Do intermediary networks help reduce government borrowing costs? Evidence from nationwide data

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Abstract

State and local governments often finance infrastructure and development projects by borrowing money from private investors in the form of municipal bonds. Governmental financial managers make a variety of decisions on how to execute this complicated and high dollar value task. Because these agencies frequently lack the technical and legal expertise necessary for the municipal bond issuance process and because the municipal bond market suffers from information asymmetry, managers often hire financial intermediaries such as banks, attorneys, and financial advisors who work, to varying extents, as a team. The ultimate goal of decision-making in this context should be to minimize the cost of borrowing. I use network analysis and high dimensional fixed effect regression models on a large, nationwide data set of municipal bond issues to study the effects of hiring more "connected" intermediaries on the cost of borrowing. The results suggest that hiring more connected banks and municipal advisors reduces interest costs by as much as 35 basis points. In contrast, more connected bond attorneys are rarely beneficial, and at times even harmful.

1 Introduction

State and local governments finance most infrastructure and development projects by borrowing money from private investors in the form of municipal bonds. Although it is a common way to raise money, issuing municipal bonds is a complicated task that exceeds the in-house technical expertise and experience of many governments. To address this difficulty, governments often hire a team of financial intermediaries to help them issue bonds. Intermediaries include independent municipal advisors, attorneys who specialize in municipal securities law, and banks that serve as underwriters. In theory, these actors create value for their clients by providing technical and legal services and by using their connections and experience to mediate information asymmetries inherent to the municipal bond market (Cobbs, Hough, and De Lara, 1993; Leland and Pyle, 1977; Millon and Thakor, 1985). Underwriters also serve as a risk-sharing mechanism (Dyl and Joehnk, 1976; West, 1967) and they conduct the search for investors, which is important because the municipal bond market is a decentralized one (Benson, 1979; Kessel, 1971; Leonard, 1998).

Hildreth (1993) argues that governmental financial managers should hire intermediaries to minimize the overall cost of borrowing, understood as the sum of fees paid to intermediaries and the interest costs of the debt. However, little is known about the effects of hiring more experienced and connected intermediaries on the actual costs governments pay to borrow money.

In this paper, I study the effects of using more connected intermediaries on the interest costs of borrowing. While the cost effects of intermediation have been studied, most of the existing work either does not address the relational nature of this phenomenon or uses statistical methods that do not fully capture its effects. Mine is the first work to use network methods, which have been developed for these types of purposes, on a comprehensive dataset of municipal bond issuances to estimate the effect of hiring decisions. I quantify the connectedness of three types of intermediaries:

underwriters, municipal advisors, and bond attorneys. These measures provide a way to rigorously summarize the extent to which each intermediary has previously worked with a large number of other actors in the bond market. I then use the connectedness measures in high dimensional fixed effects regression models to estimate the way realized bond yields (a measure of interest rates) differ across bond issues that involved more versus less connected intermediaries.

I find that high levels of connectedness for underwriters and municipal advisors is generally associated with significant interest cost savings, with estimates ranging between 3 and 35 basis points[1] in savings, while engaging highly connected bond attorneys is rarely beneficial and sometimes even harmful. Because the choice of intermediaries is just one, albeit an important one, among many that financial managers make, I also explore how connectedness interacts with other important bond characteristics. I find the connectedness of underwriters is most important when the bonds are sold through a competitive auction rather than through a negotiated deal, while municipal advisor connectedness is more important when the sale is negotiated. I also find differences in effect across credit rating categories, where bonds bearing the strongest signal of creditworthiness (AAA rating) are affected much less than either bonds with no credit rating or a credit rating below AAA, particularly with regard to underwriters. Finally, I find that the effects of underwriter connectedness are a complement to other cost-savings measures such as insurance or a bank letter of credit, while the effect for municipal advisors and bond attorneys is concentrated among bonds for which no such feature is present.

[1] Yield is commonly measured in basis points, or 1/100th of a percent.

2 Motivation & Related Literature

Determining the members of the debt management team is one of the most important decisions made by financial managers in the bond issuance process. The ultimate goal of decision-making in this context should be to minimize the overall cost to taxpayers – the sum of the fees paid to intermediaries and, more importantly, the interest paid to investors (Hildreth, 1993). The literature recognizes a tension between making the hiring and underwriting process as competitive as possible for basic economic reasons and the potential for gains in efficiency and effectiveness from trust and familiarity that can be garnered through stable and repeated interactions (Liu, 2018; Miller, 1993; Marlowe, 2013; Robbins, 2008). Scholars have also argued (and observed empirically) that relationships between the intermediaries themselves are an important determinant of municipalities' outcomes in the primary market (Luby and Moldogaziev, 2013; Miller, 1993; Moldogaziev and Luby, 2016). Intermediaries interact, to differing degrees, in the bond issuance process. Municipal advisors often do the majority of the work of consulting with bond attorneys on the legality and tax status of the securities, securing lines of credit from banks and bond insurance from insurance firms, and providing the necessary information to credit rating agencies (Forbes, Leonard, and Johnson, 1992; Liu, 2018). In negotiated sales – which constitute the majority of municipal bond issuances – municipal advisors often work closely with the underwriting bank to structure and market the securities (Forbes, Leonard, and Johnson, 1992; Liu, 2018). An entire issue is rarely underwritten by a single bank. Rather, banks form underwriting syndicates to share risk advantageously by accessing their various client bases to ensure that the issue is fully subscribed (meaning there is sufficient market demand from end investors for the underwriters to successfully re-sell the entire principal amount) (Benson, 1979).

