Payment and settlement systems: The case for mutualised risk mitigation within the Basel II framework

Received (in revised form): 1st July, 2008

Allan D. Grody
is a founding board member of the *Journal of Risk Management in Financial Institutions*, founding professor (retired) of New York University's graduate course in risk management systems, and founding partner (retired) of Coopers & Lybrand's financial services consulting practice. He began his business career in General Electric's finance business and later went on to hold increasingly responsible positions in investment management, the securities industry and international banking. He is President of Financial InterGroup Advisors and Financial InterGroup Holdings Ltd, and an advisory board member of ARC Best Practices Ltd.

Financial Intergroup, 169 East 69th Street —18th Floor, New York, NY 10021, USA
Tel: +1 917 414 3608; E-mail: agrody@financialintergroup.com

Abstract The recent stress in financial markets has called into question some fundamental infrastructure systems that are relied upon to mitigate systemic risk. The US Treasury Secretary and the President's Working Group on Financial Markets have called for a review of the regulation of payment and settlement systems that underpin the mitigation of the risk of intertwined financial firms interacting across the global capital, contract and dealer markets. This paper reports on the underlying components of this stress, the fundamental risk methodologies and data requirements that are flawed, and the possible remedies of further mutualised risk mitigation that regulators and financial institutions should consider.

Keywords: *risk management, operational risk, data management, payment and settlement, Basel II*

'Our current regulatory regime is almost solely focused above ground, at the tree level. The real threat to market stability is below ground, at the root level, where the health of financial firms is intertwined.' (US Treasury Secretary Henry M. Paulson, Jr)[1]

'... direct relationships among systems may facilitate a reduction in specific sources of operational risk by favoring the standardization, automation and integration of different payment and settlement processes. Such developments in the functioning of payment and settlement processes can reduce the complexity of payment and settlement operations and minimize the potential for human error. As a result, key sources of operational risk can be eliminated.' (Bank for International Settlements Committee on Payment and Settlement Systems)[2]

INTRODUCTION

Mutualised industry-wide risk mitigation through the sharing of

payment and settlement systems has long been a pillar of the global financial infrastructure. Payment and settlement systems are the mechanisms used to transfer funds and financial instruments between financial institutions and between financial institutions and their customers. Generally, the term is used to define a set of communications networks, information processing systems and computer facilities that are used by all financial institutions to confirm the financial obligations of counterparties conducting transactions in the capital, contract or currency markets and to permit payment for those obligations. They are generally organised as mutualised risk-sharing facilities owned by the largest financial institutions. The USA has various payment and settlement systems, some operating in real time and transacting large values, such as the Federal Reserve's wire transfer system; others operate in the retail payment space, such as debit and credit card networks; and still others operate as payment and settlement systems for securities and other financial instruments. On any business day, US payment and settlement systems settle transactions valued at over $13trn.[3]

What should be of great interest to those in the risk management profession is the vulnerability to systemic risk shared by all financial institutions using these payment and settlement systems. Here, whether in the failure of individual transactions, or in the inability of a member to meet its obligations to other members, or in systemic vulnerabilities like system-wide outages, Secretary Paulson has placed payment and settlement systems into the debate about the latest financial crisis. This is timely for two reasons, first because, as the Secretary has stated, 'the real threat to market stability is below ground, at the root level, where the health of financial firms is intertwined'.[1] Secondly, because the 'current regulatory regime is almost solely focused above ground, at the tree level',[1] leaving the major US payment and settlement systems generally not subject to any standards, nor any specifically designated regulatory system or governance structure.

INADEQUATE STRUCTURES AND VULNERABILITIES

Examples of the patchwork of overlapping and non-existent regulator oversight are apparent throughout the payment and settlement landscape. The Depository Trust Company, a securities settlement system, is a state-chartered, limited purpose trust company, and its affiliates, the National Securities Clearing Corporation and the Fixed Income Clearing Organisation, are clearing agencies registered with the Securities and Exchange Commission (SEC). Omgeo, a matching service, jointly owned by the Depository Trust and Clearing Corporation (DTCC) and the Thomson-Reuters Corporation, is organised as an SEC-exempted clearing corporation. The Continuous Linked Settlement Bank, a foreign-exchange settlement system, is a federally chartered Edge Act corporation, and SWIFT, a financial services messaging and network provider, has no specific financial regulatory charter or licence. The Options Clearing Corporation is also an SEC-chartered facility, but owned by the five SEC-regulated options exchanges. The clearing corporations of the Chicago Mercantile

Exchange and the Intercontinental Exchange are singularly owned by their exchange parents under charter by the Commodity Futures Trading Commission (CFTC). Other CFTC chartered futures and derivative clearing corporations such as the Clearing Corporation and LCH.Clearnet are separately organised entities owned by their members.

