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The Effect of the 2006 Market Makers Reform on the Liquidity of Local-Currency Unindexed Israeli Government Bonds in the Secondary Market

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השפעת רפורמת עושי השוק על רמת הנזילות בשוק איגרות החוב הממשלתיות השקליות

ינון גמרסני

תקציר

בספטמבר 2006 הושלמה רפורמת עושי השוק בשוק האג״ח הממשלתיות השקליות בישראל. עבודה זו בודקת אם הרפורמה הצליחה להשיג את אחת ממטרותיה העיקריות – הגדלת הנזילות בשוק המשני של האג״ח הממשלתיות השקליות. תחילה מתייחסת העבודה לנושא הנזילות בכלל, ובשוק האג״ח בישראל בפרט. העבודה מיישמת על שוק האג״ח הממשלתיות השקליות קבוצה רחבה של מדדי נזילות שונים, המתייחסים לפעילות השוק, עלות הנזילות ועומק השוק. בהמשך נאמדת השפעת הרפורמה על כל אחד ממדדי הנזילות. התוצאות מעלות כי הרפורמה אמנם העלתה את רמת הפעילות בשוק, אולם לא הצליחה להקטין את עלות הנזילות או להגדיל את עומק השוק. בעבודה מוצעים שני הסברים לכך: האחד – המירווח המקסימלי במערכת ה-MTS גבוה מדי; השני – פעילות עושי השוק בבורסה אינה תומכת בהספקת נזילות לשוק. העבודה גם מניחה יסודות ראשונים למדידת הנזילות בשוקי האג״ח בישראל.

The Effect of the 2006 Market Makers Reform on the Liquidity of Local-Currency Unindexed Israeli Government Bonds in the Secondary Market

Inon Gamrasni

Abstract

The extensive Market Makers Reform, established for local-currency unindexed Israeli Government bonds, was completed in September 2006. The paper examines whether one of the main goals of the reform—to increase the liquidity of secondary nominal government bonds—has been attained. First, the paper covers the liquidity issue, defining a set of liquidity indices that refers to market activity, liquidity cost and market depth. Second, the paper estimates the reform's impact on each of the liquidity indices. The results indicate that, although the reform did improve market activity, it did not improve either liquidity costs or market depth. The paper suggests two possible explanations: the maximum spread within the MTS system was too high, and the market-maker activity did not support the liquidity supply. In addition, the paper lays a preliminary foundation for measuring liquidity in the Israeli bond markets.

1. Introduction

The level of liquidity in the capital market and the securities traded on it (and the measurement of that liquidity) is important for all types of players in the market. The investor, whether private or institutional, wants the market to be as liquid as possible. A liquid market will enable the investor to buy or sell securities whenever he chooses, at minimal cost (beyond the price of the security). Stock Exchanges, investment banks, and financial intermediaries must take liquidity into consideration in their decisions—for example, which securities will move to the hold list; which will not be recommended, despite their high returns, because it will be difficult to sell them at the proper time; and which bear low liquidity, for which over-the-counter trade is worthwhile, at the cost of higher intermediary fees.

Measuring liquidity is also important for regulators, so that they will identify whether market trading is efficient enough, or whether it is necessary to improve its efficiency through structural, legislative, and other changes. By measuring liquidity, the regulatory agencies can later check the degree to which the changes they initiated were successful. Measuring liquidity also helps in the selection of bonds as market benchmarks, and in determining the dispersal and volume of government bond issues. Furthermore, a drop in liquidity on the markets may indicate conditions for a financial crisis. For these reasons, it is very important to monitor the development of liquidity in the markets.

In this study, we will examine the development of liquidity following the market makers reform in the government bond market that took effect in the second half of 2006, in which market makers were appointed for nominal government bonds. At the same time, a separate trading system for market makers was launched, which included an obligation to regularly quote the supply and demand prices. The reform had a number of declared goals, one of which was to improve liquidity in nominal government bonds on the secondary market.

The unindexed (nominal) government bond market features a high level of liquidity, compared with indexed government bonds, among other things as a result of a change in the policy for issuing government debt—a switch from issuing many small series to a smaller number of series, each of which has been significantly enlarged. The question is whether the

market makers reform caused further improvement by increasing liquidity in the nominal government bond market on the Tel Aviv Stock Exchange (TASE).[1]

In seeking to answer this question and similar questions relating to liquidity, we are faced with the problem of the vagueness of the concept of liquidity. It is easy to determine whether or not liquidity exists, but it is more difficult to define or measure it. In order to replace this vagueness with clarity, tools for quantifying liquidity must be used. It seems, however, that there are a number of different measures, each relating to a different aspect of liquidity, and not all of which always indicate the same development of liquidity. As has been done in other studies relating to other capital markets around the world, this study will define a group of measures representing different aspects of liquidity, and will then evaluate the effect of the market makers reform on liquidity in nominal government bonds.

The next section describes the market makers reform instituted by the Ministry of Finance in 2006. The paper then addresses the definition of liquidity and the measurement of liquidity in the context of government bonds in general and in the Israeli economy in particular, and reviews the relevant literature. The measures of liquidity calculated in this study will be presented afterwards. After describing the government bond market in Israel on the basis of the data and background conditions, the effect of the market makers reform on the various liquidity measures will be estimated. Finally, the paper will attempt to explain the results and summarize the findings.

2. Principles of the 2006 Market Makers Reform

The market makers reform was initiated as part of a larger package of changes relating to the management of government debt. As part of these changes, the management of government bond issues passed from the Bank of Israel to the Ministry of Finance. The Bank of Israel effectively ceased issuing government bonds by the end of March 2006, and in June 2006, management and implementation of the issues was officially handed over to the Ministry of Finance, which immediately began to hold tenders. The format and management of the

[1] Trading in nominal government bonds also takes place in the over-the-counter market, and it is possible that the reform also had an effect on the state of liquidity in that market. This study evaluates only the effect of the reform on liquidity in trading in government bonds on the TASE platform.

tenders for which the Ministry of Finance was responsible differed in several respects from the tenders conducted through the Bank of Israel.

First of all, the new tender platform was based on the Bloomberg tenders system. This system, which has been adapted for the Israeli market, is known to investors around the world, and has facilitated easier entry of foreign investors into the local government bond market. In addition, the names assigned to government bonds were changed, legislation was passed to allow for early redemption of the government bonds, ex-dates and the dates on which bonds could be issued were defined, etc.

Secondly, primary dealers, both local and foreign, were appointed, and received preference in nominal government bond tenders. Unlike the pre-reform situation, when tenders were open only to local banks and TASE members, the primary dealers can be banks or investment houses. As part of the reform, it was determined that 80 percent of any new issue would be earmarked exclusively for primary dealers, while the remaining 20 percent would also be open to local banks and TASE members. Nineteen primary dealers were appointed when the reform was launched, but their number dropped to 17 at the end of December 2007.[2]

The primary dealers were also entitled to a greenshoe allocation on the day following the tender, amounting to 15–18 percent of the volume of what they won in the tender (as of the sample period), at the average actual weighted price in the tender (the tender is a discriminatory price auction). The goal of the greenshoe allocation is to encourage the primary dealers to bid higher prices in the tender itself with the aim of upgrading their greenshoe entitlement, thereby lowering the government's debt raising costs.

At the same time, an exclusive trading system for the primary dealers was launched, based on the MTS company's trading platform (hereinafter – "MTS system" or "MTS"), so that only primary dealers are permitted to use it for trading. The purpose of the MTS system is to create an environment for foreign primary dealers similar to their familiar overseas environment.[3] The existence of this system also facilitates greater liquidity in the market by allowing primary dealers to manage their inventory effectively, thereby cutting the cost of

[2] Fourteen primary dealers operated in 2010: eight local and six foreign.
[3] This is because in a number of key overseas markets, it is accepted that the main market for trading in government bonds operates through trading systems that resemble the MTS system, and which feature OTC trading confined to dealers.

liquidity in the market. For this purpose, a lending facility of domestic government bonds exclusively for the primary dealers was also launched as a substitute for the repo market, which does not exist for government bonds, as a backup in case of a shortage in the bond inventory, in order to meet the quotation obligations in MTS (see below for a description). In this way, the primary dealers can borrow government bonds (both CPI-indexed and unindexed) from the Ministry of Finance, up to NIS 500 million per primary dealer, at the Bank of Israel interest rate minus 0.25 percent (as of the sample period).

Together with their various advantages, the primary dealers also have obligations. Two of the most important of these are the obligation to purchase at least 5 percent (as of the sample period) of the volume of government bonds issued (the purchase obligation) in the Ministry of Finance tenders (the primary market), and to provide quotations for all the relevant nominal government bonds (bonds with a term to maturity longer than one year and an issued par value of at least NIS 2 billion for regularly issued bonds, and at least NIS 4 billion for all other bonds) at least four trading days a week (Monday through Thursday) for at least five hours a day (quotation obligation). The quotation must be within the bounds of the maximum spread, and no less than the minimum quoted quantity determined from time to time by the Ministry of Finance.

The Ministry of Finance conducted the bond tenders for the first time using the Bloomberg system in June 2006, with the participation of the primary dealers. Trading through the MTS trading system also opened in September 2006, thereby completing all the planned reform measures. Concurrent with the Ministry of Finance reform, the TASE also initiated a number of changes that became effective on the date on which the MTS system went into operation. The first included appointment of market makers in government bonds on the TASE itself (to be distinguished from the market making to which the primary dealers were committed on the MTS). In practice, all the market makers in government bonds on the TASE were also primary dealers in nominal government bonds appointed by the Ministry of Finance. Seven market makers appointed by the TASE began operating on the TASE in September 2006. Five market makers currently operate on the TASE, all of which are local banks. The business hours on the TASE were extended by 50 minutes, lengthening the trading day by over 10 percent to 7 hours and 45 minutes. The main purpose of this measure was to increase the

overlap of trading hours in Israel with those of overseas stock exchanges, thereby encouraging the entry of foreign investors.

The main purpose of the reform is to cut the government's debt raising costs. Its planners also expected additional benefits: the entry of foreigners, market development, increased liquidity in the secondary market, and enhancement of transparency. As stated above, in this study, we will evaluate only the reform's contribution to liquidity in the secondary market on the TASE. Liquidity in this market was both a goal of the reform in itself and a result of achieving the other goals, such as market development—because a more developed market is more liquid—as well as a means of cutting the government's debt raising costs. When the secondary market is more liquid, the investors will demand a lower liquidity premium in the primary issues market.

3. Defining Liquidity

In order to measure liquidity, we must first define it—a definition that has puzzled many financial researchers. In the broad sense, a liquid market is one in which any quantity of a security can be bought or sold at the desired point in time, at a price reflecting its economic value, and at minimal cost. There are researchers who use a shorter definition, such as: "A completely liquid market is one in which trading takes place at no cost" (O'Hara, 1995), but the broad definition reflects a number of different aspects, as specified in Kyle (1985).

The first aspect is market depth—the capacity of the market to absorb and carry out an order of any size whatsoever. Market depth is expressed in limit orders for large quantities, both around the market price and differing widely from the market price. (Sarr and Lybek (2002) separate this aspect into two: market breadth and market depth.) The second aspect is immediacy of trading—the amount of time that it takes for a buy or sell order put on the market to be carried out. Among other things, this aspect depends on the speed at which information is distributed and the availability of the information to the various players. These factors have greatly improved all over the world in recent years, including in Israel, following technological improvements in the computer and communications systems, which have made a decisive contribution to improvement of liquidity levels in all markets.

The third aspect is flexibility—the capability of the market to rapidly revert to a price reflecting the economic value of a security, following a deviation from this value (for example, following a transaction for a particularly large quantity). A rapid flow of new orders makes this rapid reversion possible by bringing the market price back close to the economic price. The fourth and last aspect is tightness—how close the best supply and demand prices are to each other. A smaller gap between the best supply price and the best demand price (hereinafter: "the spread") means that an investor seeking liquidity will bear a lower cost. On the other hand, if the level of tightness is low (meaning that the spread is wide), an investor wishing to buy/sell immediately must make an order at a price that is higher/lower than the economic price of the asset, meaning he must bear a higher cost than when the level of tightness is greater.

4. Liquidity and Government Bonds

Demsetz (1968) found that the size of the spread, as a measure of liquidity in the stock market, is explained by the share price, the number of shareholders, and the number of markets in which the share is traded. Bonds have different characteristics than shares, which require a different approach in calculating the various estimates. Tanner and Kochin (1971) found that in the government bond market, the size of the spread is explained by the term to maturity of the bond (+; a positive impact on the size of the spread, and therefore a negative impact on the liquidity level), the total par value issued (-), the size of the coupon (-), and the yield to maturity (+). Bildersee (1980) showed that the factors explaining the size of the spread can be restricted to the total par value issued (-) and the standardized average duration (+), which in effect includes within it the term to maturity, the yield to maturity, the size of the coupon, and the bond price.

At the same time, it should be kept in mind, as shown by Chordia, Sarkar, and Subrahmanyam (2003), that there are also common factors that affect liquidity in both stocks and bonds, such as monetary policy and the trading system, and reciprocal effects between the

stock market and the bond market.[4] Stahel (2003) showed that global factors also affect liquidity.

The trading system on the TASE is based on limit orders arranged in an orders book (hereinafter: an "order-driven market" system). In this trading system, there is no intermediary between the buyer and the seller; the trading floor brings them together, and they buy and sell the security directly between themselves. As a result, there is a single transaction price that represents the value of the security at the point in time at which the transaction is carried out.

The liquidity measures, on the other hand, were developed on the basis of markets in which the trading system uses intermediaries (market makers), who are obligated to quote an ask price and a bid price at any given time (hereinafter: a "quote-driven market" system). The market maker buys a security from the party holding it at the ask price, and adds the amount purchased to his inventory. On the other side, the market maker sells a security from his inventory to the buyer at the bid price. In this trading system, at any given time, there are two prices that simultaneously represent the value of the security: the ask price and the bid price. These and other differences require adjustments of the liquidity measures, so that they will also be suitable for order-driven markets.

At the beginning of the 1990s, other order-driven markets began operating in Paris, Hong Kong, Toronto, and other places, and in recent years, on the New York Stock Exchange (NYSE) and other key US markets. The trend is towards allowing the simultaneous operation of both trading systems. The spreading use of the order-driven markets system has also inspired a suitable approach for the liquidity measures. Lee and Ready (1991), Glosten (1994), Irvine et al. (2000), and many others have contributed to the development of the measures for a market operating on the order-driven market system—adjustments that are theoretically, empirically, or technically necessary, and which have simplified the calculation process in most cases.

