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Solving the Swedish Muni Puzzle – Piece By Piece

An analysis of liquidity premiums in the unique bond market of Sweden

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ABSTRACT

This paper examines whether liquidity premiums can explain the Swedish muni puzzle. The Swedish institutional climate presents a unique setting where default risk and taxes are equivalent in the context of municipal and treasury bonds. Despite these similarities, we show that their yields still differ substantially from one another after adjusting for coupons, peaking at as high as 178 basis points during the depths of the European sovereign debt crisis. Operationalizing liquidity as proportional bid-ask spreads, we construct measures of contemporaneous and future liquidity and examine their explanatory power in the context of the Swedish muni puzzle. Adjusting for days to maturity and orthogonalizing contemporaneous liquidity relative to future liquidity, we show that differences in contemporaneous liquidity between municipal and treasury bonds can help explain the muni puzzle. The results are statistically significant on the 1 percent level using two different types of panel correlation methods. We find a significant constant of approximately 20 basis points which cannot be explained by any of the mainstream explanatory variables typical to the muni puzzle.

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I. Introduction

Since Modigliani and Miller's (1958) defining piece on capital costs and the tax advantages of debt, corporate taxes and leverage have occupied an increasing space in financial literature. Set aside the direct implications that continue to characterize investment theory, capital budgeting and corporate financing today[1], tax-shields have come to occupy a growing proportion of related financial research. Miller's (1977) retort in the wake of a growing body of counterbalancing debt drawbacks published by other authors suggests that tax exempt bonds of comparable characteristics should earn the same after-tax yield as their taxable counterpart. As Chalmers (1998) is quick to point out, however, the declining US term structure of implied tax rates between comparable municipal and government bonds is not precipitated on default risk or call options. Affectionately termed the *muni puzzle*, the phenomenon where long-term tax exempt municipal bond yields have outperformed that of their long-term taxable government-issued equivalents has received several decades of research attention. Prospective hypotheses for said after-tax yield differences have included, to name a few, institutional tax profiles and the municipal bond market's money tightness (FORTUNE, 1973), intertemporal tax timing options (Constantinides and Ingersoll, 1982), systematic risk (Chalmers, 2006) and municipal market segmentation by maturity (Kidwell and Koch, 1983). The latter is closely echoed by a corpus of divided literature on the importance of commercial banks' vested interest in short-term securities[2]. These credit institutions have, historically, accounted for a considerable portion of the US municipal market (*ibid*). In light of the maturity matching principle, commercial banks tend to favor short-term municipal bonds in lieu of their longer equivalents due to their liabilities' short average maturity. Further, municipals' tax savings look favorably to commercial banks as opposed to taxable government bonds given their often-high tax brackets vis-à-vis other financial intermediaries. Under these premises, long-term and short-term municipal bonds are imperfect substitutes, and thus attract different institutional investors. In this vein, commercial banks' short-term preferences elicit a demand-driven upward bias in long-term municipal yields compared to long-term government bonds.

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[1] See, for instance, Graham and Rogers's (2002) discussion on the impact of hedging on capital structure due to tax convexity and incentives, or Korteweg's (2010) findings on the optimal leverage ratio based on firm characteristics including corporate profitability and size.

[2] Compare, for instance, Campbell's (1980) discourse on the lackluster empirical significance of municipal maturity segmentation with that of Hendershott and Kidwell's (1978) findings between nationally and regionally marketed municipal bonds.

Despite these efforts, attempts at reconciling theories for the downward bias in long-term government bond yields have been largely unsuccessful (Liu et al., 2003). In an especially notable paper, Liu et al. (2003) anatomize the muni puzzle and find robust evidence for default and liquidity risk premiums in AAA, AA/A and BBB rated municipal bonds. Incorporating these explanatory variables dissipates much of the US term structure's municipal-government implicit tax rate, thus resolving much of the muni puzzle. Nevertheless, the deterministic role of liquidity in unravelling the muni puzzle has received a strong empirical footing whilst that of credit risk has proved less consistent. Fontaine and Garcia (2014) find liquidity premiums explain a significant portion of Treasury bonds' risk premium, Chen et al. (2007) account for as much as half the cross-sectional variation of yield spreads in corporate investment grade and junk bonds via liquidity measures and Liu et al. (2003) extend this result to investment grade municipal bond yields. Indeed, scholars by and far recognize liquidity as a meaningful and informative determinant of differing municipal and government after-tax bond yields. In spite of this, a plenitude of disparate liquidity metrics continues to occupy the liquidity literature space, making its many operationalization's less consistent than its generally agreed-upon importance as an explanatory variable to the muni puzzle[3]. With respect to default risk, Trzcinka (1982) observes that credit exposure accounts for much of the after-tax yield differential accentuated by Miller (1977), Yawitz et al. (1985) attribute their fourfold higher difference in yield spreads between prime-rated munis[4] and treasuries compared to prime- and medium-rated municipal bonds to credit risk premiums. *E contrario*, Ang et al. (1985) and Chalmers (1998) both contest the muni puzzle remains unexplained after allowing for credit rating discrepancies.

Credit risk's inconsistent explanatory power in the muni puzzle may serve as an impasse for the muni-treasury researcher. The Swedish institutional climate serves as a compelling instance where such a predicament is, by and large, avoided. Indeed, for over a decade more than half of Sweden's municipalities have collaborated under a joint inter-municipal structure coined *KommunInvest* (the Swedish Local Government Debt Office)[5] in 1986 (KommunInvest, 2017). This organizational cooperative came to fruition as a bargaining vessel for improved collective borrowing terms and access to capital markets in meeting, primarily, Sweden's municipal infrastructural needs. By the close of 2016, the institution represented some odd 275 municipalities[6] and managed 277

[3] See, for instance, Aitken and Carole (2003) for an insightful discussion on the multifaceted ways of measuring liquidity.
[4] The term "muni(s)" is used interchangeably as an abbreviation for "municipal bond(s)" herein.
[5] Abbreviated "KI" and "SLDO" henceforth.
[6] Corresponding to ~ 94.8% of all Swedish municipal jurisdictions.

SEKbn in issued bonds, analogous to ~48% of all local government loan financing (KommunInvest 2017). In 2006 KI received a AAA rating from Standard & Poor's, having held an Aaa equivalent from Moody's since 2002, making it Sweden's sole organization with triple-A/a ratings from both credit rating agencies and - more importantly - of comparable credit risk to *Riksgälden* (the Swedish National Debt Office)[7]: the legal issuer of Swedish government bonds (KommunInvest, 2017). Moreover, RiGä and KI are constitutionally-defined legal equivalents such that the latter cannot declare insolvency or bankruptcy[8] nor postpone payments unless the state itself defaults. In other words, the state bears the ultimate fiscal responsibility for the local government sector (KommunInvest, 2016). Further, legislative changes higher up the political hierarchy (i.e. government-sanctioned altercations to local government) must be compensated for so as to neutralize any financial effect to municipalities (Regeringskansliet, 1991). Local government imbalances are, moreover, adjusted annually via cost and income equalization schemes (Regeringskansliet, 2004). Swedish munis and treasuries are, therefore, indistinguishable with respect to credit risk from the perspective of both *de facto* market ratings as well as legal bankruptcies/probabilities of default. Akin to this train of thought[9], there are no tax differences characterizing the investor profiles of munis vis-à-vis Swedish government bonds.

The notion of pooling municipal financing has even prompted Ang and Green (2011) of the Hamilton Project - an economic policy initiative comprised of academics, business leaders and former public policy makers - to propose a shared non-profit organizational body (*CommonMuni*) representing US municipal interests in an endeavor to lower borrowing costs by minimizing private information and illiquidity. Lack of the latter, the authors purport, gives rise to ~$30bn in liquidity costs alone. This institutional framework is described as an independent, non-profit advisory disseminating information for the benefit of individual municipalities, states and other market participants. In this light, KI is strikingly similar to the US proposed structure demarcating ongoing politico-economic discussions within the municipal bond market, providing a pronounced context for its study in a Swedish institutional context.

[7] Abbreviated "RiGä" and "SNDO" henceforth. The SNDO retains a credit rating AAA/Aaa from Standard & Poor's, Moody's and Fitch respectively (Riksgälden, 2014).
[8] Local government is not covered by the Swedish Bankruptcy Act. Swedish Court rulings have enforced this legal doctrine (Göta Hovrätt, 1994).
[9] Pursuant to discussions with Mattias Bokenblom, Head of Research & Development, and Tobias Landström, Senior Funding Officer, of KI.

With the above in mind, this paper attempts to bridge the academic lapse in extant muni puzzle literature by investigating a unique regulatory and institutional climate which supersedes much of the clout that has typically surrounded (i) credit/default risk and (ii) tax differentials in a traditionally US-dominated municipal versus government bond space. In doing so, this study can highlight the less operationally understood liquidity risk in a rather homogenous municipal/government bond environment. Further, this thesis also sheds light on a public proposal area for policymakers to continue to develop - namely, the prospect of a shared organizational body mediating the need for liquidity and information transparency in issuing munis.

With the research question "Can liquidity premiums explain the Swedish Muni Puzzle", this paper draws inspiration from Goldreich et al. (2005) who examined how differences in liquidity measures between bonds can help explain differences in their yields. This research is to the best of our knowledge the only study examining the muni puzzle in a setting where default-risk and tax considerations can be safely ignored.

II. Literature Review

2.1 Introduction

As discussed in *I. Introduction*, examining the determinants of municipal bond yields has been of interest to academics for the better part of forty years. At the time, Hastie (1972) shed light on the differences discerning (specifically) municipal bond yields in the US by researching the effects of variables such as default history, demographics and diversification. Today, researchers are more particularly preoccupied with explaining why empirical data shows yields on long-term tax-exempt municipal bonds that are higher than expected.

This chapter is designed to familiarize the reader with all the theories and tools that have been developed and effectively used by academics in their effort to explain bond pricing in general and, through it, the muni puzzle. The *2.2 Literature survey* section aims to make systematic assessments of major literary areas based on extant research and draw key conclusions that lay the foundation for our research. This survey, particularly *2.2.3 Liquidity*, stretches beyond both the muni puzzle and general bond market to give the reader a broad and fair view of relevant past findings. To bridge the gap between past research and our research, *2.3 Theoretical framework* identifies tools and approaches from these studies that are most relevant to adopt given the distinct setting of this study.

2.2 Literature Survey

2.2.1 Taxes

When the muni puzzle has been discussed in the US, municipal bonds (tax-exempt) and government bonds (taxable) have been compared to one another. Municipal bond yields have and continue to be higher than one less the appropriate tax rate multiplied by the relevant government bond yields. In a country where bond-income taxes do not differ on a municipal or federal level, like Sweden, the comparison of munis and treasuries can be made without any correction for taxes. The implications of taxes on bond yields, however, can be extended further than the plain vanilla tax-rate differentials between US treasury and municipal bond yields when analyzing the muni puzzle. Longstaff (2011) suggests there is a negative market risk premium on the marginal tax rate due to the federal income system's progressive taxation. Progressive taxes, it is argued, move investors to higher tax brackets in economic booms, making after-tax coupon cash flows countercyclical. Resultantly, taxes' negative market risk premium make it a 'systematic asset pricing factor' increasing taxable government bond returns which, by extension, diminishes the extent of the muni puzzle. This result stands in stark contrast to Chalmers (2006), who described a "consumption risk" in the payoff timing of bond cash flows. More specifically, muni-treasury payoffs from different taxes are thought to affect their yields through the current marginal utility of consumption due to current economic conditions. Indeed, one can hypothesize a government bond investor whose taxable cash flows become exceedingly cumbersome in an economic context where the current marginal utility of consumption is high. Nevertheless, his results showed that 'systematic risk', i.e. risks that had bond price effects due to systematic correlations with consumption risk, were not likely to resolve the muni puzzle.

Generally speaking, taxes are often included in models that primarily examine other effects like that of default or liquidity risk. Liu et al. (2003), for example, obtain implicit tax rates (after taking default probabilities and liquidity risks into account) close to the statutory tax rates of institutional investors and high-income individuals.

2.2.2 Credit Risk

Default/credit risk has withheld a long-lasting tradition of as a heavily researched academic field, earning it wide acceptance as a fundamental determinant of bond yields. Yawitz et al. (1985) pioneered the terrain by studying how default probabilities affect bond prices and consequently yield spreads. More recent evidence for the relationship between bond yields and credit risk can be found through the like of Norden and Weber (2007) and Gilchrist et al. (2009) who, through the bond market, examine credit market shocks, economic activity and CDS spreads.

More than a decade after Yawitz et al.'s (1985) paper, Chalmers (1998) found that the yields of effectively default free government-secured bonds still were too high; despite credit risk's consensus-approval as a vital component of the muni puzzle, there remained other overlooked pieces of the jigsaw. Subsequent research has converged to incorporate default risk in a broader context of determinants in analyzing the muni puzzle. Several of these are discussed in *2.2.3 Liquidity*.

On a technical note, in isolating the risky characteristics of bonds researchers tend to reconstruct their yields into common, comparable metrics. Their intent is to strip out the shared, risk-free component of bond yields while making corrections for other effects that may impact the yield. Several of these otherwise extensive corrections can today be made conveniently through programs like Bloomberg or Thomson Reuters.