The vulnerability of the 'intertwined' financial system has been a subject of much debate in the context of modern automated financial markets, dating back to October 1987 when the US market infrastructure suffered its first structural collapse. Back then the stock, futures and options markets were convulsed by a cascade of sell orders prompted by a computer model that blindly adhered to its pre-programmed algorithms. The lesson learned then was that the equity markets were tightly intertwined with the options and futures markets — trouble in one quickly cascaded into the other. The lesson of today's credit crunch is the same — the models went awry, defaults began and the intertwined debt markets froze up as distress in one market cascaded into other segments.

A further vulnerability exists in the intertwined payment and settlement systems which have had their share of failures. In 1974, the Herstaat Bank failed shortly after the SWIFT inter-bank payment system went live, freezing payments and prompting the Bank for International Settlements to establish a working committee, known today as the Basel Committee, to study systemic risk;[4] the October 1987 market collapse froze funds in each of the separate stock, options and futures settlement systems, when normally such funds would be dispersed daily to member firms; the newly installed NYMEX futures clearing system failed and froze funds for a two-day period in the 1990s; on 11th September, 2001, the government securities settlement system collapsed as a result of the destruction of the Bank of New York's downtown New York facilities; and in 2005 the paper backlog of unsettled transactions in the rapidly growing over-the-counter (OTC) derivatives market nearly froze the collateralised debt and credit default swaps markets where there was no organised payment and settlement system. In recognition of this latter event, in March 2008 the President's Working Group (PWG) on Financial Markets called for an industry cooperative to design a standardised payment and settlement system for all OTC derivatives that would moderate complexity throughout the transaction life cycle and foster more accurate valuations of these financial instruments.[5]

A primary concern voiced in the most recent financial crisis, briefly commented upon at the recent Congressional hearings on the Federal Reserve's rescue of Bear Stearns, was about Bear's business of supporting an enormous network of counterparties. Bear made funds available for the purposes of paying and settling its clients' transactions. Here a failure of Bear Stearns as a member of most of these payment and settlement systems would have frozen funds for the company's own clients and for the other financial institution counterparties who, in turn, represented their own clients.

In discussing the financial crisis and the reasons for bailing out Bear Stearns, the regulators all voiced concern about the

financial markets collapsing.[6] Here they were alluding to the potential freezing up of funds in the world's payment and settlement systems. It was hardly noticed that, while choosing JP Morgan Chase (JPMC) for its vast capital reserves to rescue Bear Stearns, that JPMC was also a member of most of the world's payment and settlement systems and could step in rather seamlessly as the guarantor of Bear Stearns' payment and settlement obligations.

ADEQUACY OF CURRENT REGULATIONS

To address this most critical vulnerability, a federal charter for systemically important payment and settlement systems is being proposed, with the Federal Reserve recommended to have primary oversight responsibilities and authority to establish regulatory standards.[3] In Secretary Paulson's blueprint, he speculates that the ideal regulatory structure for payment and settlement systems may be quite different from that for other types of financial services providers.[3] This is because payment and settlement systems exist to provide services within short timeframes and with minimal financial risk to the funds and instruments transferred. Thus, risk-based capital standards, currently the focus of the Basel II capital regime, may not provide the same degree of protection for payment and settlement systems as for traditional financial institutions.

