to their liquidity condition (1) is all that is needed, which is to change the deterministic constraint into a probabilistic one:

$$\text{Prob}\left(A_i^L + (1 - h - h_i)A_i^C + \frac{(1 - h - h_i)}{(1 - h)}A_i^{RR} + L_i^N - L_i^R - \lambda \mu_i L_i^{IB} - \epsilon_i \ > \ 0 \right) \ > \ \delta_i \ (1)$$

where $\delta_i \in (0, 1)$ is bank i's threshold of materiality, below which action is required. This probabilistic condition is not unlike a value-at-risk (VaR) constraint used by portfolio managers to limit their risk exposures. One of the key differences between this condition and GHK's deterministic condition (1) is that uncertainty affects the former but not the latter. In much the same way that volatility spikes will cause portfolio managers to reduce their positions so as to bring down their VaR levels back to acceptable levels, an increase in the uncertainty surrounding the components of GHK's liquidity condition (1), or increased correlations among those components, will adversely affect (1), eventually requiring bank i to take action as the probability of satisfying the liquidity condition falls below δ. The fact that a liquidity event can be triggered by external volatility shocks that have nothing to do with valuations creates a new (and perhaps more realistic) channel for the emergence of systemic risk.

Other advantages of the probabilistic liquidity condition (1) is the ease with which subjective probabilities, prior and asymmetric information, and bank fixed effects can be incorporated into GHK's network dynamics. While this simple extension may not change the

qualitative properties of GHK's results, it may dramatically alter the empirical properties and policy implications of their analysis, which I address next.

6 Policy Implications

GHK conclude with four policy recommendations, all of which contain thoughtful innovations that will no doubt improve systemic stability. Let me discuss each of these in turn, and add a fifth recommendation.

The first of GHK's recommendations is to impose tougher liquidity provisions, which, in their words, "points towards the importance of microprudential liquidity regulation maintaining a relatively tight definition of what constitutes a liquid asset". While this proposal seems reasonable, it may be much harder to implement in practice because liquidity is not only difficult to define, the definition can vary dramatically over time and as a function of market conditions. A case in point is the U.S. auction rate securities markets which, for many years, allowed corporations and municipalities to fund billions of dollars of short-term borrowing at very competitive rates because these auction markets were highly liquid, in some cases clearing weekly. However, since February 2008 when these auctions first began to fail (the primary dealers no longer acted as "bidders of last resort"), these markets have all but disappeared, and such securities have become highly illiquid. Other recent examples of otherwise liquid securities that have episodic periods of illiquidity are long/short equity portfolios during August 2007 (the "Quant Meltdown") and even S&P 500 futures contracts on May 6, 2010 (the "Flash Crash").

Moreover, even the highly structured and stringent set of rules governing the capital requirements of designated broker/dealers under the U.S. Securities Exchange Act of 1934 (Rule 15c3–1) was not enough to save Bear Stearns, Lehman Brothers, and Merrill Lynch. Could tougher microprudential liquidity regulation have altered the fate of these storied financial institutions?

In addition, U.S. banks already have access to the Federal Reserve's discount window for short-term borrowing needs, and the Fed has deemed a remarkably broad range of collateral to be acceptable—including agricultural and raw land loans (see Table 2)—precisely to deal with the occasional liquidity crunches in the banking sector. Even with these and other Fed facilities, Copeland, Martin, and Walker (2010) conclude that "...runs in the tri-party repo market may occur precipitously, like traditional bank runs, rather than manifest themselves

as large increases in margins".

These facts suggest that more conservative liquidity provisions may not be enough, and that more dynamic regulatory oversight is needed. Such oversight may, at the very least, require greater transparency from a broader set of financial institutions that provide liquidity, not just banks. In particular, broker/dealers, hedge funds, insurance companies, mutual funds, ETFs, and sovereign wealth funds are now inextricably involved in providing liquidity to the general public, hence their actions and reactions must be taken into account. In addition, if we wish to actively manage systemic risk more broadly in the financial sector— to the same degree that the Fed has managed systemic risk in the banking industry over the last century—we may have no choice but to place the shadow banking system under the Fed's purview, which may reduce liquidity and raise borrowing costs.

Greater transparency must also involve changes in accounting practices that better reflect realistic and timely market valuations, not optimistic assessments that may be influenced by business circumstances. As Jacob Goldfield (2010) recently observed, "market prices are almost always wrong, but they should never be ignored". While the Financial Accounting Standards Board (FASB) Rule 157, which calls for mark-to-market or "fair value" accounting, was a step in this direction, FASB eased these rules in April 2009 (see FASB, 2009) for situations involving thinly traded and disorderly markets in response to intense pressure from policymakers and industry groups.