These relationships are described in the literature as the "debt management network" (Miller, 1993). Some researchers have argued that while a municipality's

decision-making about their own network is important, Municipality A's outcomes may be affected by interactions between intermediaries in Municipality B's debt management network and beyond (Luby and Moldogaziev, 2013; Moldogaziev and Luby, 2016). A number of empirical papers attempt to quantify the effect of repeated intermediary interaction on primary market outcomes using conventional methods such as including counts of past interactions as regressors in regression models (Luby and Moldogaziev, 2013; Moldogaziev and Luby, 2016). The literature has also long suggested that financial intermediaries' prestige in the industry – usually measured by market share – affects municipalities' outcomes by way of search effectiveness and information provision through third-party certification. Network science has emerged as a conceptual framework and analytical tool for just these types of complex social phenomena. However, the municipal securities literature has not incorporated network analysis extensively. The published work that does exist applies network analysis to the secondary market for municipal securities, a context in which municipalities are affected indirectly; investor outcomes and market liquidity are the focus (Li and Schürhoff, 2019). To my knowledge, only one paper, a working paper by Marlowe (2013) uses network analysis with regard to the municipal securities primary market. I extend his analysis of three states' intermediary networks with more recent, nationwide data. I also extend the analysis to consider differential effects of intermediary connectedness by method of sale, by credit risk as measured by credit rating, and by the purchase of credit enhancements.

In this article, I provide evidence on the effect of intermediary connectedness – measured by network centrality – of underwriters, municipal advisors, and bond attorneys on the primary market yield of municipal bonds issued nationwide from the period 2002 to 2018. The article proceeds as follows: in the next section I describe the role of financial intermediation in the municipal securities market, its theoretical basis, and the relevant literature, as well as argue for the applicability of network

science to the research question at hand. Following that, I describe the data and empirical approach. In the next section, I present my empirical results. Finally, I conclude with policy implications and some thoughts on future research.

2.1 Need for Financial Intermediation & Description of Roles

2.1.1 Expertise

Financial intermediaries provide technical and legal expertise to issuers, most of which lack the requisite expertise and administrative capacity within their agencies (Cobbs, Hough, and De Lara, 1993; Liu, 2018; Miller, 1993; Vijayakumar and Daniels, 2006). Municipal advisors work to structure the securities according to the municipalities' budgetary needs and time the market to secure favorable terms (Moldogaziev and Luby, 2016). In competitive sales, where banks bid to underwrite the securities, municipal advisors frequently conduct the auction (Liu, 2018). In negotiated sales, a pre-selected underwriter or group of underwriters work with the municipal advisor (if one is engaged) in structuring and marketing (Forbes, Leonard, and Johnson, 1992; Moldogaziev and Luby, 2016).

Bond attorneys provide their professional opinion on the legality of the securities – the statute under which it is permissibly issued and the issuer's authority to secure the bonds with certain revenues – and on whether the securities meet the requirements for the federal (and sometimes state) government to exempt investors' interest income from taxable income (Hildreth, 1993).

2.1.2 Certification & Information Provision

The municipal securities market suffers from information problems, most importantly the difficulty for investors of determining the creditworthiness of securities issued in a decentralized market (Diamond, 1984; Leland and Pyle, 1977; Millon and Thakor,

1985). Financial intermediaries serve to address this asymmetry in two main and interconnected ways: by direct provision of information and through third-party certification, where the certification is itself also information provision. Municipal advisors prepare the legal documents that accompany a notice of sale of securities, detailing the issuer's fiscal position and ability to pay debt service in a timely fashion (Forbes, Leonard, and Johnson, 1992). Credit rating agencies evaluate the same and and provide their initial and ongoing official judgment. In each case, the municipal advisor and the rating agencies are using their reputational capital to assure investors that the information and judgments they are providing are trustworthy – effectively providing third-party certification (Forbes, Leonard, and Johnson, 1992). Researchers of information asymmetry originated the concept of third-party certification in securities markets with regard to underwriters (Booth and Smith, 1986). In underwriting securities, banks put their professional reputations on the line, signaling the creditworthiness of the issuer to investors and reducing the compensation for risk required by investors to lend (Booth and Smith, 1986; Campbel and Kracaw, 1980; Klein and Leffler, 1981).

2.1.3 Risk-Sharing & Market Search

The great majority of municipal bond issuances are underwritten, with only a small percentage being privately placed with the end investor. A bank, usually a group of banks, buys the full set of securities from the issuer at the time of sale; the issuing municipality receives the full proceeds at once. The underwriters then sell portions of the securities to other banks, individuals, and mutual funds, making a profit from the difference in what they paid the issuer and what they are paid when they sell. Generally speaking, the underwriting banks wish to sell all of the securities quickly; it is typically not profitable for them to hold the bonds. Thus, they take on inventory risk in underwriting – the risk that that they will not be able to sell all the bonds

quickly (Marlowe, 2013). Risk-sharing is a substantial part of the reason that an issue is rarely underwritten by just one bank; any single bank would prefer not to take on the amount of inventory risk to which they would be exposed if they purchased the full issue (Benson, 1979).