2.2.3 Liquidity

Liquidity is continuously priced throughout security markets. In the 1980s, Amihud and Mendelson (1986) demonstrated bid-ask spreads affect assets' expected returns. Later, Boudukh and Whitelaw (1993) showed that government bond prices depend on short sell constraints, echoing Vayanos's (1998) findings that transaction costs give rise to liquidity rebates in the form of lower bond prices and, hence, higher expected returns. Though the price of liquidity is ever-present across practically all asset classes (equities, treasury bonds/bills, municipal bonds, corporate bonds and so forth), there is no universally accepted way to measure or operationalize liquidity. As Goldreich et al. (2005, p.1) articulated, "[…] the notion of liquidity itself is hard to pin down". Both within and across security markets, therefore, research areas have differed widely in their methods for capturing the quintessential dynamics of liquidity. Compare, for instance, Viral et al. (2004) who made use of a liquidity-adjusted CAPM in examining 'liquidity commonality', with Goldreich et al.'s (2005) paper that examined forward-looking liquidity measures through pairs of on-the-run (i.e. most recently issued) and off-the-run bonds. Further, as Houweling et al.'s (2004) review of liquidity proxies demonstrates, the empirical literature's findings regarding the impact of liquidity on bond yields has often been multifaceted and even conflicting. More recently, Choudhry (2010) highlighted that individual proxies of liquidity are rarely satisfactory and often incomparable across markets. It is therefore hardly surprising that, as previously alluded to, past researchers have historically used a variety of measures in capturing the mechanics of liquidity (Aitken and Comerton-Forde, 2003).

Indeed, just a meager twenty years ago the corpus of literature used at least 68 measures of liquidity (Aitken and Winn, 1997).

Broadly speaking, when liquidity in bond and equity markets has been scrutinized, its measures have been categorized as either of *direct* or *indirect* nature (Houweling et al., 2005). Direct metrics tend to pertain to transactional data but have included variants of high-frequency order-based data, while indirect measures capture some general characteristic of the bond and/or end-of-day prices. As the extant research regularly bears witness to, however, that which separates indirect and direct operationalizations of liquidity has been somewhat elusive. Nevertheless, examples classic to transactional (i.e. direct) data have included quoted and effective bid-ask spreads, quoted and traded volumes and trading frequency (*ibid)*. The choice of measure used is however, as is often the case, delimited by a combination of data availability, the researcher's view on liquidity and his/her research objectives. With that said, direct measures are generally considered closer to the fundamental essence of liquidity insofar as they are directly relatable to investors' economic experiences when converting cash to assets and vice versa. For instance, in any given transaction at any given moment, investors customarily incur liquidity costs in the form of the de facto spread in a buy and sell order. Investors are, concurrently, transactionally limited by the current order volumes available in each of the buy and sell legs, i.e. the order book depth and size. With respect to indirect measures, these are commonly used to represent direct measures when direct measures are unavailable. Some sixty years ago, Fisher (1959) used the indirect measure *issued amount* of a bond as a proxy for trading volume - a direct measure of liquidity. This measure continues to be used in modern literature by authors such as Houweling et al. (2005), and has been reproduced together with other proxies like age/tenor and yield volatility (see, for instance, Sarig and Warga (1989) and Hong and Warga (2000)).

Perhaps a more evident systematization, measures can on top of being direct or indirect be *trade-* or *order*-based. In an effort to provide some clarity as to which of these are more accurate proxies for liquidity, Aitken et al. (2003) researched the differences between trade- and order based liquidity metrics for stocks. These, it was found, often yield completely different research results, wherefore order-based measures were concluded to be superior when examining the economic crisis's impact on the Indonesia Stock Exchange (previously the Jakarta Stock Exchange). Arguing that the ability to instantaneously convert cash into securities at a minimum cost (and vice versa) is the core of liquidity, the authors purported that *ex post* transaction measures like monthly turnover (i.e. trade-based measures) are inferior to *ex ante* order-based operationalizations including bid-ask spreads and order book depth.

2.2.3.1 Liquidity and Transaction Costs

At this juncture, it is necessary to explain the relationship between *transaction costs* and *liquidity* and why measurements based on spreads are widely used when measuring liquidity risk. In doing so, it is required to grasp how different areas of research categorize these concepts depending on the implicit research question being examined. As previously mentioned, Houweling et al. (2005) classified bid-ask spreads (a transaction cost) as a type of direct measure of liquidity. When transaction costs themselves are the chief research focus, however, the literature categorizes transaction costs as *explicit* or *implicit* (Aitken and Comerton-Forde, 2003). Explicit transaction costs have come to include commission costs and taxes, and lie outside of the control of the relevant exchange. Their implicit equivalents have included the bid-ask spread and various opportunity costs, and are often directly related to structural marketplace characteristics like short sell constraints. Marketplaces and exchanges often possess some inherent ability to change these implicit costs by altering technology, instrumentation and regulation (*ibid*). This strain of literature defines bid-ask spreads as a type of implicit transaction cost[10]; an investor must incur the cost of the bid-ask spread if they wish to trade in the market, and in doing so they are subject to explicit costs like taxes. By simple virtue of our intuition, higher transaction costs imply lower market liquidity. Recalling the discussion on *direct* and *indirect* measures of liquidity, the preferred *direct* measures (e.g. bid-ask spreads, in this case) should, logically, capture the relevant costs associated with trading. The literature thus gets ambiguous when bid-ask spreads are included as just one type of transaction cost, on the one hand, yet is presupposed to encompass said transaction costs on the other. Phrased differently, are transaction costs measures of liquidity, or liquidity measures of transaction costs? This obscurity can come across as a source of confusion to the uninformed reader and we are reminded of Goldreich et al.'s (2005, p.1) foreboding "the notion of liquidity itself is hard to pin down".

In this paper, which of the preceding cause-and-effect interpretations of liquidity and transaction costs is the most relevant is not discussed in greater detail. The key takeaways are that

[10] This literary body has focused on the origins of illiquidity and is often referred to as market microstructure research. This field of inquiry looks into different forms of bid-ask spreads and 'market impacts' (i.e. the costs that investors incur when driving up (down) prices with large buy (sell) quantities passed the best ask (best bid)), and the characteristics of exchanges and marketplaces giving rise to these.

transaction costs (i) can be *explicit* or *implicit*, (ii) correlate with how markets and exchanges operate in general, and (iii) are highly interconnected with bid-ask spreads. Liquidity proxies, in turn, capture general views of market liquidity effectively when seen as costs that investors must incur to trade in markets. Nonetheless, as Archarya et al. (2004) explicated, liquidity is (unfortunately) not an observable variable and consequently tangible measures such as the bid-ask spread are used as substitutes. Amihud and Mendelson (1986, p.1) voiced a similar train of thought when stating that the bid-ask spread is the sum of the buying premium and the selling concession, making it a "natural measure of liquidity". Amihud et al. (2006, p. 270), later expressed liquidity should simply be thought of as "the ease of trading a security".

2.2.3.2 Validity of Liquidity Proxies

In covering different geographical markets over elongated periods of time, research on liquidity has periodically been forced to compromise on the use of *direct* measures. So much so, that creating proxies from daily data and bond characteristics (i.e. making use of *indirect* measures) to reach valuable conclusions has become commonplace to almost all markets set aside the US treasury market, which has been demarcated by a relative abundance of information (Houweling et al., 2005). A highly influential paper by Goyenko et al. (2009) speaks to this liquidity measure concession when explaining how daily return and volume data often are used to design liquidity measures proxying investors' 'true' intra-day liquidity/transaction costs. In doing so, the authors examined the underlying assumption that transaction costs are captured by readily available proxies. When liquidity proxies are not directly connected to direct measures, the authors reasoned that consensus of the validity of indirect measures will differ substantially, driving their hypothesis that the latter measures do not accurately mirror investors' experiences when trading securities. Contrary to their ex ante beliefs, the paper found that that low-frequency measures performed surprisingly well in estimating high-frequency direct measures. Further, it was deduced that more detailed, high-frequency data was often simply not worth the time and effort it required. The measures most apt and relevant to the research at hand will, however, depend on the specific area under study. With respect to this paper, *2.3 Theoretical Framework* discusses the empirical selection of liquidity proxies considering the recent research of Goyenko et al. (2009), who, like Aitken et al. (2003), collectively determine that order-based data, as opposed to trade-based data, is superior when creating liquidity benchmarks[11].

The reader should at this point be familiarized with (i) a broad view of the type of measurements that are used in liquidity-related research (ii) how liquidity measures can be categorized/interpreted and (iii) liquidity measures' relative research appropriateness. Below follows a brief discussion on some of the main results and models used within the concepts commonality, on-the-run/off-the-run treasury bonds, current and future liquidity as well as the role of investment horizons on yields.

2.2.3.3 Liquidity and Commonality

Peter and Stamboughs (2003) showed that expected returns on stocks are cross-sectionally related to how sensitive the individual assets are to market wide, aggregate liquidity (i.e. liquidity commonality). From data stretching over a period of thirty-four years, they concluded that (after adjusting for aspects like size, momentum, value and market return sensitivity) the average return on high liquidity sensitive stocks was 7.5 percent higher than that of low liquidity sensitive stocks. The majority of the various areas within liquidity research are covered in the equities literature[12]. As the above Peter and Stamboughs (2003) example indicates, liquidity commonality is no exception. A growing corpus of evidence, however, has been presented in extant bond and non-equities literature[13] which asserts that assets are, in general, exposed to the phenomenon of market wide liquidity, reflected in underlying prices.

It would seem, therefore, that the working consensus is that exposure to market liquidity is reflected in most if not all financial markets' prices. With that said, liquidity *risk* per se is far from the only way liquidity affects asset pricing. Importantly, the absolute *level* of liquidity is also an actively priced component of the wider market liquidity/liquidity commonality (Amihud et al., 2006). Previously mentioned Chen et al. (2007) employed cross-sectional liquidity levels in accounting for as much as half of the cross-sectional variation of investment-grade and speculative-grade bond yield

[11] Effective and realized spreads as well as price impacts are calculated using TAQ and Rule 605 data. Rule 605 data is said to be better for several reasons. For example, the midpoint is taken at the time of receipt (not execution), i.e. Rule 605 data allows for order-based rather than trade-based data.
[12] See, for example, Huberman and Halka (2001) and Hasbrouck and Seppi (2001).
[13] See, for example, Beber et al. (2009), Lin et al. (2011) and Geanakoplos (2003) for insights on the liquidity commonality of sovereign bonds, corporate bonds and the holistic financial system, respectively.

spreads. Moreover, scholars contend that risk-averse investors are compensated for not just the lack of ease of trading *today*, but equally the riskiness of potential *future* liquidity, as the below elaborates.

2.2.3.4 Current and Future Liquidity, and on-, off-the-run Bonds

A bond is on-the-run if it was the most recently issued in a series of periodically issued securities. All other bonds are, hence, off-the-run. On-the-run bonds are primarily discussed when analyzing treasuries, particularly US treasuries[14], but are also relevant for other bond types when researching liquidity (see the previously discussed Houweling et al. (2005)). Whichever the case, 'on-the-run' and 'off-the-run' have become salient bond classifications due to their substantially different liquidity characteristics. Specifically, the former is considerably more liquid as it earns more trading interest, frequency and volume. US treasury notes are issued on a rolling basis, auctioned every month and mature after two years - hence, there are consistently twenty-four two-year treasury notes outstanding. Goldreich et al. (2005) used this predictability to determine whether *future* liquidity was being priced using a total of seven different liquidity measures. Fourteen years prior, Amihud and Mendelson (1991) maintained that liquidity-related costs are incurred several times during the life of an asset, such that the present value of liquidity costs ultimately determines in what manner asset prices ought to be affected by liquidity. Goldreich et al.'s (2005) obtained results were paramount to the literary body of liquidity and bond yields. Briefly, they evidenced (i) exact measures and statistical interpretations explaining differences in liquidity between on-the-run and off-the-run bonds, (ii) further insight into the relative explanatory powers of different proxies for liquidity, and (iii) that investors price not only *contemporaneous*/current liquidity (i.e. liquidity *today*), but also *future* liquidity.

2.2.3.5 Liquidity and Investment Horizons

Yet another branch of liquidity worth noting is the effect of investment horizons on the costs to investors, and thus their (net) return of holding the asset. Amihud and Mendelson (1991) elucidated that a short horizon implies an investor ought to hold a more liquid asset or risk transaction costs exhausting all returns. A long investment horizon, as the authors would have it, suggests holding an illiquid asset as the net return is boasted by liquidity costs that are never actually incurred. These investment horizon dynamics are reducible to two distinct investor-groups; those with long, and those with short investment horizons. This categorization has become known as a type of *clientele*

[14] See, for example, Pasquariello and Paolo (2009) and Goyenko et al. (2009).

effect. By consequence, non-linear relationships are thought to exist between liquidity and returns (Amihud and Mendelson, 1986).

