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Review of Futures Markets

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Editor's Note
The International Mathematical Finance Conference will be held March 22-24, in Miami, Florida (Westin Colonnade, Coral Gables). This conference is intended to expand the knowledge of theory and application of mathematical finance, and to enhance the interchange of ideas between academics and practitioners of mathematical finance — the application of mathematics, numerical methods and statistics to financial issues. Multiple sessions are planned, with peer-reviewed paper presentations, discussants, open question and answer, panel discussion, and presentations by invited speakers. The Keynote Speaker is Chris Barnett, Distinguished Research Fellow, Imperial College, London.
For more information visit the conference website:
www.bradley.edu/academic/continue/professionals/imfc/index.dot

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IN THIS ISSUE

In this special issue we are very pleased to present four papers that were awarded grants from the Institute for Financial Markets, for the contributions their papers make to the research literature. The mission of the IFM, a nonprofit 501(c)(3) organization, is to "increase the technical competence of those in the global financial markets and the financial services industry through research, educational publications and industry services." These papers represent the latest research that focuses on the practical implications of risk and regulation in derivative markets. The selection process was rigorous and included the evaluations of industry experts.

Perhaps the biggest regulatory change to derivatives in the United States appears to be the Dodd-Frank Act. While still in the rulemaking phase, with many pieces still to be implemented, the changes are profound. This regulation introduces sweeping reform to the US financial community and, combined with the Basel III regulatory structure, will present a significant set of challenges to the industry. "The Tale of Two Regulations – Dodd-Frank Act and Basel III: A Review and Comparison of the Two Regulatory Frameworks" provides a thorough discussion of both regulations and then analyzes the impact that each has on financial systems. In this study Paskelian and Bell examine the behavior of the largest 100 U.S. banks from 2001– 2011 to determine to what extent the increase in capital requirements will lead to higher loan rates and slower loan growth, representing undesirable side effects. Using a structural model of bank behavior from Chami and Cosimano (2010) and Barajas et al. (2010), they identify the optimal holding of equity by banks. Their results indicate that the largest banks in the world would raise their lending rates by an average 13.6 basis points in order to increase their equity-to-asset ratio by the 1.3 percentage points required on average to achieve the new Basel III ratio requirement. When viewed in combination with the Federal Reserve's current monetary policy, their empirical results suggest the possibility of long-term pressure on U.S. banks to broaden income sources and improve risk management by transforming operating models. Once the Federal Reserve begins the process of taking steps to allow interest rates to rise, lending rates are predicted to increase dramatically. These results have important implications to policy makers and the financial institutions they regulate.

Aroskar provides a comparative analysis of regulation of over-the-counter derivatives in the United States, the European Union, and Singapore. These jurisdictions require central clearing and reporting of OTC derivatives, with a major difference being that the United States and the European Union require mandatory trading of cleared derivatives. Singapore requires only central clearing but not trading of all assets except foreign exchange swaps and forwards. In "OTC Derivatives: A Comparative Analysis of Regulation in the United States, European Union, and Singapore" the author also points out that implementation is proceeding in different stages across jurisdictions, and, thus, these two differences have the potential to result in regulatory arbitrage across jurisdictions.

Capponi and Chen, in their article "Systemic Risk: Clustering and Contagion Mechanisms," develop a multi-period clearing payment system. The authors model the impact of default events introducing a novel mathematical structure, the systemic graph, to measure the contagion and systemic effects propagating over time. Their framework is able to capture the systemic effects of default propagation within a financial network over a particular time horizon. They analyze both domino and clustering effects arising in the financial network, showing that there exists a unique clearing payment sequence. The authors introduced the systemic graph to precisely quantify the cascade and clustering phenomena appearing in the financial network. Using two relevant cases – homogeneous and heterogeneous liability structures – their results indicate that default cascades are common when interbank liabilities are homogeneous. However, when the financial network is heterogeneous, default events cluster as the reduced payments coming from defaulted entities have a stronger impact on the solvency state of the remaining entities. Higher correlations between interbank liabilities make the domino effect smaller, and default clustering higher. While small volatilities have a minor impact on the default status of the network, higher values will make simultaneous default occurrences more likely.

In the final paper, Switzer, Shan, and Sahut present two hypotheses: first, that the Dodd-Frank derivative provisions may improve the efficiency of the exchange traded markets due to an increase of arbitrage by traders on the exchange traded markets, as opposed to the OTC markets. And, alternatively, they hypothesize that Dodd-Frank adversely affects the OTC markets relative to the exchange traded markets, as trading in both the former and the latter may be confounded due to additional "noise." In "The Impact of Derivatives Regulations on the Liquidity and Pricing Efficiency of Exchange Traded Derivatives" the authors test these hypotheses by examining the impact of key Dodd-Frank regulations on market activity for financial derivatives (futures and option contracts on US T bonds, Eurodollar futures and options, and S&P 500 futures contracts) and on foreign exchange derivatives (futures and options contracts on EUROs British Pounds, and Canadian dollars). They conclude (1) that the negative association of Dodd-Frank with the other financial derivative products is consistent with Duffie's (2012) hypothesis of a withdrawal of participants in markets for US assets (OTC and exchange traded) due to a reduction of quality of fundamentals, but (2) the increased liquidity of foreign currency derivatives is not consistent with Greenspan's (2011) warning of an exodus of foreign exchange derivatives from the United States.

Mark E. Holder

THE TALE OF TWO REGULATIONS — DODD-FRANK ACT AND BASEL III: A REVIEW AND COMPARISON OF THE TWO REGULATORY FRAMEWORKS

Ohannes George Paskelian and Stephen Bell*

The worldwide financial crisis of 2008 highlighted the weaknesses of the financial regulatory environment. In the United States, the Dodd-Frank Act (2010) was passed to curb and prevent the financial and regulatory shortcomings that resulted in the meltdown. Likewise, the Basel III framework was developed to strengthen international banking sector regulation, supervision, and risk management. In this paper, we provide a comprehensive overview of the Dodd-Frank Act (2010) and Basel III. In addition, the paper provides an analysis of the impact of Dodd-Frank on United States financial system competitiveness when compared to worldwide financial systems. We also provide a discussion of the anticipated implementation procedures that will be necessary to comply with the regulations and quantitative requirements of the Dodd-Frank and Basel III regulatory frameworks. Finally, we empirically examine the impact of Basel III regulatory requirements on optimal equity holdings of large banks. Our results suggest that the implementation of Basel III by US large banks will increase bank lending rates, which in turn could counteract the effect of any economic growth policies.

The recent financial crisis imposed unprecedented damage on financial markets and institutions around the world. The world faced a near catastrophic financial meltdown, which triggered the worst recession since the Great Depression of the 1930s in the United States and Europe. The crisis revealed fundamental weaknesses in the financial regulatory systems of the United States, Europe, and other countries. Those weaknesses made regulatory reforms an urgent priority.

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While the recession caused by the crisis has technically ended, the regulatory response is just beginning. In the United States, the Dodd-Frank Wall Street Reform and Consumer Protection Act (2010) was passed to curb and prevent the financial and regulatory shortcomings that have been blamed for causing the 2008 crisis. In conjunction with the Dodd-Frank Act (2010), the Basel Committee on Banking and Supervision updated its framework, labeled Basel III, as a global regulatory standard on bank capital adequacy, stress testing, and market liquidity risk.

In this paper, we provide a comprehensive overview of the Dodd-Frank Act (2010) and Basel III. We compare and contrast the similarities and differences between these post-2008 financial crisis regulatory frameworks. In addition, we analyze the impact of Dodd-Frank on United States financial system competitiveness when compared to worldwide financial systems. We also discuss the anticipated financial institution implementation procedures that will be necessary to comply with the regulatory and quantitative requirements of the Dodd-Frank and Basel III regulatory frameworks. The empirical portion examines the effect of Basel III capital requirements on lending cost levels in US banks.

The empirical study adds to the body of knowledge by showing that the higher capital requirements imposed by Basel III will likely raise loan rates charged by financial institutions. The higher loan rates could counteract low interest rate monetary policies designed to stimulate investment and economic growth. Using a structural model of bank behavior from Chami and Cosimano (2010) and Barajas et al. (2010), our empirical study identifies optimal bank equity holdings. We estimate that the 100 largest banks in the United States would raise lending rates by 13.6 basis points in order to increase their respective equity-to-asset ratios by the 1.3 percentage points needed to achieve the new Basel III 7% equity to new risk-weighted asset ratio requirement.

The remainder of the paper is organized as follows: Section I overviews and summarizes the Dodd-Frank Act of 2010, while Section II overviews and summarizes Basel III regulation. Section III provides a comprehensive comparison of the two regulatory frameworks, and Section IV examines anticipated implementation procedures and challenges. Section V presents a statistical analysis of the implications of the Basel III regulations. Section VI is the conclusion.

I. DODD-FRANK SUMMARY

Many economists argue that the financial collapse was the primary factor in causing the recession that followed the financial crisis. The Dodd-Frank Act (2010) is a sweeping legislation designed to address problems and areas of need in the regulatory framework governing US financial institutions. Chief among the regulatory reforms affecting the financial industry is the creation of the Financial Stability Oversight Council, which provides a top layer of oversight for financial institutions as well as for the numerous financial regulatory agencies already in place. The lack of coordinated effort in implementing policy and regulatory enforcement among the many regulatory agencies governing the financial industry was a particular concern. In addition, the Council's purpose is to identify risks affecting US financial system stability and to appropriately respond to any threats to the system posed by those same risks.

The Dodd-Frank legislation seeks to strengthen financial institutions by making capital and leverage requirements more stringent. The legislation also restricts the securitization market and provides for a new resolution procedure for financial companies. The Dodd-Frank Act places significant new regulatory restrictions on the derivatives sector. The Act also addresses regulatory reform in the areas of the Volcker Rule governing proprietary trading, adviser registration for specified private funds, and credit rating agency activities (Davis, Polk, and Wardwell 2010).

A. Bank Capital and the Collins Amendment

The Collins Amendment to the Dodd-Frank Act requires that the risk-based capital standards applicable to US insured depository financial institutions will also extend to US bank holding companies, US intermediate holding companies of foreign banking organizations, and systemically important non-bank financial institutions. The Collins Amendment capital requirements measure is the ratio of regulatory capital requirements over risk-weighted assets. Leverage capital requirements must include the ratio of regulatory capital components over average total assets. The capitalization requirements provide categories for Tier 1 and Tier 2 requirements. Tier 1 capital applies to banks and thrift holding companies with more than $15 billion in assets. The Collins Amendment will eliminate hybrid securities as a component of Tier 1 capital and will only allow such securities to be included in measures of Tier 2 capital.

The Collins Amendment does not simply adopt the Basel III guidelines. Instead, the Amendment establishes the minimum leverage and capital floors referenced above and only allows US regulatory authorities to adopt Basel III capital guidelines so long as those guidelines do not violate the established Collins Amendment floors. Thus, the overall effect of the Collins Amendment is to establish current leverage and risk-based capital requirements applicable to insured depository institutions as the minimum standard not only for depository institutions but also for bank holding companies and systemically important non-bank financial institutions. In addition, the legislation grants the Federal Reserve the power to impose an exemption from those same requirements. If the Federal Reserve, in coordination with the Financial Stability Oversight Council, determines that the capital and leverage requirements are not appropriate for the non-bank financial company in question, then the Federal Reserve may impose custom-made, but similarly stringent, capital and leverage control mechanisms (Davis et al. 2010).

B. Derivatives

The Dodd-Frank Act (2010) comprehensively regulates most derivatives transactions formerly deregulated by the Commodity Futures Modernization Act of 2000. The most significant parts of the derivatives regulatory section are (1) mandatory clearing through regulated central clearing organizations and mandatory trading through either regulated exchanges or swap execution facilities; (2) new categories of regulated market participants, including swap dealers and major swap participants; and (3) expanded regulatory coverage of swap activities performed by bank affiliates rather than banks themselves.

The Dodd-Frank Act (2010) regulates credit default swaps, interest rate swaps, and total return swaps on a broad range of asset categories. Swaps based on a single security or a narrow based index of securities are generally regulated by the SEC, while swaps based on broad-based securities indices, government securities, and most other reference assets are regulated by the US Commodity Futures Trading Commission (CFTC). Options on equities and other securities, certain forward contracts, and futures contracts are excluded from the definition of swap, and their current regulatory status is generally not affected by the Act. The definition of swap excludes sales of a non-financial commodity or security for deferred shipment or delivery that are intended to be physically settled as well as any transaction providing for the purchase or sale of one or more securities on a fixed basis that is subject to the Securities Act and the Securities Exchange Act of 1934. The Dodd-Frank Act (2010) provides that foreign exchange swaps and forwards will be considered to be swaps, and subject to CFTC jurisdiction, unless Treasury makes a written determination that either or both types of transactions (1) should not be regulated as swaps and (2) are not structured to evade the Act (Davis et al. 2010).

C. Dodd-Frank Act Key Provision Summary

1. Credit Rating Agency Regulatory Supervision

The Dodd-Frank Act (2010) calls for the establishment of a new Office of Credit Ratings to regulate credit rating agencies. The SEC will require national credit rating agencies to provide evidence of an effective internal control structure. The new regulations impose more stringent public disclosure requirements for rating methodology and due diligence activities. The Dodd-Frank Act (2010) gives authority to the SEC to impose penalties on national credit rating agencies for failing to produce accurate ratings. Furthermore, the Dodd-Frank Act (2010) creates a new private civil cause of action for plaintiff-investors harmed by the acts or omissions of rating agencies in knowingly or recklessly failing to perform due diligence of facts pertinent to establishing a financial rating or failing to obtain analysis from independent sources when establishing ratings.

2. Over-the-Counter Derivative Regulations

The Dodd-Frank Act authorizes the CFTC and SEC to require centralized clearing of over-the-counter derivatives. Regulatory agencies will consider factors such as trading liquidity, operational clearing expertise, and systemic risk in making a determination about whether derivatives are to be cleared for trading. Over-the-counter derivatives that are cleared will be subject to real-time public reporting, which will result in greater public access to trading transactions. Each trade transaction will be reported to a swap data repository.

Over-the-counter derivative market participants defined as swap dealers or major swap participants will be subject to registration, capital, reporting, and recordkeeping regulations. Such dealers will be required to disclose risks and conflicts of interest to counterparties in a given trade.

The Dodd-Frank Act (2010) also imposes position limits that restrict the size of over-the-counter derivatives which any person or entity can hold. Further, swap dealers and major swap participants are prohibited from governmental assistance through Federal Reserve Discount Window access. Federal Deposit Insurance Corporation (FDIC) insured institutions defined as swap dealers will be required to place derivative investments in an affiliate of the bank holding company that is non-FDIC insured and independently capitalized. The Dodd-Frank Act (2010) creates a private civil cause of action for plaintiffs harmed by persons who manipulate over-the-counter derivative contracts in violation of CFTC rules.

3. Private Fund Adviser Regulations

The Dodd-Frank Act (2010) requires advisers to private funds with $100 million or more in assets to register with the SEC as investment advisers. The effect of the new legislation is to raise the SEC registration asset threshold from $25 million to $100 million. Those advisers that fall below the threshold will be required to register with his/her home state. Registered advisers subject to SEC regulation are also subject to recordkeeping and reporting requirements as well as examinations by SEC personnel. Advisers who solely advise venture capital funds are exempt from the SEC registration requirement. Advisers to family offices and advisers to small business investment companies are exempt as well; however, it should be noted that exempt advisers still have reporting and recordkeeping requirements.

4. Originators of Asset-Backed Securities

Dodd-Frank Act (2010) requires that originators of asset-backed securities are to retain a credit risk of 5% or more of the asset-backed security if such security is transferred or conveyed to a third party. In addition, originators are subject to more stringent reporting and disclosure requirements with respect to the quality of the assets backing the securities.

5. Security Law Enforcement and Legal Remedies

The Dodd-Frank Act provides that violators of certain sections of the 1940 Investment Advisers Act will be barred from associating with other broker-dealers, investment advisers, transfer agents, or credit rating agencies. Similarly, Regulation D protections provided under the Securities Act of 1933, which exempt companies issuing securities from registration with SEC, will not apply to offerings made by known "bad actors" who have either been barred from association with regulated entities as described above, or if said bad actors have been convicted of a felony or misdemeanor in connection with the sale of securities or a false SEC filing.

The Dodd-Frank Act (2010) expands liability exposure to those individuals who either aid or abet the commission of securities violations. The government can undertake enforcement steps against those who knowingly or recklessly provide substantial assistance toward commission of a securities violation.

The Dodd-Frank Act (2010) strengthens SEC enforcement by permitting the agency to assess monetary penalties against individual violators as well as regulated entities. The legislation expands federal court jurisdiction by permitting the SEC to exercise its enforcement powers against individuals and entities taking significant steps to further the commission of a securities violation — even if those steps take place outside of the United States.

6. Federal Reserve Supervision

The Act creates the position of Vice-Chairman for Supervision within the Board of Governors of the Federal Reserve System, a member from the Board of Governors designated by the President of the United States by and with the advice and consent of the Senate. The duties of this position include the development of recommendations for supervision and regulation of depository institution holding companies and other financial institutions supervised by the Federal Reserve. The Dodd-Frank Act (2010) empowers the Federal Reserve to regulate fees charged by merchants for accepting debit cards in given debit card transactions.

7. Authority to Seize Failing Financial Institutions

The Dodd-Frank Act (2010) provides that the FDIC may seize, break-up, and wind down a failing financial company. This power enables the FDIC to seize any company falling under the broadly defined term "financial company" including bank holding companies, non-bank financial companies under the supervision of the Federal Reserve, and companies determined by the Federal Reserve to be predominantly involved in financial transactions. It is well known that the FDIC has been empowered to seize and resolve depository institutions for many decades. This provision extends the FDIC resolution power to more broadly defined "financial companies" as outlined above.

The resolution process will allow the FDIC to take over management of financial company assets, arrange mergers with or sales to financially healthy companies, and transfer assets and/or liabilities as deemed necessary. The FDIC will have the regulatory authority to provide financial assistance and a corresponding repayment plan to troubled financial companies. The repayment plan gives payment priority to the repayment plan over shareholders of the troubled company; that is, shareholders do not receive payment until after FDIC financial assistance has been fully repaid through the repayment plan.

8. Volcker Rule

The Act includes implementation of the Volcker rule, which generally speaking prevents proprietary trading by insured depository financial institutions and bank holding companies. These institutions are also prohibited from sponsoring or investing in either private equity funds or hedge funds. Proprietary trading is defined as transactions taking place from the trading account of a financial entity. The sponsoring of private equity funds is defined as either serving as a private fund partner or managing member, or participation in the selection of private fund directors, trustees, or managers. Furthermore, affected financial institutions are prohibited from engaging in marketing activities that share the name of the private fund in question.

There is a significant exception to the Volcker Rule allowing financial institutions to sponsor a private equity or hedge fund but only if the institution provides fiduciary, trust, or investment advisory services to the fund. Clearly, the intent of Congress in adding the Volcker Rule to the Act is to prohibit conflicts of interest between a financial institution and its clients. The above-referenced Volcker Rule exception requires that the financial institution give full disclosure to client of any proprietary trading that may be in conflict with investment advice being given to clients. Congressional testimony in the aftermath of the 2008 financial meltdown shows evidence that allegedly financial institutions were taking short positions on proprietary investments while giving conflicting "buy" advice to clients. This type of testimony led to the inclusion of the Volcker Rule in the legislation; however, strong lobbying efforts were successful in including significant exceptions that have served to weaken the strength of the rule (Davis et al. 2010).

9. Hotel California Rule

This provision is named after the Eagles song, which includes the line: "You can check out any time you like, but you can never leave." The Dodd-Frank Act (2010) provides that former bank holding companies with total consolidated assets of $50 billion or more as of January 1, 2010, and that have received financial assistance under the TARP plan will be treated as non-bank financial companies to be supervised by the Federal Reserve. This regulation comes into play in the event that an entity existing as a bank holding company any time before January 1, 2010, ceases to exist as a bank holding company any time after January 1, 2010 (and meets the asset size and TARP aid definitions stated above). The obvious intent of this legislation is to prevent financial institutions, perceived as having systemic risk, from merely changing legal form in order to escape Federal Reserve regulatory supervision. Thus, while an entity can change its business form to something other than the title of bank holding company, the Hotel California Rule makes sure that the entity in question will never leave the supervision of the Federal Reserve.

II. BASEL III SUMMARY

On December 16, 2010, the Basel Committee adopted rules designed to strengthen the world banking and financial institution framework. The Committee focused on reform of bank capital quality, quantity, liquidity, control of derivatives, restriction of leverage levels, and the accumulation of capital buffers in anticipation of either capital growth or periods of losses. This approach was implemented as a direct result of the 2008–2009 worldwide financial crisis in which the international banking community witnessed the failure of some of its largest financial institutions due to inadequate capitalization, excessive leverage, bank funding programs that had low levels of liquidity, and lack of bank "rainy day" buffers designed to soften the blow of a major recession. The Basel III rule development process is reflected by the following timeline:

(i) 2009: Basel III Rules published as proposals.

(ii) July 2010: Committee provisionally adopts proposals (with changes).

(iii) November 2010: The G-20 Seoul meeting results in approval of Basel III Rule content and time deadlines.

(iv) January 2011: Quality of capital Basel III Rules further strengthened by the addition of greater loss buffer requirements for all Additional Tier I and Tier 2 instruments.

The Basel III Rules supplement rather than supersede the previously formulated July 2009 rules developed by the Basel Committee, which were implemented in 2011. The July 2009 rules were designed to improve bank trading book capital requirements by enforcing an incremental default risk charge on trades involving bank assets. Also, bank securitization risk exposure was reduced by requiring that resecuritization risk be more strongly capitalized. The July 2009 rules allow the imposition of stronger capital requirements for the time period prior to the time the Basel III Rules take effect (Bank of International Settlements 2010a).

A. Basel III Capital Quality Reforms

A bank's Tier 1 capital shall be primarily comprised of Common Equity Tier 1 ordinary shares. Any non-Common Equity Tier 1 capital, hereinafter referred to as Additional Tier 1 capital, will be strictly regulated and must be capable of supporting a bank as a going concern. All additional Tier 1 shares must be able to withstand losses caused by bank issuer nonviability. In the event of the occurrence of nonviability, the shares will either convert to common equity shares or the principal write-down mechanism process will be initiated.

Tier 1 capital ratios are to be raised from the Basel II level of 4% risk-weighted to 6% by 2015. The Common Equity Tier 1 share of risk-weighted assets shall increase from the current 2% minimum level to the 4.5% minimum level by 2015. These ratio requirements reflect the Committee's recognition of the lessening of Tier 1 capital quality in the years leading up to the 2008–2009 financial crisis and the resultant desire to improve the quality of Tier 1 capital instruments as part of the overall effort to strengthen the international banking system.

Although the Committee's rules clearly reflect a preference for Common Equity Tier 1 capital, instruments known as Additional Tier 1 capital are permitted. Basel III sets forth criteria that must be met in order for Additional Tier 1 capital to qualify as part of overall Tier 1 capital:

(1) payments shall be discretionary in order to assist the firm in avoiding default;

(2) instruments shall not contribute to liabilities exceeding assets thus avoiding firm insolvency; and

(3) instruments must be able to sustain losses while the firm remains a going concern.

Additional Tier 1 capital will be fully subordinated to general creditors, coupons or dividends can be cancelled at the discretion of the firm, no maturity dates will be applied to the instruments, and there will be no incentive to seek early redemption of the instruments.

The previously applied Tier 2 capital subcategories have been eliminated by Basel III. Now all Tier 2 capital will be subject to a single set of entry criteria. Tier 2 capital must have a loss absorption provision, which, upon initiation of the triggering process, shall either have the principal written off or be converted to common equity. The triggering mechanism is the earlier decision by the appropriate regulatory authority that a write-off is necessary to avoid nonviability, or a decision to inject public sector funds in order to stave off nonviability.

B. Capital Deduction Treatment Reform

The Basel III Committee reformed the subject area of deductions from capital, with the most significant rule change being that deductions must primarily be charged against the stronger Common Equity Tier I capital rather than spread among Tier 1 and Tier 2 capital instruments as is now the case.

Deductions, which must now be fully subtracted from capital, include deferred tax assets, cash flow hedge reserves, shortfalls on provisions to expected losses, and gains on securitization transaction sales. Also included in these deductions are change in credit risk gains or losses on fair valued liabilities, deferred benefit pension fund assets and liabilities, investments in own shares, reciprocal cross holdings in other financial institutions, excess holding in the capital of banks or financial institutions deemed material ("material" defined as 10% or more of the capital of the issuer).

Furthermore, certain minority interests, mortgage servicing rights, significant assets in the common shares of unconsolidated financial institutions, and recognized deferred tax assets that arise from temporary differences will all be subject to the 10% rule; that is, if any one of these instruments is counted as comprising 10% or more of Common Equity Tier 1 capital, the bank must deduct the excess over 10%. In addition, if these items in the aggregate total 15% or more of Common Equity Tier 1 capital, the excess over 15% must be deducted.