Underwriters also fulfill the search function. As previously stated, this is a decentralized market, meaning securities are bought and sold over the counter rather than through a centralized exchange as in equity markets. Underwriting banks rely on their past investors and also market to new investors to match the securities with buyers (Benson, 1979; Kessel, 1971; Leonard, 1998). While underwriters must be compensated for their search efforts, the burden of search would surely be higher should municipalities attempt to find their own investors.

2.2 Why Decision-Making on Financial Intermediation Matters

Financial managers decide which types of financial intermediaries to employ on a given debt issue. Researchers have focused on whether certain types of intermediaries are effective in lowering the issuance and interest costs of bond sales in which they are involved. The great majority of debt issues are underwritten, so scholarly work has mostly concerned whether it is beneficial to include in the debt issuance process municipal advisors (Forbes, Leonard, and Johnson, 1992; Luby and Moldogaziev, 2013; Vijayakumar and Daniels, 2006) and credit rating agencies (Boot, Milbourn, and Schmeits, 2006; Johnson and Kriz, 2002; Peng and Brucato, 2004). Inclusion of an indicator variable for municipal advisor involvement and for credit ratings and the number of credit ratings is standard for bond pricing models that concern other primary research questions – these are nearly universally considered important control variables.

The selection of specific firms in intermediary roles has also been a topic of study, particularly which individual characteristics are important for issuer outcomes. At the

most basic level, the quality of the intermediation services matter (Allen and Dudney, 2010; Daniels et al., 2018). Quality has been measured a number of ways, and in particular the related concepts of intermediary prestige and reputation are invoked as important measures (Daniels and Vijayakumar, 2007; Luby and Moldogaziev, 2013). In the only work to use network methods to examine the municipal securities primary market, Marlowe (2013) moves the concepts of prestige and reputation – often measured with the share of total issues on which an intermediary is involved – toward a network concept, that of network centrality. Other studies examine the effect of low-quality financial intermediation in terms of incompetence, mismanagement, and outright fraud (Butler, Fauver, and Mortal, 2009; Miller, 1993). Finally, a set of papers investigates whether the geographical location of an intermediary and their proximity to the issuer is meaningful for issuers (Butler, 2008; Luby and Moldogaziev, 2013; Moldogaziev and Luby, 2016; Vijayakumar and Daniels, 2006).

While conventional regression methods are sufficient to analyze the factors mentioned so far in this section (perhaps with the exception of intermediary prestige), another set of characteristics covered in the literature may be more adequately explored using network methods. Researchers have questioned whether, for an individual issuer, repeated use of the same financial intermediaries and the same debt management network is beneficial or harmful (Dzigbede, 2019; Marlowe, 2007; Robbins, 2008). In particular, this question is raised in instances of political corruption, pay-to-play, and kickbacks in debt issuance (Butler, Fauver, and Mortal, 2009; Miller, 1993). Of greatest relevance to this article are those works that pull away from looking at the effect of an individual issuer's past decision-making on current decision-making and current outcomes, broadening the view to what is occurring in the market as whole. In some sense the question of prestige and reputation addressed earlier takes a market view, but some researchers have gone further to claim that inter-dependencies may arise between intermediaries who work together regularly, for good or ill (Liu, 2018;

Luby and Moldogaziev, 2013; Miller, 1993; Moldogaziev and Luby, 2016).

2.3 Why Network Analysis is a Contribution

Network concepts and network analysis are useful in studying phenomena in which interconnectedness, interdependencies, and the complex structure of a social environment can be explicitly acknowledged and their effects estimated. Importantly, network data are inherently relational, so the fundamental assumptions in linear regression methods of independent, identically distributed observations are violated (Contractor, Wasserman, and Faust, 2006). This is because it is common in relational data for a connection between two actors to depend on other connections and actors in the network and on previous instances of the network (Cranmer and Desmarais, 2011). Networks such as these are complex systems and their collective behavior is difficult to understand merely from knowledge of the system's components (Barabási, 2016). The development of network science as a field is due to the realization that across an enormous diversity of complex systems, there is a common set of fundamental laws and principles driving the structure and evolution of networks; consequently, a common set of mathematical tools has been developed to explore complex systems (Barabási, 2016).

As previously mentioned, the only paper to use network methods to study the financial intermediation network in the municipal securities primary market is Marlowe's analysis of California, Washington, and Texas (2013). His work demonstrates the applicability and potential superiority of network analysis to this area of research, with new findings that could not have been uncovered with regression analysis. Most notably, he finds that the prestige of a financial intermediary, measured as market share in most work and hypothesized to result in cost savings for issuers, in fact is associated with higher costs. Rather, it is the financial intermediary's *network centrality* that is associated with lower costs. Centrality is one of the most widely used and also most

basic of network statistics, but its effect on the pricing of primary market securities could not have been estimated without consideration of the full market structure in a network context.

3 Empirical Approach

To measure the effect of financial intermediary connectedness (network position) on bond pricing, I begin by constructing the financial intermediary network, which accounts for each time each intermediary works with each other intermediary, if at all, on a municipal bond issue. These networks are constructed on an annual basis – I produce networks for each year of the period 2002 to 2018. For each annual network, I calculate measures of each intermediary's network position, or relative importance within the intermediary network, using network analysis estimators. I then include these measures in regressions that are otherwise typical to bond pricing studies.

