FEEDBACK MECHANISMS IN THE FINANCIAL SYSTEM: A MODERN VIEW

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Abstract

There is significant empirical evidence of dynamic feedback effects in financial crises. Evidence shows that financial system has a number of elements with procyclical response to various shocks. Under shocks, these elements can initiate a dynamic sequence from being shock absorbers into shock amplifiers. The purpose of this study is to conduct an integrative review of the feedback mechanisms that have been developed to theoretically explain financial system dynamics. Ability to understand various theoretical feedbacks consistently and comprehensively facilitates policy actions to prevent undesirable amplifications. Accordingly, this paper systematically reviews precedent concepts of amplifications and feedbacks. This study proceeds from definitions, then explains the view of positive and negative feedbacks in the financial system, and proposes a typology for organization of systemic feedbacks identified in theoretical literature. The proposed typology incorporates key aspects of a modern financial system and key intermediary functions of financial institutions: transformation of assets and liabilities, credit, and liquidity. In addition to the traditional delegated monitoring intermediary functions, the feedbacks also include key features of modern financial intermediaries: loan sales and off-balance sheet activities, including commitments, securitizations, and derivatives.

"FEEDBACK: It is the fundamental principle that underlies all self-regulating systems, not only machines but also the processes of life… (Arnold Tustin, Scientific American, Sept. 1953)

Introduction

The recent financial crisis of 2007-2010 provided many examples of significantly destabilizing dynamic processes affecting the behavior of the financial system. In particular, the most recent crisis was characterized by accelerated reactions and spillovers between different financial markets and the macro economy. This has been pointed out by many observers. As the financial crisis was gaining momentum in late 2007, Borio (2007, p. 10) noted that financial system has a number of "natural procyclical elements" that turn it 'from being a shock absorber… into a shock amplifier"[1]. In the crisis post-mortem, a number of authors study the destabilizing patterns of market dynamics empirically. For example, Gai and Kapadia (2010) consider how financial system interdependencies have created an environment in which feedback elements create amplified responses to shocks to the financial system. The 2009 Geneva Report on the World Economy provides evidence of the role plaid by certain amplifying spirals in the propagation of the crisis. Its authors Brunnermeier, Crocket, Goodhart, Hellwig, Persaud, and Shin state: "We believe that it is this internal, self-amplifying dynamic that has lain at the root of both the recent, and virtually all prior, financial crises."[2]

The relative dearth of theoretical models that comprehensively consider these dynamic effects is all the more striking. In its December 2010 issue of the "Financial Stability Review", The European Central Bank considered the deficits of existing models and concluded that that up to now dynamics in financial systems have not adequately assessed in risk models as a driver of crises and that "very significant further research efforts are needed"[3].

Recent series of deep disturbances to the global financial system highlight the need for a systemic feedback theory. The urgency of the study of systemic feedbacks is supported by two polar observations: first, feedbacks can amplify crises, and, second, feedbacks can counteract crises.

The objective of this paper is to explore literature on various theoretical systemic feedback mechanisms and to provide a direction toward a unifying theoretical framework of systemic feedbacks within financial systems. This review will contribute three main results: first, establish a consistent approach that allows subsequent integration of theoretical economic feedback models, second, contribute elements of structural typology of systemic feedback that improve analytical identification and monitoring of feedback outcomes, third, establish principles for a comprehensive framework of systemic feedbacks that can be used in subsequent economic policy research.

The rest of this paper is organized as follows. Section 2 discusses the concepts and definition of systemic feedbacks in literature. It provides a broad review of propagation mechanisms, following established patterns of mechanism

[1] "To be sure, given the presence of positive feedback mechanisms, the financial system has a number of natural procyclical elements. This is part of its physiology. Excessive procyclicality refers to the pathological manifestation of the same processes. It refers, that is, to those episodes in which, given the limitations in risk perceptions and incentives, the processes go too far, sowing the seeds of subsequent financial instability with *potentially serious macroeconomic costs*. From being a shock absorber, the financial system turns into a shock amplifier."

[2] Brunnermeier, et. al (2009, p.5)

[3] ECB (2010 b, p. 138)

classification, and then suggests an alternative typological approach. Section 3 concludes by summarizing principles for building a comprehensive framework of systemic feedback for economic policy objectives.

Concepts of systemic financial feedbacks in economic literature

A review of the theoretical literature on systemic feedbacks in financial systems reveals diversity of terms used for the same underlying economic concept. The existence of various terms for systemic feedbacks in literature further complicates the task of establishing a comprehensive and unifying framework for their analysis. Therefore, a logical place to start the literature review is to provide a survey of the definitional terms used in literature and to establish our definition.

We wish to focus on the fundamental processes by which an economic system acts to either increase or decrease a change to the input. Irving Fisher (1933) provides an early example of this in describing the concept of debt deflation: "when borrowers (firms) are highly leveraged, a small shock that affects their productivity or their net wealth can trigger a series of bankruptcies, which generate a decrease in investment, and this in demand for intermediate goods, as a consequence in prices. This aggravates the real indebtedness of the productive sector, which may provoke a further series of failures, with a cumulative effect."[4] Since Fisher's debt deflation, a number of related concepts have been identified to describe similar effects resulting from interactions among different sets of factors. These effects may include adverse selection, credit chains, liquidity spirals, information asymmetry, financial acceleration, and others. There are good reasons to uniquely identify these effects in terms of their unique economic mechanisms. However, doing so also tends to obscure some fundamental features that these different mechanisms may have in common. Thus, concurrent with the research to more fully detail the newly recognized patterns of interactions, economic research has also been very concerned with the complementary challenge of understanding their emergence and function from a more general and fundamental theoretical viewpoint.

It is useful to reference several of the important contributions in the pioneering stage of this strand of unifying research. Motivated by the "small shocks, large cycles" puzzle, in their 1996 seminal study Bernanke, Gertler, Gilchrist (1996) show that adverse shocks can propagate through economic systems with an amplifying effect, introducing the concepts of "*financial accelerator"* and *"financial propagation mechanism."* Other authors have proposed other unifying aspects of these mechanisms. In a study of agent behavior, Bikhchandani and Sharma (2001) point out that propagation of effects through economic systems frequently follows *"cascades"* and is characterized by *"positive feedback"*, stating that "behavior in cascades is fragile with respect to small shocks."[5] Borio, Furfine, Lowe (2001) emphasize that *"financial system's amplification mechanisms"* result in *"adverse feedback effects"* and are prone to *"contagion"* and *"procyclicality."* DeBandt and Hartmann (2002) generalize various *"propagation mechanisms"*, *"propagation chains"*, and *"contagion"* as manifestations of *"feedback effects".* The authors make a key connection of this concept to systemic risk: "At the heart of systemic risk are contagion effects, various forms of external effects. The concept also includes financial instabilities in response to aggregate shocks." They view the emergence of systemic risk through two elements: first, the shock disturbances, and second, the feedback mechanisms. The authors distinguish that the systemic feedback effects may emerge either through narrow or wide shocks. "The second key element in systemic events in the narrow sense is the mechanism through which shocks propagate from one financial institution or market to the other. In our view, this is the very core of the systemic risk concept."[6] In addition, they underscore that while transmission of shocks through an economic system tends to be naturally self-regulating, the feedback mechanisms can lead to conditions of systemic risk, characterized

[4] Freixas and Rochet (2008), p. 195

[5] p. 288

[6] DeBandt and Hartmann (2002), p. 43.

by violent and destabilizing non-linearities.[7] DeBandt and Hartmann conclude by urging additional research on systemic feedback mechanisms, "given the importance of systemic risk for the understanding of financial crises and for policies to ensure the stability of financial systems."[8]

The recent financial crisis clearly increased the urgency and sharpened the focus in this line of research. Thus, many important contributions are quite recent. Allen and Carletti (2008a) extend the general inquiry into *"propagation of shocks"*, *"transmission mechanism"*, *"contagion"*, and "*amplification effect*". They examine *"the implications for the role of the financial system as a shock absorber or amplifier"* — the question raised by Borio (2007) — and argue that the answer lies in the occurrence of market failure and specifically *"financial fragility, contagion and asset price bubbles"* as modes of market failure.[9] In the second edition of their study of the microeconomics of banking, Freixas and Rochet (2008) note recent "spectacular… development of academic research" in this area. While focusing on financial imperfections, the transmission of monetary policy, and the theoretical foundations of banking regulation, they also review key theoretical studies of *"feedback effects"* and *"propagation mechanisms."*

Often the concepts of feedback, contagion, amplification and procyclicality are applied in parallel (Gai and Kapadia 2010, Korinek 2009, Tirole 2009). Mostly feedbacks are referred to as processes leading subsequently from one state of systemic activity to another thereby spreading out from one element of the system to another (contagion). Accordingly, amplification gives some sense of the magnitude and speed of these dynamic processes – mostly in the sense of acceleration and magnification of already existing developments (procyclicality, Bijlsma et al. 2010, p. 39). Hence, whereas feedbacks can be related to the direction of dynamic effects and contagion to the series of elements involved, amplification and procyclicality reflect the intensity of these processes. While feedback, contagion, amplification and procyclicality therefore may point to different dimensions of a system's dynamic, they are often used in a similar way with amplification and procyclicality caused by feedbacks and contagion or feedbacks assumed to produce some increasing or decreasing effects via transmission across different elements.[10]

While definitions of feedbacks undergo some historical and interdisciplinary alterations, there are several common characteristics. First, feedbacks mostly reference an underlying system as the specific environment determining their origin, propagation and intensity. The system basically comprises its boundary (scope), the systems elements and their connectivity. While feedback has been applied to almost all forms of dynamic systems, the relevant environment for this study is the financial system shared by the macroeconomic environment on the one hand and the microeconomic environment on the other.