The measurement of liquidity has focused on the tightness aspect, which reflects the cost of liquidity for an investor by estimating the spread. The focus on the spread as an estimate of

[4] For further discussion of the differences between the stock market and the government bond market, see Gravelle (2002).

liquidity is due to both a broad theoretical background[5] supporting the spread as an estimate of liquidity and to the availability of the data necessary to calculate the spread. With the computerization of trading, improved trading methods and data collection, and the greater availability of intraday data, research began to estimate additional liquidity measures relating to the other aspects of liquidity more frequently.

To summarize, the availability of the data needed to measure liquidity in the government bond market as a result of technological improvements in the US capital market has made it possible to develop a theoretical background for liquidity measures relating to aspects other than tightness. More extensive use of the trading system prevailing in Israel, which is based on limit orders listed in an orders book (an order-driven market) has led to the adaptation of the measures developed in quote-driven markets to this trading system as well. This combination of factors has also created a sufficiently broad infrastructure for measuring liquidity in the government bond market in Israel.

5. A Review of the Literature

In addition to the spread between supply and demand prices, the first studies about liquidity in government bonds also focused on the additional amount that investors are willing to pay for liquidity, beyond the bond price itself (hereinafter: the "liquidity premium"). Amihud and Mendelson (1991a), Kamara (1994), Cheung, de Jong, and Rindi (2003), and others compared the liquidity of on-the-run government bonds (the most recent bond issued for a given time to maturity) to the liquidity of off-the-run government bonds (the last bond issued for a given time to maturity before the on-the-run bond for the same time to maturity). This was done by measuring the spread for each of them. The two bonds have the same cash flow and issuers risk, but one of them (the off-the-run bond) has been in the market for a longer time.

They found that on-the-run bonds are more liquid than off-the-run bonds, because their average spread is narrower. Furthermore, they found that the yield on on-the-run bonds was less than the yield on the corresponding off-the-run bonds, and concluded from this that the investors were willing to pay a premium for this liquidity.

[5] A summary of the main theoretical approaches that led to a focus on the spread can be found in Madhavan (2000).

Together with the spread, the liquidity premium for bonds was the main object of early research into the liquidity of government bonds. In contrast, Strebulaev (2002) ruled out the existence of the liquidity premium, and explained the findings through different tax rates, non-overlapping maturity dates, and other things. This would mean that the cost of liquidity was reflected exclusively in the spread between the supply and demand prices, and not in a higher price for bonds with greater liquidity.

In Israel, the period of time between the times to maturity of nominal government bonds was around one year, and sometimes longer. In this case, the yield curve has a positive slope (a rising curve), meaning that the yield to maturity of an off-the-run bond (which is also the bond with a shorter time to maturity) is much lower than that of an on-the-run bond, and the result will be a negative liquidity premium. This measure is therefore irrelevant to the Israeli market.[6]

In Greece, where the differences in time between the terms to maturity of government bonds are similar to those in Israel, Christodoulopoulos et al. (2005) found that the liquidity premium in the bond market was indeed negative. This contrasted with the study of Fleming (2003), which found a positive liquidity premium in the US bond market, where there is an overlap between the terms to maturity of on-the-run and off-the-run bonds.

The surplus liquidity of on-the-run bonds in the US is explained by two factors. First, an off-the-run bond is on the market for a longer time, so that a large portion of its issued quantity is "locked up" in the investors' investment portfolio, and the liquid amount available for trading is correspondingly less than for an on-the-run bond (Amihud and Mendelson, 1991). In Israel, this factor is less self-evident, because a bond usually reverts to being on-the-run even after it has been off-the-run on the market for a long time[7], so that at the time it reverts to being on the run, a large portion of its issued quantity has already been "locked up". In addition, the new issued quantities in that stage of the bond are small, compared with the quantity previously issued. The "locked up" quantity is therefore relatively large, certainly in comparison with bonds that only recently turn to off-the-run bonds.

[6] When the yield curve decreases, a positive liquidity premium is obviously expected, but this will be upwardly biased, for the same reason.

[7] This occurs, for example, when a bond that had been issued with10 years to maturity, becomes an off-the-run bond when its time to maturity becomes much shorter than the 10-year benchmark, and reverts to being an on-the-run bond as its time to maturity draws close to the 5-year benchmark.

The second factor is the developed repo and futures markets signed for certain series, which are usually on-the-run. The demand created for them as a result of their being underlying assets for derivatives is what makes them more liquid and higher-priced (with a correspondingly lower yield). In Israel, the futures market was negligible during the sample period, as was the repo market, which existed only for *makam* (STLs). In view of this, and also due to other problems (see Fleming, 2003), we will not include the liquidity premium as one of the measures in our comparative analysis below.[8]

As noted above, developments in computerization and collection of trading data in recent years have led to the development of additional liquidity measures, beyond the spread and the liquidity premium. Sarr and Lybek (2002) examined the level of liquidity in the stock market, the foreign exchange market, and the government bond market, with reference to measures relating to all four aspects: market depth, immediacy, flexibility, and tightness. At the same time, the database at their disposal included only daily or less frequent data. Since they had no intraday data[9], the liquidity measures that they used provide a rather rough measurement of liquidity, since they are more suitable for use with intraday data.

The importance of using intraday data in measuring liquidity is a result of its definition. Among other things, liquidity means the ability to trade a security at any point in time that an investor wishes. Assuming that we are using the spread at the end of the trading day as a measure of liquidity, this spread represents the state of liquidity at the end of the trading day. It is possible that the levels of liquidity are completely different during the trading day. In practice, many studies have shown that according to all of the measures, liquidity varies during the trading day.

Cyree and Winters (2001) show that, like other markets, such as the stock market and the futures market, there is a regular pattern in the government bond market of lower liquidity at

[8] Even though in the type of comparative analysis that we use, what is important is the development of the index over time, not its value (Christodoulopoulos et al. (2005)), and since the measure can be calculated for at most two shekel bonds, as a result of the small number of series in the "Shachar" market in Israel, the value, together with the liquidity premium for the other measures, is negligible.

[9] Intraday data are trading data sampled many times during the trading day, not merely at its end or beginning and the like. The term "intraday data" sometimes refers to data sampled at defined intervals, such as five minutes or 30 minutes, and can also refer to data that include any trading movement in a security (tick-by-tick), including any change in the orders book for any reason whatsoever, and any transaction actually carried out.

the beginning and end of the trading day, with higher levels of liquidity at mid-day. Data representing a single point in time, such as the daily figures, therefore do not represent the liquidity for the market players. On the other hand, daily averages, based on intraday figures, represent the level of liquidity during the entire trading day, and therefore constitute a more exact reflection of the state of liquidity in the market actually experienced by the investors and traders.

Fleming (2003) examined the liquidity of the US government bond market by also making use of intraday data. He used the following measures in his study: turnover, trading frequency (the number of transactions per time unit), the spread between the supply and demand prices, the quoted quantity, the transaction size, the price impact (hereinafter: "PI"), and the liquidity premium. Combining the measures makes it possible to obtain a complete picture of all four aspects of liquidity.

Fleming began by defining that a good measure of liquidity should (1) be based on quantification of the cost of liquidity for an investor; (2) correspond to the prevailing conception of liquidity in the market; (3) be easy to calculate and understand; and (4) be available in real time. The problem with this definition is that a market consensus that during a given period, the entire market, or a specific security, was more liquid than during a different period does not always exist. On the other hand, in the US, following the 1998 crash in the capital markets, it was universally agreed that the level of liquidity in the market was especially low, a fact that helped Fleming select a representative measure for liquidity. He found that the spread and PI were the most suitable good measures of liquidity, but the spread was preferable to PI because it was easier to calculate and understand, and was available in real time. A calculation of the correlation between the spread and the PI showed that it was high, and the spread could therefore serve as a sole measure of liquidity.

Christodoulopoulos et al. (2005) conducted a similar examination of liquidity in the government bond market in Greece, and arrived at the same result—that the spread and PI could be used as measures representing the level of liquidity in this market, with preference for the spread, because it is easier to calculate. On the other hand, D'souza, Gaa, and Yang (2003) found that in Canada, although the spread and the PI were the most suitable measures of liquidity, the measures of market activity (turnover and trading frequency) were highly

correlated with the spread and the PI, and since the former were simpler to calculate, they were preferable, according to Fleming's definition, for representing the level of liquidity in the Canadian government bond market.

It is important to note that the studies examining the level of liquidity in the government bond markets in the US, Canada, and Greece, which took into account measures relating to all four aspects, and other studies relating to liquidity in the government bond market, used only data for trading between market makers, who account for most of the trading in government bonds in those markets. In contrast, the current article will evaluate liquidity according to trading data for the public at large (not only market makers) on the TASE, where most trading in government bonds in Israel takes place. Another point in the context of studies relating to all four aspects of liquidity is that the measures that were examined do not allow for a complete comparison of liquidity between different bonds, because these measures do not include adjustments for the term to maturity, nominal interest rate, size of the series, etc., which affect liquidity. This study performs the main adjustments necessary to facilitate a comparison between liquidity in different bonds, both by calculating the measures as a proportion of total issued capital and by using yield to maturity instead of prices.

There has been very little research over the years involving the measuring of liquidity in the various capital markets in Israel (the stock, foreign exchange, government bond, and corporate bond markets). Amihud, Mendelson, and Lauterbach (1997) examined the effect on liquidity of the transition to the 'continuous trading sessions' system on the TASE, which began in 1987. They found that after a share switched to trading using the 'continuous trading sessions' system (in which each security is traded several times a day, in contrast with the previous situation, in which each share was traded once a day), its liquidity improved considerably in terms of the size of its spread, volatility, and turnover. Furthermore, they found that a share that had switched to trading using the new system generated a higher than normal yield in the period following the transition, compared with the normal yield obtained before the transition to the new system. They also found improvement in the liquidity of other securities related to a share that switched to trading using the new system. The transition to the 'continuous trading sessions' system is a structural change in the capital market that contributed to the immediacy and flexibility aspects of liquidity, which were also reflected in improved tightness and market depth—a good example of the reciprocal influences between

the various aspects, the complexity of liquidity, and the reciprocal connection between the various measures of liquidity.

Kalay, Wei, and Wohl (2000) examined the effect of the transition to continuous trading on the TASE in 1997, and obtained a similar result. They mainly used turnover to measure the improvement in the liquidity of shares, and discovered that the transition to continuous trading also benefited small shares. In contrast, Kalay, Sade, and Wohl (2004) and Kalay and Wohl (2004) examined liquidity on the TASE only in the opening stage.

Benita, Lauterbach, and Socianu (2004) examined liquidity in the foreign exchange market as part of an examination of the effects of structural changes that took place in the foreign exchange market during the 1990s. Among other things, they tested the trading spread, the size of turnover, market depth, and PI. Although they found that turnover increased following the structural changes, indicating a rise in liquidity, they also found that volatility increased, which indicates a decrease in liquidity. Karpoff (1987) documented a positive comovement of this type between volatility and turnover; I address this finding below.

Crema (2006) began by examining liquidity in the *makam* market. In the second stage, he conducted an aggregate examination of liquidity in the stock, foreign exchange, and government bond markets, utilizing a systematic approach to testing stability in the Israeli capital markets. In measuring liquidity in the *makam* market, some of the measures were examined without using high frequency data. It was found that liquidity had significantly improved in the *makam* market in recent years, probability as a result of the expansion of the nominal government bond market.

6. The Indices

Market liquidity can be separated into four different aspects, as described in Section 3. In contrast, actual liquidity is measured using a group of liquidity measures, each of which can reflect more than one aspect. We will divide the liquidity measures into a number of main groups[10]: measures of market activity—the turnover rate and the trading frequency; measures

[10] The division is according to the direct characteristics of the liquidity measures, not according to the aspects of liquidity, which are frequently represented only indirectly by the measures.

of transaction costs—the spread and the CRT measure (explained below); and measures of market depth—PI, transaction size, and the quoted quantity. The purpose of using many measures is to obtain an overall picture of liquidity encompassing all four aspects of liquidity.

6.1. Measures of Market Activity

6.1.1. Turnover Rate

Turnover, the total cash volume of securities traded during a unit of time, is frequently cited as a single measure of liquidity. The widespread use of turnover as a measure of liquidity is due to its availability and ease of calculation from a practical standpoint, and from a theoretical standpoint due to the fact that in markets and securities characterized by relatively high trading activity the per unit trading costs are relatively low, i.e. the liquidity level is high (this measure can be indirectly assigned to the tightness or market depth aspects). This theoretical approach therefore regards turnover and the other measures of market activity as indirect measures of liquidity. The advantage of turnover lies in the fact that it is a combination of the transaction size (which measures market depth) and the trading frequency. Changes in the average transaction size or the number of transactions per time unit will therefore also affect the turnover. Huang, Cai, and Wang (2002) found that there is a strong connection between turnover and trading frequency, but that the connection between turnover and transaction size was weaker.

Although a large turnover is often considered a sign of a high liquidity level, Karpoff (1987) documented a positive connection between turnover and volatility. A turnover-volatility connection was found in many studies dealing with the stock, foreign exchange, and futures markets. It was found that periods of great price volatility feature a low liquidity level (a wide spread), simultaneous with an increase in market activity. This means that a positive connection exists between turnover and price volatility, while a high degree of volatility is in itself a sign of low liquidity. Huang, Cai, and Wang (2000) found that this documented positive connection in the stock, foreign exchange, and futures markets was also valid in the government bond market.

Comparing the turnover of different securities, or different markets, on its own is somewhat problematic. For example, we would naturally expect to see a significantly larger

turnover in a security having billions of shekels of issued capital, than with a security with tens or hundreds of millions of shekels in issued capital. In order to sidestep this problem, turnover in each security is divided by the total issued capital held by the public. This ratio reflects the proportion of the issued capital traded during a time unit (hereinafter: the "turnover rate"). The turnover rate behaves like the turnover, but facilitates a comparison or consolidation between the turnover rates of different bonds.

6.1.2. Trading Frequency

Trading frequency is measured as the average time in hours between transactions in a time unit. As with turnover, trading frequency measures liquidity from a market activity standpoint, and therefore also constitutes an indirect measure of liquidity (this measure can be assigned to the tightness, flexibility, and market depth aspects). Jones, Kaul, and Lipson (1994) showed that in the stock market, there is a high positive correlation between trading turnover and price volatility that is due almost exclusively to the number of transactions, not their size. Huang, Cai, and Wang (2002) confirmed this finding for the government bond market, and found, as did Jones et al. (1994), that the cause of the positive turnover-volatility connection was trading frequency. This argument indicates that volatility has a strong direct effect on trading frequency, while the influence of trading volatility on turnover is only indirect, through trading frequency.