2.2.3.6 Liquidity vs Default Risk

Researchers have devoted a substantial amount of time and effort in explaining the relative importance of liquidity and default risk, as well as the circumstances where one matters more than the other. Their interaction and dependence on factors including macroeconomic conditions and financial distress have also been subject to much deliberation. Beber et al. (2009) show that at different times and for different reasons, credit quality and liquidity are both demanded by investors. As Codogno et al. (2003) suggested six years prior, Beber et al. (2009) support the notion that European sovereign yield spreads are primarily driven by credit quality. In low credit countries, however, the authors convincingly demonstrated that the concern for liquidity outweighs that of credit quality. Moreover, in times of market distress, cash flows are typically seen as chasing liquidity, i.e. there is a flight-to-liquidity, not a flight-to-quality (*ibid*). Liquidity also stands as the most important determinant when the bond market is exposed to sizeable capital in- or outflows, accounting for the lion's share of sovereign yield spreads. This is an especially powerful result since past research by Ericsson and Renault (2006) previously presented evidence that, in the US corporate bond market, credit quality and liquidity were positively correlated, which has complicated the separation of the two concepts.

Bao et al. (2011, p.911) found similar results as Beber et al. (2009) by examining US corporate bonds between 2003 and 2009, and concluded that there is a "strong link between bond illiquidity and bond prices". Even for AAA-rated bonds, illiquidity on a market level affects bond yield variation over time, dwarfing the credit risk component. This result both supports and contests the research of Longstaff et al. (2005), who used the credit default swap market to examine the relative importance of credit and other risk classes, principally liquidity risk. The component of the yield spread *not* due to credit risk was, both papers found, shown to be time varying and related to bond-specific-[15] as well as macro-liquidity measures in the bond market. At the same time, Longstaff et al. (2005) attributed most the observed yield spread (51%) of AAA/AA-rated bonds to credit risk.

[15] These included, among others, bid-ask spreads, accessibility to the bond issue in the market and the age of the bond.

2.2.4 Interest Rate Risk

Discussing interest rate risk for treasury and municipal bonds may, at first, seem somewhat odd given their latent relationship to the bond market. On that note, however, given that the yield curve can look different at different times, and is delimited by some form of non-linear shape across maturities (Chan et al. 1992, Duffee 2002), there is an innate risk in holding bonds with different maturities or positions on the yield curve. In the literary body, the discrepancy of time itself and the risk that comes with it is often adjusted using (i) some variant of interpolation between known yields at different maturities[16], (ii) some version of hypothetical security yield comparison[17] (iii) and/or assumptions that can justify not making any corrections due, in large part, to almost identical maturity dates.

2.2.5 Underwriter Reputation

Another perhaps less obvious and less quantifiable aspect to consider when analyzing bond prices and the muni puzzle is that of the underwriter's reputation. In the US, municipal bonds have over time seen higher issuance prices afforded by larger and more prestigious underwriters (Daniels and Vijayakumar, 2007). Their stronger reputational backing, it is argued, promotes less information asymmetry between issuers and borrowers, augmenting said issue prices (*ibid*). Fang (2005) echoed this prospect by documenting lower earned yields in issues from reputable banks. Despite higher fees, he contends, the issuer's net proceeds increase. This phenomenon is most pronounced in speculative grade bonds. Put simply, underwritings from reputable banks signal high issue quality (*ibid*).

2.2.6 Investor Attention

Investors, like all people, have a finite information processing ability under a certain period of time, i.e. limited attention. Akin to underwriter reputation, this is a somewhat less defined area than many more tangible determinants of bond yields. Psychological studies examining investor attention are vast and can, for a rather comprehensive reading, be explored through the reviews of Khaneman (1972) as well as Pashler and Johnston (1998).

Due to this inherent human limitation, investors have been shown to first focus on, and process, market-level information when market-wide uncertainty has suddenly increased. Only once

[16] See, for example, Amihud and Mendelson's (1991) linear weighted scheme.
[17] Goldreich et al. (2005) elegantly implemented this correction.

this is done, are investor resources dedicated to idiosyncratic information of interest. This is a (relatively) short-term phenomenon and takes less than 10 days to complete (Peng et al., 2007). Nevertheless, investor attention is exceedingly hard to measure. The rise of information technology has made data collection pertaining to investor behavior more transparent and quantifiable, producing new operationalized measures of investor attention such as the google search frequency measure "Search Volume Index" (SVI). An increase in the SVI metric is consistently correlated with higher first day returns in the event of an IPO, followed by a subsequent underperformance in the long-run (Da et al., 2011). Further, investor attention research often questions rational investor models. For example, processing more sector-wide than firm-specific information (coined *category-learning behavior*) coupled with investor overconfidence creates return co-movement characteristics in the market that cannot be explained by models based upon agents acting completely rationally (Peng and Xiong, 2006).

2.3 Theoretical Framework

Even though all research discussed in the literature review is relevant for the understanding of the issues raised in this paper, the theoretical framework aims at using the literature review as a backdrop to establish what past studied areas are closest to and most applicable for the empirical process and setting of this study. The literature narrows down substantially for three reasons: (i) it is simply not possible to examine all aspects that can possibly influence bond yields, (ii) the muni puzzle can, in Sweden, be examined from a perspective where several factors are naturally eliminated, and (iii) scarce data availability has constrained the possibility of using other albeit less robust variables from past research.

2.3.1 Taxes

Even though taxes play a significant role when examining the muni puzzle in the US, the fact that municipal bonds are not tax exempt in Sweden eliminates any need for tax-rate adjustments. Neither is there any need to discuss negative market risk premiums or systematic correlations with consumption risk as discussed through Longstaff (2011) and Chalmers (2006).

2.3.2 Credit Risk

Analogous to taxes, there is little doubt that credit/default risks are actively at work in the muni puzzle. In the Swedish institutional climate, however, both KI and RiGä have identical credit ratings in the bond market and, more importantly, are constitutional equivalents. Moreover, RiGä has taken upon itself a statutory role comparable to 'lender of last resort' in the unlikely event of KI's insolvency - in other words, KI cannot default without RiGä doing so. KI is, in the same vein, unable to declare bankruptcy due to its municipal representation. Consequently, no specific model incorporating credit risk is used herein.

2.3.3 Liquidity

The bulk of previous research that lays the foundation to this paper is liquidity-related. Indeed, liquidity appears as the most promising contender in explaining the Swedish muni puzzle given the absence of tax and credit differentials between munis and treasuries. In selectively choosing the most relevant research to incorporate and build upon, certain papers are naturally more suitable than others given the field's rather extensive coverage of different asset classes, markets and methods[18]. Combining the limited data available for the purposes of this study with the historically exuberant amount of liquidity measures (Aitken and Winn, 1997) of different validities (Houweling et al., 2005, Goldreich et al., 2005), it is crucial that a relevant, economically relatable measure is chosen that accurately portrays investors' experienced liquidity costs.

Drawing on mainstream conclusions shared by the better part of extant research[19], the analytical approach and the liquidity measure should capture the level of liquidity today and be receptive to the eventuality of a forward-looking investor realizing the implications of incurring costs relating to trading an asset over time. Moreover, learning from the results of Goyenko et al. (2009) and Aitken et al. (2003), order-based results are generally superior to trade-based measures. Direct measures are furthermore seen as preferable in liquidity research. Recall, however, Goyenko et al.'s (2009) study that demonstrated low-frequency end-of-day data (or even monthly or yearly data) performs practically as effectively as high-frequency equivalents. Finally, Bao et al. (2011) and Amihud and Mendelson (1991) showed that liquidity is properly modeled when changes in measures of indirect and direct costs give rise to changes in bond prices and, by extension, yields.

Goldreich et al. (2005) is a considerable source of inspiration to this paper for two principal reasons. First, their research provides an intuitive rationale and simple mathematical procedure in modelling how liquidity measures affect bond yields. Second, their flexible methodology qualifies as

[18] This refers to the larger market microstructure domain of liquidity based asset pricing and its implications for solving financial puzzles.

[19] Predominantly including, yet not limited to, the mentioned Amihud and Yakov (2006), Amihud and Mendelson (1991), Beber et al. (2009) and Chen et al. (2007).

extendable to the muni puzzle while being sensitive to the key conclusions discussed in the previous paragraph. Phrased differently, their approach is both highly reliable and salient while being accommodative to other studies' insights as well as different independent and dependent variables.

2.3.4 Interest Rate Risk

Similar to taxes and credit risk, no interest rate risk will have to be discussed and accounted for as the method used eliminates any discrepancies in maturities and thus any yield curve difficulties.

2.3.5 Underwriter Reputation

No quantitative appreciation of underwriter reputation will be covered in this paper. Following discussions with professionals working at KI has made this area of study seem rather irrelevant as there should be no consistent, significant difference between municipal and treasury bond issuers in Sweden. This view is solidified by the fact that KI has historically and continues to use Sweden's four largest banks as underwriters in their issues and market makers in the secondary market.

2.3.6 Investor Attention

Investor attention is known from research like Peng and Lin (2007) as well as Da and Zhi (2011) to impact financial markets, and is thus probably the most overlooked field of study in this paper. For reasons relating to difficulties in quantifying investor attention, this otherwise behaviorally relevant area is omitted and discussed in further detail in *VI. Limitations of research.*

III. Research Design

3.1 Problematization, Purpose & Contribution

To briefly recapitulate, recall that Goldreich et al. (2005) and Liu et al's. (2003) studies provide highly salient insights to the muni puzzle by consideration of credit risk/liquidity premiums and current/future liquidity respectively. Despite this, few if any studies have observed the muni puzzle in an institutional context characterized by identical tax laws and default risks. Such a climate allows for the explicit study of other understudied factors given the field's traditional US preoccupation where treasuries and munis are delineated by distinct tax codes and credit risks. This literature discrepancy materialized into the research question: "Can liquidity premiums explain the Swedish muni puzzle?" given liquidity's widely acknowledged relevance albeit disputed operational implication. In answering the above, the purpose of the research paper became to help fill this knowledge gap and in doing so, provide more conclusive results in determining how and under what pretenses liquidity premiums may account for differences in municipal and treasury yields.

3.2 Scientific Perspective

Unsurprisingly, extant literature on the subject almost unilaterally makes use of a quantitative research approach in determining the muni puzzle's most influential explanatory variables. This paper is no exception and converges to the norm - indeed, to draw meaningful conclusions and make statistically defensible inferences as to liquidity's role in the Swedish muni puzzle, a quantitative study is the only feasible research design (King et al., 1995). Implicit to this research approach lays a set of epistemological and ontological assumptions in the form of positivism and objectivism (Bryman, 2012). Together, these both constrain and mediate the researcher's ability to analyze, infer and conclude, thereby building the methodological pretense for the research itself. Positivism and objectivism, Bryman (2012) deliberates, confer a rather precise understanding of objective knowledge and social reality that promotes a comprehension of observed phenomena through sensation, tests hypotheses and empirical inquiries through theoretical induction, contests normative claims with scientific statements[20] and advocates value-free research in a context where social actors are independent of social phenomena and vice versa.

In Bryman's (2012) vein, this paper's "social reality" of differing Swedish muni and treasury yields represents an external actuality to be deciphered by the researcher through reliable and valid operationalizations of concepts and resulting data collection methods. With this in mind, this paper seeks to deductively describe a generalizable, exogenous reality by drawing on a sample of municipal and treasury bonds. In doing so, we employ what Mackenzie and House (1978) phrased a deductive nomological reasoning which, broadly speaking, seeks to produce general law-like explanations through the process of deduction. This way of reasoning is rooted in a long-lasting scientific empirical consensus comprised of logical empiricists who sought to substitute vague and ununderstood concepts (*explicandums*) by clearer, more defined replacements (*explicatums*). In relation to this research paper, the *explicandum* of interest is the muni puzzle. Our resultant explicatum is then, after due diligence of this study's inherent limitations, rated and appraised based on its measures of (i) similarity to the explicandum, (ii) exactness, (iii) fruitfulness and (iv) simplicity (Salmon, 1989). In light of these criteria, *explanatory* investigations must not be confused with *evidence-*

[20] Since normative proclamations' objectivity is not discernible through phenomenalism/sensation.

seeking. To paraphrase Salmon's (1989, pp.6-7) highly illustrative example, scientists believe distant galaxies are moving away from us at high velocities based on evidence of their red-shift light. The underlying reason for this observed phenomenon, however, stems from the "big bang theory" rather than galaxies' red shift per se. In pursuing an explanatory understanding of the muni puzzle, the deductive nomological approach presupposes an *explanandum* and *explanans* statement. Briefly, as Salmon (1989, pp.8-10) elaborates, the task of the *explanandum* is to describe, understand and validate the occurrence of the observed phenomenon while the *explanans* specifies the antecedent premises breeding the observed phenomenon in the form of at least *one* general law essential to the legitimacy of the argument, such that had it been omitted the argument would lose its validity. Arguments meeting these prerequisites qualify as *potential explanations* (*ibid*). Hence, in the deductive-nomological model, the explanation of phenomena is reducible to a logical connection between the *explanandum* and *explanans* statements. Moreover, in the deductive nomological sense, should the *explanans* statements be true, the argument and explanation constitutes a *true explanation*. In light of this paper, the *explanandum* statements describe the muni puzzle as a *de facto* well-documented phenomenon centered around the prospect that the after-tax yields on munis and treasuries are (fundamentally) different from one-another along the longer end of the yield-curve. Such is the case even in the Swedish institutional climate whose municipal and government issuers are delineated by tax and credit homogeneity. In this vein, liquidity is thought to explain the still divergent muni and treasury yields. The *explanadum* statements' preconditions and premises (i.e. *explanans* statements) include, for instance, that investors are rational, risk-averse and markets relatively efficient - omitting either of these seriously jeopardizes liquidity premiums' validity and legitimacy as both a *potential* and *true* explanation to the Swedish muni puzzle.