Second, feedbacks are conceived as a response to some excitation of the system affecting the system's level of activity. More specifically, the response may go back to the excitation itself (a procyclical effect) thereby altering the level of excitation with further effects for the system. Some feedbacks are thus incentivized by themselves and may reverberate due to own initial excitation (self-feeding process, Korinek 2009, p. 3).

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[7] Ibid: "However, from a conceptual point of view it is important that the transmission of shocks is a natural part of the self-stabilising adjustments of the market system to a new equilibrium. What one has in mind with the concept of systemic risk (in the narrow sense) are propagations that are not incorporated in market prices ex ante or can lead to general destabilisation. Such propagations, including those taking the form of externalities, may show particularly "violent" features, such as cumulative reinforcement ("non-linearities"), for example through abrupt changes in expectations"

[8] p. 37

[9] Allen and Carletti (2008, p. 3): "The key issue that determines whether the financial system is a shock absorber or amplifier is whether there is a market failure. Without a market failure, the financial system is a shock absorber. With a market failure, it is an amplifier."

[10] E.g. Geršl and Jakubik (2010, p. 2) refer to multi-round feedbacks as a „magnification of swings" and as a major driver for procyclicality. See as well Gai and Kapadia (2010), p. 3.

Third, and more generally, feedbacks are a driver of the system´s dynamic behavior. This includes impacts on the system's activity or equilibrium level where the variation may have a positive (amplifying, reinforcing) or negative (attenuating, balancing) consequence or may have a complex mixed dynamic from alternating accelerating and dampening effects. Similarly, feedbacks are conceived as multi-round effects, that is a series of incentives and responses. In recent literature this is described as spill-over, further-round, contagion, cascade or snowballing effect (Kapadia et al. 2010, p. 3).[11]

There is a growing realization among economists that the structure and the behavior are connected (May and Arinaminpathy 2010). This dependency on organizational and dynamic aspects can be summarized by referring to feedbacks as "systemic feedbacks" (Brunnermeier et al. 2010, Korinek 2009).

Role of feedbacks in financial crises

Several authors address feedbacks of liquidity and interbank effects. Esser and Mönch (2003) develop an amplifying feedback mechanism driven by formal elements and narrowing its economic application on the topic of stochastic liquidity feedbacks. Aikman et al. (2007, p. 7) studies interbank feedback in times of crisis, arguing that reducing credit lines and rising interest rates in times of crisis decrease the growth potential of the real economy, leading to adverse second round effects, such as higher default rates. This, in turn, may result in downgrades of financial intermediaries and reducing credit and liquidity extensions to the financial intermediaries in the interbank markets in further rounds.

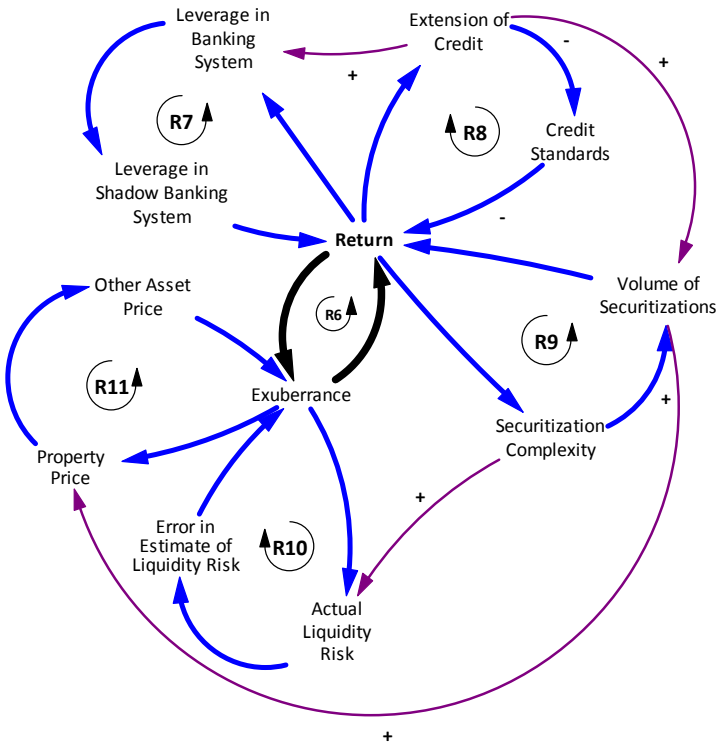
Amplification mechanisms during liquidity crises are modeled in Krishnamurthy (2008). Two amplification channels are looked at, the first one generated by some market shock and the subsequent need for liquidity. Since the sale of assets leads to declining prices and less cash flow from sales, further disinvestment is needed and a balance sheet amplification mechanism is generated. The second mechanism is induced by the dynamic effects of rising market opacity and demand for liquidity.

Sarkar and Shrader (2010, pp. 2-4) see the decreasing net worth of institutions and collaterizable value for secured funding (balance sheet mechanism) as explanatory for first round of crisis. Further rounds are then triggered by asymmetric information and concerns about default risk of banks (adverse selection mechanism).

A number of authors study interactions and construct combinations of individual feedbacks. Financial Services Authority (2009) suggested that a complex set of six interrelated feedbacks (see Figure 1) has been responsible for the transatlantic financial crisis: "Very low yields, both real and nominal, on risk-free government securities created the macro-economic background which, combined with financial innovation, produced six interrelated effects that ultimately proved unsustainable."

[11] The pattern aspect of dynamic response can be the source of qualitative assessment of systemic feedback models. See Barlas and Kanar (2000).

Figure 1 – Financial Services Authority (2009); Financial Risk Outlook 2009, London 2009, p. 6



Meh and Moran (2010) study interactions for banking feedbacks with monetary policy. They find that "moderate downturns associated with well-capitalized banks require less aggressive actions from monetary authorities." Krishnamurthy (2010) distinguishes two broad classes of feedback mechanisms: "balance sheet amplifiers (e.g., leverage, tight credit conditions, limited capital) and information amplifiers (e.g., opacity, complexity, and uncertainty)."[12] Gersl and Jakubik (2010, pp. 2-3) consider a wide range of interconnected factors such as "natural" factors (information asymmetry, over-optimism, herd behavior, fluctuations in balance-sheet quality, financial innovation) and "other" factors (regulation, accounting). Using this complex aggregation of feedbacks, they simulate effects for the Czech economy during the transatlantic financial crisis of 2007-2009. In their model declining asset values lead to decreases in bank equity. As credit standards rise due to bank defensive actions, credit extension decreases, resulting in a 1-2% reduction in the Czech GDP.

Gai and Kapadia (2010) model complex networks of direct (loss) and indirect (write downs) bank contagion and amplification effects. They use a balance sheet approach which models banks as holding illiquid external assets (A^M) and interbank assets (A^{IB}) as well as liabilities from other banks (L^{IB}). This makes the banks vulnerable to shocks from the default of other banks and from writing down the value of assets. The intensity of the shocks as they propagate within the system is based on the degree of incoming and outgoing links between banks, the extent of the shock and bank capital. The main result of modifying the degree of interbank links is that as the connectivity within the system goes up the frequency of contagion is reduced while the extent of contagion losses is increased ("robust-yet-fragile").

In a related study Kapadia et al. (2010) construct a direct connectivity cascade mechanism showing propagation of failure through interactions of bank funding, confidence, asset sales, bank failure, liquidity hoarding, and counterparty factors.

[12] Krishnamurthy (2009), p. 1

Feedback heterogeneity

In the context of economic-financial systems Kapadia et al. (2010) distinguish six attributes of a feedback. They are: intensity, direction, origin, and sensitivity (see Table 1).

Table 1 — Attributes of feedback heterogeneity (after Kapadia 2010)

Intensity	1) constant, increasing, decreasing
	2) linear, non-linear
	3) one-step, multiple (cumulative) steps
Direction	4) direct, indirect (with at least one element between departing and ending point of the process)
Origin	5) starting from the macro-economy or the financial system with an emphasis on the asset-side (banks´ lending behavior) or the liability-side (banks´ funding behavior)
Sensitivity	6) latent, active (depending from whether a critical threshold is attained or not)

It is useful to distinguish between feedbacks within the macro economy and the financial sector. In this context, the distinction between asset and liability side feedbacks is particularly relevant. Asset and liability side feedbacks refer to the direction of feedbacks seen from the financial intermediary's balance sheet. Aikman et al. (2009, p. 7) link asset-side feedbacks to the effects banks' lending behavior may have for the real economy. Reducing credits and rising interest rates in times of market distress reduce the potential of the real economy further and higher defaults may be a consequence in the second round. Liability-side effects focus on the effects the downgrading of banks (as a consequence of shocks) may have on funding costs and the acceptance of banks on the money markets. The multiple-step propagation of this mechanism clearly widens the envelope of the mechanism outcomes.