Chan and Fong (2000) assert that the main cause of the positive turnover-volatility connection is net trading turnover (total turnover in transactions initiated by the buyer, minus total turnover in transactions initiated by the seller), which varies directly with price volatility. When this factor was neutralized, it was found that the turnover-volatility connection became extremely weak. This means that an especially high net turnover causes an increase in volatility, but this phenomenon results from an increase in the number of transactions, not an increase in the average transaction size, because the connection between turnover and transaction size is relatively weak.

In the stock market, this phenomenon can be explained by the presence of asymmetric information possessed by a limited number of market players, which increases the risk, and therefore also price volatility (Kyle, 1985). These players attempt to exploit their asymmetric information by buying or selling the security, and prefer to do this by conducting many

medium-volume transactions, instead of a single large transaction. The result is therefore that volatility in the market increases in tandem with trading frequency and turnover.

Harris (2003) distinguishes between fundamental volatility originating in new information or uncertainty about fundamentals that affect the economic value of a security (for bonds, for example: monetary policy, insolvency risks, inflation forecasts, and so forth.), which has a negative connection with market activity (turnover and trading frequency), and temporary volatility originating in non-fundamental factors, chiefly activity by those possessing asymmetric information, which causes the very common positive connection observed between the measures of market activity and volatility. The difficulty in separating fundamental volatility from temporary volatility makes it difficult to interpret the measures of market activity as a high or low liquidity level.

In the government bonds market, the phenomenon of asymmetric information is either completely absent or negligible. It is therefore more correct to explain the turnover-volatility connection by a different interpretation of common information. According to Kandel and Pearson (1995) and Bamber, Barron, and Stober (1999), each market player will interpret new common information reaching the market differently. As a result, each player will act in the market according to his new assessment, therefore causing a large turnover with an increase in the number of transactions, even if the new common information does not differ from the forecasts, and does not cause a change in price. The result in this case will also be a large turnover resulting from an increase in the number of transactions which, as noted above, is linked to a high volatility level.

In an order-driven market, transaction frequency can be measured on the basis of limit orders or market orders. When a large market order is injected into the market and executed against a number of limit transactions waiting for implementation, it is possible to count either the number of limit transactions, which in effect are carried out simultaneously, or to count a single transaction – the market transaction. By definition, trading frequency based solely on market transactions is lower (the value of the measure is higher). Trading frequency based on limit transactions, however, also reflects market depth, in addition to the average time period between transactions. Since smaller limit orders (relatively shallow market depth) means that each market order is carried out opposite more limit orders, it seems that trading

frequency would improve. In order to avoid confusion between market depth and trading frequency, which would make it difficult to interpret the development of the trading frequency measure, trading frequency in this security will be calculated as the average time between **market** transactions.

Summarizing the market activity measures, we have seen that the existing measures for market activity—the turnover rate measure and the trading frequency measure—do not enable us to draw unequivocal conclusions about the liquidity level, because they tend to increase not only at a higher liquidity level, but also at a higher risk level (reflected in high volatility), i.e. when liquidity is lower as well. In other words, the market activity measures reflect the liquidity level in the absence of exceptional events in the markets. When volatility in the markets increases as a result of some exceptional event, it is not desirable to rely on these measures.

6.2. Cost Measures

6.2.1. The Spread

The accepted measure of the cost of liquidity is the spread between the best supply and demand prices. The spread measure represents the tightness aspect, and reflects the ex-ante cost of buying liquidity. As noted, in order-driven markets, there are two types of orders: limit orders and market orders. An investor giving a limit order to the market is agreeing to wait for the transaction he wants, and he is therefore considered to be a seller of liquidity. An investor giving a market order wants his transaction to be carried out immediately, and he is therefore considered to a buyer of liquidity. The liquidity seller, who makes a limit order, is taking the risk that the transaction that he wants will not take place at all—if the price of the security moves away from the price that he offered. He therefore will ask to be compensated for the risk to which he is exposed as a result of supplying liquidity to the market. This compensation is reflected in the spread borne by the party injecting the market order.

One of the problems of measuring the spread between supply and demand prices in bonds is differing degrees of sensitivity of the yield to maturity to changes in the price when the terms to maturity are different. With a bond having a long duration, a small change in the price will cause almost no change in the yield to maturity, while with a bond having a short

duration, the same change in the price will cause a significant change in yield to maturity. As a result, the fact that the spreads for long-term bonds are larger than for short-term bonds does not indicate a difference between them in liquidity.

Figures 1 and 2 show the spreads during the sample period for two nominal government bonds (both with relatively high liquidity). One of the bonds has a five-year average time to maturity, and the other a two-year average time to maturity—a difference of only three years. Figure 1 shows the spread based on the prices, and the significant difference between the spreads of the two bonds. Figure 2, on the other hand, displays the spreads based on the bonds' yields, and in this case the spreads are similar, as expected, because the two bonds have high liquidity. Therefore, in order to facilitate consolidation into a single weighted measure of bonds with different durations, we will calculate the spread as the difference between the **yield to maturity** calculated from the purchase price and the yield to maturity calculated from the sale price, rather than the spread between the purchase and sale **prices**.

Figure 1: Comparison of Price Spread: Long-Term vs. Short-Term Bonds

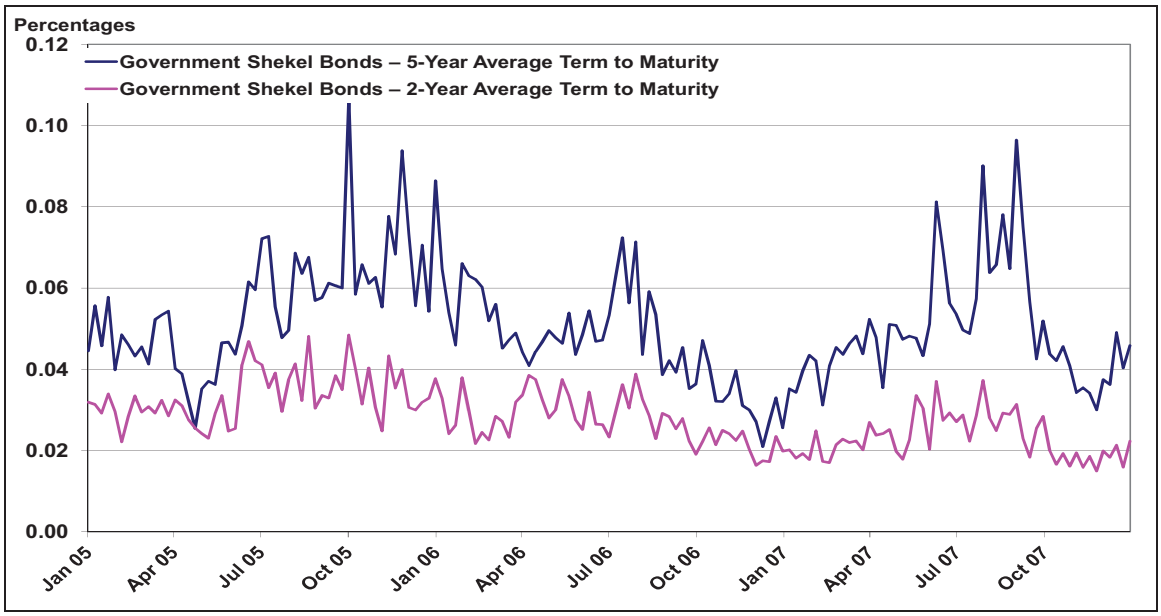
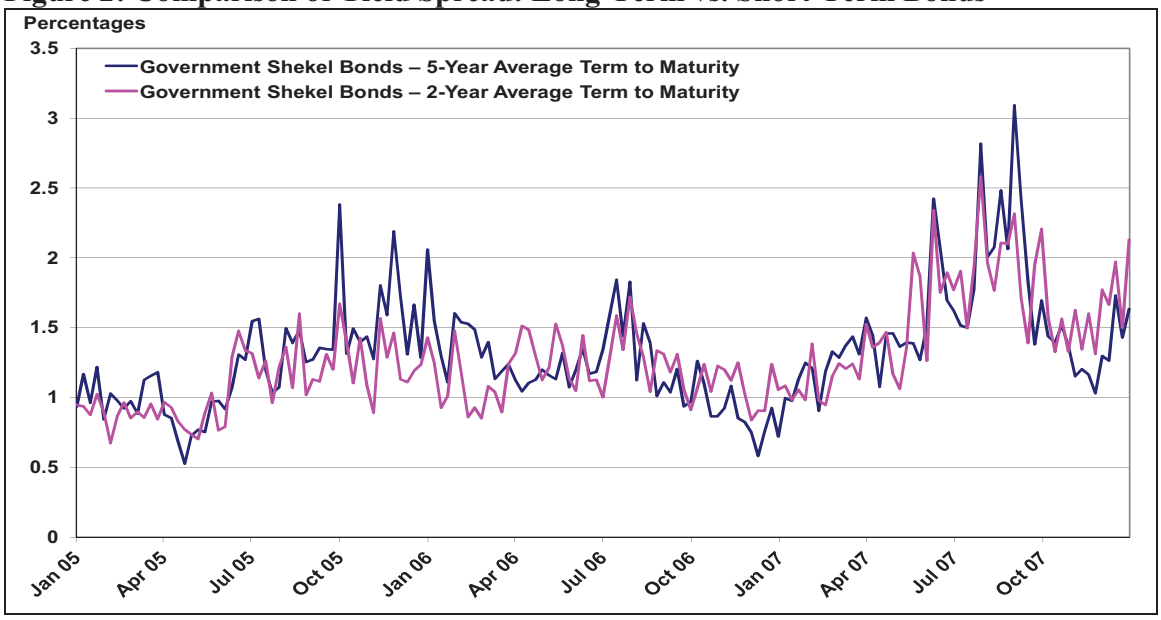


Figure 2: Comparison of Yield Spread: Long-Term vs. Short-Term Bonds



6.2.2. CRT(D)

The "cost of a round trip" measure (hereinafter: "CRT") developed by Irvine, Benston, and Kandel (2000) measures the cost of round tripping, in which a given security is bought and sold at the same time for D shekels. The advantage of this measure over the spread is that it takes market depth into account.[11] The CRT examines the market's capability to supply liquidity of a given size (D shekels). For example, when the quantity of supply at the best price is smaller than D, the purchased quantity is supplemented from the supply quantity at the second-best price, which is, however, a higher price, thereby increasing the round tripping cost. Therefore, when the quoted quantities at the best supply and demand prices are larger, the CRT is lower, and liquidity is higher. Furthermore, when the bid-ask spread is narrower, and the gaps between the best quoted price and the second-best, the second and third-best, etc. are smaller on each side of the orders book, the CRT measure is smaller, and liquidity is higher. This means that the CRT reflects both the tightness and the market depth aspects. In contrast to the other measures reflecting cost (the spread measure and the PI and volatility measures below), the CRT measure reflects the cost in terms of price, not yield to maturity.

[11] When both the supplied and demanded quantities at the best supply and demand prices are greater than D, the CRT gives the same result as the spread. This is not the case when D is greater than the supplied or demanded quantity at the best supply and demand prices.

The advantage of the CRT is in its being a combination of the spread and market depth. Its disadvantage is in determining the size of D. A larger D increases the round tripping cost, because it will be necessary to buy/sell at more costly prices located deeper within the orders book. A D that is too small, so that the best supply and demand always include it, will produce the same measure as the spread, and therefore loses its advantage—the combination of market depth and spread. Determining D, which is subjective and arguable, therefore affects the level and significance of the resulting measure. In this study, D was chosen so that 80 percent of the actual transactions were smaller than it, and only 20 percent larger than it. This value was selected so that the round tripping distribution usually covers the three best quoted prices on both the demand side and the supply side.

6.3. Measures of Market Depth

6.3.1. Price Impact (PI)

PI measures the change in the price of the security after a transaction is carried out, relative to the quantity of the security that changed hands in that transaction. Although this measure can be classified as a measure of cost (Fleming, 2003), it can also be classified as a measure of market depth, because in a deep market, the change in price resulting from a large transaction will be relatively small (i.e. the index reflects both the tightness aspect and the market depth aspect). This measure is based on the model in Kyle (1985), which examined the effect of investors with asymmetric knowledge on prices through the size of the order that they inject into the market. The measure itself is the coefficient of the transaction size as the explanatory variable for the change in price. It is customary to estimate the connection between the change in price in a fixed time interval and the net turnover (the quantity traded as a result of a transaction initiated by the sellers, minus the quantity traded as a result of a transaction initiated by the buyers) in the same time interval. Alternatively, following studies that showed that an increase in turnover resulting from the existence of asymmetric knowledge possessed by investors was due to a rise in trading frequency, it is customary to estimate the connection between the change in price and the net number of transactions in the same time interval. This study uses yield to maturity instead of prices, for the same reason mentioned for the spread.

The estimated equation is therefore:

$$\left(\sum_{i_1}^{i} YTM_{i-1} - YTM_i \right)_t = \beta_0 + \beta_1 * NT_t + \varepsilon_t$$

where *NT* is the net number of transactions in the set time interval (in this study, an interval of 30 minutes was set).[12]

The $\boldsymbol{\beta_1}$ obtained is the PI measure. The measure is estimated according to intraday data for each trading week.

In order to calculate PI, it is necessary to know the initiator of each transaction—whether it was the seller or the buyer. In the US and other markets operating through market makers that quote bid and ask prices, identifying the seller is fairly simple, as it is usually included in the rawest information: a transaction carried out at the bid price identifies the initiator of the transaction as the seller, and a transaction carried out at the ask price identifies the initiator of the transaction as the buyer. In a stock exchange that uses the order-driven markets system, this possibility does not always exist. The tick test model, constructed by Lee and Ready (1991), is therefore used to identify the initiator of each transaction. This model identifies the initiating party according to price dynamics. In this study, we did not need this model, because the intraday data obtained from the TASE enable us to definitely identify the initiator of the transaction. It is of interest to note that identification according to the tick test model and definite identification from TASE data give the same results in a very high proportion of cases.

PI is a very useful measure for parties carrying out large-scale transactions or a number of successive transactions. Together with the spread, it provides a very broad picture of the state of the security's liquidity. The disadvantages of the PI measure are the need to determine the transaction initiator (when this information is lacking), the complexity of calculating the measure (in comparison with other measures), and the difficulty in calculating it in real time (Fleming, 2003).

