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Essays in State and Local Government Debt Management: Networks, Strategic Refinancing, and Regulatory Disclosure

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ABSTRACT

ESSAYS IN STATE AND LOCAL GOVERNMENT DEBT MANAGEMENT: NETWORKS, STRATEGIC REFINANCING, AND REGULATORY DISCLOSURE

By

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This three-essay dissertation attempts to fill research gaps in three streams of literature on municipal debt management. The first essay focuses on stability of debt management networks. Debt network stability is the extent to which municipal issuers repeatedly use the same financial intermediaries to issue new bonds. The essay examines whether network stability lowers subnational governments' new issue borrowing costs in primary markets for municipal bonds. The analytical design combines social network theory and cross-sectional modeling and centers on state debt management networks in California. Findings show that after a critical threshold of repeat issuer-intermediary interactions is attained, municipal borrowing costs tend to decrease as networks become more stable.

The second essay analyzes strategic refinancing decisions in primary markets for municipal bonds. It focuses on school district debt refinancing transactions and quantifies the opportunity costs, or option value loss, associated with the timing of transactions. The essay uses Monte Carlo simulation and financial option-pricing techniques to analyze a

random sample of Texas school district bonds. Findings show that school districts' refinancing transactions resulted in option value loss equivalent to millions of dollars.

In the third essay, I investigate the extent to which regulatory interventions in municipal bond secondary markets reduce inefficiencies in municipal securities pricing. In particular, I analyze the trade price impacts of the 2008 implementation of new disclosure interventions. I apply time series regressions, with robustness checks, to a large dataset of trades in California's general obligation bonds. Results show that the interventions reduced pricing inefficiencies in secondary markets as a whole; however, big (or institutional) investors continue to have a marginal price advantage over small (or retail) investors in securities trading.

The three essays shed more light on debt management in primary and secondary markets for municipal bonds. They cover some of the frontier research topics on debt issuance, refinancing, and trading. The essays provide a way to gauge the efficient level of interdependence in debt management networks, present an empirical framework for evaluating the timing of school district debt refinancing transactions, and offer insights that should guide regulatory policy discussions on fair pricing of debt securities.

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ACCEPTANCE

This dissertation was prepared under the direction of the candidate's Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Public Policy in the Andrew Young School of Policy Studies of Georgia State University.

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To my father, Steve,

Thanks for everything.

To my wife, Vera,

With deep love and immense gratitude.

To my children, Alan and Alvin,

You bring me joy, always.

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CHAPTER 1

INTRODUCTION

Municipal bond markets serve a crucial need for subnational governments seeking to raise capital for long-term projects. Borrowing long-term enables states, counties, cities, school districts, and special districts to realize immediate benefits from their investments, instead of postponing benefits for many years until annual income streams accumulate enough capital to fund projects.

In the United States, municipal borrowings have grown significantly over the years. State and local governments' outstanding debt obligations totaled $3.7 trillion in 2014 (Securities and Exchange Commission, 2015). Between 1945 and 1981, the size of the municipal bond market grew by $488 billion, and from 1982 to 2014, market size expanded by $3.2 trillion (Securities Industry and Financial Markets Association, 2015). New debt issues have historically accounted for the larger proportion of total debt obligations (on average, 60 percent during the past two decades) but in recent years refinancing (or refunding) issues have gained importance and outpaced new capital. Figure 1.1 illustrates trends in outstanding debt obligations of state and local governments and Figure 1.2 traces the patterns in new and refunding debt issues.

Along with its growth in size, the municipal debt market has become more sophisticated in the types of debt instruments available to investors. Compared to earlier decades where simpler instruments (e.g., fixed rate general obligation bonds) dominated the market, new debt instruments (e.g., variable-rate obligations, derivative securities, tax-exempt inverse floaters, and interest rate swaps) now offer more flexibility to issuers (Hildreth & Zorn, 2005) but make municipal debt management more complicated.

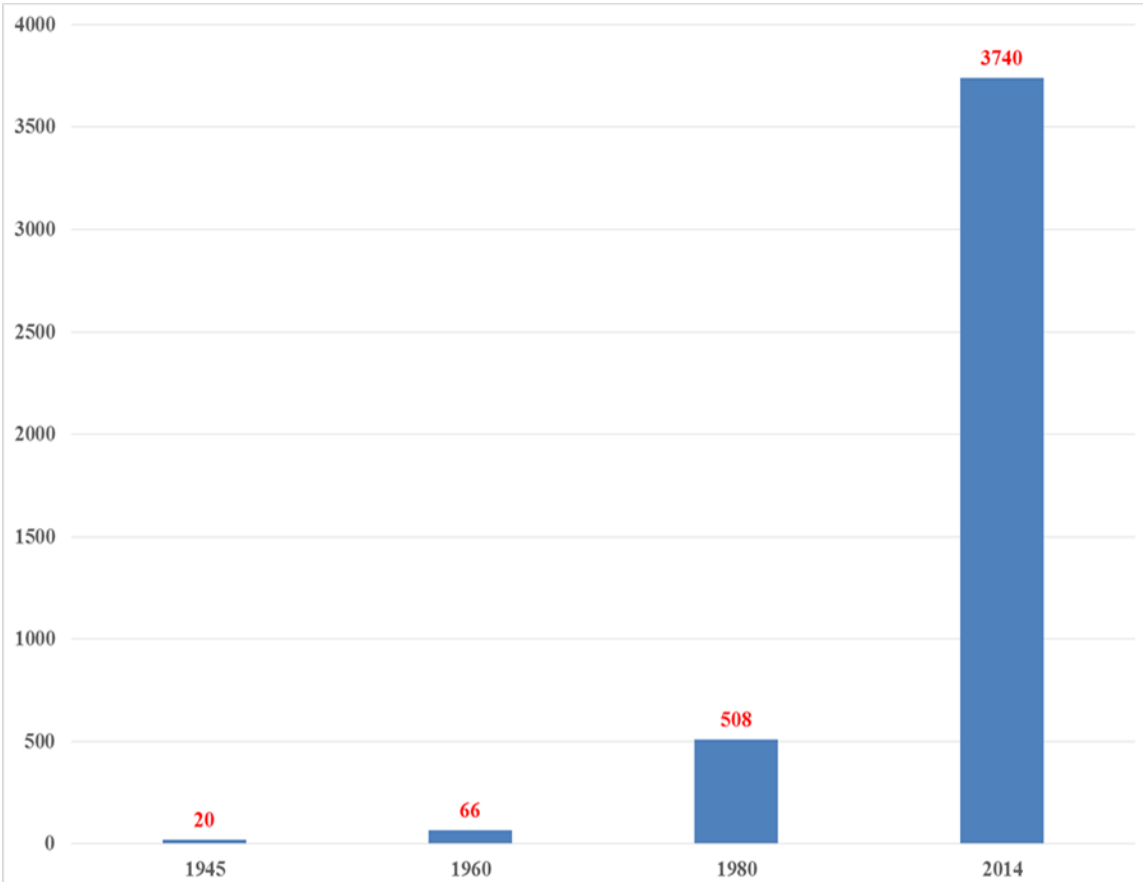

Figure 1.1. Outstanding Debt Obligations of State and Local Governments. Displayed in Billion U.S. Dollars. Data is from Securities and Exchange Commission (2015) and Securities Industry and Financial Markets Association (2015).

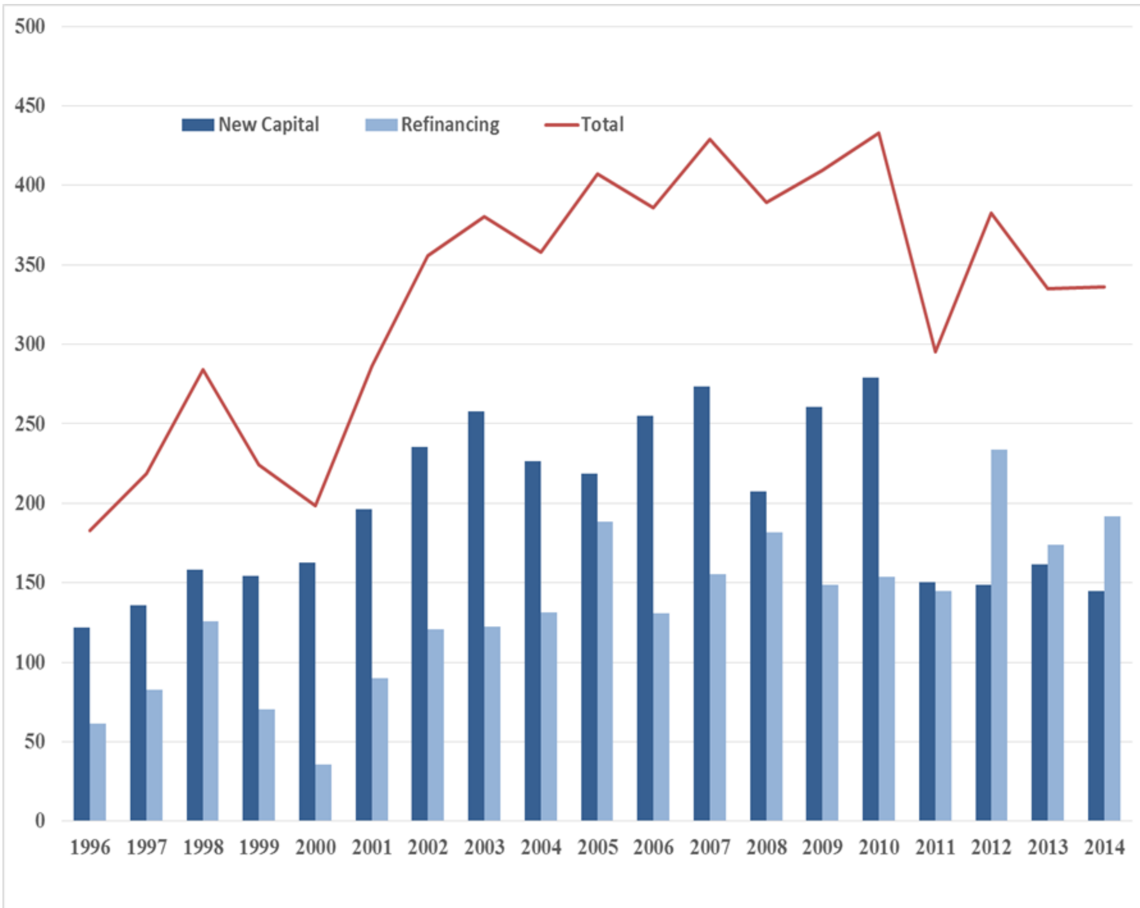

Figure 1.2. State and Local Government New and Refunding Debt Issues. Displayed in Billion U.S. Dollars. Data sources are Securities and Exchange Commission (2015) and Securities Industry and Financial Markets Association (2015).

Subnational government transactions in municipal debt markets have faced increased public scrutiny in recent decades as markets have become larger and more sophisticated. Citizens deserve to know whether state and local governments make efficient use of public funds in municipal debt transactions. Additionally, municipal debt market regulators have a responsibility to ensure that market practices are transparent and trade prices are efficient.

Within these contexts, municipal finance scholars have tried to expand knowledge on the most efficient ways to manage debt issuance and trading. Despite active scholarship in state and local government debt management, areas of research remain to be examined in more detail. This dissertation attempts to fill gaps in the municipal finance literature by investigating three interconnected themes.

The first theme concerns networks in state and local government debt issuance. It analyzes how stability of debt networks, defined as the extent to which issuers repeatedly use the same financial intermediaries to issue new bonds, affect municipal borrowing costs in primary markets. Existing research on network stability and borrowing costs either lack formal empirical models for testing the stability-borrowing cost relationship, or present analytical framework that do not fully capture the dynamic market environments within which debt management networks form and function. The dissertation tests an analytical model that combines social network theory and cross-sectional regressions to deepen understanding of the impact of debt network stability on municipal borrowing costs.

The second theme relates to strategic refinancing decisions in municipal bond primary markets. Prior research pays little attention to the opportunity costs, or option value loss, associated with the timing of municipal bond refinancing transactions; even the few studies within this research stream use estimation procedures and simplifying assumptions that do not fully account for the option value loss associated with the timing of transactions. This dissertation focuses on school districts, given the absence of detailed attention to their refinancing transactions in the academic literature. It uses Monte Carlo simulation and financial option-pricing procedures to analyze the option value loss associated with a more sophisticated form of debt refinancing called advance refunding.[1]

The third theme focuses on pricing of trades in secondary markets for municipal securities. Over the years, regulatory disclosure interventions in secondary markets have spurred a growing body of research on the impacts of interventions on securities trade pricing. However, existing studies do not provide a full picture of regulatory effectiveness – some studies do not extend to more recent interventions, and those that do either ignore the influence of market-wide factors on trade prices or find weak evidence to explain the differences in trade pricing that tend to exist between individual and institutional investor groups. This dissertation investigates the latest wave of regulatory interventions, which spanned March 31, 2008 and June 1, 2009. It uses time series regressions to test whether the interventions enhanced price efficiency in municipal securities secondary markets. Additionally, the dissertation investigates whether the interventions affected investor groups differently – in particular, it explores the difference in trade price impacts, if any, between institutional and retail investors.

The three themes are interconnected: debt issuance occurs in primary markets, where state and local governments raise funds to undertake capital projects that provide

[1] See Chapter 2 for a more detailed explanation of an advance refunding debt transaction and the measurement of option value loss.

long-term benefits for citizens; debt refinancing occurs sometime after state and local governments' initial issuance, when prevailing market conditions make it feasible for governments to exercise the call option on outstanding bonds prior to debt maturity and reap interest cost savings; and issuer-specific, bond-related, and primary market conditions affect pricing of debt securities in secondary markets, where retail and institutional investors trade.

All three streams of literature derive from efficiency motivations – those of state and local governments seeking to minimize the cost of debt issuance and maximize savings from refinancing, and of market regulators introducing reforms to enhance efficient pricing of municipal securities trades. The next sections of this chapter describe the general structure of the markets within which debt issuance, bond refinancing, and securities trading all take place, and present the road map for analyses in this dissertation.

1.1 Structure and Function of U.S. Municipal Bond Markets

U.S. municipal bond markets consist of two sub-markets – the primary market and the secondary market. The primary market is where state and local governments issue debt to raise capital for long-term projects. In the secondary market, broker dealers sell the original debt securities to institutional and retail investors and facilitate buying and re-selling of securities among investors (Government Accountability Office, 2012). The municipal bond market consists of a large number of participants from the public and private sectors. Participants from the public sector include states, counties, cities, and school districts, and private sector participants consist of underwriters, municipal (or financial) advisors, bond lawyers, retail investors, institutional investors, and insurance companies, among others.

Municipal bond markets attain a level of equilibrium as market mechanisms steer the divergent economic goals of market agents towards the common goal of market efficiency. Hildreth (1993) identified the critical role underwriters play in steering issuer goals and investor expectations toward equilibrium in municipal bond markets. He explained how state and local governments seek the lowest cost of capital over a desired repayment schedule, while investors desire the highest rate of return on the capital they loan as well as repayment of their principal upon maturity; within this setting, underwriters work to steer issuer goals and investor expectations towards market equilibrium and obtain a risk premium in return for their services. Other studies, such as Leland and Pyle (1977), Millon and Thakor (1985), and Peng and Brucato Jr. (2004), highlight the roles of bond lawyers, municipal advisors, and credit rating agencies in facilitating the transfer of information among issuers and investors to resolve information asymmetry and enhance market efficiency.

1.2 State and Local Government Debt Issuance in Primary Markets

Municipal debt issuance is a complex process that embraces public and private sector actors and spans different stages, such as timing of the debt issuance, designing features of the bond issue, and securing specialized services from municipal advisors, bond lawyers, and underwriters, for the sale of bonds (Simonsen & Hill, 1998). Method of sale is a major consideration in municipal debt issuance. The academic literature identifies two main methods of sale, namely competitive bidding and negotiated sales

(Simonsen & Hill, 1998; Fruits, Booth, Pozdena, & Smith, 2008). Competitive bidding is where many underwriters bid for sale of a debt issue and the issuer awards sale of the issue to the bidder offering the lowest interest cost of issuance. In negotiated sales, the issuer directly selects an underwriter and negotiates interest costs of issuance and other terms with the underwriter.

Institutional rules, statutes, and limits govern debt issuance across U.S. states. These institutional mechanisms aim at achieving efficient use of public funds in debt transactions. They also seek to hold public managers accountable to local citizens. Poterba and Rueben (2001), Lowery and Alt (2001), Johnson and Kriz (2005), Ter-Minassian (2007), and Dove (2014) are among the authors that discuss various legal and fiscal constraints characterizing the municipal bond issuance process. Despite the existence of legal and fiscal constraints, state and local government debt issuance has, in a few instances, been plagued by financial malfeasance arising from perverse networks of issuers and financial intermediaries.[2]

Refinancing of debt occurs in primary markets. After an initial issuance, prevailing market conditions may make it feasible for an issuer to exercise the call provision in their original debt issue and replace the original debt with new debt at a lower interest cost. The refinancing strategy may generate millions of dollars in interest costs savings for the municipality. However, in complicated forms of refinancing such as advance refunding, where an issuer can engage in refinancing before the call date in the

[2] For example, in 2009, Bloomberg News reported an alleged case of impropriety in the choice of an underwriter for a new debt issue by Palm Beach County, Florida. According to the report, the County Commissioner allegedly helped steer public underwriting business to underwriting firms that employed her spouse. - See Bloomberg News, "Palm Beach Scandal Helps Bids After Official Negotiated Favors," March 10, 2009.

original bond, timing of transactions becomes a critical factor in ensuring efficiency of debt management.

1.3 Trading of Municipal Securities in Secondary Markets

Secondary markets are the domain for municipal bond trades. Trading takes place between market dealers and investors and among market dealers.[3] Dealers buy securities from investors seeking to sell rather than hold securities to maturity; dealers resell the securities to another investor or sell back to the market, and charge a premium for facilitating the market exchange.[4]

The Municipal Securities Rulemaking Board (2014b) identified key characteristics of secondary market trading in U.S. municipal bond markets. The report indicated that about one-half of trades in the market had a trade size below $25,000 and traded 10 or fewer times. This indicates a substantial amount of retail investor activity and lack of liquidity in the market. Figure 1.3 traces the number and par value (or principal amount) of trades occurring each month in recent years, and Figure 1.4 shows the distribution of total yearly trades categorized according to trade size.

[3] The Securities Exchange Act of 1934 describes a dealer as a person or firm engaged in facilitating securities transactions for the account of that person or firm.
[4] See the MSRB's overview of trading in secondary markets at the following internet link: http://www.msrb.org/Municipal-Bond-Market/How-the-Market-Works/Secondary-Market-Trading.aspx

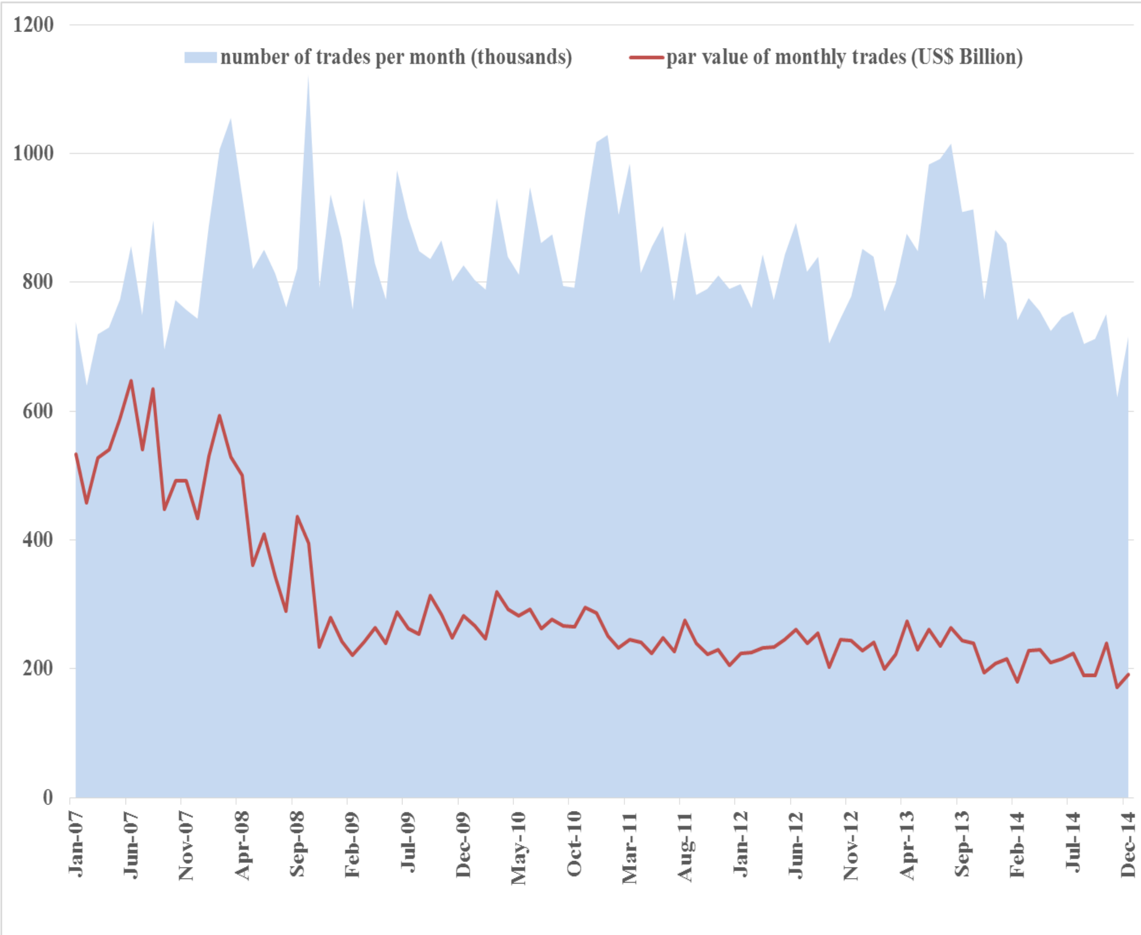

Figure 1.3. Trading of Municipal Debt Securities. Compiled from Securities and Exchange Commission (2015) and Securities Industry and Financial Markets Association (2015) data.

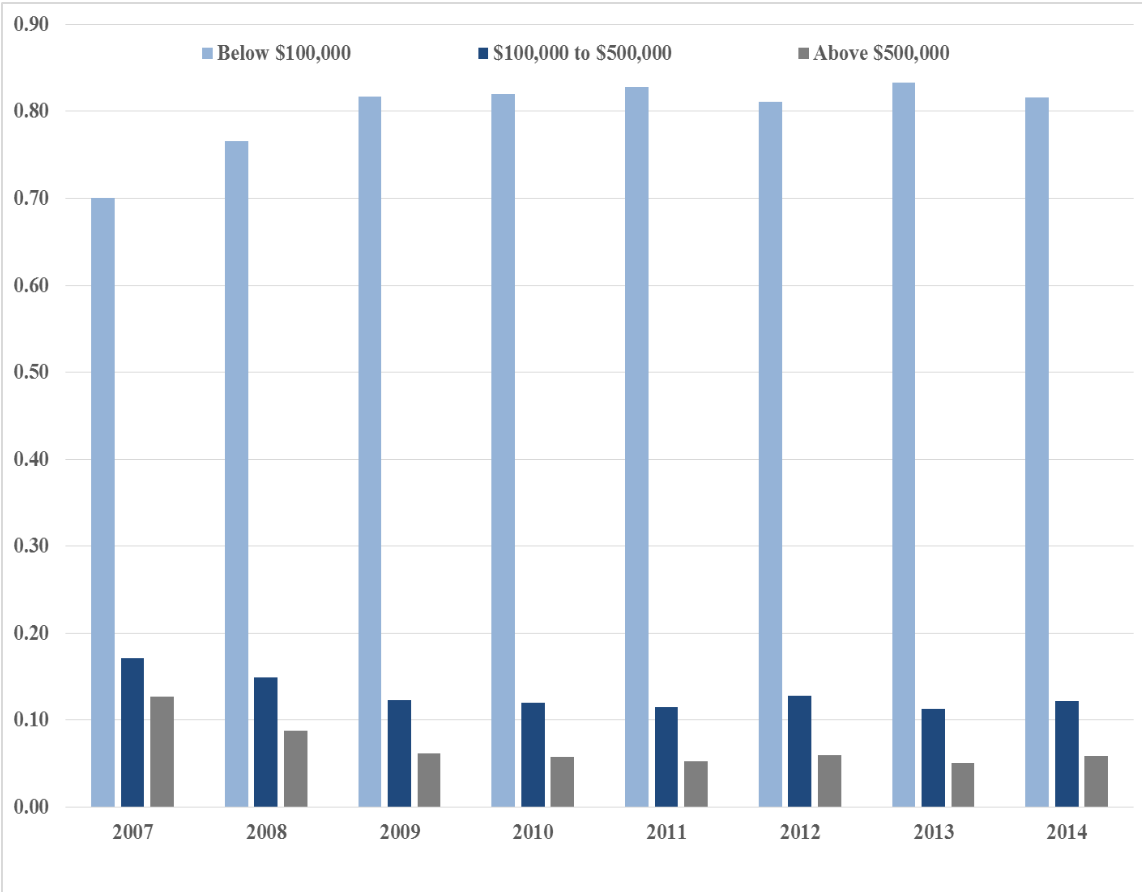

Figure 1.4. Distribution of Trades According to Size of Trade. Compiled using data from Securities and Exchange Commission (2015) and Securities Industry and Financial Markets Association (2015).

1.4 Structure of the Dissertation

This chapter provides a broad overview of the structure of U.S. municipal bond markets and explains some core considerations in municipal bond issuance and trading. Remaining chapters provide more detail on the three streams of literature discussed above and present research questions arising from those streams. Chapter 2 analyzes the relationship between network stability and borrowing costs in municipal debt issuance, Chapter 3 investigates the option value effects of school district bond refinancing decisions, and Chapter 4 examines the impacts of regulatory disclosure interventions on price behavior in municipal securities secondary markets.

CHAPTER 2

NETWORKS AND BORROWING COSTS IN MUNICIPAL DEBT ISSUANCE

2.1 Background and Research Questions

Debt management networks may be defined as interactions among state and local government debt issuers and the financial intermediaries involved in debt issuance (Marlowe, 2013). Networks may involve repeat interactions and long-term relationships among network members in municipal debt markets (Li & Schürhoff, 2012). Figure 2.1 illustrates a debt management network existing among a municipal debt issuer and three financial intermediaries – a municipal or financial advisor, bond lawyer, and underwriter.

Underwriters work with municipal issuers to structure the bond sale (Simonsen & Hill, 1998; Fruits, Booth, Pozdena, & Smith, 2008).[5] Municipal advisors give issuers financial advice on debt issuance, investment of issuance proceeds, and use of derivatives, among others (Luby & Hildreth, 2014), and bond lawyers give informed opinions on the legal status of municipal securities, assuring investors that the securities are binding legal obligations of the issuer (Johnson, Luby, & Moldogaziev, 2014).

Municipal finance researchers have used social network theory to explain the impacts of networks on state and local government debt management outcomes. Social network theory combines insights from the management (inter-organizational theory) and behavioral (small group theory) sciences and examines the roles of social actors and the ties that bind different actors together (Scott, 2012; Wasserman & Faust, 1994).