GHK's second policy recommendation addresses these concerns by calling for time-varying macroprudential policies that adapt countercyclically to business and credit cycles, and for systemic surcharges to deal with the public goods nature of systemic stability. Both of these proposals attempt to remedy the growing mismatch between financial innovation and regulatory inertia, and involve a paradigm shift in regulatory oversight from static to dynamic policies. Of course, the successful implementation of such dynamic policies relies heavily on accurate and timely measures of systemic risk (both aggregate and firm-specific contributions) and economic conditions, but we do have the technology to realize these ambitious objectives today. The more relevant issue is whether or not we have the political will to implement such policies, and this remains to be seen.

GHK's third policy recommendation is for creating greater network transparency, and this should be a priority for every regulator, policymaker, and even for finance practitioners. The adage that "one cannot manage what one does not measure" is particularly relevant

Collateral Category[2]	Margins for Securities (% of market value or internal fair market value estimate)[3]			Margins for Loans (% of internal fair market value estimate)	
	Duration Buckets			Individually Deposited Loans[4,5]	Group Deposited Loans[4]
	0-5	>5-10	>10		
U.S. Treasuries & Fully Guaranteed Agencies					
Bill/Notes/Bonds/Inflation Indexed	99%	97%	96%		
Zero Coupon, STRIPs[6]	98%	96%	92%		
FDIC Temporary Liquidity Guarantee Program & NCUA Temporary Corporate Credit Union Liquidity Guarantee Program					
Bills/Notes/Bonds - U.S. Dollar Denominated	98%	96%	95%		
Bills/Notes/Bonds - Foreign Denominated[7]	92%	90%	89%		
Zero Coupon - U.S. Dollar Denominated	97%	95%	91%		
Government Sponsored Enterprises					
Bills/Notes/Bonds	98%	96%	95%		
Zero Coupon	97%	95%	91%		
Foreign Government Agencies					
U.S. Dollar Denominated	98%	96%	93%		
AAA rated - Foreign Denominated[7]	92%	90%	87%		
Foreign Government, Foreign Government Guaranteed, and Brady Bonds					
AAA rated - U.S. Dollar Denominated	98%	96%	95%		
BBB-AA rated - U.S. Dollar Denominated	97%	95%	94%		
Foreign Denominated[7]	92%	90%	89%		
Supranationals					
Bills/Notes/Bonds - U.S. Dollar Denominated	98%	96%	95%		
Bills/Notes/Bonds - AAA rated - Foreign Denominated[7]	92%	90%	89%		
Zero Coupon	97%	95%	91%		
Corporate Bonds					
AAA rated - U.S. Dollar Denominated	97%	95%	94%		
BBB-AA rated - U.S. Dollar Denominated	95%	93%	92%		
AAA rated - Foreign Denominated[7]	91%	89%	88%		
Covered Bonds					
AAA rated - U.S. Issued	97%	95%	94%		
BBB-AA rated - U.S. Issued	95%	93%	92%		
German Jumbo Pfandbriefe					
AAA rated - U.S. Dollar Denominated	98%	96%	95%		
AAA rated - Foreign Denominated[7]	92%	90%	89%		
Municipal Bonds					
U.S. Dollar Denominated	98%	96%	95%		
AAA rated - Foreign Denominated[7]	92%	90%	89%		
Asset Backed Securities					
AAA rated	98%	95%	83%		
BBB-AA rated	89%	86%	82%		
Collateralized Debt Obligations - AAA rated	92%	91%	90%		
Commercial Mortgage Backed Securities - AAA rated	97%	93%	92%		
Agency Backed Mortgages[8]					
Pass Throughs	98%	96%	95%		
CMOs	98%	96%	90%		
Private Label CMOs - AAA rated	90%	84%	83%		
Trust Preferred Securities	93%	92%	91%		
Term Deposit Facility - Term Deposits	100%				
Certificates of Deposit, Bankers' Acceptances, Commercial Paper, Asset Backed Commercial Paper	97%				
GSE Stock		65%			
Agricultural Loans					
Minimal Risk Rated[9]				91% to 96%	91%
Normal Risk Rated[10]				67% to 95%	67%
Commercial Loans & Leases					
Minimal Risk Rated[9]				87% to 96%	87%
Normal Risk Rated[10]				63% to 95%	63%
US Agency Guaranteed Loans				96%	96%
Commercial Real Estate Loans					
Minimal Risk Rated[9]				78% to 96%	78%
Normal Risk Rated[10]				57% to 95%	57%
Construction Loans					
Minimal Risk Rated[9]				71% to 96%	71%
Normal Risk Rated[10]				63% to 94%	63%
Raw Land Loans					
Minimal Risk Rated[9]				54% to 96%	54%
Normal Risk Rated[10]				44% to 94%	44%
1-4 Family Mortgage Loans (first lien)				78% to 96%	76%
1-4 Family Mortgage Loans (second lien, home equity)				77% to 95%	72%
Private Banking Loans				90% to 96%	90%
Consumer Loans - Unsecured				60% to 96%	60%
Consumer Loans & Leases (auto, boat, etc.)				76% to 96%	76%
Consumer Loans - Credit Card Receivables					59%
Consumer Loans - Subprime Credit Card Receivables					54%
Student Loans					83%

Notes:

1. The document is for informational purposes only and is subject to change without notice. This margins schedule is not binding on the Federal Reserve System in any particular transaction.