At its heart, Basel II sets a risk-adjusted capital standard for the risk faced by financial institutions. It also provides for capital reduction incentives for those financial enterprises that install a risk framework and risk culture that embeds systematic, enterprise-wide risk monitoring and control systems, thus helping to mitigate risk and prevent losses. Looking within the general structure of Basel's broad categorisation of risk, it would appear that the payment and settlement business line, now categorised exclusively under banking and, thus, suggesting monetary settlements exclusively, should be reviewed with a view to also being included as a loss event type under the asset management, trading and sales, retail brokerage and corporate finance business lines.[7] Doing so would assure that this business line categorisation would capture physical assets and contract settlements in addition to traditional money settlements such as foreign exchange, Federal Reserve wire transfers, SWIFT payments and credit/debit card settlements. Physical asset and contract settlements include futures, equities, derivatives, sovereign debt, corporate, municipal and provisional debt, and other such transactions where there is not only a cash payment and settlement, but additionally the clearance and settlement of the non-cash portion of the transaction.

BACKGROUND OF PAYMENT AND SETTLEMENT SYSTEMS

Financial transactions have traditionally been entered into through direct negotiation between principal parties and/or their agents. In the pre-industrial and, later, pre-information ages, these face-to-face negotiations would simultaneously result in the physical transfer of the traded goods. In later developments, the goods were transferred and paid for at a later stage beyond the agreement, wherein the principals or, more likely, their agents, would reference the original terms as

recorded on paper records and assure the finality of the transaction on that basis.

Historically, the failure or otherwise to identify the details of a financial transaction in order to finalise the purchase or sale of such items as a security, physical asset or a contract was left to the visual inspection of the underlying goods or security certificates, or the reading of the details of the contract. The expectations of the purchaser and seller or, more generally, their agents as to the value, terms and conditions of the agreed transaction would be communicated to each separately by the different parties to the original negotiation. When communicated and verified by visual inspection, the transaction was finalised or settled. If the details did not agree, it would be referred to as a failed transaction (a failed, busted, or out trade, or a DK — 'don't know' trade), and left, without payment, to be further investigated. Later, revised details would be conveyed to each party and a further attempt to settle the transaction undertaken.

Until the end of the 19th century, transactions of this nature were carried out bilaterally, that is, between two parties, first through barter transactions and then through representative collateral, such as bank notes, warehouse receipts, warrants, currencies, contracts and the like. In the USA, in the closing decade of the 19th century, the Minneapolis Grain Exchange formed the first payment and settlement 'clearing association', which permitted multi-party transactions first to be netted, then to be novated through means of a central counterparty. This payment and settlement mechanism was referred to as a 'clearing house'.[8]

Leading up to this innovation was the progress in creating transaction standards for the underlying collateral, in this case grain, such as size of contracts, grade of grain, delivery location and delivery date. Each party to a transaction would submit the details as to number of bushels, agreed price, date for delivery and with whom they transacted the agreement (the counterparty) to the clearing house. The clearing house would match the transaction to the other side, that is, the identical but mirror image of the transaction (the buyer's transaction details matched to the seller's details). When judged as matched, the clearing house would pool the transactions, netting the money owed to individual transactors and the net number of contracts each retained to fulfil, but in an obligation to the clearing house, no longer to each other. The original parties to the transaction would be separated from the fulfilment of the contract, with the clearing house now standing in their place. Thus, mutualised risk sharing became part of the financial transaction landscape, with each member standing up to guarantee the collective interests of all members and, in turn, all of their member's clients.

CURRENT ENVIRONMENT

To this day, this same process is carried out in most organised financial transaction markets, although in a much speedier and more automated manner. Here transactions are standardised; parties trade and agree on price and/or quantity and submit the transaction to a matching process, after which it is netted with obligations of net quantity and value determined between transactors and, where central counterparties exist, novated and settled. Where no formal

matching process is organised, two counterparties verify the details of the trade and await the fulfilment of same, such as when a ship container is unloaded and its contents verified by an agent against a shipping manifest. In this example and in other non-centralised financial markets such as trade finance, OTC derivatives or the reinsurance markets, standards in the form of standard bills of lading, International Swaps and Derivatives Association contract definitions and the like are prerequisites to an organised, smoothly functioning market.

Recognising the current financial crisis had been created by product failures in the OTC derivatives markets, the PWG is calling for an integrated payment and settlement infrastructure that electronically captures all significant processing events over the entire life cycle of a trade. The PWG is also calling for standardisation and interoperability of infrastructure components and enhancing participants' ability to manage counterparty risk through both netting and collateral agreements, and by promoting portfolio reconciliation and the accurate valuation of trades. The PWG further expects all major asset classes and product types to be included, encompassing both the buy side as well as the dealer community.