3.3 Method

Munis and treasuries, two "bond types" from the public sector, are in spite of their many similarities seldom identical in all regards. This presents some challenges the researcher must address to make municipal and government bonds comparable[21]. With respect to the former, all non-rated bonds are removed. Further, all callable bonds (i.e. bonds with executable redemption clauses prior to maturity) are excluded since this embedded 'option' has an intrinsic value distorting yields when

[21] Despite KI's multiple triple-A ratings as an issuer, the market may in practice determine unrated bonds as different credits from their rated counterparts. Other potential pitfalls this paper seeks to circumvent include issues relating to the potential seniority of rated vis-à-vis unrated bonds in the event of default. To err on the side of caution, therefore, this study precludes these bonds.

juxtaposing non-callable and callable bonds. Further, for the sake of simplicity, all non-SEK denominated bonds are omitted from the sample. Including Swedish bonds issued in foreign currencies would incorporate a degree of, albeit manageable, exchange rate risk while exposing bonds to less workable macroeconomic risks (e.g. Eurobonds and domestic SEK-bonds are dependent on different central banks' monetary policies). Equally, all KI's Euro Medium Term Notes are precluded from the study as these have no dedicated market makers and are, by extension, not part of a liquid secondary market. After these corrective measures are implemented, twenty munis remain relevant to this paper's study.

On the government side of the equation, all real (inflation-adjusted) bonds are excluded since these, naturally, are price-distorting compared to the nominal munis. Further, all T-bills (i.e. bonds with maturities less than one year) are excluded as these tend to behave differently from the majority of bonds with longer maturities and are on the short-end of the yield curve - i.e. not where the muni puzzle has traditionally been observed. Lastly, this research paper pairs munis and treasuries with the exact same expiration date in order to make said bonds as fundamentally comparable as possible. This produces a total of seven "bond pairs" of munis and treasuries, as indicated in the below table. Of these, bond pairs 1-3 have already expired at the time of writing of this study.

TABLE 1

Muni-Treasury bond pairs with identical expiration dates

The Treasury and Muni nomenclature outlined below is formatted by a series name, a unique identifier (ISIN) and coupon rate and should resultant be read as "Series name – ISIN – coupon rate"

BOND PAIR	MATURITY	RIGÄ BOND (TREASURY)	KI BOND (MUNI)
1	2017-08-12	1051 - SE0001811399 – 3,75%	1708 - SE0003787985 – 4%
2	2019-03-12	1052 - SE0002241083 – 4,25%	1903 - SE0005131299 – 2,25%
3	2020-12-01	1047 – SE0001149311 – 5%	2012 - SE0005705621 – 2,5%
4	2022-06-01	1054 – SE0003784461 – 3,5%	2206 - SE0009269418 – 0,25%
5	2014-05-05	1041 -SE0000412389 - 6,75%	1405 - SE0004243129 – 2,25%
6	2012-10-08	1046 - SE0000909640 - 5,5%	1210 - SE0003555697 – 1,75%
7	2015-08-12	1049 - SE0001250135 - 4,5%	1508 - SE0003555689 – 2,75%

In studying the disparities between these seven paired Swedish muni and treasury returns, their daily close-of-day prices are gathered from Bloomberg. Despite the paper's efforts to control for some of the varying characteristics demarcating KI and RiGä bonds, an attempt at bridging their different coupons highlighted above is needed. In response to this, Bloomberg's ASW (asset swap spread) function is made use of. This command has seen repeated use in neighboring research including Zaghinik (2014) and Pianiselli and Zaghini (2014), yet has to the best of our knowledge not directly been used when examining the muni puzzle. In short, this input relates bond prices to an interest rate swap in which Investor A longs the bond and enters into an interest rate swap with Financial Institution B delivering the bond. Investor A pays a fixed rate and receives floating, effectively transforming the fixed coupon on the bond into a (typically) LIBOR-based floating coupon. The below diagram illustrates these ownership and transaction dynamics more carefully.

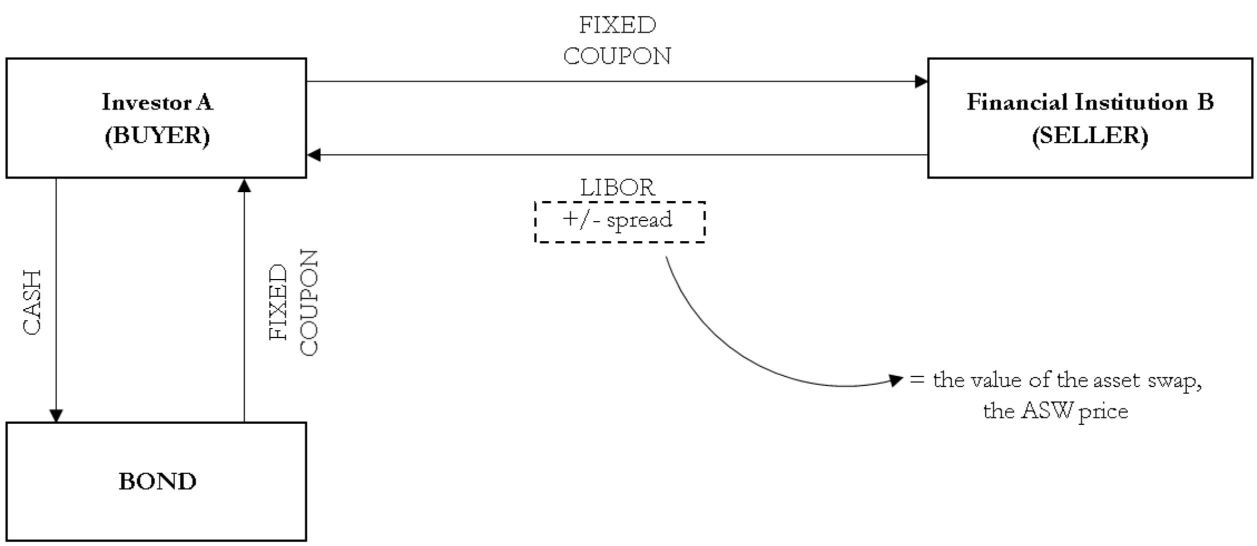


Diagram 1: The ASW function illustrated by ownership and transaction branch. The value of the ASW, i.e. the ASW price, is equivalent to the credit spread above or below LIBOR.

In this asset swap, the protection seller agrees to pay the protection buyer LIBOR +/- a spread in return for the risky cash flows of the bond. In the event of default, the protection buyer will continue to receive the LIBOR +/- a spread from the protection seller. This spread, then, represents the credit spread between the bond's risky coupon payments and the fixed-to-floating swap rate. The value of the asset swap (i.e. the ASW price), therefore, must be this credit spread over/under LIBOR. As with all derivatives, the intrinsic value of this asset swap is zero at inception, yet with the passage of time and resulting changes in market conditions (ergo, dynamic LIBOR rates and bond credit risks), the transaction hedge/asset swap derives a value and price. The ASW, therefore, is nothing more than an interest rate hedge (fixed-to-floating) coupled with an insurance policy against the bond cash flows' credit risk, i.e. its probability of default. Naturally, both KI and RiGä are privy to the same market-wide interest swap rate at any point in time. Equally, insurance against their potential insolvencies ought to be equivalent given their identical statutory credit risks and market-priced credit ratings. Accordingly, indistinguishable credit risks should translate to the same credit spread, i.e. the same ASW price. The ASW function, therefore, effectively voids differences in coupons while maintaining the risk characteristics inherent to the bonds.

Once done, comparable yields[22] in the form of ASW prices are obtained for each of the fourteen combined municipal and government bonds. When said bonds' ASW yields then are subtracted from one another, producing ASW yield differences, municipal ASW yields are reduced by treasury ASW yields.

3.4 Empirical & Ethical Reflections

It is worth noting that all relevant cited academic literature herein is peer-reviewed and previously cited. To the best of our knowledge, therefore, there is little to no reason to question the credibility and legitimacy of the extant literature made use of in this study. Furthermore, all data collection procedures have been limited to the use of Bloomberg, Thomson Reuters and information provided from KommunInvest and are therefore, by and large, secondary information sources unencumbered by the often greater care and concern implicit to the handling of primary sources. With respect to the private discussions held with Mattias Bokenblom and Tobias Landström of KI, due consideration was given in maintaining the integrity and representativeness of their voiced thoughts, ideas and insights. Had this study investigated an area akin to the, for instance, aforementioned Hamilton Project's proposition of a communal body, a more socially sensitive nature would have presented itself given the implications for taxpayers at stake.

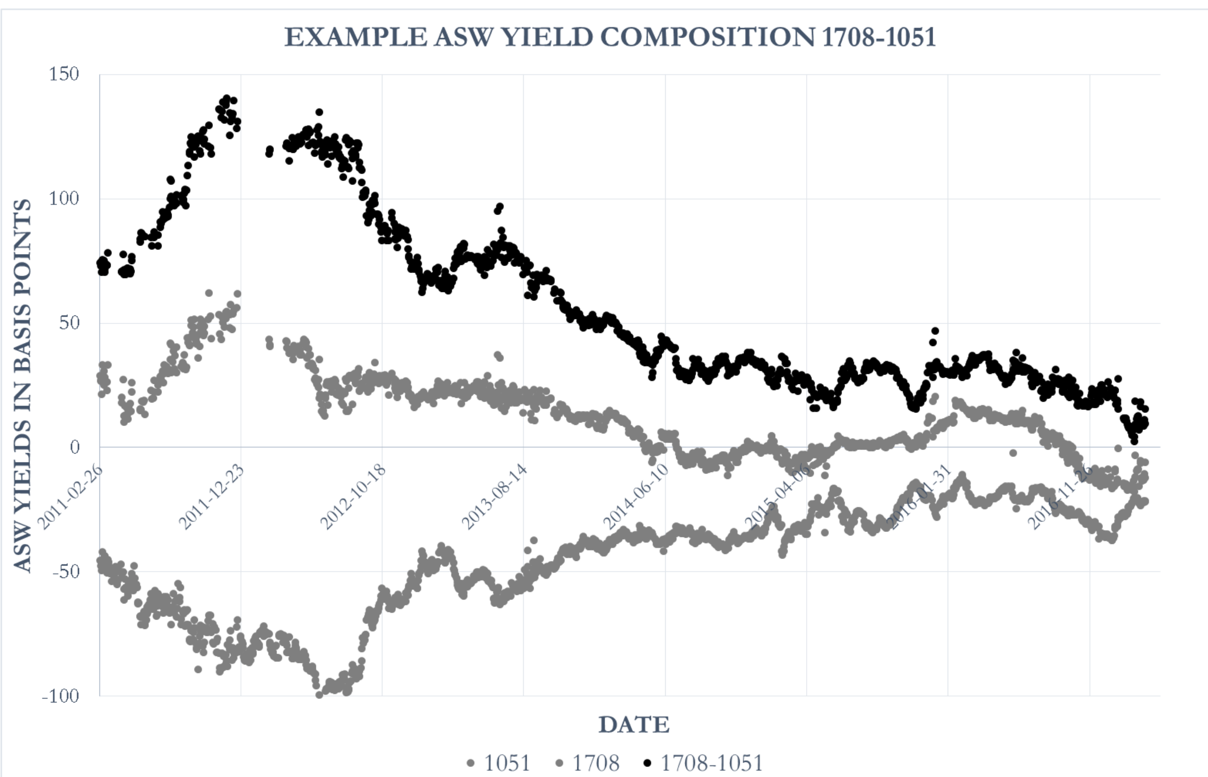
[22] Specifically, yields to maturities (YTM). Henceforth, all yield-related data is of the YTM sort and used interchangeably with the concepts of "yield" and "returns".

IV. Analysis & Findings

In the following sections the paper presents the general properties of the ASW yield differences between munis and treasuries, in turn mediating the effect liquidity has on these differences. In minimizing the study's exposure to statistical pitfalls, we examine the presence of heteroscedasticity and autocorrelation before running a series of cross-sectional time-series FGLS (Feasible Generalized Least Squares) panel regressions as well as a panel-correlated regression.