Note that deductions will be phased in at a rate of 20% per year for a five-year period beginning in 2014 and ending in 2018. Minimum Common Equity Tier 1 and Tier 1 requirements will be phased in with full compliance (Common Equity Tier 1 ratio of 4.5% and 6% Tier 1 ratio) being achieved by January 2015.

Grandfathering of existing capital instruments was addressed by the Committee with the Basel III regulation being that capital *not* qualifying as Common Equity Tier 1 capital on January 1, 2013, will not be counted as such after that date; that is, grandfathering will not be permitted for Common Equity Tier 1 capital. However, grandfathering will be allowed for Additional Tier 1 and Tier 2 instruments with qualifying instruments being counted as Additional Tier 1 and Tier 2 capital over a 10-year period beginning January 2013.

1. Capital Requirements for Derivatives, Repos, and Security Financing Transactions

The Committee substantially increased the capital requirements for derivatives, repos, and security financing activities not cleared by a central counterparty. The Committee also mandated that the above-referenced instruments and activities will be subject to much stricter margin and disclosure requirements by January 2013.

2. New Capital Buffer Requirements for Loss Periods and Excess Growth Periods

The Basel III Committee requires banks to adhere to two new capital buffer requirements: (1) a capital reserve buffer up to 2.5% of Common Equity Tier 1 capital to be built up during strong economic growth periods in order to develop a "rainy day" reserve from which to draw during loss periods, and (2) a 2% Tier 1 capital buffer to be initiated by regulatory authorities during periods of excess credit growth.

3. Leverage Restriction

The Committee further demonstrated its concerns over the issues of excess risk exposure and capital quality by imposing a 3% leverage ratio restriction on Tier 1 capital. The leverage ratio restriction will be measured using Tier 1 capital during the implementation phase beginning January 2013 and ending January 2017.

4. Asset Liquidity Reform

The Basel III Committee's concern about the quantity and quality of bank liquidity led to the enactment of a required liquidity coverage ratio and a net stable funding ratio. The Committee's goal was to improve the overall level of bank liquidity, in particular during times of financial downturn or crisis. The net stable funding ratio is designed to require banks to match funding liquidity with asset profile liquidity.

5. Evaluation of Capital Reform Effectiveness

The Committee's decision to increase the Common Equity Tier 1 capital and Tier 1 capital ratios will significantly improve bank capital quality. However, intense lobbying efforts by the banking industry have weakened the overall effectiveness of the reforms. Originally, the 2009 Basel III proposals required full deduction of minority interests, mortgage servicing rights, deferred tax assets arising from temporary timing differences, and investments in the common shares of unconsolidated financial institutions. These activities present potential conflicts of interest and leave the door open for accounting abuses, which shift losses elsewhere in order to make firm value appear better to investors. This was what the Committee had in mind when it required full deduction from capital for investments in own shares and reciprocal cross holdings in other financial institutions. Ultimately the Committee's original full deduction proposal was reduced to the previously discussed weaker 10%/15% (aggregate) final Basel III deduction rule.

The Committee's actions reflected its strong desire to have Common Equity Tier 1 capital be the primary instrument to implement its capital quality improvement reform. The Committee's goals were accomplished to the extent that the Common Equity Tier 1 ratio requirement was more than doubled. However, the Committee compromised by allowing less desirable Additional Tier 1 and Tier 2 capital to remain in its various forms over a 10-year phase-out basis beginning in 2013. This concession in part weakens the achievement of higher capital quality reform (BIS, 2010a,b).

III. BASEL III AND THE DODD-FRANK ACT: A COMPARISON

Both Basel III and the Dodd-Frank Act address the issue of higher quantitative and qualitative capital requirements. Basel III sets minimum common equity requirements for Tier 1 at 4.5%. The minimum Tier 1 capital requirement will increase from 4% to 6%. All of these ratios are based on risk-weighted assets.

The Collins Amendment portion of Dodd-Frank establishes minimum leverage and risk-based capital floors and only allows US regulatory agencies to adopt Basel III capital guidelines as long as those guidelines do not violate the established Collins Amendment floors. In all likelihood, Collins Amendment requirements will exceed the Basel III guidelines, thus creating a competitive advantage for non-US financial institutions not subject to the Collins Amendment. This could result in arbitrage opportunities for investors and owners of those same international financial institutions.

Both Basel III and Dodd-Frank Act eliminate trust-preferred securities from the calculation of Tier 1 capital requirements. However, the two regulatory schemes differ greatly in their respective transition periods. Under the Collins Amendment, Tier 1 capital requirements will exclude trust-preferred securities over a three-year phase-out period ending January 2016. In contrast, Basel III provides a much more generous 10-year phase-out period ending January 2023. The advantage from the phase-out period differential clearly lies with institutions subject only to Basel III regulations. At the same time, Dodd-Frank permits trust-preferred securities issued before May 19, 2010, to be grandfathered as Tier 1 capital. Basel III does not permit any grandfathering exception (Barnard and Avery 2011).

Basel III imposes a mandatory capital conservation buffer requirement and a discretionary countercyclical capital buffer. The capital conservation buffer must be in the form of common equity and is considered a rainy day fund which can be reduced during periods of financial downturn or stress. The non-binding countercyclical buffer is a fund designed to increase (and provide additional strength) during times of excessive credit growth, which could result in higher levels of potentially damaging systemic risk. The Dodd-Frank Act does not require either of these buffer funds.

The treatment of credit rating agencies is dramatically different between the Dodd-Frank Act and Basel III. Due in part to allegations of improper determination of financial ratings, the Dodd-Frank Act requires that newly developed financial regulations are not to be based on credit rating determinations from national credit rating agencies. In contrast, the Basel III regulations are heavily based on credit rating agency input. In addition, under the Dodd-Frank Act the credit rating agencies are subject to new regulatory requirements including more stringent public disclosure of rating methodologies, stronger evidence of effective internal controls, and better due diligence activities.

Finally, the Dodd-Frank Act and Basel III treat credit risk retention very differently with respect to securitized asset originators. The Dodd-Frank Act requires that originators of securitized assets retain 5% of the asset credit risk. In contrast, Basel III does not require securitized asset originators to retain any credit risk in the issued securities. Dodd-Frank's approach to this issue is to align the financial incentives of investors and originators by requiring both groups to be subject to credit risk, thereby improving loan quality and security performance. The Basel III approach (no originator credit risk retention) has both weakness and benefit. Banks not required to retain credit risk will force investors to carry the additional burden of greater research resource investment in order to determine whether investments are good or not. Basel III regulators argue that the Dodd-Frank Act risk retention requirement for originators will stifle lending and freeze capital markets. Thus, they argue that the lack of a credit risk retention requirement will lead to greater lending and a more robust macroeconomic recovery (Barnard and Avery 2011).

IV. ISSUES WITH DODD-FRANK ACT AND BASEL III IMPLEMENTATION

A. Basel III Implementation Problems

The adoption and implementation of the Basel III regulatory structure will greatly challenge the banking community on a worldwide basis. According to a report published by Moody's Analytics (2011), the new regulations will require much more effort aimed at creating a considerably more sophisticated technological approach to gathering, storage, access, and analysis of the data necessary to comply with the new regulations. The challenge of implementing the new Basel III regulations will vary from region to region worldwide. For example, the EU plans to utilize a uniform set of regulations among all of its members as it makes the transition from Basel II to Basel III. The United States, not having adopted Basel II, will be integrating the provisions of the Dodd-Frank Act with Basel III. Eastern European, Middle Eastern, and African nations may either fully adopt Basel III or use the framework as a set of guidelines to follow as best they can. Financial institutions with multiple worldwide offices in different regions will be faced with the task of integrating compliance with Basel III regulations, knowing that compliance and adoption of the Basel III framework will greatly vary between countries and regions. Local regulators will have to work closely with financial institutions in order to provide a consistent application of the regulations so as not to create confusion about reporting requirements and compliance.

Perhaps the most daunting task facing both regulators and the financial community will be the data management requirements necessary to provide a centralized data repository accessible to both the institution and to regulators. Financial institutions will be required to generate financial reports from the data showing compliance with the new capital, leverage, and liquidity ratio requirements. These reports will necessarily have to be in a format meeting the requirements of regulators (Casey 2011).

The regulators receiving financial reports from banks will need to have access to the data to accurately verify report results. Likewise, banks without centralized databases will have a difficult time retrieving data necessary to comply with regulatory requirements and stress testing. It will be critical for financial institutions to create and maintain an easily accessible, user-friendly data repository so that the regulatory requirements of Basel III do not become overwhelming. Financial institutions can take one of two basic approaches to Basel III compliance. One option is to merely add to the financial organization's existing business model framework. The institutions will make the necessary additions to the existing framework so that Basel III capital and leverage ratios can be managed, stress tested, and reported. The advantage of this type of approach is that it is arguably less disruptive to current business operations and will probably be less expensive than a complete overhaul of the business model tailored to regulatory requirements. Conversely, the second approach would be to create a completely new business model more completely integrating the new Basel III regulatory requirements. This approach may lower costs in the long run when compared to a piecemeal approach. Further, it will necessarily include a more integrated view of the overall structure of the organization, which will combine profit and regulatory concerns, as the organization moves forward in the new regulatory environment.

No matter what approach is taken with respect to Basel III compliance, it will be much more efficient for financial organizations to have a centralized, integrated approach to databases needed for compliance reports, recordkeeping, stress testing, and report generation. The centralized system must be user-friendly for both organization employees and Basel III compliance regulators. The great advantage of such a system will be the "big picture" overview provided to the organization; that is, decision-making will be based on an overall understanding of risk, leverage, profitability, and regulatory issues. The creation of a centralized, integrated data management system with the capability of handling firm decisions while meeting Basel III compliance standards has the great potential to improve financial institution efficiency on a worldwide basis (Casey 2011).

B. Dodd-Frank Implementation Problems

As is the case with the implementation of Basel III, financial institutions subject to the Dodd-Frank Act will find that the creation of a centralized data management repository will be one of the primary challenges in comporting with the regulatory structure. Financial institutions will be required to complete reports on leverage, liquidity, and capital requirements ratios in an efficient fashion. The data will have to be gathered and delivered in a transparent manner so that institution managers and Dodd-Frank regulators can access the information for verification. This can only be done with a much more sophisticated data management approach to gathering, storing, and accessing financial information (Davis et al. 2010).

The proprietary trading restriction imposed by the Volcker Rule will tend to be problematic. The intent of the restriction is to prevent financial institutions from acting in a manner that conflicts with the interests of its clients. However, actual enforcement of the regulation will be difficult due to the fact that regulators will experience difficulty in interpreting the actions of a financial institution when the institution engages in financial transactions.

Financial institutions face a very serious problem when trying to integrate Dodd-Frank with the provisions of Basel III. This will be particularly true for larger financial institutions that have multiple international offices. The success or failure of the Dodd-Frank Act will be determined by the ability of regulators and financial institutions to work well together in a spirit of cooperation and good faith. As was mentioned, the data management issues will be critical as well. The regulatory provisions are truly a work in progress and will require that workable, practical solutions be found (Casey 2011).

V. EMPIRICAL ANALYSIS OF BASEL III

This study adds to the body of knowledge by demonstrating that the increased Basel III capital requirements will significantly raise lending costs which in turn will increase the interest rates charged by financial institutions to their customers. The higher interest rate charges will likely result in lower levels of investment in the worldwide economy, thus leading to slow economic growth. The Basel III regulations significantly increase bank capital requirements. The implementation of these capital requirements is based on the premise that higher capital requirements lower leverage and reduce the likelihood of bank failures (see, e.g., Admati et al. 2010). Opponents point out that higher capital requirements have the effect of increasing the marginal cost of raising capital, which will result in higher lending prices, slower loan growth, and ultimately cause a macroeconomic slowdown or a diminished economic recovery (e.g., BIS 2010b; Angelini et al. 2011).

Several studies have found that increases in the capital to asset ratio, like those to be imposed by Basel III, have resulted in significantly larger lending spreads. This supports the argument that the Basel III capital requirements will result in higher lending costs to consumers, which in turn will slow down loan growth and any economic recovery (Kashyap, Stein, and Hanson 2010; BIS 2010b; Angelini et al. 2011; Slovik and Cournede 2011).

The analysis will follow the assumptions made by Cosimano and Hakura (2011) that regulatory capital constraints result in loan demand shocks, which are in turn transmitted to the credit supply. Increased capital requirements will result in higher marginal costs for equity holdings and in turn higher lending rate costs. The study relies on a capital channel structural model developed by Chami and Cosimano (2010) as well as an analysis of large bank holding companies in the United States (Barajas et al. 2010). We use US bank data for the period 2001–2011 to investigate the impact of the new capital requirements for the 100 largest US banks.

A. Empirical Model

The model estimation relies on a generalized method of moment (GMM) estimation procedure that observes the simultaneous decisions of a bank to determine (1) how much capital to hold, (2) loan rate levels, and (3) loan portfolio size. The first stage regression for bank capital holdings is specified in terms of periods: period changes in capital, interest expenses, and non-interest expenses (Chami and Cosimano 2010; Cosimano and Hakura 2011). The study hypothesizes that there is a negative and convex relationship between bank capital and the three above-referenced factors. This is based on the conclusion that an increase in future loan marginal cost will result in a reduced loan level. The second stage regression portion of the study utilizes bank loan rates as the dependent variable and is specified in terms of the optimal bank capital predicted by the first stage regression, interest and non-interest expenses, and economic activity levels. A regression of total loans on the predicted loan rate from the second stage GMM regression is then used to determine the interest elasticity of loan demand. Annual data for commercial banks of the United States are collected from the Bankscope database for the 2001–2011 period. We restrict our analysis to the largest 100 commercial banks.

Following Chami and Cosimano (2001, 2010) and Cosimano and Hakura (2011) bank capital levels are dependent on management's view of optimal future loan levels. Capital is seen as a call option in which the strike price is the difference between the expected optimal loans and the amount of loans supported by the capital. The capital requirement restricts loan levels since a fraction of loans must be held as capital. Banks will lose future opportunities as measured by the capital constraint shadow price in the event that next period's optimal loan level exceeds the capital limit. In this case, total capital has a positive option value, which will result in a tendency for the bank to hold more capital than required in an effort to increase its supply of loans in the future. In contrast, if future loan demand is low, causing the loan demand shock to fall below the critical level, then accumulations to total capital in anticipation of higher demand (which does not actually occur) will result in a zero payoff.

Banks with more capital will have a higher strike price since their loan capacity is greater. Thus, greater capital accumulations in the current period will result in less demand for future capital K'. An increase in loan marginal cost will result in bank forecasts of higher future marginal costs based on the tendency that such expectations perpetuate themselves in future periods. Consequently, a bank anticipates a decrease in optimal future loans and will in turn reduce holdings of capital in the current period. Similarly, an increase in marginal revenue related to stronger economic activity will lead to an increase in optimal loans so that the optimal capital levels increase.

In view of this analysis and following Barajas et al. (2010), the relation for the bank choice of capital is specified as:

$$\frac{K'}{A} = a_0 + (a_1 + a_2\frac{K}{A})x\Delta\frac{K}{A} + (a_3 + a_4\frac{K}{A})r_D + (a_5 + a_6\frac{K}{A})(C_L + C_D) + a_7\log(A) + \varepsilon_3 \tag{1}$$

Call options are generally decreasing and convex in the strike price. As a result, we expect $(a_1 + a_2 \frac{K}{A}) < 0$, such that $a_2 > 0$ and $a_1 < 0$. Similarly, it is expected that $a_3 < 0$, $a_4 > 0$, $a_5 < 0$ and $a_6 > 0$. So, for example, a decrease in capital in the past that lowers the strike price should lead to a significant increase in total current capital. This impact should be smaller when the bank has more initial capital, consistent with the convex property of call options. In addition, a decrease in interest and non-interest expenses should lead to an increase in bank capital at a decreasing rate. Banks are assumed to have some monopoly power so that they choose the loan rate, r^L, such that the marginal revenue of loans is equal to its marginal cost. The marginal cost consists of the interest rate on deposits, r^D, and the non-interest marginal factor cost of loans and deposits, respectively, CL and CD. The marginal cost of loans also depends on the risk adjusted rate of return on capital (RAROC). Thus, total marginal cost, MC, is given by:

$$MC = \frac{D}{A}(r^D + C_D) + C_L + \frac{A-D}{A} r^K \tag{2}$$

Here, r^K is the return on equity, A is total assets, and D is deposits so that bank capital is K' = A–D. As a result, the marginal cost increases with an increase in bank capital only if $r^K > r^D + C_D$. Loan marginal revenue is dependent on the degree to which economic activity (M) affects loan demand. As a result, the optimal loan rate is given by:

$$r^L = b_0 + b_1 r^D + b_2(C_L + C_D) + b_3 \frac{K'}{A} + b_4 \log(A) + b_5 M + \varepsilon_1 \tag{3}$$

An increase in the deposit rate, the noninterest cost of deposits, and the provision for loan losses would lead to an increase in the loan rate, since the marginal cost of loans would increase. The marginal cost also increases with an increase in RAROC. This effect is measured by the optimal capital asset ratio K'/A as given in equation (3) above. An increase in loan demand, as shown by the level of economic activity M (measured by the level of real GDP and the inflation rate), will increase both marginal revenue and the loan rate. Finally, ε is the estimation error.

Loan demand levels, given a degree of monopoly power, are affected by both economic activity M and the optimal bank loan rate as determined in equation (3) above. Thus, loan demand, L, can be modeled as:

$$L = c_0 - c_1 r^L + c_2 M + \varepsilon_2 \tag{4}$$

where *ci*, *i* = 0,1,2 are parameters to be estimated. It is expected that an increase in the loan rate will reduce loan demand, and thus reduce the amount of loans issued by the bank. Conversely, economic activity increases would result in higher loan demand. Note that *c1* and *c2* capture the long-run responses of loans to changes in loan rates and the level of economic activity. Given that the variables are nonstationary (I(1)), we test the null hypothesis of no cointegration in the model. We were able to reject the null hypothesis; that is, cointegration was found.

Banks simultaneously choose optimal capital holdings, the loan rate, and the quantity of loans. The simultaneous nature of this determination requires use of a generalized method of moments (GMM) estimation procedure. In the first stage, the capital regression is estimated to determine the bank's projected or optimal level of capital. The change in the capital-to-asset ratio, the interest expense ratio, the noninterest expense ratio, and the nonperforming loans to total assets ratio, as well as the interaction of each of these variables with the previous period capital-to-asset ratio, are assumed to be decision-making tools to determine the optimal capital ratio. The predicted demand for capital is then used in the second-stage regression to determine the bank's loan rate. The GMM estimations are conducted using the Bartlett kernel function, thereby yielding heteroskedasticity- and autocorrelation-consistent (HAC) standard errors. Lastly, the loan demand regression is estimated using the GMM loan rate estimates as an explanatory variable.

B. Estimation Results and Analysis

Table 1 provides estimates of the capital choice equation and the loan rate equation, respectively. These estimates are obtained using GMM for the 100 largest banks in the United States as measured by their assets in 2006. Heteroskedasticity- and autocorrelation-consistent standard errors are reported in parentheses. The dependent variable in the first stage capital equation is the equity to asset ratio.

Table 1 shows that for the 100 largest banks, the choice of bank capital in a given period was negatively related to the prior change in the equity to asset ratio, $a_1 < 0$, and positively related to the interaction between this change and the initial level, $a_2 > 0$, but these effects are not significant. The interest expense to asset ratio has the expected negative sign $a_3 < 0$ and is statistically significant at the 1% level, so that a 1% increase in the interest expense ratio reduces the banks' holding of equity by 2.957%. The interaction term with the initial equity-to-asset ratio, $a_4 > 0$, has the correct positive sign, so that banks with a 1% higher equity-to-asset ratio would reduce their optimal holding of equity by 2.64% for a 1% increase in the interest expense ratio. The marginal cost of deposits and loans is measured by the non-interest expense to asset ratio and the nonperforming loan to asset ratio. Both effects are negative $a_5 < 0$ as expected but only the non-interest expense ratio is statistically significant at the 1% level. A 1% increase in non-interest expense ratio leads to a 0.721% reduction in capital which is increased to 0.667% for a bank with 1% higher equity-to-asset ratio. With an adjusted R-square of 62%, the optimal equity equation is supported by the data for the largest banks in the United States.

Table 1 also reports the second stage loan rate regression equation. An increase by 1% in the equity-to-asset ratio yields a statistically significant 13.6 basis point increase in the interest income ratio or loan rate. Therefore it can be concluded that the net cost of raising equity is about 13.6 basis points for the 100 largest banks

Table 1. GMM First-Stage and Second-Stage Regressions.

	E/A Ratio		Interest Income/A
Constant	9.59***	Constant	1.528***
	(2.584)		(0.718)
Δ E/A (lagged)	-0.428	E/A	0.136***
	(0.418)		(0.0318)
Δ E/A (lagged)*E/A	0.0287	Interest Expense	1.058***
	(0.218)		(0.0327)
Interest Expense	-2.957***	Non-Interest	0.217***
	(0.512)	Expense	(0.0387)
Interest Expense*E/A	0.317***	Non-Performing	0.000394
	(0.087)	loans/A	(0.000287)
Non-Interest Expense	-0.721***	Log (A)	-0.0527
	(0.205)		(0.0328)
Non-Interest Expense*E/A	0.0536***		
	(0.018)		
Non-Performing loans/A	0.0052		
	(0.002)		
Non-Performing loans/A*E/A	-0.0018		
	(0.000)		
Log (A)	0.071		
	(0.057)		
Adjusted R-squared	0.6182		0.8961

The table shows the first and second stages GMM regression for the equity-asset ratio and the interest income-asset ratio. In addition to the variables listed above year dummies are included. Heteroskedasticity-and autocorrelation-consistent standard errors are shown in parentheses, and significances of 1 (***), 5 (**), and 10 (*) percent are indicated.

in the United States. It should be noted that this is a long-run relationship; therefore, the estimated effect cannot be attributed to temporary asymmetric information effects as was the case in Admati et al. (2010).

A 1% increase in the interest expense ratio leads to an increase in the interest income to asset ratio of 1.058%. This effect is significant at the 1% level. A 1% increase in the non-interest expense ratio also has a significant positive effect on the interest income ratio, but it changes the interest income ratio by only 0.217%. The nonperforming loans-to-assets ratio has a positive but insignificant effect.

Table 2 reports long-run loan demand equation estimates for the 100 largest banks. The equation is estimated using the previously predicted loan rate. The loan rate has the expected negative impact on loans issued by studied banks. The coefficient (–0.085) can be used to estimate the elasticity of loan demand –0.135 (–0.085*(4.53/2.86)), 4.53 being the average loan rate in the sample, divided by 2.86, the average level of loans in the sample. The elasticity of loan demand estimate shows an absolute value of less than one, which reflects the fact that the largest banks are operating at loan levels associated with negative marginal revenue. Generally speaking, many large bank customers lack access to alternative fund

Table 2. Loan Demand Equation.

	Loans
Constant	-7.3874***
	(2.117)
Real GDP	-0.000715**
	(0.00052)
CPI	-0.00069
	(0.0175)
Predicted Loan Rate	-0.08542***
	(0.03847)
R-squared	0.425

Robust standard errors are shown in parentheses, and significances of 1 (***), 5 (**), and 10 (*) percent are indicated.

sources other than bank loans, suggesting lack of access to capital markets. Consequently, a 1% increase in the predicted loan rate leads to a reduction in loans by the world's largest banks by about 1.135%.

The BIS (2010c) and the Committee of European Banking Supervisors (CEBS 2010) have conducted quantitative impact studies, which report additional capital needs for banks under Basel III given their respective financial positions on December 31, 2009. The BIS study is for banks in 23 jurisdictions across the world, while the CEBS report is for 19 European countries. Both studies report information for Group 1 banks having at least 3 billion Euros of Tier 1 capital, a capital level consistent with the largest US banks. The BIS (CEBS) estimates that under Basel III the equity to risk-weighted asset (CET1) ratio would fall to 5.7% (4.9%) from 11.1% (10.7%) for the gross CET1 ratio (pre-Basel III ratio) for Group 1 banks. A large portion of this decline can be attributed to the loss of goodwill associated with tighter bank equity standards. Other factors causing the decline include stricter rules on risk-weighted assets, adjustments for counterparty risk, and application of the capital definition.

The results of this study can be used to infer the impact of more stringent loan rate capital regulations for the largest banks. Under the Basel III regulations, the largest banks would be required to increase their equity-to-asset ratio from 5.7 % to 7%. The results reported in Table 1 show that a 1.3 percentage point increase in the equity-to-asset ratio would tend to increase the loan rate by 0.1768% (0.136*1.3%).