3.1 Description of the Data

My data consist of municipal bond issues reported in Ipreo Municipal Application, a proprietary data resource owned by IHS Markit and licensed to Indiana University. I begin with the universe of bond data captured by Ipreo for the period 2002 to 2018. I develop two distinct datasets, described in brief in Table 1. The first column describes the pricing dataset, which consists of bonds for which there are no observations missing information on characteristics which are critical for pricing analysis. The second column describes the network dataset, which consists of all observations included in the original data, regardless of missing values for variables that will ultimately be included in my pricing regressions. I use the network dataset to construct the annual intermediary networks and calculate network statistics. In network analysis, it is highly desirable to have access to the most complete version of the empirical net-

work as possible, as the statistics generated are by nature relational, and missing data results in misrepresentation of the underlying structural phenomenon.

The pricing dataset consists of 930,851 observations at the maturity level, representing 64,478 issues by 17,184 governmental issuers from 50 states and the District of Columbia. For these bonds, 1,983 underwriters, 967 municipal advisors, and 1,613 bond counselors were involved over the period. The network dataset numbers 1,931,579 observations at the issue-intermediary level, for 226,793 issues by 34,634 issuers in 57 states, the District of Columbia, and U.S. territories. Over the period, 2,072 underwriters, 1,132 municipal advisors, and 1,736 bond attorneys were involved in issuance. Summary statistics for the pricing dataset are shown in Table 2.

Table 1: Data Description, in brief

	Pricing Dataset	Network Dataset
Issues	64,478	226,793
Issuers	17,184	34,634
States, DC, & U.S. Territories	51	57
Underwriters	1,983	2,072
Municipal Advisors	967	1,132
Bond Attorneys	1,613	1,736
Observations	930,851	1,931,579

Data from Ipreo Municipal Application

3.2 Description of the Network

In their original form, the data (and the phenomenon they represent) constitute a two-mode network, in which there are two overarching types of actors (referred to as nodes or vertices in network science), the issuers and the intermediaries (underwriters, municipal advisors, and bond attorneys) with which they work on a given issue. Few network estimators are suitable for two-mode networks, so convention is to convert them to a one-mode network through a process called projection. Projecting to one-mode results in a network in which all nodes are intermediaries and connections

Table 2: Descriptive Statistics: Pricing Dataset, N=930,851

Variables	Mean	Std. Dev.	Min	Max
Yield on Maturity	2.76	1.22	0.28	6.02
Issue Par Amount	61,738,304	185,420,064	29,919	7,921,515,008
Years to Maturity	9.52	6.19	0	100
Bond Buyer 20 Index	4.16	0.54	2.85	6.01
AAA	0.099	0.3	0	1
AA	0.41	0.49	0	1
A	0.25	0.43	0	1
BBB or lower	0.18	0.38	0	1
Not Rated	0.067	0.25	0	1
Subject to AMT	0.012	0.11	0	1
Taxable	0.055	0.23	0	1
Tax Exempt	0.93	0.25	0	1
Appropriation-backed	0.0041	0.064	0	1
Double-Barreled	0.0016	0.04	0	1
General Obligation	0.66	0.47	0	1
Revenue-backed	0.33	0.47	0	1
Bank Qualified	0.38	0.48	0	1
Callable	0.87	0.34	0	1
City	0.35	0.48	0	1
City and County	0.0062	0.078	0	1
County	0.12	0.32	0	1
Higher Education	0.016	0.13	0	1
School District	0.22	0.42	0	1
Special District	0.046	0.21	0	1
State	0.13	0.33	0	1
Competitive Sale	0.55	0.5	0	1
Negotiated Sale	0.45	0.5	0	1
Private Placement	0.0014	0.038	0	1
Credit Enhanced	0.000015	0.0039	0	1
Issuer Insured	0.071	0.26	0	1
Insured	0.29	0.45	0	1
Refunding	0.54	0.5	0	1
Sinking Fund	0.08	0.27	0	1

Data from Ipreo Municipal Application & Thomson Reuters

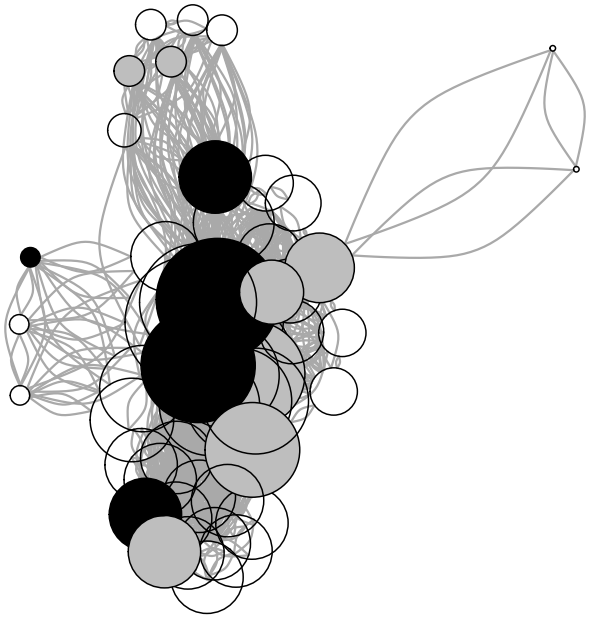
(or ties) between them arise from their having worked together on one or more issues; issuers are not represented in the network except implicitly. The nodes have their basic intermediary types as attributes, allowing me to distinguish between underwriters, advisors, and attorneys. I work with two types of networks: one in which

the ties between nodes are unweighted and one in which the they are weighted by the number of times the two intermediaries have worked together. The latter factors in the intensity of interaction or level of familiarity between two intermediaries.