2. Obligations of the pledging depository institution are not eligible collateral.

3. Eligible securities for which a third party price is not available are assigned an internally modeled value. The margin for the >10 duration bucket is applied to such securities.

4. Individually deposited loans are loans pledged to the Federal Reserve Banks via the Automated Loan Deposit system. Loans pledged through other means are classified as group deposited loans.

5. The margin applied to individually deposited loans is determined by the maturity and coupon of the loan.

6. Includes structured Guaranteed Notes issued by FDIC or NCUA which do not accrue interest at a stated rate and do not make any payments prior to maturity.

7. Eligible foreign currencies are Japanese Yen, Euro, Australian Dollars, Canadian Dollars, British Pounds, Danish Krone, Swiss Francs, and Swedish Krona.

8. Includes structured Guaranteed Notes issued by FDIC or NCUA which may be backed by loans, RMBS, CMBS, or ABS.

9. "Minimal Risk" is equivalent to investment grade.

10. "Normal Risk" is equivalent to below investment grade while remaining a "pass credit" from a regulatory standpoint.

Table 2: U.S. Federal Reserve Bank discount window and payment system risk collateral margins as of June 5, 2011. U.S. Federal Reserve Bank.

with respect to the financial system, and a network map is the starting point. While the wisdom of recommendation is obvious, there is an important and as-yet-unresolved issue of data privacy that must be considered. In some cases, knowledge of network exposures can yield significant strategic business advantages, hence such information must either be encrypted or otherwise protected so as to maintain confidentiality while providing regulators with sufficient transparency to fulfill their responsibilities. This is an area where the newly formed U.S. Office of Financial Research (OFR), and recent technological advances in data storage, archiving, encryption, and secure computation may be able to make great strides.

GHK's final policy recommendation is for more netting and centralized clearing of counterparty exposures, especially with respect to derivatives transactions. This proposal is also eminently sensible, and can greatly increase the risk-bearing capacity of the financial system as we have witnessed in the past with a number of over-the-counter (OTC) markets that have moved to standardized contracts and organized exchanges, e.g., common stock options pre- and post-1973, and S&P 500 forward vs. futures contracts pre- and post-1982. However, we should also acknowledge the importance of customized financial contracts in allowing individuals and institutions to achieve their desired risk/reward profiles, in which case centralized clearing may not be ideal for those markets and counterparties. While standardized contracts, daily settlement, and a centralized clearing corporation may be perfectly reasonable for the credit default swaps market, it would significantly reduce the benefits of the interest-rate and foreign-currency swaps markets to current participants.

In such cases, even if centralized clearing is not feasible, Shimko's (2010, p. 46) innovative proposal for centralized collateral may be a good alternative:

> Centralized collateral requires all counterparties to be bound by rules for collateral dispute resolution and to use a centralized authority only for the purpose of monitoring collateral and reassigning ownership of the collateral based on changes in market valuations. Actual collateral is held by each counterpartys respective custody agent. This allows all trades to be eligible for centralized collateral reassignment without the need to centralize all clearing functions. In particular, no centralized price discovery is needed. There is also no need to register every trade, and indeed, a registry of complex trades serves no public good if no one outside the counterparties involved knows how to value them.

This proposal addresses one of the primary drivers of recent liquidity crises: valuation un-

certainty regarding collateral that was considered liquid at one point, but which became illiquid during periods of market distress. By agreeing in advance to objective valuation methods that apply even during market dislocations, and legal resolution procedures in case of default, a large amount uncertainty surrounding GHK's liquidity condition (1) may be eliminated.

To GHK's four recommendations, I would add a fifth, which is to create an investigatory body to conduct forensic examinations of financial disasters that parallels the U.S. National Transportation Safety Board (NTSB), the organization responsible for sifting through the wreckage of airplane crashes, collecting the black boxes, performing conclusive studies of each accident, and making safety recommendations (see Fielding, Lo, and Yang, 2011 for a more detailed discussion of this proposal). Without an ongoing feedback loop that enables us to learn from our mistakes, it is virtually guaranteed that crises will continue to occur. The OFR may eventually take on this critical role, and the sooner the better.

7   Conclusion

Gai, Haldane, and Kapadia have provided a great public service by raising our collective awareness to the dynamics of the global financial network. Their insightful analysis is not only elegant from an analytical perspective, but it clearly has a number of practical implications for regulators, policymakers, and practitioners. It is particularly encouraging that all three authors are affiliated with the Bank of England (with Mr. Haldane playing a central role as Executive Director for Financial Stability) which has quickly established a leadership position among government agencies in the international community in responding productively and proactively to the Financial Crisis of 2007–2008. While the standard disclaimer appears on the title page of their article, we can only hope that the Bank of England and other stakeholders do come to share the very thoughtful views of these three authors.

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