The results from Table 1 reflect the impact of the Basel III requirement that over the long run, loans will be subject to an increase in the equity ratio of 1.135%. The resulting increase in capital would lead to a 3.4% (0.154/4.53) increase in the loan rate when the equity-to-asset ratio is used as a proxy for the new regulation. Given a long run elasticity of loan demand with respect to the loan rate of –0.135%, this would result in an overall reduction of loans by 1.135%. Our results are broadly consistent with the findings from BIS (2010c) and CEBS (2010) for the loan rate, which found that the mean, weighted by GDP, lending rate would increase across 53 models by 16.7 basis points over eight years and 15 basis points, respectively.

VI. CONCLUSIONS

The Basel III regulatory structure significantly increases the capital requirements for institutions operating in the international financial community. One of the inherent problems in applying the Basel III regulations will be the development of centralized data management repositories. The challenge facing financial institutions subject to Basel III (and to Dodd-Frank) will be the rather monumental task of centralizing institutional data so that required reports and recordkeeping can be accessed by both the institution and regulators seeking to verify report results. For affected large financial institutions in the United States, there will be the additional challenge of integrating and synthesizing the Basel III regulatory structure with Dodd-Frank Act regulations.

The Dodd-Frank Act introduces sweeping reform to the US financial community. The Act provides for new capital requirement rules, credit rating agency regulations, more stringent regulation of over-the-counter derivatives, new registration requirements for hedge fund and private equity fund advisers, and required risk-sharing for loan originators.

The Act provides that banks must be "well capitalized" and "well managed," as determined by the appropriate governing agencies. It empowers the Financial Stability Oversight Council to identify and seek solutions to systemic financial risks. Among the most important parts of this provision is that the Council can aid in identifying nonfinancial institutions that pose systemic risk danger to the U.S. financial system. These institutions will, in turn, be subject to direct Federal Reserve and/or SEC financial regulatory supervision.

The Dodd-Frank Act either fails to provide a solution for some problems, or it provides weak regulations easily thwarted by financial institutions. For example, the imposition of Volcker Rule regulations prohibiting proprietary trading is in conflict with the aims of client-investor funds. The larger banks are already seeking to circumvent the spirit of this rule by reclassifying risk traders as "money managers" while claiming that any trades made by managers are automatically approved by investor-clients who (they argue) gave them authority to invest funds on their behalf. Regulators will have to correct this problem by prohibiting such reclassification or abandon the idea of going forward with the Volcker Rule.

No regulations are imposed by the Act on credit rating agencies to address the problem of banks shopping for favorable ratings on debt securities that they underwrite. However, the Act does impose significant restrictions on the credit rating agencies by forcing transparency and independence in investment rating determinations and allowing substantial regulatory agency penalties as well as legislatively creating a new private civil cause of action for credit rating agency rating determination tortious acts or omissions.

As a result of the 2008 financial crisis, the BIS (2010a) developed the Basel III regulatory structure, which focused on the imposition of more stringent bank capital requirements. There has been much speculation concerning the impact of the new capital requirements on cost increases to both banks and their customers. In this study, we examine the behavior of the largest 100 US banks from 2001–

2011 to determine to what extent the increase in capital requirements will lead to higher loan rates and slower loan growth.

Using a structural model of bank behavior from Chami and Cosimano (2010) and Barajas et al. (2010), this study identifies the optimal holding of equity by banks. The study results indicate that the largest banks in the world would raise their lending rates by an average 13.6 basis points in order to increase their equity-to-asset ratio by the 1.3 percentage points required to achieve the new Basel III 7.0% risk-weighted asset ratio regulation.

An additional feature of Basel III is a countercyclical capital requirement, which will likely lead to an additional increase in the required capital ratios subject to a declaration of "excessive credit growth." The estimations in this paper suggest that such a declaration is predicted to reduce large bank loans by 1.135%. As a result, a declaration of "excessive credit growth" could have a significant countercyclical impact. This result indicates that such a declaration should be closely coordinated with monetary policy decision-making. Otherwise, a simultaneous declaration of "excessive credit growth" combined with a contractionary monetary policy could result in an undesired "overkill" scenario where credit growth and contractionary monetary policy cause an excessively harsh economic downturn.

Regulators should be cautioned that excessive zeal in the implementation and enforcement of the new regulations will have a cost in the form of reduced loan availability and credit growth in the economy. Policymakers must approach these problems with a sense of balance. Sometimes regulations have unintended consequences; therefore, regulators must guard against rigidity in thinking and acknowledge that the regulatory structure they will be implementing and enforcing should be treated as a work in progress, which may very well require changes in the regulations themselves as well as changes in the approach regulators take when working with the financial institutions they govern.

Our empirical results, when viewed in combination with the Federal Reserve's current monetary policy, suggest the possibility of long-term pressure on US banks to broaden income sources and improve risk management by transforming operating models. Once the Federal Reserve begins the process of taking steps to allow interest rates to rise, lending rates will increase dramatically in the United States. The challenge for financial institutions will be in finding ways to save capital to meet Basel III requirements while simultaneously developing quality corporate clients, expanding retail business, and growing high-end financial services. These goals are posing challenges in their own right, including identification of quality clients, development of accurate pricing strategies, measurement of client and product profit contribution, determination of accurate risk exposure, and accrual of sufficient capital reserves. The results provided in our study have important implications to policy makers and the financial institutions they regulate. Policy makers must recognize the impact of the the Dodd-Frank Act and Basel III regulatory frameworks on both financial institutions and the overall performance of the economy. Financial institution executives must find ways to improve the efficiencies of their respective operations while complying with the applicable regulatory frameworks.

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OTC DERIVATIVES: A COMPARATIVE ANALYSIS OF REGULATION IN THE UNITED STATES, EUROPEAN UNION, AND SINGAPORE

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This study compares the regulation of OTC derivatives in the United States, European Union, and Singapore. All jurisdictions require central clearing and reporting of OTC derivatives. The onus of reporting falls primarily on financial counterparties to an OTC contract. The main difference in regulation is that only the United States and the European Union require mandatory trading of cleared derivatives. Additionally, implementation is proceeding in different stages across jurisdictions. These two differences have the potential to result in regulatory arbitrage across jurisdictions.

The over-the-counter (OTC) derivatives market is the largest financial market worldwide. It represents various financial and nonfinancial participants in the United States, Europe, Hong Kong, Singapore, and other financial centers. Nonfinancial participants usually use these markets to hedge business risks, while financial participants use them for both speculation and hedging.

According to the Bank of International Settlements' semiannual survey, the OTC derivatives market has grown from $603.9 trillion in December 2009 to $647.8 trillion in December 2011. As seen in Figure 1, interest rate contracts represent 85% of the total OTC derivatives, while credit default swaps represent 5% of the total OTC derivatives and commodity contracts, equity linked contracts, and foreign exchange contracts each represent 1% of the total OTC derivatives contracts (BIS 2012).

OTC contracts were blamed for the credit crisis of 2008 (Dømler 2012). This led to the Pittsburgh Declaration by G20 members to regulate the OTC derivatives market:

> All standardized OTC derivative contracts should be traded on exchanges or electronic trading platforms, where appropriate, and cleared through central counterparties by end-2012 at the latest. OTC derivative contracts should be reported to trade repositories. Non-centrally cleared contracts should be subject to higher capital requirements. We ask the FSB and its

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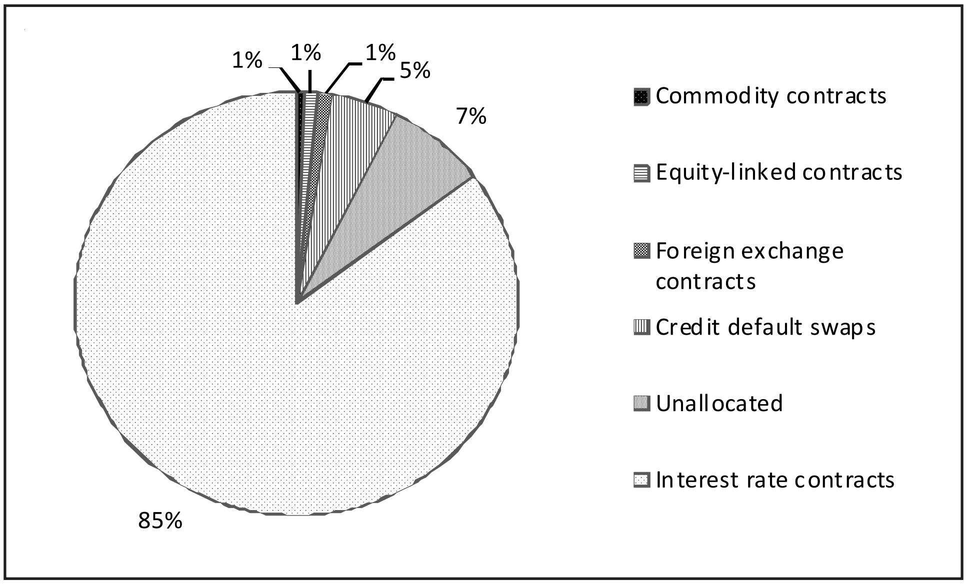
Figure 1. Outstanding OTC Derivatives by Categories.



> relevant members to assess regularly implementation and whether it is sufficient to improve transparency in the derivatives markets, mitigate systemic risk, and protect against market abuse (*Financial Times* 2009).

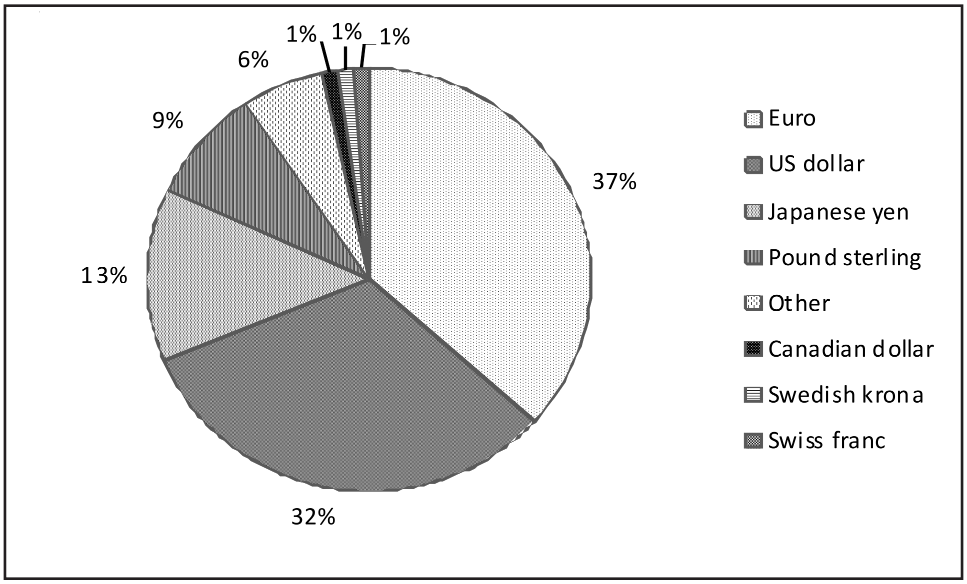
Ever since the declaration there has been sweeping regulation on both sides of the Atlantic with the Dodd-Frank Act in the United States and European Market Infrastructure Regulation (EMIR) in the European Union (EU). Other nations around the world have also formulated their own regulations to monitor and regulate the OTC markets.

This study compares and contrasts regulation of the OTC derivatives markets in three different jurisdictions, the United States, the European Union, and Singapore. As depicted in Figure 2, 32% and 37% of the single currency interest rate OTC derivatives contracts were in US dollars and euros, respectively. These two regulatory regimes were the first to propose regulation of OTC derivatives. The advent of these regulations has led some to fear a loss of OTC markets in countries where there is less or no regulation. Additionally, it is possible for counterparties in countries that have less stringent regulation to avoid business with the US counterparties (e.g., Armstrong 2012).

Singapore has been chosen in this study since regulation of its OTC market has only recently been proposed in February 2012. Also, Singapore does not form a part of the G20. Hence, it serves as an excellent case where there may be a perception that Singapore has less stringent regulations than the G20 countries.[1]

1. The author would like to thank the anonymous reviewer who pointed out that this perception may not be correct, especially in light of the stricter requirements that go beyond Basel III. (See Armstrong and Lim 2011, UPDATE 1-Singapore banks to face tougher capital rules than Basel III. Reuters, http://www.reuters.com/article/2011/06/28/singapore-basel-idUSL3E7HS1TM20110628.)

Figure 2. Percentage of Outstanding OTC Single-Currency Interest Rate Derivatives.



I. LITERATURE REVIEW

A. Central Clearing

An OTC derivative transaction between two parties has inherent risk of default by a counterparty. Before 2007, market participants preferred searching for the best value to close out an OTC position rather than looking for a reduction in counterparty credit risk. This meant that the close out of the OTC position may not have been with the original counterparty (Vause 2010). This resulted in offsetting contracts with a best value provider. Consequently, the number of outstanding OTC contracts increased.

After the credit crisis, management of counterparty credit risk became important. There are various techniques used to reduce counterparty risk, including trade compression and central clearing through a central counterparty (CCP). Standardization of contracts is essential for using trade compression and CCPs (Vause 2010). Trade compression reduces counterparty risk by reducing the number of outstanding contracts among market participants. However, market participants are still subject to bilateral credit risk for the remaining contracts (Weistroffer 2009). This risk could be eliminated using a central counterparty.

A central counterparty (CCP) provides risk mitigation by imposing itself between the buyer and the seller. Thus, it is a buyer to the seller and seller to the buyer. In case of a default by any one of its members, the CCP is the only party that will be affected. All other members of the CCP system remain unaffected. The CCP can reduce or eliminate the impact of default by a member through collateral management.

A CCP could give an open offer to act as a counterparty to members or become a counterparty after an OTC contract has been signed between two parties. In the latter case, the original contract is void when the CCP becomes the counterparty. Using CCPs doubles the total number of contracts; however, there are also possibilities of netting across contracts (Vause 2010).

Another advantage of a CCP is multilateral netting where, instead of there being one buyer to a seller, CCPs can take off-setting positions with multiple members and, thus, diversify away the risk. The CCP could provide anonymity to transactions and thereby reduce the impact of the trader's position. Additionally, the CCP could provide post-trade management and provide financial management of members' collateral deposits.[2] Thus, a CCP is in a much better position to ensure fulfillment of obligations to its trading members than a bilateral OTC contract.

Cecchetti, Gyntelberg, and Hollanders (2009) indicate that using CCPs improves counterparty risk management and multilateral netting and increases transparency of prices and volume to regulators and the public. Using a CCP can also reduce operational risks and efficiently manage collateral. A CCP is in a better position to mark to market and to manage and evaluate exposure.

Acharya and Bisin (2010) indicate that OTC markets are opaque and participants possess private information that provides them incentive to leverage their position. This increases their likelihood of default. Centralized clearing by a CCP would reduce this opacity by either setting competitive prices or providing transparency of trade positions. Culp (2010) indicates that the CCP structure is time-tested and has sustained various market disruptions and individual institutional defaults. Benefits of using a CCP include a reduction in credit risk and evaluation of exposure, transparency of pricing, evaluation of correlation of exposures, default resolution, and default loss reduction.

Novation of a contract using a CCP concentrates risk with the CCP and, to that extent, will contribute to the systemic risk (BIS 2004; Koeppl and Monnet 2008). The CCP has offsetting long and short positions. Hence, they do not have any directional risk. However, they do face counterparty risk (Duffie, Li, and Lubke 2010). With a CCP, bilateral risk is replaced with that of the failure of a market participant in the CCP. This risk is separate from the operational failure of a CCP (Weistroffer 2009).

Biais, Heider, and Hoerova (2012), Milne (2012), and Pirrong (2010) indicate that central clearing mutualizes risk but does not eliminate risk. Such mutualization can be detrimental to the market as players possess private information, leading to underpricing of risk. Liu (2010) indicates that central clearing reduces counterparty risk but not default risk. Thus, governance and choice of financially robust market participants are more important than central clearing to the elimination of risk. Pirrong (2009) indicates information asymmetry could lead to a preference for bilateral arrangements over that of a CCP. In bilateral arrangements, parties to a contract can better monitor, and hence price, counterparty credit risk. Thus, the benefit of a CCP does not outweigh its cost. Lewandowska and Mack (2010) show

2. http://www.cmegroup.com/clearing/cme-clearing-overview/about-central-counterparties.html.

that multilateral arrangements provide comparable netting efficiency to that of CCP clearing.

Culp (2010) suggests that members could resist clearing through a CCP if they see that the credit risk mitigation is marginal, the margin requirements are not for risk management, or the pricing is not acceptable. Further, the study states that the imposition of the margin is costly due to opportunity cost. Additionally, marking-to-market will impose liquidity constraints on dealers. CCP-required standardization may preclude market participants from being able to effectively hedge their risks as the standardized products lead to basis risk and do not exactly offset their risk exposure. Finally, CCP risk managers who perceive themselves at an information disadvantage with respect to its members may impose higher requirements of collateral (Weistroffer 2009).

Studies have suggested various methods of organizing a CCP, the optimal number of CCPs, and ways CCPs may cope with losses. Koeppl and Monnet (2008) indicate that CCPs can be structured as mutual ownership or for-profit organizations. To secure itself from default by any of its members, a CCP will require margin and a default fund. A profit-maximizing CCP will require a larger default fund, whereas a mutualized CCP will enforce a higher margin requirement. In stressed market conditions, a profit-maximizing CCP will provide efficient trading, while a user CCP will shut down.

The Committee on the Global Financial System (2011) indicates that indirect access of clearing through dealers leads to a concentration of risk at these dealers. Also, it makes the system uncompetitive compared to one in which market participants have direct access to clearing. Indirect clearing can be efficient if end users have portability of their accounts across dealers. A domestic CCP may be helpful in maintaining regulatory oversight; however, multiple CCPs will lead to fragmentation and an increased need for collateral. The Committee further advocates coordination of regulation among global regulators to avoid regulatory arbitrage. Links between multiple CCPs will be advantageous due to multilateral netting possibilities through an expanded number of counterparties. However, these links could provide propagation of shocks and systemic risk.

Duffie and Zhu (2011) advocate having a lower number of CCPs as it will reduce counterparty credit risk. Having a separate CCP for each asset will reduce netting benefits across assets. It will also increase collateral needs and counterparty credit risk. Hence, having interoperability agreements will be beneficial. Multiple CCPs will have initial margin and equity requirements for each CCP. There is also a potential for regulatory arbitrage. Finally, trade and positions across multiple CCPs need to be consolidated.

A CCP could create a fund by contributions from its members. This fund could be utilized in case of default by a member to settle claims with the surviving counterparties (BIS 2004). The net obligations could be limited to the size of this fund. To mitigate this risk, CCPs could impose initial and variation margins, depending on the size and liquidity of positions. Additionally, they could impose capital requirements to create a fund for mutualizing losses (Duffie et al. 2010).

Cecchetti et al. (2009) indicate that a CCP may need access to liquidity from the central bank in times of market stress or in the case of reduced liquidity due to a member's default.

B. Trade Repositories

In addition to central clearing, regulators across jurisdictions have proposed trade repositories. It has been contended by studies such as Wilkins and Woodman (2010) that there was not enough information about the OTC trades before the crisis. Regulators lacked information about the size of trades and the volume of trades linked to a counterparty. Hence, they were not in a position to identify concentration of risk in a contract or an institution. There was no central database where regulators could gather and analyze OTC information. Studies have suggested that a trade repository (TR) would help reduce this opacity.

Trade repositories can disseminate trade data to the public and help increase market transparency. They can help OTC market participants ascertain the deal on their trades. A trade repository is an institution that maintains a centralized database that records details about OTC derivatives contracts. The purpose of a trade repository is to increase pre-trade (quotes) and post-trade (information on executed trades) transparency. It is a single place where regulators can access data about the entire OTC market, a single trade, or any institution. The objective of a TR is to provide a centralized location where regulators can access data to monitor the OTC market. Regulators can identify concentrations of risk in a trade or with an institution before such concentration becomes destabilizing for the market. They can perform post-mortems on trades and identify guilty parties or aspects that are suspicious or illegal. Trade repositories can help manage trade life cycle events (Hollanders 2012).

Russo (2010) thinks that reporting of OTC trades should be mandatory. Additionally, TRs should give free access to regulators to the information stored in the registry (Wilkins and Woodman 2010). By disseminating trade information to market participants, TRs can improve market transparency and confidence in market participants. This dissemination of information will strengthen OTC markets.

Wilkins and Woodman (2010) advocate exchange trading of standardized and liquid OTC derivatives to improve transparency. Market participants can access firm quotes and see trade prices. This information will help level the playing field for both sophisticated and unsophisticated market participants. Electronic trading platforms, by providing indicative quotes, can offer limited pre-trade transparency.

Avellaneda and Cont (2010) distinguish between pre-trade and post-trade transparency of OTC derivatives data and between regulatory and public dissemination of data where participants in the interest rate swap market use these instruments to hedge the underlying interest rate risk. Standard interest rate derivatives market trades are usually large, OTC, and institutional. Pre-trade information can be disseminated among dealers using dealer networks such as ICAP, Tradition, BGC, and Tullet Prebon. Quotes from dealer networks could be used to provide aggregate indicators of market variables to the whole market.

Post-trade information includes detailed information about trades. Avellaneda and Cont (2010) suggest that electronic trading platforms and clearing facilitites can facilitate processing and transmission of post-trade data to regulators and trade repositories. However, there are impediments to post-trade reporting. Electronic networks have not yet gained traction in OTC markets. Clearing facilities keep trade information confidential and, hence, do not disseminate this information to the market.

Exchange trading of derivative contracts can help pre-trade and post-trade transparency. However, corporations using customized variations of tenors and maturity may not be able to use exchanges, unless the exchanges offer a wide range or variety of products. Additionally, Avellaneda and Cont (2010) and Wilkins and Woodman (2010) indicate that when the trade size is large and volume low, market makers may have to hold a position for a longer period of time. In fragmented markets, full transparency is feasible as a single position does not affect the price. However, when the size of the position is greater than average trading volume, full transparency will lead to front running and will dissuade market makers as they may not be able to offload risk (Avellaneda and Cont 2010). Hence, full post-trade disclosure may adversely affect market makers. They may be reluctant to enter a trade and provide a market (Wilkins and Woodman 2010). Additionally, dealers could stop or reduce OTC market participation in favor of standardized exchange contracts. Both these measures will reduce liquidity in the OTC market and may be, in general, detrimental.

Tuckman (2010) argues that the objective of ascertaining counterparty credit risk may not be met if the data are anonymized or if there is no reporting of intra-company trade. As such, market stability may be impacted.

Knowledge of price and volume data can help market participants decide on the appropriate capital to cushion potential losses and other risk management procedures. Price information can reduce collateral disputes. Public information can help identify counterparty credit risk and help calm markets as the market participants ascertain exposure level to derivatives (Duffie et al. 2010).

Avellaneda and Cont (2010) suggest that if post-trade transparency is mandated, then such dissemination should be delayed and capped at a certain threshold. Duffie et al. (2010) indicate that position data should be reported with a delay. This delay will help market participants trade on fundamental information rather than on market information. Additionally, this delay will reduce the price impact of the knowledge of real time position information and help market makers exit or change positions at close to the available market price.

This study finds that while mandatory clearing is required in all jurisdictions, there are differences in cleared assets, timing, and exemption of parties. Only Singapore exempts foreign exchange swaps and forwards from clearing. Both the EU and Singapore require immediate clearing for all asset classes. The United States phases in clearing based on asset and counterparties to a transaction. All financial institutions face stricter regulations in the EU, with the United States and Singapore exempting smaller financial institutions. Though in theory all jurisdictions are less stringent on nonfinancial institutions, there could be differences in the levels used to decide the size of an institution. There are also differences in organizational requirements for a CCP in these jurisdictions. These differences in requirements for assets, timing, and counterparties could lead to regulatory arbitrage across jurisdictions. Singapore, alone, does not mandate trading of cleared derivatives. This exemption increases the choices available to market participants who trade OTC products.

Regulations in all three jurisdictions focus on the collection of data and reporting to the TR to increase post-trade transparency. All jurisdictions require reporting of both cleared and uncleared OTC derivatives in all asset classes. However, there is no consistency in priority given to asset classes in various jurisdictions.

In all jurisdictions, the onus of reporting is mostly on large financial institutions. While the United States focuses on complete reporting by both financial and nonfinancial institutions, the EU and Singapore are less stringent on nonfinancial institutions. Also, only the United States has a phased-in approach to reporting depending on the institution's category. This difference in reporting requirements based on asset classes and institutions creates differing costs for reporting entities. As such, there is the potential that these reporting entities will choose more favorable jurisdictions for OTC derivatives, leading to regulatory arbitrage.

The rest of the paper is organized as follows. First, I discuss the scope of the regulations governing central clearing, margin requirements on noncentrally cleared derivatives, backloading of existing transactions, trading, and trade repositories in each of the jurisdictions. This discussion is followed by a comparison of those same regulations and, finally, concluding remarks.