[12] The selected interval balances the need for a sufficient number of observations in each interval and the need for a minimum number of time intervals in each trading week in order to estimate the equation.

6.3.2. The Quoted Quantity

The quoted quantity represents the quantity that can be traded immediately, and thereby serves in practice as an ex-ante measure of market depth. This measure is calculated as an average of the amount of supply and the amount of demand of the best supply and demand quotations. This measure represents the other side of the spread measure, i.e. the average supply and demand quantities at the measured spread. While the quoted quantity is supposed to include all the existing offers to buy or sell, the information available in practice includes only the quantities at the first three limit prices on each side (the supply side and the demand side) of the orders book. Therefore, whether the three best offers on each side are used, or whether the quantities of only the best offer on each side are used, the resulting measure will be a downwardly biased estimate of the market depth. Nevertheless, both in order to follow suit with general practice around the world with respect to this measure[13], and in order to preserve the parallel to the spread measure, we will calculate the quoted quantity only by the quantities offered at the best supply and demand quotations.

6.3.3. The Transaction Size

The transaction size measure calculates the size of the average transaction in a time unit. This unit is usually a trading day or week, but this measure is also sometimes calculated for smaller time units. A relatively large average transaction size indicates that the security's market depth is large enough to facilitate large-scale transactions. The advantage of this measure is especially clear in markets in which the quoted quantity is a minimum starting point for negotiations on the quantity in the final transaction, so that this quantity actually has a downward bias, and the transaction size measure that includes the actual transactions is therefore usually a more accurate measure. In this study, however, we are examining the liquidity level in the government bond market, which uses an order-driven markets system, in which there is no possibility of negotiating the quantity of the final transaction; this advantage of the transaction size measure over the quoted quantity measure is therefore less significant.

[13] On most stock exchanges, the available information of the quoted quantities in the orders book exists only for the best supply and demand quotations (for example, see D'souza et al. (2003), Section 2.4).

As with trading frequency, it is also important with the average transaction size to distinguish between measurement of the average transaction size of limit orders and the average for market orders. When a market order is carried out in its entirety opposite a single limit order, the result is identical, but when the market order is carried out opposite a number of limit orders, we get different results, which should be interpreted differently. The average transaction according to limit orders ostensibly reflects the average size of these orders, but in practice, it is difficult to interpret its meaning. Assume that a market order for 100 units is injected into the market simultaneously with two orders at the best price. The first in line is a limit order for 99 units, and the second is for 101 units – an average supply of 100 units, the same as the market order. Carrying out the market order will be divided into two transactions: a transaction for 99 units and an order for one unit – and the average transaction size will be 50 units, half the size of the average of the limit orders. On the other hand, the average for transactions according to market orders always reflects precisely the average size of the market orders.[14] The transaction size measured below therefore refers to the average size of the market transactions.

As mentioned above, the transaction size measure is one of the elements of the trading turnover measure. In contrast to turnover and trading frequency, it does not feature a positive connection with price volatility. Actually, Huang, Cai, and Wang (2000) found a negative connection between transaction size and volatility. Consequently, this measure can also be used as a substitute for measures of market activity having a relatively high correlation with trading volatility.

[14] In practice, pure market orders, i.e. orders with no limit, are almost never submitted to the TASE; orders are usually submitted with a limit. When the submitted limit is the same as the limit on the opposite side of the orders book, and the order is carried out immediately (and is not even recorded in the orders book), we regard it as a market order. In some cases, the quantity of the market order is greater than the quantity of the limit order on the other side, and the market order is therefore carried out only in part, with the balance being recorded as a limit order. It can be argued that for this reason, the average according to the market transactions also does not reflect **exactly** the average size of the market transactions. This, however, should be interpreted so that the side making the market order, who sees the orders book with the limit order on the other side, is submitting a market order of the same size as the limit order, and is also submitting a limit order of the same size as the balance. In this way, the market order constitutes two orders: a market order with the same size as the opposite limit order and a limit order at the same price with the same size as the balance.

6.4. Volatility

In this study, volatility is based on the development of intraday prices. Formerly, in the absence of available intraday data, the GARCH model, which derives σ_t from a series of prices with daily frequency in order to estimate volatility, was frequently used. By using intraday data, the actual volatility of prices during the trading day can be calculated. This approach has become more common in the literature in recent years. As with the other measures based on bond prices, in calculating volatility, it is also preferable to use yield to maturity instead of prices in order to facilitate comparison between securities with different durations.

In this study, the calculated volatility is the standard deviation of the change between the highest and lowest yields to maturity during a period of 15 minutes.[15] This way of calculating volatility reflects the flexibility aspect: Since the change in yield to maturity is measured between time intervals, and not between one transaction and another, if the yield to maturity reverts to its level (for any reason at all) following a large deviation during the same time period—a development indicating a high degree of flexibility in prices—a lower level of volatility will be measured.

In none of the studies that examined liquidity in the bond market comprehensively for all aspects, as this study does, was volatility included as a measure of liquidity. Nevertheless, the connection between each measure and volatility was examined in these studies, and was found to be a major factor in determining whether a given measure did a good job of representing liquidity. This use of volatility is a result of its status as an important factor that affects the size of most of the measures. Fleming (2003) also found that price volatility could serve as a measure of liquidity for all intents and purposes: The spread is positively correlated with volatility, because a high level of volatility exposes the supplier of liquidity to the risk that the transaction he wants will never take place, and the spread compensates him for this risk (the tightness aspect). Volatility influences the spread, because the presence of high volatility makes it difficult for investors to know the real price of the security (the flexibility

[15] The selected time period differs from the time period in the calculation of PI, both because the limitation of a minimum number of time periods in a trading week does not exist (a limitation stemming from the use of regression in calculating PI), and because of the character of the data. Since I am not comparing the two measures, the difference in time periods has no meaning here.

aspect), and they will therefore demand compensation for the risk of a transaction taking place at a money-losing price. This compensation is reflected in a wider spread (Harris, 2003). By definition, PI is also larger when volatility is greater. The same is true for the other measures of market depth, which are correlated with volatility, as volatility is lower when the market is deeper. The complex connection between volatility and trading turnover and frequency is described extensively in the section explaining the measures of market activity. Volatility will therefore play an important role as an explanatory variable in understanding the development of the liquidity measures.

7. The Market Structure and the Data

7.1. Background

The nominal government bond market has been operating in Israel since 1995, joining the indexed government bond market, which has been operating in Israel almost since Israel became independent. These two debt raising instruments jointly constitute almost the entire tradeable government bond market in Israel. From its inception, the indexed government bond market has featured a limited number of series, and the difference in term to maturity between consecutive series varies from one to two years. At the same time, during the sample period (2005–2007), the issued capital in each series was quite high, compared with the indexed government bond market, in which the differences in term to maturity between any two consecutive series were much smaller.[16] At the end of 2007, the average market value of nominal government bonds from the 11 different series stood at about NIS 10 billion (similar to the median). The term to maturity at issuance of nominal government bonds can range from one to twenty years, and in practice tradable nominal debt was issued during the sample period for series whose effective term to maturity at issuance varied around two, five, 10, and 20 years.[17]

Like most securities in Israel, nominal government bond are traded mostly on the TASE, which uses the order-driven system. Until mid-2006, turnover in nominal government bonds

[16] In recent years, the indexed government bond market has gradually shifted to a structure similar to that of the nominal government bond market, as a result of similar policies.
[17] Issuance of nominal government bonds for periods longer than 10 years began only after September 2006.

on the TASE accounted for over 90 percent of total trading in these bonds, while the remainder was traded on the over-the-counter (OTC) market. In July 2006, the volume of OTC trading began to increase, and the volume of OTC trade in nominal government bonds rose significantly in comparison with the TASE turnover. Between the beginning of 2007 and September 2008, the volume of OTC trading in nominal bonds reached one-third of the TASE turnover. This ratio later stabilized at around one-fifth.

Starting in September 2006, trading also took place through the MTS Israel system used by the primary dealers appointed for this purpose by the Ministry of Finance. Nineteen primary dealers were appointed when the reform was launched: eight foreign and 11 local market makers. Fifteen of these market makers were banks, and four were other financial institutions.[18] The MTS system was used by primary dealers exclusively for trading between each other, and as a supplement to trading between them and large investors, and they were required to make quotations on it continuously. In contrast, trading on the TASE also includes traders, households, and small investors, in addition to the large investors and market makers. Primary dealers are required to make quotations only on MTS, not on the TASE or OTC.

The TASE trading platform is order-driven, and also uses this system for government bonds. This contrasts with most of the world's capital markets, on which trading in government bonds is quote-driven, designed for very large transactions, and usually designated for large investors only. This study is based on the TASE data.

7.2. The Data

The sample period begins in January 2005, ends in December 2007, and includes the transactions book and the quotations book for trading in nominal government bonds on the TASE. The beginning of the sample period leaves enough time before the beginning of the reform (September 2006). The end of the sample period was selected in order to avoid a problem of the effect of the global crisis, which reached a peak in late 2008. It is not clear, however, whether this problem was successfully sidestepped. The rising trend in volatility began in early 2007, and was supported by an increase in the implied standard deviation in the

[18] As of 2010, 14 primary dealers were operating in the market, six of which were foreign.

shekel-dollar market and in the VIX index—increases in indices that indicate a rise in the risk perceived by the market. It is possible that these reflected the beginning of the global crisis.

The transactions book includes all the transactions carried out in nominal government bonds during the entire sample period. The transactions book includes details such as the date, number of the security, time of the transaction (to a hundredth of a second), and the price and quantity of the transaction. In addition, the order numbers of the seller and the buyer are given for each transaction. The latter makes it possible to identify the initiator of the transaction, which will always have a higher order number. The quotations book is composed of lines of data that include the date, number of the security, time of the transaction (to a hundredth of a second), the stage of trading, the three best supply prices, the three best demand prices, and the total quantity supplied or demanded at each price (a total of 12 price and quantity fields per row). Any change in one of these 12 fields results in a new updated line of data.

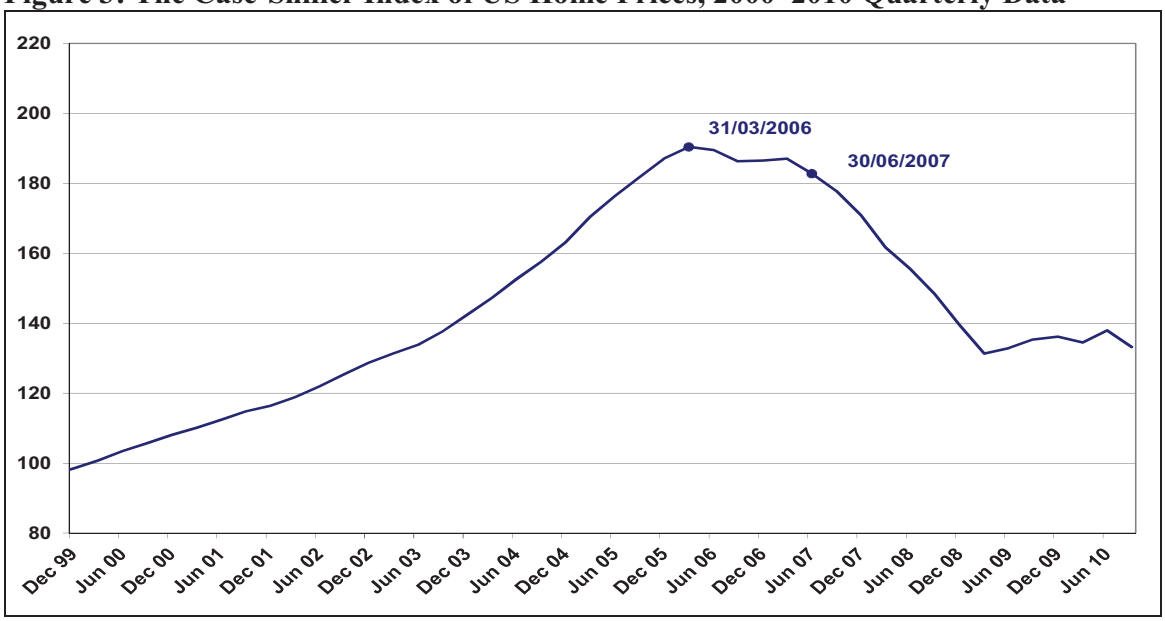
The raw database covers the activity of 13 nominal government bonds traded during the sample period, and contains approximately one million transactions and 4.6 million quotation lines over 738 trading days. Observations not belonging to the continuous trading stage, matching transactions, and outlier observations were omitted from the database, as were bonds for which the trading day took place less than a year after they were first issued, and those that had less than a year remaining before their maturity date.

7.3. The Background Conditions

The economic environment in Israel changed during the sample period—from an environment of rapid growth, which prevailed after the emergence from recession in 2003, to a pre-crisis environment in which the first signs of the global financial crisis were visible. This crisis, the worst in recent decades, which reached a peak in the fourth quarter of 2008, began to emerge in early 2007. The Case-Shiller Index for home prices in the US (Figure 3), shows that American home prices, which had been exhibiting bubble behavior since the beginning of the decade, stopped rising in the second quarter of 2006. Later, especially from the second quarter of 2007 onwards, they began to drop precipitously, and the bubble burst. The bursting of the home price bubble in the US, together with the securitization of mortgages there, were among the main factors in the recent global crisis. This drop in housing prices in

the US precipitated a domino effect in the US financial markets, which later also affected non-financial activity in the US and all over the world.