Heading this call, The Clearing Corporation (CCorp), formerly the clearing corporation servicing the Chicago Board of Trade, announced in May 2008 that it had signed an agreement with the DTCC that would facilitate central counterparty services for the OTC derivatives marketplace. This followed a corporate restructuring that resulted in CCorp's ownership by 17 major financial institutions. The reconstituted CCorp will initially become a centralised clearing facility for the credit default swaps market.[9]

Again in May 2008, the Governing Council of the European Central Bank issued a proposal to all European central securities depositories (CSDs) to join the TARGET2-Securities (TS2) initiative to settle the cash legs of securities transactions. The objective of the initiative is to maximise safety and efficiency in the settlement of euro-denominated securities transactions. The TS2 settlement system, as proposed, will not be a CSD, as it will not hold for beneficial interest security positions, nor will it deal with issuers or manage corporate events. Comparing TS2 with the US Fedwire securities system, which is a fully-fledged CSD, but only for a limited category of securities (mainly government securities), TS2 will be for all euro securities but only for the cash leg of the transaction.[10]

Central counterparties play a significant risk mitigation role in netting or novation systems, the dominant architectures of global payment and settlement systems. Here, the obligations between parties in the original transactions are separated from the parties they may be representing. As an illustration, Bank A, acting as agent on behalf of a client, buys 1,000 shares of a stock from Agent B at a price discovered on a stock exchange. Then, acting on behalf of a second client, Bank A sells 1,000 shares of the same stock to the same agent at a different price. In respect of the number of shares, the obligation to the parties in the original transaction in the payment and settlement system is netted to zero; however, the parties settle the difference of the value (price × shares in each

instance) with each other. Of course, Bank A must still receive the shares from his client, pay out the proceeds of the sale, deliver the shares to the other client and receive money from the purchase. These clients, in turn, may be acting on behalf of their clients, as in the case of an investment manager representing mutual funds or pension funds. These mutual funds and pension funds, in turn, have agents representing their interests in keeping the records of the changing inventory of securities and moneys.

Today's highly automated financial markets require the electronically represented components of the transaction, wherever in the transaction life cycle, to be verified by matching each side of the transaction to the other. Where there are mismatches on any of the critical data elements, the transaction is cycled back to its originators at the most immediate previous stage for correction and resubmission. Problems arise in that this method delays the transaction, causing unnecessary repair work and associated labour costs. When the transaction does not get repaired in sufficient time, it fails to settle. What then ensues is a loss of money to both original counterparties to the transaction. The seller has paid their client for the full value of the transaction when they have not themselves received any payment, and the purchaser must borrow and pay for the securities, then deposit the value into their client's account, while not having received the securities themselves from the seller.

SYSTEMIC RISK

A significant problem of systemic risk to the global financial industry has historically been embedded in the matching process as transactions entered into must await a period of time before they are finalised (while actual transfer of the electronic representation of the assets and payment takes place). This delay is a function of each financial institution independently sourcing from multiple vendors and public sources the referential data that comprise the data elements used in matching. Each side of a transaction, as represented for example by a unique product, business entity code or valuation price, or delivery address and account number, requires identical codes to match. Further, most payment and settlement system operators have their own proprietary coding requirements. A period of time is thus required to reconcile differences. This period varies depending upon the financial product traded, the region or country traded within, and the domicile of the counterparties that traverse different market closing time zones. This lack of timeliness has resulted in failures of financial institutions between the trade date and the settlement date, specific financial transactions that are unresolved at settlement date, and fraudulent trades. All financial transaction markets have a goal of shortening the settlement cycles with a vision towards simultaneous real-time trading, payment and settlement.

Today, through automated matching within these payment and settlement systems, when electronic details of a transaction do not match, costly exception processing routines are followed, some automated, many manual. Surveys have found that, in 30–45 per cent of the cases of failed transactions, the problem lies with faulty reference data.[11] The value of these mismatched transactions can be

estimated against the nearly $7.5trn in daily settlement value at risk in the USA in 2007 at the DTCC alone.[12] Globally, SWIFT estimated in 2002 that the work effort involved in repairing these mismatched transactions cost the industry $12bn annually.[13]

Similarly, product inventory adjustments within these systems (due to reorganisations such as mergers or tenders) and additional cash flows from dividends and interest payments on this inventory, are increasingly being automated. In each of these two categories, the DTCC in 2007 reported processing nearly $1.9trn of corporate action value.[12] Complicating these announced events is the voluntary nature of some of them, necessitating interactive communication with the beneficial inventory holder, before action can be effected. As these corporate directives are usually unstructured text published as a press release or regulatory filing, and then interpreted through independently sourced reference data intermediaries, financial enterprises occasionally receive erroneous adjustment information or payments that they then apply to their product inventory. In some instances such events are completely missed or go unreported.