[5] Most bonds are structured as part of a serial issuance, with multiple CUSIPs per issuance (The Bond Market Association, 2001). A CUSIP is an alphanumeric code that uniquely identifies each maturity of a debt issue (MSRB, 2014a).

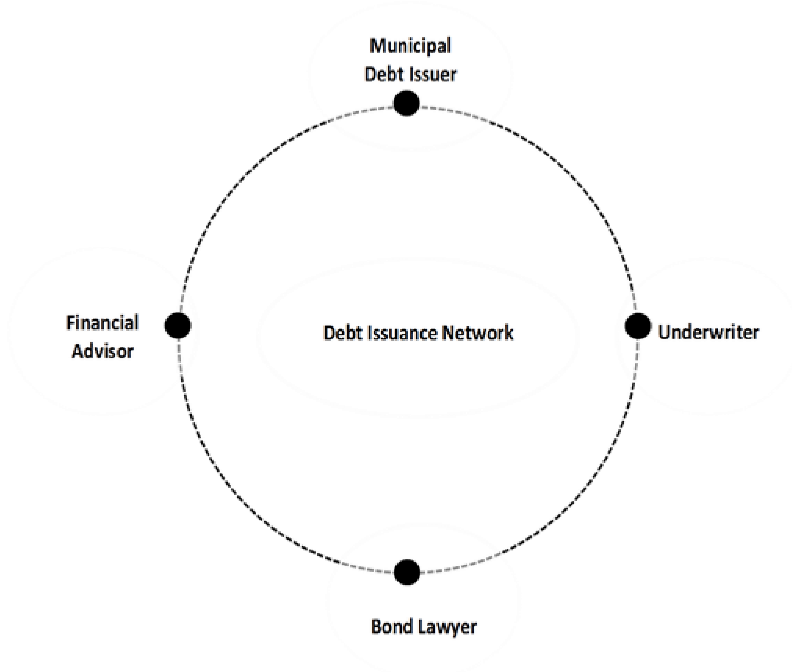

Figure 2.1. Illustration of a Debt Management Network.

Different actors may come together in a social network and work towards a common goal that yields economic or social benefits for all members (Worley & Mirvis, 2013). However, the extent to which the social network achieves its goals may depend on the structural properties of the network (Aral & Alstyne, 2007).

In the municipal finance literature, emphasis on the structural properties of networks has been motivated, in part, by cases of impropriety and collusion between subnational issuers and financial intermediaries involved in debt issuance. Hildreth and Zorn (2005) examined recent defaults and/or debt management problems involving school districts (e.g., California's Richmond Unified School District in 1991), cities (e.g., Cleveland in 1978), counties (e.g., Orange County in 1994) and states (e.g., Louisiana in 1988, Connecticut in 1991, and California in 2001) and highlighted how, in some instances, improper and unethical practices saddled the bond issuance process. Such cases deepen research interest in the structural properties of issuer-intermediary networks and the level of interdependence within networks that will ensure more efficient debt management outcomes for state and local governments.

Municipal finance scholars have drawn from social network theory to explore how specific properties of debt networks, such as stability, affect debt management outcomes such as borrowing costs. Debt network stability is the extent to which a municipal issuer repeatedly uses the same financial intermediaries in new debt issuance (Marlowe, 2013). The concept of stability implies permanence of membership of the network as well as redundancy of members' ties with others both inside and outside of the network (Aldrich & Whetton, 1981).

Miller and Justice (2012) examined stability of the network between issuers and intermediaries involved in municipal debt issuance. They highlighted how network stability affects municipal borrowing costs through channels of risk-taking, learning, innovation, and adaptation. On the one hand, more stable networks generate greater opportunities for learning, than less stable networks do, and greater opportunities lead network members to innovate and adapt to new strategies that make errors less likely and outcomes more beneficial. On the other hand, more stable networks have a greater likelihood to yield to the imposition of one member's narrow views on what strategies the network should pursue, resulting in more errors in strategy, greater risk-taking, and less beneficial outcomes.

Direct empirical tests of the impacts of network stability on borrowing outcomes is lacking in the academic literature. Miller (1993), Miller (1996), and Miller and Justice (2012) examined network stability effects on municipal borrowing costs but did not test a formal empirical model; nevertheless, Miller and Justice (2012) outlined a set of propositions to guide future studies. Also, empirical tests of network effects on borrowing costs have focused on network centrality, rather than network stability, leaving a gap in understanding of how network stability directly impacts state and local government borrowing costs.[6]

In the present study, I extend existing knowledge on debt management networks by designing and testing an empirical model that links network stability to municipal borrowing costs. I examine whether higher levels of network stability are associated with lower municipal borrowing costs. I apply cross-sectional regression analysis to a

[6] Network centrality refers to a financial intermediary's place among issuers in the municipal bond market (Marlowe, 2013).

comprehensive dataset on new debt issues in California, and focus on the period starting from 2005 to 2014. I ask the following research question: What is the relationship between network stability and subnational governments' new issue borrowing costs in municipal debt markets?

In the next sections of this chapter, I examine the academic literature further to develop hypotheses. I also outline the study methodology, discuss data and variable formulations, present estimation results, and provide policy implications and directions for future research.

2.2 Literature Review and Research Hypotheses

In this review of the academic literature, I examine the stream of literature that links debt management networks with municipal borrowing costs. I also discuss other determinants of borrowing costs, including method of debt issuance, which is a major theme in studies of state and local government borrowing costs. I outline hypotheses based on the literature review.

2.2.1 Studies of Debt Networks and Borrowing Costs

As noted earlier, municipal finance research has focused on two structural properties of debt management networks. Some studies have explored, without formally testing, the impacts of network stability on municipal borrowing costs in primary markets (e.g., Miller & Justice, 2012) while other studies have formally tested the impacts of network centrality on borrowing costs in primary markets (e.g., Marlowe, 2013) as well as its impacts on trading costs in secondary markets (e.g., Li & Schürhoff, 2012).[7]

With regard to network stability, scholars have not directly tested its impacts on debt management outcomes such as borrowing costs. Miller and Justice (2012) used outcomes from a simulation exercise involving goal-oriented graduate students to develop two propositions on the borrowing cost effects of network stability. They focused on how resource-based and incentive-related differences among team members affected stability of the team and how, in turn, team stability affected team performance.

The first proposition suggests a negative relationship between network stability and debt management outcomes such as borrowing costs. More stable networks of issuers and financial intermediaries produce greater learning opportunities among network members than is the case for less stable networks, and greater opportunities for learning lead to innovation and adaptation to new strategies among network members, which yields more beneficial outcomes, including lower municipal borrowing costs.

In contrast, the second proposition defines a positive relationship between network stability and outcomes such as borrowing costs. As stability of networks increases, members are more likely to yield to the imposition of one member's narrow views on the most efficient strategy the network should pursue. Potential domination of network strategy by a single member as network stability increases, raises the probability

[7] Marlowe's (2013) study of network centrality in primary markets examined how a financial intermediary's place among issuers in the market affects interest costs on new issue municipal bonds. He found that borrowing costs are lower when more central players are involved in municipal bond sales. Similarly, Li and Schürhoff (2012) analyzed how centrality of a dealer within a network of dealers affects the dealer's trading costs. Among other findings, the authors showed that central dealers charge considerably larger mark-up prices than dealers at the periphery of the trading network, and as centrality of the dealers intermediating in trade increases, informational efficiency of trade prices also increases. These findings on network centrality give insights on the scope of analytical work on debt management networks, even though the main point of focus in the present study is network stability.

of the network making more errors in strategy, undertaking greater risks, and reaping less beneficial outcomes such as higher issuer borrowing costs.

The academic literature is not unanimous on whether debt network stability should have a positive or negative impact on issuers' borrowing costs. Nevertheless, I hypothesize a negative relationship between network stability and municipal borrowing costs, based on the first proposition in Miller and Justice (2012) described above. Specifically, I test the following hypothesis:

H2.1 State and local governments' borrowing costs decrease as debt management networks they belong to become more stable.

2.2.2 Studies Linking Method of Debt Issuance to Borrowing Costs

Studies of the relationship between method of sale and borrowing costs are set in the theory of market efficiency. According to Fama (1970), market efficiency exists when prices in a market fully reflect available information. He noted that such prices provide accurate signals for resource allocation such that firms can make production-investment decisions and investors can choose among investment alternatives, all under conditions of zero transactions costs and costless information acquisition and processing. Similarly, Jensen (1978) and Jarrow and Larsson (2012) explained market efficiency within the context of zero economic profits by noting that efficiency exists if it is impossible for some market participants to make economic profits by trading on the basis of market information sets available to those participants.

Furthermore, Akerlof (1970) discussed the implications of market inefficiency and asymmetric information. He hypothesized that under conditions of asymmetric information, sellers possess more information than buyers and because good and bad products have the same market price, buyers cannot tell the difference between the products, and eventually, the sequence of bad products driving out good products could lead to market collapse. Akerlof's diagnoses of uneven concentrations of power, uncertainty, and inefficient pricing aptly describe conditions in municipal bond markets.

Drawing from finance theories on market efficiency, public administration scholars have analyzed the extent to which a chosen method of debt issuance mitigates information asymmetry and generates interest cost savings for the municipality. Most studies find that competitive bidding yields lower borrowing costs (e.g., Bland, 1985; Simonsen & Robbins, 1996; Guzman & Moldogaziev, 2012) while a small number of studies show that negotiated sales have similar (e.g., Stevens & Wood, 1998) or lower (e.g., Kriz, 2003) borrowing costs.[8]

Competitive bidding leads to lower borrowing costs because the method involves the release of more information about an issuer and the debt issue than in negotiated sales; therefore, information asymmetry problems in competitive sales are fewer, transaction costs are smaller, and borrowing costs are lower. Peng and Brucato Jr. (2004), for example, examined information asymmetry in municipal bond issuance and found that market and institutional mechanisms, such as issuance by competitive rather than negotiated methods, helped to ease information asymmetry in the municipal bond market,

[8] Despite the overwhelming empirical evidence that competitive sales are associated with lower borrowing costs, a larger proportion of state and local government debt issuers prefer negotiated sales to competitive sales. For example, Securities Industry and Financial Markets Association (2015) data showed that, on average, negotiated sales accounted for 78.5 percent of all municipal bond sales from 1996 to 2011. On this subject, Hackbart and Denison (2014) highlighted factors other than interest costs that could determine whether an issuer uses the competitive or negotiated sale method. These factors include complexity of the transaction, market conditions, whether the bond is backed by a new revenue source, and whether the issuer has been active in the bond market previously.

thereby reducing issuers' borrowing costs. Based on the above explanations, I test the following hypothesis on the relationship between method of debt issuance and municipal borrowing costs:

H2.2: Issuers that sell debt by competitive bidding face lower borrowing costs than those that utilize the negotiated sale method of debt issuance.

2.2.3 Review of Other Determinants of Borrowing Costs

Besides network stability and method of debt issuance, the academic literature discusses bond-specific, issuer-related, and market condition variables that affect municipal borrowing costs. I focus on three of these variables, namely size of an issue, credit rating of an issue, and market-wide conditions, and present hypotheses for testing their impacts on municipal borrowing costs.

2.2.3.1 Size of a debt issue

Larger debt issues are more likely to incur lower transaction costs than smaller debt issues because issuers of larger issues often employ the services of large financial intermediaries who typically operate at marginally lower transaction costs than small intermediaries, therefore larger debt issues have lower borrowing costs than smaller debt issues (Marlowe, 2011). Also, issuers often sell larger issues in national markets, where information asymmetry problems are limited, resulting in smaller transaction costs and lower borrowing costs; on the other hand, it is common for local investors to absorb smaller issues in local and regional markets where information asymmetry issues could raise transaction costs and lead to higher borrowing costs (Bland, 1985; Peng & Brucato

Jr., 2004). Additionally, local investors may know more about the smaller debt issue in local and regional markets than the information the issuer makes available market-wide; thus, rational investors will view this information mismatch as disadvantageous to them and the information asymmetry surrounding the smaller issue will result in higher interest costs for the issuer compared to a larger issue (Peng & Brucato Jr., 2004). Consequently, I test the following hypothesis:

H2.3: Size of a debt issue is negatively associated with municipal borrowing costs.

2.2.3.2 Credit rating of an issue

Credit rating of a debt issue contains information that signals the issuer's credit worthiness in respect of the specific debt obligation (Standard and Poor's, 2015). The rating serves to mitigate information asymmetry about the debt issue. As such, issues with higher credit ratings face smaller transaction costs, hence lower borrowing costs, than issues with lower credit ratings (Peng & Brucato Jr., 2004; Boot, Milbourn, & Schmeits, 2006; Daniels & Ejara, 2009). I test the following hypothesis based on findings in existing studies:

H2.4: Debt issues with higher credit ratings face lower borrowing costs than issues with lower credit ratings.

2.2.3.3 Market-wide conditions

Municipal bond market conditions determine the type of environment within which state and local governments issue debt, the risks and uncertainties associated with their operations, and the interest cost savings they can achieve. Worsening municipal market conditions, which reflect in widening yield spreads, raise transaction costs in debt markets and increase borrowing costs significantly (Peng & Brucato Jr., 2004; Moldogaziev, 2012). Thus, I test the following hypothesis:

H2.5: State and local governments' borrowing costs increase as municipal market-wide conditions worsen.

2.2.3.4 Other Bond-specific factors

Other determinants of municipal borrowing costs include term to maturity of the bond (Marlowe, 2011), type of bond (Daniels & Ejara, 2009), purpose of the bond (Peng & Brucato Jr., 2004), whether the bond is insured (Moldogaziev, 2012; Peng & Brucato Jr., 2004), and whether it has a call provision (Peng & Brucato Jr., 2004). Investors tend to associate a longer term to maturity with higher probability of default and interest rate risk, therefore borrowing costs tend to rise as term to maturity increases (Marlowe 2009).

Also, market agents view revenue bond types as more risky investments than general obligation bond types due to the less certain nature of the income stream backing revenue bonds – general obligation bonds are supported by the full faith and taxing power of the municipal borrower, while revenue bonds are supported by the income streams from the projects they finance; therefore, issuers are more likely to incur higher borrowing costs with revenue bonds than general obligation bonds (Daniels & Ejara, 2009).

Furthermore, market agents consider municipal borrowing for the purpose of financing health care and economic development projects to be more risky than borrowing for education, utility, and government general purpose projects, therefore issuers will incur higher borrowing costs for health care and economic development projects than for purposes that agents perceive to be less risky (Leonard, 1983). Finally, Peng and Brucato Jr. (2004) showed that an issue's call provision and insurance status are certification mechanisms that serve to mitigate information asymmetry concerns about the issue and limit investor uncertainty about the investment, therefore issues that have call provisions and insurance will be associated with lower municipal borrowing costs.

2.3 Data and Variables

I created a sample of municipal bonds, or CUSIPs, using data on California.[9] I focus on California for two reasons. The State makes available, and from a single source, data on true interest costs of bonds as well as specific information on the financial intermediaries involved with issuing each bond. This information is available from the California Debt and Investment Advisory Commission (CDIAC). The CDIAC datasets list the underwriter, municipal advisor, bond lawyer, and guarantor involved with each bond, in addition to bond-specific and issuer-related details. Finding detailed data on true

[9] Most of the bonds in the sample are part of a serial issuance, with multiple CUSIPs per issuance. For example, the State of California made six new general obligation debt issues in 2014; the issues amounted to 116 CUSIPs altogether – on average, 19 CUSIPs per issuance (California Debt and Investment Advisory Commission, 2015). In analyses of state and local government debt, academic researchers (e.g., Ang, et al., 2013; Cestau, Green, & Schurhoff, 2013; Harris & Piwowar, 2006) use CUSIPs as the 'bond' issue and not the complete serial sale. The present study uses a similar approach.

interest costs and financial intermediaries from a single source such as the CDIAC makes it convenient to analyze issuer-intermediary networks and impacts on borrowing costs.

Additionally, California is the leading source of municipal debt issues among U.S. states. In 2013, for example, the state accounted for 14.2 percent of all outstanding state and local government debt obligations in the Unites States, higher than New York (11.7 percent) and Texas (9.0 per cent), the second and third leading sources, respectively (U.S. Census Bureau, 2014). Figure 2.2 displays the share of each state's debt in total outstanding municipal debt of all U.S. states, and Table 2.1 shows the total amount of state and local government debt outstanding for each U.S. state.

Thus, California is a large source of information on municipal debt issuance patterns. However, this study is cautious about making generalizations to nation-wide contexts using the California dataset alone. Nevertheless, as descriptive statistics in Section 2.5.1 show, the California sample exhibits substantial variability similar to what exists in the population of U.S. municipal debt issues.

I focus on state-issued fixed rate general obligation bonds with maturities greater than 3 years. Marlowe (2009) noted how municipal bonds that have variable rates and maturities less than 3 years sell in markets other than primary markets thereby complicating analyses if they are included in a sample for estimation. Also, I focus my analysis on networks between the state government debt issuer and underwriters. Networks between underwriters and other subnational governments, such as school districts, cities, and counties, are beyond the scope of this study, as are the more intricate issuer-underwriter-financial advisor networks that could form in municipal debt issuance.

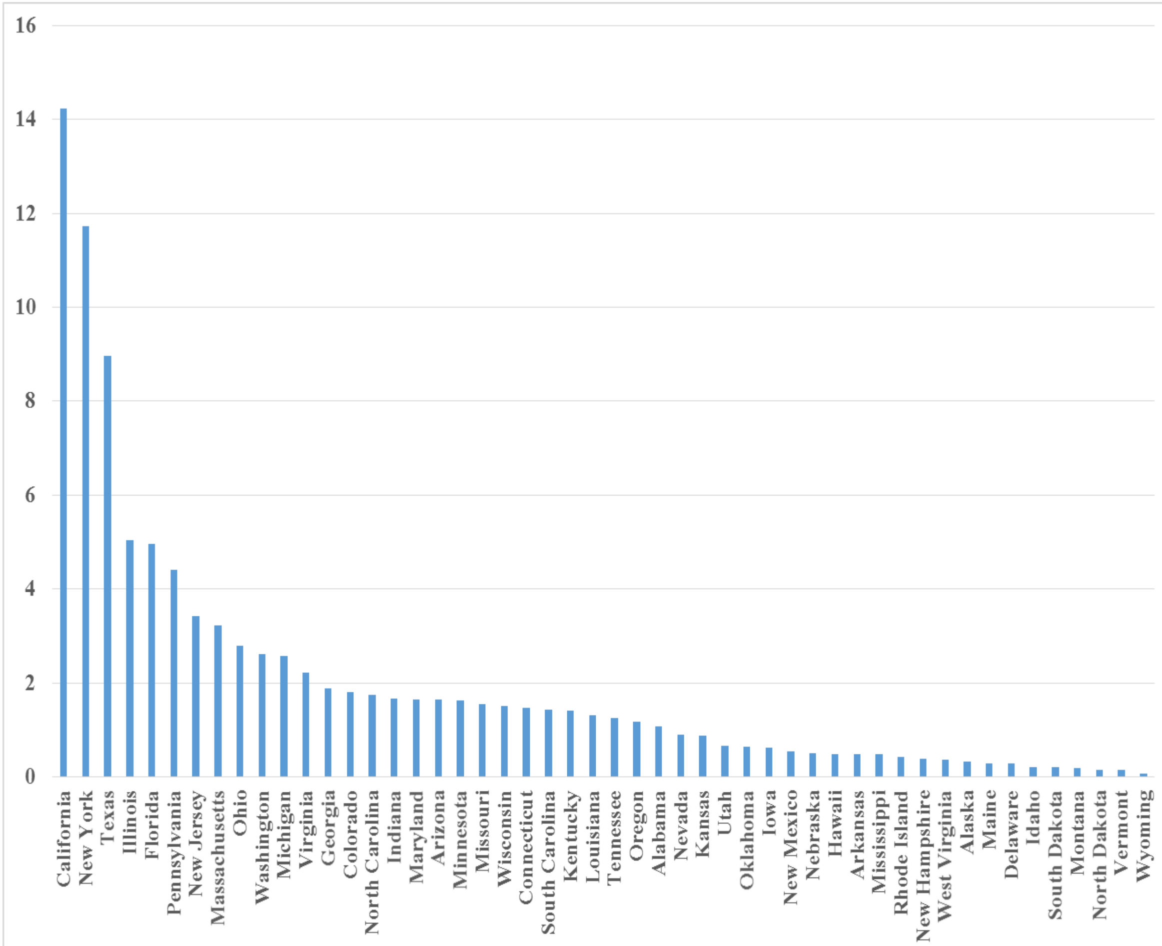

Figure 2.2. States' Municipal Debt as a share of all U.S. States' Municipal Debt Obligations. Compiled using data from the Annual Survey of State and Local Government Finances conducted by the U.S. Census Bureau (2014).

Table 2.1

U.S. States' Municipal Debt Outstanding in 2013

State	Debt	State	Debt
California	420.3	Tennessee	36.8
New York	346.2	Oregon	34.8
Texas	264.7	Alabama	31.6
Illinois	148.7	Nevada	26.8
Florida	146.4	Kansas	25.8
Pennsylvania	130.2	Utah	19.6
New Jersey	101.0	Oklahoma	18.9
Massachusetts	95.4	Iowa	18.5
Ohio	82.5	New Mexico	16.3
Washington	77.3	Nebraska	15.0
Michigan	76.3	Hawaii	14.3
Virginia	65.5	Arkansas	14.2
Georgia	55.7	Mississippi	14.1
Colorado	53.2	Rhode Island	12.3
North Carolina	51.5	New Hampshire	11.4
Indiana	49.4	West Virginia	10.9
Maryland	48.9	Alaska	9.6
Arizona	48.7	Maine	8.4
Minnesota	48.0	Delaware	8.3
Missouri	45.6	Idaho	5.9
Wisconsin	44.4	South Dakota	5.9
Connecticut	43.4	Montana	5.3
South Carolina	42.3	North Dakota	4.7
Kentucky	41.7	Vermont	4.5
Louisiana	39.0	Wyoming	2.0

Note. Compiled using data from U.S. Census Bureau (2014). Figures are in Billion U.S. Dollars. Total debt was $2,954.7 billion for all U.S. states, including $12.4 billion for the District of Columbia.

The analysis covers 2005 to 2014. The main source of data is the CDIAC. The data includes bond-specific details such as date of issuance, principal amount at issuance, term to maturity, bond purpose, funding source, type of bond, method of sale, credit rating of bond, refunding status, and whether the bond is subject to state and federal taxation. Information on municipal market-wide conditions is from the *Bond Buyer*. Table 2.2 shows a summary of the variables and expected effects on borrowing costs.

In total, California state and local governments issued 16,922 bonds, or CUSIPs, between 2005 and 2014, out of which 1,129 bonds were state government bonds. I apply several filters to arrive at the estimation sample. I delete observations with term to maturity less than 3 years, bonds with variable interest rates, and bonds with no information on true interest costs. The sample for estimation and analysis consists of 1,063 fixed-rate state government general obligation bonds from 2005 to 2014.

Borrowing cost is the dependent variable in the analysis. I measure municipal borrowing costs using true interest costs (TIC), which is available in the CDIAC datasets. Hildreth and Zorn (2005) highlighted this measure as the standard gauge of borrowing costs in municipal finance. TIC is the discount rate that sets proceeds of a bond sale equal to its long-term cash flows, as Equation 2.1 shows. *P* stands for bond price, *e* represents number of periods to earliest maturity of the bond, *s* is the number of semi-annual periods to final maturity of the bond, *n* represents years to maturity, *t* is the period index, *C* represents the coupon rate, *M* stands for the value of the bond at maturity, and *TIC* is the true interest cost (see Marlowe, 2009).

$$P = \sum_{n=e}^{s} \left(\sum_{t=1}^{n} \frac{C_t}{(1+TIC)^t} + \frac{M}{(1+TIC)^n} \right) \qquad (2.1)$$

Table 2.2

Variables and Expected Effects on Borrowing Costs

Variable	Effect	Measurement
Borrowing cost of new debt issue		True interest costs (TIC) of municipal bond. (Pen & Brucatto Jr., 2004; Fruit et al., 2008)
Stability of issuer-underwriter network	-	Number of repeat interactions between an issuer and underwriter within the past 3 years. (Hiklin, 2004; Li & Schurhoff, 2012)
Method of debt issuance	+	Coded 1 for negotiated and 0 for competitive sales. (Marlowe, 2009)
Size of debt issue	-	Total par value of municipal bond. (Marlowe, 2013; Bland, 1985)
Credit rating of issue	-	Ordinal level variable representing a continuum of low to high rating of bonds; junk bonds, single-A bonds, double-A bonds, and triple-A bonds. (Moldogaziev, 2012; Pen & Brucato Jr., 2004)
Term to maturity of bond	+	Number of years from date of municipal bond issuance to maturity date of bond. (Marlowe, 2011)
Current market conditions	+	Market yield spread based on the yields of 20-year and 5-year general obligation bonds. (Peng & Brucato Jr., 2004; Moldogaziev, 2012)

Debt network stability is the independent variable of utmost interest in this study. I draw from the scant literature on municipal debt networks and measure network stability as the number of times within the past 3 years the state government used the same underwriting firm to issue new bonds. This medium-term time frame is reasonable for identifying the pattern of repeat issuer-underwriter interactions that could emerge in debt issuance. Also, since the sample period in this study spans 2005 and 2014, I stretch the measurement of issuer-underwriter interactions beyond 2005 to the 3 years preceding that year; therefore, measurement of network stability uses data covering 2002 to 2014.

Other independent variables include issue size, term to maturity of the bond, credit rating of the bond, method of debt issuance, and municipal market-wide conditions. I measure issue size as total par value of the bond (Marlowe, 2013; Bland, 1985) and gauge credit rating of the issue using an ordinal scale that combines Standard and Poor's (S&P) and Moody's credit rating symbols. The scale consists of different rating categories from 1 to 3, defined in ascending order of a bond's credit rating (see Marlowe, 2011; Capeci, 1991; Bank for International Settlements, 2014).

In addition, I measure term to maturity as the number of years from the issuance date to maturity date of the bond (Marlowe, 2011). Method of sale is coded 1 for negotiated sales, and coded 0 for competitive sales (Marlowe, 2009). Finally, I gauge market-wide conditions at the time of debt issuance using the yield spread between long-term (20 year) and short-term (5 year) municipal bond market rates (Moldogaziev & Luby, 2012; Kalotay & May, 1998).

2.4 Empirical Framework

Cross-sectional modelling is an appropriate estimation framework for assessing the impacts of network stability on municipal borrowing costs in the context of a single U.S. state. Cross-sectional regressions can accommodate non-linear patterns and year effects in the borrowing cost function and give additional insights on municipal bond issuance patterns.