II. REGULATORY AUTHORITY

The US Commodity Futures Trading Commission (CFTC) is charged with the regulation of all OTC derivatives except the OTC derivatives based on exchange-traded securities. The US Securities and Exchange Commission (SEC) is charged with the regulation of OTC derivatives representing exchanged-traded securities

The European Securities Market Authority (ESMA) is the EU-wide regulator charged with drafting regulations on OTC derivatives. It is the sole authority that approves OTC products for mandatory central clearing.

The Monetary Authority of Singapore (MAS) is the sole authority responsible for regulating OTC derivatives market in Singapore.

The United States is the only jurisdiction in this study that has multiple authorities regulating OTC derivatives market. This may lead to delay in legislation on differences in the timing and compliance mandated by the two authorities.

III. REGULATORY REQUIREMENTS

In the United States, OTC derivative contracts called *swaps* are regulated and include all asset classes, interest rate, commodity, equity, foreign exchange, and credit default swaps. Two authorities in the United States regulate swaps. Swaps regulated by the SEC are focused on securities and include single security total returns or narrowly based indexed total returns. All other swaps including optionality in a total return swap are regulated by the CFTC.

A bilateral mixed swap with a counterparty that is a registered dealer or a major participant with the CFTC and the SEC will be subject to key provisions of the Commodity Exchange Act (CEA) and related CFTC rules and requirements of the federal securities law. For all other mixed swaps, joint permission could be sought to comply with the parallel provisions of either the CEA or the Securities Exchange Act.

The European Market Infrastructure Regulation (EMIR) incorporates all derivatives contracts that are traded OTC and not on a regulated market. There are no exclusions for any particular type of derivatives.

The Monetary Authority of Singapore incorporates all derivatives contracts. The definition of a derivative contract is very broad and includes forwards, options, and swaps.

Of the authorities in these three jurisdictions, all have very comprehensive definitions of derivatives contracts. The US definition, though, is very prescriptive (detailed) and has specific exemptions for insurance, consumer and commercial transactions, and commodity forwards. The EU and Singapore are very broad in their definition and do not have any exceptions. Additionally, complications in the registration with either the SEC or the CFTC are confusing and could be costly.

A. Central Clearing

1. United States

All swaps, regardless of their asset class, need to be centrally cleared. There is a possibility that the Treasury Secretary may exempt foreign exchange swaps and forwards from central clearing. However, the latest clarification from the CFTC (2012) indicated that even if such an exemption from the swap regulation were to be granted by the Treasury Secretary, the swaps would still be subject to reporting requirements under the CEA.

Certain insurance products and commodity forward contracts are not required to be centrally cleared. Additionally, the Federal Energy Regulatory Commission regulates instruments or electricity transactions that the CFTC finds to be in the public interest are exempt from central clearing.

End users of derivatives are exempt from central clearing. Additionally, the definition of end user is expanded to include small financial institutions (with assets of $10 billion or less) (CFTC and SEC 2012) to be exempt from the regulation. Cooperatives such as farm credit unions and credit unions are also exempt from clearing requirements.

2. European Union

All standardized OTC derivatives that have met predetermined criteria need to be centrally cleared. All firms, financial and nonfinancial, that have substantial OTC derivatives contracts need to use central counterparty clearing houses.

Nonfinancial firms below a certain "clearing threshold" are exempt from clearing through a CCP. Any OTC contract that is considered to be a hedge is exempt from clearing and as such does not even count toward the total clearing threshold. The threshold has yet to be set by the ESMA and the European Systemic Risk Board.

The "European System of Central Banks, public bodies charged with or intervening in the public debt, and the Bank for International Settlements" (EUR-Lex 2010) are not subject to clearing. There is a temporary exemption from clearing through the CCP for pension funds. There is also an exemption for intragroup transactions subject to higher bilateral collateralization by the EMIR.

3. Singapore

All standardized OTC derivatives need to be centrally cleared. Singapore dollars interest rate swaps and US dollar interest rate swaps, and nondeliverable forwards (NDFs) denominated in certain Asian currencies have been prioritized for mandatory clearing followed by other asset classes in the future. The MAS exempts foreign exchange forwards and swaps from the clearing obligation. However, currency options, NDFs, and currency swaps are not exempt. They identify the Dodd-Frank Act in the United States for such exemptions or nonexemptions. Clearing is required when at least one leg of the OTC contract is booked in Singapore and if either one of the parties is a resident or has a presence in Singapore and has a clearing mandate.

B. Requirements of CCPs

The CFTC may exempt a foreign CCP from registration if it determines that the CCP is regulated and supervised by an appropriate authority in its home country with regulations comparable to those of the United States.

A CCP is required to maintain adequate capital to cover at a minimum a loss by a defaulting member and one year's operations. It is required to have sufficient liquidity arrangements to settle claims in a timely manner. Organizationally, the board needs to have market participants as its members. The CCP should have fitness standards for its board, members of a disciplinary committee should reduce (mitigate) any conflicts of interest, and it should maintain segregation of client funds. The CCP should be able to measure and manage risks.

The European Union recognizes a third country CCP if the ESMA is satisfied that the regulations in that third country are equivalent to that of the EU. Further, the CCP should be regulated in that third country and that third country regulator must have cooperation arrangements with the ESMA.

The ESMA is responsible for the identification of contracts that need to be centrally cleared (Europa.eu 2012). A competent authority in a member state can authorize a CCP; as such, it will then be recognized and can operate in the entire EU.

There are permanent capital requirements for CCPs of €5 million. A CCP is required to maintain sufficient funds to cover losses by a defaulting clearing member in excess of the margin posted and default funds. These funds include insurance arrangements, additional funds by other nondefaulting clearing members, and loss sharing arrangements. Additionally, a CCP should have appropriate liquidity arrangements (EUR-Lex 2010).

There are specific organizational and governance requirements for CCPs. These include separation of risk management and operations, remuneration policies to encourage risk management, and frequent and independent audits. Additionally, CCPs must have independent board members and a risk committee chaired by an independent board member. Finally, there are specific guidelines to avoid a conflict of interest and maintain segregation of client funds (EUR-Lex 2010).

Singapore has no requirement of clearing through only domestic CCPs. Singapore-based corporations can act as clearing houses if they are approved. Foreign clearing houses can operate in Singapore if they are recognized.

There are no specific requirements of the central counterparties in relation to the amount of capital required. The only presumption is that the clearing house needs to have sufficient financial, human, and system resources (MAS 2012). The MAS requires segregation of client funds.

C. Margin Requirement for Noncleared OTC Derivatives

In the United States, the CFTC (2011) proposes rulemaking for initial margin and variation margin for swap dealers (SD) and major swap participants (MSP) for which there is no "prudential regulator" on swaps that are not centrally cleared through a derivative clearing organization. The proposal allows for netting of legally enforceable positive and negative marking to market swaps and reduction in margin requirements with off-setting risk characteristics. Only swaps entered after the effective date of the regulation are covered. The forthcoming capital rules will encompass existing swaps. There are no margin requirements on nonfinancial end users. Initial and variation margin requirements would not be required if payments are below the "minimum transfer amount" of $100,000.

SD, MSP, or financial entities can post initial margins in the form of cash; US government or agency securities; senior debt obligations of the Federal National Mortgage Association, the Federal Home Loan Mortgage Corporation, a Federal Home Loan Bank, or the Federal Agricultural Mortgage Corporation; or any "insured obligation of a farm" credit system bank. A variation margin has to be posted in cash or US Treasury securities. For nonfinancial entities, there is flexibility about assets that could be used as long as their value can be easily assessed on a periodic basis.

Those SD and MSP that have a "prudential regulator" are required to meet the margin requirements of that regulator. A prudential regulator is the Federal Reserve Board, the Office of the Comptroller of the Currency, the Federal Deposit Insurance Corporation, the Farm Credit Administration, or the Federal Housing Finance Agency. These commissions will propose capital requirements and financial condition reporting for SD and MSP at a later date.

In the EU, financial and nonfinancial firms that enter into OTC contracts that are not centrally cleared through a CCP have to adopt procedures to measure, monitor, and mitigate both operational and credit risk including timely electronic confirmation of contract terms and early dispute resolution. Additionally, the contracts have to be marked to market on a daily basis. Finally, there should be appropriate exchange of segregated collateral or appropriate and proportionate holding of capital. These rules are applicable only to market participants subject to central clearing obligations (Herbert Smith LLP 2012).

Singapore recommends financial buffers of capital and margins to mitigate the risk of OTC derivatives that are not centrally cleared. The amount of capital and margin should reflect and be proportionate to the risk of noncentrally cleared OTC contracts.

The MAS will be implementing the Basel III requirements of capital for banks and will seek to align capital requirements of other regulated financial institutions with Basel III. The MAS will seek to align margin requirements on noncentrally cleared derivatives in accordance with the recommendations of the working group made up of representatives from the Basel Committee on Banking Supervision (BCBS), the Committee on the Global Financial System, the Committee on Payment and Settlement Systems, and the International Organization of Securities Commissions.

D. Trading

All centrally cleared swaps in the United States are required to trade on a swap execution facility unless the swap execution facility or exchange does not accept the swaps. In the EU, all cleared OTC derivatives have trading requirements mandated by the Markets in Financial Instruments Directive. The MAS does not require trading of centrally cleared OTC derivatives in Singapore.

E. Backloading of Existing OTC Contracts

In the United States, the Dodd-Frank Act applies to swaps entered only after the mandatory clearing requirement. However, this exemption is not applicable for reporting. The EU has proposed to require backloading of outstanding contracts with remaining maturities over a certain threshold (MAS 2012). In Singapore, a contract for a product subject to mandatory central clearing and having more than a year left before maturity is backloaded. Table 1 summarizes the regulatory requirements for these three jurisdictions.

F. Reporting Requirements

1. United States

In the United States, swaps trade repositories are regulated by the CFTC or the SEC. TRs authorized by the CFTC (SEC) deal in swaps regulated by the CFTC (SEC). All traded or bilaterally negotiated swaps have to be reported. These swaps

Table 1. Summary of Regulatory Requirements by Jurisdiction.

	United States	European Union	Singapore
Mandatory clearing	Yes	Yes	Yes
Who will clear	All financials,all end users, all above $10 billion	All financials and non-financials above a threshold. Temporary exemption for pension funds	All financial counterparties above a threshold, at least one leg in Singapore or one of the parties in Singapore
Assets	All assets	All assets	All except foreign exchange swaps and forwards
Domestic CCP only	Yes (exception if foreign CCP is in comparable jurisdiction)	Yes (exception if foreign CCP is in comparable jurisdiction and contract with foreign regulator)	No
Backloading	Yes	Yes, above a threshold	Yes, above a year
Interoperability	None	Yes	None
Mandatory trading	Yes	Yes	No
Margin requirement for non-centrally cleared derivatives	Yes	Yes	Yes
Base capital for CCP	Yes	Yes	Yes
Organizational requirements	Yes	Yes	Yes
Loss Mitigation	Capital for loss and one year operation liquidity arrangements	Capital liquidity arrangements, default funds, and insurance guarantees	N/A

have to be between two unrelated parties and any changes to the swap agreement have to be reported.

If a swap is executed by a swap execution facility (SEF) or designated contract market (DCM), the SEF or the CCP is required to report swap data to the TR as soon as technologically possible. For an off-facility swap, the hierarchy lies with the SD followed by MSP, followed by a non-SD or non-MSP. When the counterparties are within the same category, they have to choose which one of them will report. Both parties can choose to report and there is no condition of nonduplication. The party required to report is ultimately liable for the reported data even if that party contracts reporting to a third party (Young et al. 2012).

Any swap (mandatory cleared or nonmandatory) that is cleared before the reporting deadlines for primary data can be reported by the clearing facility. Confirmation data on a cleared swap need to be reported by the clearing facility. For a noncleared swap, confirmation data need to be reported by the counterparty as soon as technologically possible. Any changes to the swap over its lifetime need to be reported by the respective parties listed above. Additionally, the state of the swap needs to be reported daily to the TR (Young et al. 2012).

There is a real time public reporting obligation by a TR. Such reporting will not identify the counterparty and should be done when technologically possible. These records must be retained for the life of the swap and for five years after the termination of the swap.

A TR needs to be appropriately organized and be able to perform its duties in a fair, equitable, and consistent manner. The TR should have emergency procedures and system safeguards and provide data to regulators.

2. European Union

The ESMA has the regulatory power to register a trade repository in Europe. Regulators in individual countries cannot do so. Foreign authorities can deal with the ESMA for exchange of information and bilateral negotiations.

Foreign TRs are recognized if regulations in the foreign country are comparable to those of the EU and there is appropriate surveillance in that third country. Additionally, there should be agreement between that country and the EU for exchange of information.

Financial counterparties are required to report to a TR and to report to regulatory authorities if a TR is unable to record a contract. A counterparty required to report may delegate such reporting to another counterparty. Reporting should include the parties to the contract, the underlying type of contract, maturity, and the notional value. A nonfinancial counterparty, above the information threshold, is required to report on OTC contracts. Such reporting must be done in one business day from the execution, modification, or clearing of the contract. There should be no duplication.

The regulation has proposed robust governance arrangements including organizational structure to ensure continuity, orderly functioning of the TR, quality of management, and adequate policies and procedures. Operational requirements include a secure TR with policies for business continuity and disaster recovery. Data reported to a TR should be confidential even from affiliates or the parent of the TR.

A TR will share information with (a) the ESMA; (b) the competent authorities supervising undertaking subject to the reporting obligation under Article 6; (c) the competent authority supervising CCPs accessing the trade repository; and (d) the relevant central banks of the European System of Central Banks. A TR will maintain confidentiality of information and maintain records for at least 10 years after the termination of a contract. A TR will aggregate data based on both class of derivatives and reporting entity.

3. Singapore

The MAS does not require reporting to a domestic TR. The MAS has proposed two types of trade repositories — approved and recognized overseas trade repositories (ATR and ROTR). Approved TRs are domestic, whereas ROTRs are foreign incorporated TRs. The MAS has not required foreign regulators to indemnify ATRs or ROTRs before obtaining data from them.

The MAS has proposed reporting for all asset classes of derivatives. However, it recommends a phased implementation of the reporting requirement with a priority given to asset derivatives from a significant share of the Singapore OTC market interest rate, foreign exchange, and oil derivatives. Oil forms a significant part of the physical market during the Asian time zone, but it does not form a significant part of the Singapore derivatives market.

All contracts that are booked or traded in Singapore or denominated in Singapore dollars are required to be reported. All contracts where the underlying entity or market participant is resident or has a presence in Singapore also need to be reported. Any foreign finance entities are not required to report in Singapore. However, if MAS has an interest in an entity, it will seek information from a foreign authority.

All financial entities and any nonfinancial entity above a threshold (that takes into account the asset size of the entity) have to report. Additionally, group-wide reporting is required for Singapore incorporated banks.

Singapore allows single-sided reporting and third-party reporting. While single-sided reporting is mandatory for financial entities, only one of the nonfinancial entities (among a group) needs to report. Foreign entities are not required to report, and public bodies are excluded from reporting.

Transaction-level data, including transaction economics, counterparty, underlying entity information, and operational and event data, need to be reported. The content of the data needs to be reported in both functional and data field approaches. Any changes to the terms of the contract over its life need to be reported. The MAS has proposed a legal entity identifier and standard product classification system, but has not required it. The data need to be reported within one business day of the transaction. The MAS requires backloading of pre-existing contracts.

Both TRs are required to have safe and efficient operations with appropriate risk management and security. They are required to avoid conflict of interest and maintain confidentiality of user information. They are required to maintain transparent reporting with authorities. The MAS is considering minimum base capital requirements on TRs. A ROTR may comply with comparable regulations in home jurisdictions. Table 2 summarizes the reporting requirements for the three jurisdictions.

IV. COMPARISON OF REGULATORY REQUIREMENTS

A. Clearing Requirements

Clearing exemptions for a certain asset class may not necessarily mean that these assets will not move to central clearing. As mentioned before, noncentrally cleared assets are required to maintain higher collateral. This increased requirement in collateral may lead to prohibitive costs.

The EU regulation is stricter for all financial entities as it gives no exemption on the size of the financial entity. Financial entities in Singapore below a certain threshold (below $10 billion in the United States) have an exemption from central clearing. As such, they and those exempted entities in the United States may have reduced costs and a competitive advantage over larger domestic rivals and all EU rivals.

The regulations for nonfinancial entities below a certain threshold are comparable in their exemption. While the United States has specified a $10 billion threshold, such has not yet been specified by the EU and Singapore. Any differences among these jurisdictions in the clearing threshold will be beneficial to the entities in respective jurisdictions.

The EU is the only jurisdiction that exempts pensions from clearing requirements. The idea is that pensions are mostly fully invested. To subject them to the clearing requirement will be detrimental to the pension funds.

However, pensions do deal in derivatives to hedge their interest rate and inflation risk. Leahy and Hurrell (2012) indicate that in many cases pension funds hedge those risks with financial counterparties. A requirement on financial counterparties to hold higher collateral on noncentrally cleared derivatives will require them to hold higher collateral for derivative hedges they enter with pension funds. This increases the cost to financial institutions which, in turn, pass them on to pension funds.

An exemption given to any nonfinancial entity below a certain threshold may still be costly for these institutions because, in most cases, the counterparty to these transactions may be a larger financial institution. To the extent that these larger financial institutions have to hold higher collateral, nonfinancial entities will bear a higher cost. This defeats the very purpose of the exemption. The alternative will be that even the exempt nonfinancial institutions will have to centrally clear their products.

Only Singapore gives an exemption from central clearing to domestic and foreign central banks and supranational institutions. The EU regulation exempts member state banks from central clearing but is not clear on exemptions for foreign central banks.

B. Requirements for CCPs

The United States and EU require clearing through a domestic CCP. Clearing through a foreign CCP is acceptable in these jurisdictions if a foreign CCP is under a jurisdiction that has regulations comparable to that of either the United States or the EU. There are concerns that such requirement of equivalence in regulation will result in comparing identical points of regulations rather than the intent of regulations in foreign jurisdictions. The requirement for equivalency in foreign jurisdictions results in central clearing through a domestic CCP rather than foreign CCP. Having multiple CCPs will result in fragmentation of clearing.

Singapore is the only jurisdiction that allows central clearing using a foreign CCP without requiring investigation of regulations and agreements with foreign regulators. As such, Singapore has much more flexible regulations with respect to the choice of the CCP.

The EU has the most prescriptive regulation on the organization of a CCP and a choice of model for the CCP. The regulation indicates a mutualized CCP where the losses of a clearing member's default are mutualized through a default fund and loss sharing. As mentioned by Koeppl and Monnet (2008), this mutualization may ensure that the impact of default is minimized and may not pose systemic risk. However, liquidity may be affected in the case of default as the CCP focuses on default resolution rather than efficient trading, which is taken care of by the regulation through liquidity arrangements and insurance guarantees.

Only Europe allows interoperability of a CCP and, to that extent, reduces risk. Thus, it allows netting across asset classes. As such, there is a reduced need for collateral. Further, multilateral netting across asset classes also reduces risk.

C. Backloading of Existing Contracts

Backloading of contracts written prior to the regulation requires market participants to clear through CCPs. When these contracts were written, there was no regulation requiring OTC contracts to novate through a CCP. The choice of the counterparty was based on the best value provided rather than the counterparty credit risk and any mandated collateral requirements. Additionally, requiring these contracts to clear through a CCP subjects them to the model of a CCP. Backloading is of particular importance in the case of jurisdiction, such as the EU, that prescribes a CCP model. Each CCP model has specific costs. These costs may not have been considered while writing the original contracts. As such, the original contracts may be uneconomical for market participants subject to new regulations.

The US regulation is strict as it requires backloading with no exemption for the size or the duration of the contract. Therefore, market participants will face additional costs in the United States.

Table 2. Summary of Reporting Requirements.

	United States	European Union	Singapore
Reporting by TR			
Real time public reporting	Yes	No	No
Time delay to report to SDR	Minutes, "as soon as technologically possible"	++1 day	++1 day
Disclosure of identity of counterparty to public	No	No	No
Notional amount reporting to public	Capped	N/A	N/A
Recordkeeping	5 years until swap terminated, 2 years after termination	10 years	N/A
Regulation of TR			
Domestic only	No	No	No
Cooperation among regulators required	Yes	Yes	Yes
Indemnity required	Yes	No	No
Governance of TRs	Yes	Yes	Yes
Capital requirement	No	No	No
Foreign TR reporting	Yes	Yes	Yes
3rd party reporting	Yes	Yes	Yes
Single-party reporting	Yes	Yes	Yes
Double reporting	Yes	No	No

Table 2, continued. Summary of Reporting Requirements.

	United States	**European Union**	**Singapore**
Regulated by	CFTC or SEC	ESMA	MAS
Reporting for Products			
Required for cleared derivatives	Yes	Yes	Yes
Required for un-cleared derivatives	Yes	Yes	Yes
Phased-in reporting by product	Interest rate first followed by foreign exchange & commodity	None	Interest rate, foreign exchange, & oil first, followed by others
Phased reporting by entity	SD and MSP first, followed by non-SD & non-MSP	None	None
Threshold	None	Yes	Yes
Backloading	None	Yes	Yes, over 1 year
Intragroup trades	Not reported	Not reported	Not reported
What swaps need to be reported	All	All	All
When reported	Upon execution and changes	Upon execution and changes	Upon execution and changes
Confirmed	Yes	N/A	N/A
Subsequent changes to the swap	Reported	Reported	Reported
Daily value of the swap	Yes*	N/A	N/A

The EU regulation is most beneficial for transactions below the threshold and does not benefit any specific asset class. The Singapore regulation has the potential to benefit foreign exchange contracts (Global Financial Markets Association 2012) as they are typically short term in nature. As indicated, 99% of these contracts are for less than one year and hence do not need to be renegotiated.

D. Margin Requirements for Noncleared OTC Derivatives

All jurisdictions require an initial and variation margin. The US regulation has details about netting among legally enforceable offsetting contracts and "minimum transfer" amount. The United States exempts all nonfinancial end users, while the EU exempts any user not subject to central clearing. Singapore is not clear on this requirement. As all jurisdictions subject financial companies to these regulations, their costs may increase to hold collateral and margins. To the extent that these financial companies are on the other side of the contract with exempt companies, financial companies are still subject to these regulations. It is likely that these additional costs will be passed on to the nonfinancial companies exempt from the regulation.

E. Reporting Requirements

Reporting requirements are consistent across all three regulatory environments in that they require reporting on all asset classes. However, there is a difference in the timeline for reporting. In Europe, there is no phasing in. Singapore requires interest rate, foreign exchanges, and oil derivatives to be reported, followed by others. Finally, the United States has the most tiered reporting requirement. Interest rate derivatives are to be reported first, followed by the foreign exchange and commodity derivatives. Both cleared and uncleared trades need to be reported in all three jurisdictions.

The Singaporean requirement of reporting affects any party or transactions related to Singapore. Singapore is a relatively smaller market; hence, its immediate reporting requirement of foreign exchange and oil derivatives, which are additional to that of the United States of interest rate derivatives, may not affect a significant number of market participants or transactions.

The European requirement of immediate reporting of all assets will be a dominating requirement. Phasing-in allowed by the United States will give little flexibility if most of the transactions are cross-border.

All countries require financial institutions to report. However, there are significant differences. While Singapore requires only financial institutions above a threshold to report, both the EU and the United States require all financial institutions to report.

Nonfinancial entities only above a certain threshold are required to report in both the EU and Singapore. In the United States, while nonfinancial institutions are the last to report, there is no exemption for smaller institutions. The Singapore regulation is more accommodating for smaller (financial and nonfinancial) institutions and will help such institutions keep costs down.

Only the US regulation has phased-in reporting, with financial institutions reporting first, followed by nonfinancial institutions. This gives nonfinancial institutions additional time to comply.

All three jurisdictions allow third-party reporting and single-sided reporting. However, only the United States allows for double reporting. Double reporting might be beneficial to the trade repository to confirm the accuracy of the data being reported. It would be costly for the trade repository to verify the accuracy of the data if double reporting is not allowed. However, double reporting involves costs associated with consolidation of data and the reporting costs incurred by each counterparty.

Time to report information to the trade repository is almost immediate in the United States. Both the EU and Singapore allow one day to report information to the trade repository. All three countries require not only initial reporting but also any subsequent changes to the contract. The Depository Trust and Clearing Corporation (DTCC 2012) believes that for day+1 care should be taken to avoid intraday cutoff.

Only the United States requires real time public reporting by the TR. While all countries require that the identity of the counterparties be kept confidential, only the United States requires the notional amount of the swap to be capped while public reporting. Capping of notional amounts will provide an added measure of security in keeping the identity of the counterparty confidential.