4.1 Summary of the Difference in ASW Yields for Municipal and Treasury Bonds

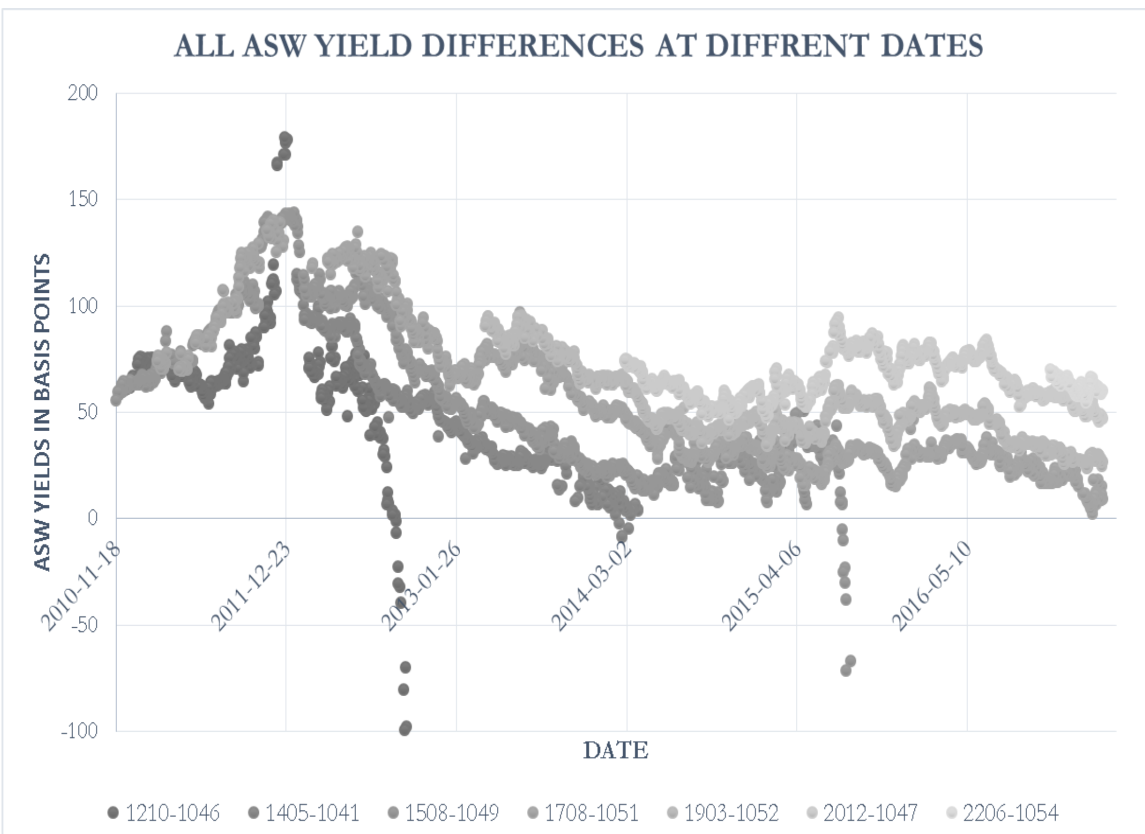
Having collected and maturity-matched the ASW yields for all relevant municipal and treasury bonds, the difference in the yields of any pair can be presented graphically. One such representation is shown in **Graph 1**, where the yields of KI bond 1708, and RiGä bond 1051 are presented together with the difference between the two, $ASW\ yield\ (Muni) - ASW\ yield\ (Treasury)$.



Graph 1: In the above graph, the municipal bond issued by KI, 1708, and the treasury bond issued by RiGä, 1051, are shown. Their individual (grey) ASW yields, as well as the difference between the two (black) are plotted over time. The distance between the grey data points equal the value of the black values.

Several conclusions can be drawn from this graphical data. First, there is a significant difference between the two securities' yields, peaking at 139 basis points in late 2011. Secondly, notice that by simple power of observation the ASW yields for the individual bonds approach zero the closer to maturity they are. This is hardly surprising given bond yields naturally converge to nil as claims to cash flows steadily decrease approaching maturity. Lastly, even though the general trend indicates a decrease in the difference in ASW yields, they initially move in opposite directions. This indicates that investors perceived the municipal bond's value to be decreasing in relation to its treasury counterpart during this specific time. These movements, however, occurred during a period characterized by high liquidity volatility when the European sovereign debt crisis neared its most pressing levels.

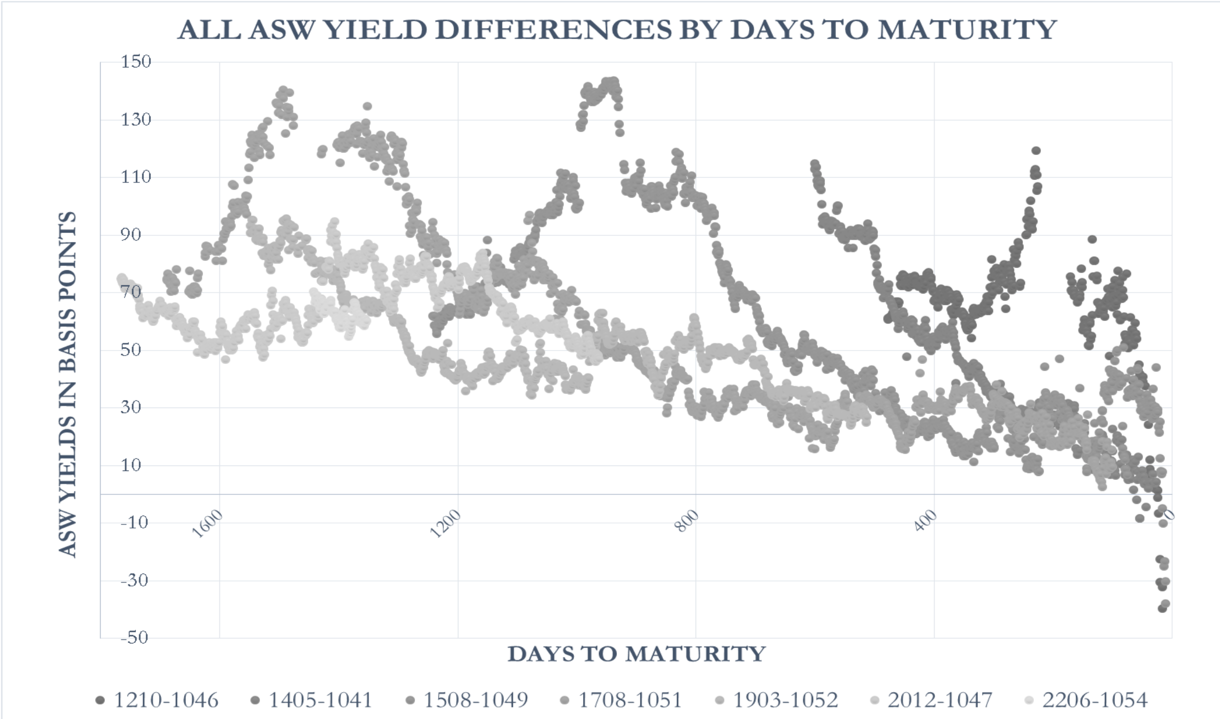
In **Graph 2**, the previous exercise is replicated for all seven municipal and treasury bond pairs. The bond pairs are, accordingly, plotted over a time-series beginning at the oldest municipal bond's initial issue, and ending the 24th of March 2017. Three bond pairs have already matured, and the remaining four are still trading as of the last day of the data collection period.



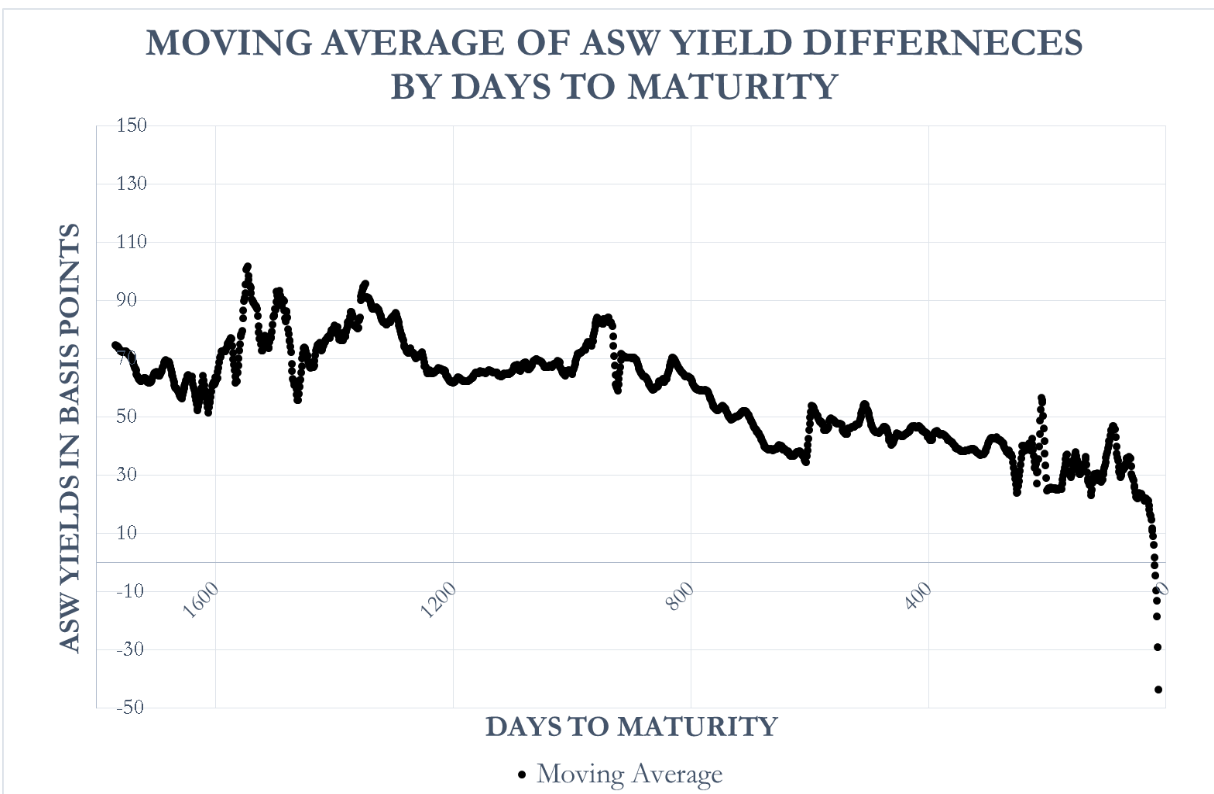
Graph 2: In the above graph, the ASW yield difference between municipal and treasury bonds are plotted for all bond pairs. For example, bond pair 1708-1051 which was highlighted in graph 1, is included as one of seven pairs.

The properties described relating to the bond pair displayed in **Graph 1** seem to apply for all other bond pairs. The highest measure of differences in ASW yields across all pairs is 178 basis points. The market is repeatedly valuing munis lower than treasuries. When a new municipal bond is issued the same recurring pattern presents itself in the form of a downward trend of differences in ASW yields. This creates the 'superimposed' image exhibited in **Graph 2**, where new bond pairs appear rolling and overlaid. The presence of cross-sectional, inter-panel co-movements over time also seems quite apparent. Late 2011 notwithstanding, several bond pairs see concurrent increases and decreases in ASW yield differences in, particularly, late-2015 to mid-2016. Jointly considering the indistinguishable credit risk of the bonds issued by KI and RiGä with the market movements shown in **Graph 1** and **Graph 2**, some initial inquiries can be made. First, recalling the research by the likes of Peter and Stamboughs (2003) and Geanakoplos (2003) (i.e. assets are cross-sectionally exposed to market wide liquidity, part of the wider liquidity commonality, and prices are affected by this phenomenon) the paper's hypothesized liquidity premium now emerges as a plausible empirical candidate for deciphering the Swedish muni puzzle. This potential explanation becomes especially convincing when considering, as Beber et al. (2009) among others showed, market stress prompts a flight to liquidity rather than credit quality. When large capital in/outflows delineate the bond market (as was the case during the European sovereign debt crisis), liquidity is the main contributor to sovereign yield spreads. This rationale suggests increasing ASW yield differences between munis and treasuries, as depicted in late 2011 in both **Graph 1** and **Graph 2**.

Another perhaps more intuitive way to construct the ASW yield differences is by days to maturity along the x-axis (see **Graph 3**). This arrangement demonstrates the inherent relationship between bond prices and time more clearly. A natural consequence of this portrayal, however, is that the general market co-movements illustrated in **Graph 2** are less discernible. For illustrative purposes, **Graph 4** depicts a time-series moving average of the seven cross-sectional bond pairs so as to provide a sense of their general movements approaching maturity.



Graph 3: The same bond pairs as in the previous graph are above plotted with days to maturity on the x-axis. As previously, ASW yields are defined in basis points along the y-axis.



Graph 4: In the above graph, a moving average of the bond pairs' cross-sectional average ASW yield difference is seen against days to maturity along the x-axis.

From this section we can conclude that in a setting without differences in default risk, taxes, interest rate risk and underwriter reputation, there is still a substantial difference between the yields of munis and treasuries to be accounted for. Though these aforementioned parameters are left un-modeled in this paper and thus cannot be assigned any absolute or relative explanatory power, **Graph 1-4** support the notion that default risk and tax effects do not fully resolve the muni puzzle. This study, instead, confines its resources to modelling liquidity premiums given its high contextual relevance as a potential determinant of ASW yield differences. Ideally, this will contribute some valuable insights as to how liquidity provides explanatory power to the muni puzzle, adding clarity to the research field in the Swedish market and general bond market at large.

4.2 Describing the Variables and the Panel data

For every panel variable (i.e. bond pair), and every time interval in the relevant time series (i.e. date), observations exist for both our dependent variable and independent variables. Our variables are defined as follows.