Equation 2.2 shows the general form of the cross-sectional model in this study. y_i represents true interest costs of a municipal bond, $\boldsymbol{x}$ is a vector of independent variables [$\boldsymbol{x_i} = \{x_{1,i}, x_{2,i}, \ldots\ x_{k,i}\}$], $\boldsymbol{\beta}$ is the vector of coefficients associated with the independent variables [$\boldsymbol{\beta} = \{\beta_1, \beta_2, \ldots\ \beta_k\}$], *i* stands for the list of municipal bonds (*i* = 1, … , *n*), and ε_{it} is the error term (its mean is equal to zero, and it is uncorrelated with itself or $\boldsymbol{x}$).

$$y_i = \propto + \boldsymbol{\beta x_i} + \varepsilon_i \qquad (2.2)$$

The equation accommodates analysis of non-linear patterns and year effects. I analyze non-linear patterns in debt network stability using squared terms ($x_{1,i}^2$). Specifically, I examine the second power of the network stability variable to determine whether it is able to explain additional variation in municipal borrowing costs. Furthermore, I use categorical variables defined by year of debt issuance ($I_{1,i}$) to account for secular trends in the cross-sectional models. I estimate the models using robust standard errors adjusted for heteroscedasticity.

2.5 Results

2.5.1 Descriptive Statistics

A descriptive summary of the data is in Table 2.3. On average, true interest costs ranged from 3.41 to 5.23 percent (*M*=4.32, *SD*=0.91), reflecting considerable variation in cost of capital for municipal bonds covered in this study. Network stability varied widely in the sample. On average, each underwriter had between 12 and 103 (*M*=57.73, *SD*=45.50) repeat interactions with the State of California during 3 years of previous debt issuance activity.

Issue size also varied widely in the sample – its standard deviation was $151 million (*M*=70.5, *SD*=151.25). Term to maturity also varied substantially. On average, each bond in the sample had a term to maturity between 17.5 and 30 years (*M*=23.75, *SD*=6.24). Also, the maturities ranged from 3 to 35 years (*MIN*=2.89, *MAX*=35.04); this medium to long-term coverage reflects the exclusion of shorter maturities, which tend to sell in markets other than primary markets, from analyses in the present study.

Preliminary inspection of the data on issue credit rating shows variation across municipal bonds and within each year. The descriptive statistics provide further insights and show that, on average, issue credit rating was between 0.64 and 2.38 (*M*=1.51, *SD*=0.87) on an ordinal scale starting from 1 (lower rating) to 3 (higher rating) .

California issued more debt by negotiated sales (*N*=791) than competitive bidding (*N*=272) during the sample period. This trend seems to align well with the nation-wide pattern of state and local governments' preference for negotiated debt issuance despite overwhelming evidence that competitive sales result in lower interest costs. As for

Table 2.3

Descriptive Statistics for the Sample of Municipal Bonds

	Mean	Standard Deviation	Min	Median	Max
True interest costs	4.32	0.91	0.96	4.30	7.44
Network stability	57.73	45.50	0.00	47.00	205.00
Issue size (million dollars)	70.53	151.25	0.01	13.42	1556.00
Term to maturity (years)	23.75	6.24	2.89	24.23	35.04
Credit rating underlying issue	1.51	0.87	1.00	1.00	3.00
Issuance Method (Negotiated=1)	0.74	0.44	0	1	1
Market yield spread	1.22	0.77	0.37	0.98	3.11
Market Index	117.69	7.53	102.50	115.74	130.73

Note. N = 1,063.

municipal market-wide conditions, the statistics show that, on average, yield spreads associated with each municipal bond varied between 0.45 and 1.99 percent (*M*=1.22, *SD*=0.77) with an upper bound of 3.11 percent (*MAX*=3.11).

Information on underwriting activity in California gives additional insights on the descriptive statistics for network stability. The top five underwriting firms in the California sample are J.P Morgan Securities Incorporated, Merrill Lynch and Company, Citigroup Capital Markets Incorporated, Goldman Sachs and Company, and Morgan Stanley and Company. These firms lead in terms of the number and total amount of their municipal bond underwriting business with the state from 2005 to 2014. By comparison, the same firms are among the topmost 10 municipal debt underwriting firms nationwide (Bloomberg LLP., 2015).

Tables 2.4 and 2.5 provide details on the number and dollar amount of underwriting activity in the sample data. In total, the State of California engaged underwriters with 1,063 municipal bonds, or CUSIPs, worth $74.97 billion from 2005 to 2014. Of that total, the top five underwriters accounted for more than 78 percent of the number of municipal bonds and more than 79 percent of the amount of underwriting business. These statistics provide background information for computing the number of repeat interactions between the state government issuer and each underwriter in the sample.

Table 2.4

Number of State Government Bonds Underwritten from 2005 to 2014

Underwriting Firm	Number of Bonds	Share (%)
JP Morgan Securities Inc.	256	24.1
Merrill Lynch and Company	254	23.9
Citigroup Capital Markets Inc.	144	13.5
Goldman Sachs and Company	96	9.0
Morgan Stanley and Company	83	7.8
RBC Capital Markets	72	6.8
Wells Fargo Bank National Association	48	4.5
Bank of America Merrill Lynch	39	3.7
E.L. De La Rosa and Company	30	2.8
Lehman Brothers	23	2.2
Banc of America Securities	13	1.2
Bear Stearns and Company	2	0.2
UBS Securities LLC	2	0.2
Barclays Capital Inc.	1	0.1

Note. *N* = 1,063. Compiled using data from California Debt and Investment Advisory Commission (2015).

Table 2.5

Municipal Bond Underwriting Business from 2005 to 2014

Underwriting Firm	Amount (Billion Dollars)	Share (Percent)
Merrill Lynch and Company	23.4	31.2
JP Morgan Securities Inc.	13.5	18.1
Citigroup Capital Markets Inc.	11.5	15.4
Goldman Sachs and Company	5.9	7.9
Morgan Stanley and Company	5.1	6.8
E.L. De La Rosa and Company	3.1	4.1
RBC Capital Markets	3.0	4.0
Wells Fargo Bank National Association	2.9	3.9
Bank of America Merrill Lynch	2.4	3.2
Lehman Brothers	1.4	1.9
Banc of America Securities	1.0	1.4
UBS Securities LLC	1.0	1.3
Barclays Capital Inc.	0.4	0.6
Bear Stearns and Company	0.2	0.3

Note. Total amount of underwriting business by all firms was $74.97 billion.
Compiled from California Debt and Investment Advisory Commission (2015) datasets.

2.5.2 Cross-sectional Regression Estimates

I present estimates from two separate regressions. The first regression follows the basic model of true interest costs in Equation 2.2. In the second regression, I introduce curvilinear effects of network stability in the basic model of true interest costs. The two regressions test this study's main hypothesis that municipal governments' borrowing costs decline as debt management networks they belong to become more stable. Both estimations utilize heteroscedasticity-robust standard errors.

Also, multicollinearity is not a major problem in the regressions, as variance inflation factors in each regression indicate. Appendix A presents multicollinearity diagnostics for each regression. Furthermore, residual diagnostic tests for the regressions show that residuals are close to a normal distribution in each regression. Appendices B and C display standardized normal probability (P-P) plots of residuals from each regression. The next sections explain the regressions in more detail.

2.5.2.1 Estimates of the Basic Model of True Interest Costs

Table 2.6 presents a summary of results from estimation of the basic model of true interest costs. The full regression output is in Appendix D and shows categorical variables for year of debt issuance. Tests of the coefficients of the year variables show that these variables differ significantly among themselves. The F-statistic ($F = 119.68$, $p < 0.01$) in Table 2.6 shows that the dependent variable, true interest costs, is significantly related to at least one of the independent variables in the population. The R^2 statistic ($R^2 = 0.703$) shows that the regression model of true interest costs explains at least 70.3 percent of the variation in true interest costs.

Table 2.6

Basic Linear Model: Estimates of the Determinants of Municipal Borrowing Costs

Variable	True Interest Costs
Network stability	0.00109*** (0.000410)
Issue size (million dollars)	0.000167 (0.000105)
Term to maturity (years)	0.0420*** (0.00516)
Credit rating of issue	-0.156*** (0.0566)
Method of issuance (negotiated=1)	0.291*** (0.0528)
Market yield spread	0.242*** (0.0368)
Constant	3.468*** (0.229)
Observations	1,063
F (15, 1047) Prob > *F*	119.68 0.000
R-squared	0.703

Note. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Estimates of the impact of network stability on true interest costs do not support this study's hypothesis that municipal governments' borrowing costs decline as debt management networks they belong to become more stable. The coefficient of the variable measuring network stability is positive and significant at the 1 percent level ($t = 2.67$). It shows that an additional increase in network stability – in other words, one more repeated interaction between an issuer and an underwriter in new debt issuance – raises true interest costs by 0.11 basis points.

While this result does not support the stated hypothesis, it tends to support the alternative view in the academic literature that increasing network stability breeds insularity among network members, and the likely imposition of one member's narrow views about the most efficient debt management strategy raises the likelihood that the network will make more errors in strategy, undertake more risks, and incur higher borrowing costs.

Other independent variables in the basic model of true interest costs, with the exception of issue size, show estimates that are consistent with the theoretical expectations summarized in Table 2.1. As Table 2.6 shows, the variables measuring term to maturity, credit rating, method of issuance, and market conditions, are all significant at the 1 percent level. Term to maturity is positively associated with true interest costs. An increase in term to maturity raises true interest costs by 4.20 basis points. This supports the hypothesis that investors tend to associate a longer term to maturity with a higher likelihood of default and interest rate risk, which causes borrowing costs to rise as term to maturity increases.

Credit rating of a municipal bond has a negative relationship with true interest costs. As credit rating rises, true interest costs decrease by 15.60 basis points, and this confirms the hypothesis that credit rating of a municipal bond serves as a signal of the credit worthiness of the issuer and the specific bond, reduces information asymmetry about the bond, and lowers transaction costs for the issuer, therefore higher credit ratings tend to be associated with lower borrowing costs.

Effects of debt issuance method on true interest costs support the view in the academic literature that, by comparing bids of underwriters to find the underwriter offering the least interest cost for a bond, competitive sales minimize information asymmetry and will result in lower borrowing costs than negotiated sales. The coefficient of the variable measuring method of issuance shows that negotiated sales incur higher borrowing costs, on average 29.05 basis points more, than competitive sales.

Market conditions are also positively related to borrowing costs in the regressions. A rise in the market yield spread, which indicates worsening market conditions, increases true interest costs by 24.17 basis points. This evidence is consistent with the hypothesis that worsening municipal market conditions raise the risks and uncertainties associated with state and local government debt issuance, increase transaction costs, and lead to higher interest costs.

As for the variable measuring issue size, its coefficient is not significant in the basic model of true interest costs. I investigated this relationship further within subsets of the sample defined according to quartiles of issue size. This sub-sample analysis also did not identify any significant effects of issue size on municipal borrowing costs. Also, I explored curvilinear effects of issue size by adding a square term of the variable in the basic model of true interest costs and still did not find significant effects. Thus, the present study does not find results to support the hypothesis that size of debt issuance is negatively related to borrowing costs. It is likely that for the cross-section of municipal bonds in this study, determination of a bond's true interest costs pays little or no attention to size of bond as a signal of interest rate risk.

2.5.2.2 Estimates of the Model with Curvilinear Network Effects

Table 2.7 presents estimates of the regression capturing curvilinear effects of network stability on borrowing costs.[10] The *F*-statistic ($F = 115.29$, $p < 0.01$) shows that true interest cost of debt issuance is significantly related to at least one of the explanatory variables in the population and the R^2 statistic ($R^2 = 0.704$) indicates that the regression model explains at least 70.4 percent of the variation in true interest costs.

Estimates of the network stability variables show that a statistically significant curvilinear relationship exists between network stability and true interest costs. The coefficients of the variables measuring network stability and its square-term are significant at the 1 percent ($t = 2.69$) and 5 percent ($t = 1.92$) levels, respectively. The coefficients show that an increase in network stability – or one more repeat interaction between an issuer and underwriter – increases true interest costs of debt issuance by 0.29 basis points; however each additional repeat interaction raises interest costs less than the one before it, and interest costs reach a peak, then decrease at an increasing rate.

[10] The full regression output includes categorical variables for year of debt issuance and is in Appendix E.

Table 2.7

Model with Curvilinear Network Effects: Estimates of the Determinants of Municipal Borrowing Costs

Variable	True Interest Costs
Network stability	0.00290*** (0.00108)
Network stability (square term)	-0.0000119** (0.0000062)
Issue size (million dollars)	0.000173 (0.000105)
Term to maturity (years)	0.0419*** (0.00516)
Credit rating of issue	-0.156*** (0.0576)
Method of issuance (negotiated=1)	0.292*** (0.0527)
Market yield spread	0.256*** (0.0398)
Constant	3.401*** (0.241)
Observations	1,063
F (16, 1046) Prob > *F*	115.29 0.000
R-squared	0.704

Note. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The critical value in the network stability-interest costs relationship is determined from the coefficients of the variables measuring network stability (b_1 = 0.00290) and its square-term (b_2 = - 0.0000119) using the following standard formula: $- b_1 / 2b_2$. Based on this formula, true interest costs reach a peak at 121 repeat interactions. In other words, each new issuance of a municipal bond, or CUSIP, will lead to lower borrowing costs only after the issuer repeatedly used the same underwriting firm to sell 121 municipal bonds in the preceding 3-year period. Figure 2.3 depicts the curvilinear relationship between network stability (*s*) and borrowing costs (*r*) and shows the critical value (*s**).

Overall, the regression estimates in the model adjusted for curvilinear effects give additional insights on network stability effects on municipal borrowing costs. The estimates show a threshold beyond which higher levels of network stability may lead to lower borrowing costs, and the finding tends to support the study hypothesis.

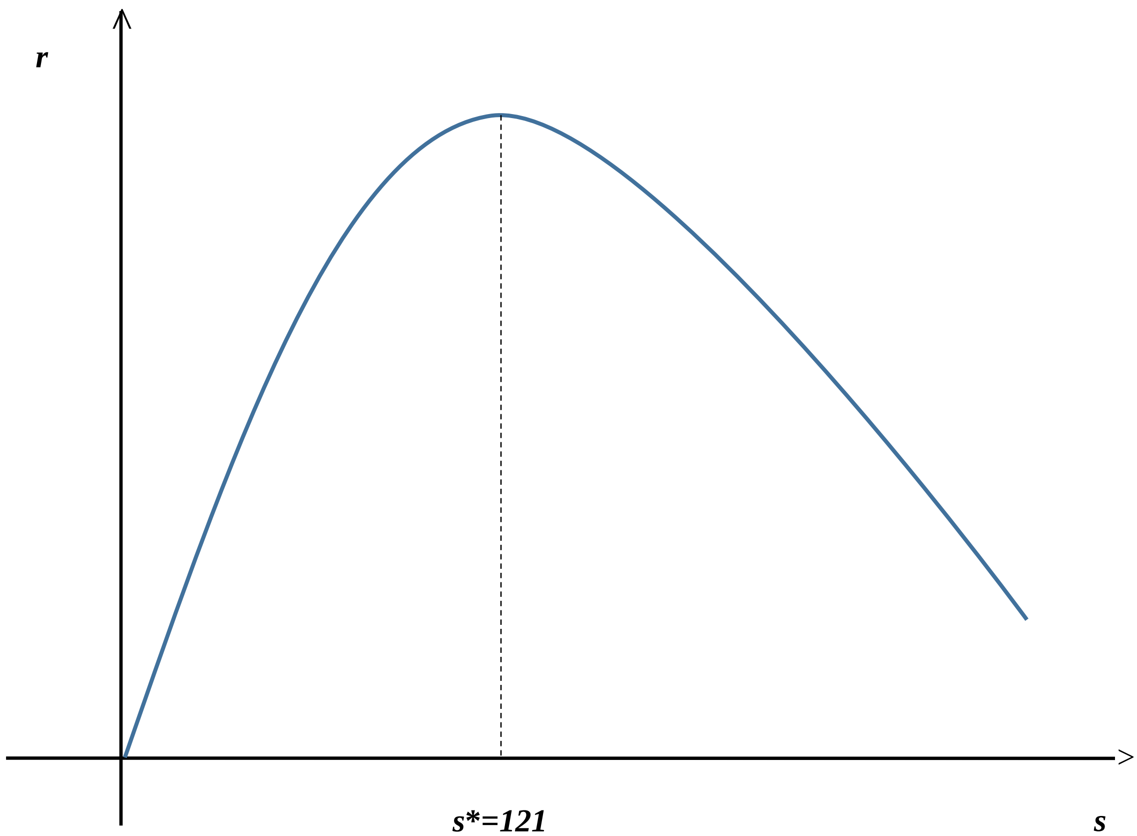

Figure 2.3. Curvilinear Relationship between Debt Network Stability and Municipal Borrowing Costs.

2.6 Summary, Conclusions, and Directions for Future Research

This study investigated municipal debt management networks. It analyzed the relationship between network stability and municipal borrowing costs. Results show that municipal borrowing costs increase as debt management networks become more stable, but beyond a certain threshold of stability – in particular, after an issuer repeatedly used the same underwriting firm for 121 municipal bonds, or CUSIPs, in the preceding 3 years – borrowing costs tend to decline with each additional increase in stability. This number of separate CUSIPs is best understood in the context that most bonds are structured as part of a serial issuance, and each issuance could consist of scores of CUSIPs.

Findings from this study deepen understanding of the impacts of network stability on municipal borrowing costs and present debt management policy implications. Stability of debt networks generally increases municipal borrowing costs. Depending on the size of the municipal bond, higher borrowing costs from increased stability can amount to millions of dollars and constrain municipal budgets. The academic literature explains how insularity and risk-taking both increase among network members as networks become more stable, and highlights how that could raise state and local government borrowing costs. Thus, the empirical finding that a positive statistical relationship exists between network stability and municipal borrowing costs should renew state and local managers' focus on the stability properties and efficient performance of local debt management networks. In addition, knowing that a critical threshold exists beyond which network stability can be interest-cost reducing should guide municipal debt managers in gauging the efficient level of repeat interactions that can attenuate interest cost losses for the municipality.

This study is limited in its coverage of U.S. states. The empirical analyses are based on patterns in municipal debt issuance in California. Also, the sample dataset is limited to state government bonds and the networks that form between the state government and underwriting firms. More information is required on other U.S. states, and other levels of municipal government such as school districts, cities, and counties, to make cogent nationwide generalizations on the impacts of network stability on state and local government borrowing costs. Still, the California data displays considerable variability in bond-specific, issuer-related, and market condition variables to support inferences about nation-wide patterns in municipal debt management networks and borrowing costs.

Much of the work on debt management networks to date have focused on network stability and centrality. More analytical work is needed in public administration contexts to fully explain how additional structural properties of networks can be applied to the complex public policy problems that affect state and local governments. Future studies should explore, for example, whether or how network cohesion – or the minimum number of members who if removed from a network could disconnect the group – matters in municipal debt issuance.

CHAPTER 3

MANAGING SCHOOL DISTRICT DEBT IN COMPLEX FINANCIAL MARKETS: AN ANALYSIS OF THE OPTION VALUE LOSS IN DEBT REFINANCING

3.1 Background and Research Questions

Over the last three decades, the markets within which state and local governments manage their debt have become more complex. Major tax reforms have prompted stringent changes in arbitrage rules related to debt financing (Hildreth & Zorn, 2005), the Great Recession has spawned severe changes in liquidity and credit dynamics affecting risk taking and portfolio management (Bordo & Landon-Lane, 2013; Taylor, 2014), and sophisticated financing vehicles continue to proliferate and provide unique opportunities for restructuring debt obligations (Luby & Kravchuk, 2012). Amidst these complex and evolving market environments, state and local government debt issuers have employed innovative debt management strategies to maximize interest cost savings but these strategies also present inherent risks.

Refinancing is a common debt management strategy among state and local governments. It is the issuance of new debt to replace outstanding debt. Debt refinancing may be compared to mortgage refinancing in residential housing contexts, even though there are key differences. When the mortgage rate declines, a homeowner will take on a new mortgage loan to replace the old mortgage loan which has a higher mortgage rate. This reduces the homeowner’s monthly mortgage payment. However, any similarities between municipal debt refinancing and mortgage refinancing end at this point due to the existence of call and put options in municipal bonds.

A call option gives the seller of the option (the municipal debt issuer) the right, and not the obligation, to redeem a municipal bond at a certain price and on a given date prior to maturity of the option (Securities and Exchange Commission, 2015). On the other hand, a put option gives the investor the right, and not the obligation, to sell a municipal bond at a certain price and on a stated date prior to its maturity (Parkinson, 1977). Issuers pay a premium to have the right to redeem a municipal bond. They pay this premium at the time of exercising the option and this premium reflects in the exercise or strike price of the option.

With the call option in particular, an issuer may exercise the option on an existing bond when interest rates are lower on the call date. By replacing an existing bond with a new bond at a lower interest rate, the issuer obtains interest cost savings that can provide a measure of budget relief for the municipality. It is also possible that an issuer will refinance an existing bond several years prior to the call date of the bond; this is a sophisticated form of debt refinancing known as advance refunding.

In an advance refunding, an issuer sells a new bond several years in advance of the call date of an existing bond, invests proceeds from sale of the new bond in an escrow account to earn interest, and uses proceeds from the escrow account to fund interest payments to holders of the older bond until the call date when the issuer pays off all debt obligations (Securities and Exchange Commission, 2015; Moldogaziev & Luby, 2012). In this transaction, the new bond is called a refunding bond while the older bond is called a refunded bond. Figure 3.1 illustrates the mechanics of an advance refunding debt transaction.

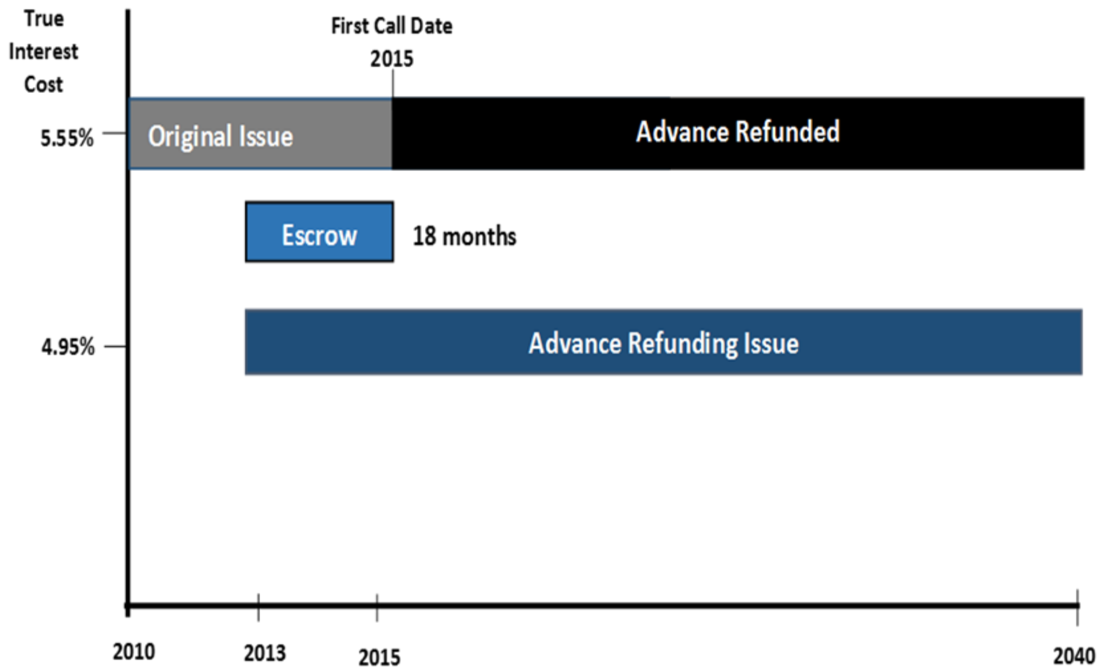

Figure 3.1. Illustration of How Advance Bond Refunding Works.

Advance refunding differs from current refunding in regard to the length of time within which an issuer must retire all principal and interest payments on a refunded bond. In a current refunding, an issuer must use the proceeds from a refunding bond to retire all principal and interest payments on a refunded bond within ninety days of the advance refunding transaction. By contrast, in an advance refunding, an issuer must retire all principal and interest payments on the refunded bond at least 90 days after the issuance of the refunding bond (Moldogaziev & Luby, 2012).

Issuers engage in advance refunding for at least three reasons (Peng, 2005). The first reason is the interest cost savings the debt management strategy gives issuers. When interest rates decline, issuers do not have to wait until the call date of an existing bond to refinance the bond. Early exercise of the call option generates interest cost savings for the municipality. A second reason is to lengthen the final maturity of debt obligations and reduce debt service payments. Even when interest rates are not lower prior to the call date, an issuer may replace an existing bond with a new bond in order to spread the debt obligation over a longer time horizon and pay less in debt service. Lengthening the maturity structure of the debt obligation in this way produces immediate budget relief for the municipality, although in present value terms the issuer's debt service obligation may not be lower. A third reason is to get out of restrictive bond covenants in the older bond, such as the requirement of a debt reserve fund.

What makes advance refunding a complicated debt refinancing strategy is the timing of the transaction. Existing federal tax law allows only a one-time execution of an advance refunding transaction on a bond. Thus, an issuer must choose the most appropriate time to engage in advance refunding to reap maximal interest cost savings from the transaction. When interest rates decline, an issuer may advance refund a bond anytime between the date of original issuance and the first call date of the bond. Advance refunding results in a gain for the issuer through lower debt service. If the issuer had not advance refunded the bond, the issuer would be incurring higher interest costs from the time point defined by the refunding date until the call date. Thus, the gains from advance refunding can amount to millions of dollars in savings for a munciipality. Figure 3.2 illustrates the interest cost savings that may accrue from advance refunding at a lower interest rate.

On the other hand, by exercising the one-time opportunity to advance refund a bond when interest rates decline, the issuer loses the option to call the bond at a later date, if interest rates decline further between the advance refunding date and the call date. This lost option, or opportunity cost, is known as an option value loss. Figure 3.3 illustrates the option value loss in an advance refunding transaction. Finance theory provides a way to gauge this option value loss in dollar terms using the concept of a put option and financial option valuation methods (Ang, Green, & Xing, 2013). Therefore, the option value loss serves as a gauge of the efficiency of an issuer's timing of the advance refunding transaction.

Only a few studies have examined option value loss, or the closely related subject of interest cost savings, in advance refunding debt transactions. Previous studies (e.g., Dyl & Joehnk, 1976; Zhang & Li, 2004) have examined in detail the interest cost savings from advance refunding. In the present study, I shift the focus of empirical analyses from interest cost savings to option value loss. The goal is to obtain an outcome measure to gauge the efficiency of advance refunding in municipal bond markets.

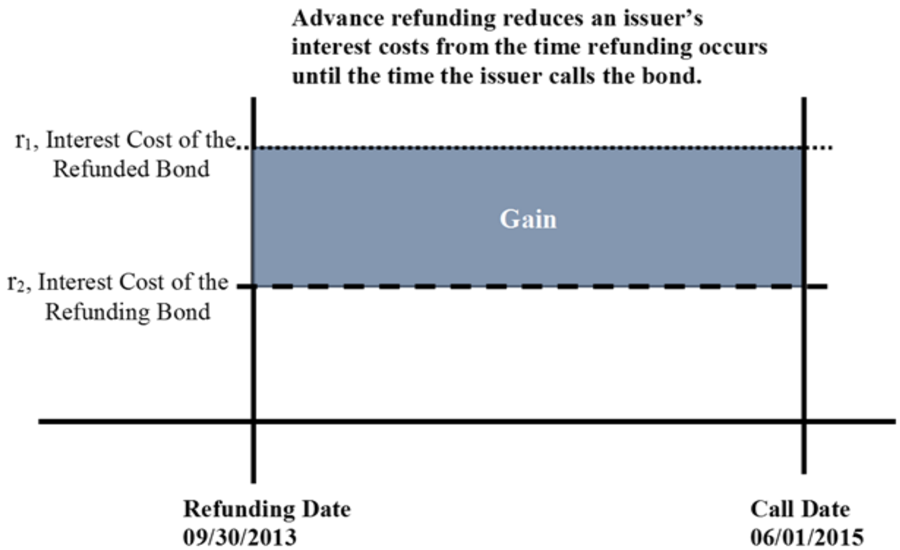

Figure 3.2. Illustration of the Gains from Advance Bond Refunding.