From a bank supervisor's point of view the above formal aspects of systemic feedbacks need to be supplemented by additional aspects that describe how systemic feedbacks work, in particular by the additional details of their origination and behavior sensitivity. As will be discussed below, the growing intersection between financial and real economic markets necessitates a broader approach to dampen feedbacks. In a series of papers, Robert May and colleagues discuss specific need for ex-ante policy by showing that systemic feedbacks originate from certain "*threshold breakpoints*"[13] via "*seemingly minor happenstances*."[14] Kiyotaki and Moore (1997a) also emphasize the aspect of duration of feedbacks with timely limited or extended impact[15]. Therefore, further attributes of feedbacks can be added that seem particularly relevant for supervisory policy:

Table 2 — Additional attributes of feedback heterogeneity

Duration	7) static (within 1 period), dynamic (intertemporal)
Direction	8) uni-directional, multi-directional (bifurcation)
Impact	9) positive (trend is increased), negative (trend is decreased)

[13] May and Arinaminpathy 2010, p. 823
[14] May et al. (2008), p. 893
[15] Kiyotaki and Moore (1997a), p. 213-214

Toward a topology of systemic feedback mechanisms

Table 3 shows a proposed typology for an investigation of systemic feedbacks. The differentiation of systemic feedbacks by classes, which serves as a starting point for this review, is based on revisions of typological precedents of Sarkar and Shrader (2010) and Bijlsma et al. (2010). Additional insight on suggested classes and subclasses of systemic feedbacks is based on literature dedicated to narrower thematic overviews of economic mechanisms. De Bandt and Hartmann (2002), Allen and Carletti (2008a), Allen /Babus /Carletti (2009), and Wagner (2010) are helpful for general understanding of the types of mechanisms associated with systemic risk and particularly for insight on the structural and interconnective mechanisms. Kuttner Ken N. / Mosser, Patricia C. (2002) review a taxonomy of the monetary transmission mechanism—discussed in this paper as an order of structural / regulation/ incentive regulation mechanism. Allen and Carletti (2008b) provide a review of literature on the fair value accounting mechanism—discussed in this paper as an order of structural / regulation/ structural regulation mechanism. Bernanke, Gertler, Gilchrist (1996) review literature on the financial accelerator mechanism—discussed in this paper as the balance sheet mechanism, which is in turn a subclass of interconnective / asset liability transformation mechanism. Tirole (2009) reviews liquidity transformation mechanisms—discussed in this paper as an order of structural / regulation/ structural regulation mechanism as a class of interconnective mechanisms. Borio, Furfine, Lowe (2001) is a general reference for several different types of procyclical systemic feedbacks as well as a source of insight on cognitive bias, a subclass of behavioral / uncertainty mechanism. Bikhchandani and Sharma (2001) provide overview herding (rational and irrational)—discussed in this paper as a subclass of behavioral / information mechanism.

Table 3 — A proposed typology of systemic feedbacks

Subsystem	Class	Subclass	Order
Structural	1 Composition	—Connectivity	Direct
			Indirect
		—Concentration	
		—Correlation	
	2 Regulation	—Incentive regulation	Monetary policy
			Financial liberalization
			Risk-based capital
		—Structural regulation	Fair-value accounting
			Fractional reserve
		—Ex-post crisis intervention	
Interconnective	3 Assets and Liabilities transformation	—Balance sheet	
		—Asset/Liability maturity mismatch	
	4 Credit transformation	—Credit chains	
	5 Liquidity transformation	—Fire sale	
		—Liq adverse selection	
		—Liquidity hoarding	
	6 FX transformation	—Exchange Rate	
Behavioral	7 Uncertainty	—Knightian	
		—Cognitive bias	
	8 Information	—Asymmetry	Ex-ante (adverse selection)
			Interim (moral hazard)
			Ex-post (costly state verification)
		—Spillovers	
		—Sensitivity	
		—Herding	Rational
			Irrational

A review of systemic feedback mechanisms

In this section we systematically review the systemic feedback mechanisms which we classify as structural in Table 3. We further divide them into two classes: composition feedbacks and regulation feedbacks. The feedback interactions are shown using the influence notation (see Box 1).

Box 1— Influence notation for systemic feedback mechanisms

The mechanisms are described by listing sequential interactions between interacting variables and using the following arrow notation.
↗is positive link defined as follows. "A positive link means that if the cause increases, the effect increases above what it would otherwise have been, and if the cause decreases, the effect decreases below what it would otherwise have been." (Sterman, 2000, p. 139)
↘is negative link defined as follows. "A negative link means that if the cause increases, the effect decreases below what it would otherwise have been, and if the cause decreases, the effect increases above what it would otherwise have been." (Sterman, 2000, p. 139)
⤤ is defined as delayed positive link.
⤥ is defined as delayed negative link.
A loop mechanism is net positive (procyclical or self-reinforcing) if it results from all positive influences or an even number of negative influences. Such mechanism is denoted R.
A loop mechanism is net negative (countercyclical or self-correcting) if it results from an odd number of negative influences. Such mechanism is denoted C.[16]

Structural feedbacks | Composition feedbacks

Structural feedbacks | Composition feedbacks | Connectivity feedbacks| Direct connectivity feedback mechanism

Direct connectivity feedback arises from "direct interdependencies ... from interbank on-balance and off-balance sheet exposures."[17] This mechanism is investigated by Freixas and Parigi (1998), Allen and Gale (2000), Freixas et al. (2000), and Dasgupta (2004). In this mechanism, the precise nature of the shared (interdependent) assets is secondary to the existence of direct connections between institutions. Bijlsma points out that "these direct contractual connections may be due to payment and settlement relationships, for example credit lines that facilitate the transfer of money from one bank to another through the large-value payment system. They can also result from the cross holding of deposits for clearance, regulatory or insurance reasons. Another source may be counter-party credit exposure on derivatives, or loans in the interbank market that allow banks to insure against liquidity shocks."[18]

The main interaction involves a double chain of interbank positive feedbacks triggered by a common factor:

$$\begin{matrix} Investor\ confidence \begin{cases} \nearrow Interbank\ Deposits \searrow \\ \searrow Probability\ of\ run\ on\ Bank\ i \nearrow \end{cases} \\ Liabilities\ of\ Debtor\ Bank\ i \ \searrow Probability\ of\ run\ on\ Bank\ i \end{matrix} \qquad \text{(R.DC.1)}$$

and

[16] Explanation of mathematics of loop polarity is found in Sterman (2000), pp. 145-146
[17] Bijlsma et.al (2010) , p.24
[18] Ibid.

$Liabilities\ of\ Debtor\ Bank\ i \nearrow Assets\ of\ Creditor\ Bank \nearrow Liabilities\ of\ Debtor\ Bank\ i$(R.DC.2)

It should be emphasized that direct connectivity mechanism propagates through the financial system by interweaving through symmetrical linkages of directly connected institutions, from liability side of one net borrower institution to the asset side of another net lender institution. Various authors model the direct connectivity mechanism using diverse originating shocks: Freixas (2000) applies a regional consumption shock, Allen and Gale (2000) apply a regional shock, and Dasgupta (2004) applies a shock to cross-held deposits. Clearly, the direct connectivity mechanism can be related to a series of other financial system feedbacks through its common factors, for example, investor confidence. The studies of direct connectivity also consider diverse types of direct connections. Freixas and Parigi (1998) "compare contagion in net and gross payment systems. In a net payment system, banks extend credit to each other and settle at the end of the day. In a gross payment system, banks settle transactions on a one-to-one basis with central bank money… Freixas et al. (2000) show how shocks can spread through the payment system."[19]

Structural feedbacks | Composition feedbacks | Connectivity feedbacks| Indirect connectivity feedback mechanism

By contrast with direct connectivity feedback mechanism, indirect mechanism can propagate on the same side of financial institutions: either asset side or liability side. There are distinct triggers on each side: shock to borrowers on the asset side, and shock to creditors on the liability side. In addition, the indirect connectivity mechanism can be seen as a general case of the direct connectivity mechanism, where the feedbacks originating on asset or liability sides can propagate across institutions sharing related exposures (e.g. via fair-value accounting mechanism). In the latter case, it is possible for asset side feedbacks to propagate to liability side feedbacks and vice versa. The mechanism has been studied by Kyle and Xiong (2001), Goldstein and Pauzner (2004), Leitner (2005), Allen et al. (2010), and Castiglionesi et al. (2010).