All three countries have similar governance of TRs. TRs are required to keep data confidential. The MAS proposal indicates that data collected by a TR serve a regulatory purpose. However, it does not specifically prohibit use of that data by affiliates of the TR or the TR itself for commercial use. Such absence of a specific prohibition may allow these private entities to benefit from privileged information (Argus 2012).

Only the EU prohibits the TR from sharing data with its parent or a subsidiary. Only Singapore is considering base capital requirement from the TR.

Singapore has no requirement for the time to keep records. The United States requires the data to be kept for 5 years and the EU for 10 years after the expiration of the contract.

The objective of the OTC regulation is to improve collection and monitoring of the OTC market. As such, the regulators in the three jurisdictions have focused on post-trade transparency. A major portion of this post-trade transparency deals with reporting information to the TR in a timely manner. Market participants in the United States face the most stringent deadline regarding reporting of information to the TR upon execution. All three jurisdictions have comparable information that needs to be reported.

In all jurisdictions, the onus of reporting falls primarily on financial institutions. Singapore is more favorable to smaller financial institutions. In the United States, nonfinancial institutions have to report only when there is no financial counterparty.

Both Singapore and the EU require only nonfinancial institutions above a certain threshold to report. Thus, regulations in Singapore and the EU are more favorable to smaller, nonfinancial institutions. Additionally, a potential for regulatory arbitrage is possible depending on the threshold level used.

The bulk of the above regulations focus on reducing reporting and regulatory costs for nonfinancial participants and smaller institutions. The idea is that as these participants do not regularly deal with derivatives, it will be costly for them to report. Even if these participants deal with derivatives, the financial counterparties have the requisite manpower and systems to meet the reporting obligations. Thus, it will be more cost effective to use their existing system for reporting.

Single-sided reporting is based on the same concept as stated above. However, only mandating a single counterparty to report while reducing reporting and reconciliation costs may increase inaccuracies in reported data. Improper data will definitely not help the regulators to properly maintain the markets. Though single-sided reporting may reduce costs, there may be situations in which double-sided reporting is preferred. This might be in the case of firms that want to be consistent with reporting and report all their trades. Also, if a party is ultimately responsible for the accuracy of a trade, it may want to report it. Finally, double reporting may be essential for trade repositories as it will be easier to compare and note and/or correct differences (DTCC 2012).

To avoid fractioning of data across jurisdictions and TRs, regulators in all three countries approve of reporting to TRs in foreign jurisdictions. They condition this approval on agreements between regulators in foreign countries with domestic regulators and compatibility of regulation. Bilateral negotiations between jurisdictions could take a considerable amount of time. The two regulators in the United States, the CFTC and SEC, had to go through various negotiations and time to propose rules on OTC derivatives. Hence, it is possible that market participants may have to report in various TRs leading to duplication and increased costs. There is also a chance that this will lead to fragmentation of data. Any fragmentation of data will not give regulators a complete picture of a market participant's exposure or about an asset class. Hence, regulators will not be in a position to maintain global concentration of positions by asset on a counterparty.

Regulators in all three jurisdictions have erred on maintaining confidentiality. The US regulation is more stringent, not just requiring counterparty confidentiality but also requiring capping of the notional amount in public reporting. This requirement will not help post-trade transparency. However, where markets are more concentrated by few participants, it is wise to maintain trade confidentiality. This will help market makers provide liquidity in the market.

V. CONCLUSION

This study compares clearing and reporting regulation of OTC derivatives in Singapore, the United States, and the EU on assets, institutions, and the timing of regulation. The United States and the EU require central clearing and trading of all asset classes. Singapore requires only central clearing but not trading of all assets except foreign exchange swaps and forwards. Further, only the United States has phased implementation for reporting; Singapore prioritizes foreign exchange derivatives, interest rate contracts, and oil contracts. As the United States is in the most advanced stages of implementation of OTC regulation, the phasing in will be only a marginal reprieve. Singapore's clearing regulation is less stringent on foreign exchange derivatives but not on reporting.

Small nonfinancial companies in Singapore and the EU face no regulation of mandatory clearing and reporting. While smaller financial companies have no clearing requirements in Singapore and the United States, they do face reporting requirements (last to report). Hence, the bulk of the regulation is to minimize costs for nonfinancial companies, in particular, the smaller nonfinancial institutions. Regulatory arbitrage is thus possible only based on the threshold used for clearing and reporting in each of the jurisdictions.

The United States is in the most advanced stages of the derivatives regulation. It has both adopted and implemented regulations on clearing and reporting. The EU has agreement among members on the OTC regulation but has not yet implemented the regulation. Finally, Singapore has not yet adopted nor implemented OTC regulation (Financial Stability Board 2012). Thus, it is the time to implement regulation that may lead to a regulatory arbitrage towards the EU and Singapore.

The main difference in the three regulatory jurisdictions is the nonrequirement of trading of cleared derivatives in Singapore. This difference has the potential to provide substantial choices in trading venues for market participants.

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SYSTEMIC RISK: CLUSTERING AND CONTAGION MECHANISMS

Agostino Capponi and Peng-Chu Chen*

We propose a general framework to capture both contagion and clustering mechanisms arising in financial networks when balance sheet linkages across entities exist. Building on Eisenberg and Noe (2001), we develop a multi-period clearing payment system, where the financial network evolves stochastically over time. We model explicitly the impact of default events on the state of the network and introduce a novel mathematical structure, the systemic graph, to measure the contagion and systemic effects propagating in the network over time. Numerically, we show that domino effects appear when the interbank liability structure is homogeneous, whereas clustering effects are noticeable when the structure is heterogeneous. Larger correlations between interbank liabilities reduce the domino contribution to systemic risk and increase default clustering, especially if liability exposures are highly volatile.

Financial institutions are connected to each other via a sophisticated network of bilateral exposures originating from derivatives trades, such as options, futures, and credit default swaps. Such trades expose each counterparty not only to market risk but also to counterparty risk. Indeed, through these linkages, distress or failure of a financial institution triggering large unexpected losses on its trades can seriously affect the financial status of its counterparties in the network, possibly leading them into default. The recursive interdependence in this network of exposures is typically referred to as *systemic risk*, and has been responsible for many failures and credit quality deteriorations experienced by banks during the crisis. (See also Capponi 2012 and Capponi and Larsson 2012 for more details.)

In stable times, the behavior of the network does not exhibit any anomalous behavior. However, in times of financial distress, the recent crisis has demonstrated that default events originating in a specific area of the network may propagate wider in the financial system and affect zones that were not considered particularly vulnerable to a given adverse scenario. Such an intricate structure of linkages can

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be naturally captured by using a network representation of the financial system. Starting with the seminal paper by Allen and Gale (2001), who employed an equilibrium approach to model the propagation of financial distress in a credit network, many other approaches have been proposed to explain this phenomenon. Gai and Kapadia (2010) use statistical techniques from network theory to model how contagion spreads via counterparty exposures. Battiston et al. (2012a) describe the time evolution of the interbank network, and introduce the financial accelerator to characterize the feedback effect arising from changes in the financial conditions of an agent. Battiston et al. (2012b) demonstrate that the systemic risk does not necessarily decrease if the connectivity of the underlying financial network increases. Cifuentes, Ferrucci, and Shin (2005) show that the effects of financial distress at some financial institutions can force other financial entities to write down the value of their assets, and this may consequently trigger other defaults. Using a static approach, Amini, Cont, and Minca (2011) analyze default contagion and short term counterparty risk in the context of interbank lending, using tools from random graph theory. Reduced form models of dynamic contagion are instead considered in Dai Pra et al. (2009) and Dai Pra and Tolotti (2009), and most recently by Cvitanic, Ma, and Zhang (2010) and Giesecke, Spiliopoulos, and Sowers (2011). Capponi and Larsson (2012) analyze the systemic risk associated with default of a company via the interplay between equilibrium behavior of investors, risk preferences, and cyclicality properties of the default intensity.

We propose a novel framework aimed at capturing both *clustering* and *contagion* mechanisms arising from balance sheet interactions across entities. Our framework builds on the approach proposed by Eisenberg and Noe (2001), who develop a fairly general model of a clearing system, and then analyze the systemic effects of the default of an entity on its counterparties. Differently from Eisenberg and Noe (2001), who consider a static one-period model, we allow for stochastic dynamics to describe the time evolution of the financial network, and model the impact of default events on the state of the network. We allow for *multiple clearing* dates, with clearing payments satisfying the standard conditions imposed by bankruptcy laws in each date (limited liability of equity, absolute priority requirements, and proportional repayments of liabilities in default). In each time period, the financial system is modeled as a digraph, where nodes represent entities and edges liability relations between them.

Although our framework accommodates any liability structure, we specialize it to the case where such liabilities consist of call options in order to capture the impact of volatility on interbank liabilities, a relevant driver of counterparty risk propagation in financial markets. As option instruments are highly sensitive to volatility, the resulting analysis can provide systemic risk indicators in financially distressed environments. We further remark that options represent a sizable component of the total liabilities of an institution, and must be listed on the balance sheet according to the accounting classification requirements in Financial Accounting Standards Boards (2007).

Each node is associated with assets and operating cash inflows that the underlying entity possesses, and can be active or defaulted. The state of network is fully characterized by the state of all nodes, as well as by the interbank liability structure. We introduce a novel mathematical structure, the *systemic graph*, which provides a complete representation of the clustering and contagion effects within the network. The vertices of such a graph are called clusters and can be of two types, *source* and *contaminated*. Each cluster identifies an area of the network consisting of simultaneously defaulting nodes, which influenced each other because of direct or indirect linkages in the underlying liability graph. The source clusters represent the triggering components of systemic failures. The contaminated clusters, instead, identify areas of the financial network that defaulted because of the dynamic consequences implied from previous failures in other areas of the network.

The systemic graph represents a useful tool for systemic risk analysis, as it allows to fully track default cascades. Given a source cluster, each directed path originating from it identifies a path of systemic failure, which may then be closely monitored by a regulator wishing to take precautionary measures to prevent systemic crises. By a numerical analysis summarized by the systemic graph, we show that a *default cascade* is more frequent when the interbank liability structure is homogeneous; that is, the amounts of liabilities between any pair of nodes are of similar size. On the contrary, when the network is heterogeneous, default events tend to *cluster*, that is, to occur simultaneously, given that the reduced payments coming from defaulted entities have a stronger impact on the solvency state of the remaining entities. Moreover, higher volatility in exposures and interbank correlations exacerbate simultaneous occurrence of defaults, and result in large clusters of defaulted nodes.

The rest of the paper is organized as follows. Section I provides the framework. Section II develops the multi-period clearing system model. Section III develops measures of systemic risk for the network. Section IV concludes the paper.

I. FRAMEWORK

The financial network is modeled as a digraph $G = (V, E)$, where the set V of nodes represents the financial firms, and the set E of edges the liability relations between nodes (a directed edge between node i and j indicates that i is a debtor of node j). We consider a finite time horizon, which is divided into discrete intervals, $[t, t + 1)$, that are indexed by $t \in \{0, 1, \dots, T\}$. The financial system is fully characterized by the following quantities associated to node $i \in V$ and edge $(i, j) \in E$ in each time t.

$\mathbf{L}^t \in \mathbb{R}^{n\times n}_{\geq 0}$, L^t_{ij} : liability node i owes to j at time t

$\mathbf{l}^t \in \mathbb{R}^{n}_{\geq 0}$, l^t_i : total liabilities node i owes to other nodes at time t.

$l^t_i = \sum_{j\neq i, j\in V} L^t_{ij}$.

$\mathbf{\Pi}^t \in \mathbb{R}^{n\times n}_{[0,1]}$, Π^t_{ij} : liability of i to j as a proportion of i's total liabilities at time t.

$$\Pi^t_{ij} = \frac{L^t_{ij}}{l^t_i} \text{ if } l^t_i > 0 \text{ ; 0 otherwise.}$$

$\mathbf{p}^t \in \mathbb{R}^n_{\geq 0}$, p_i^t: payments node i makes to other nodes at time t.
$\iota^t \in \mathbb{R}^n_{>0}$, ι_i^t: operating cash inflow node i has at time t.
$\mathbf{c}^t \in \mathbb{R}^n_{\geq 0}$, c_i^t: cash node i owns at time t.[1]

Both liabilities and operating cash inflows are modeled via stochastic processes. As mentioned in the introduction, the term structure of liabilities is assumed to consist of options with different expirations, sold by each node of the network to any other at initial time. We denote the underlying asset on which the call option sold by i to j is written by x_{ij}^t and denote the corresponding strike price by K_{ij}^t. Further, the number of options is denoted by N_{ij}^t. We then have that the liability i owes to j at time t is:

$$L_{ij}^t = N_{ij}^t (x_{ij}^t - K_{ij}^t)^+.$$

We also impose that all nodes have positive operating cash inflow for all times; that is, for each i, ι_i^t is an almost surely positive stochastic process, $t \in \{0, 1, \ldots, T\}$. This is one of the simplest sufficient conditions needed to guarantee the uniqueness of clearing payments in the single-period model developed in Eisenberg and Noe (2001). Such an assumption will be used when we prove the uniqueness of clearing payment sequence in Section II.

The time behavior of the financial network over time may be described by the pair $(\mathbf{L}^t, \iota^t)$, $t \in \{0, 1, \ldots, T\}$, of stochastic processes. Given a time evolving financial network $(\mathbf{L}^t, \iota^t)$, our objective is to model the propagation of defaults within the network, and provide effective measures to assess the systemic risk level.

II. MODEL

We develop a model for a multi-period multilateral clearing system, based on the framework described above. We start providing preliminary definitions that will be used subsequently in the paper.

The *cash* of node i at time t, denoted by c_i^t, is recursively defined as:

$$\begin{cases} c_i^0 = \sum_{j \neq i, i \in V} \Pi_{ji}^0 \rho_j^0 + \iota_i^0 \\ c_i^t = \sum_{j \neq i, i \in V} \Pi_{ji}^t \rho_j^t + \iota_i^t + (1+r)(c_i^{t-1} - l_i^{t-1})^+ \quad \text{for } t \in \{1, \ldots, T\}, \end{cases} \tag{2.1}$$

where r is the market interest rate, assumed to be deterministic.

Definition 2.1. A node $i \in V$ *defaults* at time t if it cannot repay in full its liabilities due at t using his available cash, that is, $c_i^t < l_i^t$. The *default set* by the end of time $t-1$, denoted by D^t, includes all nodes, which defaulted by time $s \leq t-1$.

Clearly, $D^0 = \emptyset$.

1. Strictly speaking, this also includes cash equivalents, that is, assets which are readily convertible into cash, such as money market holdings, short-term government bonds, or treasury bills.

A. Default Mechanism

Suppose a node i defaults by the end of time t. Then all liabilities owed by node i from $t + 1$ to T are due immediately, while the financial claims against other nodes from $t + 1$ to T cannot be realized yet. According to Chapter 7 under the bankruptcy laws of the United States, a bankruptcy trustee is appointed by the node i's creditors to administer the bankruptcy estate. The trustee in general sells all the assets through an auction and distributes the proceeds to the creditors (see Bris, Welch, and Zhu 2006). In the context of our model, we assume that the trustee collects the payments that node i is supposed to receive from its debtors in the network, and distributes them to node i's creditors after the assumed time horizon. Although a defaulted node is replaced by a bankruptcy trustee, mathematically, we continue to use the same notation of a defaulted node for the trustee; such a replacement has no impact on any of following computations.

B. Clearing Payment Sequence

Due to the presence of multiple clearing dates, we need to define a sequence of clearing payments, that is, payments that each node makes under a multi-period multilateral clearing system. Such a sequence also satisfies the standard conditions imposed by the bankruptcy law mentioned in Eisenberg and Noe (2001).

Definition 2.2. Given a time sequence $\{(\mathbf{L}^t, \iota^t)\}_{t=0}^{T}$, a time sequence of $\{\mathbf{p}^{t*}\}_{t=0}^{T}$ is a *clearing payment sequence* if it satisfies the following conditions:

a. *Payment less than liability*. The total payment p_i^{t*} node i makes is non-negative and does not exceed total liability l_i^t outstanding in each time period t:

$$0 \leq p_i^{t*} \leq l_i^t \; for \; i \in V, t \in \{0,1,...,T\}.$$

b. *Proportional reypayment of liabilities.* A node $i \in V$ repays liabilities to one of his creditors according to a proportional mechanism; that is, node i pays $\Pi_{ij}^t p_i^{t*}$ to node j at time t.

c. *Absolute priority requirements.* In each time interval t, either node i repays in full its liabilities or, if it defaults, it uses all node i's available cash to repay current creditors. Mathematically:

$$p_i^{t*} = \mathbf{1}_{i \notin D^t} \min\{l_i^t, c_i^t\} \quad \text{for } i \in V, t \in \{0,1,...,T\} \tag{2.2}$$

Lemma 2.3. In case of a single clearing date, the clearing payment sequence defined above coincides with the clearing payment vector in Eisenberg and Noe (2001), and it is unique.

Proof. For a single clearing date, $D^0 = \emptyset$ by definition. By equation (2.2):

$$p_i^0 = \min\left\{ l_i^0, c_i^0 = \sum_{j \neq i, j \in V} \Pi_{ji}^0 p_j^0 + \iota_i^0 \right\} \text{for } i \in V.$$

The solution is the clearing payment vector defined in Eisenberg and Noe (2001). As, by assumption, all nodes in the network have positive operating cash inflow, then by Eisenberg and Noe (2001), Theorem 2, the clearing vector is unique.

Lemma 2.4. Given a sequence of financial networks, there exists a unique clearing payment sequence.

Proof. We prove the above lemma by induction. At time 0, by Lemma 2.3, $\mathbf{p}^0$ exists and is unique. Suppose the statement to be true for time $t-1$. At time t, since the remaining cash $(c^{t-1} - \mathbf{1}^{t-1}) \vee \mathbf{0}$ is determined from $t-1$, we redefine $\iota^t + (1+r)(\mathbf{c}^{t-1} - \mathbf{1}^{t-1}) \vee \mathbf{0} = \tilde{\iota}^t$ and rewrite (2.2) as:

$$\begin{cases} p_i^t = \min\left\{l_i^t, c_i^t = \Sigma_{j \neq i, j \in V} \Pi_{ji}^t p_j^t + \tilde{\iota}_i^t\right\} & \text{for } i \notin D^t \\ p_i^t = 0 & \text{for } i \in D^t \end{cases}$$

By Eisenberg and Noe (2001) there exists a unique solution, $\mathbf{p}^t$, to the above system of equations. Thus, in each time interval there exists a unique payment vector, and hence a unique clearing payment sequence.

III. MEASURING SYSTEMIC RISK

A. Computation

Given a sequence of financial networks, Algorithm 1 given below recovers the clearing payment sequence and the associated sequence of default sets.

Algorithm 1: Default Propagation Algorithm.

procedure DEFAULT PROPAGATION ($\left\{(L^t, \iota^t)\right\}_{t=0}^{T}$)
for $t \leftarrow 0$ to T **do**
Solve (2.2) by the *fictitious default algorithm*,
return $\mathbf{p}^t$, $\mathbf{c}^t$
$D^{t+1} \leftarrow D^t \cup \{i \in V \mid c_i^t < l_i^t\}$.
end for
end procedure

The algorithm uses the *fictitious default algorithm* proposed by Eisenberg and Noe (2001) as a subroutine. The latter is an efficient algorithm to recover the clearing payment vector at a given time. Using the fact that the fictitious default algorithm will take at most n steps to recover the clearing payment in each time interval, the proposed algorithm will terminate in $n(T+1)$ steps.

B. Systemic Graph and Measures

We measure the systemic risk across two dimensions: default cascades occurring across time (domino effect), and default clustering, that is, blocks of nodes defaulting on a fixed time. Before proceeding further, we review the concept of a strongly connected component of a graph. Given a graph G, a component C is said to be *strongly connected* if for any pair x, y of nodes in C, there exists at least a directed path from x to y in the subgraph induced by C, and all directed paths only cross nodes in C. Notice that, given two strongly connected components C_1 and C_2, there exists no direct edge from a node in C_1 to a node in C_2.

We construct an acyclic graph, called the *systemic graph*, which consists of clusters of two types: *source* and *contaminated*. Such clusters are obtained from the execution of the algorithm 1 as follows. Let $\{D^1, D^2, \ldots D^T\}$ be the time sequence of default sets.

- t =1. Denote by $\{C_1^1, C_2^1 ..., C_i^1\}$ the clusters formed at t =1. Each cluster $C_j^1 \subset D^1$ is a strongly connected component of the subgraph of G induced by D^1. Each cluster C_j^1, $1 \leq j \leq i$ is called a *source* cluster. Next we compute the list of all nodes *contaminated* by each cluster C_j^1. A node y is contaminated by the cluster C_j^1, if there exists at least one node in C_j^1 that has liabilities towards y at time 1.
- $t = k$, $k \geq 2$. Denote by $\{C_1^k, C_2^k ..., C_l^k\}$ the clusters formed at $t = k$. If a cluster C_m^k contains at least one contaminated node, then its type becomes contaminated. If no node in the cluster C_m^k is contaminated, then the cluster is a source cluster. We insert a direct edge between C_i^h and C_l^k, $h < k$, if there exists a node in the cluster C_l^k, which was contaminated by a node in the cluster C_i^h.

In particular, notice that source clusters do not have incoming edges. Contaminated clusters, instead, must necessarily have incoming edges, but do not necessarily have outgoing edges. Some observations are in order. It may happen that two initially disconnected components of the systemic graph can later recombine into one component. If this happens at time t, it means that a cluster C_i^t is contaminated by two clusters C_j^s and C_k^s, formed at time $s < t$. The source clusters model the triggering components of the systemic failures and capture the clustering effect. The domino effect is measured by the maximum depth of the systemic graph (the higher the depth, the higher the effect).

C. Simulation Results

We provide an illustration of contagion and clustering effects captured by our framework. More specifically, we consider two different network configurations: (1) homogeneous interbank liabilities and (2) heterogeneous interbank liabilities. In the homogeneous case, liabilities between each pair of nodes are of similar size; in the heterogeneous case, each node always has higher netted liabilities towards lower indexed nodes (i.e., he needs to pays more than what he receives). Next, we present the results of Monte Carlo simulations under both scenarios. We consider a fully connected network of 40 nodes, and assume a time horizon $T = 40$, thus resulting in 40 payment periods. We fix the number of runs to 50. Throughout our simulations, we assume that the asset values underlying the call option liability follow geometric Brownian motions. We fix the strikes K_{ij}^t to 10 for all t and $i, j \in V$; the number of

Table 1. Monte-Carlo Statistics Reporting Systemic Components of the Network.