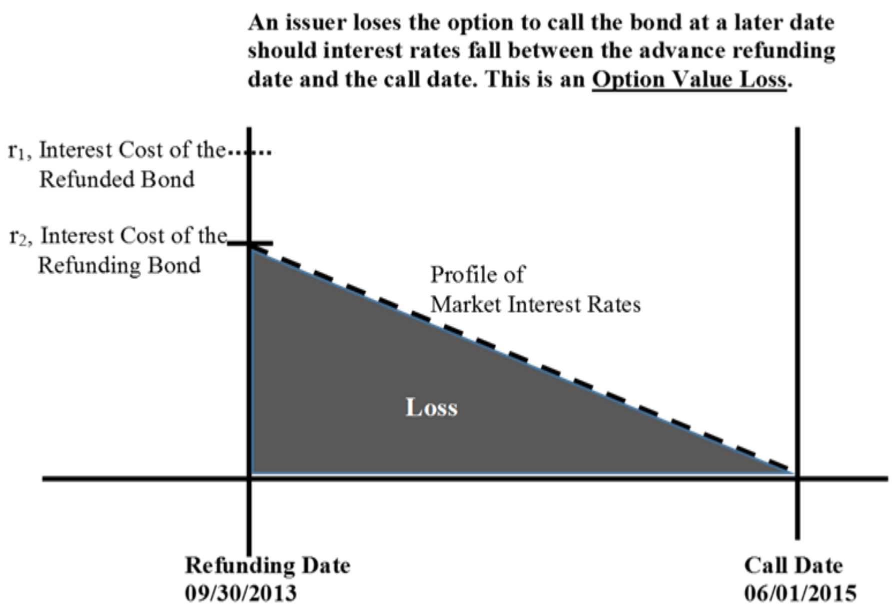

Figure 3.3. Illustration of the Option Value Loss in Advance Refunding.

Currently, Ang et al. (2013) is the only study that measured option value loss in state and local government debt refinancing. However, the study relies on simplifying assumptions about how option prices respond to underlying risk factors in an advance refunding transaction. For example, the study assumes that market price of risk changes linearly, or according to a time-varying trend, once per year. This assumption constrains the number of iterations in estimation, does not accurately represent volatility in market price of bonds, and can lead to imprecise estimates of option value loss.

In the present study, I use Monte Carlo simulation procedures to compute option value loss. This approach improves upon the linear approach to measuring option value loss in Ang et al. (2013). The logic of the Monte Carlo approach to option valuation, and the value-added from using this approach in measuring option value loss, is well established in the academic literature (Bouchard & Warin, 2012; Boyle, 1977; Broadie & Glasserman, 1997). The method is based on the reasoning that the distribution of bond prices at the time of maturity, or at a specified time in the future such as the call date, is determined by a non-linear random process generating movements in future prices (Boyle, 1977). The non-linear random process the Monte Carlo procedure utilizes gives a more accurate representation of the dynamics in market prices than the methods in existing studies on option value loss. Accordingly, Ibanez and Zapatero (2004) noted that "Monte Carlo simulation is the appropriate method for problems of higher dimension and/or stochastic parameters" (page 253).

In addition, existing work does not explain the extent to which major economic downturns affect option value loss. Economic shocks affect market agents' expectations and valuation of municipal securities (Easley & O'Hara, 2010). During economic downturns, market agents tend to lower their expectations of future returns on investments. This lowering of expectations raises risk and uncertainty regarding the future path of market interest rates. Thus, advance refunding outcomes during periods of economic downturn will differ significantly from outcomes in stable economic times. In the present study, I assess the influence of a major economic downturn, the Great Recession, on municipal bond advance refunding outcomes.

More importantly, the present study focuses on school districts. Ang et al. (2013), the only existing study on option value loss in municipal debt refinancing, covered state and local governments broadly and presented only scant information on school districts' market operations. The study noted that school districts incur the worst option value losses among subnational governments; however, the study did not provide information on the specific patterns and magnitudes of school district option value loss in municipal bond markets. The present study focuses on school district option value loss to shed more light on the efficient timing of their transactions in municipal bond markets. Too, the focus on school districts in the present study should lay the groundwork for future studies that investigate the relationship between efficiency of school district debt management outcomes and the quality of education in the local community.

Trends in school district debt refinancing reveal a significant amount of advance refunding activity. Data from Bloomberg LLP. (2015) show that school districts advance refunded 14,826 bonds, worth $38.3 billion in par value, from 2005 to 2014. This amount compares with $851.6 billion in par value of all state and local government advance refunding during the same period. Furthermore, advance refunding activity among school districts appears to be associated with swings in the economy: activity peaked prior to the

Great Recession, slowed during the recession years, and resurged moderately in the years immediately following.[11] Market forecasts suggest that continued recovery in advance refunding activity is likely as economic conditions improve further (Securities and Exchange Commission, 2015). Figure 3.4 traces the number of advance refunding transactions from 2005 to 2014 and Figure 3.5 shows the dollar value of the transactions.

School districts may have engaged in refunding to obtain interest cost savings, but how well they timed their transactions to minimize option value loss remains to be adequately assessed. I ask the following questions: How much option value do school districts lose from advance refunding, and how do economic downturns, such as the Great Recession, affect advance refunding outcomes in municipal bond markets?

I situate the study in strategic choice theory (Child, 1972; Miles, 1978) considering that other studies (e.g., Hildreth, 1993) have demonstrated the theory's applicability to municipal debt issuance contexts. In the next sections, I explain the strategic choice theoretic frame underpinning this study, give a brief overview of the factors that motivate the decision to engage in advance refunding, identify and explain how specific parameters influence option value loss in advance refunding, examine previous work to provide insights on advance refunding outcomes and develop hypotheses, discuss the data, methodology, and results for the present study, and outline policy implications and directions for future research.

[11] The National Bureau of Economic Research (NBER) determined that the Great Recession began in December 2007 and ended in June 2009, extending over an 18-month period.

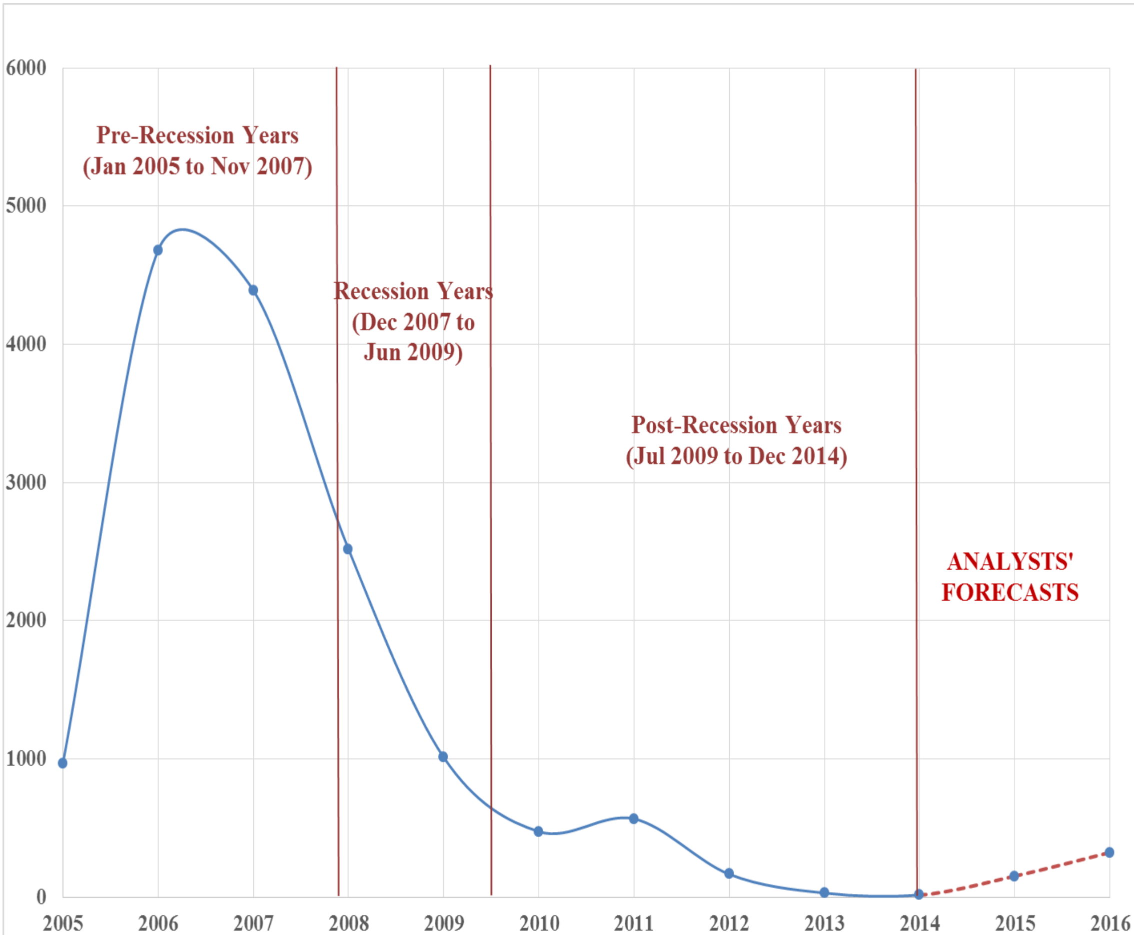

Figure 3.4. Number of Advance Refunding Transactions by U.S. School Districts. Data spans 2005 to 2014 and is compiled using debt issuance data from Bloomberg LLP. (2015).

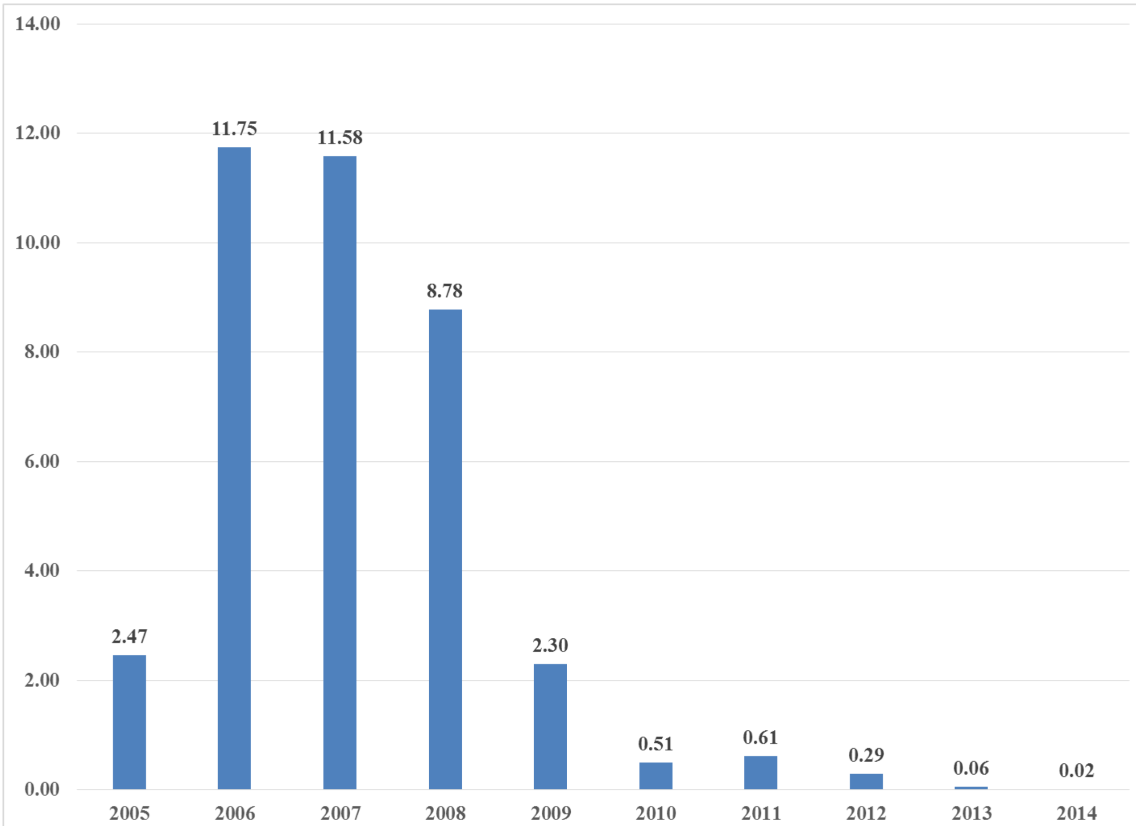

Figure 3.5. Par Value of U.S. School District Advance Refunding Transactions. Data is compiled from Bloomberg LLP. (2015), spans 2005 to 2014, and is displayed in Billion U.S. Dollars.

3.2 Strategic Choice Theory and the Advance Refunding Debt Transaction

Strategic choice theory explains the role leaders, or leading groups within an organization, play in influencing the organization's choices in a dynamic political process such that the choices become part of an organizational learning process that adapts to both internal political situations and changing external environments (Child, 1972; Miles, 1978; Child, 1997). The strategic choice theoretic framework has been used variously in the academic literature to study local government contracting-out choices (Ferris & Graddy, 1986), municipal government sector choices for public service delivery (Feiock, Clingermayer, & Dasse, 2003), local government service provision choices within metropolitan areas (Joassart-Marcelli & Musso, 2005), local level decisions on social welfare provision (Craw, 2010), municipal choices during a recession (Nelson, 2012), and choice of foreign markets in sovereign bond issuance (Siegfried, Simeonova, & Vespro, 2007).

The present study extends application of strategic choice theory to the school district debt refinancing research domain. Hildreth (1993) studied state and local governments' strategic choices in capital markets. He highlighted the important role a subnational government's chief financial officer plays in designing appropriate strategies to achieve efficient outcomes amidst changing market conditions. His descriptions of state and local governments' strategic debt market choices provide a way for connecting strategic choice theory to school districts' bond refinancing decisions in the following way: school district boards are a top decision-making group in school district debt management; board members – or other external agents to whom they delegate authority – make strategic choices among debt refinancing options in rapidly changing economic and political environments; and option value losses from the choices school district boards make provide a way to gauge debt management efficiency and public managers' accountability to citizens.

Essentially, the decision-making structure, debt management functions, and accountability standards of school district boards make it plausible to connect the strategic choice theory to school district advance refunding outcomes. Setting the advance refunding decision within the strategic choice theoretic framework requires consideration of two decision-making scenarios facing school district leaders. The first involves the decision on whether to engage in advance refunding or not. Concerning this decision, the academic literature outlines a range of bond-specific, issuer-related, market-centric, and political factors that school district managers consider. I provide a brief explanation of these factors in Section 3.3.

Following the decision to engage – rather than not to engage – in advance refunding, a second decision scenario concerns when to execute the refunding transaction. As Figure 3.3 illustrates, the second decision scenario defines a time space for an advance refunding transaction – that is, anytime from the date of original issuance to the first call date of the bond. That existing federal tax law allows only a one-time execution of advance refunding on a municipal bond makes this decision scenario a crucial one. Overall, school district managers' decision to engage in advance refunding, and their strategic choice between different time points in executing the transaction, directly affects interest cost savings and, in particular, option value loss.

3.3 What Motivates the Decision to Engage in Advance Debt Refunding?

A formal test of the factors that motivate subnational governments' decision to engage in advance refunding is not the focus of this study. Nevertheless, this section gives brief explanations on the determinants of the advance refunding decision to provide background information on the decision-making scenarios in municipal debt refinancing.

Economic, financial, and political considerations influence subnational governments' decision to engage in advance refunding in municipal bond markets. Earlier attempts at explaining determinants of the refinancing decision focused on interest cost savings motivations (Dyl & Joehnk, 1976; Joehnk & Dyl, 1979). However, more recent efforts have broadened the scope of analysis to include market-wide economic factors and political considerations (Vijayakumar, 1995; Gupta & Lee, 2006; Zhang & Li, 2004; Moldogaziev & Luby, 2012; Luby, 2014). Scholars commonly consider how size of the debt issue, market-wide interest rates and yield curves, credit rating of the municipal debt issuer, and political structures in the debt-issuing jurisdiction, all influence the decision to engage in advance refunding.

3.3.1 Size of debt issue and other issue-specific characteristics

Larger debt issues have lower interest costs than smaller issues because larger debt issuers often utilize the services of large financial intermediaries who typically operate at lower transaction costs (Emery & Finnerty, 1991; Marlowe, 2011). Larger issues also have more investor interest than smaller issues (McCauley & Remolona, 2000). Therefore, subnational issuers are more likely to engage in advance refunding of larger issues because they can obtain greater interest cost savings from larger issues than smaller issues (Vijayakumar, 1995; Moldogaziev & Luby, 2012).

Additionally, issuers are more likely to advance refund their bonds if the bonds have shorter maturities than when the bonds have longer maturities. Investors associate shorter maturities with lower likelihood of default and interest rate risk, and bonds with shorter maturities tend to have lower borrowing costs (Marlowe 2009). Therefore, issuers are more likely to advance refund bonds with shorter maturities because issuers can obtain larger interest cost savings from shorter-term bonds than longer-term bonds.

Issue purpose is another determinant of advance refunding. Market agents view state and local government borrowing for education, utility, and government general purpose projects to be less risky than borrowing for health care and economic development projects, therefore issuers tend to incur lower borrowing costs for education, utility, and government general purpose projects that agents perceive to be less risky (Leonard, 1983). Thus, issuers are more likely to engage in advance refunding of less risky bonds because interest cost savings will be larger for these bonds than for more risky bonds.

3.3.2 Market-wide interest rates

Issuers are more likely to engage in advance refunding when market-wide interest rates are lower than when rates are higher because interest cost savings are larger when rates are lower (Dyl & Joehnk, 1976; Zhang & Li, 2004; Joehnk & Dyl, 1979; Vijayakumar, 1995). Also, in terms of the spread between long-term (20 years or more) and short-term (5 years or less) municipal market rates, larger yield spreads represent expectations of higher future interest rates in the market, therefore issuers are more likely to engage in advance refunding in the current market environment to obtain interest cost savings (Moldogaziev & Luby, 2012).

3.3.3 Credit rating and financial viability conditions of an issuer

Credit ratings represent the level of creditworthiness of an issuer. More creditworthy issuers incur lower interest costs in debt issuance, hence are more likely to engage in advance refunding to obtain greater cost benefits than less creditworthy issuers (Moldogaziev & Luby, 2012; Vijayakumar, 1995). Similarly, weak financial conditions of an issuer, such as when an issuer cannot fulfill existing provisions in a bond covenant and is facing default, can cause the issuer to re-write and exit the existing provisions through an advance refunding (Ziese & Taylor, 1977).

3.3.4 Political Structures

Vijayakumar (1995) explained political incentives for advance refunding in the context of highly competitive political environments where leaders can utilize the refunding decision for patronage purposes, because the decision to refinance can provide substantial revenue to firms that politicians select to oversee the refunding process. Also, issuers may have a political incentive to engage in advance refunding and achieve lower debt service and budget flexibility.

3.4 How Specific Parameters Influence Option Value Loss

As noted earlier, advance refunding involves two interconnected decisions – the decision about whether to engage in advance refunding or not, and if the decision is to engage in refunding, the strategic choice of a specific time to execute the transaction and maximize interest cost savings while minimizing opportunity costs or option value loss associated with the transaction. The magnitude of option value loss in advance refunding is contingent on three main factors: (1) time remaining until the call date; (2) risk free interest rates corresponding to the life remaining on the call provision; and (3) variance in the future value of the advanced refunded bond.

3.4.1 Time Remaining Until Call Date

Option value loss is greater if there is a longer time remaining between the time advance refunding occurs and the call date of the refunded bond (Ang et al., 2013). Longer time horizons heighten uncertainty about the profile of market interest rates and amplify the risk of alternative timing scenarios offering more interest cost savings than the existing refunding strategy.

3.4.2 Risk-free Interest Rates

Rises in risk-free interest rates magnify option value loss. Advance refunding is a pre-commitment to the call provision in a refunded bond and causes issuers to forfeit the option to call the bond again should interest rates rise, on average, prior to the call date (Ang et al., 2013; Kalotay & May, 1998; Miller & Folta, 2002). Therefore, rises in risk free interest rates raise the present value of any interest cost savings that could have occurred between the time refunding occurs and the call date, thereby amplifying the opportunity costs associated with the advance refunding transaction.

3.4.3 Volatility in the Future Value of the Bond

Volatility in the future value of an advance refunded bond is positively related to option value loss. Higher rates of volatility in a bond's trade prices reflect investor uncertainty about future yields on the bond, making it more advantageous for an issuer to delay refunding until expected interest cost savings for the bond are more certain (Kalotay & May, 1998) and opportunity costs less magnified.

3.5 Insights from Previous Studies on Advance Refunding Outcomes

This section presents an overview of existing studies on advance refunding outcomes in municipal bond markets. It considers studies that assess interest cost savings and examines work on option value loss. While estimation of interest cost savings is not the focus of the present study, the brief discussion of studies on the topic could be useful for understanding the analytical procedures in advance refunding studies, how the approaches have evolved over time, and how the methods could shape investigations on option value loss.

Measurement of advance refunding gains and losses has evolved from simple cost-benefit calculations (e.g. Dyl & Joehnk, 1976; Kalotay & May, 1998; Brooks, 1999) to more intricate option pricing models (Orr, la Nuez, & Manuel, 2014; Zhang & Li, 2004) that draw from a diverse range of mathematical finance formulations such as the Vasicek (1977) models, Hull and White (1990) formulae, and Monte Carlo methods.

Cost-benefit calculation of advance refunding outcomes involves five steps: (1) determining the initial cash flow, (2) determining the periodic cash flows of old and new bonds, (3) determining the appropriate discount rate, (4) determining the present value of the differential cash flows, and (5) computing the present value savings from advance refunding (Joehnk & Dyl, 1979).

Researchers using cost-benefit methods have found that advance refunding transactions result in positive net present value savings for the issuer (Dyl & Joehnk, 1976) and savings tend to increase as efficiency of refunding operations – measured as the ratio of present value cash flow savings to the total option value relinquished in a refunding activity – improve (Kalotay, Yang, & Fabozzi, 2007).[12]

Studies that employ more sophisticated models to compute advance refunding outcomes often proceed in three steps: (1) determining the values for a set of simulation parameters that include market interest rates (either risk-free or with interest arbitrage) and volatility in price of bonds, (2) simulating multiple expected paths for bond price dynamics, and (3) computing the average of expected prices along the paths to determine the present value of gains or losses.

Zhang and Li (2004) computed the net present value of interest cost savings from an advance refunding. They used a binomial probability model of future prices of an advance refunded bond to estimate the intrinsic value of the option on the bond. The model included information on coupon rates, market yield curves, and future bond prices. Their analysis utilized data on 60 bonds issued in the State of New York in 2001. They found that for coupon rates ranging between 2.4 and 3.0 percent, advance refunding

[12] Kalotay et al. (2007) did not directly estimate option value relinquished or lost; rather, they analyzed a hypothetical advance refunding bond transaction.

resulted in interest cost savings ranging from 0.12 to 8.54 percent of par value, in present value terms.

Zhang and Li also extended their analysis to cover refunding efficiency. Similar to Dyl and Joehnk (1976), they defined refunding efficiency as the ratio of the present value of interest cost savings to the par value of the advance refunded bond. Refunding efficiency ranged from 0.07 to 0.98, with most of the advance refunding transactions in the sample having a ratio close to 1. Ratios closer to 1 depict greater levels of refunding efficiency.

Orr, la Nuez, and Manuel (2013) also investigated interest cost savings from advance refunding. They analyzed the outcomes from a hypothetical advance refunding bond transaction and found that issuers can accrue net present value savings ranging from $3 to $12 per $100 of par value for coupon rates between 2.5 and 5 percent. They used a simulation procedure to generate 10,000 trials of multiple-market yield curves from 1970 to 2013 to calculate the net present value of interest cost savings. Similarly, Orr et al. (2014) assessed competing refunding policies for a sample of 220 bonds. They found that net present value savings of up to 3 percent of par value were possible at high levels of refunding efficiency.

Studies of the interest cost savings from advance refunding give useful insights on municipal governments' transactions. However, as already noted, the focus in this study is on the intrinsic – or option value – loss issuers incur in these transactions. Ang et al. (2013) is the only existing study that attempts to compute the option value loss from advance debt refunding. They analyzed a large dataset of U.S. state and local governments' advance refunding transactions from 1995 to 2009. Their analysis utilized a single factor term structure model based on the specification in Vasicek (1977) and Hull and White (1990) to value the option value loss from refunding. Single factor models attempt to explain how changes in short-term market rates affect the return on a portfolio of securities. Using this modelling approach to option pricing, Ang et al. found that, in a typical advance refunding transaction, issuers' option value loss is approximately 1 percent of par value. Option value losses in their sample ranged from $0.05 to $30.50 per $100 of par value. Also, the authors ranked the 50 largest option value losses in their sample according to type of municipal issuer and found that school districts incurred 30 of the largest option value losses.

Ang et al.'s finding that school districts incurred a majority of the worst option value losses seems to conform with the view in the municipal finance literature that school districts face peculiar challenges in debt management (Simonsen, Robbins, & Helgerson, 2001). Still, Ang et al. (2013) did not provide details on the specific patterns and magnitudes of school districts' option value loss in municipal bond markets.

Another limitation of Ang et al. (2013) is the assumption that short-term market rates – which represent the market price of risk – change linearly, or according to a time-varying trend, once per year. Zhang and Li (2004) highlighted how market interest rates are non-linear and random, or stochastic, and can change anytime between the advance refunding date and the call or final maturity date. Zhan and Li's characterization of interest rate behavior is accommodated within the Monte Carlo setting for option valuation. The Monte Carlo method assumes a stochastic process for determining the distribution of bond prices at the call or final maturity date. It discounts the average of the future prices into present value terms to obtain option value loss. The method meets the important criteria of unbiasedness, efficiency, and consistency (Mooney, 1977).

Consequently, I use the Monte Carlo method of option valuation to test the following hypothesis on school district advance debt refunding:

H.3.1: School districts lose option value, equivalent to significant amounts of dollars, in advance refunding bond transactions.

Finally, previous studies of advance refunding outcomes in municipal bond markets ignored the influence of economic shocks. Economic downturns tend to lower market agents' expectations and their valuation of municipal securities (Easley & O'Hara, 2010) which heightens risk and uncertainty about future prices of bonds and exacerbates option value loss. Hence, I test the following hypothesis, using the Great Recession as a natural experiment:

H.3.2: Option value loss is more severe during economic recessions.

3.6 Data and Measurement of Variables

Bloomberg LLP is the main source of data for analysis. I collect data on school district advance debt refunding. The data give details on an advance refunded bond and include information on date of original issuance, date on which the issuer advance refunded, call date embedded in the bond, price of the bond on the call date, par value of the bond, time to maturity, coupon rate, and identity of the school district issuer.