The value of losses due to faulty corporate action data is reported by US firms to be 5–10 per cent of their operational costs for processing corporate actions.[14] In a study conducted for the DTCC in 2004, annual industry trading losses due to faulty corporate action data were estimated to be €1.5–8bn.[15] In the USA, the DTCC and sponsoring securities firms are leading an initiative to create at source (ie directly through the reporting corporations) corporate event announcement templates and standards for organising such data for direct entry to the SEC's EDGAR corporate filing system.

A WAY FORWARD

To date, mutualised risk sharing within payment and settlement systems has only been applied to the value portion of transactions (principally quantities, transaction prices and currency values). These same techniques, however, can be applied to the matching and settling of the reference data components of these transactions. While not value-bearing, reference data are at the heart of the intertwined payment and settlement system. Acquiring, maintaining and managing such data is costly, estimated at upwards of $1.25bn annually for each of the largest financial enterprises, with faulty data being at the core of significant components of operational losses.[16]

The importance of reference data can be understood by recognising that all financial transactions are represented as data in information systems. If the data are wrong, the transaction does not settle. The retail industry understood this issue a long time ago and standardised on universal barcode identifiers for products and electronic data interchange standards for communicating across suppliers, distributors and retailers. The financial payment and settlement infrastructure similarly has such identifiers for financial products; supply chain participants (counterparties, financial intermediaries, corporations, issuers, etc); financial markets and currency designations; valuation and market prices; and other referential information such as credit ratings and economic data used in valuation models.

However, financial industry reference data that should be standardised and identical across each organisation are not. These data are sourced independently, with each financial institution performing duplicative functions in an attempt to represent each unique product, business entity and valuation price identically, but failing to do so. The consequence is that proprietary and conflicting identification codes exist across the entire range of referential data, including such fundamental identifiers as symbols for corporate issuers, symbols used in contract markets, numbering conventions for securities, supply chain business entity identifiers and counterparty identifiers. To compound the problem, payment and settlement systems operators and even regulators maintain proprietary codes and duplicate sourcing and maintenance functions. Even dates and rates for corporate events and valuation prices for all manner of traded financial instruments are obtained and organised in this manner. Such reference data are represented as 70 per cent of the data content of financial transactions.[16] Thus, the effect on operating costs and operational risk in faulty data entering the payment and settlement systems is significant. In fact, those infrastructure institutions that operate payment and settlement systems have capital structures that are primarily supporting the risk of mismatched transactions caused by faulty data.

The majority of operational losses are due to transaction processing errors — the failure of people, systems and the data they act upon to operate seamlessly, from origination of the transaction through to payment and settlement.[17] This is sometimes referred to as straight-through-processing. These losses result from human error, from failure to follow existing procedures, or from inadequacies within the procedure when first established, such as wrong codes or identifiers. These losses are normally considered unintentional and correctable with proper business planning and controls.

The Basel Committee has stated that financial institutions will be allowed to reduce their capital allocations for operational risk by as much as 20 per cent through risk mitigation.[18] Currently, the primary risk mitigate used for operational risk is insurance. While not specifically making any reference to outsourcing, but certainly embracing it in concept, such 'risk mitigates other than insurance' can certainly be construed as an 'outsourced' or mutually owned payment and settlement system. The risk mitigating and captive insurance structures of such payment and settlement systems should make risk mitigates available for capital relief under the relevant Basel II criteria. One such entity, the Global Joint Venture Matching Service, now known as Omgeo, was approved by the SEC in 2001 as an exempt clearing corporation to mitigate post-trade risk in the matching and settlement of institutional securities. A similar exempt status could be obtained for an entity formed to match and settle a set of standardised reference data for universal use in the pre-trade data assembly process, the valuation and price assembly process, and in assembling data for corporate event activities. If such an entity were organised in collaboration with large financial institutions (say, similar in governance to most other such industry-wide risk mitigating infrastructure

entities) then it would be a useful vehicle to minimise operational risk for all who subscribe to its standardised data. This would include mitigating the risk of incorrect portfolio valuations, failed transactions, incorrect inventory adjustments, and erroneous dividend and interest payments.