Figure 1 is a visual example of a small portion of the financial intermediary network. Represented are the intermediaries involved in seven bond issues from 2005. The circles represent each intermediary. Transparent nodes are underwriters (N=46), black are advisors (N=5), and grey are attorneys (N=7). The size of each node describes its degree – the larger the circle, the more nodes to which that node is connected within this small portion of the network. The lines are edges, also called ties, and represent an instance when the connected nodes worked together on a bond issue – if two nodes are not connected by a tie, it means that they did not work together during 2005. There are 1,240 edges in the graph.

To estimate the effect of intermediaries' network position on borrowing cost, I follow the approach used by Li and Schurhoff (2019) and Marlowe (2013). First, I calculate on an annual basis for each intermediary five commonly used measures of network position: degree centrality, eigenvector centrality, betweenness centrality, closeness centrality, and transitivity. The degree of a node is simply the number of nodes in the network to which it connects. Betweenness centrality is meant to summarize to what extent a node is located between other pairs of nodes, representing a perspective that importance is related to where a node is located with regard to paths in the network. This measure is often used to think about how communication takes place, where nodes on many paths are likely more critical to a given process. Closeness centrality is the notion that a node that's "close" to many other nodes is a central or important one, where closeness is measured as the geodesic distance between connected nodes. Eigenvector centrality is a measure of status, prestige, or rank. This measure captures information on the centrality of a node's neighbors – or, how connected a node's connections are. Transitivity measures the likelihood that any two

Figure 1: Graphical Representation of Network Structure



intermediaries with which a particular intermediary has worked are also connected. It is sometimes referred to as cliquishness or the clustering coefficient.

Once calculated for each intermediary each year, I collapse the five measures into a single index using principal component analysis, again following Li and Schurhoff (2019) and Marlowe (2013). I assign to each bond issue the previous year's centrality index for each intermediary involved. Because a bond issue typically involves multiple underwriters and, more infrequently, multiple municipal advisors and bond attorneys, I take the mean of the centrality index within each type – in other words, for each issue I have a variable representing the average centrality index for underwriters,

for advisors, and for attorneys, respectively. Finally, I convert each of the average centrality indices to the percentile it occupies in the overall distribution of centrality indices by type, such that the variables are bounded between zero and one for ease of interpretation. I do this separately for unweighted centrality measures and for those weighted by number of interactions within a year.

3.3 Econometric Model

To estimate the effect of intermediary connectedness, I use a high dimensional fixed effects regression model that includes the constructed measures of intermediary centrality and covariates standard in bond pricing models. I use $Yield_{migt}$ to represent the yield of maturity m from issue i by issuer g in year t. $Underwriter\text{-}Centrality_{ig(t-1)}$ is the average centrality of the underwriters used by issuer g for issue i; it is subscripted by $(t-1)$ to emphasize that connectedness is measured using the underwriters bond market participation in the previous year and so is not affected by the current issue. The variables for municipal advisors and bond attorneys follow the same convention. In the model, the parameter estimates signified by β_1, β_2, and β_3 represent the effect on yield in basis points of hiring a group of underwriters, municipal advisors, and bond attorneys, respectively, from the top of the within-type distribution of centrality versus the bottom. I use year fixed effects (γ) to account for secular trends in the market that affect the yield of all bonds in common and issuer fixed effects (λ) to account for differences in experience, expertise, credit quality, fiscal position, and the underlying economy of jurisdictions. I estimate standard errors using a cluster robust variance matrix that allows for heteroskedasticity and dependence across any observations from the same issuer.

$$
\begin{aligned}
\textit{Yield}_{migt} = \quad & \alpha_0 + \beta_1 \textit{Underwriter-Centrality}_{ig(t-1)} \\
& + \beta_2 \textit{Municipal-Advisor-Centrality}_{ig(t-1)} \\
& + \beta_3 \textit{Bond-Attorney-Centrality}_{ig(t-1)} \\
& + \beta \mathbf{X}_m + \beta \mathbf{X}_i + \beta \mathbf{X}_g \\
& + \gamma_g + \lambda_t + \epsilon_{migt}
\end{aligned}
$$

where...

m indexes bond maturities

i indexes bond issues

g indexes issuers

X are vectors of covariates at the maturity-, issue-, and issuer-level

γ are issuer fixed effects

λ are year fixed effects

and ϵ are standard errors clustered at the issuer level

4 Results

4.1 Effect of Intermediary Network Position on Yield

For brevity and focus, in Tables 3-9 I present results only for the primary variables of interest. At the end of this section, Table 10 shows the full regression results from the same specification as column 1 in Table 3, accompanied by discussion of the covariates. Covariate results are similar throughout and available upon request. Table 3 displays the estimates of interest from the main specifications – the full sample of maturities for which bond pricing covariates are available and for which at least one underwriter, one municipal advisor, and one bond attorney were involved in the issue. Column 2 presents results using the centrality measures as weighted by number of intermediary interactions for the year. The parameter estimates should be interpreted as the basis point change in yield on maturity associated with the within-type average

centrality index for involved intermediaries in the 99th percentile of the centrality index distribution versus the 1st percentile. In both specifications, underwriter centrality is associated with a decrease in yield, about 8 basis points in the specification using unweighted centrality and about 13 in column 2 ($p < 0.01$). Municipal advisor unweighted centrality is associated with a 3 basis point reduction while weighted centrality has about a -5.5 basis point effect ($p < 0.1$). Bond attorney centrality, however, is associated with a higher yield, between a 7 basis point ($p < 0.01$) and a statistically insignificant 2 basis point increase, approximately.