Mean Value of Measures	Homogeneous	Heterogeneous
(1) Maximum depth of domino chain	19.02	5.10
(2) Total number of defaulted nodes	32.84	40.00
(3) Elapsed time before all defaults occur	31.54	5.60
(4) Default propagating rate = (2) / (3)	1.05	7.54

options each node holds, N_{ij}^t, is 1 for all t and $i, j \in V$. The operating cash in inflow that each node has at time 0 is $\iota_i^0 = 120$, for $i \in V$. Homogeneous and heterogeneous liability matrices are characterized by the initial value of the asset. In the homogeneous case, the asset at time 0 is given by:

$$x_{ij}^0 = \begin{cases} 30 & for\ i, j \in V, i \neq j \\ 0 & for\ i, j \in V, i = j, \end{cases}$$

whereas in heterogeneous case, it is

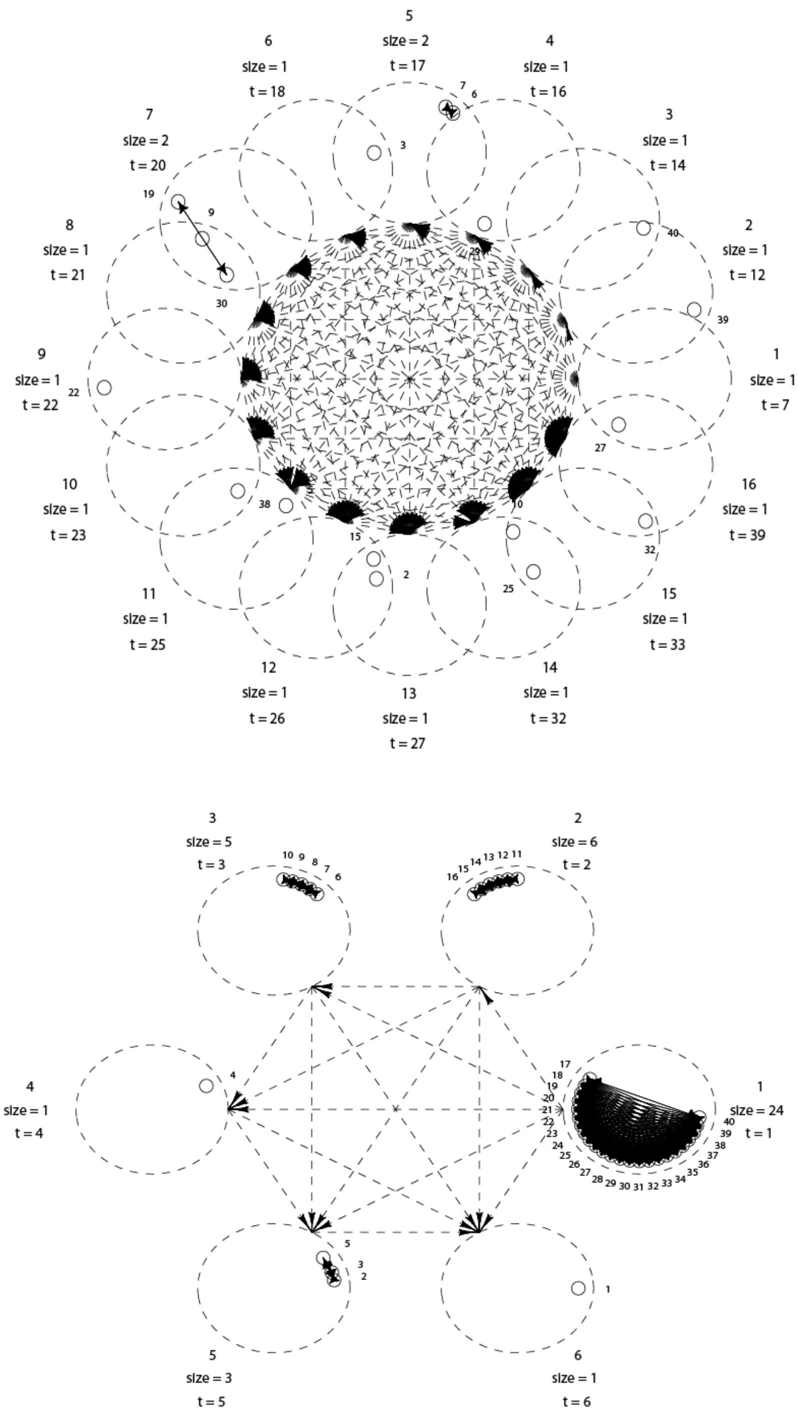
$$x_{ij}^0 = \begin{cases} 39 & for\ i, j \in V, i > j \\ 21 & for\ i, j \in V, i < j \\ 0 & for\ i, j \in V, i = j. \end{cases}$$

Systemic Graph. We start presenting the results obtained under a scenario where the asset values x_i^t's are assumed to be uncorrelated, and the diffusion coefficients are the same, that is, $\mu_i = 0.1$ and $\sigma_i = 0.4$ for all i. The relevant statistics are provided in Table 1. We also report the systemic graph extracted from a snapshot of our simulations in Figure 1.

Both Table 1 and Figure 1 show that when the network has a homogeneous liability structure, default events happen in cascade. As all nodes are equally liable and creditors to each other, the failure of a node on a given date does not impact significantly the currently solvent nodes within the network. On the other hand, when the network is heterogeneous, defaults cluster. This is because the reduced payments coming from defaulted nodes have a stronger immediate impact on the solvency state of the others. Indeed, when node N defaults, node $N - 1$ will receive a reduced payment from N and will have to pay all other nodes more than what it receives. This will trigger its default immediately and propagate recursively to lower indexed nodes, thus resulting in clusters with larger size.

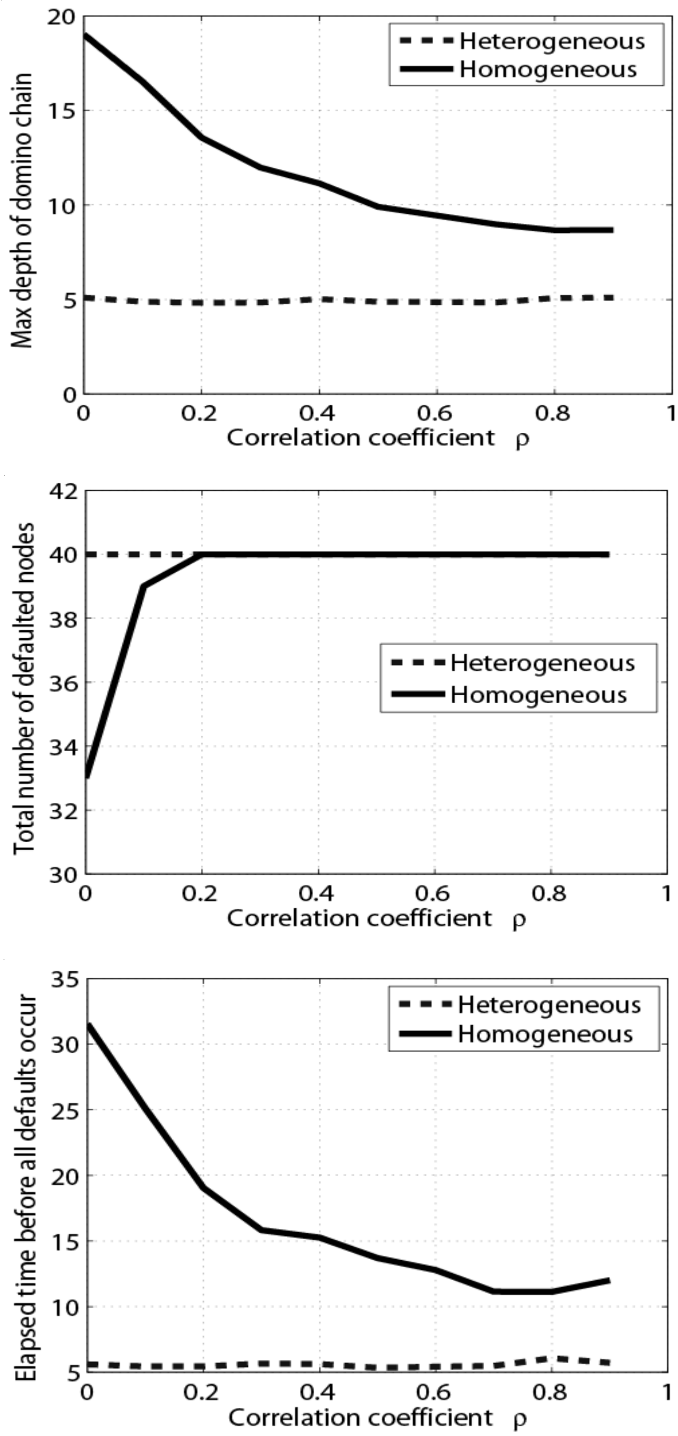
Such observed effects are consistent with empirical evidence provided in the academic literature by Angelini, Maresca, and Russo (1996), who analyzed the knock-on possibility within the Italian intraday netting system, and Furfine (2003), who considered the degree to which the failure of one bank would cause other failures in the federal fund market of the United States. A common theme of their results suggests that the scenario in which default events cluster depends on the systemic importance of the failing bank. We observe similar behaviors in our simulations, where in the homogeneous case none of the nodes is systemically

Figure 1. Systemic Graphs.



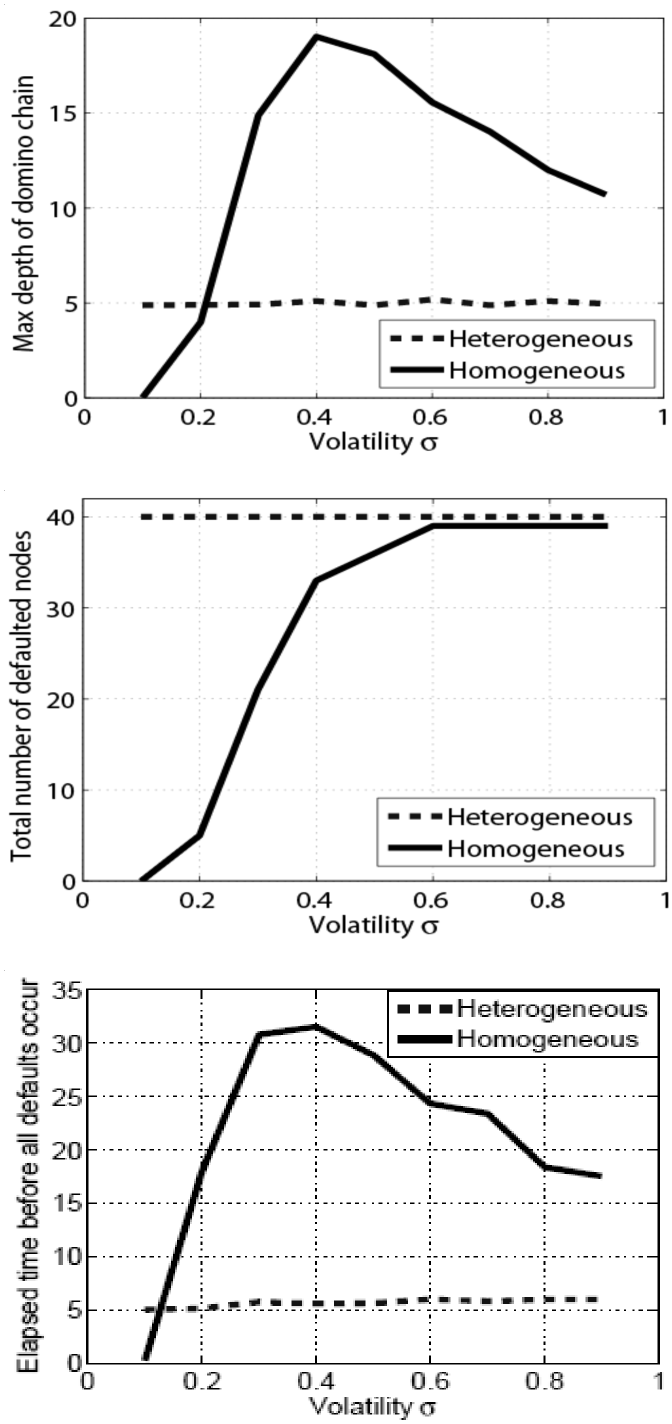
The top panel shows the systemic graph for the homogeneous case. The bottom panel shows the graph for the heterogeneous case. Arrows between nodes represent contamination relations.

Figure 2. Correlation Graphs.



All graphs are generated by assuming that all asset values are equally correlated with each other. The correlation parameter ρ is varied, while volatilities are always fixed to $\mu = 0.1$ and $\sigma = 0.4$.

Figure 3. Volatility Graphs.



All graphs are generated by assuming that all asset values are uncorrelated with each other, and have equal drift and volatility. We report the systemic behavior as a function of the volatility parameter σ.

more important than others, and consequently the failure of one node does not make significant knock-on impact on other nodes on the same date. On the other hand in the heterogeneous case, the larger liabilities owed by higher indexed nodes make them systemically more important than lower indexed nodes. Consequently they are able to trigger knock-on impact on the other nodes.

In practice, financial institutions with larger liabilities and size of exposures tend to be systemically more important according to the assessment methodology developed in Basel III (BCBS 2010). This is consistent with the results obtained in the heterogeneous case. Hence, they support the preventive measures against systemically important financial institutions suggested in Basel III (BCBS 2011), where such institutions are subject to higher capital requirements.

Another empirical study supporting our numerical results is the one conducted by Cont, Santos, and Moussa (2012). They show that the interbank Brazilian network exhibits a heterogeneous structure, both in terms of network connectivity and size of liability exposures. Indeed, there exists a strong positive correlation between the interbank liability size and the likelihood that default events cluster around a node. Their findings are consistent with results we obtain for the heterogeneous network structure, where we see that defaults of higher indexed node cluster at the earliest time due to their higher liabilities exposures.

They find that clusters of defaulted nodes are of small sizes and consist of systemically important nodes. In our numerical simulations, clusters are of larger size, most likely because we consider an extreme case where the network is fully connected, whereas the interbank Brazilian network may not be fully connected. We further remark that our framework captures not only the knock-on impact caused by the failing nodes but also the transmission effects propagating in cascade to the next dates.

Volatility and Correlation Effects. We analyze how volatility and correlation impact the systemic behavior of the network. Due to high heterogeneity of liability exposures in the heterogeneous configuration, both clustering and domino effects are mildly affected by increases in correlation or volatility. Differently, when the network is homogeneous, correlation increases will be associated with closer co-movements of the node's liability exposures and consequently result in larger default clustering (defaults are more likely to occur simultaneously), and shorter default cascades. This is clearly captured in Figure 2, where we also see that increases in correlation reduce the time before all defaults occur.

Figure 3 shows that when volatility is small, few nodes default if the network has a homogeneous liability structure. As the liabilities exhibit a small fluctuation around the initial values, the payments that each node will receive from creditors will be sufficient to repay debtors (also consider that each node has operating cash inflows to use). As volatility increases, the optionality embedded in the liability exposures will increase the risk, and consequently result in a larger number of defaults, and more noticeable domino effects. However, when the volatility becomes too large, the further amplification introduced by the optionality in interbank liabilities will make the network become more heterogeneous, and consequently result in a larger cluster and smaller domino effect.

IV. CONCLUSIONS

We developed a multi-period clearing payment system building on the approach originally proposed by Eisenberg and Noe (2001). Our framework is able to capture the systemic effects of default propagation within a financial network over a time horizon. We analyze both domino and clustering effects arising in the financial network. We have shown that there exists a unique clearing payment sequence and provided an algorithm to recover it. We introduced a novel object, the systemic graph, to precisely quantify the cascade and clustering phenomena appearing in the network.

In order to assess the behavior of the network in highly volatility environments, we specialized our framework to the case when the term structure of liabilities consists of call options. We numerically analyzed the clustering and domino effect in the network under two relevant cases, namely homogeneous and heterogeneous liability structures. Our results indicate that default cascades are common when interbank liabilities are homogeneous. On the contrary, when the network is heterogeneous, default events cluster as the reduced payments coming from defaulted entities have a stronger impact on the solvency state of the remaining entities. Higher correlations between interbank liabilities make the domino effect smaller, and default clustering higher. While small volatilities have a minor impact on the default status of the network, higher values will make simultaneous default occurrences more likely.

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THE IMPACT OF DERIVATIVES REGULATIONS ON THE LIQUIDITY AND PRICING EFFICIENCY OF EXCHANGE TRADED DERIVATIVES

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This paper looks at the impact of derivatives regulation on liquidity and mispricing of US derivatives markets. In particular, we test the hypothesis that Dodd-Frank derivative provisions may improve the efficiency of the exchange traded markets due to an increase of arbitrage by traders on the exchange traded markets, as opposed to the OTC markets. The alternative hypothesis is that Dodd-Frank adversely affects the OTC markets relative to the exchange traded markets, as trading in both the former and the latter may be confounded due to additional "noise." To test these hypotheses, we examine the impact of key Dodd-Frank events on market activity for financial derivatives (futures and option contracts on US T bonds, Eurodollar futures and options, and S&P 500 Futures contracts) and on foreign exchange derivatives (futures and options contracts on EUROs, British Pounds, and Canadian dollars). First, we look at how liquidity on the markets has been affected. Next, we test for mispricing of derivatives contracts. We find that measured liquidity does fall for US financial futures and options but rises for foreign exchange futures and options subsequent to the introduction of the Treasury guidelines for over-the-counter (OTC) trading. We also find that the efficiency of the US exchange traded futures markets has improved, as reflected by a reduction in mispricing in the S&P futures contracts; some improvement in pricing efficiency is also shown for nearby Eurodollar futures contracts. These results are consistent with an increase of arbitrage by traders on the exchange traded markets, as opposed to the OTC markets, in contrast to the "noise" model.

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The financial crisis has given rise to increased regulatory activism around the world. In the United States, policy makers responded to widespread calls for regulatory reform to address perceived supervisory deficiencies with the Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank). One of the criticisms of Dodd-Frank is that the uncertainty of its provisions, such as section 13 of the Bank Holding Company Act (the "Volker Rule"), will increase volatility and adversely affect market efficiency. Some commentators, for example Greenspan (2011) and Duffie (2012), have suggested that Dodd-Frank will have undesirable implications to the markets in general, by lowering the quality of information about fundamentals, which would reduce efficient price discovery, as well as through a reduction of liquidity. However, this may be offset through a migration of market making and investment activities to other trading venues. Duffie (2012) discusses problems associated with migration to non-bank firms such as hedge funds and insurance companies. This paper looks at the implications of another possible conduit for trade migration: ***the redirection of trades from the OTC markets to that of exchange traded derivatives.*** Such a redirection could be expected to the extent that the exchange traded markets substitute for the OTC markets (see, e.g., Switzer and Fan 2007). A migration from the OTC markets that increases activity in exchange traded derivatives in general, which benefit from volatility, might be posited to improve the efficiency of the latter.

How regulatory changes per se affect market liquidity and efficiency remain open questions in the literature. The events surrounding key Dodd-Frank regulations provide a useful setting to add to the literature on how the regulatory process can affect the behavior of market participants, as reflected in trading volume and efficient pricing of exchange traded derivatives. The remainder of this paper is organized as follows. In Section I, we look at the impact of key Dodd-Frank event dates on the liquidity of US financial derivatives markets. In Section II we look at pricing efficiency based on the cost-of carry for S&P futures contracts. In Section III, we look at deviations of futures from implied forward prices for Eurodollar contracts. The paper concludes with a summary in Section IV.

I. DODD-FRANK AND THE LIQUIDITY OF DERIVATIVES MARKETS

In this section, we look at the impact of Dodd Frank on the liquidity of US derivatives markets. A key driver in previous studies of market liquidity is volatility, which, as mentioned previously, might be expected to increase, given the uncertainty in the implementation of Dodd-Frank regulations. Clark (1973) asserts that an unobservable factor that reflects new information arrival affects both volume and volatility. Tauchen and Pitts (1983) propose two theoretical explanations for the co-movement of volatility and trade volume in markets. Chen, Cuny, and Haugen (1995) examine how volatility affects the basis and open interest of stock index futures. In their model, an increase in volatility entices more traders into the market to share the risk. Rather than reducing risk exposure through selling stocks, investors take advantage of the derivatives markets; for example, they share risk by selling the S&P 500 futures, which causes open interest to increase. Their results are consistent with this model. When there is a large positive shift in volatility, a strong positive relation between volatility and open interest is observed.

Our model reexamines the linkages for volume and volatility, extending the Chen et al. (1995) and Bhargava and Malhotra (2007) studies using more recent data. We also incorporate structural shifts associated with key Dodd-Frank announcement days for a wider variety of derivative products into the models. We look at financial derivatives: futures and option contracts on US T bonds and Eurodollars as well as S&P 500 futures contracts. We also look at foreign exchange derivatives: futures and options contracts on EUROs, British Pounds, and Canadian dollars.

Our objective is to look at a full range of market derivative products as they might be affected by Dodd-Frank. We chose to look at the derivative products separately, which allows us to abstract from possible distortionary effects that may affect specific instruments. For example, futures contracts would not be subject to "moneyness" biases such as are typically found in exchange traded options.

The basic regression of open interest extends Chen et al. (1995) and Bhargava and Malhotra (2007) as follows:

$$OpenInterest_r = a_0 + a_1\, OpenInterest_{t-1} + a_2 HistoricalVar_t + a_3\, DoddFrank_t + \in_t \quad (1)$$

where OpenInterest is the sum of open interest across the relevant contracts, and HistoricalVar is the historical volatility of the underlying asset. *DoddFrank* is a dummy variable equal to one at the date of and subsequent to three "watershed" Dodd-Frank announcement dates.[1] We use open interest, rather than trading volume, as our measure of liquidity to capture how restrictions on OTC markets entice new participants to migrate to the exchange traded markets. This is in the same spirit as Chen et al. (1995), who focus on the role of volatility in inducing new market participants. Using volume as a measure of liquidity would not necessarily capture market migration effects. Trading volume could increase in a market due to entry or exit, which would not allow us to isolate the direction of the migration effect.

The selection of key announcement dates involved the consideration of a number of issues relevant to testing for the impact of financial regulations. First, we wanted to ensure that the announcement dates do not coincide with any other major regulatory announcements, or financial industry specific announcements. In addition, we wanted to identify major events in which specific measures by which regulatory intent will be implemented. Dodd-Frank follows standard procedure in the development of US financial regulation: Its promulgation is a consideration for politicians, while its

1. The Dodd-Frank dummy variables are equal to one beginning on the date of each announcement until the end of the sample. This allows us to test if the announcements have separate effects, as well as to identify when the Dodd-Frank measures get imparted into the markets. For example, if each of the breakpoint dummy variables is significant, this would suggest that Dodd-Frank is a continuous process with distinct episodes.

implementation is the responsibility of the regulatory agencies mandated by the legislation itself (Fullenkamp and Sharma 2012). As a result, one must draw a distinction between regulatory events relating to Dodd-Frank, which we will refer to as "mandates," that is, those which specify what regulatory deficiency is to be addressed and by whom, versus "implementation" related events, which specify actions that will be taken, or specify measures to be included in rules enforced by regulators. We choose as announcement events "implementation" date events, since they are most relevant to market participants.

Our first event occurs on **August 11, 2009**, when the Treasury formally submitted to Congress, a "Proposed OTC Derivatives Act," which called for central clearing and more stringent oversight of OTC markets through stricter recordkeeping and data-reporting requirements. In addition, the Treasury proposal outlined the need for greater capital and margin requirements for OTC market participants, with the intention of increasing the overall stability of the financial system. This event represents an important moment in defining the shape of OTC legislation, and was the basis for much of what would later become the OTC portion of HR 4173 (the House version of what would later become Dodd-Frank). This proposal was highly implementation-related and provided financial institutions around the world a foretaste of forthcoming OTC regulation, and the concomitant compliance costs.

The second selected event occurs on **June 25, 2010**, with the completion of the reconciliation of the House and Senate versions of the bill. By the afternoon of the 25th an outline of the final version of Dodd-Frank was released to the public. The implementation of the Act was widely expected to have a negative impact on the operation of many financial institutions. However, the impact of the announcement on the markets might be expected to be somewhat muted, given the advanced scrutiny of market participants of the House and Senate proposals. Furthermore, many components of the reconciled version of the bill were considered as *favorable news*, since they were less harsh than initially proposed in the original House and Senate versions (Paletta 2010).

Our third selected event is **October 6, 2011**, which is the first trading day following the leak of a memorandum containing a draft of the Volcker Rule, ahead of the scheduled (October 11) FDIC conference (McGrane and Patterson 2011). The Volcker Rule prohibits banks or institutions that own banks from engaging in proprietary trading on their own account, that is, trading that is not at the behest of clients. Furthermore, banks are proscribed from owning or investing in hedge funds or private equity funds. From a financial economics perspective, the rule may seem to undermine market completeness, by potentially eliminating arbitrage activities by important financial agents. The Volker rule leak event is a surprise that contains salient material information that was confirmed at the formal release date. In an efficient market, one might expect that the market response to this event subsumes the effects of the formal release date announcement. Switzer and Sheahan-Lee (2013) show that this is indeed the case in their study of bank stock price reactions to the Volker rule.

Table 1. Open Interest Regressions for Futures Contracts.

Underlying asset	model	Independent variables				Durbin Watson statistic	Adj. R squared
Treasury Date		intercept	DoddFrank	HistVar	Lag(OI)		
Eurodollar	Model1	9251274	-1065095			.01	.118
		(163.6)**	(-13.88)**				
	Model2	9830834	-1599466	-331296.7		.01	.163
		(114.5)**	(-16.6)**	(-8.8)**			
	Model3	44314.62	-10497.8	-5957	.996	2.104	.99
		(1.76)	(-1.24)	(-4.2)**	(378.8)**		
10 yr treasury bond	Model1	1943392	-336060.8			.005	.107
		(103.2)**	(-13.144)**				
	Model2	2807549	-694123	-11779.5		.042	.81
		(190.96)**	(-54.37)**	(-72.81)**			
	Model3	11180	-1240.9	-46.88	.995	2.03	.996
		(2.28)*	(-.5953)	(-2.9)**	(484.9)**		
S&P 500	Model1	583236.5	-263534.9			.18	.768
		(207.1)**	(-68.89)**				
	Model2	591289	-268520.7	-7.99		.18	.77
		(166.2)**	(-66.37)**	(-3.68)**			
	Model3	48535.6	-21778	.72	.915	2.37	.962
		(7.62)**	(-6.745)**	(1.28)	(84.6)**		
EURO	Model1	181030.9	53776.24			.082	.21
		(88.98)**	(19.45)**				
	Model2	212982	49879.5	-235.37		.097	.33
		(77.16)**	(19.45)**	(-15.79)**			
	Model3	9322.5	2494.2	-9.11	.955	2.324	.937
		(5.57)**	(2.84)**	(-2.52)*	(124.97)**		

Table 1, continued. Open Interest Regressions for Futures Contracts.