Panel variable, P: $Pairnumber = 1, 2, \dots, 7$
Time Variable, t: $Date$

Dependent variable:
For every $P\ and\ t$:

$$ASWMT = ASW\ yield\ (Muni) - ASW\ yield\ (Treasury)$$

Independent variables:
For every $P\ and\ t$:, the contemporaneous (or current) cost of trading (i.e. liquidity premium, expressed in basis points) for the individual bond can be defined as:

$$Contemporaneous\ Cost\ of\ Muni\colon\ C_M = 10000 \cdot \frac{Ask - Bid}{Mid}$$

$$Contemporaneous\ Cost\ of\ Treasury\colon C_T = 10000 \cdot \frac{Ask - Bid}{Mid}$$

These measures are *proportional* in the sense that the spread is divided with the mid price. The difference in costs of trading these bonds can simply be defined as:

$$Difference\ in\ Contemporaneous\ Cost: C_M - C_T$$

For every $P\ and\ t$, the future (or expected) cost of trading (i.e. liquidity premium) characterizing the individual bond can be defined as the average of all the forthcoming proportional bid-ask spreads in the time series:

$$Future\ (i.e. expected)\ cost\ of\ Muni: \overline{C_M} = \frac{1}{n} \cdot \sum_{t}^{Maturity} C_M$$

$$Future\ (i.e. expected)\ cost\ of\ Treasury: \overline{C_T} = \frac{1}{n} \cdot \sum_{t}^{Maturity} C_T$$

Where $n = number\ of\ days\ from\ today\ to\ maturity$

Akin to contemporaneous liquidity, the difference in future liquidity costs of trading between munis and treasuries simplify to:

$$Difference\ in\ future\ cost: \overline{C_M} - \overline{C_T}$$

Using these variables, the effect of liquidity premiums can be examined. It must be iterated that, unlike the research conducted by Goldreich et al. (2005), there is no obvious predictability to investors as to how liquidity should change over time in this paper. The on-the-run/off-the-run bonds used in Goldreich et al.'s (2005) study had a clear development over a fixed time period and were delimited by recurring, repetitive cycles of known market features and liquidity characteristics. Herein, on the other hand, the characteristics of the trading environment are far from foreseeable. Imagine, for the sake of argument, a well-informed US treasury note investor awaiting the current monthly issue. He or she is well aware of the liquidity dynamics at play; the on-the-run issues will attract wide investor intention, while new off-the-run bonds will slump in liquidity. A comparable Swedish muni and treasury investor, however, has limited to no liquidity foresight at his or her disposal, making inferable predictions as to the future liquidity of each bond, at most, an educated guess. With this in mind, current liquidity, rather than future liquidity, is thought to be the factor that has the most relevance in investors' pricing of munis and treasuries. Nevertheless, the economic intuition provided by researchers such as Amihud and Mendelson (1991) and Chen et al. (2007) concerning the relationship between the present value of coming costs and asset prices, suggests omitting future liquidity in this paper's model specification as a potential way of overlooking an important measure.

4.3 Examining the Presence of and Adjusting for Heteroscedasticity and Autocorrelation

The variance of our pairwise panel residuals runs the risk of being significantly different from one another. Cross-sectional datasets treating different countries, states or other commonly used panel classifications are known to in this sense be problematic as they may have fundamental differences in scale. In this dataset, such is not the issue as every pair is by construction identical in its fundamentals (i.e. consists of one bond issued by KI, and one bond issued by RiGä). At the same time, the muni and treasury pairs run over different time periods, and these periods can, as exemplified in **Graph 1** and **Graph 2**, be characterized by more or less turbulent yields. Using a likelihood ratio (LR) test, the panel data is examined and a significant test statistic obtained, indicating a strong presence of heteroscedasticity. All regressions are therefore panel-adjusted for heteroscedasticity to obtain more robust and reliable results.

Using future liquidity presumably leads to substantial serial/autocorrelation since the averages of coming future bid-ask spreads will, on any day, include all but the previous day's data point. A serial correlation corrective procedure followed by a Wooldridge test for autocorrelation in panel data shows the cause for concern to be valid. Contemporaneous (i.e. today's) liquidity might not be as obviously burdened by autocorrelation. Nevertheless, performing the same tests as for future liquidity reveal that even the former shows statistically significant signs of autocorrelation. Erring on the side of prudence, while aligning our methodological construct to that of Goldreich et al. (2005), all regressions are therefore adjusted for panel-specific autocorrelation. The regressions are also repeated by panel-specific first-differencing as yet another avenue in adjusting for first-order autocorrelation. This approach is, again, consistent with the practices used by Goldreich et al. (2005), yet the relative importance of first differencing herein is not as great given this paper's lower number of panels and relatively-speaking longer time period.

4.4 The Basic Regressions

Analogous to that of Goldreich et al. (2005), a cross-sectional time-series model for panel data is used. Due to the long time series and few panels however, dummies for each bond pair do not have to be incorporated in the model to adjust for cross-sectional differences. As mentioned, a Feasible Generalized Least Squares (FGLS) model is used. As discussed in *4.1 Summary of the Difference in ASW Yields for Municipal and Treasury Bonds* section and displayed in **Graph 2**, the regressions would potentially benefit from being adjusted for disturbances that are not i.i.d[23]. In other words, in a panel data setting where there are signs of heteroscedastic disturbances which are contemporaneously correlated across panels, it would be advantageous to substitute the described FGLS model for a linear regression with panel-correlated standard errors. Unfortunately, as not all bond pairs run over exactly the same time-frame, this removes some of the advantage of employing such a regression. In spite of this, much of the combined panel time-series are overlapping, and as such *4.6 Time and Contemporaneous Liquidity - Is Liquidity Just Capturing the Time Effect?* implements a panel-correlated standard error model as the standard error in that estimation process (i.e. the Prais-Winston regression) is often higher, allowing for more conservative statistical claims to be made.

For the current proportional bid-ask spread, we run a regression using the model presented below (where adjustments for heteroscedasticity and first-order autocorrelation are made as described in the previous section).

$$ASWMT_{it} = \beta(C_M - C_T)_{it} + \varepsilon_{it}$$

The results for both the above panel regression model and the panel regression using first differencing are reported in **Table 2**. Current liquidity is significant on the 1-percent level, providing the paper's first statistical insight as to whether the market prices liquidity. First differencing does not support this result, however, as the *t* test statistic is insignificant. The panel regression's coefficient of 0.159 is interpreted as the following: a one basis point increase (decrease) in the difference in muni and treasury proportional bid-ask spreads will increase (decrease) the difference in ASW muni and treasury yields by 0.159 basis points.

[23] Independent and identically distributed.

TABLE 2

Regression of Difference in ASW Yields Between Municipal and Treasury bonds on Contemporaneous Liquidity Differences Between the Same Bonds

This table shows the results of heteroskedastic and autocorrelation adjusted FGLS regressions of differences in ASW yields between municipal and treasury bonds (in basis points) on differences in contemporaneous proportional bid-ask spreads (in basis points) between the municipal and treasury bonds. Including dummies in the regression would increase the chi2, but give no information about how liquidity is correlated with yields.

$$ASWMT_{it} = \beta(C_M - C_T)_{it} + \varepsilon_{it}$$

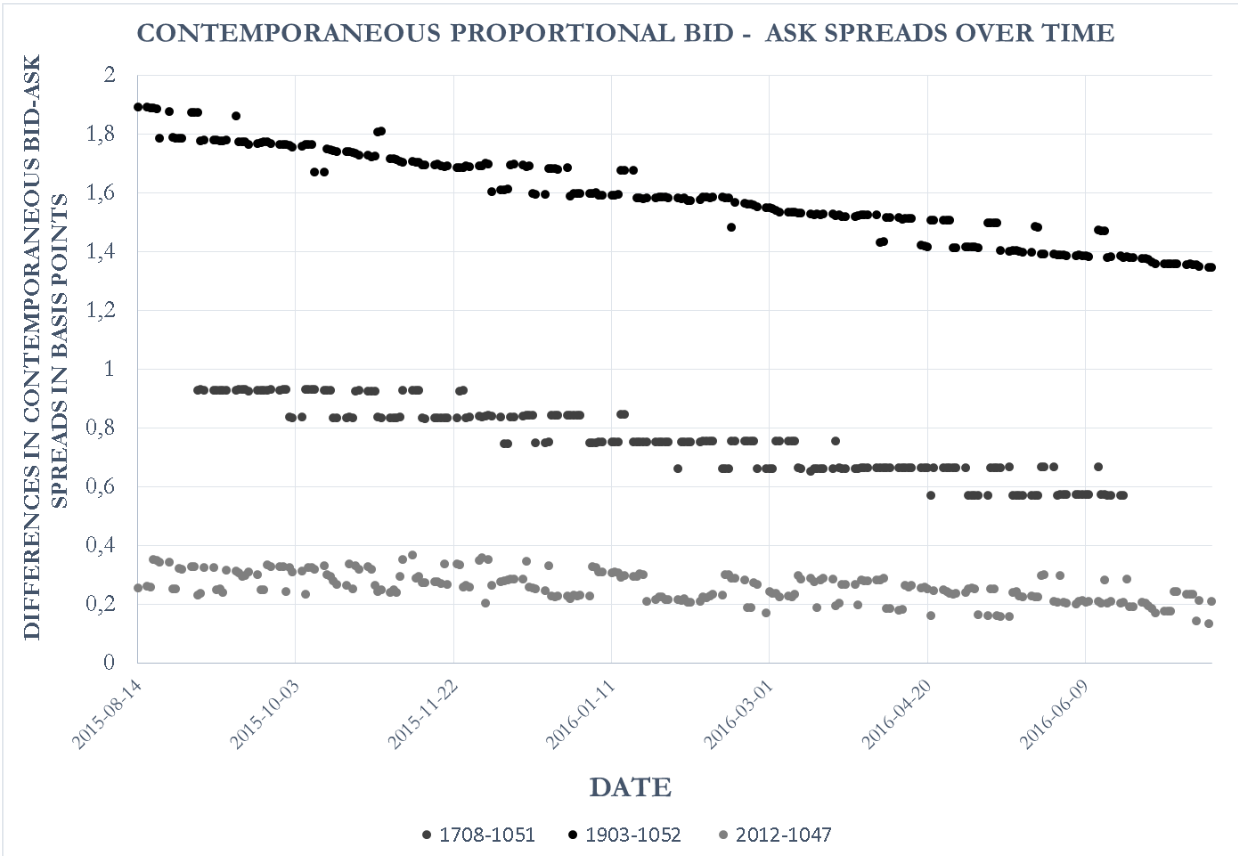
The regression is repeated in first-differences in the right side of the table. R-squared are not obtained in FGLS models.

	PANEL REGRESSION			PANEL REGRESSION (FIRST DIFFERENCES)		
	N obs.	Coeff.	St. error	N obs.	Coeff.	St. error
Contemporaneuous Liquidity Difference	5,273	0.159***	0.051	5,266	0.041	0.033
Constant		57.061***	2.289		0.066*	0.036
Chi2		9.73***			1.53	

Notes: *Significant at the 10 percent level; **Significant at the 5 percent level; ***Significant at the 1 percent level. N obs is 7 observations fewer using first differences as the first observation in every panel has no value to refer to.

To further investigate why first differencing returns non-significant results when examining the relationship between differences in current bid-ask spreads and differences in ASW yields, a chosen period of time between mid-September 2016 and the beginning of August 2015 is plotted with current spread differences along the y-axis. The three bond pairs with decreasing spread differences that are plotted in **Graph 5** effectively communicate that on an intra-day basis, movements can behave erratically. Bid-ask spread differences often shift, transitioning up and down, under the pretext of a more long-term downward movement. It seems quite reasonable, then, that since first differencing operates intra-day, insignificant results are obtained[24].

[24] To clarify, graph 5 does not show results after first differencing, but the actual differences in contemporaneous proportional bid-ask spreads.



Graph 5: In the above graph, the difference in contemporaneous proportional bid-ask spreads are shown over approximately a year between August 2015 and med-September 2016.

4.5 Contemporaneous and Future Liquidity - is Current Liquidity Just a Proxy for Future Liquidity?

Although the economic rationale underpinning the inclusion of future liquidity to the model specification is highly questionable, this study does so on the grounds that it helps clarify (i.e. separate) the relationship of contemporaneous liquidity *from* future liquidity itself.

Taking the above into consideration, the forthcoming regression adjusts for any potential effect future liquidity has on yields that may be inadvertently captured in the model's measure of contemporaneous liquidity. More specifically, the differences in contemporaneous liquidity premiums are orthogonalized relative to the measure of differences in future liquidity[25]. Should investors be truly forward looking and able to predict liquidity costs better than what would be

[25] This process is equivalent to regressing current liquidity on future liquidity, and taking the residual from that regression as the independent variable when then examining the potential effect current liquidity may have on yields.

expected given the lack of foreseeable cycles of liquidity, one would anticipate the orthogonalized measure of current liquidity to be stripped of most of its explanatory power. With that said, the now modified equation used to examine ASW yields follows:

$$ASWMT_{it} = \Upsilon(C_M - C_T)_{it}^{orth} + \beta(\overline{C_M} - \overline{C_T})_{it} + \varepsilon_{it}$$

Table 3 shows the results obtained from the above regression as well as the panel regression using first-differencing. Having now considered future liquidity, the test statistic in the panel regression indicates differences in contemporaneous liquidity between munis and treasuries can help explain our dependent variable, ASWMT. Differences in future liquidity are also significant in this regression, which challenges this study's voiced *a priori* expectations given the innate difficulty investors experience in gauging future muni and treasury liquidity. Reinterpreting this result, however, the reader should bear in mind that the orthogonalized nature of contemporaneous liquidity leaves its shared explanatory power with future liquidity in future liquidity itself. Using an orthogonalized measure in the regression is by construction a way of allowing a separate, more easily understood coefficient of contemporaneous liquidity. Even though future liquidity is

TABLE 3

Regression of Difference in ASW Yields Between Municipal and Treasury bonds on Orthogonalized Contemporaneous liquidity Differences and Future Liquidity Differences Between the Same Bonds

This table shows the results of heteroskedastic and autocorrelation adjusted FGLS regressions of differences in ASW yields between municipal and treasury bonds (in basis points) on differences in orthogonalized contemporaneous and future (averaged) proportional bid-ask spreads (in basis points) between the municipal and treasury bonds. The coefficient on the orthogonalized contemporaneous liquidity difference is stripped of any explanatory power relative future liquidity differences.

$$ASWMT_{it} = \Upsilon(C_M - C_T)_{it}^{orth} + \beta(\overline{C_M} - \overline{C_T})_{it} + \varepsilon_{it}$$

The regression is repeated in first-differences in the right side of the table.