I focus my analysis on Texas school districts. Hicklin (2004) emphasized the advantages of analyzing school district management outcomes within the setting of a single U.S. state, noting that it allows empirical testing of data from a single source and reduces measurement inconsistency. Texas is a unique choice for analysis due to two main reasons. The State is the leading source of school district advance refunding transactions among U.S. states. It accounts for the largest share of transactions both in terms of frequency and total par value, as shown in Appendix F.[13] Texas also has a large and diverse population of school districts which allows for considerable variability in the data. The State accounts for 10.1 percent of the nation's K-12 enrollments, second to California which constitutes 12.5 percent.

The study uses a random sample of 100 bonds, or CUSIPs, advance refunded by Texas school districts between January 1, 2005 and December 31, 2014. Using a random sample to analyze patterns in municipal bond markets is not uncommon in the academic literature. Zhang and Li (2004) used a sample of 61 municipal bonds to analyze advance refunding patterns. Similarly, Orr and de la Nuez (2014) created a random sample of 220 municipal bonds to analyze competing advance refunding policies. Also, Vijayakumar (1995) used a sample of 102 general obligation bonds to study state and local government advance refunding decisions. In the present study, I use a random sample of 100 advance refunded school district bonds to glean insights about the magnitude of option value loss among school districts, and to provide an empirical basis for future larger-scale explorations of patterns in school district advance refunding outcomes in municipal bond markets.

Preliminary exploration of the 100, randomly selected, advance refunded Texas school district bonds reveals that the bonds are from 32 school district debt issuers spread across different geographical regions in Texas. These school district issuers also fall

[13] State-specific statutes, fiscal rules and conventions may affect the extent to which school districts within a particular U.S. state undertake advance refunding of bonds.

within the lower, middle, and upper levels of property tax revenue base. They also represent small, medium, and large enrolment size categories of Texas school districts. These variations in the sample should support inferences about the population of school district advance refunding transactions.

Computing option value loss requires information on uncertainty in future prices of the advance refunded bond. This option valuation parameter is explained in Section 3.4.3. I follow the approach in Ang et al. (2013) and use volatility in secondary market trade prices of an advance refunded bond as a measure of uncertainty in its future prices.[14] Consequently, I gather information on all trades in a bond for each of the advance refunded bonds in the sample. This makes it possible to calculate uncertainty that is specific to the advance refunded bond. In all, I gather 7,800 observations of secondary market trade prices for the advance refunded bonds in the sample. Data on trade prices is from the Municipal Securities Rulemaking Board's Electronic Municipal Market Access platform.

Option value loss computation also requires information on risk free interest rates. The link between risk-free interest rates and the magnitude of option value loss is explained in Section 3.4.2. I use data from the U.S. Treasury's State and Local Government Series (SLGS) interest rate tables. The SLGS emerged as a risk-free investment vehicle among state and local governments, following the federal government's restriction on investment of proceeds (e.g., from advance refunding) in

[14] Using volatility in secondary market trade prices as a gauge of uncertainty in the future value of a bond seems to be the standard approach in the financial option valuation literature. Both Beatty and Ritter (1986) and Miller and Reilly (1987) explain how secondary market trade prices contain information about the value of securities in the primary market. Also, Green (2004) notes that "when some market participants have private information about the value of an asset, their trades reveal information to the market." (p. 1201).

higher-yielding instruments to earn arbitrage profits. Consequently, states, counties, cities, and school districts lock-in savings from advance refunding by placing proceeds in an escrow fund which holds yield-restricted U.S. Treasury securities (such as the SLGS) that match scheduled principal and interest payments on the advance refunded bonds (U.S. Department of the Treasury, 2011). In collecting data on SLGS rates, I ensure that the rates correspond to the life remaining in the advance refunded bond's call provision.

3.7 Methodology

I compute option value loss using three main steps. First, I define a scenario for option valuation where school districts have a one-time opportunity to advance refund a bond prior to the call date of the bond. This option pricing scenario is closely aligned with existing federal tax law limiting, to just once, the number of times state and local governments can execute an advance refunding operation for a particular municipal bond. Thus, the option pricing approach defines two discrete time periods for option valuation – a time prior to expiration of the call option (date of advance refunding) and the time at which the call option on the bond expires (call date) and the issuer must proceed with current refunding.

Next, I define the statistical process for future prices of the advance refunded bond. I follow the theoretical approach in Haug (2007) and Katz and McCormick (2009) and specify a stochastic process for determining future prices of advance refunded bonds. As noted in Section 3.5, the random non-linear process for generating future price paths is more representative of the behavior of market interest rates and asset prices in financial markets (Zhang & Li, 2004).[15]

Thus, following Haug (2007) and Katz and McCormick (2009), Equation 3.1 outlines the stochastic process for determining future prices of the advance refunded bond. The model sets the natural logarithm of the advance refunded bond's prices to follow the geometric Brownian motion in a Monte Carlo setting. The setting allows the process that generates future bond prices to be determined stochastically, and to follow thousands (e.g., 100,000) of future price paths. In Equation 3.1, S is the price of the advance refunded bond, ΔS is the change in price of the advance refunded bond, Δt is the time interval, and ϵ_t is the random draw from a standard normal distribution with mean (μ) and standard deviation (σ) equal to *0* and *1* respectively.

$$S + \Delta S = S\, exp\left[\left(\mu - \frac{1}{2}\sigma^2\right)\Delta t + \sigma\epsilon_t\sqrt{\Delta t}\right] \qquad (3.1)$$

Finally, I use an option valuation model to price the options on the advance refunded bond and determine option value loss. Ang et al. (2013) noted that a model to compute option value loss in an advance refunding must measure the value of a put option on the advance refunded bond. They noted the following:

> "The value lost to issuers from the pre-refunding decision is the value of a put option exercisable at the call price of the original bond with a maturity equal to the call date of the original bond." (p. 20)

[15] What actually happened to interest rates and bond prices is known ex-post. At the time that advance refunding occurs, however, it is not certain whether future prices of the advance refunded bond will be higher or lower, on average, compared to prices at the time of refunding. The Monte Carlo option-pricing technique simulates a series of random non-linear paths for future prices of the advance refunded. The method assumes a stochastic process for determining the distribution of bond prices at the call or final maturity date of the bond. This forward-looking, or ex-ante, approach more accurately reflects the uncertainty about future interest rates and bond prices that issuers face at the time of advance refunding.

In option valuation, the value of a put option is expressed as the difference between the exercise price of an asset and the price of the asset at the expiration of the option. Equation 3.2 outlines the value of the put option on an advance refunded bond using the basic model outlined in Haug (2007). The specification in Equation 3.2 is the main model for computing option value loss in the present study. It accomodates the stochastic process for determining future prices described in Equation 3.1. Thus, Equation 3.1 is a subset of Equation 3.2 and the two equations are connected by means of the parameter S. In Equation 3.2, p is the put option on the advance refunded bond, S is the price of the advance refunded bond, T is the time remaining until the call date, X is the exercise price on the call date, and r is the risk-free market interest rate.

$$p = \frac{e^{-rT}}{n} \sum_{i=1}^{n} max\left[X - Se^{(b-\sigma^2/2)T+\sigma\epsilon_i\sqrt{T}}, 0\right] \qquad (3.2)$$

Equation 3.2 computes option value loss as the discounted average of option prices for the advance refunded bond. It computes the discounted average of option prices along all simulated paths of future prices of the advance refunded bond. I quantify this loss as a proportion of the par value of the advance refunded bond and sum up the losses for all school district transactions in the sample over the study period. Furthermore, I group the sample estimates of option value loss into epochs preceding, during, and after the Great Recession to assess the magnitude of loss across time periods.

3.8 Results

MATLAB is the programming software used to implement the Monte Carlo option pricing model in the present study. The program simulation codes are based on Equation 3.2 and are displayed in Appendix G. Monte Carlo simulations show patterns in school districts' option value loss. Figure 3.6 shows the option value loss associated with each of the 100 advance refunded school district bonds in the sample. Three major tiers of option value loss can be identified: losses below $2 per $100 of par value; losses ranging between $2 and $5 per $100 of par value; and losses that extend beyond $5 per $100 of par value. These lower, medium, and upper tiers of option value loss account for 35 percent, 36 percent, and 29 percent of all transactions, respectively. Option value losses ranged from $0.06 to $27.16 per $100 of par value. Appendix H shows the histogram of the distribution of option value loss.

Table 3.1 presents sample statistics from the Monte Carlo simulations. On average, school districts executed advance refunding transactions 2.4 years prior to the call date of the advance refunded bonds. Also, volatility in the price of bonds underlying these transactions was substantial, at 9.5 percent on average. Risk-free interest rates associated with the maturity structure of the advance refunded bonds were moderate, at 2.0 percent on average, and did not change dramatically over the time period covered in this study. As noted earlier, time to the call date, volatility in bond price, and changes in risk free interest rates, all combine to influence the magnitude of option value loss in an advance refunding bond transaction.

Results from Table 3.1 show that between 2005 and 2014 school districts lost, on average, $3.28 per $100 of the par value of bonds in their advance refunding transactions. As discussed earlier, this result on school districts reveals a greater magnitude of loss, on average, compared to Ang et al.'s (2013) estimate of $1 per $100 of par value for all state and local governments. The larger average margin of loss in the present study could be a reflection of the peculiar challenges school districts face in complex financial markets.

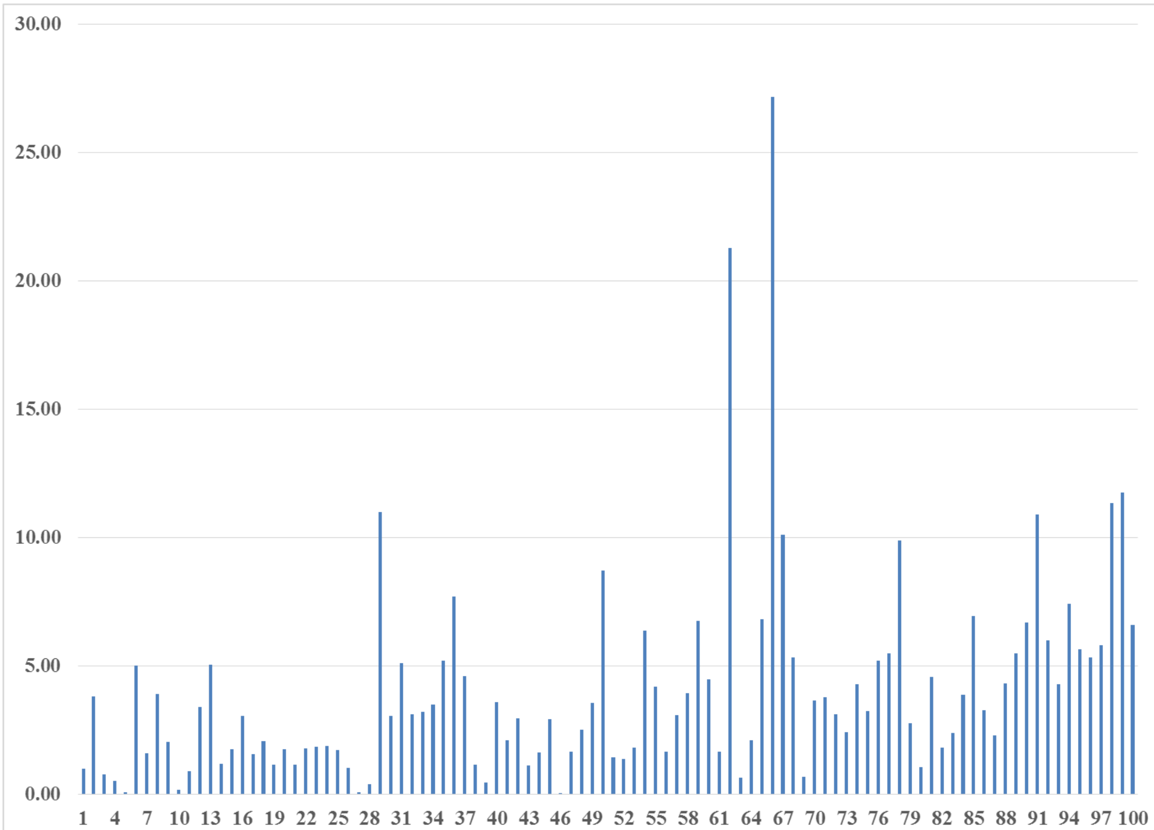

Figure 3.6. Option Value Loss in a Random Sample of School District Advance Refunding Transactions.

Table 3.1

Monte Carlo Simulations of Option Value Loss: Results for Full Sample of Advance Refunded School District Bonds

Option Valuation Results	
Total Par Value Advance Refunded ($ Millions)	510.86
Total Option-Value Loss ($ Millions)	16.78
Percent of Par Value Lost to School Districts	3.28
Monte Carlo Simulation Parameters	
Risk-free interest rate, r (sample average)	0.020
Volatility in bond price, σ (sample average)	0.095
Years remaining until call date, T (sample average)	2.41
Number of simulations per asset pricing scenario, M	100,000
Sample Statistics	
Number of advance refunded bonds	100
Number of trades in advance refunded bonds	7,800

Indeed, it is unsurprising that school districts' option value losses ranged from $0.06 to $27.16 in the present study. By comparison, losses ranged from $0.05 to $30.50 per $100 of par value in Ang et al. (2013), and the authors noted (without giving specific details) that school districts incurred a majority of the worst option value losses. Overall, the findings reported in Table 3.1 confirm this study's hypothesis that school districts lose option value, equivalent to significant amounts of money, in advance refunding transactions.

Results also confirm the hypothesis that school district option value loss is more severe during economic recessions. As Table 3.2 shows, average option value loss in the period prior to the Great Recession was $1.83 per $100 of par value. During the recession, average losses increased to $3.46 per $100 of par value. In the years immediately following the recession, option value losses lingered on, reaching $4.45 per $100 of par value, on average.

While macroeconomic shocks, such as downturns in the economy, may have magnified school districts' losses in municipal bond markets, specific aspects of their transactions also may have resulted in losses. For one thing, outcomes from an advance refunding transaction are more adverse the longer the time span between the refunding date and the call date of the refunded bond. For the sample of school district bonds in this study, average time to the call date is 2.4 years. This relatively lengthy window raises uncertainty about the profile of market interest rates between the time advance refunding occurs and the call date of the advance refunded bond. Such uncertainty heightens the risks associated with the advance refunding transaction and amplifies option value loss. In addition, school district bonds in the sample, typical of municipal bonds generally,

Table 3.2

Monte Carlo Simulations of Option Value Loss: Results for Advance Refunding Transactions in Different Time Periods

Panel A: Option-Value Loss in Pre-Recession years	
Total Par Value Advance Refunded ($ Millions)	127.63
Total Option-Value Loss ($ Millions)	2.33
Percent of Par Value Lost to School Districts	1.83
Panel B: Option-Value Loss During the Recession	
Total Par Value Advance Refunded ($ Millions)	283.24
Total Option-Value Loss ($ Millions)	9.79
Percent of Par Value Lost to School Districts	3.46
Panel C: Option-Value Loss in Post-Recession years	
Total Par Value Advance Refunded ($ Millions)	99.99
Total Option-Value Loss ($ Millions)	4.44
Percent of Par Value Lost to School Districts	4.45

trade infrequently in secondary markets. A large proportion of the bonds in the sample, about 80 percent, traded less than 100 times over the entire tenure of the bond, causing considerable volatility in their trade prices.

3.9 Conclusions, Policy Implications, and Directions for Future Research

Advance refunding may be an attractive interest-cost saving strategy for school districts but the transaction can generate significant opportunity costs equivalent to millions of dollars if it is not properly timed, or if it responds adversely to underlying bond-specific and market-risk factors. This study contributes to the scant literature on advance refunding in municipal bond markets by: (1) focusing exclusively on school districts, (2) analyzing option value loss in school district advance refunding transactions, (3) using the Monte Carlo technique for option-pricing to quantify school districts option value loss, and (4) accommodating the influence of external disturbances, such as the Great Recession, in advance refunding outcomes. Findings show that school districts lost option value, equivalent to millions of dollars, from their advance refunding bond transactions between 2005 and 2014, and option value losses were more severe during downturns in the economy.

School district debt managers must consider the timing of bond transactions, especially in dynamic market environments that easily exacerbate losses from ill-timed operations. Debt managers that take into account volatility in the price of a bond, the profile of current and future market rates, and macroeconomic swings, are more likely to minimize option value loss in advance refunding and generate savings for their school districts. Further, municipal bond market regulators have an obligation to improve the environment for secondary market trading of bonds. As regulators work to enhance market efficiency, and trading activity in bonds increases, option value losses will be mitigated due to decreased volatility in bond prices.

This study did not examine all possible advance refunding scenarios facing public debt managers in municipal bond markets. For example, it is plausible to compute the option value loss school districts incur when they advance refund at a specific time, relative to refunding at an optimal date. The computation of option value loss in that case will require a derivation of the optimal exercise date. This is a research subject future studies could explore further. To that end, existing work on optimal timing of advance refunding (e.g., Kalotay & May, 1998) can provide a useful guide.

Finally, future studies should explore the linkages between outcomes from school district debt management strategies and the quality of education in the local community: Do school districts that incur the largest losses in financial market transactions also lag behind in educational quality in the local community? What causations, if any, exist between outcomes from market transactions and educational outcomes? Answers to these questions will provide a way to assess school district financial management in the context of its impacts on educational outcomes of children in the local community.

CHAPTER 4

REGULATION AND THE PUBLIC INTEREST: DOES REGULATORY DISCLOSURE IMPROVE PRICE EFFICIENCY IN MUNICIPAL SECURITIES SECONDARY MARKETS?

4.1 Statement of the Problem and Research Questions

Regulation of municipal bond markets involves a partnership between the Securities and Exchange Commission (SEC), the Financial Industry Regulatory Authority (FINRA), and the Municipal Securities Rulemaking Board (MSRB). Of the three agencies, the MSRB has a mandate to provide regulatory oversight on brokers, dealers, and municipal advisors, with the goal of promoting fair issuance and trading practices to enhance market efficiency (Government Accountability Office, 2012).

Since its creation in 1975, the MSRB has required market dealers to disclose information on primary market issuance and secondary market trading of municipal securities. However, a major leap forward occurred on March 31, 2008 when the Board launched the Electronic Municipal Market Access (EMMA) – an online disclosure portal that provides free public access to municipal bond disclosure documents and near real-time data on secondary market trade prices. Between March 31 2008 and June 1 2009, the MSRB, with approval by the SEC, implemented a series of major disclosure requirements, including auction rate securities disclosure, variable rate demand obligations transparency, all-electronic official statement dissemination standards, and electronic continuing disclosure. The MSRB required broker-dealers to disclose trade information, on a near-real time basis, to the EMMA information platform. The goal was to strengthen the information environment for municipal bond issuance and trading.

The EMMA information disclosure regime provides a natural experiment for re-examining the impact of regulatory interventions on municipal securities trade prices. Most of the existing studies on secondary market information disclosure (e.g., Schultz, 2012) analyzed earlier information disclosure regimes. The few studies on the EMMA disclosure interventions (e.g., MSRB, 2014b) do not provide a full picture of regulatory effectiveness because they ignore the influence of market-wide factors on securities trade prices. I attempt to fill that research gap by considering trade-specific, bond-related, and market-wide factors in analysis of trade price effects of the EMMA regulatory interventions. Specifically, I address the following research question: What is the impact of the EMMA regulatory interventions on secondary market pricing of municipal bonds?

Another source of concern for regulatory policy is the finding that trade prices in municipal securities secondary markets tend to favor big (or institutional) investors over small (or retail) investors (Schultz, 2012; Harris & Piwowar, 2006; Green, Hollifield, & Schurhoff, 2007). The few studies on the EMMA interventions (e.g., Cuny, 2013) do not fully explicate this problem, as they do not present strong evidence that the interventions reduced the price advantage institutional investors have over retail investors in municipal securities secondary market trades. The present study attempts to fill that gap in the literature by examining whether the EMMA information disclosure initiatives had significantly different price impacts between retail and institutional investors. Hence, I address the following research question: How has institutional investors' trade price advantage over retail investors changed in the aftermath of the EMMA regulatory interventions?

In the next sections, I examine in more detail the academic literature on the trade price impacts of regulatory disclosure interventions in municipal bond markets and outline hypotheses based on the literature review. Further, I present the data, methodology, and empirical findings of the study, and provide policy recommendations and directions for future studies.

4.2 Literature Review and Research Hypotheses

Market efficiency is a major emphasis in regulation of financial markets. Fama (1970) explained that efficiency exists when prices fully reflect available information in a market, such that firms can make production-investment decisions and investors can choose among investment alternatives with zero transaction costs. Other researchers, notably Jensen (1978) and Jarrow and Larsson (2012), state that market efficiency exists if it is impossible for some market participants to make economic profits by trading on the basis of market information sets available to them only. According to Akerlof (1970), the potential for quality uncertainty and information asymmetry in markets accounts for the existence of economic and regulatory institutions that aim at reducing distortions in markets.[16]

Besides market efficiency, the public administration literature has discussed rule of law (Argyriades, 2003), equity (Kelly, 1998), citizen participation (DeLeon &

[16] Among other illustrations of inefficiency in markets, Akerlof (1970) discussed extortionate rates charged by local moneylenders in underdeveloped credit markets and the control of such markets by dominant market players.

Denhardt, 2000), and citizens' welfare (Piotrowski & Rosenbloom, 2002) as important to the determination of market outcomes and regulation policy. Researchers have found evidence that securities trading is less transparent in municipal bond markets, compared to corporate bond markets (Chakravarty & Sarkar, 2003), and trade prices tend to favor institutional investors over retail investors (Schultz, 2012; Green et al., 2007), which raises equity and citizen welfare implications. Moreover, Hildreth and Zorn (2005) chronicled a number of recent defaults and/or debt management problems involving state and local governments and noted how those adverse outcomes prompted regulatory provisions aimed at adequate protection for taxpayers.

By means of continuing disclosure requirements in both primary and secondary markets, the SEC, working together with the MSRB, seeks to ensure that trade prices investors face are fair and efficient. The regulatory landscape for municipal securities has recorded significant milestones since Congress and the SEC created the MSRB in 1975. Appendix I gives a detailed timeline of regulatory initiatives. Over the years, the MSRB has established Uniform Practice Rules (1976), created Rules on Underwriting Practices, Fair Practice, and Yield Comparisons (1978), released a Comprehensive Report on Pricing (1980), required Filings of Disclosure Documents (1990), adopted the groundbreaking Pay-to-Play Rule G-37 (1993), published Daily Trade Reports to enhance market transparency (1998), made available Comprehensive Real-Time Trade Reports and required dealers to submit transaction information to the MSRB within 15 minutes of execution of all trades (2005), and launched EMMA (2008), a disclosure platform which for the first time made available, from a single source and free of charge, historical and real-time municipal securities trade data (Municipal Securities Rulemaking Board, 2014a).

Studies have analyzed the impacts of information disclosure initiatives on outcomes such as pricing and liquidity in the secondary market. A recent study by the MSRB (Municipal Securities Rulemaking Board, 2014b) showed that increased information disclosure following the EMMA interventions in 2008 had a restraining impact on mark-up prices of municipal securities trades. However, the study did not analyze the influence of market-wide factors; thus, it did not present a full picture of the trade price impacts of EMMA regulatory interventions.

Other notable contributions on the relationship between regulatory disclosure initiatives and pricing outcomes in secondary municipal bond markets include Reck and Wilson (2006), Green et al. (2007), Schultz (2012), and Cuny (2013). Reck and Wilson (2006) assessed the impact of a new disclosure requirement, initiated in 1994, on price transparency in the secondary market. The 1994 rule was an improvement on a previous rule in 1989 (Rule 15c2-12) and required that brokers, dealers, and underwriters obtain a written agreement from issuers of municipal bonds that they will make continuing annual disclosures on their bond sales to the public. The 1989 rule had required underwriters to obtain bond issuance information but not on a continuing annual basis. Reck and Wilson compared efficiency of pricing in the pre-rule (1978–1989) and post-rule (1996-1998) periods. They examined the annual disclosure documents of 289 cities across 30 U.S. states and used data on end-of-the-month secondary market trade prices of general obligation bonds. They found that the post-rule period witnessed less market return variability (or more efficient pricing) than the pre-rule period. According to the authors, the requirement of continuing disclosure led to more diffuse adjustments of trade prices in the post-rule period.

Green et al. (2007) did not focus on a specific information disclosure event. They created a statistical distinction between informed and uninformed investors in the secondary market to assess the impact of increased information disclosure on trade prices. They used size of transactions as the measure of information disparities; larger transaction sizes representing informed or institutional investors, and smaller sizes signifying uninformed or retail investors. The authors found that more informed (institutional) investors faced trade prices that were close to the reoffering price of the bond while uninformed (retail) traders faced higher levels of price dispersion.

Schultz (2012) focused on MSRB's introduction of a new information disclosure requirement in 2005. In that year, the regulatory agency required that market participants disclose comprehensive trade reports within 15 minutes of the transaction. Schultz found that improved information disclosure under the comprehensive 15-minute time-lag trade reporting reduced price mark-ups for the market as a whole, and raised institutional investor prices relative to retail investor prices. He argued that the increase in institutional investor trade prices was due to adjustment of market prices from a prior market imbalance wherein institutional investors had an informational advantage over retail investors.

Cuny (2013) measured the impacts of the EMMA information disclosure regime. She assessed the impact of disclosure initiatives in three main areas: (1) supply of information disclosure in the market, (2) trade volume or market liquidity, and (3) mark-up prices retail investors face relative to institutional investor mark-up prices. Cuny's study covered 2007 to 2012 and her results showed that information disclosure initiatives under EMMA increased supply of information disclosure and trade volume among market participants. However, she did not find strong evidence that the disclosure initiatives lessened the informational advantage institutional investors have over retail investors. The lack of strong evidence on the impact of the EMMA interventions on trade prices different investor segments face makes it necessary to re-examine the impact of the interventions using more recent data.

Schultz's (2012) study was considerably different from Cuny's (2013) work. The two scholars investigated different disclosure initiatives; Schultz examined MSRB's 15 minute-lag comprehensive trade reporting requirement initiated in 2005, while Cuny studied the EMMA near-real time information disclosure requirements initiated in 2008. Further, Schultz assessed the effect of information disclosure on trade prices in the market as a whole and on different market segments, while Cuny focused only on trade price effects among different investor segments – the market-wide analysis in Cuny's work centered on trade volume and liquidity, and not trade price effects. Also, whereas Schultz found evidence that increased information disclosure reduced informational bias between retail and institutional investor segments, Cuny found weak evidence.

The present study builds on the existing literature in two major ways. I assess the impact of the EMMA information disclosure interventions on trade prices in the secondary market as a whole. This extends the knowledge in previous studies (e.g., Schultz, 2012) that assessed the price impacts of information disclosure using previous regulatory disclosure initiatives. It also extends knowledge in previous studies (e.g., Cuny, 2013) that did not examine EMMA's impacts on trade pricing in the secondary market as a whole.

Furthermore, by including market-wide conditions in the analysis, the present study gives a more complete picture of the impact of the EMMA interventions on trade prices, compared to the approach in previous studies (e.g., MSRB, 2014b). I expect to find that information disclosure interventions improve trade price efficiency in municipal securities secondary markets, consistent with predictions in the theory of market efficiency.