Underlying asset	model	Independent variables				Durbin Watson statistic	Adj. R squared
Treasury Date		intercept	DoddFrank	HistVar	Lag(OI)		
British pound	Model1	113906.8	13799.4			.085	.04
		(88.16)**	(7.86)**				
	Model2	130831.8	7317.9	-111.27		.097	.16
		(77.43)**	(4.3)**	(-14.33)**			
	Model3	5492.44	541.96	-2.85	.96	2.247	.92
		(5.16)**	(1.024)	(-1.53)	(122.35)**		
Canadian dollar	Model1	111022	7549.5			.084	.017
		(100.7)**	(5.04)**				
	Model2	141505.8	-2678.46	-169.02		.147	.434
		(112.58)**	(-2.27)*	(-32.5)**			
	Model3	6033.59	262.38	-3.61	.95	2.124	.92
		(5.63)**	(.59)	(-2.55)*	(117.3)**		
Conference Date							
Eurodollar	Model1	8753293	-206776.1			.0088	.0036
		(168.46)**	(-2.48)*				
	Model2	8708810	-166234.9	32889.16		.0089	.0035
		(122.1)**	(-1.76)	(.91)			
	Model3	31502.5	-5360.91	-5663.5	.997	2.106	.99
		(1.42)	(-0.67)	(-4.066)**	(402.9)**		
10 yr treasury bond	Model1	1806861	-117851.4			.004	.012
		(105.5)**	(-4.285)**				
	Model2	2492980	-402082.2	-10124.98		.0145	.55
		(122.8)**	(-20.27)**	(-41.17)**			
	Model3	10707	-1659.6	-46.48	.996	2.035	.996
		(2.67)**	(-.88)	(-3.08)**	(538.8)**		

Table 1, continued. Open Interest Regressions for Futures Contracts.

Underlying asset	model	Independent variables				Durbin Watson statistic	Adj. R squared
Conference Date		intercept	DoddFrank	HistVar	Lag(OI)		
S&P 500	Model1	530416.6	-231922.6			.096	.57
		(159.7)**	(-43.5)**				
	Model2	518902	-226227.7	14.12		.098	.577
		(127.98)**	(-41.77)**	(4.97)**			
	Model3	23971.96	-10292	.887	.95	2.41	.96
		(5.49)**	(-4.2)**	(1.57)	(116.9)**		
EURO	Model1	184746.7	65595.9			.093	.297
		(111.37)**	(24.61)**				
	Model2	217938.6	65304.77	-260.92		.118	.44
		(96.247)**	(27.51)**	(-19.34)**			
	Model3	10787.87	3331.4	-10.29	.95	2.3165	.937
		(6.11)**	(3.485)**	(-2.84)**	(116.1)**		
British pound	Model1	113494.2	20359.54			.089	.085
		(104)**	(11.61)**				
	Model2	128487.6	13379.33	-101.94		.0998	.184
		(83.59)**	(7.69)**	(-13.15)**			
	Model3	5648.17	804.2	-2.68	.95	2.245	.92
		(5.4)**	(1.45)	(-1.44)	(119.9)**		
Canadian dollar	Model1	110797.8	11135.5			.086	.0356
		(117.3)**	(7.34)**				
	Model2	140981.8	-2300.15	-169.26		.147	.433
		(117.88)**	(-1.86)	(-31.71)**			
	Model3	6034.4	445.7	-3.45	.95	2.124	.92
		(5.71)**	(.97)	(-2.41)*	(116.89)**		

Table 1, continued. Open Interest Regressions for Futures Contracts.

Underlying asset	model	Independent variables				Durbin Watson statistic	Adj. R squared
Volker Date		intercept	DoddFrank	HistVar	Lag(OI)		
Eurodollar	Model1	8747749	-461355.5			.012	.0089
		(197.86)**	(-4.2)**				
	Model2	8718387	-434382	28606.4		.011	.009
		(156.5)**	(-3.8)**	(.867)			
	Model3	31516	-7810.8	-5582.9	.997	2.106	.99
		(1.43)	(-.75)	(-4.078)**	(401.3)**		
10 yr treasury bond	Model1	1771717	-65440.87			.004	.0015
		(120.44)**	(-1.79)				
	Model2	2335538	-322681.5	-9182.8		.011	.469
		(121.7)**	(-11.66)**	(-35.45)**			
	Model3	9545.3	-785.55	-43.55	.996	2.03	.996
		(2.53)*	(-.32)	(-2.95)**	(546.99)**		
S&P 500	Model1	475707	-217245.9			.0576	.285
		(130.2)**	(-23.95)**				
	Model2	452209.1	-210602.6	33.65		.061	.328
		(104.8)**	(-23.87)**	(9.6)**			
	Model3	13382.7	-6170.3	.834	.97	2.437	.96
		(4.33)**	(-2.45)*	(1.468)	(151.6)**		

Table 1, continued. Open Interest Regressions for Futures Contracts.

Underlying asset	model	Independent variables				Durbin Watson statistic	Adj. R squared
Volker Date		intercept	DoddFrank	HistVar	Lag(OI)		
EURO	Model1	192693.3	108303.7			.124	.461
		(155.3)**	(35.05)**				
	Model2	223700	105547.4	-241.1		.162	.585
		(120.8)**	(38.88)**	(-20.7)**			
	Model3	14633.4	7525.6	-11.27	.93	2.3	.938
		(7.3)**	(5.22)**	(-3.11)**	(100.43)**		
British pound	Model1	112739	53600.8			.124	.34
		(142.24)**	(27.15)**				
	Model2	123867	48111.02	-84.96		.139	.41
		(110)**	(25.19)**	(-13.2)**			
	Model3	7451.7	3005.98	-2.95	.94	2.23	.92
		(6.5)**	(3.56)**	(-1.63)	(100.54)**		
Canadian dollar	Model1	112293.8	17473.83			.087	.05
		(140.15)**	(8.76)**				
	Model2	137568.4	7977.5	-160.88		.149	.44
		(136.78)**	(5.12)**	(-31.73)**			
	Model3	6242.1	931.03	-3.56	.95	2.123	.92
		(5.96)**	(1.55)	(-2.55)*	(115.5)**		

This table shows the results of the regressions for open interest for Exchange Traded Futures Contracts' three models:

Model 1: $OpenInterest_r = a_0 + a_1\ DoddFrank_t + \epsilon_t$ (1a)

Model 2: $OpenInterest_r = a_0 + a_1\ HistoricalVar_t + a_2 DoddFrank_t + \epsilon_t$ (1b)

Model 3: $OpenInterest_r = a_0 + a_1\ OpenInterest_{t-1} + a_2 HistoricalVar_t + a_3\ DoddFrank_t + \epsilon_t$ (1c)

The panels: Treasury Date, Conference Date, and Volker Date show the results for the three Dodd-Frank structural break points: Aug.11, 2009, Jun.25, 2010, and Oct. 6, 2011, respectively. The numbers in the table give the coefficient estimate of the explainable variables and t-statistics in the parenthesis, with * significant at .05 level and ** significant at .01 level.

Table 2. Open Interest Regressions for Call Options.

Underlying asset	model	Independent variables				Durbin Watson statistic	Adj. R squared
Treasury Date		intercept	DoddFrank	HistVar	Lag(OI)		
Eurodollar	Model1	11110293	-6015890			.0454	.606
		(116.3)**	(-46.63)**				
	Model2	10759291	-5692162	199953.7		.045	.608
		(72.32)**	(-34.23)**	(3.07)**			
	Model3	236525.7	-147278	-2604.47	.98	1.37	.98
		(3.7)**	(-3.47)**	(-.52)	(179.8)**		
10 yr treasury bond	Model1	1044361	-295457.5			.11	.19
		(88.2)**	(-18.4)**				
	Model2	1316545	-408107.6	-3713.78		.14	.352
		(73.3)**	(-26.2)**	(-18.78)**			
	Model3	62063.6	-17932.94	-37.22	.94	2.004	.91
		(5.55)**	(-2.85)**	(-.85)	(105.94)**		
S&P 500	Model1	280235.3	-98541.67			.18	.402
		(119.7)**	(-31.02)**				
	Model2	292412	-106068.5	-12.01		.187	.42
		(99.82)**	(-31.9)**	(-6.74)**			
	Model3	25197.6	-8884.03	.36	.91	2.022	.898
		(7.81)**	(-5.2)**	(.755)	(81.65)**		
EURO	Model1	57010.93	40980.92			.132	.357
		(53.25)**	(28.2)**				
	Model2	61767.56	40386.56	-34.92		.134	.364
		(39.42)**	(27.8)**	(-4.14)**			
	Model3	3851.2	2786.324	-.945	.93	2.078	.92
		(5.27)**	(4.29)**	(-.403)	(99.1)**		

Table 2, continued. Open Interest Regressions for Call Options.

Underlying asset	model	Independent variables				Durbin Watson statistic	Adj. R squared
Treasury Date		intercept	DoddFrank	HistVar	Lag(OI)		
British pound	Model1	14434	5351.49			.069	.095
		(45)**	(12.3)**				
	Model2	13760.5	5610.7	4.41		.069	.0975
		(30.7)**	(12.44)**	(2.15)*			
	Model3	480.4	204.13	.166	.96	2.097	.938
		(3.37)**	(1.65)	(.41)	(139.7)**		
Canadian dollar	Model1	17127.6	3574.84			.145	.085
		(75.26)**	(11.58)**				
	Model2	18252.39	3195.3	-6.22		.147	.097
		(53.7)**	(10.03)**	(-4.43)**			
	Model3	1301.78	247.2	-.378	.93	2.007	.87
		(6.5)**	(1.99)*	(-1.06)	(93.25)**		
Conference Date							
Eurodollar	Model1	9846937	-5189630			.03	.434
		(99.765)**	(-32.95)**				
	Model2	8682386	-4128451	862583.6		.034	.497
		(68)**	(-24.5)**	(13.32)**			
	Model3	122577.7	-78891.6	-561.69	.99	1.37	.98
		(2.57)*	(-2.21)*	(-.11)	(215.6)**		
10 yr treasury bond	Model1	954910.7	-182905.5			.096	.07
		(86.96)**	(-10.4)**				
	Model2	1148330	-262925.9	-2856.9		.108	.167
		(63.11)**	(-14.8)**	(-12.95)**			
	Model3	48142.63	-10401.12	-13.86	.95	2.012	.912
		(5.18)**	(-1.79)	(-.33)	(115.75)**		

Table 2, continued. Open Interest Regressions for Call Options.

Underlying asset	model	Independent variables				Durbin Watson statistic	Adj. R squared
Conference Date		intercept	DoddFrank	HistVar	Lag(OI)		
S&P 500	Model1	252705.4	-66912.3			.13	.177
		(106.4)**	(-17.58)**				
	Model2	253385.6	-67318.75	-.664		.131	.177
		(86.53)**	(-17.24)**	(-.324)			
	Model3	16474.3	-4314.2	.4896	.933	2.045	.896
		(6.51)**	(-2.89)**	(1.02)	(96.39)**		
EURO	Model1	70475.94	22605.8			.094	.104
		(64.5)**	(12.88)**				
	Model2	77757.68	22523.93	-57.1		.096	.12
		(46.88)**	(12.98)**	(-5.79)**			
	Model3	3554.784	879.3	-1.88	.95	2.096	.92
		(4.85)**	(1.56)	(-.8)	(118.7)**		
British pound	Model1	15762.41	4059.68			.0658	.052
		(55.59)**	(8.92)**				
	Model2	15254.19	4296.9	3.45		.0659	.053
		(36.1)**	(8.99)**	(1.62)			
	Model3	536.5	52.03	0.033	.97	2.099	.939
		(3.82)**	(.42)	(0.08)	(143.25)**		
Canadian dollar	Model1	18241.72	2129.7			.137	.0285
		(89.99)**	(6.55)**				
	Model2	19629.34	1510.4	-7.76		.139	.046
		(59.13)**	(4.4)**	(-5.25)**			
	Model3	1325.2	92.56	-.462	.93	2.012	.87
		(6.565)**	(.74)	(-1.27)	(96.5)**		

Table 2, continued. Open Interest Regressions for Call Options.

Underlying asset	model	Independent variables				Durbin Watson statistic	Adj. R squared
Volker Date		intercept	DoddFrank	HistVar	Lag(OI)		
Eurodollar	Model1	8568632	-4635147			.02	.198
		(85.6)**	(-18.74)**				
	Model2	7197107	-3375860	1343922		0.028	.38
		(65.04)**	(-14.94)**	(20.43)**			
	Model3	66109	-52370.7	344.7	.99	1.37	.984
		(1.85)	(-1.33)	(.07)	(254.4)**		
10 yr treasury bond	Model1	930473.3	-288697.6			.1	.1
		(100.9)**	(-12.6)**				
	Model2	1090577	-361633.8	-2610.87		.112	.186
		(69.56)**	(-16.02)**	(-12.32)**			
	Model3	47163.43	-14413.33	-10.9	.95	2.011	.912
		(5.28)**	(-1.86)	(-.26)	(113.7)**		
S&P 500	Model1	239697.8	-80069.5			.126	.145
		(115.96)**	(-15.63)**				
	Model2	236505.4	-79205.1	4.65		.126	.148
		(94.1)**	(-15.44)**	(2.28)*			
	Model3	15337.2	-5402.96	.574	.935	2.046	.896
		(6.56)**	(-2.8)**	(1.2)	(97.7)**		

Table 2, continued. Open Interest Regressions for Call Options.

Underlying asset	model	Independent variables				Durbin Watson statistic	Adj. R squared
Volker Date		intercept	DoddFrank	HistVar	Lag(OI)		
EURO	Model1	78804.4	2755.5			.084	.00018
		(79.9)**	(1.12)				
	Model2	86238.8	2082.26	-57.69		.086	.02
		(51.9)**	(.86)	(-5.53)**			
	Model3	3579.6	102.3	-2.02	.96	2.101	.92
		(4.82)**	(.14)	(-.86)	(125.8)**		
British pound	Model1	18091.86	-4666.6			.065	.039
		(74.2)**	(-7.69)**				
	Model2	18897.13	-5064.56	-6.14		.066	0.044
		(51.6)**	(-8.17)**	(-2.94)**			
	Model3	618.2	-182.95	-.104	.97	2.099	.939
		(4.17)**	(-1.145)	(-.26)	(144.4)**		
Canadian dollar	Model1	18987.46	503.57			.133	.00023
		(108.1)**	(1.153)				
	Model2	20569.95	-92.3	-10.06		.138	.033
		(72.69)**	(-.21)	(-7.06)**			
	Model3	1354.88	-29.276	-.55	.93	2.013	.87
		(6.73)**	(-.184)	(-1.55)	(98)**		

Table 3. Open Interest Regressions for Put Options.

Underlying asset	model	Independent variables				Durbin Watson statistic	Adj. R squared
Treasury Date		intercept	DoddFrank	HistVar	Lag(OI)		
Eurodollar	Model1	9913346	-2859060			1.964	.0017
		(8.645)**	(-1.85)				
	Model2	8733923	-1771163	671011		1.965	.0015
		(4.87)**	(-.88)	(.86)			
	Model3	10114784	-3204726	-245737	.025	2.017	.0014
		(7.8)**	(-1.96)*	(-.81)	(.93)		
10 yr treasury bond	Model1	1113088	-244650			.123	.0994
		(77.59)**	(-12.58)**				
	Model2	1509601	-408757	-5410.2		.176	.358
		(73.59)**	(-22.97)**	(-23.95)**			
	Model3	79340.91	-18492.6	-84.34	.93	2.0145	.89
		(5.9)**	(-2.42)*	(-1.49)	(98.04)**		
S&P 500	Model1	597100.8	-282730			.112	.474
		(102.8)**	(-35.89)**				
	Model2	675232.7	-331318.2	-77.08		.143	.582
		(102.7)**	(-44.4)**	(-19.28)**			
	Model3	34925.35	-16810.2	-1.289	.944	2.051	.944
		(6.06)**	(-4.565)**	(-1.389)	(107.9)**		
EURO	Model1	889901.9	-754256			2.008	-.000004
		(1.597)	(-.997)				
	Model2	1500167	-830512	-4480		2.01	.000015
		(1.829)	(-1.09)	(-1.014)			
	Model3	1167628	-809494.7	-1922.1	-.0017	2.006	-.0012
		(1.575)	(-1.058)	(-.56)	(-.0625)		

Table 3, continued. Open Interest Regressions for Put Options.

Underlying asset	model	Independent variables				Durbin Watson statistic	Adj. R squared
		intercept	DoddFrank	HistVar	Lag(OI)		
Treasury Date							
British pound	Model1	2979498	-2955388			2.009	.00013
		(1.49)	(-1.087)				
	Model2	4540749	-3556383	-10230.8		2.009	-.00013
		(1.62)	(-1.26)	(-.8)			
	Model3	3314802	-3122135	-1927.6	-.0016	2.006	-.00125
		(1.29)	(-1.104)	(-.197)	(-.06)		
Canadian dollar	Model1	839297.2	-817494.9			2.0085	.00012
		(1.5)	(-1.08)				
	Model2	1012879	-876036.7	-959.92		2.009	-.00053
		(1.21)	(-1.115)	(-.277)			
	Model3	868780.9	-833018	-122.58	-.0015	2.006	-.0013
		(1.21)	(-1.067)	(-.052)	(-.055)		
Conference Date							
Eurodollar	Model1	9162239	-2081242			1.962	.00052
		(9.26)**	(-1.32)				
	Model2	7886180	-918272.8	943672.6		1.965	.0011
		(5.8)**	(-.51)	(1.37)			
	Model3	9155846	-2247551	-166877	0.03	2.017	.000028
		(8.31)**	(-1.38)	(-.56)	(.98)		
10 yr treasury bond	Model1	1027769	-122566			.113	.0234
		(79.59)**	(-5.92)**				
	Model2	1331522	-248233	-4486.6		.14	.207
		(65.3)**	(-12.48)**	(-18.15)**			
	Model3	64898.8	-9391.67	-53.88	.94	2.02	.891
		(5.66)**	(-1.29)	(-.98)	(104.3)**		

Table 3, continued. Open Interest Regressions for Put Options.

Underlying asset	model	Independent variables				Durbin Watson statistic	Adj. R squared
Conference Date		intercept	DoddFrank	HistVar	Lag(OI)		
S&P 500	Model1	523333	-205390			.0766	.239
		(86.7)**	(-21.23)**				
	Model2	559737.2	-223977.8	-43.23		.081	.276
		(77.06)**	(-23.13)**	(-8.51)**			
	Model3	19887.7	-7674.96	-.531	.963	2.068	.943
		(4.71)**	(-2.5)*	(-.583)	(132.7)**		
EURO	Model1	694985.3	-552382			2.008	-.00034
		(1.44)	(-.71)				
	Model2	1208766	-558159	-4028.7		2.009	-.000456
		(1.635)	(-.72)	(-.92)			
	Model3	917542.6	-577733	-1652.9	-.0012	2.006	-.0016
		(1.38)	(-.74)	(-.483)	(-0.05)		
British pound	Model1	2233283	-2209540			2.008	-.00026
		(1.29)	(-.795)				
	Model2	3684264	-2886892	-9841.3		2.009	-.00056
		(1.425)	(-.99)	(-.76)			
	Model3	2444251	-2327163	-1295.9	-.001	2.006	-.00165
		(1.06)	(-.802)	(-.13)	(-.044)		
Canadian dollar	Model1	632770.4	-610887.9			2.008	-.00026
		(1.31)	(-.79)				
	Model2	800416.8	-685691	-938.3		2.008	-.000916
		(1.004)	(-.83)	(-.264)			
	Model3	650308.1	-621690	-75.5	-.001	2.006	-.0017
		(.99)	(-.767)	(-.03)	(-.04)		

Table 3, continued. Open Interest Regressions for Put Options.

Underlying asset	model	Independent variables				Durbin Watson statistic	Adj. R squared
Volker Date		intercept	DoddFrank	HistVar	Lag(OI)		
Eurodollar	Model1	8717814	-2273364			1.961	.000134
		(10.34)**	(-1.09)				
	Model2	7690599	-1330059	1004727		1.965	.0012
		(7.25)**	(-.61)	(1.595)			
	Model3	8605641	-2327582	-116573	.027	2.017	-.00046
		(9.28)**	(-1.101)	(-.4)	(1.002)		
10 yr treasury bond	Model1	998020.3	-110962			.112	.0106
		(89.95)**	(-4.03)**				
	Model2	1240796	-221560	-3959		.134	.1615
		(67.95)**	(-8.43)**	(-16.04)**			
	Model3	60580.97	-7454.3	-43.7	.94	2.022	.891
		(5.68)**	(-.79)	(-.81)	(105.4)**		
S&P 500	Model1	474348.5	-190152			.066	.117
		(85.41)**	(-13.82)**				
	Model2	490943.4	-195047	-23.36		.067	.128
		(72.99)**	(-14.21)**	(-4.28)**			
	Model3	15606.6	-6391.75	-.312	.968	2.074	.943
		(4.42)**	(-1.71)	(-.345)	(143.5)**		

Table 3, continued. Open Interest Regressions for Put Options.

Underlying asset	model	Independent variables				Durbin Watson statistic	Adj. R squared
Volker Date		intercept	DoddFrank	HistVar	Lag(OI)		
EURO	Model1	545736.8	-403232.8			2.007	-.00059
		(1.33)	(-.39)				
	Model2	1074041	-451076.3	-4099.85		2.009	-.0007
		(1.53)	(-.44)	(-.93)			
	Model3	761500.4	-445672.4	-1627.4	-.001	2.006	-.0018
		(1.25)	(-.43)	(-.475)	(-.038)		
British pound	Model1	1637637	-1621303			2.007	-.00056
		(1.1)	(-.44)				
	Model2	2614011	-2103776	-7442		2.008	-.001
		(1.17)	(-.56)	(-.586)			
	Model3	1631748	-1621132	95.41	-.0008	2.0056	-.002
		(.83)	(-.43)	(.01)	(-.03)		
Canadian dollar	Model1	467626.5	-445398			2.007	-.00057
		(1.135)	(-.435)				
	Model2	500648.7	-457831.5	-209.93		2.007	-.0013
		(.74)	(-.44)	(-.06)			
	Model3	424198.3	-425316.4	282	-.0008	2.006	-.002
		(.762)	(-.41)	(.12)	(-.03)		

Table 4. Mispricing Series for S&P 500 Futures February 2004 – August 2012 (Pre vs. Post-OTC Guidelines[a]).

Panel A. Daily Data	02/04 – 08/09	08/09 – 08/2012	02/04 – 08/12
1. Average Mispricing			
N	1411	750	2161
Mean (%)	.000713	-.000130	.000420
Standard Deviation (%)	.002251	.001486	.002058
Minimum (%)	-.012880	-.007074	-.012880
Maximum (%)	.018113	.007743	.018113
t-statistic	11.89*	-2.39*	9.49*
t-statistic of difference between periods[b]			9.24*
2. Average Absolute Mispricing			
N	1411	750	2161
Mean (%)	.001487	.001085	.001348
Standard Deviation (%)	.001833	.001023	.001611
Minimum (%)	$1.89*10^{-7}$	$5.89*10^{-7}$	.000000189
Maximum (%)	.018113	.007743	.018113
t-statistic	30.47011*	29.04008*	38.90*
t-statistic of difference between periods[b]			5.56*

[a]The mispricing series are as defined in the equation $x_t = (F(t,T) - F^e(\text{t,T}))/P_t$ where $F_{(t,T)}$ is the actual index price, and $F^e_{(t,T)} = P_t e^{(r-d)(t-T)}$.
[b] The *t*-statistic measures the difference between the average mispricing between the Pre- and Post-OTC guideline periods.
(*) indicates significant at .01 level.

A. Data

Daily data of open interest for futures and options are collected from Bloomberg. The data cover the period from January 2007 to June 2012 (1,436 observations). The underlying assets include Eurodollar, 10 year Treasury Bond, S&P 500, and three foreign currencies (the EURO, the British Pound, and the Canadian dollar). The variances are estimated by historical 90 day and 10 day volatility of the underlying assets and are obtained from Bloomberg.

B. Empirical Results and Discussion

Table 1 below shows the estimation results for three variants of equation (1) for the futures contracts. The panels denoted — Treasury Date, Conference Date, and Volker Date — provide the results when the Dodd-Frank announcement date is August 11, 2009, June 25, 2010, and October 6, 2011, respectively.

Three variants of (1) are estimated:

Model1:

$$OpenInterest_r = a_0 + a_1\, DoddFrank_t + \epsilon_t \quad (1a)$$

Model 2:

$$OpenInterest_r = a_0 + a_1\ HistoricalVar_t + a_2 DoddFrank_t + \in_t \quad (1b)$$

Model 3:

$$OpenInterest_r = a_0 + a_1\ OpenInterest_{t-1} + a_2 HistoricalVar_t + a_3\ DoddFrank_t + \in_t \quad (1c)$$

On the whole, the results show some variation in the goodness of fit of the models across the different derivatives products examined, with better fits observed for the initial US treasury proposal on derivatives (August 11, 2009), so our discussion will focus on these results. Similar to Chen et al. (1995), we observe a positive effect of volatility on open interest for the S&P 500 futures contracts, when including lagged open interest in the equation (Model 3). This is consistent with the hypothesis that market volatility helps to induce participation in the S&P 500 futures contracts. However, the result is not statistically significant. In addition, it does not hold for the other futures contracts. On the contrary, volatility appears to reduce open interest for Eurodollar futures, T bond futures, and the three currencies examined.