	PANEL REGRESSION			PANEL REGRESSION (FIRST DIFFERENCES)		
	N obs.	Coeff.	St. error	N obs.	Coeff.	St. error
Orthogonalized **Contemporaneous** Liquidity Difference	5,273	1.277***	0.423	5,266	0.287	0.261
Future Liquidity Difference		1.340**	0.618		2.372	2.029
Constant		58.079***	2.318		0.065*	0.036
Chi2		14.02***			2.59	

Notes: *Significant at the 10 percent level; **Significant at the 5 percent level; ***Significant at the 1 percent level. N obs is 7 observations fewer using first differences as the first observation in every panel has no value to refer to.

statistically significant at the 5-percent level, differences in future liquidity in the form of average proportional bid-ask spreads cannot confidently be concluded to have causal implications on the prices of bonds. Moreover, as previously mentioned, there is little to lackluster economic intuition for subsuming investors can accurately predict muni and treasury liquidity changes. With respect to the first-differencing panel regression, the results are not significant for either liquidity measure, echoing the findings of Goldreich et al. (2005) after looking at intra-day changes over their time-series. In brief, including future liquidity and orthogonalizing contemporaneous (current) liquidity has served as an exercise to better separate the two, after which future liquidity is promptly excluded for the same economic reasons as alluded to previously.

4.6 Time and Contemporaneous Liquidity - Is Liquidity Just Capturing the Time Effect?

Due to the inherent relationship between time and yields, a variable comprised of days to maturity is added to the model specification, in line with Goldreich et al.'s (2005) design. If the measure of differences in contemporaneous liquidity is just capturing time to maturity, the obtained results would be spurious and have no 'real' explanatory power. The model is therefore re-specified in the following way:

$$ASWMT_{it} = \beta\tau_{it} + \Upsilon(C_M - C_T)_{it}^{orth} + \varepsilon_{it}$$

Notice that the measure of differences in future liquidity between the bond types is no longer included in the model, as motivated in the previous section. A question that may have occurred to the reader, at this point, asks why the panel is not set with days to maturity (as opposed to date) as the relevant cross-sectional time-series input. It might indeed, at first glance, seem appropriate given the natural relationship displayed in **Graph 3**. Statistical methods intent on doing so, however, would unfortunately make it impossible to apply the aforementioned linear regression with panel-correlated standard errors, discussed in greater depth shortly.

The results from the above specified regression are reported in **Table 4**. No first-differencing is reported this time as the collinearity in the resulting differenced days to maturity variable would be exceedingly high - an output value of -1 would consistently be obtained, set aside those few dates dropped due to missing ASW yields. The current liquidity bid-ask spread differences are still highly significant, despite a slightly lower coefficient, when taking into consideration days left to maturity.

As expected, the coefficient on days to maturity is highly significant, but should logically be seen as a control variable rather than a variable that provides any previously unknown information.

In **Table 4**, the results of the same model using panel correlated standard errors (xtpsce[26]) is presented. There are two main reasons for this amendment. First, **Graph 2** tells us that contemporaneous cross-sectional correlation is present. Second, the standard xtgls[27] method might suffer from anti-conservative standard errors as variance is implicitly assumed to be constant within panels. For most panels with many time periods, the xtgls model is often very useful since it is asymptotically efficient if all underlying statistical assumptions are met. When standard errors are not

TABLE 4

Regression of Difference in ASW Yields Between Municipal and Treasury bonds on Orthogonalized Contemporaneous Liquidity Differences Between the Same Bonds Time to Maturity

This table shows the results of heteroskedastic and autocorrelation adjusted FGLS regressions of differences in ASW yields between municipal and treasury bonds (in basis points) on time to maturity and differences in orthogonalized contemporaneous and future (averaged) proportional bid-ask spreads (in basis points) between the municipal and treasury bonds. The coefficient on the orthogonalized contemporaneous liquidity difference is stripped of any explanatory power relative future liquidity differences.

$$ASWMT_{it} = \beta\tau_{it} + \Upsilon(C_M - C_T)_{it}^{orth} + \varepsilon_{it}$$

The regression is then repeated using a Prais-Winston approach of estimating penel correlated standard errors on the right side of the table. The coefficients on contemporaneous liquidity are still statistically significant for both these approaches after taking days to maturity into consideration. Any common factor with future liquidity is excluded from our contemporaneous measure of liquidity. The chi2 is improved relative the previous regression since time to maturity was previously captured in the constant. An R-squared for the Prais-Winston regression is included, but should be interpreted with caution.

	PANEL REGRESSION				
		FGLS (xtgls)		Prais-Winston (xtpcse)	
	N obs. (for both regressions)	Coeff.	St. error	Coeff.	St. error panel correlated
Days To Maturity	5,273	0.044***	0.004	0.041***	0.001
Orthogonalized **Contemporaneuous** Liquidity Difference		1.155***	0.326	3.669***	1.274
Constant		21.020***	3.149	17.675***	1.336
Chi2		173.79***		1348.55***	
R-sqaured				0.073	

Notes: *Significant at the 10 percent level; **Significant at the 5 percent level; ***Significant at the 1 percent level.

[26] xtpcse is the STATA command that calculates panel-corrected standard error (PCSE) estimates for linear cross-sectional time-series models where the parameters are estimated by either OLS or Prais-Winsten regressions.

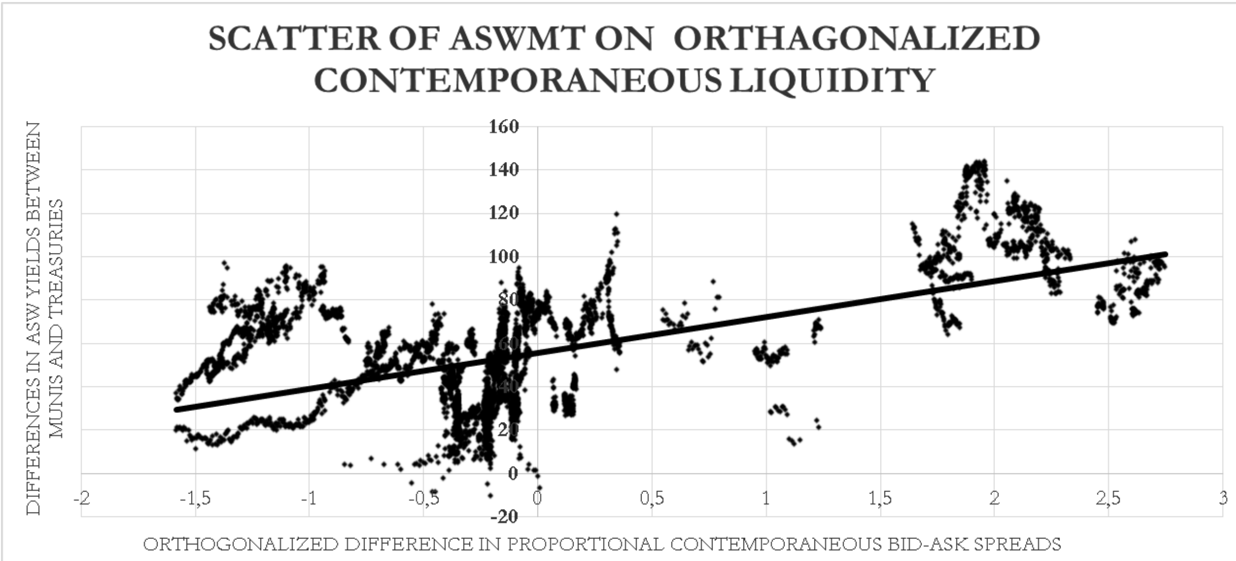
[27] xtgls is a STATA command that fits panel-data linear models by using feasible generalized least squares. This is the method used in sections *4.4 The Basic Regressions* and *4.5. Contemporaneous and Future Liquidity - is Current Liquidity Just a Proxy for Future Liquidity?*

constant within panels, a key assumption is violated, leading to said anti-conservative standard errors. The xtpcse regression, on the other hand, can account for non-constant standard errors using a Prais-Winston regression to estimate parameter values. Pairwise selection has to be specified, which allows the regression to draw conclusions using cross-sectional correlations even though the time-periods are not continuously overlapping (Vince Wiggins, 2017). Had the time periods been perfectly aligned, the xtpcse approach would have been used throughout this paper without any palpable drawbacks. Using both the xtgls and xtpcse, therefore, serves as a means to achieve robust results. The panel correlated standard error approach assumes autocorrelation by default (*ibid*), which is set as being panel-specific. With this approach, the orthogonalized coefficient on contemporaneous liquidity is still statistically significant on the 1% level after accounting for days to maturity, which provides further comfort and reassurance that current liquidity is equivocal in explaining the Swedish muni puzzle. The xtpcse regression also reports an R-squared. The total sum of squares from a xtpcse regression, however, cannot be usefully decomposed and interpreted in its traditional sense. As a quality measure of the model's explanatory power, therefore, the metric is unclear (Wooldridge, 2012) and hence left undiscussed.

There is another, perhaps more serious statistical consideration that needs to be addressed in order to claim that a liquidity premium exists and can help explain the differences in ASW yields. Since the regressions estimate a linear relationship between the dependent and independent variables, any drastically deviating data from a linear relationship would raise serious questions as to the appropriateness of this paper's modelling techniques. In **Graph 6**, a scatterplot of ASWMT and the orthogonalized measure of differences in current liquidity is shown[28]. Notice that, in general, the trend appears linear (as opposed to logarithmic or polynomial). Due to the scarce number of bond pairs though, the data appears to be far from randomly, evenly distributed around the trend line. This incites some cause for concern as to whether the model specification is truly valid and robust. Relief can be found in that GLS estimation (as opposed to regular OLS and weighted least squares) can effectively be used when correlation between residuals exists to a certain degree. The feasible (i.e. implementable) version of GLS, which is used in our regression models, is asymptotically efficient (Hansen, 2007), meaning that if the sample is not medium to small, the results are fully maintainable. Statistically speaking, then, the methods used are probable to be both sound and

[28] The line is not estimated by STATA, but rather through Excel as a simple method of facilitating the interpretation of the data points.

legitimate given the study's large sample of over 5,000 observations and corrections for the presence of heteroscedasticity and first-order serial autocorrelation (*ibid*).



Graph 6: In the above graph, the difference in ASW yields between munis and treasuries is plotted on the y-axis, and the orthogonalized difference in proportional contemporaneous proportional bid-ask spreads on the x-axis. Some negative ASW yield observations are left out to better illustrate the relationship.

Several key points of information regarding the explanatory power of contemporaneous liquidity on yields can be found in **Graph 6**. First, notice the existence of negative differences between the liquidity measures of munis and treasuries. This suggests that municipal bonds can, at times, be more liquid than treasury bonds. Moreover, even when this is the case, treasury bonds by and large still trade at a lower yield relative to munis. Second, when differences in bid-ask spreads are at their highest, ASW yield differences are almost exclusively highly positive. The lion's share of these data points relate to times when municipal bonds have been recently issued. As previously mentioned, this paper does not cover microstructure models of liquidity which focus on the 'origin' of liquidity. Yet the fact that there are highly-positive, instantaneous differences in liquidity bid-ask spreads upon issuance, and that these time periods correspond with high ASW yield differences, should prove valuable intel for market participants including KI and RiGä.

The less than perfectly linear relationship between the variables in **Graph 6** also seems to give rise to clusters of data. Spreads can remain relatively constant when yields move up and/or down. This can signal that investors react to general levels of bid-ask spreads (rather than reacting to changes in liquidity on an intra-day basis) and trade on that information. Such an interpretation would not contradict previous research or compromise the consensus understanding of flight-to-liquidity which, during times of market distress, need not be precipitated on drastic changes to liquidity in the short-term.

Examining the region around the general trend-line's y-intercept in **Graph 6** (i.e. the model's constant), the ASW yields are largely contained to the 10 to 100 basis points span. In the same vein, the regressions that take days to maturity into consideration (which is difficult to illustrate in two-dimensional space) estimate their model constants' 95% confidence interval to be 14.84 to 27.12 and 15.06 to 20.29 for the xtgls and xtpcse regression respectively. Both model variants scrutinized, therefore, showcase a sizeable and significant difference in ASW yields left to be explained even after accounting for liquidity.