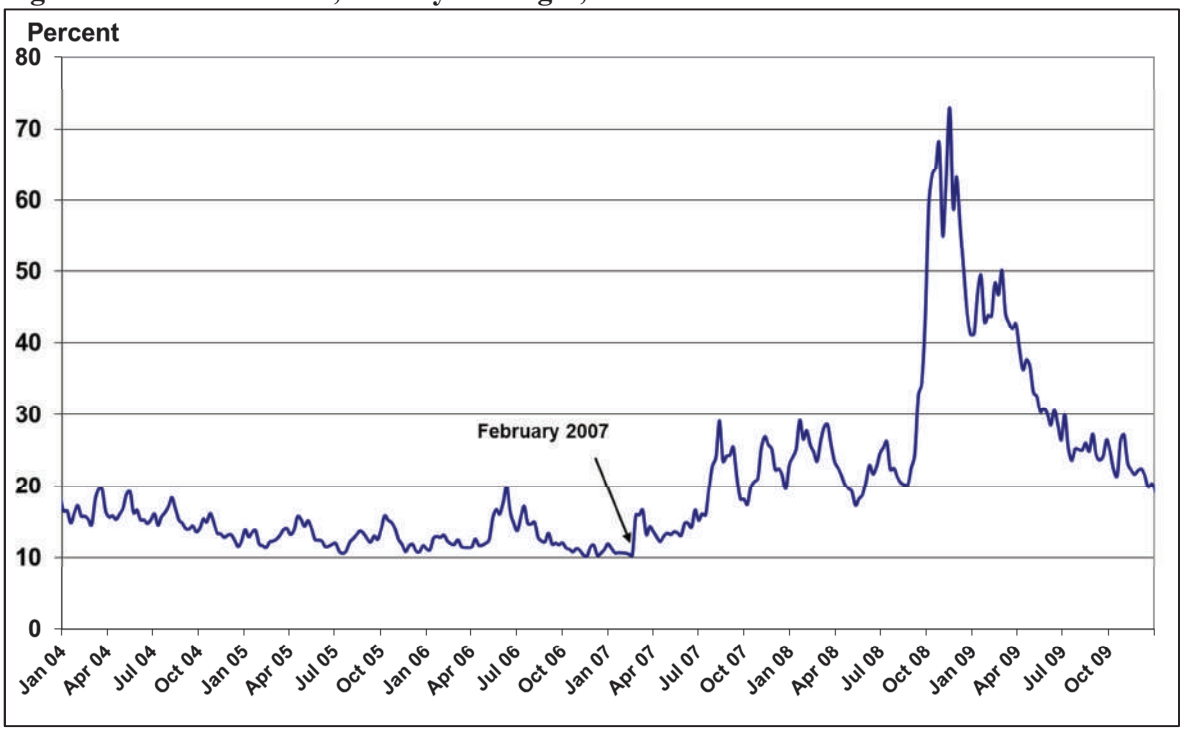
Figure 3: The Case-Shiller Index of US Home Prices, 2000–2010 Quarterly Data



Source: Bloomberg.

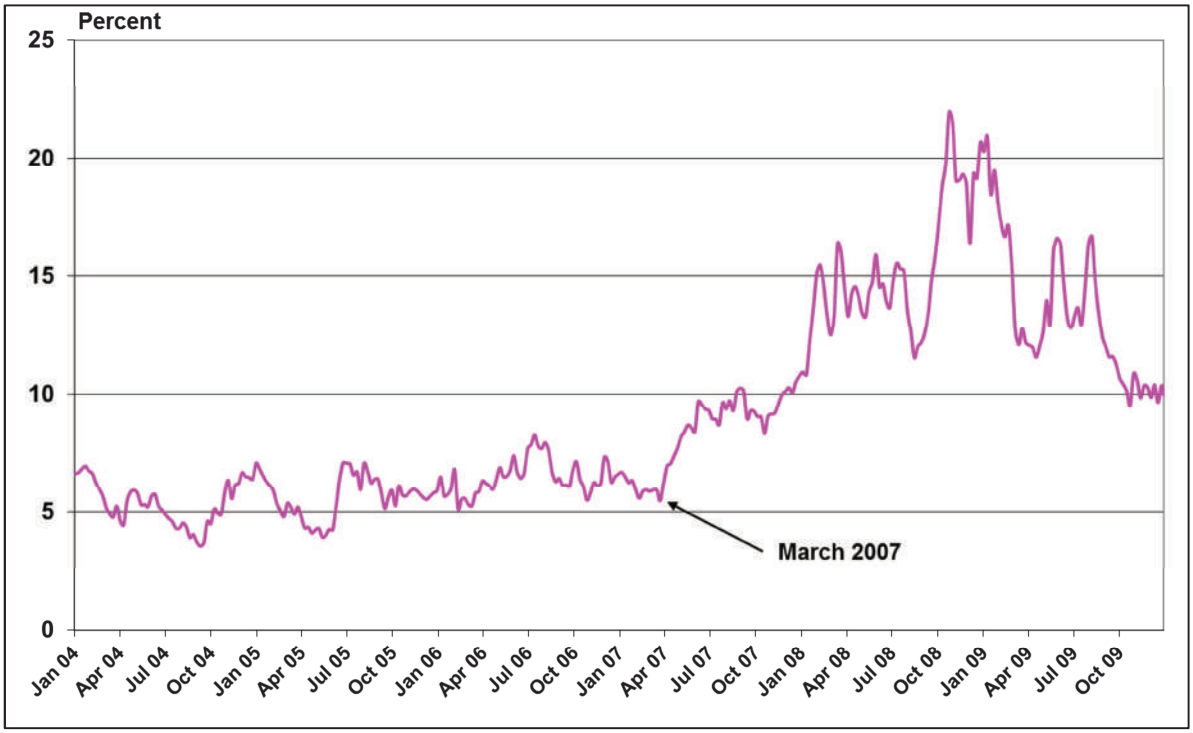
The first signs of the crisis, which can be identified using the Case-Shiller Index, therefore began as early as the beginning of 2007. Further signs of the emerging global crisis can also be seen in Figure 4, which displays the VIX Index (the "fear index") from 2004 to 2009. The graph shows that the rising trend, which peaked in late 2008, began as early as February 2007. The VIX Index reflects the market risks as assessed by the investors in the US. The influence of US risks on the Israeli economy was also passed on through both the overseas activity of Israeli investors and activity in Israel by foreign investors. An example of this can be seen in the implied standard deviations derived from the shekel-dollar options (Figure 5), which began to rise as early as March 2007, a trend that continued until the crisis reached a peak in early 2009.

Figure 4: The VIX Index, Weekly Averages, 2004–2009



Source: Bloomberg.

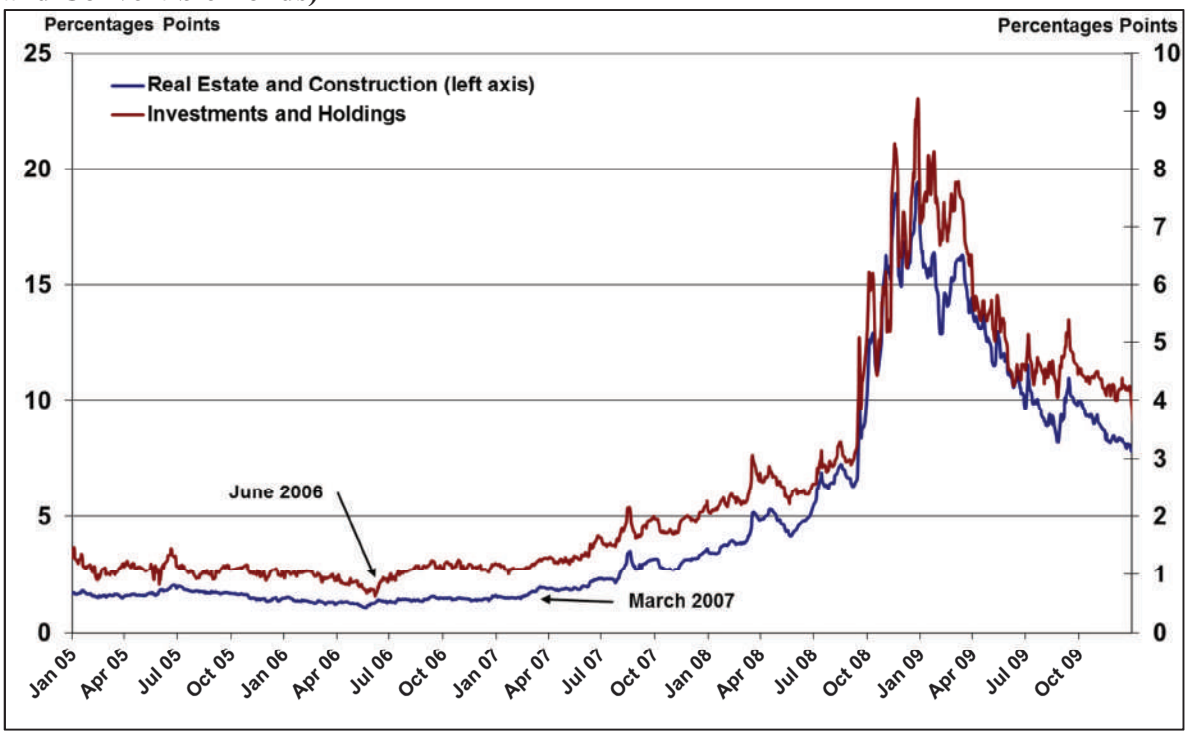
Figure 5: Implied Standard Deviation for Shekel-Dollar Options, –Weekly Averages, 2004–2009



Source: Bank of Israel.

The global crisis also reached Israel through another channel—by way of Israeli real estate companies with large-scale overseas investments.[19] The severe real estate crisis abroad that began at that time had a negative impact on these companies. Figure 6 displays the spread in yields between corporate bonds in the real estate sector and "Galil" bonds. This spread, which reflects the industry risk, indicates the beginning of a rising trend in March 2007, which subsequently became stronger. It is interesting to see that the trend in yield spreads in the investments and holdings industry reversed itself even earlier, in June 2006, with the beginning of a rising trend that picked up steam in early 2007 and during that year.

Figure 6: Yield Spreads: Indexed Corporate Bonds in the Real Estate Industry and in Investments vs. Indexed Government Bonds (Galil), 2006-2009 (Excluding Structured and Convertible Bonds)



Source: Bank of Israel.

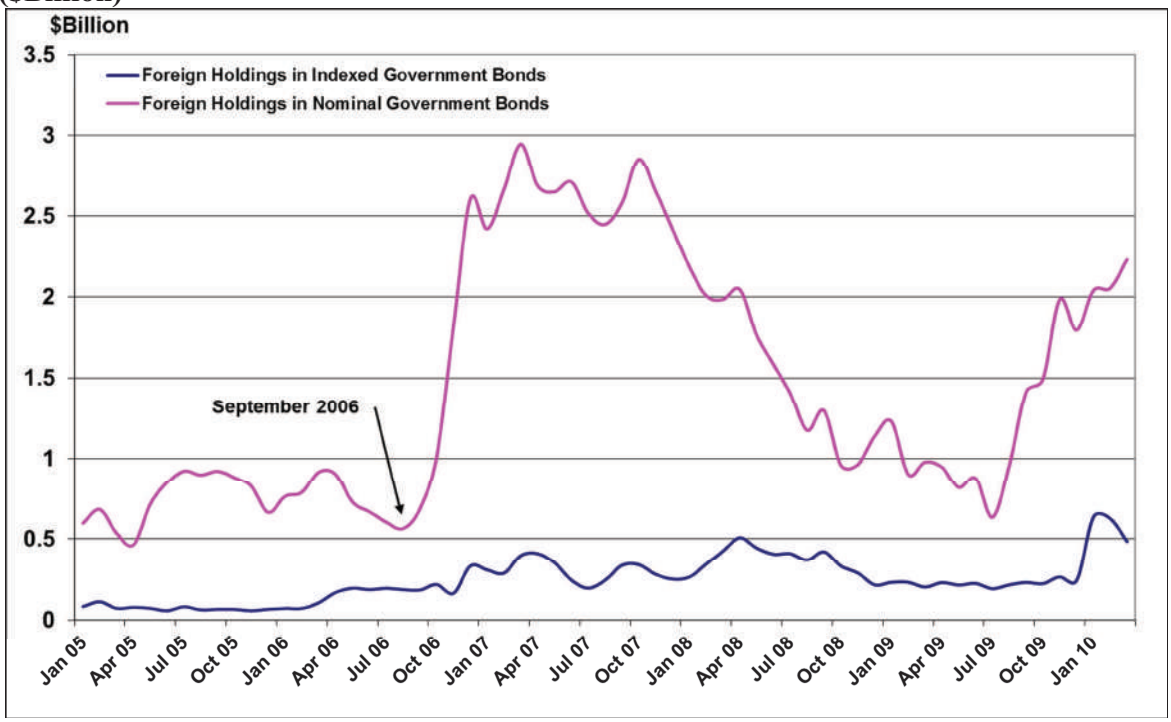
The increased risk overseas, at a time when stability and steady growth prevailed in the Israeli economy[20], made the economy attractive to foreign investors seeking safe investments. The launching of the reform in government bonds in September 2006 encouraged the entry of

[19] A check by the TASE in September 2006 revealed that 60 percent of investments by companies included in the Tel Aviv Real Estate-15 Index were made overseas.

[20] As reflected in a drop in the public debt, government budget deficits that were lower than the deficit target, and implementation of structural reforms.

investors into the nominal government bond market. Figure 7 highlights the increase in foreign holdings of nominal government bonds in September 2006—the proportion of foreign holdings in this market grew five-fold before the end of that year. This took place in a period in which the monetary interest rate in Israel was lower than that in the US. Foreign holdings remained relatively stable throughout 2007, until the end of the sample period.

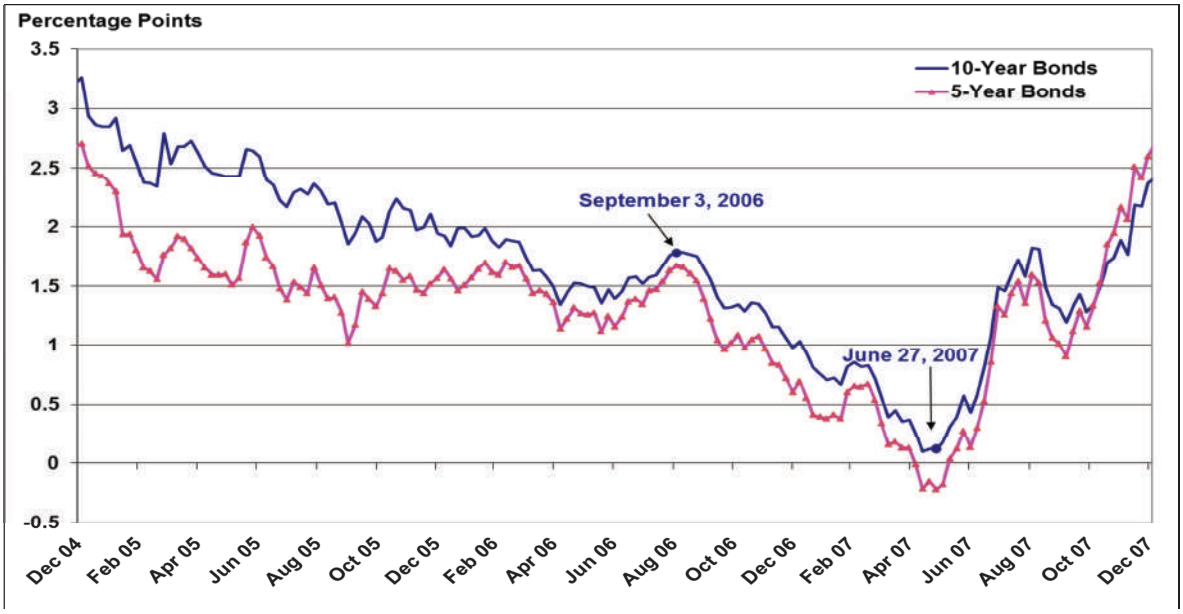
Figure 7: Foreign Holdings in Indexed and Nominal Government Bonds 2005-2009 ($Billion)



Source: Bank of Israel.