As Bijlsma (2010) points out, in addition to shared exposures the indirect interdependencies can arise "because banks endogenously choose to hold correlated portfolios."[20] Thus, the indirect connectivity mechanism described above can be considered independently. However, from policymaker's perspective, in order to assess "the policy consequences of interconnectedness,"[21] it is also important to consider the relationship of this mechanism to other interactions. Several studies of indirect connectivity pursue this objective. Allen et al. (2010) discuss connection of indirect connectivity mechanism with funding liquidity:

> *"The emergence of financial instruments in the form of credit default swaps and other credit derivative products, loan sales and collateralized loan obligations has improved the possibility for financial institutions to diversify risk. However, it has also led to more overlap and more similarities among their portfolios. This has increased the probability that the failure of one institution is likely to coincide with the failure of other similar institutions. Combining this with a greater reliance on wholesale short term finance has increased rollover risk for financial institutions. When a bank is in difficulty, investors may fear that other banks with similar portfolios will also be in trouble and hence may refuse to reinvest their funds. Financial markets can dry up and push all banks into difficulties."*

[19] Bijlsma et.al (2010) , p.26
[20] Bijlsma (2010, p. 26)
[21] Ibid.

A similar set of factors is also present in Castiglionesi et al. (2010) who "investigate how increased financial integration affects financial intermediaries' incentives to hold liquidity. Under integration, banks hold less liquid assets, an effect which is stronger if there is less aggregate uncertainty."[22]

$$\begin{array}{c} Financial\ Innovation\ \nearrow Risk\ transfer\ instruments\ \nearrow \\ Risk\ diversification\ \nearrow Financial\ integration\ \&\ asset\ overlap\ \nearrow \\ Portfolio\ similarity \begin{cases} \nearrow Probability\ of\ indirect\ contagion \\ \searrow Aggregate\ uncertainty \nearrow Hoarding\ of\ Liquid\ Assets \end{cases} \end{array} \quad \text{(ICI.A)}$$

$$\begin{cases} Funding\ Liqudity\ (wholesale\ short\ term) \nearrow \\ Investor\ confidence \searrow \end{cases} Rollover\ funding\ risk\ \searrow Funding\ liquidity\ \searrow$$
$$Probability\ of\ indirect\ contagion \searrow\ Investor\ confidence \quad \text{(IC.B)}$$

Using these extensions allows propagation of indirect connectivity mechanism to arise endogenously. In this extended indirect connectivity mechanism the positive feedbacks originate in Bank i, R.IC.1 and R.IC.2 involve shared borrowers and shared creditors respectively. Any of these Bank i feedbacks can propagate to Bank j via endogenous probability of indirect contagion. As shown, probability of indirect contagion is subject to an endogenous jump from the interaction of positive feedback R.IC.5 to the delayed negative feedback R.IC.6:

$$Probability\ of\ indirect\ contagion \searrow\ Investor\ confidence \searrow\ Rollover\ funding\ risk\ \searrow$$
$$Funding\ liquidity\ \searrow Probability\ of\ indirect\ contagion \quad \text{(R.IC.5)}$$
$$Funding\ liquidity \nearrow\ Rollover\ funding\ risk \searrow\ Funding\ liquidity \quad \text{(C.IC.5)}$$

Allen et al. (2010) also establish a connection to other network mechanisms, such as credit chains and netting arrangements. They "consider the systemic risk resulting from overlapping portfolio exposures and investigate when different network structures are stable. They show that there does not exists a monotonic relationship welfare and between interconnectedness."[23] One policy implication of Allen et al. 2010) is that regulators "should therefore be careful in drawing policy conclusions on the optimal level of interconnectedness or the type of interconnections."[24]

Structural feedbacks | Composition feedbacks | Concentration feedback mechanism

Concentration feedback mechanism emerges through industrial organization approach to banking that examines the accumulation of market power in financial intermediaries. This approach has evolved separately through seminal work of Monti (1972) and Klein (1971) who consider the determination of rates on banking products within structural settings confronting the banking firm. In particular, Monti-Klein model considers the relationship of "external economic and market structure variables"[25] and sets "forth a theory [of the banking firm" in a manner which specifically allows for the role of market structure and competition within the structural relations which the bank confronts."[26] These structural relations include "the external and competitive environment in which the bank operates, [which is,] in turn … largely determined by bank regulation."[27]

The equation outcomes of the original models for monopolistic competition are expressed as functions of elasticities of the banking products and costs and can be seen as adaptations "of the familiar equalities between Lerner indices (price minus cost divided by price) and inverse elasticities. The greater the market power of the bank on deposits

22 Ibid.
23 Bijlsman(2010), p. 27
24 Ibid.
25 Klein, (1971) p. 217
26 Klein (1971), p. 206
27 Ibid.

(resp. loans), the smaller the elasticity and the higher the Lerner index.. The intuitive result is that intermediation margins are higher when banks have a higher market power."[28]

$$Market\ Power \nearrow Intermediation\ Margins \nearrow Market\ Power \quad \text{(R.CF.1)}$$

This is clearly a self-reinforcing positive feedback mechanism. Freixas and Rochet point out that "an immediate consequence of this result is that intermediation margins will be adversely affected if substitutes to banking products appear on financial markets (e.g., when households have access to money market funds as substitutes for banking deposits, and when firms issue securities on financial markets as a substitute for bank loans)."[29] Thus, a balancing negative mechanism exists:

$$Banking\ Product\ Substitutes \searrow Market\ Power \nearrow Intermediation\ Margins \nearrow Market\ Power \quad \text{(C.CF.1)}$$

The Monti-Klein can be easily restated for oligopolistic competition. In a Cournot equilibrium of N banks, the profit maximizing rate are stated exactly as for monopolistic completion, except that the elasticities are multiplied by N. Thus, at the most fundamental level, existence of completion serves to balance the banking market power mechanism:

$$Intensity\ of\ Competition \searrow Market\ Power \nearrow Intermediation\ Margins \nearrow Market\ Power \quad \text{(C.CF.1')}$$

However, the dampening effect of this negative feedback mechanism has a different effect on the asset-side and liability-side of banking products. In this version of the model, as the intensity of competition increases, banking asset-side product sensitivity (resp. liability-side product sensitivity) becomes less (resp. more) sensitive to changes in the money market rate.[30]

$$Intensity\ of\ Competition \searrow FI\ Asset\ Sensitivity \nearrow Market\ Power \nearrow Intermediation\ Margins \nearrow Market\ Power \quad \text{(C.CF.1A)}$$

$$Intensity\ of\ Competition \nearrow FI\ Liability\ Sensitivity \searrow Market\ Power \nearrow Intermediation\ Margins \nearrow Market\ Power \quad \text{(C.CF.1B)}$$

This results in a more nuanced detailing of the negative feedback.[31]

Prisman et al. (1986) provide an important extension to the basic concentration feedback mechanism that connects it through intermediation margin to two additional positive feedbacks: first, through credit extension, state of economy and funding costs (R.CF.2) and second, through credit extension, financial intermediary size, total liquidity, and funding costs (R.CF.2A):

$$Intermediation\ Margin \nearrow Volume\ of\ Credit \nearrow State\ of\ economy \searrow Funding\ costs \searrow Intermediation\ Margins \quad \text{(R.CF.2)}$$

$$Intermediation\ Margin \nearrow Volume\ of\ Credit \nearrow Size\ of\ Banking\ System \nearrow Size\ of\ Banks \nearrow Total\ Liquidity \searrow Funding\ costs \searrow Intermediation\ Margins \quad \text{(R.CF.2A)}$$

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[28] Freixas, Rochet (2008), p. 79

[29] Ibid.

[30] Freixas, Rochet (2008), p. 80

[31] The concentration feedback mechanism emerging in the Monti-Klein model is well supported by empirical evidence. See Freixas, Rochet (2008), pp. 80-81 for a summary of empirical evidence.

The motivation for the extension is driven by an unsatisfactory assumption built-into the original Monti-Klein model. The original model assumes that pricing of asset side products is independent of pricing of the liability side products. This assumption has two main undesirable effects: first, it ignores liquidity risk contrary to the practical necessities of bank asset-liability management; second, it implies that deposit regulation would have no effect on credit markets.[32] The authors introduce liquidity risk into the Monti-Klein model, via "randomness into volume of funds collected or distributed by the bank."[33] The introduction of randomness into bank asset and liabilities provides a key to the interdependence between bank assets and liabilities and allows inclusion of uncertainty into the modeling framework.[34] In this model, banks are required to pay a penalty when liquidity shortage exists. The outcome equations of the Prisman, Slovin and Sushka model are identical to the Monti-Klein results, expressing equilibrium rates on banking products in terms of bank market power (Lerner index) and banking product elasticities, except that bank market power is modified by including the expected costs of liquidity shortfall.