4.7 Relating the Results to the Muni Puzzle

Having amended differences in current proportional bid-ask spreads through orthogonalization while accounting for days left to maturity in modelling differences in ASW yields, we are left with the task of relating the paper's findings to the muni puzzle. Given the hard-to-decipher R-squared of the regression based upon an FGLS approach, the interpretation of the results are grounded in other rationales. Specifically, a general discussion of the statistical power of our explanatory variables put in relation to the setting of this study is relevant. To recapitulate, the reader should recognize that in this study's climate, there should not be any default risk, tax-risk difference or varying exposure to the yield curve (i.e. interest rate risk) at work in the differences in ASW yields. Having limited the scope of this study to modelling liquidity, the only variables potentially omitted are those completely overlooked or neglected in *2.2 Literature Survey*. One such determinant springs to mind: the elusive and fleeting investor attention. Whether omitted or unnoticed, these variables undoubtedly seem to matter, as conveyed by the large (~20 basis points) and statistically significant model constants presented. These constants open up for interesting discussions regarding asset pricing factors that may not have been generally discussed in research examining the muni puzzle. At the same time, the panel regressions in sections *4.4-4.6* reveal a rather compelling story: contemporaneous liquidity matters in explaining yield differences between municipal and government bonds over the maturity spectrum, thus helping to explain the Swedish muni puzzle.

4.8 Concluding remarks

Differences in ASW yields reached levels of 178 basis points during the European sovereign debt crisis. Clearly, there are important asset pricing factors that differ between the two bond types: munis and treasuries. Liquidity premiums are a well-suited candidate in explaining the muni puzzle residual in an institutional context unencumbered by tax, credit or interest rate risk differentials in the municipal and government space. Operationalized as the commonly used measure of (proportional, contemporaneous) bid-ask spreads, liquidity premiums are statistically significant using two types of Feasible Generalized Least Squares (FGLS) methods. Discontinuous patterns of rather stagnant differences in current proportional bid-ask spreads under a longer downward trend suggest investors might not be reacting to short-term changes in liquidity. This observed phenomenon also makes first differencing less reliable and telling. Moreover, a highly significant constant shows absent variables remain important, opening up for discussions as to what unconsidered determinants in this paper's literature survey could potentially be influential in explaining the muni puzzle.

V. Discussion & Critical Reflections

Having analyzed a substantial amount of market movements and statistics, the results will now be critically reflected upon, related to the research question and put in context using the elements discussed in the theoretical framework. Three ways the results in this paper can be incorporated in other research are also discussed. Finally, the paper's findings are discussed from the view of societal knowledge contribution and implications for policymakers.

5.1 Connecting the Findings to Theory

Akin to Longstaff et al. (2005) and Bao et al. (2011), this paper demonstrates that the component of the yield not due to credit risk is time varying. Longstaff et al. (2005) also presented evidence that this residual component is related to macro liquidity measures in the bond market. No liquidity measures for the market (or models incorporating sensitivity to market wide liquidity) are presented in this paper, but given the known bond market characteristics during the European debt crisis, there are clear indications that the bonds analyzed in this paper also move with market wide liquidity.

Having delineated and analyzed the way bid-ask spreads behave both over time and relative to yields in the municipal and treasury bond market, it is more easily understood as to why a large corpus of measures continue to proxy liquidity in past and current research. Contemporaneous proportional bid-ask spreads, which should capture liquidity in an effective manner relative to many other measures, still experience the setbacks and odd movements displayed and described in **Graph 5** and **Graph 6**. Bao et al. (2011) and Amihud and Mendelson (1991) argue that liquidity is properly modeled if changes in measures of costs give rise to changes in bond prices. A natural consequence of the data characteristics in this study is then, of course, that this criterion cannot be met on a day-to-day basis due to the persistence in bid-ask spreads visible in **Graph 5**.

Some discrepancies are, however, to be expected between previous theory and the findings of new studies. It is especially reasonable to expect results which do not conform to earlier research when a method and logic (adapted from Goldreich et al. (2005)) is applied on an unfamiliar problem (i.e. the muni puzzle) in a market where the conundrum in question has not historically been addressed (i.e. the Swedish bond market).

Findings from Peng and Lin (2007) and Da and Zhi (2011) who analyzed the implications of investor attention on financial markets have been briefly mentioned, but otherwise generally overlooked. Whether the effect of an inclusion of variables capturing differences in investor attention would have been great enough to account for the documented constant in the model is a question future research ought to dedicate time and effort to.

5.2 The Research Question in a Broader Sense

The aim of this paper is not to solve the concept of the muni puzzle in its broadest sense. Indeed, such an undertaking would be to misunderstand the limitations of this study. In the US, which is where the muni puzzle is primarily discussed, researchers must consider default risk and tax implications *together* with liquidity, and consequently assign relative importance to these factors. A similar strategy is clearly not relevant in Sweden. Instead, the results can complement the research conducted in a more multi-factor market setting. There are at least three ways this paper can be considered in other research. Researchers can: (i) compare the unexplained difference between municipal and treasury bonds after their adjustment for credit risk and see if it resembles the data presented in section *4.1 Summary of the Difference in ASW Yields for Municipal and Treasury Bonds*[29] , (ii)

[29] Of course, other aspects must be considered simultaneously so as not to wrongly assume the Swedish municipal and treasury bonds are equivalent to the market instruments under study.

use the sections *4.4 Basic Regressions* to *4.7 Relating the Results to the Muni Puzzle* to potentially clear up some confusion whether liquidity matters after already having considered the aspects which are naturally eliminated in the Swedish market, (iii) further examine whether any remaining asset pricing factors have a significant enough explanatory power to 'fill the gap' that the constant in the final model in section *4.7 Relating the Results to the Muni Puzzle* now occupies.

5.3 Knowledge Contribution and Implications for Policymakers

KI can be studied by initiative takers including the academics, business leaders and former public policy makers behind the Hamilton project (discussed in *I. introduction*). Since KI has successfully lowered the borrowing costs for the Swedish municipalities, it can serve as an example not just for the US, but also other countries internationally. The results discussed in section *4.7 Relating the Results to the Muni Puzzle* have further implications for policymakers where organizational bodies pooling municipal bonds are already implemented. The fact that there is still a yield differential between KI's and RiGä's bonds having considered liquidity implies that policymakers might have to consider other aspects like investor attention. Implementing an organizational body similar to KI might not, therefore, be enough to lower the costs associated with providing financing to municipalities to desired levels.

5.4 Future Research

Given the significant constant in the regression models, further research is needed to fully understand the Swedish muni puzzle and with it, the muni puzzle at large. Identifying and quantifying other factors than credit risk, tax related effects, interest rate risk, and underwriter reputation could also be of interest internationally.

Future research could also examine the effect of quantitative easing (QE) on the yields of municipal and treasury bonds. In Sweden, QE is an extensively used monetary policy. Interestingly, KI has in an open letter to the Swedish central bank asked them not to buy their bonds for liquidity reasons (Munkhammar, 2016).

VI. Limitations of research

6.1 Data

Accessing data for all bond pairs needed to calculate relevant, valid measures of liquidity proved to be difficult. Consequently, the conclusions relating to whether a liquidity premium can explain the Swedish muni puzzle are exclusively based on measures of the bid-ask spread. Including other measures could potentially strengthen or nuance the view of the existence of a liquidity premium. Then again, the proportional bid-ask spread has proven to be a highly valid measure of liquidity in the related literature, and its significance using two statistical methods in this paper reinforces that finding. Furthermore, including certain variables for reasons only pertaining to the quantity of coefficients can have undesired effects. For example, consider the study by Aitken and Carole (2003) where the researchers study volume before and after the crisis on the Jakarta Exchange. The results indicated a sharp, 51% trading volume increase, suggesting the crisis had positive implications on liquidity. The market consensus, on the other hand, was that a liquidity crisis was unfolding.

Using finer data, such as hourly or minute data, would from a purely theoretical standpoint be closer to the essence of liquidity, and could potentially capture the relationship between yields and liquidity in a different fashion. Then again, the reader should recall that finer data is not necessarily more accurate, and the value added to the analysis of such an inclusion might not be worth the time and effort that it entails. Adding more data points in a paper like this might be particularly useless when considering the already discontinuous patterns characterizing bid-ask spreads (apparent in **Graph 5**).

Analyzing a larger amount of bond pairs would, however, be beneficial to the study. Seven bond pairs are quite substantially fewer than the 55 that are used in the research by Goldreich et al. (2005). Relatively few panels, with different lengths, running over different periods, become statistically challenging. Furthermore, graphical presentations and interpretations become more difficult, burdening the economic intuition, with data displaying these characteristics. The scarcity of bond pairs comes with a silver lining, however: having excluded real bonds, T-bills, callable bonds and non-SEK denominated bonds, as well as only used bonds with perfectly matched maturity dates, the data set becomes highly statistically analyzable without extensive model-modifications. Consequently, the results of this paper do not have to rely on yield curve extrapolation or any other type of estimation procedure which relies on assumptions about risks, investor behavior or other asset pricing factors. The same cannot be said about the method of Goldreich et al. (2005), for instance, where corrections for asynchronous quotes are made to avoid the distortionary effects intraday interest rate changes may have on obtained results. Moreover, to fairly compare papers regarding the data sample, one should consider the lengths of the time series. For some bond pairs, the series ranges several years, whereas in Goldreich et al. (2005), and of course other similar research, the series are considerably shorter. In total, this paper considers over 5,200 observations, compared to the 1,210 in the paper from Goldreich et al. (2005)[30].

6.2 Models

One primary limitation regarding the model used is that the regressions and estimated coefficients are difficult to interpret. The dependent variable is expressed in basis points (in a yield difference context). The independent variable is also expressed in basis points, but in an orthogonalized form and based on a difference in two proportions (as defined in *4.2. Describing the Variables and Our Panel Data*). This might cause confusion, especially given that the panel correlated method yields a coefficient which differs from the standard cross-sectional time-series FGLS regression. If future, (i.e. average) liquidity had been of primary interest, the coefficient on that variable could have been interpreted as the marginal investor's per-year probability of trading[31]. In a conservative manner, the reader of this paper should instead consider the statistically significant coefficient as a general indication for the correlation between trading liquidity differences and yield differences.

Another limitation in this paper is that the clientele effect due to investment horizons has not been modeled. A nonlinear relationship can in theory exists between liquidity and yields. There are two reasons for why this phenomenon has not been examined further. First, drawing inspiration from Goldreich et al. (2005), who does not make such a correction, the risks from including clientele effects (e.g. risks of model misspecification or further complicating the coefficient interpretation) was believed to be higher than the potential benefits associated with its implementation. Secondly, no clear indication for a nonlinear-relationship was found.

One aspect that has been consistently discussed throughout this paper is how investor attention is thought to affect yields. The lack of modeling of such a factor undoubtedly affects this paper's capability in drawing more nuanced conclusions. One can further imagine that liquidity and investor attention are (positively) correlated, introducing omitted variable bias in the regression

[30] Of course, the papers are not perfectly comparable since Goldreich et al. (2005) averages their dependent variable by the cross section of bond pairs, and also uses seven measures of liquidity in total.
[31] The reader is directed to Goldreich et al. (2005) and Amihud and Mendelson (1985) for the intuition behind this interpretation.

models. As discussed in *2.2.5 Investor Attention* though, collecting and analyzing relevant information is not always easy. Even with google search frequency based measures, such a procedure is not straightforward. Discussions regarding market efficiencies would realistically also have to be incorporated, which complicates the analysis drastically.

VII. Conclusion

With comparable credit risk and identical tax treatment, the municipal and treasury bonds issued by *KommunInvest* (the Swedish Local Government Debt Office) and *Riksgälden* (the Swedish National Debt Office) respectively, serve as ideal candidates for examining the impact of liquidity premiums on bond yields. Using data from Bloomberg and Thomson Reuters, this paper finds that despite the fundamental similarities between Swedish munis and treasuries, a substantial and enduring difference in their (ASW) yields exists in the longer end of the yield curve, reaching levels of 178 basis points during the European sovereign debt crisis. This is the Swedish embodiment of the more traditionally US-dominated muni puzzle. In examining the research question "Can liquidity premiums explain the Swedish Muni Puzzle?", non-callable, SEK-denominated, non-real munis are paired with perfectly maturity-matched treasuries - yielding a total of seven bond pairs stretching over a combined 5,200 observations between September, 2010 and March, 2017.

Liquidity differences are operationalized as the proportional bid-ask spread of the muni subtracted by the proportional bid-ask spread of its treasury pair. To estimate a measure of future liquidity, all coming contemporaneous (current) measures of liquidity are averaged at each time *t*. Orthogonalizing differences in contemporaneous liquidity relative the differences in future liquidity, the effect of current liquidity is isolated. Adjusting for days to maturity, the ASW yields of the seven bond pairs are regressed against the orthogonalized measure of differences in contemporaneous liquidity bid-ask spreads. In the final model, both a cross-sectional time-series Feasible Generalized Least Squares (FGLS) method adjusted for heteroscedasticity and panel-specific autocorrelation and a panel correlated standard error regression are used.

The coefficients on the measure of liquidity are statistically significant on a 1 percent level for both regressions, thus suggesting liquidity premiums help explain the Swedish muni puzzle. A constant in the region of ~20 basis points also opens up for discussions regarding thus far potentially overlooked variables, including investor attention. Three ways our research can be incorporated and considered in other, future research are suggested. Policymakers having implemented similar organizations to KommunInvest would be wise not to neglect due consideration for the muni puzzle's antecedents other than its mainstream determinants, captured in this paper's constant.

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