The increase in foreign holdings in September 2006 generated demand pressure that caused an almost immediate steep downward trend in nominal bond yields. This trend continued until mid-2007, with a narrowing of differences in yields between Israel and the US (Figure 8), where yields to maturity did not fall at that time. Later, a rise in yields in Israel in the second half of 2007, coupled with a drop in yields in the US, caused the differences in yields to revert to their levels of early 2005. The narrow differences in yields that emerged following the entry of nonresidents in the second half of 2006 reflect the improvement in the Israeli economy, relative to overseas markets.

Figure 8: Differences between Israel and the US in Yield to Maturity on Nominal Government Bonds

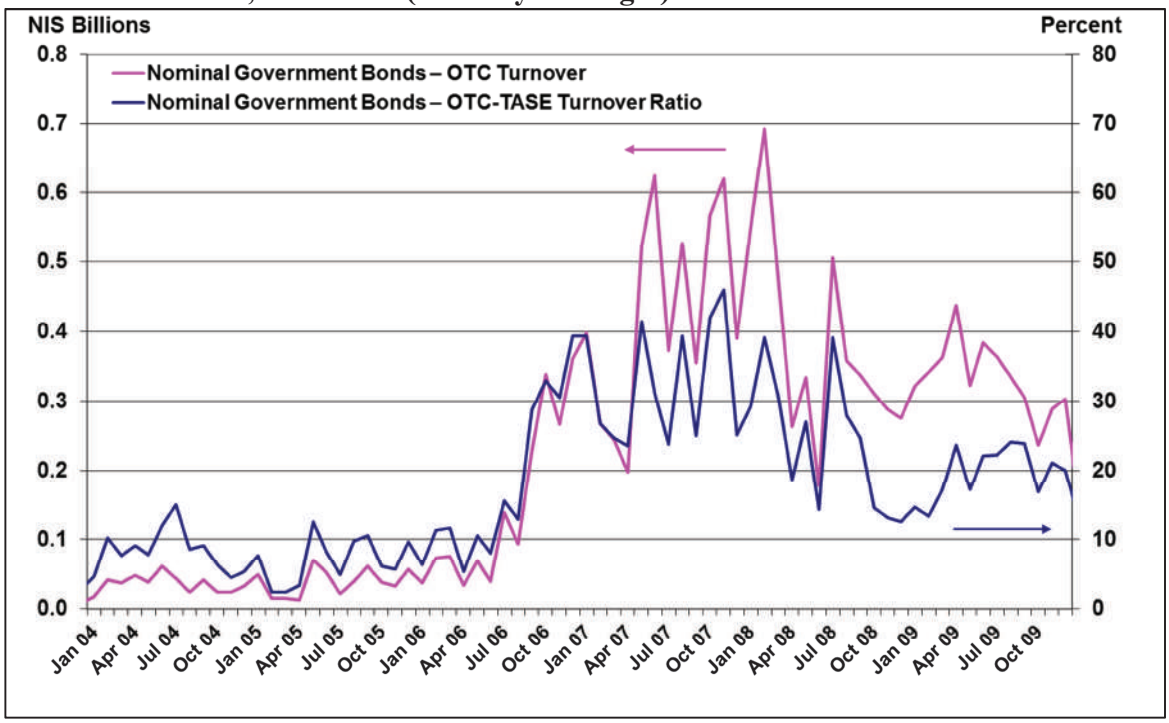


Source: Bloomberg and Bank of Israel.

The 2006 market makers reform had other, more direct, effects, in addition to the entry of foreign investors. The volume of OTC trading in nominal government bonds was lower than the trading volume on the TASE, with the former accounting for about 10 percent of total trade volume (Figure 9). As early as July 2006, when the first issues managed by the Ministry of Finance through the Bloomberg tenders system began, OTC trading turnover in nominal government bonds began to rise, as did the ratio of OTC turnover to TASE turnover, which doubled. In September 2006, with the initiation of the other elements of the reform (MTS, TASE market making, etc.), the ratio doubled again, reaching about 30 percent, and remaining around this level until the worsening of the global crisis in September 2008.

The change in OTC turnover is related to the entry of nonresidents, but this is probably not the only reason. Between October 2008 and July 2009, there were almost no nonresidents in the market—their holdings totaled only $1 billion, close to the level of the balances in the first half of 2006 (Figure 7)—while OTC turnover in nominal government bonds remained at a higher level than before the increase in nonresidents' holdings in 2006. In April 2009, this proportion rose to over 20 percent, while nonresidents' holdings remained unchanged. When the nonresidents returned to the market and increased their holdings in nominal government bonds, starting in August 2009, the proportion of OTC trading turnover remained unchanged.

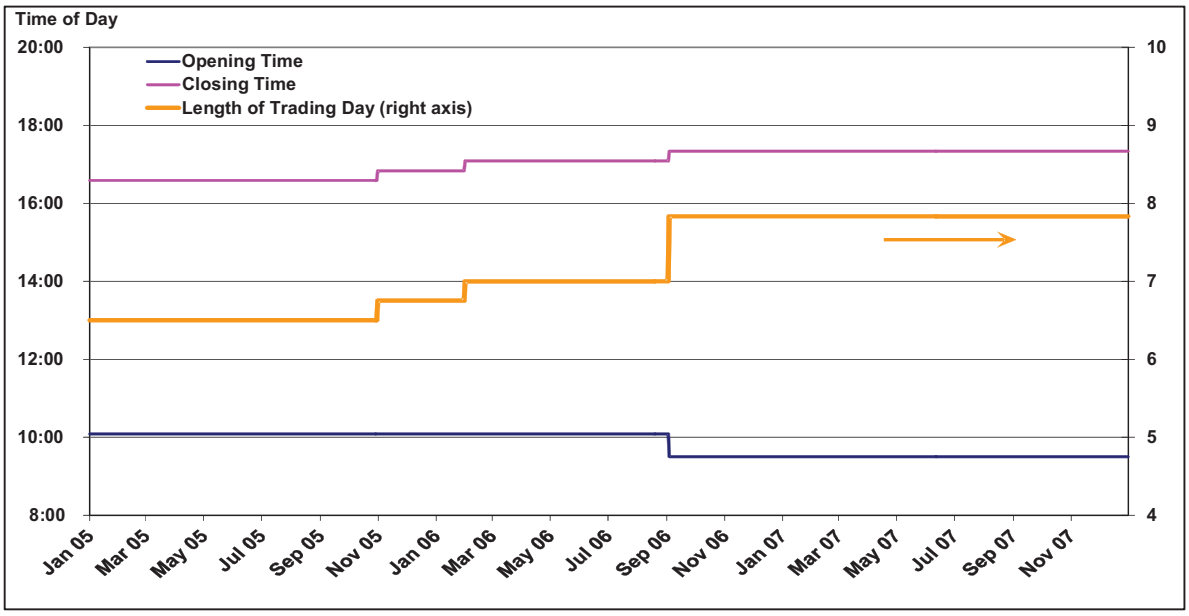
Figure 9: OTC Turnover in Nominal Government Bonds: Volume and the Ratio relative to TASE Turnover, 2004-2009 (Monthly Averages)



Source: Tel Aviv Stock Exchange.

As noted above in the description of the reform, the TASE initiated other changes, which were put into effect on the date on which the market makers reform was launched at the beginning of September 2006. The first change was an extension of the trading day (Figure 10). As far back as late 2005, the TASE began to extend the trading day in order to increase the overlap in trading time between it and overseas stock exchanges. The trading day was extended twice, by 15 minutes each time, in November 2005 and February 2006, solely through the introduction of a later closing hour. The trading day was extended again in September 2006, this time by 50 minutes, triple the previous extensions: 15 minutes at the end of the trading day and 35 minutes at its beginning.

Figure 10: Length of Trading Day and Opening and Closing of Trading Times on the Tel Aviv Stock Exchange



Source: Tel Aviv Stock Exchange.

The second change initiated by the TASE when the market makers reform was launched in September 2006 was the use of market makers in the nominal government bonds market. When the reform was launched, five local banks and three brokers were appointed as TASE market makers. Today only the five local banks fulfill this role. In principal, there is no connection between these market makers and the primary dealers appointed by the Ministry of Finance, but in practice, all the market makers on the TASE are also primary dealers. As early as the fourth quarter of 2006, the market makers' turnover on the TASE totaled about NIS 250 million—one third of the TASE turnover (turnover net of market makers transactions). During 2007, this proportion grew, reaching a peak of 90 percent of total TASE turnover at the end of 2007. During 2008, activity by the market makers on the TASE dropped to only 20 percent of TASE turnover.

7.4. Measures of Liquidity

All the measures of liquidity described in Section 6, including those that can be calculated from the aggregate data published by the TASE, are based on the intraday database. In addition to the advantage of working with a single database, the use of intraday data increases the degrees of freedom in calculating the measures. For example, it is possible to use only

transactions from the continuous trading stage, omitting transactions from the opening and closing stages; measuring the liquidity of the latter is beyond the scope of this article. It is also possible to count the market transactions and obtain their average size using the intraday database.

The measures that are based on the orders book—the spread, the quoted quantity, and CRT—are weighted according to time. This means that each row of data receives its share of the measure according to the period of time it was in effect, until the following row of data replaces it. The turnover rate was calculated at the weekly level, and was then standardized according to the actual number of trading hours in that week. Volatility was calculated in 15-minute time intervals, and PI in 30-minute time intervals.

The measures were calculated at a weekly frequency. Calculating the measures at a daily frequency generates very noisy data, among other things because of the seasonal effect of the days of the week. Monthly data have low noise, but create a shortage of observations, and because of the character of the financial markets, which respond rapidly to changes, it is possible to miss changes occurring during the month that are not reflected in the monthly data.

Each measure was first calculated separately for each bond, and a weighted measure was then calculated for the entire nominal government bond market. The weight assigned to each bond was its issued capital (in terms of face value) in proportion to the total issued capital (in terms of face value) of all the bonds included in the measure for that week. The population of bonds included in the weighted measure varies, and depends on a number of criteria. Bonds whose issuance date was less than one year ago, or which have less than one year left before their maturity date, were not included in the weighted measure. The same is true of bonds with an issued capital of less than NIS 1.5 billion and bonds for which the measure changed sharply during the week, in comparison with changes in the other bonds.

Table 1A contains theoretical statistics for the various liquidity measures, the average issued capital and the total issued capital for all in-sample securities, foreign holdings, and yield to maturity during the sample period (2005–2007). Tables 1B and 1C display the statistics divided into the periods before and after September 2006, respectively. A comparison between the average measures in the period before the reform and those in the period after it shows that market activity grew in the period following the reform. The

turnover rate increased from 0.07 percent to 0.12 percent, while trading frequency, which reflects the average length of time between transactions, dropped from 0.08 to 0.06. The level of significance for both these figures was less than 1 percent.

The picture for the cost of liquidity is less clear. The spread increased a little, but this increase was not significant. The CRT measure, on the other hand, declined from 0.12 percent to 0.09 percent, at a level of significance of less than 1 percent. This opposite result could be obtained, among other things, because the spread is based on yields, while the CRT is based on transaction prices. Moreover, the CRT also reflects market depth, because it measures the cost of buying supply and selling demand at the three best prices, while the spread relates only to the cost of liquidity for the best supply and demand yields, and does not relate to quantities at all. A rise in the quoted quantity, which did occur, as we will see, can therefore cause an improvement in the CRT, especially if the spread measure shows no significant change. Indeed, Figure 11 shows that from the end of 2005 until mid-2006, while the CRT measure was declining (reflecting an improvement), the quoted quantity measure rose.

According to the market depth measures, the quoted quantity almost doubled after the reform was initiated, at a level of significance of less than 1 percent, from NIS 900,000 to NIS 1.7 million. The average transaction size was also up—by almost 50%, from about NIS 500,000 to NIS 750,000. In contrast, the median transaction size actually fell during the period following the beginning of the reform. This contrary development indicates that the upward change in the average transaction size was due to an injection of large orders, which had a positive effect on the average, while most of the transactions carried out, as reflected in the median, featured an injection of smaller orders.

Table 1A: The Liquidity Measures – Descriptive Statistics for 2005-2007

	Turnover Rate (per trading hour)	**Trading Frequency** (in hours)	**Spread** (percentage points)	**CRT**	**Yield Impact** (percentage points)	**Quoted Quantity** (NIS millions of par value)	**Average Transaction Size** (NIS millions of par value)	**Median Transaction Size** (NIS millions of par value)	**Volatility**	**Average Issued Capital°** (NIS billions of par value)	**Total Issued Capital°** (NIS billions of par value)	**Foreign Holdings** ($ billion)	**Average Yield to Maturity°** (percent)
Obs.	157	157	157	157	157	157	157	157	157	157	157	157	157
Average	0.09%	0.07	1.3	0.11%	0.10	1.3	0.63	0.18	0.010	11.8	64.0	1.5	5.4
Median	0.08%	0.07	1.2	0.10%	0.10	1.2	0.58	0.18	0.009	11.6	65.3	0.9	5.3
Maximum	0.43%	0.12	2.3	0.21%	0.23	3.2	1.41	0.38	0.029	13.2	73.4	2.9	6.4
Minimum	0.03%	0.03	0.8	0.06%	0.04	0.4	0.32	0.07	0.005	10.4	50.8	0.5	4.2
S.D.	0.05%	0.02	0.3	0.04%	0.03	0.6	0.19	0.05	0.003	0.6	5.9	0.9	0.5
Table 1B: The Liquidity Measures – Descriptive Statistics for January 2005-August 2006 (before the reform)													
Obs.	87	87	87	87	87	87	87	87	87	87	87	87	87
Average	0.07%	0.08	1.2	0.12%	0.10	0.9	0.53	0.20	0.009	12.2	63.0	0.75	5.7
Median	0.06%	0.08	1.2	0.12%	0.09	0.8	0.50	0.20	0.009	12.1	60.7	0.76	5.6
Maximum	0.13%	0.12	1.7	0.21%	0.18	2.8	0.87	0.36	0.017	13.2	73.4	0.92	6.4
Minimum	0.03%	0.04	0.8	0.06%	0.04	0.4	0.32	0.08	0.005	11.3	50.8	0.47	5.0
S.D.	0.02%	0.02	0.2	0.04%	0.03	0.4	0.12	0.05	0.002	0.5	6.3	0.14	0.4
Table 1C: The Liquidity Measures – Descriptive Statistics for September 2006-December 2007 (after the reform)													
Obs.	70	70	70	70	70	70	70	70	70	70	70	70	70
Average	**0.12%	**0.06	1.3	**0.09%	*0.11	**1.7	**0.75	**0.16	**0.011	**11.3	*65.2	2.3	**5.2
Median	0.10%	0.06	1.2	0.09%	0.10	1.5	0.74	0.16	0.010	11.3	67.8	2.6	5.1
Maximum	0.43%	0.12	2.3	0.14%	0.23	3.2	1.41	0.38	0.029	11.6	72.9	2.9	6.3
Minimum	0.04%	0.03	0.8	0.06%	0.05	0.9	0.44	0.07	0.006	10.4	58.2	0.7	4.2
S.D.	0.06%	0.02	0.3	0.02%	0.03	0.5	0.19	0.05	0.004	0.4	5.2	0.6	0.5

° For securities included in the weighted average.