The Prisman et al. extension has important implications for central banks, since the penalty for liquidity shortfall is set by regulatory discount window policies. The authors show that an increase in the penalty rate (discount window rate) leads to decreases in the volume of credit and increases in the volume of deposits, and that increase in the uncertainty of withdrawals tends to lead to decrease in the volume of credit.

$$Discount\ window\ rate \nearrow Intermediation\ Costs \searrow Intermediation\ Margins \begin{cases} \nearrow Volume\ of\ Credit \\ \searrow Volume\ of\ Deposits \end{cases} \quad \text{(R.CF.2)}$$

> *"Intuitively, the presence of [discount window rate] recourse acts as safety net for banks. At low penalty rates, this recourse sets a floor below the bank in an inexpensive manner should there be a deleterious realization of the disturbance (for example, an exceptionally high quantity of loans) so that it is rational for the bank to absorb the increased risk. On the other hand, if recourse is very expensive, then the bank will respond to greater uncertainty by reducing the loan rate and increasing the deposit rate. The same reasoning applies if the quantity of deposits is uncertain. Since the type and price of recourse is an important component of bank regulation, the results suggest that the response of banks to increased uncertainty in the lending (funding) environment depends on the stance taken by regulators in the pricing of recourse... In effect, recourse in the presence of low penalty rates, gives banks a mechanism that makes them well suited to dealing with uncertain loan demand."*[35]
>
> *"Furthermore, the development of markets in which banks obtain elastically supplied funds makes bank lending more aggressive. The growth of the federal funds market, the deregulation of deposit markets, and the advent of deposit rate setting by banks, lowers the point of marginal expected profit sought by a bank which implies lower loan rates (and increased expected lending). This results in more aggressive loan rate behavior by banks and an increase in the expected size of banks and the banking system."*[36]

[32] Freixas, Rochet (2008), pp. 275-277.
[33] Freixas, Rochet (2008), pp. 275
[34] Uncertainty is modeled as variance of deposit withdrawals.
[35] Prisman et al. (1986), p. 301
[36] Ibid.

$$Liquidity\ market\ (Elastic\ Funding\ Substitutes) \searrow Marginal\ expected\ profit \nearrow Loan\ rate \searrow Credit\ Extension \nearrow Size\ of\ Banking\ System \nearrow Size\ of\ Banks \nearrow Liquidity\ market$$ (R.CF.3A)

This is a positive feedback mechanism. A drop in liquidity leads to a death spiral shutdown of credit extension. Prisman et al. point that by extension, this feedback mechanism can also include deregulation:

$$Deregulation\ of\ deposit\ products \nearrow Innovations\ in\ deposit\ products \nearrow Total\ Funding\ Liquidity\ (Elastic\ Funding\ Substitutes) \searrow Funding\ Costs \nearrow Asset\ Margin \nearrow Credit\ Extension \nearrow Size\ of\ Banking\ System \nearrow Size\ of\ Banks \nearrow Total\ Liquidity$$ (R.CF.3B)

In a low penalty rate environment, the positive feedback serves to further induce risk taking behavior by those who already have access to the discount window: "…for the component of the banking system which is already aggressive, particularly the large money market banks, a low penalty rate is an inducement to become even more aggressive."[37]

> *"The model also implies that given the different perceptions of the penalty rate by these two general categories of banks, the effect of increased uncertainty in financial markets will also be different for each group. Banks who borrow frequently and perceive that the discount rate is low and that the Federal Reserve stands prepared to provide recourse at that rate, will become more aggressive in lending in response to increased uncertainty. In contrast, banks with the perception that the penalty rate is high will respond to increased uncertainty by becoming less aggressive."*[38]

Structural feedbacks | Composition feedbacks | Correlation feedback mechanism

Correlation among financial intermediaries is considered a prominent factor in many structural feedbacks models. This strand of literature includes studies of Acharya (2009), Acharya and Yorulmazer (2009), among others. In this paper, correlation feedback is discussed under its alternative treatment as a factor in a behavioral (herding) feedback mechanism.

Structural feedbacks | Regulatory feedbacks

The literature on reinforcing and balancing feedbacks in economics (aka procyclical and countercyclical effects) does not seem to dwell on the fundamental assumption that the "invisible hand" requires the basic overall mechanism to be balancing and how banking by all accounts tends to be procyclical[39]... Hence the need for supervision and regulation, and its introduction of the balancing mechanics into the financial system. Considering a class of regulatory feedback mechanisms, "an initial question people need to ask, however, is to what extent the procyclicality is inherent in the banking system and how much is caused by the regulations in place, such as deposit insurance and TBTF."[40]

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37 Prisman et al. (1986), p. 303

38 Ibid.

39 See, Gorton (2010) for a discussion of this relative to the banking panic of 2007. A nice passage on this is in Allen and Saunders (2003, p.3): *"Banking is a procyclical business. That is, banks tend to contract their lending activity when business turns down because of their concern about loan quality and repayment probability. This exacerbates the economic downturn as credit constrained businesses and individuals cut back on their real investment activity. In contrast, banks expand their lending activity during boom periods, thereby contributing to a possible overheating of the economy that may transform an economic expansion into an inflationary spiral…As stated by Andrew Crockett, the General Manager of the BIS, in a lecture on February 13, 2001: "[U]nderlying risk builds up as expansion and leverage continues, while apparent risk declines, with the rise in collateral values….[r]isks and imbalances have actually accumulated in the later stages of an upswing, only to materialise in the ensuing recession."*

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Structural feedbacks | Regulatory feedbacks | Incentive regulation | Risk-based capital

The studies of Allen and Saunders (2003), and Gordy and Howells (2004) address a basic reinforcing (procyclical) mechanism in banking that relates the state of economy, risk accumulation by financial intermediaries, and credit extension:

$$State\ of\ Economy \nearrow Credit\ Risk\ in\ FI \nearrow Credit\ Extension \nearrow State\ of\ Economy \quad \text{(R1.1)}$$

Allen and Saunders review this mechanism in theoretical and empirical studies and show that while many models of credit recognize the reinforcing loop between the state of the economy and the probability of default, few theoretical and empirical models also incorporate the cycle-dependent severity of credit losses, loss given default (LGD).

The introduction of capital regulations extends the pathway in this loop, but does not transform it:

$$State\ of\ Economy \nearrow Credit\ Risk\ in\ FI \nearrow \mathbf{Bank\ Capital} \nearrow Credit\ Extension \nearrow State\ of\ Economy \quad \text{(R1.2)}$$

It should be noted that Basel II capital regulations did not create the procyclicality in banking. The R1 mechanism is fundamental. To the policymakers, Basel II capital requirements offers specific pathways to counteract the procyclical effects, through three specific different intervention channels (Tiers I, II, and III of Basel II capital regulations). There are three naturally occurring pathways that create balancing (countercyclical) feedback loops C1 and C2 below.

$$FI\ Credit\ Risk \nearrow FI\ Risk\ Capital \swarrow FI\ Credit\ Risk \quad \text{(C1)}$$

$$Gap\ Below\ Min\ Capital\ Requirements \nearrow \mathbf{Sale\ of\ Assets} \nearrow FI\ Risk\ Capital \swarrow Gap\ Below\ Min\ Capital\ Requirements \quad \text{(C2)}$$

$$Gap\ Below\ Min\ Capital\ Requirements \nearrow \mathbf{Raise\ Capital} \nearrow FI\ Risk\ Capital \swarrow Gap\ Below\ Min\ Capital\ Requirements \quad \text{(C3)}$$

Note that the only difference between the C2 and C3 pathways are the endogenous responses of FI to counteract the capital shortfall: by selling assets (in C2) or by raising capital (in C3). In addition, the three endogenous balancing pathways are non-exclusive: a financial intermediary may choose to pursue all three at the same time or prioritize them in order of efficiency. Gordy and Howells (2004) explore the three different channels of counteracting the procyclicality afforded by Basel II (Tier I, Tier II, and Tier III). They detail and analyze the three regulatory options of changing the $GAP\ BELOW\ MIN\ CAPITAL\ REQUIREMENTS$ in a countercyclical manner.

Structural feedbacks | Regulatory feedbacks | Incentive regulation | Financial liberalization, universal banking, and TBTF

A large body of academic research exists on the subjects of feedback mechanisms linked to structural aspects of financial regulation, specifically, financial liberalization or deregulation, universal banking, and TBTF. Up to now, this

research has concentrated on economic history and has established a strong empirical link between regulation and systemic crises. The definitive recent studies of this topic include Calomiris (2000), Stern and Feldman (2004), and Wilmarth (2002, 2003, 2009).