The Dodd Frank structural breakpoints appear to be negatively associated with open interest, but only for the financial futures, that is, Eurodollar futures contract, T-bond future contracts and the S&P futures contracts. However, this relationship is not significant for the Eurodollar contracts and the T-bond contracts.[2] For two of the foreign currency futures contracts, the EURO and British pounds, open interest actually increases significantly subsequent to Dodd-Frank dates. For the Canadian dollar futures contracts, the open interest enhancing effects of Dodd-Frank are not significant, after taking into account historical volatility and lagged open interest effects. In sum, the results suggest that the assertion that Dodd-Frank has detrimental liquidity effects across all exchange traded derivatives products is not sustained.

Table 2 provides the estimates of the open interest regressions for the call option contracts. The results for call options are for the most part, qualitatively

2. It may be the case, as the referee pointed out, that the Dodd-Frank variable should not be expected to be the most significant factor underlying the secular decline in liquidity of the Eurodollar futures contract, which we further document in Section III below. This decline may be related to other important but extraneous factors, including the extremely low Federal funds rate (approximately zero) since January 2009. This may explain why, as we show in Table 1, the Dodd-Frank dummy variable becomes insignificant when we include historical volatility and lagged open interest as regressors. Another extraneous factor that may be important is the impact of LIBOR manipulation (the LIBOR scandal). In this vein Park and Switzer (1995) document evidence of market manipulation through private information in LIBOR settlement over the period June 1982–June 1992, many years before the formal exposure of the LIBOR scandal. If such manipulation is persistent through time, its effects along with any secular decline in open interest would be internalized in the lagged open interest variable, which is significant. We explore this issue further in Section III below. The first fines imposed concerning the LIBOR scandal occur on June 27, 2012, after our event date and estimation period date, when Barclays Bank was fined \$200 million by the Commodity Futures Trading Commission, \$160 million by the United States Department of Justice, and £59.5 million by the UK Financial Services Authority. Awareness of the breadth of the scandal accelerated in July 2010 when the US Congress began its investigation into the case.

similar to those of the futures contracts, with some exceptions. Historical volatility is positively associated with open interest for the S&P 500 contracts, as in Chen et al. (1995), but this effect is not significant when lagged open interest is included. Lagged open interest also appears to subsume volatility effects for the other contracts. Dodd-Frank dummy variables remain significantly negative, but only for the financial futures contracts. They are positive for the currency call options.

Table 3 provides the estimates of the Open Interest regressions for the Put Option contracts. The results differ for these contracts relative to the futures contracts and the call options contracts. In contrast with the call options, volatility has a negative effect on open interest, but similar to the call options regressions it is insignificant in the full model (Model 3) when lagged open interest is added as a regressor. Similar to the call options and futures contracts, the Dodd-Frank structural break points are associated with significantly declining open interest levels for the S&P futures and T-Bond futures contracts. However, the Dodd Frank dummy variables are not significant for any of the other market traded derivatives contracts.

To summarize, based on these results, measured liquidity does appear to fall for many US financial futures and options. Interestingly, the relationship is not significant for US T-bond futures or call options. This result may be due to expectations that T-bonds would be exempted from Dodd-Frank and the Volker rule. Such expectations have been justified by subsequent regulatory rulings. The significantly negative association of Dodd-Frank with the liquidity of the other financial derivative products is consistent with Duffie (2012). Increased liquidity of foreign currency derivatives, however, is not consistent with the fear expressed by Greenspan (2011), that "a significant proportion of the foreign exchange derivatives market would leave the US." However, this result need not rule out increased participation in the US foreign exchange derivative markets due to planned migration of asset holders and investors to foreign venues in order to escape the regulatory tax (Houston, Lin, and Ma 2012).

In the next section, we will examine the effects of Dodd-Frank on the efficiency of exchange traded futures contracts.

II. THE IMPACT OF DODD FRANK ON MISPRICING OF S&P FUTURES CONTRACTS

In this section, we test the hypothesis that Dodd-Frank derivative provisions may improve the efficiency of the exchange traded markets due to an increase of arbitrage by traders on the exchange traded markets, as opposed to the OTC markets. The alternative hypothesis is that Dodd-Frank adversely affects the OTC markets relative to the exchange traded markets, as trading in both the former and the latter may be confounded due to additional "noise" (see, e.g., Verma 2012).

The approach we take is to test for changes in mispricing of derivative contracts as a result of the introduction of Dodd-Frank regulations pertinent to derivatives markets.

A. Empirical Modeling

As in Switzer et al. (2000) the theoretical futures price used to test for market efficiency is the Cost of Carry relationship. As noted therein, the relationship is obtained from an arbitrage strategy that consists of a long position in the index portfolio, with a price P_0 and a short position in an equal amount of index futures, priced at F_0. Over time, the hedged strategy will yield a fixed capital gain of $F_0 - P_0$, as well as a flow of dividends. In the absence of dividend risk, the position is riskless and hence should earn the riskless rate of interest. To prevent profitable arbitrage, the theoretical equilibrium futures price at time t F_t^e can be written as:

$$F_t^e = P_t e^{r(T-t)} - D_{(t,T)} \tag{2}$$

where T is the maturity date and $D(t,T)$ is the cumulative value of dividends paid assuming reinvestment at the riskless rate of interest r up to date T is held until the futures contract expires.

We adopt a commonly used formula for mispricing for index futures (e.g., MacKinlay and Ramaswamy 1988; Bhatt and Cakici 1990; Switzer et al. 2000; Andane, Lafuente, and Novales 2009; and others). Assuming a constant dividend yield d, mispricing is measured as the difference between the actual futures price and its theoretical equilibrium price, deflated by the underlying index:

$$x_t = (F(t,T) - F_t^e)/P_t \tag{3}$$

where $F(t,T)$ is the actual index futures price, and $F_t^e = P_t e^{r-d(T-t)}$.

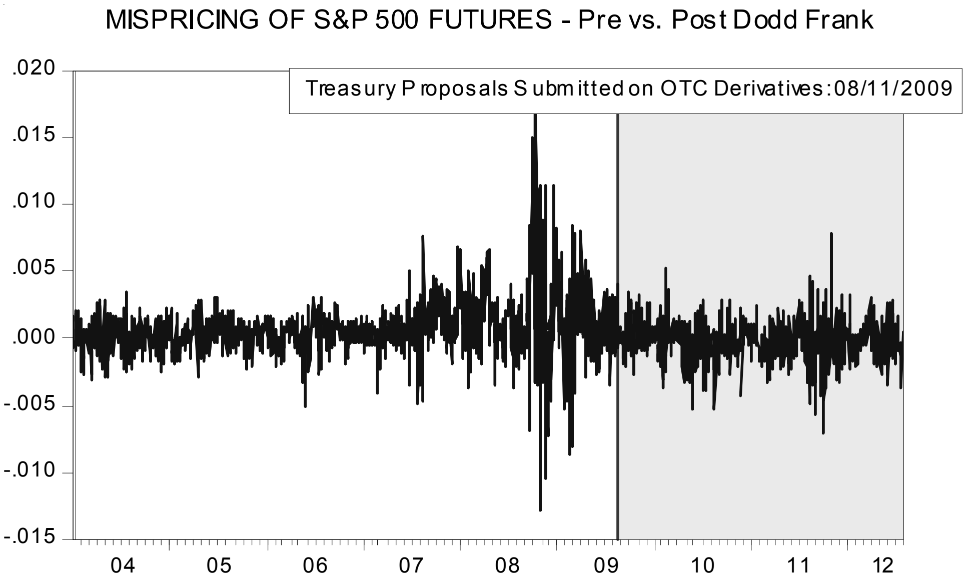
B. Description of the Data

The futures data used in this study are for the nearby Chicago Mercantile Exchange (CMER) S&P 500 Index futures contracts, and for the Eurodollar Futures Contracts for the period February 1, 2004, through July 31, 2012. We perform the analyses using daily data (2,161 observations). We use the actual daily dividend series for the S&P 500 obtained from Standard and Poor's. Daily three-month Treasury Bill rates from Bloomberg are used for the riskless rate of interest.

C. Empirical Results

Figure 1 shows the path of mispricing over the sample period. As is noted therein, the most severe periods of the financial crisis in 2008 were associated with extremely large levels of mispricing. The structural break point that we use is the onset of the Dodd-Frank regulatory period, which we define as the date of the Treasury submission of specific legislative proposals regarding derivatives to Congress, August 11, 2009. Our hypothesis is that arbitrage activities in the exchange traded markets would increase in anticipation of the final mandated restrictions on using OTC markets for this purpose. There is evidence of market participants'

Figure 1. Mispricing of S&P Futures Contracts for the Period 02/01/2004 to 31/07/2012.



reacting to anticipated changes in the regulatory environment. Indeed, an internal report from Deutsche Bank's head of government affairs for the Americas (leaked to the media on July 7, 2010) states that "opportunities for global regulatory arbitrage could be significant."[3] We noted in the previous section that this date appeared most significant as a watershed for open interest variations associated with Dodd-Frank across a wide variety of exchange traded contracts. Some evidence of a reduction of mispricing can be observed in Figure 1 in the shaded area to the right of the August 11, 2009 vertical line. This is confirmed in the statistical analyses. Table 4 shows that average mispricing has declined in the period subsequent to Dodd-Frank. Indeed the t statistics for a reduction in mispricing and a reduction in absolute mispricing are both significant at the 1% level.

Table 5 shows regression results for the signed mispricing series and for the absolute mispricing on a dummy variable that is equal to 1 on the day of and subsequent to of the Treasury OTC report release date dummy variable. Panel A shows the results for the signed mispricing regression, while Panel B uses the absolute mispricing series as the dependent variable. In both cases, the dummy variable coefficients are significant at the 1% level. These results provide further confirmation of the improved efficiency hypothesis, as opposed to the induced noise hypothesis. There was a very significant increase in mispricing prior to the Dodd-Frank related events that can be linked to the global financial crisis. Our basic point is that this mispricing has come down coincidentally to the new legislative efforts to regulate the markets. We might conjecture that given the high degree of volatility

3. See http://www.foxbusiness.com/markets/2010/07/07/deutsche-bank-rips-financial-reform/#ixzz2HmqZt0pX.

Table 5. Estimates of Daily Futures Mispricing.

Panel A

Dependent Variable is the signed mispricing series:

$$x_t = \alpha_0 + \alpha_1 dum_t + e_t$$

where dum is equal to 1 after August 11, 2009 (Treasury OTC Report Release Date) and 0 otherwise.

	Parameter	t-statistic	
a_0	.000713	13.260*	
a_1	-.000843	-9.238*	$R^2 = .0380$

Panel B

Dependent Variable is the absolute mispricing series

$$|x_t| = \beta_0 + \beta_1 dum_t + e_t$$

where dum is equal to 1 after August 11, 2009 (Treasury OTC Report Release Date) and 0 otherwise.

	Parameter	t-statistic	
a_0	.001487	34.927*	
a_1	-.000402	-45.568*	R^2=.0142

(*)indicates significance at .01 level

lingering in the markets, which may in part be associated with the continued regulative uncertainty, that it may be a long while before markets return to pre-crisis mispricing levels.

III. DODD FRANK AND THE DEVIATIONS OF EURODOLLAR FUTURES VERSUS FORWARD CONTRACTS

As a final test, we explore the impact of Dodd-Frank on pricing efficiency using the metric of the deviation of Eurodollar futures yields from implied forward contract rates. We use Eurodollar futures prices and 1, 3, 6, 9, and 12 month LIBOR quotations in the analysis. Daily Eurodollar futures prices and daily spot LIBOR quotations are obtained from the Bloomberg. Our sample period is from January 2007 through June 2012.

Three-month implied forward rates are computed from LIBOR spot quotations based on the the Grinblatt and Jegadeesh (1996) formula (with time measured in years):

$$f(s, s+0.25) = d(s, s+0.25)*[P(0, s)/P(0, s+0.25)-1] \quad (4)$$

where f(s, y) is the annualized Eurodollar forward rate at time 0 over the period s to y; d(s,y) is the LIBOR conversion factor, computed as 360/number of days between

Table 6. Futures-Forward Yield Differences – with Treasury Date Breakpoint.

Panel A

Year	DIFF0.25_0.5			DIFF0.5_0.75			DIFF0.75_1			T	
	Mean	Median	N	Mean	Median	N	Mean	Median	N	Avg. Volume	Avg. O.I.
01/07-06/12	-38.70 (-20.42)**	-27.08	285	-49.27 (- 25.20)**	-48.74	285	-62.43 (-26.17)**	-73.62	272	273,669	1,168,244
01/07-08/09	-46.76 (-13.00)**	-31.25	136	-39.87 (-10.96)**	-18.89	136	-42.48 (-10.90)**	-21.77	136	327,113	1,309,352
08/09-06/12	-31.29 (-25.02)**	-25.86	149	-57.84 (-41.37)**	-52.69	149	-82.39 (-62.25)**	-78.22	136	223,799	1,036,576

Table 6, continued. Futures-Forward Yield Differences – with Treasury Date Breakpoint.

Panel B

Year	DIFF1		DIFF2		DIFF3	
	Mean	Median	Mean	Median	Mean	Median
01/07-06/12	-39.02 (-6.04)**	-26.24	-50.39 (-7.71)**	-46.10	-64.53 (-7.57)**	-76.53
01/07-08/09	-46.65 (-3.45)**	-27.52	-43.20 (-3.28)**	-25.41	-47.57 (-3.20)*	-26.51
08/09-06/12	-33.15 (-6.86)**	-25.70	-56.38 (-11.51)**	-52.74	-81.49 (-17.51)**	-81.45

This table shows the difference in basis points between the futures and forward Eurodollar yields expressed in basis using weekly (Thursday) data from January 2007 through June 2012, using the Treasury Date 08/11/2009 as the Breakpoint. The table also reports the average volume and average open interest of weekly (Thursday) data of the four (or three) nearest maturity futures contracts for different sample periods. In Panel A, implied forward yields are computed from quoted LIBOR rates and futures yields are obtained by interpolating between the futures transaction prices. DIFF0.25_0.5 is the time t difference between the annualized futures and forward yields for the interval t+0.25 to t+0.5. DIFF0.5_0.75 and DIFF0.75_1 are the time t yield difference for the intervals t+0.5 to t+0.75 and t+0.75 to t+1, respectively.. Panel B reports the results using the spot LIBOR interpolation method to compute the implied forward rates. We use the 1, 3, 6, 9, and 12 month LIBOR quotations to fit a cubic spline to obtain the entire term structure of spot LIBOR rates for each date in our sample period. The implied forward rate, f(s, s+0.25), is computed from those interpolated LIBOR rates using equation (4), and is compared with futures rate F(s, s+0.25) of each of the three nearest maturing futures contracts. DIFF1 is the difference between the annualized 3-month futures and forward yields on the date of maturity of the nearest maturity futures contract. DIFF2 is the difference between annualized 3-month futures and forward yields on the date of maturity of the next-to-nearest maturity futures contract. DIFF3 is the difference between annualized 3-month futures and forward yields on the date of maturity of the third-to-nearest maturity futures contracts. N is the number of observations. The t-statistics are presented in parentheses ; ** denotes significance at the 1% level; *denotes significant at the 5% level.

Table 7. Futures-Forward Yield Differences – with Conference Date Breakpoint.

Panel A

Year	DIFF0.25_0.5			DIFF0.5_0.75			DIFF0.75_1				
	Mean	Median	N	Mean	Median	N	Mean	Median	N	Avg. Volume	Avg. O.I.
01/07-06/12	-38.70 (-20.42)**	-27.08	285	-49.27 (-25.20)**	-48.74	285	-62.43 (-26.17)**	-73.62	272	273,669	1,168,244
01/07-06/10	-43.19 (-15.35)**	-28.59	182	-47.47 (-15.89)**	-47.21	182	-54.25 (-16.31)**	-59.64	182	303,299	1,221,864
06/10-06/12	-30.68 (-23.34)**	-26.26	103	-52.44 (-45.82)**	-49.51	103	-78.98 (-52.78)**	-76.38	90	219,607	1,070,411

Table 7, continued. Futures-Forward Yield Differences – with Conference Date Breakpoint.

Panel B

Year	DIFF1		DIFF2		DIFF3	
	Mean	Median	Mean	Median	Mean	Median
01/07-06/12	-39.02	-26.24	-50.39	-46.10	-64.53	-76.53
	(-6.04)**		(-7.71)**		(-7.57)**	
01/07-06/10	-42.48	-26.79	-50.17	-46.61	-59.69	-63.41
	(-4.25)**		(-5.00)**		(-5.05)**	
06/10-06/12	-33.63	-26.05	-50.77	-46.10	-75.82	-76.53
	(-5.73)**		(-10.13)**		(-12.39)**	

This table shows the difference in basis points between the futures and forward Eurodollar yields expressed in basis using weekly (Thursday) data from January 2007 through June 2012, using the Conference Date 06/25/2010 as the Breakpoint. The table also reports the average volume and average open interest of weekly (Thursday) data of the four (or three) nearest maturity futures contracts for different sample periods. In Panel A, implied forward yields are computed from quoted LIBOR rates and futures yields are obtained by interpolating between the futures transaction prices. DIFF0.25_0.5 is the time t difference between the annualized futures and forward yields for the interval t+0.25 to t+0.5. DIFF0.5_0.75 and DIFF0.75_1 are the time t yield difference for the intervals t+0.5 to t+0.75 and t+0.75 to t+1, respectively.. Panel B of Tables 6 and 7 reports the results using the spot LIBOR interpolation method to compute the implied forward rates. We use the 1, 3, 6, 9, and 12 month LIBOR quotations to fit a cubic spline to obtain the entire term structure of spot LIBOR rates for each date in our sample period. The implied forward rate, f(s, s+0.25), is computed from those interpolated LIBOR rates using equation (4), and is compared with futures rate F(s, s+0.25) of each of the three nearest maturing futures contracts. DIFF1 is the difference between the annualized 3-month futures and forward yields on the date of maturity of the nearest maturity futures contract. DIFF2 is the difference between annualized 3-month futures and forward yields on the date of maturity of the next-to-nearest maturity futures contract. DIFF3 is the difference between annualized 3-month futures and forward yields on the date of maturity of the third-to-nearest maturity futures contracts. N is the number of observations. The t-statistics are presented in parentheses ; ** denotes significance at the 1% level; *denotes significant at the 5% level.

s and y and $P(s,y) = 1/[1+L_s(y\text{-}s)/d(s,y)]$ is the time s price of \$1 paid out at y in the Eurodollar market, and $L_s(y\text{-}s)$ is the (y-s) year LIBOR rate prevailing at time s. The futures rate is computed with the daily closing price of the futures contract (Futures Price_t) that matures on date s from the expression:

$$F(s, s+0.25; t) = 1\text{-Futures Price}_t/100. \tag{5}$$

where F(s,y,t) is the annualized futures rate at time t for the interval s to y.

The futures rate intervals do not in general coincide with the forward rate intervals. We replicate the two interpolation methods used by Grinblatt and Jegadeesh (1996) to align the intervals. With the futures interpolation method, we fit a cubic spline to the futures rates of the four nearest maturing contracts to construct an interpolated term structure of futures rates. We focus on futures contracts maturing in March, June, September, and December in our sample period. For each sampling date, we use the future prices of the four nearest maturing contracts on that date to fit a curve, and pick interpolated futures rates for intervals that coincide with the forward rate intervals to get F(0.25, 0.5), F(0.5, 0.75), and F(0.75, 1). We then compare these interpolated rates with the implied forward rates, f(0.25, 0.5), f(0.5, 0.75), and f(0.75, 1).

The analysis is performed using two breakpoints. Table 6 uses the Treasury Date (08/11/09) as the breakpoint, while Table 7 shows the results using the Conference date (06/25/2010) breakpoint. These tables present the differences between the futures and forward Eurodollar yields expressed in basis points employing weekly (Thursday) data from January 2007 through June 2012. We also include the average volume and average open interest of weekly (Thursday) data of the four (or three) nearest maturity futures contracts for different sample periods.

In Panel A of Tables 6 and 7, implied forward yields are computed from quoted LIBOR rates and futures yields are obtained by interpolating between the futures transaction prices. DIFF0.25_0.5 is the time t difference between the annualized futures and forward yields for the interval t+0.25 to t+0.5; DIFF0.5_0.75 and DIFF0.75_1 are the time t yield difference for the intervals t+0.5 to t+0.75 and t+0.75 to t+1, respectively; N is the number of observations.

Panel B (of both Tables 6 and 7) reports the results using the spot LIBOR interpolation method to compute the implied forward rates. We use the 1, 3, 6, 9, and 12 month LIBOR quotations to fit a cubic spline to obtain the entire term structure of spot LIBOR rates for each date in our sample period. The implied forward rate, f(s, s+0.25), is computed from those interpolated LIBOR rates using equation (4), and is compared with futures rate F(s, s+0.25) of each of the three nearest maturing futures contracts. DIFF1 is the difference between the annualized three-month futures and forward yields on the date of maturity of the nearest maturity futures contract. DIFF2 is the difference between annualized three-month futures and forward yields on the date of maturity of the next-to-nearest maturity futures contract. DIFF3 is the difference between annualized three-month futures and forward yields on the date of maturity of the third-to-nearest maturity futures contracts. We interpolated the four nearest maturity futures contracts starting from 1/2/2007 to 3/19/2012 to obtain F(.25, .5), F(.5, .75), and F(.75, 1). We interpolated the three nearest maturity futures contracts starting from 3/20/2012 to 6/19/2012 to obtain F(.25, .5) and F(.5, .75).

As is shown in these tables, aggregate trading volume and open interest in the Eurodollar contracts decline in the period of the study. Again, this is in part likely a consequence of the low Fed funds rate since January 2009. In general, we find that futures rates are below forward rates throughout the sample. This phenomenon is also observed in the latter part of the Grinblatt and Jegadeesh (1996) sample, which covers the period 1987–1992. The downward bias appears to be exacerbated in our sample, amounting to over 30 basis points for nearby contracts, and considerably more for the more distant contracts.

Some evidence of improved price efficiency is shown for the Dodd-Frank breakpoints for nearby contracts — ranging between 13 and 15 basis points, depending on whether we use the Treasury or Conference dates as breakpoints. The differential between futures and forward rates widens, however, for more distant contracts. This widening may be due to a shift to shorter maturity preferences for futures traders, with the increase in market uncertainty.

IV. SUMMARY AND CONCLUSIONS

This report provides new evidence on the impact of key Dodd-Frank events on market activity for financial derivatives (futures and option contracts on US T bonds, Eurodollar futures and options, and S&P 500 Futures contracts) and on foreign exchange derivatives (futures and options contracts on EUROs, British pounds, and Canadian dollars). First, we look at how liquidity on the markets has been affected. Next, we test for mispricing of derivatives contracts.

We find that measured liquidity does fall for US financial futures and options but rises for foreign exchange futures and options subsequent to the introduction of the Treasury guidelines for OTC trading. Specifically, the Dodd-Frank structural breakpoints appear to be negatively associated with open interest, but only for certain financial futures. However, this relationship is not significant for the Eurodollar contracts and the T-bond contracts. The lack of significance for the Eurodollar contracts may be due to the overwhelming effects of a decline in interest rates over the sample period, with the Fed maintaining the Fed funds rate at close to zero since January 2009. The lack of significance for T-bonds could be due to the expectation (which has been subsequently justified) of an exemption of T-bonds from Dodd-Frank and the Volcker Rule.

The significantly negative association of Dodd-Frank with the other financial derivative products is consistent with Duffie's (2012) hypothesis of a withdrawal of participants in markets for US assets (OTC and exchange traded) due to a reduction of quality of fundamentals. The increased liquidity of foreign currency derivatives, however, is not consistent with Greenspan's (2011) warning of an exodus of foreign exchange derivatives from the United States. However, our result may not preclude increased participation in the US foreign exchange derivative markets due to planned migration of asset holders and investors to foreign venues in order to escape the regulatory tax (Houston et al. 2012).

Finally, our study shows mixed results on how Dodd-Frank derivative provisions affect the efficiency of the exchange traded markets. An increase in efficiency reflected by lower deviations of futures prices from their cost of carry is observed for the S&P futures contracts. This may reflect an increase of arbitrage by traders on the exchange traded markets, as opposed to the OTC markets. Increased pricing efficiency based on lower spreads between futures and implied forwards for nearby Eurodollar contracts is also observed. This is not the case, however, for more distant futures.

At this juncture in time, the implementation of the individual provisions of Dodd-Frank has been piecemeal and heavily delayed. The implications of such delays are certainly worth investigating as topics for future research, along with additional comparative impact studies of Dodd-Frank on US versus foreign derivatives markets and financial institutions.

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