In the OTC derivatives markets, a mutualised risk mitigating facility as proposed by the PWG and supported under Secretary Paulson's blueprint for payment and settlement systems would be a welcome addition to reducing the risk at the root of intertwined financial institutions.[5] Acting as the central counterparty for an integrated operational infrastructure, it could support the seamless payment and settlement of OTC derivatives contracts through promoting the standardisation of data and the interoperability of infrastructure components. Presumably, it could evolve from the proposed centralised clearing facility for the credit default swaps market discussed previously. Such activities would enhance participants' ability to manage counterparty risk through accepted netting, collateral and novation techniques, promote the near real-time reconciliation of portfolios and accurately value trades.

CONCLUSION

By any standard, the costs and operational risk consequences of faulty data and non-standardised payment and settlement systems are significant. Failed transactions and reporting processes need to be either manually reprocessed and/or reported into spreadsheets where they can be controlled, investigated, repaired and then reprocessed. Additional verifications and reconciliations are introduced to control the multiple data sources that have to be created in manual workarounds and spreadsheets outside their respective automated payment and settlement processing systems. In this way these systems lose their capability for straight-through processing.

While faulty data have been a persistent impediment to systemic risk mitigation across the global capital and investment markets, the consequences are not yet fully appreciated in fulfilling the new Basel II requirements for identifying causal factors in operational loss events. Risk managers should now be focusing on the importance of data as they ponder the underlying dynamics of operational loss events and the systemic risk exposures that exist in payment and settlement systems.

Regulators, practitioners and other thought leaders would be well advised to focus on the last leg in Basel II's mandate, that of operational risk, in its entirety. Faulty data and their consequence in payment and settlement systems is but one of many areas of risk that financial institutions are exposed to from the consequences of non-standardised and faulty data. In fact, Basel II classifies operational loss events as resulting from internal fraud, external fraud, employment practices and workplace safety, clients/products/business practices, damage to physical assets, business interruption and systems failures, and execution/delivery/process management. Here, many recent events can be attributed in part, if not in total, to data problems within these proscribed loss events. Citibank reported, for example, that its market value-at-risk number does not include CDO positions because they are hard to value in the

absence of prices or model inputs;[19] Credit Suisse took a $2.8bn write-down for valuation-model pricing errors and use of stale prices;[20] Société Générale reported a $4.9bn loss from trader fraud where improper counterparty codes were used and no systematic ability existed to look across proprietary systems position data and external exchange position data;[21] and Bear Stearns nearly collapsed because it could not price its mortgage portfolios, among other things.

Solving this longstanding industry-wide problem and thereby realising the objectives of reduced systemic risk within a centrally regulated seamless real-time payment and settlement system would be a just reward for the financial institutions which embrace more mutualised risk mitigation solutions within the framework of Basel II. In response, regulators may be willing to revisit Basel's current limit of a maximum reduction of 20 per cent of the total operational capital charge in the measures of operational risk.

References

1 Paulson, Jr, H. M. (2008) Remarks on the 'Blueprint for Regulatory Reform', 31st March, US Treasury Press Release hp-897, available at: http://www.ustreas.gov/press/releases/hp897.htm (accessed 2nd August, 2008).

2 Bank for International Settlements, Committee on Payment and Settlement Systems (2008) 'The interdependencies of payment and settlement systems', CPSS Publications No. 84, Basel, BIS.

3 US Department of the Treasury (2008) 'Blueprint for a Modernized Financial Regulatory Structure', available at: http://www.treas.gov/press/releases/reports/Blueprint.pdf (accessed 2nd August, 2008).

4 Bradley, C. M. (2008) 'Consumers of financial services and multi-level regulation in the European Union', *Fordham International Law Journal*, Vol. 31, p. 703, available at: http://ssrn.com/abstract=1132366 (accessed 2nd August, 2008).