Kemerrer (1910) states that between 1890 and 1908, there were 28 US banking panics. Miron (1986) finds that banking panics In the United States were seasonal prior to the creation of the Federal Reserve. Freixas and Rochet (2008) discuss that many financial crises worldwide have been in part initiated by a global movement toward financial deregulation as supported by a large number of empirical studies of the relationship between crises and regulation. Kaminsky and Reinhart (1999)[41] suggest that "crises may have common origins in the deregulation of the financial system and the boom-bust cycles and asset bubbles that, all too often, accompany financial liberalization." Caprio and Klingebiel (1996)[42] provide cross-country evidence of a natural lag between financial liberalization and adjustment of regulatory structure and supervisory practices, which may partially explain the link between deregulation and banking crises. Mishkin (1997)[43] emphasizes this point in discussing the US savings and loan crisis: "deregulation of a financial system and rapid credit growth can be disastrous if banking institutions and their regulators do not have sufficient expertise to keep risk taking in check." There are numerous empirical studies supporting this connection, for example McKinnon and Huw (1996), Sachs et al. (1996), and Weller (1999). In an extensive empirical review of US Bank deregulation, Calomiris (2000) finds that "the single most important factor in banking instability has been the organization of the banking industry."[44]

In addition to the lag between the financial deregulation and regulatory adjustments cited by many authors, another mechanism linking deregulation and systemic risk is risk diversification. Universal banking allows financial intermediaries to grow larger and more diverse, thereby benefiting from more efficient portfolio diversification to take larger risk. Post Glass–Steagall Act of 1993 and the Bank Holding Company Act of 1956 and prior to the financial deregulation of 1999, US financial intermediaries were not allowed to become universal banks. Examining US and German universal banking history during 1870-1914, Calomiris concludes that evidence "suggests that German industrial growth was helped, and American growth was hindered, by their respective financial systems."[45] Modern finance portfolio theory offers an intuitive explanation for this growth. From the viewpoint of an individual universal bank, a larger and more diverse bank is more insulated from the risk of failure and, thus, could be individually "safer." Paradoxically, as more institutions become larger and universally alike, once crisis sets in, contagion among institutions can be expected to persist longer and recovery can be expected to take more time. Empirical evidence is presented in Oet et al. (2011). The apparent safety of an individual large and diversified financial institution is also the source of moral hazard and an implicit too-big-to-fail (TBTF) subsidy. Critics of the Financial Modernization Act have argued that institution-specific benefit in portfolio diversification would be offset by increase in systemic risk accompanying the growth of universal banks. Reviewing studies of systemic risk in a post deregulation era, Wilmarth (2002) writes that "doubts about the claimed advantages of universal banks are buttressed by concerns that financial conglomeration will aggravate the problem of systemic risk in financial markets."

Prior to the Financial Services Modernization Act of 1999, FI size and complexity in the US interacted in a balanced way through the following negative feedback loop:

$$Size \nearrow FI\ Capital \searrow Efficiency \nearrow Size \qquad \text{(C6)}$$

While financial institutions could grow larger, they had limited capacity for risk diversification. In absence of universal banking, even large financial institutions had limited market power. As FIs become less efficient, they reach

41 p. 480
42 p. 24 and p.30
43 p. 28
44 p. 3
45 p. 265

a limit on the ability to grow. The introduction of universal banking in the US has allowed additional interaction among the variables of this negative C6 feedback loop, creating the following new positive feedback (R4):

$$FI\ size(complexity) \nearrow\ Leverage(risk\ taking) \nearrow\ Risk\ diversification \nearrow Shock\ resistance \nearrow\ FI\ Capital \nearrow Survival\ rate \nearrow\ Faith\ in\ liquidity \nearrow\ Implicit\ TBTF\ guaranty \searrow\ Financing\ premium\ in\ credit\ markets \searrow Creditors\ belief\ in\ minimal\ exposures \nearrow FI\ size(complexity) \quad \text{(R4)}$$

FDIC Chairman Sheila Bair described the R4 positive feedback as follows:

> *"The notion of too big to fail creates **a vicious circle** that needs to be broken. Large firms are able to raise huge amounts of debt and equity and are given access to the credit markets at favorable terms without consideration of the firms' risk profile. Investors and creditors believe their exposure is minimal since they also believe the government will not allow these firms to fail. The large firms leverage these funds and become even larger, which makes investors and creditors more complacent and more likely to extend credit and funds without fear of losses. In some respects, investors, creditors, and the firms themselves are making a bet that they are immune from the risks of failure and loss because they have become too big, believing that regulators will avoid taking action for fear of the repercussions on the broader market and economy."*[46]

The R4 feedback tells a story of big becoming bigger and small becoming smaller. On its own, this feedback is positive and self-reinforcing. The mechanism is inherently unstable: in the event of a large shock, the reversal in the feedback can lead to a systemic collapse of the TBTF. Several key elements of the mechanism are behavioral: faith in continued market liquidity and implicit TBTF guaranty.

From the standpoint of the R4 feedback mechanism, the intent of the Basel II capital regime can be viewed as the provision of a deterrent between size / complexity and risk taking through risk-based capital. Basel II attempts to establish a stabilizing negative feedback in the TBTF mechanism. The need for an additional strengthening of a stabilizing effect has been emphasized by the ineffectiveness of the nascent Basel II regime to avert the Panic of 2007. Basel III proposes a set of complementary liquidity ratios to create an additional negative feedback aimed to balance the incentives to take on more risk as FI institution size and complexity increase. The specific requirements are designed to penalize larger and more complex institutions with requirements to keep idle liquid reserves, thus physically reducing their capacity for competitively efficient risk taking.

Wilmarth (2002a) discusses regulatory attempts (Basel II) to create disincentives between FI growth and risk taking, arguing that these attempts are not adequate: "domestic and foreign regulators have responded to the growing risks of financial holding companies by attempting to improve the effectiveness of capital requirements, supervisory oversight and market discipline. However,…these regulatory initiatives will not adequately control the risk-taking incentives of financial conglomerates."[47]

Wilmarth states that Basel II regulations can be viewed as designed to result in negative feedback using three tiers of Base II regulations (Tier I – Capital Requirements, Tier II – Supervisory Oversight, and Tier III – Market Discipline):

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[46] Statement of Sheila C. Bair Chairman, Federal Deposit Insurance Corporation on Establishing a Framework for Systemic Risk Regulation before the Committee on Banking, Housing and Urban Affairs, U.S. Senate; Room 534, Dirksen Senate Office Building, July 23, 2009

[47] p. 6

$$Risk\ taking \nearrow \begin{cases} Tier\ I = Capital\ Reqs \\ Tier\ II = Supervisory\ Oversight \searrow Risk\ taking \\ Tier\ III = Market\ Discipline \end{cases} \quad \text{(C7)}$$

Presciently, Wilmarth (2002a) makes a case that each of the Basel II Tiers, will in fact, prove inadequate by resulting in unintended positive feedbacks. He discusses that the main driver for the unintended effects is the existence of the implicit TBTF guaranty. Wilmarth argues that given the existence of implicit TBTF guaranty, all three Basel II Tiers result in increased risk taking and positive feedback: Tier I Capital requirements lead to moral hazard, Tier II supervisory oversight in practice leads to supervisory forbearance, and Tier III market discipline functions as a herd mechanism.

$$\begin{cases} Risk\ taking \nearrow (R4) \nearrow Implicit\ TBTF\ Guaranty \nearrow \\ \quad Tier\ I = Capital\ Reqs \nearrow Moral\ Hazard \\ Tier\ II = Supervisory\ Oversight \nearrow Supervisory\ Forbearance \nearrow Risk\ taking \\ \quad Tier\ III = Market\ Discipline \swarrow Herd\ Mechanism \end{cases} \quad \text{(R7)}$$

Wilmarth further strengthens his argument by explaining the mechanism of the positive interaction tier-by-tier. For Tier I, the moral hazard involves increased incentives to game the capital requirements by shifting exposures off-balance sheet:

$$Tier\ I \nearrow Moral\ Hazard \nearrow Shift\ to\ OBS \nearrow Shadow\ FI\ Industry \nearrow Risk\ taking \quad \text{(R7.I)}$$

For Tier II, supervisory forbearance involves principle-based rather than rule-based regulations, leading to lack of precise enforcement rules and soft supervisory enforcement practices:

$$Tier\ II \nearrow soft\ supervisory\ practices\ and\ lack\ of\ precise\ enforcement\ rules \nearrow Risk\ taking \quad \text{(R7.II)}$$

For Tier III, market discipline negatively stems from the underlying herd mechanism which is in turn caused by procyclical momentum behavior:

$$Tier\ III \nearrow Momentum\ behavior \nearrow Herd\ mechanism \nearrow$$
$$Conflicts\ of\ Interests \searrow Market\ discipline \searrow Risk\ taking \quad \text{(R7.III)}$$

Wilmarth (2009) emphasizes this critique of market discipline as follows: "…observers have highlighted that market discipline is inherently **procyclical, because it is too lax during euphoric "bubbles" and too extreme during panic-induced "busts."** In addition, the effectiveness of market discipline is undermined by "self reinforcing herd and momentum effects," which cause market participants to follow the herd even when they have doubts about the wisdom of the course the herd is pursuing."[48]

$$State\ of\ Economy \nearrow Momentum\ behavior \nearrow Herd\ Mechanism \nearrow$$
$$Conflicts\ of\ Interests \searrow Market\ discipline \searrow$$
$$Risk\ taking \searrow Market\ constraints\ on\ growth \searrow State\ of\ Economy \quad \text{(R7.III)}$$

Wilmarth (2002a) describes the liberalization feedback mechanism, considering the historical developments that lead to the Financial Services Modernization Act and the transformation of C6 negative feedback loop to R4 positive feedback loop. Tracing the positive interaction between the pressure to consolidate and risk-diversification, Wilmarth identifies interim historical influences of financial industry lobbying and the U.S. liberalization laws (1980-1999):

[48] Wilmarth (2009, p. 1048)

$$Consolidation\ pressure \nearrow Fin\ Industry\ Lobbying \nearrow Liberalization\ Laws\ (1980-1999) \nearrow Risk\ Diversification$$