As the theory would suggest, transaction costs in municipal securities trading arise partly from information asymmetry between market dealers and investors (Green et al., 2007). In the absence of timely and accessible market-wide information, investors incur high search costs for fundamental information on trades and dealers charge higher mark-up prices to maintain their premiums in the high cost information environment. High search costs also create wide differences (or differentials) and rapid changes (or volatility) in prices investors face, thereby creating pricing distortions and limiting price efficiency. However, public dissemination of executed trade prices reduces search and transaction costs for investors and lowers distortions in mark-up prices broker-dealers charge (Schultz, 2012). Thus, I test the following hypothesis (Reck & Wilson, 2006; Schultz, 2012):

H.4.1: EMMA regulatory disclosure interventions are associated with a significant improvement in the efficiency of municipal securities secondary market trade prices.

Another significant contribution of the present study is the comparative assessment of regulatory disclosure impacts on retail and institutional investor segments of the secondary market. As highlighted above, previous studies on the subject either focus on regulatory disclosure regimes prior to EMMA (e.g., Reck & Wilson, 2006;

Schultz, 2012) or do not find strong evidence of EMMA's impacts (e.g., Cuny, 2013). In the present study, I use more recent data to examine whether the EMMA regulatory disclosure interventions are associated with a reduction in the trade price advantage institutional investors have over retail investors.

Based on market efficiency theory, I expect regulatory disclosure interventions to reduce the informational advantage an investor segment may have over another in trade pricing. Different segments of investors face different prices in securities trades because dealers discriminate between investors they view as informed about relative prices – institutional investors – and those investors they consider to be unsophisticated and lacking fundamental information about relative trade prices – retail investors (Green et al., 2007). Dealers view institutional investors as more informed than retail investors because institutions are able to collect price quotes from more dealers and are more aware of trade prices that other institutions pay (Schultz, 2012). As such, the informational advantage institutional investors have over retail investors allows dealers to extract higher rents from retail investors in the form of higher mark-up prices, compared to institutional investors (Keloharju & Torstila, 2002). Therefore, regulatory disclosure initiatives drive public dissemination of executed trade prices to even out the information environment among different investor groups and counteract any rent-seeking behaviors of dealers. Thus, I test the following hypothesis (Reck & Wilson, 2006; Schultz, 2012; Cuny, 2013):

H.4.2: The EMMA regulatory disclosure interventions are associated with a reduction in the price advantage institutional investors have over retail investors in municipal securities secondary market trades.

Other factors influence trade prices and these include trade-specific (trade frequency and trade size), bond-related (issue size, term to maturity, and coupon rate), and market condition (yield spread between long-term and short-term bonds) variables. Trade frequency refers to the number of times a bond trades in the secondary market during the day or week. An increase in trade frequency is associated with lower cost of trading and improvement in price efficiency (Conrad, Wahal, & Xiang, 2015). However, an increase in the number of trades may also cause the range of daily or weekly prices to increase and raise volatility in these prices (Downing & Zhang, 2004) due to the larger volume of different price quotes for the bond, ceteris paribus. Increasing price differentials and volatility reflect distortions and inefficiency in trade pricing.

Trade size is the dollar value of the block of a bond that is traded. The academic literature distinguishes between small trades by retail investors and large trades by institutional investors (Reck & Wilson, 2006; Schultz, 2012) and, in most cases, uses thresholds based on dollar amount traded to distinguish between the two types of investor trades. Trade size is negatively related to price differentials and volatility in secondary market trading. Smaller trade sizes create a noisy trading environment that widens the range of daily trade prices and increases volatility in the prices (Downing & Zhang, 2004). Increasing price differentials and volatility signal inefficient pricing.

Issue size refers to the dollar amount of the debt issue in the primary market for municipal securities. Similar to trade size, the academic literature distinguishes between smaller issues and larger issues and notes how size of debt issuance may reflect variations in fiscal capacity, access to national markets, and other characteristics among issuers (Daniels & Ejara, 2009; Peng & Brucato Jr., 2004). In secondary market securities trading, issue size is positively related to daily price differentials and volatility in daily prices. Investors prefer to trade in larger issues and the increase in demand for these debt issues, particularly from retail investors who flock to them, raises the range of daily prices, increases price differentials, and heightens price volatility (Downing & Zhang, 2004; Moldogaziev, 2012), which all reflect inefficient pricing.

Term to maturity is the number of years remaining from the time a subnational government issues debt in the primary market until the time the bond matures and the issuer pays bondholders the face value of the bond. Term to maturity is expected to be positively related to differentials and volatility in daily prices of secondary market trades. Debt issues with longer term to maturity tend to have more enhanced features, such as call provisions and insurance, which compensate for any wide distortions or volatility in their pricing and make them more preferred investment assets among secondary market traders (Downing & Zhang, 2004).

Coupon rate is the annual or semi-annual interest an issuer pays to bondholders. Issuers may set coupon rates to be fixed or flexible at the time of debt issuance in the primary market. Fixed coupon rates allow bondholders in primary markets to know with certainty how much interest they will earn over the term of the bond. Flexible coupon rates, on the other hand, allow some variation in interest payments in response to market-wide interest rate changes or interest rate risk. Investors in secondary markets tend to demand higher yields or coupons to compensate for higher interest rate risk and price volatility (Moldogaziev, 2012). Therefore, coupon rate is expected to have a positive relationship with range and volatility of trade prices on a given day.

Market-wide interest rate conditions contain information on investors' expectations about future rates and their perceptions of risks and uncertainties in the municipal market. Scholars have analyzed market-wide interest rate conditions using indices that measure the spread between long-term (20 years or more) and short-term (5 years or less) bonds (Moldogaziev, 2012; Peng & Brucato Jr., 2004). Widening spreads indicate increasing tensions and uncertainties in the municipal securities market and tend to raise the daily range and volatility of trade prices (Harris & Piwowar, 2006).

4.3 Data, Sample, and Variables

Between March 31 2008 and June 1 2009, the MSRB implemented a series of major disclosure initiatives through its EMMA information dissemination platform with the goal of strengthening the information environment for municipal bond trades. The pre-EMMA and post-EMMA time frames define a natural break point for data on secondary market trades of municipal securities. The event studies literature gives insights on the appropriate length of time to choose in before-and-after analyses. Scholars have suggested that, in studies of events related to the municipal bond market, using transaction prices occurring several years before and after an event substantially increases the power of empirical tests, despite the greater non-event noise that a lengthier window could generate (Ederington, Guan, & Yang, 2015). In the present study, I set the event window from 2005 to 2014, which is a lengthy period, to accommodate analysis of several market trends and their interplay with municipal securities secondary market prices. By comparison, Cuny's (2013) study on EMMA impacts covers 2007 to 2012.

Furthermore, event studies emphasize careful selection of event dates within the full length of time defined for the study (Binder, 1985). Especially in regard to analysis of regulatory effects, the academic literature demonstrates that events are often long anticipated by market agents (Binder, 1998), and even when they do occur, they may require some time to be built into agents' reactions; therefore, impact analysis must consider not only the dates they occur but also allow for flexibility around specified event dates (Sorokina, Booth, & Thornton Jr, 2013) or adjust for a transition period (Chalmers, Liu, & Wang, 2013). Implementation of the latest disclosure initiatives spanned March 31, 2008 and June 1, 2009; therefore, I set the pre-regulatory disclosure period between March 31, 2008 and June 30, 2009 to allow up to 30 days for the transition.[17] Consequently, I measure the impacts of regulatory disclosure on trade prices using a categorical variable named *EMMA* that is coded 1 for the post-EMMA regime (after June 30, 2009) and 0 for the pre-EMMA regime (before June 30, 2009).

Trade price differential is the dependent variable in this study. I measure trade price differential as the difference between the lowest price of a customer-buy transaction and the highest price of a customer-sell transaction on a given day. For trades that are not paired, I use the average price of interdealer trades on a given day. Downing and Zhang (2004) and Moldogaziev (2012) used a similar approach for computing trade price range but aggregated trade prices into weekly rather than daily bundles. Choice of a daily periodicity for this study provides a way to tease out more information on the determinants of trade prices in new information environments characterized by near-real time market data. Furthermore, I obtain an alternative measure of the dependent variable

[17] In their study of an earlier regulatory disclosure regime, Chalmers et al. (2013) set a transition period of 2 months. Cuny (2013) also set a transition period of 6 months. The present study uses a 30-day transition period. I analyzed the robustness of the 30-day transition period by examining alternative transition periods of 3 months (September 1, 2009) and 6 months (December 1, 2009) but these sensitivity tests did not significantly alter the impacts of regulatory disclosure on price efficiency.

using volatility in trade prices, which I compute as the price differential weighted by average price of paired or interdealer trades on a given day (Downing & Zhang, 2004).

Independent variables include trade frequency, trade size, issue size, term to maturity, coupon rate, and market yield spread. I measure trade frequency as the number of times a bond, or CUSIP, is traded on a given day (Moldogaziev, 2012). Trade size is an interval level variable that measures, in millions of dollars, the par value of trade in a security or bond. Also, scholars have used size of trade as a proxy for the type of investor (institutional or retail) involved in the security trade. Following the lead of earlier studies (e.g., Peng & Brucato Jr., 2004; Harris & Piwowar, 2006), I categorize trades with par value less than $100,000 as retail investments and trades with par value greater than or equal to $100,000 as institutional investor trades. Both trade frequency and trade size are trade-specific variables and describe activity in the secondary market for municipal securities.

Issue size is an interval level variable measured in million dollars (Downing & Zhang, 2004). Term to maturity is also an interval level variable representing the number of years from the time of issuance until maturity of the bond (Moldogaziev, 2012). Similarly, coupon rate is an interval level variable that describes the annual interest an issuer pays to bondholders. All three variables are issue-specific and describe features associated with primary market issuance of bonds traded in the secondary market.

Market yield spread is an interval level variable that gauges municipal market-wide interest rate conditions and expectations. It is defined as the yield spread obtained from long-term (20 years or more) bonds and short-term (5 years or less) notes (Harris & Piwowar, 2006; Moldogaziev, 2012). I use a market index that tracks the spread between the long-term bonds and short-term notes while allowing for cross-market dynamics between municipal and Treasury markets.

Source of data for the municipal market index is the Federal Reserve Bank of St. Louis. Other sources of data are MSRB and Bloomberg LLP. Trade data from MSRB consists of information on trading and settlement dates, trade amounts, transaction prices, yields, and transaction type (e.g., customer purchase, customer sale, or interdealer transaction). Bloomberg LLP. gives information on primary market debt issuance, including date of issuance, size of the issue, term to maturity, coupon rate, issuer's credit rating, and whether a bond is insured or not.

I limit consideration of municipal securities secondary market trades to bonds issued in California for two reasons. California is one of three U.S. states – Texas and Washington are the others – that require issuers to disclose underwriter spreads and other sets of transaction price information, making transactions data publicly available through oversight agencies, namely, the California Debt and Investment Advisory Commission, the Texas Bond Review Board, and the Washington State Department of Commerce; these datasets provide useful comparisons with MSRB and Bloomberg data to ensure consistency of data in secondary market trade analyses (Marlowe, 2013).

California is also the leading source of municipal securities secondary market trades among all U.S. states. California accounted for 16.1 percent of all daily trades nationwide from 2005 to 2014; it topped New York (13.2 percent) and Texas (10.1 percent), which had the second and third largest shares, respectively, with all the other states accounting for average daily trade shares below 5 percent. While data on California alone may not be representative of patterns in municipal securities trading in the entire nation, trading patterns in the state show considerable coverage and variation to support generalizations, as shown in the descriptive statistics in Section 4.5.1.

To arrive at the sample of municipal bond trades for empirical analysis, I draw a random sample of 100 municipal bonds, or CUSIPs. These are California state government fixed-rate general obligation bonds stratified across the 10-year period starting from 2005 to 2014. I trace each of the 100 bonds in the secondary market for the first six months of trading. Moldogaziev (2012) used a 5-month window to trace trading activity of bonds in the secondary market and highlighted how a window lasting several months is appropriate for capturing pricing behavior during the times that bonds are on-the-run (active trading in a bond that occurs during the days immediately following its issuance) and off-the-run (relatively calmer periods of trading in a bond usually after the first 90 days of issuance).

The stratified random sample of 100 municipal bonds, or CUSIPs, issued by California from 2005 to 2014, generates 27,807 observations of municipal bond trades, being trades in all bonds during the first six months of their issuance. Next, I classify trade information for each bond by trading day. All 27,807 trades in the 100 bonds occur over 2,720 days. Classifying the data into bond trading days makes it possible to measure the range of trade prices of a bond on a particular trading day and to calculate the differential between the lowest and the highest prices on that day. It also allows for computing the volatility in trade prices of a bond on a particular day. Thus, the unit of analysis is average trade price of a bond on a particular day, and there are 2,720 observational units over the sample period. Appendix J displays a bloc of the dataset following the descriptions above. It shows estimation data for the first 50 days, out of the 2,720 trading days.

4.4 Methodology

Time series regressions utilize data on the same observational unit at multiple time periods. The time series analytical frame is suitable for analyzing secondary market municipal securities prices – which tend to vary over time – and the trade-specific and market-wide determinants of those prices.[18] I use the time series regression methodology to estimate the impacts of the EMMA intervention on trade price differentials and volatility in trade prices in municipal securities secondary markets.

Equation 4.1 specifies the general form of the time series model. y_t stands for the trade price differential (difference between the lowest price of a customer-buy and the highest price of a customer-sell trade in a particular bond) on a given day *t*. Alternatively, y_t stands for volatility in the average daily trade price of a bond. $\boldsymbol{x}$ is a vector of explanatory variables that captures specific factors relating to the individual bond trade (trade frequency and trade size), bond characteristics underlying the trade (issue size, term to maturity, and coupon rate), and market factors influencing the trade (market yield spread). $\boldsymbol{\beta}$ is the vector of coefficients associated with the explanatory variables ($\boldsymbol{\beta} = \{\beta_1, \beta_2, \ldots \beta_k\}$) and e_t is the error term.

$$y_t = \boldsymbol{x\beta} + e_t \qquad (4.1)$$

[18] Harris and Piwowar (2006), for example, used time series estimations to analyze average transaction costs in municipal securities secondary markets. They generated trade data from a one-year sample (November 1999 to October 2000) of U.S. municipal bonds. The data covered 254 trading days and their time series analysis accounted for the transaction cost effects of trade-specific (e.g., trade size) and bond-related (e.g., term to maturity) factors.

Also, Equation 4.1 includes a categorical explanatory variable, *EMMA*, that takes the value 1 for the post-EMMA years (July 1, 2009 to December 31, 2014) and 0 for the pre-EMMA years (January 1, 2005 to June 30, 2009), after adjusting for a 30-day transition period. The coefficient of *EMMA* measures the effect of new information disclosure initiatives on efficiency of municipal securities trade pricing.

Additionally, I analyze the impacts of regulatory disclosure initiatives among different segments of investors by estimating separate regressions of Equation 4.1 for institutional and retail investor trades, making sure to exclude the variable measuring trade size from the regressions, since that variable defines the thresholds for categorizing the full dataset into institutional (trade amount of $100,000 or more) and retail (trade amount less than $100,000) investor sub-samples. I then compare the coefficients of the EMMA variable from the two sub-sample regressions to determine whether price effects of regulatory interventions are the same across retail and institutional investor segments.

I use another measure to gauge the impact of new information disclosure initiatives on trade prices. The measure is based on an econometric procedure that has been used in more recent studies in finance (e.g., Lee, Strong, & Zhu, 2014; Hribar, Kravet, & Wilson, 2014). To proceed, I generate residuals from an initial regression of Equation 4.1, making sure to exclude the policy variable, *EMMA*, from that regression. The residual series represent the difference between observed and predicted values of trade prices (the dependent variable) and are the unexplained trade prices in the initial regression. These unexplained trade prices also indicate bias in trade pricing and contain information about pricing quality in the information environment for municipal securities trading.

Consequently, I modify Equation 4.1 to include the pricing quality variable. Consistent with the treatment of residual variables in the academic literature, I conjecture that pricing quality is the extent to which trade-specific, bond-related, market-condition, and other factors accurately reflect trade price differentials and volatility in secondary market municipal securities trades. I expect the size of the coefficient of the pricing bias variable to be decreasing between lower (pre-EMMA) and higher (post-EMMA) information disclosure regimes. Thus, I create two sub-samples of trades occurring in the pre-EMMA and post-EMMA periods and examine whether pricing bias decreased across these low and high information-disclosure regimes.

Equation 4.2 presents details of the modified model. X_1 is the pricing quality variable. I use the logarithm of the residual series to control for outliers in estimation. I also examine several properties of the residuals (trend, drift, normality, and independence) to ensure robustness of the estimates. $\{X_2, X_3, \dots X_k\}$ are other explanatory variables in the modified trade price equation. $\{\beta_1, \beta_2, \dots \beta_k\}$ are the coefficients associated with each explanatory variable, and ε_t is the error term.

$$\ln(y_t) = \beta_1 X_1 + \beta_2 X_2 + \dots \beta_k X_k + \varepsilon_t \quad (4.2)$$

For both the full sample of municipal security trades and sub-samples of the data, I investigate linear and non-linear patterns in the time series models of trade price. I analyze patterns using unit root tests, powers of explanatory variables ($x_{1,i}^2$), and time of the year effects of trading days ($I_{1,i}$).[19] Also, I use heteroskedasticity-robust standard

[19] Sheppard (2002) discussed the general assumption in the literature that high frequency data on financial markets exhibit calendar effects in January and December and noted the suitability of dummy variables in capturing those effects. The January effect holds that returns (or trade price differentials, in the context of the present study) are higher in January as investors return to the market. On the other hand, the December effect assumes that returns (or differentials) are lower in December as investors engage in portfolio

errors. Wooldridge (2010) underscored the importance of correcting for heteroskedasticity because its presence can invalidate standard errors, *t* statistics, and *F* statistics, thereby complicating statistical inference.

Finally, I assess whether the Great Recession significantly altered the relationship between regulatory disclosure and price efficiency in municipal securities secondary markets. Easley and O'Hara (2010) described how the Great Recession may have affected investors and their valuation of municipal securities (with potential effects on trade price differentials and volatility). My approach in analyzing the Great Recession effects relies on Lee et al. (2014). They accounted for the Great Recession in their study of regulatory disclosure and security mispricing in stock markets. Following their lead, I exclude municipal securities trades executed during the Great Recession (December 2007 to June 2009) from the pre-EMMA regime (January 2005 to June 2009) and assess the trade price impacts of regulatory disclosure between the pre-EMMA and post EMMA (July 2009 to December 2014) periods. I expect to find no significant difference in the pricing effects of regulatory disclosure after controlling for the Great Recession.

4.5 Results

4.5.1 Descriptive Statistics

Table 4.1 shows descriptive statistics of the sample data. Overall, average daily trade prices were higher in the post-regulatory disclosure period (*M*=108.95, *SD*=7.36) than in the pre-regulatory disclosure period (*M*=103.57, *SD*=4.02), possibly reflecting investors' demand for gradually increasing yields as more information on bonds became

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rebalancing, mostly due to realized losses. It is not entirely clear whether these propositions fit municipal securities trades as they do stock and corporate bond market trades.

Table 4.1

Descriptive Statistics for Full Sample of Municipal Securities Trades

	Mean	Standard Deviation	Q1	Median	Q3
Panel A: Pre-regulatory disclosure regime (January 1, 2005 – June 30, 2009)					
Trade price	103.57	4.02	100.10	103.55	106.90
Trade price differential	1.67	1.28	0.50	1.56	2.56
Trade price volatility	0.016	0.013	0.005	0.015	0.025
Trade Frequency	12	37	2	4	9
Trade size	514,086	2,137,506	37,500	85,000	253,462
Issue size ($ million)	128.2	142.3	21.4	68.3	200.0
Term to maturity	15	7	9	13	20
Coupon rate	5.05	0.46	5.00	5.00	5.25
Market yield spread	2.03	1.30	0.72	2.34	3.27
Market yield index	72.82	46.48	25.81	83.87	117.20
N = 1,115					
Panel B: Post-regulatory disclosure regime (July 1, 2009 – December 31, 2014)					
Trade price	108.95	7.36	102.64	108.68	115.21
Trade price differential	1.55	1.16	0.45	1.56	2.39
Trade price volatility	0.014	0.011	0.004	0.015	0.022
Trade Frequency	9	17	2	4	9
Trade size	661,788	1,773,291	39,286	102,500	406,250
Issue size ($ million)	108.4	137.7	25.0	58.6	124.8
Term to maturity	15	8	8	14	19
Coupon rate	4.80	1.00	4.00	5.00	5.00
Market yield spread	2.47	0.69	1.90	2.23	3.13
Market yield index	88.56	24.89	68.10	79.93	112.19
N = 1,605					

available. Trade price differentials decreased, on average, between the lower information (*M*=1.67, *SD*=1.28) and higher information (*M*=1.55, *SD*=1.16) environments. Similarly, average volatility in trade prices decreased between the pre-regulatory disclosure (*M*=0.016, *SD*=0.013) and post-regulatory disclosure (*M*=0.014, *SD*=0.011) periods. Altogether, the sample statistics seem to suggest that increased information disclosure is associated with more efficient pricing in municipal securities secondary markets.

It is also remarkable that trade frequency declined, on average, between the pre-regulatory disclosure (*M*=12, *SD*=37) and post-regulatory disclosure (*M*=9, *SD*=17) regimes. The decline could be evidence of a slowdown in activity, or liquidity, between the low and high information environments. However, the trade frequency statistic must be considered in the context of trade size effects. On average, trade sizes increased between the pre-EMMA (*M*=514,086, *SD*=2,137,506) and post-EMMA (*M*=661,788, *SD*=1,773,291) periods, reflecting more depth of transactions despite the marginal decrease in frequency.

Primary market indicators of trade prices remained largely the same between the pre-EMMA and post-EMMA periods but municipal market-wide yield spreads widened considerably from the low information (*M*=2.03, *SD*=1.30) to high information (*M*=2.47, *SD*=0.69) regimes. This outcome could be due to several factors. It could be that the improved information environment following regulatory disclosure interventions made it possible for market agents to more adequately assess risk and uncertainty associated with securities trading; therefore, the marginal increase in average yield spreads in the era following the interventions served as a correction for mispricing of risk in the low information environment. Or it could be that the marginal increase in yield spreads in the post-regulatory disclosure period (July 1, 2009 to December 31, 2014) is a reflection of the increased risk environment in the period, given that the period immediately follows the Great Recession (December 2007 to June 2009).

Overall, the sample statistics give preliminary indications of how regulatory disclosure interventions, along with other trade-specific, bond-related, and market condition factors, affect efficiency of trade prices. Figures 4.1, 4.2, and 4.3 illustrate these preliminary indications further. The first graph shows a general decline (*slope*=-0.00007) in trade price differentials between 2005 and 2014. In the second and third graphs, trade price differentials declined more steeply in the post-EMMA regime (*slope*=-0.0005) compared to the pre-EMMA regime (*slope*=-0.00006). I explore these sample statistics further in an empirical framework.

4.5.2 Unit Root Tests

Prior to estimating the trade pricing model, I examine the time series properties of the dependent variable and interval-level explanatory variables. Unit root tests provide a way to check whether the model variables are stationary for estimation. The Dickey-Fuller unit root test (Dickey & Fuller, 1979) checks whether a variable follows a unit-root process. It tests the null hypothesis that the variable contains a unit root against an alternative one that the variable is generated by a stationary process. A variable that is not stationary must be differenced *d* times to become stationary and integrated of order *d*, *I(d)*, before it is used in estimations.

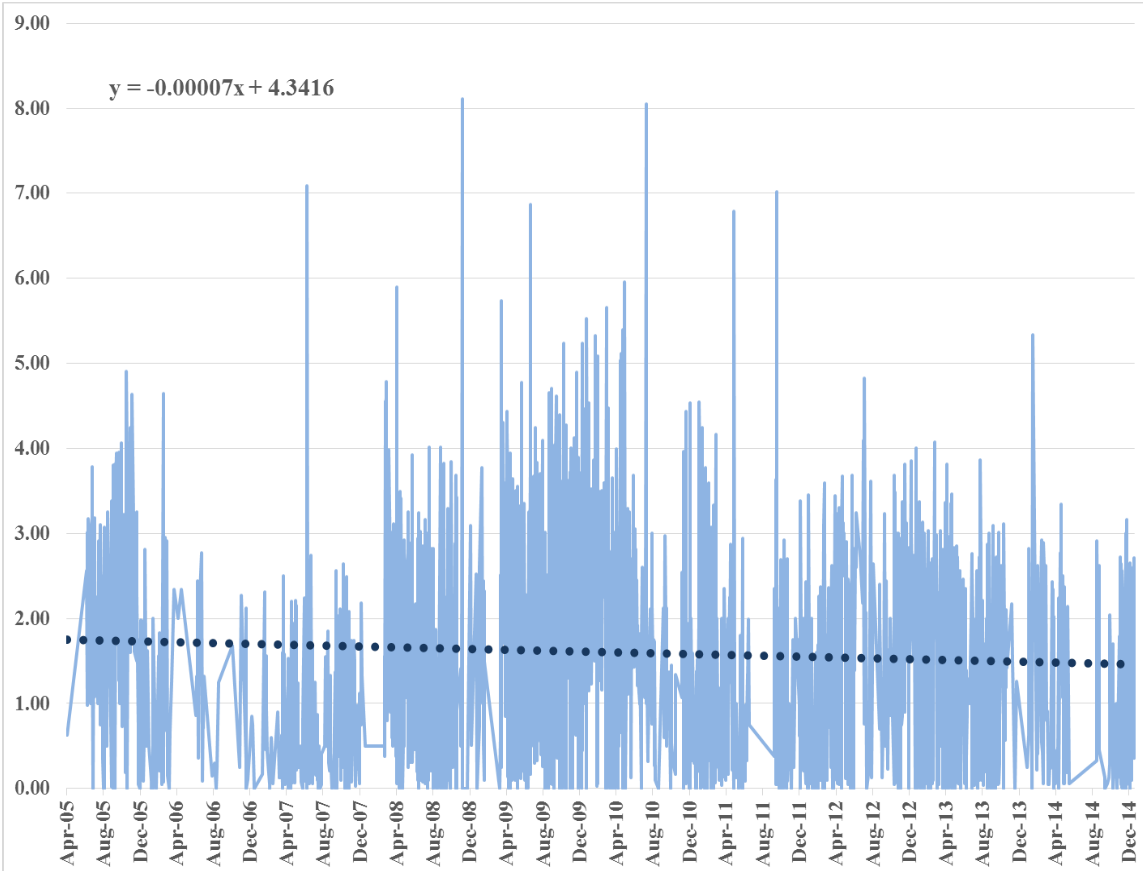

Figure 4.1. Average Daily Trade Price Differentials in Municipal Securities Secondary Markets.