* Differs from the average of the measure for the period before the reform at a 5 percent level of significance.

** Differs from the average of the measure for the period before the reform at a 1 percent level of significance.

The PI as calculated in terms of yield to maturity (hereinafter: "yield impact" or "YI") indicated an increase of about 10 percent, or 0.01 percentage points, at a 5% level of significance. This increase indicates a drop in the level of liquidity in the cost and market depths aspects. This figure is consistent with the spread (which, as noted, is not significant) and the drop in the median transaction size. On the other hand, the rise in YI is inconsistent with the rise in the level of liquidity that was recorded in the quoted quantity and average transaction size. The volatility measured after September 2006 rose with a level of significance of less than 1 percent, from 0.009 to 0.011. Most of this increase is attributed to the change in the economic environment to a pre-crisis situation, as indicated by the rise in the risk measures as presented above (in Section 7.3 – The Background Conditions), a situation that fosters greater volatility.

Figure 11, which describes the development of the liquidity measures and volatility during the sample period, helps to clarify the picture. Trading frequency indeed clearly declined in September 2006, and no less important, it became more stable. On the other hand, the turnover rate rose slightly for a short period following September 2006, and then rose substantially only in early 2007. This increase is easier to link to a rise in the risk measures, which also began in early 2007, than to the reform. It is also difficult to identify an effect of the reform in the development of the spread. A long-term downward trend in the spread, which jumped 50 percent all at once in June 2005, began in the beginning of 2006 and continued until the end of that year. This trend then reversed during the first three quarters of 2007.

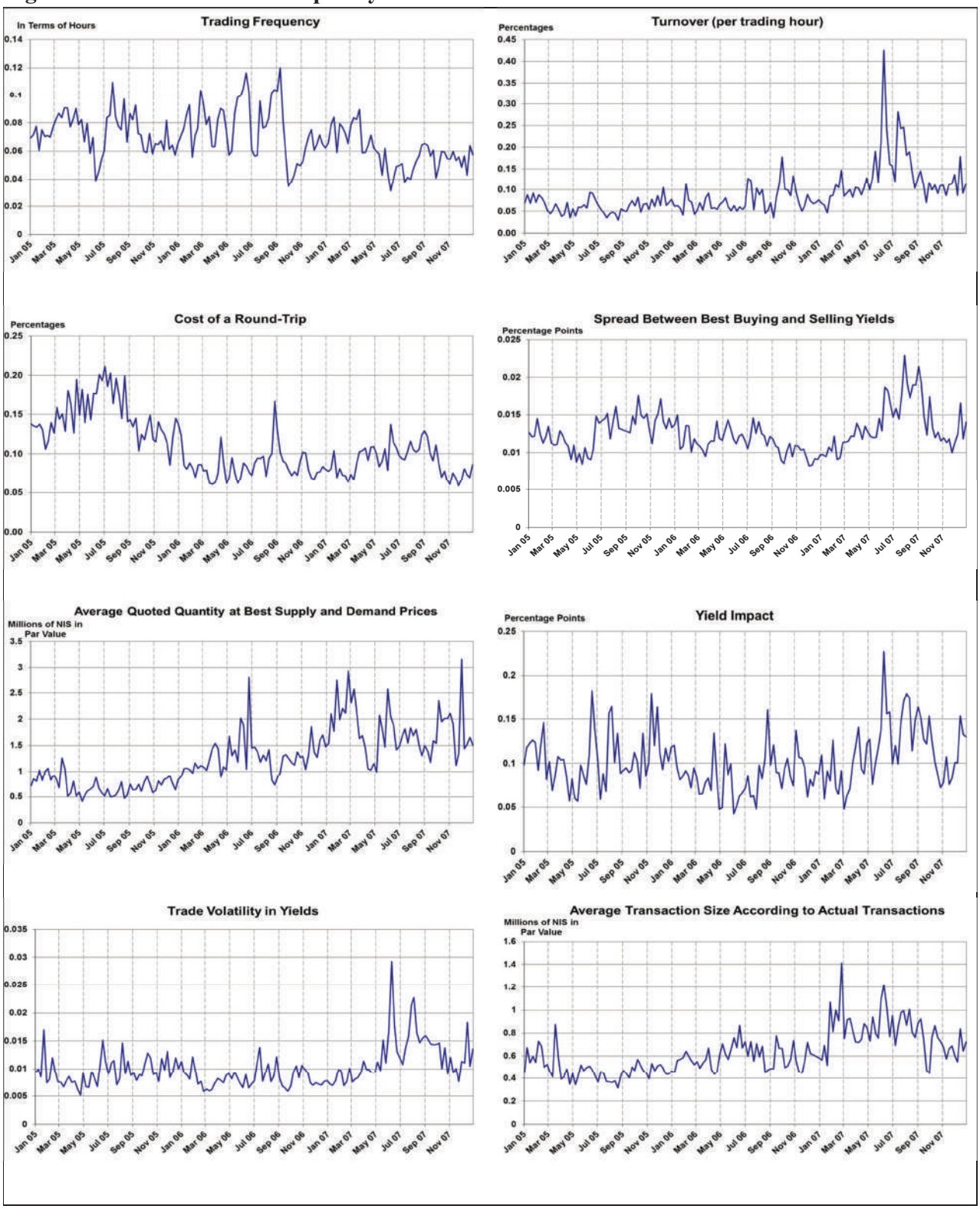
The same is true of the CRT average, which posted significant improvement in the period following September 2006: The measure moved with no trend around the period when the reform was launched, except for a very temporary rise at the end of August and the beginning of September 2006. According to Figure 11, the drop in the CRT average visible in Tables 1B and 1C is explained by the high level prevailing during 2005, which by the beginning of 2006 had reached the average level of the period following September 2006. During the second and third quarters of 2007, some rise was visible in the CRT measure.

The YI measure, which rose between the period before the reform and the period following it, according to the figures in Table 1, shows no significant change during the period when the reform was launched—it moved with no trend, following a period of decline in the first half of 2006. Later, in the first half of 2007, there was an upward trend in YI, which explains the higher average after September 2006. The rise in volatility in the second period also originates in the sharp rises that occurred only towards the second half of 2007, while no special development was recorded around the period when the reform was launched.

The two market depth measures—the quoted quantity and the transaction size—pointed to a significant increase in the average between the two periods. The chart describing the average transaction size in Figure 11 shows a moderate upward trend in this measure as early as late 2005. A halt in the rising trend is visible between May 2006 and January 2007, while the measure becomes more volatile by the end of the sample period. Only in January 2007 is a significant rise in the average transaction size posted, the influence of which continued until the end of the third quarter of 2007. The quoted quantity measure shows similar development—a moderate rise from the end of 2005, a halt in the rising trend between May and November 2006 with an increase in the measure's volatility continuing until the end of the sample period, and a further rise in the quoted quantity at the beginning of 2007.

To summarize the descriptive statistical data and the development of the measures over the period, it emerges that there was no special development of the measures around the dates on which the reform was launched. The change in the averages of the measures between the period before the reform and the period after it is explained by delayed development in late 2006 and early 2007 (in turnover rate, YI, quoted quantity, transaction size, and volatility) or by development at the beginning of the sample period (CRT). The spread measure, which had a higher average (not significantly) during the second period, was on a downward trend during the period when the reform was launched. The trading frequency measure clearly dropped when the reform was launched in September 2006, combined with a decrease in the volatility of this measure.

Figure 11: Evolution of the Liquidity Measures 2005-2007



It can be stated that even if the reform had a positive effect on the level of liquidity in the nominal government bond market, this effect is directly observable in almost none of the liquidity measures. This, however, is not sufficient grounds for concluding that the reform did not contribute to better liquidity in the market. First and foremost, it should be recalled that during the sample period, especially in the period after the reform was launched, the first signs of the global crisis began to raise the levels of market risk, and higher risk levels also have a negative impact on the level of liquidity, especially on the cost measures. Consequently, in order to estimate the effect of the reform on the state of liquidity in the market, the effects of the global crisis and other influences on the development of liquidity in the market must be neutralized.

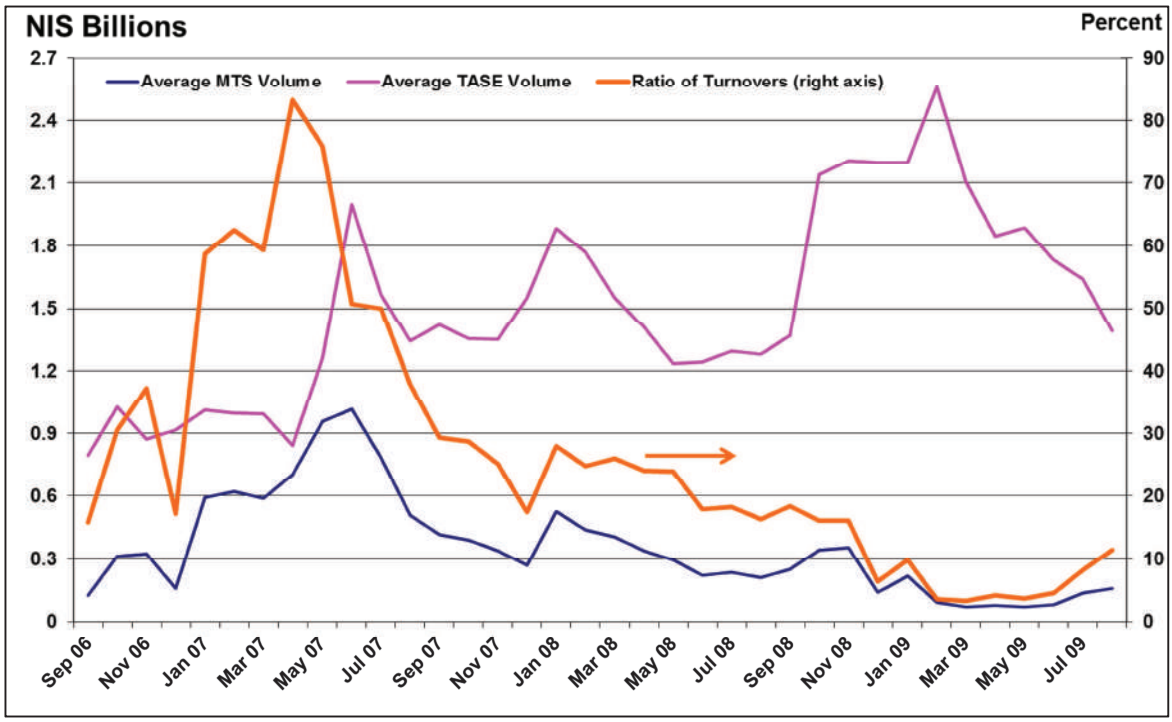
8. The Estimation

8.1. The Explanatory Variables

In estimating the effect of the market makers reform on the measures of liquidity, turnover on the MTS system (weekly turnover, standardized for the length of the trading week) is used as a proxy for the reform based on the purpose and uses for which the MTS was designed. Indeed, as mentioned in the background to the reform, the MTS system is used exclusively for trading between primary dealers, but the presence of this system can contribute to the level of liquidity on the TASE. In effect, the MTS system supports all providers of liquidity in the market: traders and investors, algo traders, market makers, and, of course, primary dealers. Without MTS, each of these parties can provide liquidity within the limitations of the inventory that he possesses. In the event that his inventory drops below a certain threshold (in a buyers' market), or rises above a certain threshold (in a sellers' market), the provider of liquidity will be forced to stop providing liquidity, and may even become a consumer of liquidity. The existence of the MTS system enables each liquidity provider to be assisted by a primary dealer to increase or decrease the inventory that he possesses, as needed, and the primary dealer can then, if necessary, apply through the MTS system to other primary dealers in order to adjust the amount of inventory in his possession. In addition, he also has at his disposal a lending facility of domestic government bonds operated by the Ministry of Finance that can supply up to NIS 500 million in bonds to each primary dealer (as of the sample period).

This entire process depends on the existence of a high liquidity level in the MTS system. If this condition is fulfilled, it will be worthwhile for the liquidity provider to purchase inventory from a primary dealer or sell inventory to a primary dealer, and it will be worthwhile for a primary dealer himself to operate on the MTS. If the liquidity level on the MTS is too low, and the cost of liquidity too high, the cost of adjusting inventory will be high, liquidity providers will reduce their involvement, and the MTS system will therefore be unsuccessful in fulfilling its role. In principle, given that the primary dealers' share of issues by the Ministry of Finance reaches 80 percent, together with the existence of the lending facility, the liquidity level on the MTS can be very high. Yet Figure 12 shows that one year after the MTS system was launched, turnover on it had already dropped sharply, reaching an average daily level of only NIS 200 million in mid-2009. This level, relative to total TASE turnover, is even lower than the level prevailing in the OTC market before the reform. In the absence of other data for MTS trading, such as the Bid-Ask spread, the level of activity is an indication of the liquidity level on the MTS, and it therefore represents the reform's degree of success.

Figure 12: Government Shekel Bonds – Daily Turnover on MTS and the TASE, and the Ratio between Them, September 2006 to August 2009



Source: Tel Aviv Stock Exchange, Ministry of Finance website, and Bank of Israel Analysis.