Wilmarth explains the liberalization mechanism as a positive feedback loop (R5) by further explaining the consolidation pressure in terms of financial innovation, financial services by non-regulated entities, and the FI profit margins:

$$Financial\ Innovation(new\ products) \nearrow Financial\ Services\ by\ nonregulated\ entities \searrow FI\ Profit\ margins \searrow Consolidation\ pressure(Risk\ Diversification)(Risk\ Taking\ Capacity) \nearrow Financial\ Innovation(new\ products) \quad (R5)$$

Wilmarth (2002a) discusses two long-term correcting mechanisms to the liberalization feedback, first a concentration-based negative feedback loop (C9), then a crisis negative feedback loop (C10) that balance the R5 financial liberalization positive feedback loop I:

$$Consolidation\ Pressure \nearrow Concentration \nearrow Market\ Power \nearrow Risk\ Taking\ Capacity \searrow Consolidation\ Pressure \quad (C9)$$

$$Risk\ Taking\ Capacity \nearrow Vulnerability\ to\ capital\ markets\ disruptions \nearrow \boldsymbol{Systemic\ Risk\ failure} \searrow Risk\ Taking\ Capacity \quad (C10)$$

The TBTF mechanism interacts with other financial system mechanisms in important ways. Specifically, it interacts with the Financial Accelerator and Government Intervention mechanisms, as follows: when a macro financial shock reduces total liquidity, FI increase liquidity hoarding, drying up the market liquidity supply. The reduced market liquidity supply is associated with concurrent fire sale mechanism and results in decreasing the value of TBTF off-balance sheet and on-balance sheet assets. This reduces the TBTF solvency and initiates direct contagion among TBTF institutions, which further reduces the available total liquidity.

$$Total\ Liquidity \searrow FI\ Liquidity\ Hoarding \searrow Market\ Liquidity\ Supply \nearrow Value\ of\ OBS\ Assets \nearrow FI\ Asset\ Values \nearrow FI\ solvency \nearrow TBTF\ contagion \nearrow Total\ Liquidity \quad (R5)$$

To counteract this, government can establish programs counteracting the positive interactions among the variables in the mechanism. For example, to counteract the Liquidity Hoarding Mechanism, Government can initiate a liquidity injection program, increasing the supply of total liquidity. To counteract the asset devaluation, government can initiate a troubled asset purchase program, simultaneously removing the devalued assets from the balance sheets of institutions (e.g. transferring them to the Central Bank balance sheet) and supplying liquidity to the TBTF institutions.[49]

To the extent that a latent C6 mechanism continues to exist, then in theory, the TBTF (R4) mechanism may prove to be self-balancing in the long run. To see why this is so, consider the shock resistance variable. Under the efficient market hypothesis, increased risk diversification leads to increased ability to withstand idiosyncratic shocks. However, as FIs grow to be TBTF organizations — large and complex universal financial conglomerates — their diversified exposures become increasingly alike. Thus, an idiosyncratic shock to an asset that is significantly shared

[49] A cynical view would note that in the absence of a release to the procyclical fair-value accounting mechanism, the Central Bank balance sheet would always be called up to be the dumping ground for the crash-and-burn high-flying assets of the TBTF institutions.

among this group threatens the entire group and the economy at large. Therefore, in the long run, the market participants will realize that once a certain market concentration is achieved (e.g. as institution's size and complexity reach a TBTF level), the FI shock resistance can no longer be considered to increase with size/complexity, but to decrease! This threshold can be related to the threshold at which return to scale changes size and becomes negative. Once this logic is formally incorporated into external ratings, the corresponding rating penalty can serve as an additional negative feedback mechanism.[50,51] Therefore, a reinforcement of the latent negative feedback C6 has to be among the regulatory options to balance the TBTF mechanism.

Considering the regulatory feedbacks involved in TBTF, financial liberalization, and the related Financial Accelerator and Liquidity Hoarding mechanisms, it is clear that they share a common set of factors. Wilmarth (2003) reviews evidence and studies whether "financial liberalization increases the likelihood of a systemic banking crisis." He identifies seven progressive stages linking financial liberation and systemic risk[52], as follows:

$$\begin{aligned}
&Stage\ 1: Financial\ Liberalization \nearrow FI\ Lending\ Powers\ and\ Investments \\
&\qquad \nearrow Competitive\ Pressures \nearrow \\
&Stage\ 2: Financial\ Innovation \nearrow State\ of\ Economy \nearrow Risk\ taking \nearrow Total\ Liquidity \\
&Stage\ 3: \nearrow FI\ Imbalance\ overshooting \nearrow \\
&Stage\ 4: Asset\ bust\ correction \searrow \\
&Stage\ 5: Market\ Value\ of\ Collateral\ Assets \nearrow Total\ Liquidity \nearrow State\ of\ Economy \nearrow \\
&Stage\ 6: Capacity\ to\ pay\ for\ debts \searrow FI\ Losses \searrow Investor\ Confidence \searrow Systemic\ risk \nearrow \\
&Stage\ 7: Government\ expenditure\ to\ recapitalize\ FI\ and\ protect\ depositors.
\end{aligned}$$

In addition to the previously discussed R4 and R5 feedbacks, the interaction involves two new positive feedbacks, R6 and R8, and an extended version of the long-run crisis-correcting negative feedback C10.

$$\begin{aligned}
&Total\ Liquidity \nearrow Capacity\ to\ pay\ debts \searrow FI\ losses \searrow Investor\ confidence \searrow Systemic\ Risk \\
&\qquad \searrow State\ of\ Economy \nearrow Risk\ Taking \nearrow Total\ Liquidity \qquad (R6) \\
&Financial\ innovation \nearrow State\ of\ economy \nearrow Risk\ taking \nearrow Financial\ innovation \qquad (R8) \\
&Total\ Liquidity \nearrow FI\ Imbalances \nearrow Asset\ bust \searrow FI\ Asset\ Values \nearrow FI\ solvency \\
&\nearrow Investor\ confidence \searrow Systemic\ Risk \searrow State\ of\ Economy \nearrow Risk\ Taking \nearrow Total\ Liquidity \quad (C10)
\end{aligned}$$

Structural feedbacks | Regulatory feedbacks | Structural regulation | Fair-value accounting

Fair-value accounting (FVA) is virtually identical to the fundamental R1 mechanism that emphasizes FI Asset Value rather than FI Credit Risk:

$$\begin{aligned}
&State\ of\ Economy \nearrow \boldsymbol{FVA\ Asset\ Value} \nearrow Bank\ Capital \\
&\qquad \nearrow Credit\ Extension \nearrow State\ of\ Economy \qquad (R1.3)
\end{aligned}$$

[50] The empirical evidence to-date indicates that up to now, TBTF institutions enjoyed rating benefits and funding premiums.

[51] This insight has an empirical precedent in the corporate history of the United States. Industrial conglomerates enjoyed a boom in the 1960s, e.g. ITT Corporation, Litton Industries, Gulf and Western Industries, Transamerica, etc. Their growth was reinforced by a comparative premium they enjoyed in their funding rates. When following an interest rate shock, investors realized that the conglomerate growth was no faster than that of the underlying companies, the "synergy" premium evaporated, resulting in a reversing sell-off of the conglomerate components.

[52] Wilmarth (2003, pp. 1-2)

The unique feature of this mechanism is that accelerates the interaction speed between $STATE\ OF\ ECONOMY$ and $BANK\ CAPITAL$. Whereas before the introduction of fair value accounting, the impact of an economic downturn affected Bank Capital only gradually, the new regulations transmit valuations shock virtually instantaneously[53]. $FVA\ ASSET\ VALUE$ introduces an additional acceleration via a time shortcut between the positive $STATE\ OF\ ECONOMY$ and $FVA\ ASSET\ VALUE$ interaction:

$$State\ of\ Economy \searrow Shock\ to\ fragile\ FI \nearrow Shocked\ FI\ Assets\ Fire\ Sale \searrow FVA\ Asset\ Value$$

(R1.4)

As the economy deteriorates, fragility in a single financial institution forces a fire sale of assets (the C3 balancing loop above). The fire sale prices affect asset valuations for all healthy institutions immediately, forcing them the write down the assets to market prices and affecting their capital immediately.

Several authors describe this dynamics and provide ideas for counteracting the fair value induced acceleration in R1. Panetta et al. (2009) link the fundamental interaction involved in the fair value accounting to Irving Fisher's (1933) debt deflation and the Financial Accelerator mechanisms.[54] Gorton, He and Huang (2006) provide a historical overview. Persaud (2008) describes the mechanism as follows: "when credit prices fell sharply… and assets were revalued using the new lower prices, it triggered a need for institutions to raise capital by selling assets, which pushed prices down further, causing more revaluations and more selling in a vicious circle."[55] Persaud further argues that "mark-to-market volatility added to this unstable dynamic by keeping new buyers away. Fair value accounting rules are pro-cyclical and can contribute to the systemic disappearance of liquidity."[56]

Allen and Carletti (2008b) review the arguments for and against fair value accounting. A number of critiques point out that the fair value accounting is inherently a positive feedback mechanism and that resulting procyclicality is destabilizing. The advocates of fair value accounting argue that the regulations allow for institutions to change the pricing in circumstances when market prices are no longer reflecting the security value, i.e. when markets cease to be efficient. Allen and Carletti (2008b) suggest several methods to counteract the procyclicality of fair value accounting. First, they suggest that "in financial crisis situations where liquidity is scarce and prices are low as a result, market prices should be supplemented with model-based valuations and historic cost valuations. The rest of the time and in particular when asset prices are low because expectations of future cash flows have fallen, mark-to-market accounting should instead be used."[57]

$$\text{State of Economy} \begin{cases} \nearrow \textbf{Total Liquidity} \\ \nearrow \textbf{Expectations of future cash flows} \end{cases}$$
$$\begin{cases} \searrow \text{Shock to fragile FI} \\ \nearrow \text{FVA Asset Value} \end{cases} \nearrow \text{Assets Fire Sale} \begin{cases} \searrow \text{FVA Asset Value} \\ \nearrow \textbf{HCA Asset Value} \end{cases} \qquad \text{(R1.5-C1.5)}$$

[53] Plantin et al. (2008b, p.88): "Mark-to-market accounting ensures that any price change shows up immediately on the balance sheet."