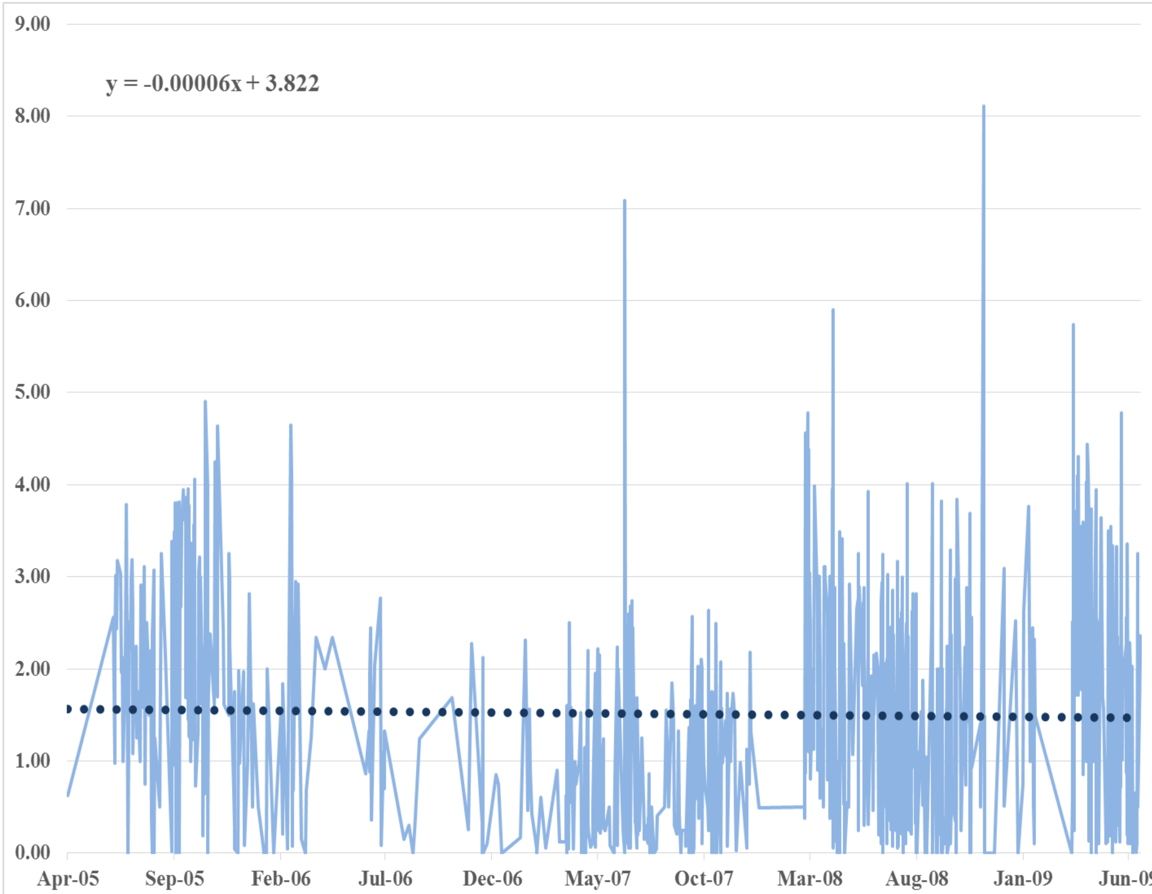

Figure 4.2. Average Daily Trade Price Differentials in the Pre-EMMA Regulatory Disclosure Regime.

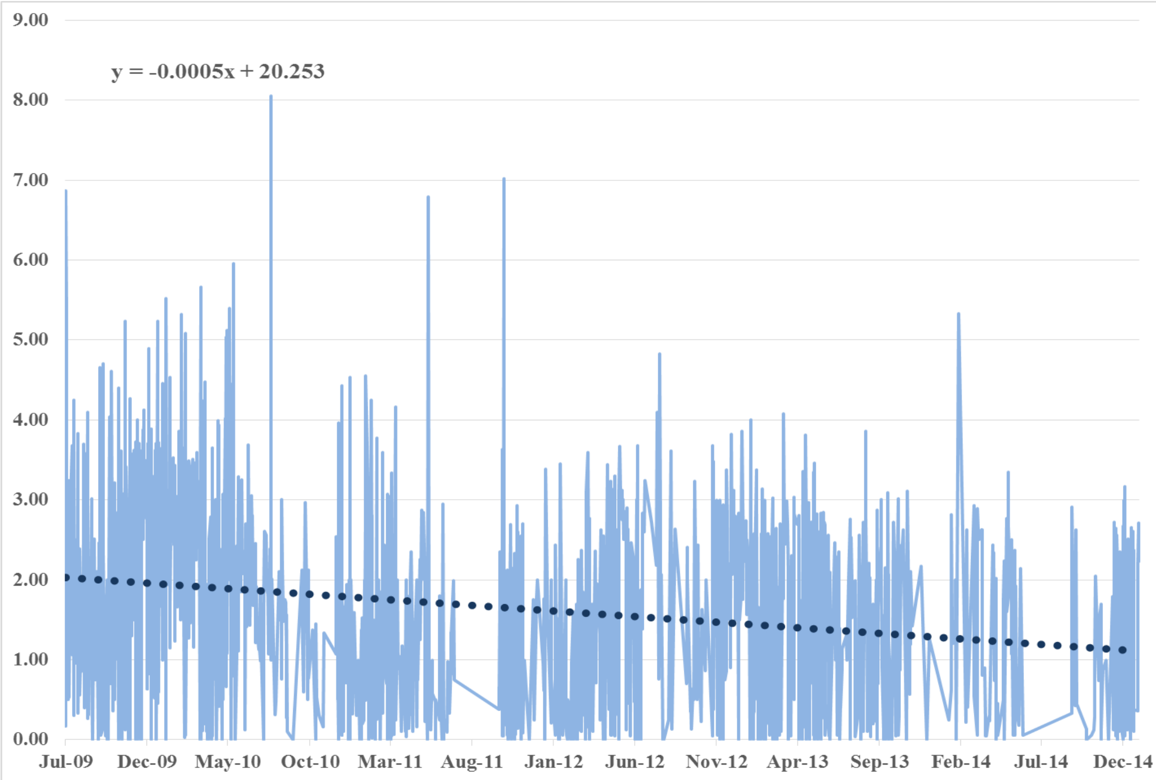

Figure 4.3. Average Daily Trade Price Differentials in the Post-EMMA Regulatory Disclosure Regime

I use the modified Dickey–Fuller *t* test proposed by Elliott, Rothenberg, and Stock (1996), which has significantly greater power than previous forms of the test. The modified test transforms the time series to a generalized least squares (GLS) regression before testing for unit roots, and it accommodates analysis of time trends and different lag structures of the variables. Appendix K shows results from the Dickey-Fuller GLS unit root tests. Results show that the variables measuring trade price differential (*t*=-18.2), trade frequency (*t*=-19.5), trade size (*t*=- 28.2), issue size (*t*=-12.6), term to maturity (*t*=-17.6), and coupon rate (*t*=-19.4) are all stationary at the 1 percent level. Also, the market yield spread variable is (weakly) significant (*t*=-1.78). Consequently, I specify all interval level variables at their levels, *I(0)*, in the trade pricing model.

4.5.3 Prais–Winsten and Cochrane–Orcutt Time Series Regressions

As noted in Section 4.4, heteroskedasticity can invalidate standard errors, *t* statistics, and *F* statistics in time series estimations and complicate statistical inference. The Prais–Winsten and Cochrane–Orcutt estimation procedure is one of the ways to correct for heterosckedasiicty to achieve robust estimation results. The approach fits a linear model using a generalized least-squares (GLS) estimator and an autoregressive specification for the error term such that the linear model corrects for first-order serially correlated residuals. Cochrane–Orcutt (1949), Prais–Winsten (1954), and Hildreth and Lu (1960) provide the underlying framework for this estimation procedure, and Becketti (2013) offers additional insights. I use the Prais-Winsten and Cochrane-Orchutt time series estimation procedure to investigate the impacts of regulatory disclosure interventions on trade pricing in municipal securities secondary markets. I examine efficiency effects on trade pricing using models of trade price differentials and trade price volatility for the full sample of municipal securities trades as well as sub-samples that group transactions into institutional and retail trades.

4.5.3.1 Trade Price Effects of Regulatory Interventions: Full Sample Estimates

Table 4.2 presents results for the determinants of trade price differential and trade price volatility for the entire sample of municipal securities trades. The *F*-statistics in the trade price differential model (F=76.20) and trade price volatility model (F=89.48) show that the dependent variable in each model is significantly related to at least one of the independent variables in the population. The R^2 statistics show that the regression model of trade price differential explains at least 16.4 percent of the variation in price differentials, while the trade price volatility model explains at least 18.8 percent of the variation in price volatility.[20]

Results confirm the hypothesis that the latest information disclosure initiatives under MSRB's EMMA regime are associated with a significant improvement in the efficiency of municipal securities trade prices. The coefficient of the variable measuring regulatory disclosure interventions is significant at the 1 percent level in the trade price differential model (t=-3.61) as well as the trade price volatility model (t=-5.49). The results show that the EMMA regulatory intervention is associated with a reduction in daily trade price differentials by a margin of $0.18, on average. Similarly,

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[20] These R^2 statistics (R^2=16.4% and R^2=18.8%) are substantial considering that the present study estimates high frequency data on daily trades of financial assets. Other studies on municipal securities secondary market pricing find similar model performance outcomes. For example, Downing and Zhang (2004) reported R^2 statistics ranging from 10.5% to 15.1% for their time series estimation of weekly trade price range models, while the Municipal Securities Rulemaking Board (2014b) showed R^2 statistics ranging from 5.3% to 7.5% for different ordinary least squares regression models of daily paired-trade price differentials.

Table 4.2

Full Sample Estimates of the Determinants of Trade Price Efficiency

Variable	Trade Price Differential	Trade Price Volatility
Policy Intervention		
EMMA	-0.178***	-0.00260***
	(0.0494)	(0.000474)
Trade-specific variables		
Trade frequency	0.00596***	0.000061***
	(0.000792)	(0.00000757)
Trade size	-0.0800***	-0.000735***
	(0.0113)	(0.000108)
Bond-related variables		
Issue size ($ million)	0.00106***	0.0000101***
	(0.000184)	(0.00000176)
Term to maturity	0.0445***	0.000475***
	(0.00326)	(0.0000312)
Coupon rate	-0.169***	-0.00217***
	(0.0308)	(0.000294)
Market condition variable		
Market yield spread	0.184***	0.00205***
	(0.0275)	(0.000264)
Constant Term	1.295***	0.0141***
	(0.142)	(0.00135)
Observations	2,719	2,719
F (7, 2711)	76.20	89.48
Prob > F	0.000	0.000
R-squared	0.164	0.188
rho	0.067	0.074
Durbin-Watson (original)	1.868	1.855
Durbin-Watson (transformed)	2.012	2.013

Note. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

volatility in trade prices declined, on average, following the EMMA regulatory disclosure initiatives. Volatility in average daily prices declined by a margin of 0.26 percent, on average, following the disclosure interventions.

Each of the other explanatory variables in the models of trade price differential and trade price volatility is statistically significant at the 1 percent level and, apart from the variable measuring coupon rate effects, all variables confirm the hypotheses linking them to trade pricing efficiency. Trade frequency is positively associated with differentials and volatility of secondary market trade prices. As number of trades increases, average daily trade price differentials widen by $0.01 and average daily volatility in prices increases by 0.01 percent. This result confirms the hypothesis that an increase in the number of trades in a security, ceteris paribus, raises the number of different price quotes for the security, widens the range of prices for the security, and increases both price differentials and volatility.

Effects of trade size on efficient pricing are larger than the price effect of trade frequency. As trade size increases, average daily trade price differentials decrease by $0.08 and average daily trade price volatility decreases by 0.08 percent. This finding provides support for the hypothesis that smaller trade sizes create a noisy trade pricing environment, which widens the range of daily prices and increases volatility in prices.

Bond related factors showed considerable differences in their impacts on trade pricing, either showing very minimal impact, relatively large effect, or a direction of impact that is contrary to the expected relationship. As issue size increases, both average daily trade price differentials ($0.001) and volatility in average daily trade price (0.001 percent) remain flat. On the other hand, an increase in term to maturity raises both average daily trade price differential ($0.04) and volatility in average daily trade prices (0.05 percent) by considerably larger margins compared to the effects of issue size. Nonetheless, the results for both issue size and term to maturity confirm stated hypotheses: investors prefer to trade in large-size issues (because retail investors tend to flock to large-size issues) and longer term issues (because longer-term issues tend to have enhanced features), and the increased demand for these issues widens price differentials and raises price volatility.

As for coupon rate effects, the results show an unexpected negative association with trade price differentials and trade price volatility. An increase in coupon rate considerably narrows both average daily trade price differentials ($0.17) and volatility in average daily trade prices (0.22 percent). This result is contrary to the stated hypothesis that investors tend to demand higher yields or coupons to compensate for higher interest rate risk and price volatility or differentials; nevertheless, it may be that higher coupons also serve as inducements for investors to hold on to bonds rather than trade them, causing declines in price differentials and volatility – the preponderance of evidence on buy and hold investors in municipal securities secondary markets seems to support this assertion. Overall, the results for bond-related factors show that maturity structure and yield considerations tend to weigh more heavily, than size of debt issue, in secondary market trade pricing.

Market yield spreads have relatively large impacts on trade price efficiency. An increase in the municipal market-wide yield spread widens average daily trade price differentials by $0.18 and increases volatility in average daily trade prices by 0.21 percent. This finding confirms the hypothesis that widening spreads indicate increasing tensions and uncertainties in the municipal securities market and tend to raise price differentials and volatility.

Further, I estimate the impacts of regulatory disclosure using a latent measure of pricing bias across high and low information regimes. I assess impacts using the full sample of municipal securities trades. As noted earlier, the measure of pricing bias derives from the residuals of an initial regression of trade prices that excludes the variable measuring regulatory interventions. The residuals represent unexplained trade prices and contain latent information about pricing quality or bias. Results in Table 4.3 confirm the expectation that the latest information disclosure initiatives are associated with a significant reduction in the effect of pricing bias on trade prices. An increase in pricing bias raised trade price differentials by 1.46 percentage points (t=2.54) in the pre-EMMA period. However, in the post-EMMA period, the effect of pricing bias on trade prices decreased from 1.46 to 1.22 percentage points (t=3.75).

Finally, I estimate time series regressions to examine whether the Great Recession significantly altered the relationship between regulatory disclosure initiatives and price efficiency in municipal securities secondary markets. As stated earlier, I exclude trades that were executed during the Great Recession (December 2007 to June 2009) from the pre-EMMA period (January 2005 to June 2009) and estimate the trade price efficiency model separately for the recession-adjusted pre-EMMA period and the post-EMMA period. After controlling for the Great Recession period, the estimation results show no significant difference in the effects of regulatory disclosure on trade price efficiency in both the trade price differential and trade price volatility models.

Table 4.3

Full Sample Estimates of the Effect of Pricing Bias on Trade Price Differentials

Variable	Trade Price Differential	
	Pre-EMMA	Post-EMMA
Pricing Bias (logarithm)	1.4649**	1.2181***
	(0.5775)	(0.3250)
Other Characteristics		
Trade frequency	0.0020	0.0037*
	(0.0015)	(0.0022)
Trade size	-0.0367	0.0230
	(0.0385)	(0.0407)
Issue size ($ million)	0.0003	0.0007**
	(0.0004)	(0.0003)
Term to maturity	0.0044	0.0105
	(0.0203)	(0.0092)
Coupon rate	0.0363	-0.0330
	(0.1673)	(0.0409)
Market yield spread	-0.0439	0.0158
	(0.1165)	(0.0578)
Constant Term	0.7814	0.9139***
	(0.6423)	(0.1516)
Observations	1,108	1,596
F	34.52	49.92
Prob > F	0.000	0.000
R-squared	0.180	0.180
rho	0.068	0.049
Durbin-Watson (original)	1.862	1.904
Durbin-Watson (transformed)	2.005	1.998

Note. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

4.5.3.2 Trade Price Effects of Regulatory Interventions: Sub-sample Estimates

Tables 4.4 and 4.5 present sub-sample estimates of trade price differentials and trade price volatility for institutional and retail investor segments of the secondary market. The *F* and R^2 statistics in each of the four models show that the dependent variable is significantly related to at least one of the independent variables in the population, and the regression models explain a considerable amount (between 15.5 and 22.6 percent) of the variation in trade price differentials and trade price volatility.

Results do not provide sufficient evidence to support the hypothesis that the EMMA regulatory disclosure interventions reduced trade pricing distortions institutional investors face by the same margin it lowered retail investors' trade price distortions. Table 4.4 shows that regulatory disclosure initiatives are associated with a statistically significant (t=-3.90) decrease in average daily trade price differentials for institutional investors, by a margin of $0.28 on average, but the effect of interventions among retail investors is not clear as the results show an insignificant statistical relationship (t=-1.70).

Trade price volatility results in Table 4.5 present a much clearer picture of the different impacts of regulatory disclosure on institutional and retail investors. Results show that disclosure interventions are associated with a statistically significant decrease in average daily trade price volatility among institutional (t=-5.21) and retail (t=-2.38) investors but volatility declined by a larger margin (0.20 percent) in the institutional investor segment compared to the retail investor segment. These findings confirm evidence on the inequities in trade pricing that tend to favor large investors over small investors in municipal securities secondary markets.

Table 4.4

Estimates of the Determinants of Trade Price Differentials in Institutional and Retail Investor Sub-samples of Municipal Securities Trades

Variable	Trade Price Differential		
	Institutional Trades	Retail Trades	Difference
Policy Intervention			
EMMA	-0.279***	-0.0759	n/a
	(0.0716)	(0.0713)	
Trade-specific variable			
Trade Frequency	0.00435***	0.0391***	-0.0348
	(0.000799)	(0.00373)	
Bond-related variables			
Issue Size	0.00143***	0.000290	n/a
	(0.000239)	(0.000301)	
Term to maturity	0.0461***	0.0404***	0.0057
	(0.00464)	(0.00507)	
Coupon rate	-0.289***	-0.0237	n/a
	(0.0397)	(0.0520)	
Market condition variable			
Market yield spread	0.274***	0.127***	0.1470
	(0.0379)	(0.0403)	
Constant Term	1.637***	0.589**	
	(0.179)	(0.263)	
Observations	1,373	1,345	
F	56.62	41.57	
Prob > F	0.000	0.000	
R-squared	0.199	0.157	
rho	0.113	0.061	
Durbin-Watson (original)	1.779	1.879	
Durbin-Watson (transformed)	2.016	2.007	

Note. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4.5

Estimates of the Determinants of Trade Price Volatility in Institutional and Retail Investor Sub-samples of Municipal Securities Trades

Variable	Trade Price Volatility		
	Institutional Trades	Retail Trades	Difference
Policy Intervention			
EMMA	-0.00358*** (0.000687)	-0.00162** (0.000683)	0.00196
Trade-specific variable			
Trade frequency	0.0000449*** (0.0000076)	0.000391*** (0.0000356)	-0.000346
Bond-related variables			
Issue Size	0.0000134*** (0.00000227)	0.00000303 (0.00000287)	n/a
Term to maturity	0.000488*** (0.0000443)	0.000430*** (0.0000484)	0.000058
Coupon rate	-0.00327*** (0.000379)	-0.000843* (0.000497)	0.002427
Market condition variable			
Market yield spread	0.00296*** (0.000363)	0.00144*** (0.000386)	0.00152
Constant	0.0171*** (0.00171)	0.00775*** (0.00251)	
Observations	1,373	1,345	
F	66.32	49.34	
Prob > F	0.000	0.000	
R-squared	0.226	0.181	
rho	0.124	0.068	
Durbin-Watson (original)	1.759	1.866	
Durbin-Watson (transformed)	2.020	2.008	

Note. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Price efficiency effects of trade-specific and market condition variables also differ considerably between institutional and retail investor segments of the secondary market. Trade frequency has a larger impact on price differentials and volatility among retail investors than institutional investors. An increase in the number of trades is associated with $0.03 more increase in average daily trade price differentials and 0.03 percent more volatility in average daily trade prices of retail investors compared to institutional investors. This result highlights how frequent trading in small sizes widens differentials and raises volatility to an extent that exceeds what will occur if markets have more depth and stability from larger-size trades sequenced more evenly over time.

Also, market yield spread effects are larger among institutional investors than retail investors. An increase in the yield spread is associated with $0.15 more increase in average daily trade price differentials and 0.15 percent more increase in trade price volatility for retail investors compared to institutional investors. This finding seems to suggest that institutional investors tend to be more risk averse about market-wide changes in risk and uncertainty than retail investors, especially given that institutional investors risk losing larger amounts in worsening market conditions than retail investors.

4.6 Conclusions, Policy Implications, and Directions for Future Research

Over the years, regulatory policy in municipal securities markets has focused on promoting increased information disclosure and transparency to enhance market efficiency. Efficient markets theory predicts that public dissemination of information on municipal securities trades will reduce search and transaction costs for investors and lower price distortions. This study analyzed the latest regulatory disclosure initiatives in municipal securities markets. The initiatives spanned March 31 2008 and June 1, 2009.

Robust time series estimations show that regulatory interventions enhanced the efficiency of trade pricing in municipal securities secondary markets as average daily price differentials and volatility both declined market-wide. However, the empirical estimates do not provide sufficient information to support the efficient markets hypothesis that public dissemination of information on executed trades will reduce information flow disparities among market segments and counteract dealer rent-seeking behaviors that generate price distortions. Findings show that institutional investors continue to have a pricing advantage over retail investors in municipal securities trade pricing.

These findings weigh into policy discussions on the merits and demerits of market regulation. Supporters of regulatory policy argue that tighter regulatory framework are needed to correct the welfare costs of price distortions in the market system while skeptics have pointed to how regulatory rules constrain competition in the private sector and limit the processes that enhance economic growth (Vocino, 2003). The present study provides evidence that interventions in municipal bond markets improve efficiency of securities pricing market-wide. This should give renewed impetus to regulatory efforts aimed at further enhancing municipal bond market efficiency.

Also, the finding that efficiency effects of regulatory interventions were larger for institutional investors than retail investors shows that policies governing municipal securities trading and pricing must respond more effectively to counteract disparities in information flow and rent-seeking behavior, which creates unequal opportunities for the retail investor segment of the market. One way is to identify spaces within dynamic market environments that are most attractive to retail investor trades and target protective regulatory schemes at these fronts. For example, new insights on specific sectors, features of securities, and dealer characteristics that retail investors tend to flock to as markets evolve can inform the types of soft enabling rules and incentives that regulators direct to specific market spaces to reduce the risks surrounding retail investor portfolios and minimize the margin of rent-seeking by securities dealers.

Overall, regulatory policy in municipal bond market contexts must stretch beyond interventions and enforcement of disclosure rules to emphasize, to a greater extent, other supportive mechanisms such as investor education. Current efforts by the SEC and MSRB at investor education are commendable but must be deepened. In today's increasingly complex markets where trading in sophisticated debt instruments proliferate, most small investors are not fully aware of the mechanics of their trading portfolios and risks therein. Increased educational interactions with the investor community using new (social) media technologies to achieve wider reach and more speedy responses to investor questions and concerns will complement, more extensively, current achievements of regulatory disclosure initiatives.

This study is limited in the extent to which it portrays trading dynamics in U.S. municipal securities markets as a whole. Data for the empirical analysis is from a random stratified sample of California state-issued general obligation bonds. While California is the leading source of municipal securities trades among U.S. states, generalizability of the findings is constrained to the extent that the data does not cover school districts, cities, counties, and other states, as well as other types of securities (e.g., revenue bonds).

Still, the present study extends existing knowledge in that it analyzes the latest regulatory interventions in municipal securities secondary markets, considers the influence of market-wide conditions, and presents stronger evidence on how the pricing advantage of institutional investors over retail investors has persisted even under improved informational environments.

Future studies should consider how existing rules and regulations in municipal securities secondary markets interact to achieve intended regulatory policy goals. Preliminary work in this area point to how the Dodd-Frank Act proposed about 200 new rules (Coates, 2015) and how rule changes proposed in the Act have generated uncertainty about regulatory policy among market agents (Nodari, 2014). Thus, it would be useful to investigate whether a threshold exists beyond which an existing set of regulatory rules and their enforcement can generate sub-optimal regulatory policy outcomes.