Table 3: Yield Regressions: All Bonds

	Unweighted Centrality	Weighted Centrality
Underwriter Centrality, (t-1)	-7.685***	-13.34***
	(1.159)	(1.043)
Municipal Advisor Centrality, (t-1)	-3.194***	-5.570***
	(1.012)	(0.964)
Bond Attorney Centrality, (t-1)	7.170***	1.628
	(2.105)	(1.690)
Observations	930,851	930,851

Clustered standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In Tables 4 and 5, I present regressions results for subsamples defined by method of sale. In competitive sales, the bonds are sold to the underwriters who offer the best price (lowest yield) in a competitive auction. In negotiated sales, the issuer selects the underwriters with whom they wish to work in advance of the sale. The underwriters then work with the issuer, and frequently the municipal advisor, to structure the securities and time the market (Robbins, 2008; Simonsen and Robbins, 1996). Because, among other differences, the roles of intermediaries differ between the methods of sale, the value of intermediation and intermediary network position may differ as well. Table 4 shows the negotiated sale subsample, in which I find that underwriter centrality is minimally associated with lower costs, with the weighted centrality mea-

sure bearing a coefficient of -2. ($p < 0.1$), and unweighted centrality having both an economically and statistically insignificant parameter estimate. Municipal advisor unweighted centrality, however, is associated with close to a 3 basis point reduction ($p < 0.1$), and a stronger negative effect (-4, $p < 0.01$) for weighted centrality. Both measures of bond attorney centrality are large, positive, and statistically significant ($P < 0.01$). In the competitive subsample (Table 5), however, underwriter centrality is very beneficial, with estimates of -14 and -22 basis points respectively for the unweighted and weighted measures ($p < 0.01$). Municipal advisor centrality is less beneficial in comparison to the negotiated sample; the unweighted measure is small and insignificant, while the weighted centrality measure is equivalent to the unweighted measure in the negotiated sample (-3, $p < 0.01$). Bond attorney centrality ceases to be disadvantageous when focusing on competitive bonds with no statistically significant finding for the unweighted measure and a 3 basis point reduction ($p < 0.1$) for the weighted measure.

Table 4: Yield Regressions: Negotiated Bonds

	Unweighted Centrality	Weighted Centrality
Underwriter Centrality, (t-1)	0.803	-2.876*
	(1.640)	(1.552)
Municipal Advisor Centrality, (t-1)	-2.775*	-4.350***
	(1.592)	(1.588)
Bond Attorney Centrality, (t-1)	14.14***	10.42***
	(3.489)	(3.014)
Observations	421,339	421,339

Clustered standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The need for and effectiveness of financial intermediation may differ by the credit quality of the issuer and the specific bond issue. Tables 6-8 present results for subsamples defined by categories of credit ratings: AAA (which is the highest possible credit rating), rated bonds with a rating lower the AAA, and not rated. Intermediary

Table 5: Yield Regressions: Competitive Bonds

	Unweighted Centrality	Weighted Centrality
Underwriter Centrality, (t-1)	-13.68***	-21.65***
	(1.886)	(1.615)
Municipal Advisor Centrality, (t-1)	0.482	-2.834***
	(1.292)	(1.093)
Bond Attorney Centrality, (t-1)	1.691	-3.018*
	(1.924)	(1.594)
Observations	508,124	508,124

Clustered standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

centrality is only beneficial among the AAA-rated bonds for weighted underwriter and municipal advisor centrality, with a reduction of 8 and 6 basis points, respectively (p < 0.01).

Table 6: Yield Regressions: AAA-Rated Bonds

	Unweighted Centrality	Weighted Centrality
Underwriter Centrality, (t-1)	4.081	-8.213***
	(3.221)	(3.159)
Municipal Advisor Centrality, (t-1)	-0.855	-6.134***
	(2.324)	(2.313)
Bond Attorney Centrality, (t-1)	2.904	-5.784
	(4.518)	(4.613)
Observations	90,909	90,909

Clustered standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7 shows that for rated bonds without the very strongest signal of creditworthiness, underwriter and municipal advisor centrality is of greater benefit than AAA-rated bonds whether considering the unweighted or weighted measure. Unweighted underwriter centrality is associated with yields 8 basis points lower, while the weighted measure has a coefficient of -14 (p < 0.01); municipal advisor centrality also has a stronger effect when measured with weights (-9) than without (-6), both

significant at the 99 percent threshold. Once again, bond attorney centrality is not beneficial, with a positive parameter estimate of 7 ($p < 0.05$) for the unweighted measure and a small and statistically insignificant estimate for the weighted measure. For issuers who choose not to acquire a credit rating and thus lack this source of information on creditworthiness, I find very strong associations between both underwriter and bond attorney centrality. Unweighted underwriter centrality is associated with a 29 basis points savings, and weighted centrality a 35 basis point reduction ($p < 0.01$). Municipal advisor centrality, while signed negative, is not statistically significant. Finally, bond attorney centrality shows a negative association with yield; the unweighted measure has a parameter estimate of -14 ($p < 0.1$) and the weighed measure has an estimate of -18 ($p < 0.01$)