[54] Panetta et al. (2009, p.5): "The idea that the financial sector can amplify the business cycle (the concept of pro-cyclicality adopted here) dates back at least to Irving Fisher (1933). In this original view, however, financial factors have an asymmetric role: financial frictions limit the availability of external finance to firms and households, worsening downturns; however, they do not have a symmetric positive role during upturns. The modern financial accelerator (FA) theory removes this asymmetry. The FA works mainly through the value of collateral: a rise in asset prices makes it easier for households and firms to obtain loans, while a decline makes it more difficult. This mechanism is pro-cyclical because asset prices tend to be positively correlated with the business cycle, and because credit availability feeds back onto investment and consumption, and hence onto economic growth."

[55] Persaud (2008, p.75)

[56] Ibid.

[57] p. 1.

The above proposal suggests splitting the State of Economy pathway into two, based on additional state variables of $TOTAL\ LIQUIDITY$ and $LONG\ INTEREST\ RATES$ (expectations of future cash flows). The second branch exhibits positive feedback. The design objective of the first branch is to arrest the spread of fire-sale prices to healthy institutions' assets. Thus, when $TOTAL\ LIQUIDITY$ is low, healthy institutions are free to choose historical cost accounting (HCA) values, balancing out the feedback. The argument is logically flawed, however. This can be shown by tracing the feedback when $TOTAL\ LIQUIDITY$ is high. In this case, there is still a small probability of shock to some fragile FI (for example, the FI may be in trouble due to bad risk management). The resulting fire sale of the FI Assets will immediately impact FVA values of all healthy institutions, since the backstop condition of low $TOTAL\ LIQUIDITY$ is absent. This argumentation suggests that it is more correct to simply introduce the option to use HCA accounting in all circumstances, as follows:

$$State\ of\ Economy \searrow Shock\ to\ fragile\ FI \nearrow Shocked\ FI\ Assets\ Fire\ Sale \begin{cases} \searrow FVA\ Asset\ Value \\ \nearrow \boldsymbol{HCA\ Asset\ Value} \end{cases} \quad \text{(R1.6-C1.6)}$$

Second, Allen and Carletti (2008b) suggest that in times of crisis (when economy state variable is low) "regulators should probably practice a form of "forbearance" in that they should allow banks not to write down the value of their assets in order to avoid artificial volatility and its consequent solvency impairment. This would help to eliminate the procyclicality problem implied by fair value accounting as there would be no need for banks to raise further capital."[58]

This second idea seems to better describe the revised feedback R1.6. The trigger in this case is not a permanent FI option to use HCA values, but regulatory forbearance. However, this second proposal suffers from the same flaw as the first. Since regulatory forbearance option is not available in normal times, it is not available to arrest the initial massive shock that occurs when fire sale prices of one distressed institution contaminate the FVA values of healthy institutions. In this situation, the regulator would only be called to grant forbearance to the survivors of an economic tsunami. Thus far, it appears that only a permanent HCA option (R1.6-C1.6) is capable of stopping the spread of fire sale pricing to healthy institutions.

An enhanced version of the above (C1.6) basic balancing mechanism is developed in a series of papers by Plantin, Sapra and Shin (2008a, 2008b) who model and discuss the impact of fair value accounting and its alternative historical cost accounting. They find "that the damage done by marking to market is greatest when claims are (i) long—lived, (ii) illiquid, and (iii) senior. These are precisely the attributes of the key balance sheet items of banks and insurance companies."[59]They provide three main results:

> "1. For sufficiently short-lived assets, marking to market induces lower inefficiencies than historical cost accounting. The converse is true for sufficiently long-lived assets.
> 2. For sufficiently liquid assets, marking to market induces lower inefficiencies than historical cost accounting. The converse is true for sufficiently illiquid assets.
> 3. For sufficiently junior assets, marking to market induces lower inefficiencies than historical cost accounting. The converse is true for sufficiently senior assets."[60]

[58] p. 11
[59] Plantin et. al. (2008a, p.1)
[60] Ibid. p.5

Plantin, Sapra and Shin (2008b) provide a critical insight that that historical cost accounting counteracts the natural procyclicality of R1 by creating incentive to sell assets when prices rise (to realize capital gain), whereas fair value accounting further reinforces the positive feedback by inducing additional purchases as the price rises and inducing fire sale as the prices drop.[61] Thus, "strategic concerns create procyclical trades that destabilize prices in the mark-to-market regime while strategic concerns result in countercyclical trades that reduce fundamental volatility in the historical cost regime."[62]

Structural feedbacks | Regulatory feedbacks | Structural regulation | Fractional reserve system

A fractional reserve system mandates that depository institutions keep a fraction of their deposits as liquidity reserve against deposit withdrawal demands. Stability of the fractional reserve system requires either a net negative feedback or a combination of positive and negative feedbacks.

$$Demand\ Deposits \nearrow Fraction\ of\ Longterm\ Investments \nearrow Credit\ Extension \nearrow State\ of\ Economy \nearrow Demand\ Deposits \quad \text{(R2)}$$

Freixas and Rochet show that stability of this system is a self-fulfilling prophecy that depends on the beliefs of consumers. If the FI is believed to be safe, its safety is reinforced by patient consumers who do not feel compelled to withdraw.

$$Anticipated\ safety\ of\ bank \nearrow Patience\ of\ consumers \searrow Demand\ for\ Liquid\ reserves \searrow FI\ Solvency \nearrow Anticipated\ safety\ of\ bank \quad \text{(R3)}$$

As can be easily seen, both feedback mechanisms are positive. Thus, if the FI is believed by some consumers to be in trouble, the corresponding increase in withdrawals makes it optimal for all depositors to withdraw, further securing the realization of the believed weakness. "This type of crisis closely resembles bank runs because they occur as self-fulfilling prophecies."[63] The shock precipitating the increase in withdraws does not need be rational. It can be triggered by random factors, for example: anything from a rational change in consumer expectations to less substantiated fears, such as observations of bankruptcy at another bank. Von Thadden (1996) shows that in a fractional reserve system there is a limit on the provision of obtainable liquidity insurance.

Freixas and Rochet discuss several proposals to counteract the positive feedback in the fractional reserve system, including narrow banking, limiting convertibility at a preannounced deposit fraction, and deposit insurance. They show that a deposit insurance scheme is optimal. It is easy to confirm that deposit insurance works through a negative feedback loop:

$$Anticipated\ safety\ of\ bank \nearrow Patience\ of\ consumers \searrow Demand\ for\ Liquid\ reserves \searrow FI\ Solvency \searrow Deposit\ Insurance\ calls \nearrow Anticipated\ safety\ of\ bank \quad \text{(R3-C3)}$$

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61 Plantin et. al. (2008b, p.92): "From a system stability perspective, inducing actions that dampen financial cycles are to be desired. Although historical cost accounting has the limitation that recent prices are not taken into account, it does have the virtue that it induces actions that dampen the financial cycle. When the market price of an asset rises above the historical cost of the asset, the manager of the firm has the incentive to sell the asset, in order to realise the capital gain. In other words, when the price rises, the incentive is to sell. Contrast this with the amplifying response of a market-to-market regime. As we saw above, when balance sheets are marked-to-market, an increase in the price of assets leads to purchases of the asset. In other words, when the price rises, the incentive is to buy more. It is this amplifying response of marking-to-market that is at the heart of the debate."

62 Ibid. p. 89

63 Freixas, Rochet (2008, p. 221)

Conclusion

As amplifications and feedbacks reflect dynamics within a system, changes in the structure and processes within a system play a major role in their explanation. The financial crisis of 2008-2010 has demonstrated that most of systemic risk came from off-balance sheet and largely non-supervised facilities such as asset-backed securities vehicles. Effects on these conduits were magnified by high leverage ratios and high opaqueness due to missing accounting and supervisory information. Acceleration mechanisms were fueled as well from higher connectivity between financial institutions and the use of sensitive derivative instruments. As a summary, the denser network between institutions, the higher speed of information transmission, and the use of highly leveraged instruments together with lacking transparency impacted the new dynamics on financial markets. Models for amplifications and feedbacks have to take into account these aspects.

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