Appendix A

Multicollinearity Diagnostics for Models of True Interest Costs

1. Variance Inflation Factors in the Basic Model

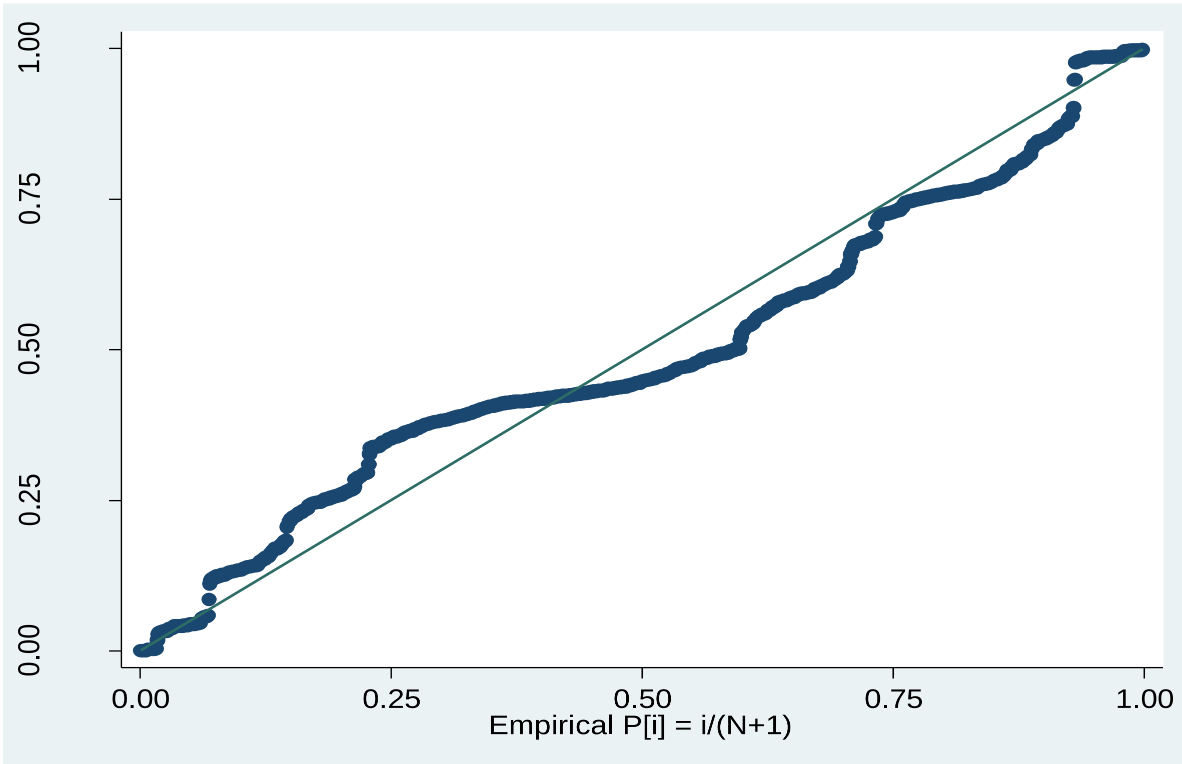
Variable	VIF	1/VIF
y2013	12.93	0.077369
ratinglmh	10.92	0.091591
y2012	10.62	0.094187
y2009	8.25	0.121238
y2014	7.90	0.126595
y2010	5.68	0.176094
y2008	5.12	0.195388
y2011	5.10	0.196258
y2007	3.08	0.325185
negotiated	2.18	0.459341
bbsdevma	1.79	0.558688
y2006	1.76	0.568070
repeat	1.56	0.639989
ttmat	1.46	0.686882
isizeM	1.08	0.924648
Mean VIF	5.29	

2. Variance Inflation Factors in the Curvilinear Regression

Variable	VIF	1/VIF
y2013	13.17	0.075949
repeatsq	12.73	0.078580
repeat	11.23	0.089045
ratinglmh	10.92	0.091590
y2012	10.62	0.094150
y2009	8.30	0.120549
y2014	7.90	0.126521
y2010	5.68	0.175918
y2011	5.14	0.194733
y2008	5.12	0.195287
y2007	3.10	0.322529
negotiated	2.18	0.459211
bbsdevma	1.97	0.506789
y2006	1.77	0.564845
ttmat	1.46	0.686772
isizeM	1.08	0.923782
Mean VIF	6.40	

Appendix B

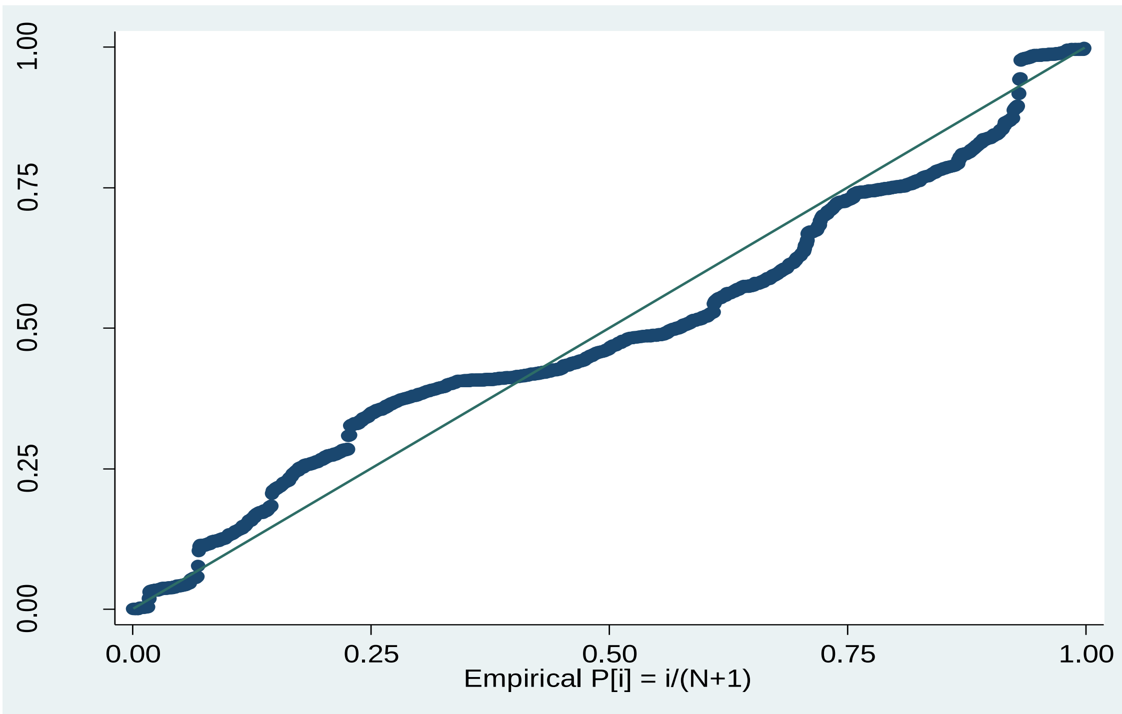
Residual Diagnostics for Basic Model of True Interest Costs



Standardized normal probability (P-P) plot

Appendix C

Residual Diagnostics for Curvilinear Model of True Interest Costs



Standardized normal probability (P-P) plot

Appendix D

Basic Model of True Interest Costs: Full Estimation Output

Variable	True Interest Costs
Network Stability	0.00109***
	(0.000410)
Issuance Size (million dollars)	0.000167
	(0.000105)
Term to maturity (years)	0.0420***
	(0.00516)
Credit rating of issue	-0.156***
	(0.0566)
Issuance method (negotiated=1)	0.291***
	(0.0528)
Market yield spread	0.242***
	(0.0368)
Year: 2006	0.0467
	(0.0396)
Year: 2007	-0.253***
	(0.0539)
Year: 2008	-0.394**
	(0.157)
Year: 2009	0.219
	(0.155)
Year: 2010	0.479***
	(0.171)
Year: 2011	-0.546***
	(0.141)
Year: 2012	-0.912***
	(0.125)
Year: 2013	-0.987***
	(0.130)
Year: 2014	-1.324***
	(0.132)
Constant	3.468***
	(0.229)
Observations	1,063
R-squared	0.703

Note. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix E

Curvilinear Model of True Interest Costs: Full Estimation Output

Variable	True Interest Costs
Network Stability	0.00290***
	(0.00108)
Network Stability (squared term)	-0.00001*
	(0.000006)
Issuance Size (million dollars)	0.00017
	(0.000105)
Term to maturity (years)	0.0419***
	(0.00516)
Credit rating of issue	-0.156***
	(0.0576)
Issuance method (negotiated=1)	0.292***
	(0.0527)
Market yield spread	0.256***
	(0.0398)
Year: 2006	0.0578
	(0.0415)
Year: 2007	-0.240***
	(0.0531)
Year: 2008	-0.388**
	(0.158)
Year: 2009	0.200
	(0.158)
Year: 2010	0.471***
	(0.171)
Year: 2011	-0.523***
	(0.143)
Year: 2012	-0.907***
	(0.127)
Year: 2013	-0.953***
	(0.132)
Year: 2014	-1.318***
	(0.133)
Constant	3.401***
	(0.241)
Observations	1,063
R-squared	0.704

Note. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Appendix F

School District Advance Refunding Transactions in U.S. States

State	Number of Transactions	Percent of Total
Texas	4168	28.1
California	1352	9.1
Pennsylvania	1190	8.0
Illinois	1157	7.8
Ohio	899	6.1
New Jersey	660	4.5
Wisconsin	561	3.8
Missouri	551	3.7
Washington	540	3.6
Colorado	420	2.8
Kansas	408	2.8
Michigan	356	2.4
Iowa	295	2.0
Minnesota	250	1.7
Oregon	243	1.6
Louisiana	215	1.5
Utah	194	1.3
South Carolina	188	1.3
Idaho	171	1.2
Alabama	125	0.8
Georgia	110	0.7
Connecticut	95	0.6
Arkansas	81	0.5
Nebraska	81	0.5
Mississippi	76	0.5
Nevada	75	0.5
Arizona	64	0.4
South Dakota	64	0.4
Montana	51	0.3
New Mexico	40	0.3
Tennessee	35	0.2
North Carolina	27	0.2
New York	24	0.2
Massachusetts	19	0.1
Maryland	19	0.1
North Dakota	14	0.1
Indiana	7	0.0
	14,825	100.0

Note. Compiled using data from Bloomberg LLP. (2015). Data starts from 2005 to 2014.

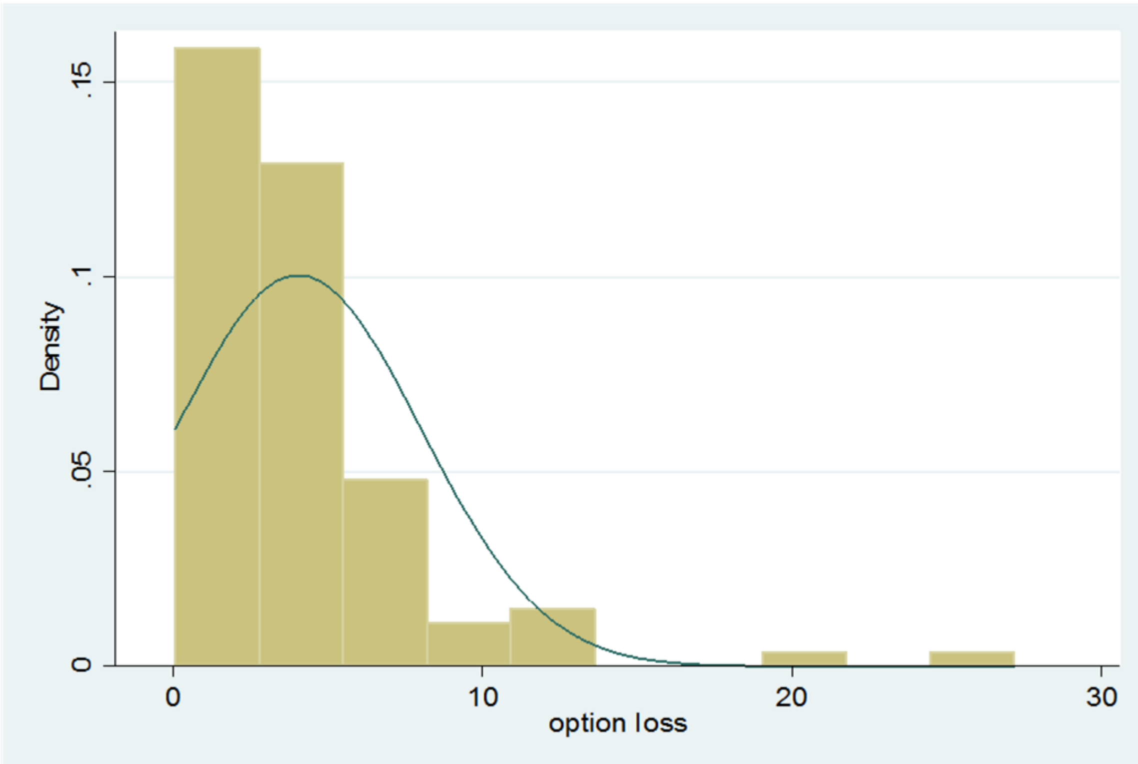
Appendix G

MATLAB Codes for Monte Carlo Option Valuation

```
%%% Option Parameters (Replace xxx with Parameter Values):
s = xxx;                      [Value of the advance refunded bond]
k = xxx;                      [Exercise price of the advance refunded bond]
r = xxx;                      [Risk-free interest rate]
sigma = xxx;                  [Volatility in trade price of advance refunded bond]
t = xxx;                      [Time remaining until call date]

%%% Monte Carlo Method Parameters:
% randn('state',0)            [ Repeatable trials on/off]
M = 1e7;                      [100,000 Monte Carlo trials]

%%% Computation of Option Value Loss
final_vals=s*exp((r-0.5*sigma^2)*t + sigma*sqrt(t)*randn(M,1));
option_values=max(k-final_vals,0);            [Evaluate the Put option]
present_vals=exp(-r*t)*option_values;         [Discount under r-n assumption]
int=1.96*std(present_vals)/sqrt(M);           [Compute confidence intervals]
put_value=mean(present_vals);                 [Take average]
display(put_value)
display([put_value-int put_value+int])

%%%% END %%%%
```

Appendix H

Histogram of the Distribution of School Districts' Option Value Loss



Appendix I

Milestones in Municipal Securities Regulation and Information Disclosure

---

1975 – Creation of the Municipal Securities Rulemaking Board

1976 – MSRB Established Uniform Practice Rules

1978 − MSRB Created Rules on Underwriting Practices, Fair Practice, and Yield Comparisons

1979 – MSRB Required Use of CUSIP Numbers

1980 – MSRB Released Report on Pricing

1982 – Tax Equity and Fiscal Responsibility Act Enacted

1984 – Automated Clearance and Settlement Systems

1989 – SEC Adopted SEC Rule 15c2-12
The SEC mandated that underwriters for most bond issues obtain the issuer's agreement to deliver an official statement to the underwriter within seven business days after the date of sale. The SEC also required underwriters to review the official statement to determine whether all key factors had been disclosed. The landmark rule promoted increased disclosure and transparency in the municipal securities market.

1990 – MSRB Required Filings of Disclosure Documents

1993/94 – Groundbreaking Pay-to-Play Rule G-37 Adopted

1995 – MSRB Created Transaction Reporting System
The MSRB developed a daily summary report of bonds traded between dealers, a first step in providing comprehensive price transparency in the municipal securities market.

1996 – MSRB Adopted Rule on Use of Outside Consultants

1998 – MSRB Published Daily Trade Reports
The MSRB implemented another major step in providing market transparency, expanding its daily reports on dealer trading to include transactions with customers.

2000/2001 – MSRB Adopted Rules on 529 Plans and Other Municipal Fund Securities

2001 – The MSRB Launched the Muni Council

2002 – Electronic Official Statement Submission System is Launched

2005 – MSRB Revised Rule G-38 to Ban Use of Consultants

2005 – MSRB Made Comprehensive Real-Time Trade Reports Available
Dealers were required to submit transaction information to the MSRB within 15 minutes of execution of all trades, providing real time public access to their fund information.

2005/2006 - MSRB Established 529 Plan Disclosure and Advertising Standards
In a series of regulatory actions, the MSRB adopted rules for disclosure and advertising of 529 plans that ensure fair and complete disclosure in the 529 plan market, consistent with mutual fund standards.

2006 - MSRB Launched Regulatory Effort to Establish All-Electronic Disclosure System for Municipal Securities
The MSRB published a concept release setting forth its vision of a centralized electronic disclosure system for the municipal securities market.

2008 – MSRB Launched the Electronic Municipal Market Access (EMMA) Website
The launch of the pilot program for the Electronic Municipal Market Access (EMMA) website was the first time that historical data and statistics on the municipal securities market were available from a single source, free of charge. EMMA is an electronic, Internet-based system that provides public access to disclosure documents, real-time trade price data and educational resources for the municipal securities market.

2009 – MSRB Launched Market Statistics on EMMA
The MSRB introduced market-wide municipal bond statistics on EMMA that allowed investors to view municipal market trading trends. The addition of daily statistics on EMMA was the first in a series of initiatives by the MSRB to provide investors with more extensive data on municipal bonds to help them better understand the market.

2009 – MSRB Provided Auction Rate Security and Variable Rate Demand Obligation Transparency
The MSRB launched a program to collect information about auction rate securities and variable rate demand obligations from broker-dealers and disseminate it to the public for free through EMMA. Dealers were required to provide the MSRB with interest rates set for auction rate securities and variable rate demand obligations. The program provided all market participants with additional critical information necessary to trade these financial products.

2009 – MSRB Implemented All-Electronic Official Statement Dissemination Standard
The MSRB revised its Rule G-32 to require municipal securities underwriters to submit electronic copies of official statements and advance refunding documents (rather than paper copies) to EMMA. Electronic documents made the submission process less costly and speeds dissemination to investors.

2009 – MSRB Began Collecting and Posting Continuing Disclosures
Under amendments to SEC Rule 15c2-12 adopted by the SEC in 2008, municipal bond issuers began to provide electronic copies of continuing disclosure documents to the MSRB through EMMA, which made them immediately available to the public. The MSRB officially began to collect all disclosure documents associated with municipal bonds under a combination of MSRB and SEC rules.

2010 – MSRB Revised Rule G-37 to Require Additional Political Contributions Disclosure
The MSRB revised its Rule G-37 to require disclosure of dealer contributions to municipal bond ballot campaigns.
Congress Expands MSRB's Mission and Jurisdiction
The Dodd-Frank Wall Street Reform and Consumer Protection Act, signed by President Barack Obama on July 21, 2010, expanded the MSRB's mission to include the protection of municipal entities and obligated persons. It also granted the MSRB rulemaking authority over municipal advisors. The MSRB's expanded mandate and mission became effective October 1, 2010.

2012 – MSRB Expands Obligations of Underwriters to their State and Local Government Clients
The MSRB issued an interpretive notice to its Rule G-17 on fair dealing to outline explicit and expanded requirements for underwriters aimed at protecting state and local governments that issue municipal bonds.

Note. Compiled using information from the Municipal Securities Rule Making Board. See www.msrb.com

Appendix J

Data for Estimating the Trade Price Impacts of Regulatory Disclosure Interventions in Municipal Securities Secondary Markets

Trade Day	Trade Price	Trade Price Differential	Trade Price Volatility	Trade Frequency	Trade Size	CUSIP	Issue Size ($ million)	Term to Maturity	Coupon Rate	Market Yield Spread
4/13/2005	99.69	0.625	0.0063	2	100000	13062RHW	0.43	11.7	4.65	1.61
6/17/2005	98.85	2.560	0.0259	18	384444	13062RME	12.87	24.0	4.375	1.1
6/20/2005	106.65	0.978	0.0092	3	8923333	13062RLZ	13.39	19.0	5	1.09
6/21/2005	99.73	3.012	0.0302	18	46111	13062RME	12.87	24.0	4.375	1.04
6/22/2005	99.62	2.441	0.0245	18	37500	13062RME	12.87	24.0	4.375	0.92
6/23/2005	99.64	3.175	0.0319	16	153125	13062RME	12.87	24.0	4.375	0.89
6/28/2005	99.73	3.036	0.0304	16	103750	13062RME	12.87	24.0	4.375	0.83
6/29/2005	100.80	1.965	0.0195	4	25000	13062RME	12.87	24.0	4.375	0.86
6/30/2005	99.87	2.125	0.0213	6	77500	13062RME	12.87	24.0	4.375	0.81
7/1/2005	99.67	1.000	0.0100	3	30000	13062RME	12.87	24.0	4.375	0.89
7/5/2005	99.96	2.250	0.0225	12	25417	13062RME	12.87	24.0	4.375	0.89
7/6/2005	99.61	3.780	0.0379	20	202000	13062RME	12.87	24.0	4.375	0.89
7/7/2005	100.12	2.242	0.0224	12	30417	13062RME	12.87	24.0	4.375	0.9
7/8/2005	100.00	0.000	0.0000	3	41667	13062RME	12.87	24.0	4.375	0.94
7/11/2005	99.92	2.511	0.0251	14	42857	13062RME	12.87	24.0	4.375	0.92
7/12/2005	99.85	2.241	0.0224	11	42273	13062RME	12.87	24.0	4.375	0.94
7/13/2005	100.03	2.967	0.0297	11	58636	13062RME	12.87	24.0	4.375	0.95
7/14/2005	100.04	3.183	0.0318	9	77222	13062RME	12.87	24.0	4.375	0.96
7/15/2005	98.96	2.625	0.0265	9	484444	13062RME	12.87	24.0	4.375	0.92
7/18/2005	99.57	1.956	0.0196	5	193000	13062RME	12.87	24.0	4.375	0.92
7/19/2005	99.98	2.119	0.0212	8	38750	13062RME	12.87	24.0	4.375	0.89
7/20/2005	99.95	2.250	0.0225	11	26364	13062RME	12.87	24.0	4.375	0.87
7/21/2005	99.79	1.250	0.0125	9	16667	13062RME	12.87	24.0	4.375	0.93
7/22/2005	99.49	1.750	0.0176	10	27000	13062RME	12.87	24.0	4.375	0.85
7/26/2005	99.95	1.000	0.0100	7	33571	13062RME	12.87	24.0	4.375	0.81

Appendix J (Continued)

Trade Day	Trade Price	Trade Price Differential	Trade Price Volatility	Trade Frequency	Trade Size	CUSIP	Issue Size ($ million)	Term to Maturity	Coupon Rate	Market Yield Spread
7/27/2005	99.11	2.915	0.0294	18	105833	13062RME	12.87	24.0	4.375	0.87
7/28/2005	99.19	2.325	0.0234	9	118889	13062RME	12.87	24.0	4.375	0.79
7/29/2005	98.66	1.586	0.0161	4	8750	13062RME	12.87	24.0	4.375	0.86
8/1/2005	98.88	3.108	0.0314	5	25000	13062RME	12.87	24.0	4.375	0.84
8/2/2005	99.85	0.750	0.0075	5	24000	13062RME	12.87	24.0	4.375	0.85
8/3/2005	99.50	2.250	0.0226	12	26250	13062RME	12.87	24.0	4.375	0.84
8/4/2005	98.95	2.500	0.0253	9	28333	13062RME	12.87	24.0	4.375	0.85
8/5/2005	98.92	2.250	0.0227	8	58750	13062RME	12.87	24.0	4.375	0.88
8/8/2005	98.60	1.500	0.0152	5	20000	13062RME	12.87	24.0	4.375	0.88
8/10/2005	98.63	2.203	0.0223	3	26667	13062RME	12.87	24.0	4.375	0.89
8/11/2005	96.93	0.337	0.0035	3	170000	13062RME	12.87	24.0	4.375	0.81
8/12/2005	102.46	0.000	0.0000	3	18333	13062RKX	12.59	20.0	4.5	0.72
8/15/2005	98.77	3.070	0.0311	6	47500	13062RME	12.87	24.0	4.375	0.73
8/16/2005	96.88	1.250	0.0129	2	100000	13062RME	12.87	24.0	4.375	0.69
8/23/2005	103.43	0.500	0.0048	2	45000	13062RKX	12.59	20.0	4.5	0.67
8/25/2005	98.27	3.250	0.0331	5	19000	13062RME	12.87	24.0	4.375	0.64
8/31/2005	98.12	2.140	0.0218	3	100000	13062RME	12.87	24.0	4.375	0.5
9/9/2005	106.81	0.015	0.0001	5	10000000	13062RRW	67.27	16.9	5	0.65
9/12/2005	99.30	2.212	0.0223	52	147212	13062RQY	27.04	23.9	4.375	0.67
9/13/2005	99.66	3.491	0.0350	45	64111	13062RQY	27.04	23.9	4.375	0.67
9/14/2005	107.21	0.950	0.0089	2	13250000	13062RRW	67.27	16.9	5	0.75
9/15/2005	99.63	3.331	0.0334	25	153000	13062RQY	27.04	23.9	4.375	0.77
9/16/2005	99.45	3.805	0.0383	25	55400	13062RQY	27.04	23.9	4.375	0.76
9/19/2005	99.24	3.000	0.0302	35	33429	13062RQY	27.04	23.9	4.375	0.67

Note. Compiled using data from the MSRB, Bloomberg LLP and the Federal Reserve Bank of St. Louis.

Appendix K

Unit Root Test Results for Variables in the Municipal Securities Trade Pricing Model

---

(1) Trade Price differential

```
. dfgls adtpxdiff, maxlag(2) notrend

DF-GLS for adtpxdiff                                     Number of obs =
2717

               DF-GLS mu       1% Critical       5% Critical      10%
Critical
  [lags]     Test Statistic        Value             Value
Value
---------------------------------------------------------------------------
---
    2           -13.236           -2.580            -1.954             -
1.631
    1           -18.168           -2.580            -1.954             -
1.631

Opt Lag (Ng-Perron seq t) =  2 with RMSE   1.21891
Min SC   =  .4046445 at lag  2 with RMSE   1.21891
Min MAIC =  .5926693 at lag  2 with RMSE   1.21891
```

(2) Trade Frequency

```
. dfgls dttfreq, maxlag(2) notrend

DF-GLS for dttfreq                                       Number of obs =
2717

               DF-GLS mu       1% Critical       5% Critical      10%
Critical
  [lags]     Test Statistic        Value             Value
Value
---------------------------------------------------------------------------
---
    2           -18.253           -2.580            -1.954             -
1.631
    1           -19.523           -2.580            -1.954             -
1.631

Opt Lag (Ng-Perron seq t) =  1 with RMSE   24.4163
Min SC   =  6.396323 at lag  1 with RMSE   24.4163
Min MAIC =   6.79476 at lag  2 with RMSE  24.41628
```

(3) Trade Size

```
. dfgls  adtsize, maxlag(2) notrend

DF-GLS for adtsize                                          Number of obs =
2717

               DF-GLS mu       1% Critical       5% Critical      10%
Critical
  [lags]     Test Statistic        Value             Value
Value
------------------------------------------------------------------------------
---
    2           -22.239           -2.580            -1.954            -
1.631
    1           -28.211           -2.580            -1.954            -
1.631

Opt Lag (Ng-Perron seq t) =  2 with RMSE   1917506
Min SC   =   28.9418 at lag  2 with RMSE   1917506
Min MAIC =  29.76917 at lag  2 with RMSE   1917506
```

(4) Issue Size

```
. dfgls matsize, maxlag(2) notrend

DF-GLS for matsize                                          Number of obs =
2717

               DF-GLS mu       1% Critical       5% Critical      10%
Critical
  [lags]     Test Statistic        Value             Value
Value
------------------------------------------------------------------------------
---
    2            -8.396           -2.580            -1.954            -
1.631
    1           -12.600           -2.580            -1.954            -
1.631

Opt Lag (Ng-Perron seq t) = 0 [use maxlag(0)]
Min SC   =  37.04406 at lag  2 with RMSE  1.10e+08
Min MAIC =   37.1029 at lag  2 with RMSE  1.10e+08
```

(5) Coupon rate

```
. dfgls coupon, maxlag(2) notrend

DF-GLS for coupon                                          Number of obs =
2717

               DF-GLS mu       1% Critical       5% Critical      10%
Critical
  [lags]     Test Statistic        Value             Value
Value
---------------------------------------------------------------------------
---
    2          -13.294           -2.580            -1.954            -
1.631
    1          -19.428           -2.580            -1.954            -
1.631

Opt Lag (Ng-Perron seq t) =  2 with RMSE  .7073662
Min SC   = -.6836826 at lag  2 with RMSE  .7073662
Min MAIC = -.4794922 at lag  2 with RMSE  .7073662
```

(6) Term to maturity

```
. dfgls  yrtmat, maxlag(2) notrend

DF-GLS for yrtmat                                          Number of obs =
2717

               DF-GLS mu       1% Critical       5% Critical      10%
Critical
  [lags]     Test Statistic        Value             Value
Value
---------------------------------------------------------------------------
---
    2          -11.392           -2.580            -1.954            -
1.631
    1          -17.555           -2.580            -1.954            -
1.631

Opt Lag (Ng-Perron seq t) =  2 with RMSE  6.079778
Min SC   =  3.618667 at lag  2 with RMSE  6.079778
Min MAIC =  3.757249 at lag  2 with RMSE  6.079778


. dfgls ycvalue, maxlag(2) notrend
```

(7) Market Yield Spread

```
DF-GLS for ycvalue                                   Number of obs =  2717

               DF-GLS mu       1% Critical       5% Critical      10%
Critical
  [lags]     Test Statistic        Value             Value
Value
---------------------------------------------------------------------------
---
    2           -1.600          -2.580            -1.954            -
1.631
    1           -1.775          -2.580            -1.954            -
1.631

Opt Lag (Ng-Perron seq t) =  2 with RMSE  .0835166
Min SC   =  -4.95669 at lag  2 with RMSE  .0835166
Min MAIC = -4.962057 at lag  2 with RMSE  .0835166


. dfgls D.ycvalue, maxlag(2) notrend

DF-GLS for D.ycvalue                                 Number of obs =  2716

               DF-GLS mu       1% Critical       5% Critical      10%
Critical
  [lags]     Test Statistic        Value             Value
Value
---------------------------------------------------------------------------
---
    2           -2.558          -2.580            -1.954            -
1.631
    1           -3.785          -2.580            -1.954            -
1.631

Opt Lag (Ng-Perron seq t) =  2 with RMSE  .0991568
Min SC   = -4.613372 at lag  2 with RMSE  .0991568
Min MAIC = -4.615713 at lag  2 with RMSE  .0991568
```

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