5 President's Working Group on Financial Markets (2008) 'Policy statement on financial markets regulation', available at: http://www.ustreas.gov/press/releases/reports/pwgpolicystatemktturmoil_0322008.pdf (accessed 2nd August, 2008).

6 *Wall Street Journal* (2008) 'Bear's Market', *Wall Street Journal*, 4th April, p. A12.

7 Grody, A., Mark, R. and Hughes, P. (2008) 'Operational risk, data management and economic capital', *Journal of Financial Transformation – Cass Institute on Risk*, June, available at http://www.capco.com/files/pdf/62/PART%202/Operational%20risk,%20data%20management,%20and%20economic%20capital.pdf (accessed 2nd August, 2008).

8 Moser, J. T. (1998) 'Contracting innovations and the evolution of clearing and settlement methods at futures exchanges' FRB of Chicago, Working Paper No. 26, August, available at: http://ssrn.com/abstract=910505 (accessed 2nd August, 2008).

9 'The Clearing Corporation and The Depository Trust and Clearing Corporation announce credit default swap (CDS) clearing facility linked to DTCC's trade information warehouse', press release, 29th May, 2008, available at: http://www.clearingcorp.com/press/pressreleases/20080528-dtcc-cds.html (accessed 2nd August, 2008).

10 Governing Council of the European Central Bank (2008) 'CSDs invited to join the TARGET2-Securities initiative', press release, 23rd May, available at: http://www.ecb.int/press/pr/date/2008/html/pr080523_2.en.html (accessed 2nd August, 2008).

11 Nelson, M. (2006) 'TowerGroup: Measuring the securities industry progress on reference data, 2002–2005', ref. no. V46:08M, TowerGroup, Needham, MA, February.
12 Depository Trust and Clearing Corporation, 'Annual report, 2007', available at: http://www.dtcc.com/downloads/annuals/2007/2007_report.pdf (accessed 2nd August, 2008).
13 Reference Data User Group (2003) 'Industry reference data issues', 10th February, available at: http://www.fisd.net/referencedata/20030210rdugindustriesissues.pdf (accessed 2nd August, 2008).
14 Group of Thirty (2003) 'Global clearing and settlement: A plan of action', available at: http://www.group30.org/pubs/pub_1339.htm (accessed 2nd August, 2008).
15 Oxera/Depository Trust and Clearing Corporation (2004) 'Corporate action processing: What are the risks?', May, available at: http://www.oxera.com/main.aspx?id=222 (accessed 2nd August, 2008).
16 Grody, A. D., Harmantzis, F. and Kaple, G. J. (2007) 'Operational risk and reference data: Exploring costs, capital requirements and risk mitigation', February, p. 44, working paper available at: http://ssrn.com/abstract=849224 (accessed 2nd August, 2008), originally presented at Financial Management Association, European Conference, Stockholm, 9th June 2006, session 47, available at http://www.fma.org/Stockholm/StockholmProgram.pdf (accessed 2nd August, 2008).
17 Harmantzis, F. C. (2003) 'Operational risk management', *ORMS Today*, Vol. 30, No. 1, available at: http://lionhrtpub.com/orms/ORMS-search.shtml (accessed 2nd August, 2008).
18 Grody, A. and Mark, R. (2007) 'Response to Federal Register/Vo. 72, No. 39/Wednesday, February 28, 2007 Request for Comment on Supervisory Guidance for Basel II Implementation', available at: http://www.federalreserve.gov/SECRS/2007/July/20070717/OP-1277/OP-1277_16_1.pdf (accessed 2nd August, 2008).
19 Citigroup (2008) 'Citi reports fourth quarter net loss of $9.83bn, loss per share of $1.99', press release, 15th January, available at: http://www.citi.com/citigroup/press/2008/080115a.htm (accesssed 2nd August, 2008).
20 Borio, C. (2008) 'The financial turmoil of 2007–?: A preliminary assessment and some policy considerations', BIS Working Paper No. 251, Monetary and Economic Department, Bank For International Settlements, Basel.
21 Société Générale (2008) 'General Inspection Department, Mission Green Summary Report', 20th May, available at: http://www.socgen.com/sg/file/fichierig/documentIG_5197/rapport missiongreen.pdf (accessed 2nd August, 2008).