Table 7: Yield Regressions: Rated Bonds, lower than AAA

	Unweighted Centrality	Weighted Centrality
Underwriter Centrality, (t-1)	-7.755***	-13.86***
	(1.610)	(1.440)
Municipal Advisor Centrality, (t-1)	-5.997***	-8.894***
	(1.250)	(1.184)
Bond Attorney Centrality, (t-1)	6.659**	0.811
	(2.626)	(2.107)
Observations	660,155	660,155

Clustered standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Issuers may rely on credit enhancements such as a bank letter of credit, insurance on the specific bond issue, or insurance more generally to mitigate information asymmetries regarding their ability to pay debt service. These credit enhancements may be either a substitute or a complement to the benefits from financial intermediation. Table 9 shows regression results for the full sample, where the specification is identical to those previously shown with the exception of the addition of an interaction term between the variables of interest and a variable equal to one if the bond is issued

Table 8: Yield Regressions: Unrated Bonds

	Unweighted Centrality	Weighted Centrality
Underwriter Centrality, (t-1)	-28.67***	-35.21***
	(6.472)	(6.304)
Municipal Advisor Centrality, (t-1)	-4.348	-3.383
	(7.154)	(6.845)
Bond Attorney Centrality, (t-1)	-14.20*	-18.39**
	(7.408)	(8.450)
Observations	61,976	61,976

Clustered standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

without a bank letter of credit, without bond insurance, and by an uninsured issuer. Interestingly, the finding from Tables 3-9 which is most robust – underwriter centrality having a negative and strongly statistically significant relationship with yield – is statistically undifferentiated between enhanced and unenhanced bonds; the parameter estimates on the Underwriter Centrality, (t-1)*Unenhanced variables, though negative, are not significant. However, both municipal advisor and bond attorney centrality are only significantly associated with yield on maturity among unenhanced bonds. Unenhanced bonds issued with the involvement of more central advisors are lower yield on average with estimates of -7 and -8 on the unweighted and weighted measures respectively, while bond attorney centrality is associated with higher yields of 11 and 10 respectively, for unenhanced bonds ($p < 0.01$).

4.1.1 Summary of Effect of Intermediary Network Position on Yield

On balance, these findings suggest strategic opportunities for issuers with respect to the network position of the intermediaries with whom they work. Underwriter centrality, when using the weighted measure, reduces yields on maturity in every specification; unweighted underwriter centrality is also beneficial with the exception on negotiated sales and AAA-rated bonds. The effects are consistently stronger in

Table 9: Yield Regressions: Unenhanced[a] interactions

	Unweighted Centrality	Weighted Centrality
Underwriter Centrality, (t-1)	-5.436***	-11.60***
	(1.424)	(1.479)
Underwriter Centrality, (t-1)*Unenhanced	-3.240	-2.455
	(2.043)	(2.034)
Municipal Advisor Centrality, (t-1)	1.763	0.417
	(1.490)	(1.452)
Municipal Advisor Centrality, (t-1)*Unenhanced	-6.731***	-8.142***
	(1.584)	(1.533)
Bond Attorney Centrality, (t-1)	-0.857	-5.471***
	(2.262)	(2.061)
Bond Attorney Centrality(t-1)*Unenhanced	10.71***	9.516***
	(1.864)	(1.784)
Unenhanced	4.820	8.388
	(11.79)	(11.72)
Observations	930,851	930,851

[a] Unenhanced bonds are those which for which the issuer is uninsured and has purchased neither a bank letter of credit nor bond insurance.
Clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

the models in which I use the weighted measures of centrality, suggesting that not only centrality but repeated interaction with other intermediaries is beneficial. Estimates of the effect of municipal advisor and bond attorney centrality are less consistent across specifications, suggesting that the policy and/or financial management decision-making implications are less clear-cut. Still, working with a more central municipal advisor is, on average, either beneficial or harmless with regard to yield, and especially likely to be beneficial for issuers who decline to purchase credit enhancements. The centrality of bond attorneys, however, is rarely a boon to issuers and their taxpayers.

Table 10: Yield Regressions: All Bonds

	Unweighted Centrality		
Underwriter Centrality, (t-1)	-7.685***	Bank Qualified	-13.17***
	(1.159)		(0.545)
Municipal Advisor Centrality, (t-1)	-3.194***	Callable	15.22***
	(1.012)		(0.553)
Bond Attorney Centrality, (t-1)	7.170***	City	-3.534
	(2.105)		(5.051)
Issue Par Amount, ln	-0.304	City and County	-14.51
	(0.272)		(9.394)
Years to Maturity	13.43***	County	-4.926
	(0.0568)		(7.922)
Bond Buyer 20 Index	68.16***	Higher Education	5.436*
	(0.680)		(2.961)
AA	12.49***	School District	2.007
	(1.068)		(6.337)
A	27.85***	Special District	-26.86***
	(1.495)		(7.553)
BBB or lower	29.47***	Competitive Sale	-11.79***
	(1.904)		(0.608)
Not Rated	63.21***	Private Placement	-3.089
	(2.388)		(11.42)
Subject to AMT	21.02***	Credit Enhanced	-165.0*
	(3.393)		(92.62)
Taxable	86.95***	Issuer Insured	-6.940***
	(0.948)		(0.956)
Appropriation-backed	17.77***	Insured	-7.364***
	(6.163)		(0.650)
Double-Barreled	-5.301	Refunding	3.237***
	(3.242)		(0.375)
Revenue-backed	9.516***	Sinking Fund	2.128***
	(1.035)		(0.715)
Constant	-155.9***		
	(6.474)		
Observations			930,851

Clustered standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.1.2 Discussion of covariates

As is typical in bond pricing studies, I include variables at the bond maturity, issue, issuer, and market level to account for their effect on primary market yield; results

are displayed in Table 10. Issue par amount, transformed to the natural log, is negative, though not statistically significant. Years to maturity, the weekly Bond Buyer 20 Index (a measure of prevailing market interest rates provided by Thomson Reuters), ratings of AA, A, BBB or lower and not rated bonds (as relative to the omitted category - AAA-rated bonds)[2], bonds subject to the alternative minimum tax or federal tax (as relative to the omitted category - exempt from federal income taxation), bonds backed by appropriation or revenue (as opposed to general obligation bonds), bonds with a call feature, refunding bonds, and bonds with a sinking fund all have a statistically significant relationship with higher yield on maturity at the 0.01 level. Double-barreled bonds (those backed both by revenue from the financed project and the taxing powers of the jurisdiction) are not statistically different than general obligation bonds with respect to yield. Special district issuers have lower yield on maturity, on average, than state issuers, significant at the 0.01 level, while cities, counties, combined city-counties, and school districts are not significantly different than states; issuers in the higher education sector pay higher yields than states, at the 0.1 level. Bonds that are bank qualified ($p < 0.01$), those that are insured or issued by an insured issuer ($p < 0.01$), bear a credit enhancement such as a bank letter of credit ($p < 0.1$) have a lower yield on average. With regards to method of sale, competitive sales are lower yield, at the 0.01 level, and private placements are no different than negotiated underwritings. These findings are consistent with the bond pricing literature (Butler, Fauver, and Mortal, 2009; Guzman and Moldogaziev, 2012; Robbins and Simonsen, 2007; Johnson and Kriz, 2002; Forbes, Leonard, and Johnson, 1992; Johnson, 1994; Moldogaziev, Greer, and Lee, 2019; Moldogaziev and Luby, 2012; Vijayakumar and Daniels, 2006).

[2]Credit rating variables are constructed by taking the highest underlying rating received from Fitch, Moody's, and Standard & Poor's.

5 Conclusion & Opportunities for Further Research

This paper is the first to use network methods on a large, nationwide dataset to estimate the importance of financial managers' decision-making with regard to the team of financial intermediaries they employ to assist them in bond issuance. I analyze the relationship between intermediary interconnectedness – operationalized with measures of network centrality – of underwriters, municipal advisors, and bond attorneys and the yield on maturity of bonds issued in the period 2002 to 2018, across the United States. I find that underwriter centrality, with few exceptions, is associated with lower borrowing costs for issuers and their taxpayers. Underwriter centrality is particularly beneficial in bonds sold through a competitive auction. The finding is consistent across ratings categories and bonds that are not rated. I also find that underwriter centrality is a complement, not a substitute, for other cost-reduction options such as insurance or credit enhancements. My findings for municipal advisor centrality are both less consistent and smaller than for underwriters. However, where statistically significant, municipal advisor centrality is beneficial, particularly for bonds with credit ratings below AAA. Bond attorney centrality, on the other hand, is most frequently associated with higher yields where regression results are statistically significant. The effects for both municipal advisor and bond attorney network position are concentrated among bonds without insurance or credit enhancements, issued by uninsured agencies. These findings suggest opportunities for public financial managers to optimize borrowing-cost-reduction options.

A natural extension of the work presented here is to conduct a comprehensive examination of the cost savings implications, including both the interest paid to investors which is captured here as well as the cost of intermediation services, bond insurance, and other credit enhancements, over terms to maturity. A weakness of this manuscript is that my data do not include information on underwriter fees, discounts, and spreads, nor on the fees paid to bond attorneys and municipal advisors, nor the

costs of insurance and credit enhancements. While interest costs are generally the majority of borrowing costs, the costs of issuance are not negligible. The ideal dependent variable would be all-in true interest cost (TIC), the discount rate setting bond sale proceeds equal to the present value of all cash outflows associated with the securities, as used by Marlowe (2013). However, information on TIC and/or issuance costs are hard to come by for a nationwide dataset, presenting a trade-off.

Other opportunities for further research include a diversification of the network measures used in analysis and more extensive modeling of the intermediary network structure. Inferential network methodologies exist that can provide evidence on financial decision-making with regard to debt management networks. The securities literature recognizes a significant amount of inertia in the selection of intermediaries by issuers. Exponential random growth models, a family of network estimators that provide inferential estimates of the factors – both endogenous and exogenous to the network structure – that influence whether two actors will be connected in a network, can shed light on the decisions made by financial managers over time. Of particular interest would be a study which incorporated information on the firms themselves and compared those attributes to network effects such as centrality or stability.

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