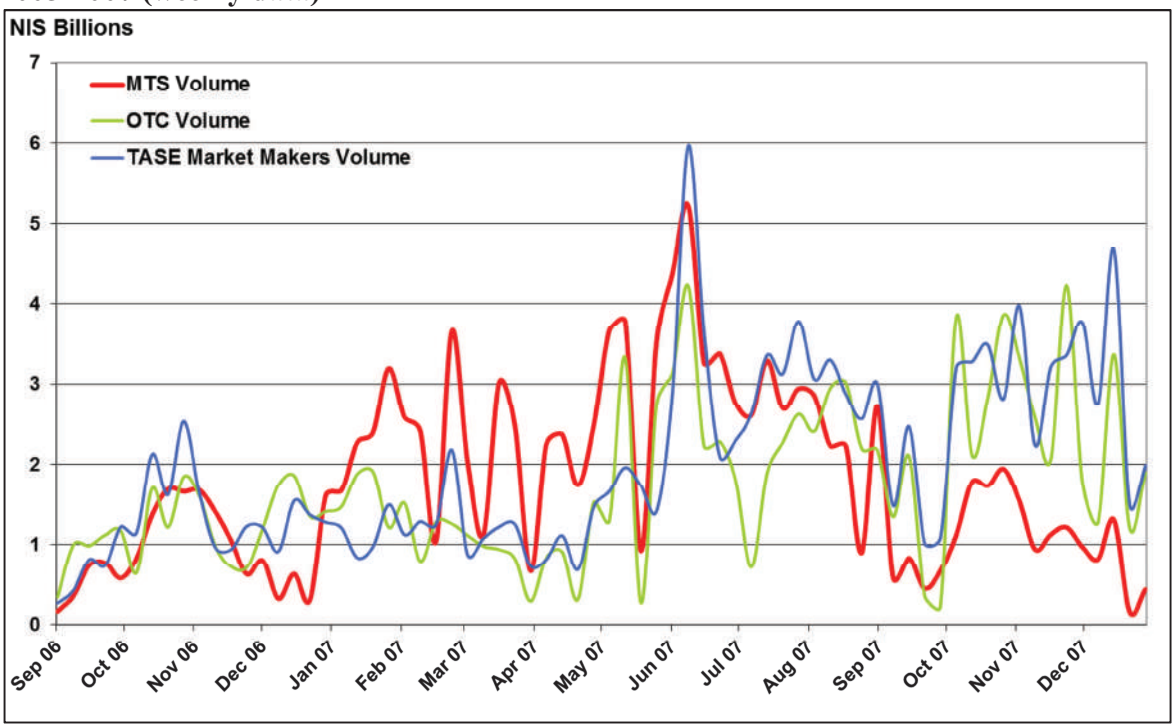
It could be argued that the primary dealers are operating on the OTC market instead of through the MTS, an assertion that can find support in the long-term rise in OTC turnover with the launching of the reform (Figure 7). Since there is a lack of detailed data, this contention cannot be ruled out, and it is possible that the primary dealers are distributing the bonds that they buy in Ministry of Finance tenders on this market. Even if this claim is true, however, it should be kept in mind that the primary dealers have no quotation obligation at all on the OTC market, that in contrast to MTS there is no orders book for OTC trading, and that in any case the OTC market lacks the transparency that exists on the MTS. Since there is no quotation obligation, liquidity providers cannot rely on the primary dealer to manage their inventory. In the event of a liquidity shortage, the primary dealer will also want to reduce his risk, and will therefore cut back on his activity, or ask too wide a spread for providing liquidity, while on the MTS, the spread that they can demand has a maximum limit, and they are committed to a minimum number of quotations. Trading on the OTC market therefore does not contribute, in this sense, to the liquidity level on the TASE.

Turnover on the MTS is therefore affected by the dissipation of the excitement surrounding the establishment of the MTS, as well as its rules, the lending reserve, and the allocation to the primary dealers of 80 percent of the volume of the issues—the core elements of the reform. Another element of the reform is the appointment of foreign primary dealers and the transition to management of tenders through the Bloomberg system, measures designed to bring foreign investors into the nominal government bond market. The entry of sophisticated foreign investors can contribute to an increase in market trading volume and enhancement of the market, thereby contributing to improvement in liquidity. However, since both the entry of foreign investors and their activity will be reflected in trading on the TASE, their activity will also ultimately be channeled into MTS trading, so that turnover on the MTS also represents the influence of the entry of foreigners on the liquidity level. In order to test sensitivity to the inclusion of MTS turnover as an explanatory variable, dummy variables for the reform will be used.

A number of explanatory variables affecting the various liquidity measures—such as OTC turnover (weekly turnover, standardized for the length of the trading week), foreign holdings and the change in them—were themselves affected by the launching of the reform. Thus, activity by market makers appointed on the TASE for nominal government bonds, whose

activity began when the reform was launched, and the extension of the trading day, also affected the various liquidity measures. The development of OTC turnover and the turnover of TASE market makers show a similar pattern throughout the sample period. This is also true of the length of the trading day and foreign holdings. These variables, which, as noted, affect the liquidity measures and were therefore included in the various estimations, show signs of high multicollinearity.

Figure 13: Development of Turnovers on MTS and OTC, and of TASE Market Makers, 2005-2007 (weekly data)



Source: Tel Aviv Stock Exchange, Ministry of Finance website, and Bank of Israel Analysis.

For example: In estimating the linear connections after the reform was launched between the turnover of the market makers on the TASE, on the MTS and in OTC trading, an R-squared of 0.1 is obtained between MTS turnover and the rest, in comparison with an R-squared of 0.5 between the turnover of market makers on the TASE and OTC turnover. Figure 13 shows the difference between the development of turnover on the MTS and the development of turnover on the TASE and the OTC market, both of which exhibit similar development. In such cases, it is customary to include all the variables, but to treat with caution the estimated coefficients of the variables having a strong linear connection between them. At the same time, the estimation is unbiased and consistent, and the estimated

coefficients for the other variables are reliable. Since the linear connection of MTS turnover with the other variables is relatively weak, its coefficient can be regarded with less concern.

Volatility was also included as an explanatory variable in the estimation equations. Volatility represents both the entry of new information into the market and an increase in the risk of steep changes in yields to maturity. As explained in the presentation of the measures, volatility affects the liquidity level in all the cost and market activity measures, except for the YI measure, which arouses concern about possible endogeny between it and volatility. High volatility represents the entry of information affecting and changing prices, while a high YI means sharp changes in prices, but resulting from few transactions, leading to higher measured volatility. In this measure, volatility measured on the *makam* market is used as a substitute, and the endogenous connection between it and YI in the government bond market is low. Volatility in the *makam* market represents the entry of information into both this market and the nominal government bond market, and also influences YI. There is no discernable reason, however, why market depth in the nominal government bond market, for example, whose market depth is expressed in YI, should affect the volatility measured in the *makam* market. Additional data are therefore used as explanatory variables for YI, as a substitute for volatility. These represent risk and entry of information—such as the implied standard deviation of shekel-dollar options, the VIX Index, and the volume of nonresidents' shekel-dollar swap transactions. In addition to volatility, the VIX Index and the implied standard deviation of shekel-dollar options were also used as explanatory variables for the spread measure, due to the relatively high sensitivity of the spread to the risk of price changes.

Concern about high multicollinearity also exists for the various risk variables, because most of them remained relatively stable in 2005–2006, but almost all of them rose significantly in 2007. A strong linear connection also exists between volatility and the turnover of TASE market makers, with an R-squared of 0.6.[21] Here, too, the estimates of these variables' coefficients should be regarded with caution, but this does not detract from the

[21] It is important to emphasize that we are not contending that the linear connection between the explanatory variables, particularly between volatility and the turnover of TASE market makers, is structural. The claim is that such a connection was found only during the sample period. This may be completely random, with no such connection existing in the long term.

estimate for the coefficient of MTS turnover, which represents the reform. This estimate can be treated in the usual manner.

One key explanatory variable is the total issued quantity (in billions of shekels of par value of the securities included in the weighted indices). The size of this variable affects the quantity available for trading, which is the effective basic supply in the market. Similarly, the weekly volume of issues causes an increase in the supply, and therefore also contributes to liquidity.[22]

TABLE 2A: Correlations Coefficients between Liquidity Measures and the Explanatory Variables January 2005 – August 2006

	OTC Turnover	Volatility	Volatility in *makam*	VIX Index	Shekel-Dollar Standard Deviation	Total Issued Capital	Foreign Holdings
Turnover rate	0.41	0.35	0.28	-0.01	0.29	0.12	-0.06
Trading frequency	-0.20	-0.47	-0.42	0.21	-0.02	0.19	-0.17
Spread	0.01	0.65	0.22	-0.09	0.48	-0.02	0.27
CRT	-0.38	0.28	0.07	-0.19	-0.32	-0.65	-0.03
YIELD IMPACT	-0.13	0.51	0.25	-0.36	-0.02	-0.21	0.08
Quoted Quantity	0.35	-0.13	-0.07	0.30	0.42	0.65	-0.15
Average Transaction Size	0.28	-0.01	0.02	0.30	0.31	0.49	-0.24

TABLE 2B: Correlations Coefficients between Liquidity Measures and the Explanatory Variables September 2006 – December 2007

	OTC Turnover	Volatility	Volatility in *makam*	VIX Index	Shekel-Dollar Standard Deviation	Total Issued Capital	Foreign Holdings
Turnover rate	0.49	0.73	0.39	0.41	0.52	0.49	0.25
Trading frequency	-0.48	-0.62	-0.49	-0.27	-0.52	-0.25	-0.10
Spread	0.37	0.86	0.50	0.64	0.66	0.56	0.31
CRT	-0.03	0.48	0.12	0.06	0.18	0.04	-0.05
YIELD IMPACT	0.27	0.76	0.46	0.38	0.54	0.29	0.10
Quoted Quantity	0.24	0.16	0.07	0.15	0.04	0.28	0.49
Average Transaction Size	0.33	0.42	0.13	0.22	0.17	0.43	0.42

[22] The effects of expectations of a change in the Bank of Israel interest rate, the Bank of Israel interest rate itself, inflation expectations in the capital market, and the Second Lebanon War were also tested. The effects of all these variables were found to be not significant for all of the liquidity measures.

Every explanatory variable was included again in the estimation after being multiplied by a dummy variable for the reform, which receives the value 1 starting in September 2006. In this way, changes in the connection between the explanatory variables and the liquidity measures caused by the reform can be detected. Tables 2A and 2B display the correlation coefficients between the liquidity measures and the explanatory variables before and after the reform. It can be seen that in a large proportion of cases, the correlation coefficients after the reform are very different from those before it. On the other hand, the correlation coefficients of volatility in *makam* with most of the measures during the second period were close to the correlation coefficients during the first period.

8.2. The Results

Table 3 displays the estimation results. All the dependent variables, i.e. the liquidity measures, were log transformed, as were the explanatory variables when possible. The level of significance for the coefficients is ranked using the * symbol. The adjusted R-squared values were relatively high, varying between 0.33 and 0.76.

As noted, MTS turnover represents the effect of the reform. The estimation results show that the reform had a positive impact on turnover rate. Even subtracting the turnover of TASE market makers did not change this result. The reform, however, did not affect trading frequency, which means that the improvement in turnover rate was due to the positive effect of the reform on the average transaction size, which was indeed found to be significant, and not to a larger number of transactions. On the other hand, the reform's effect on the spread was found to be positive and significant, meaning that the reform contributed to a wider spread, and consequently to a drop in liquidity. The reform was not found to have a significant effect on CRT, YI, or the quoted quantity. These measures are also related to the market depth aspect, and it therefore appears that the reform had no effect on market depth.

As noted, the reform had a positive impact on the average transaction size. At the same time, it should be noted that no significant effect on the median transaction was found. This means that a limited number of especially large transactions were carried out following the reform, which contributed to a rise in the average transaction size, but did not affect the median. This pattern could also explain the positive effect on the spread: Given an absence of effect on the market depth, carrying out large transactions clears the orders book at better

prices, and widens the spread until the entry of new orders. Indeed, for this reason, we would also expect a positive effect on CRT and YI, for which the estimate of the reform's effect was positive, although not significant. At the same time, the level of significance for them was not much over 10 percent, and since these measures are also related to both the cost of liquidity and market depth, it is possible that the reform's lack of influence on market depth, as indicated by the quoted quantity measure, weakened the level of significance.

Table 3: Estimation Results°

	Turnover Rate	Adjusted Turnover Rate	Trading Frequency	Spread	CRT	Yield Impact	Quoted Quantity	Average Transaction Size	Median Transaction Size
Intercept	-6.14***	-6.23***	-2.14**	-1.95***	-14.85***	-8.02***	9.68***	2.1***	1.2
OTC turnover	0.52***	0.51***	-0.23**	-0.1*	-0.23**	0.04	0.22	0.23**	0.27**
OTC turnover after September 2006	-0.55***	-0.51***	0.25**	0.08	0.23**	-0.11	-0.21	-0.21*	-0.24*
TASE market makers turnover	9.08***	4.19 *	-5.5***	-2.4**	-2	1.9	0.49	1.8	3.22**
MTS turnover	0.08**	0.08**	-0.02	0.05***	0.03	0.06	0.02	0.06**	0.04
Volatility (log)	0.3***	0.28**	-0.2**	0.4***	0.25***				
Volatility (log) after September 2006	-0.03	0.05*	0.08	0.15*	0.11				
Makam volatility (log)						0.41**			
Makam volatility (log) after September 2006						-0.29			
Standard deviation of the Tel Aviv 25 Index (log)				0.16**					
Standard deviation of the Tel Aviv 25 Index (log) after September 2006				-0.08					
VIX Index (log)				-0.03		-0.69**			
VIX Index (log) after September 2006				0.4***		0.92**			
Implied standard deviation of shekel-dollar options (log)						0.17			
Implied standard deviation of shekel-dollar options (log) after September 2006						0.57			
Length of trading day (log)					-5.94***		4.67***		
Total issued capital (log)			0.48*	0.09	-0.64**	-0.44	1.46***	1.06***	1.12**
Total issued capital (log) after September 2006			-0.12	-0.45**	-0.37	-1.06*	0.02	-0.08**	-0.02
Issued quantity at 1 lag	0.1*	0.1							
Issued quantity at 1 lag after September 2006	-0.16**	-0.23**							
Nonresidents' holdings (log)				0.16**			-0.41**	-0.34**	-0.47**
Nonresidents' holdings (log) after September 2006				-0.2**			0.47**	0.35**	0.04
Change in nonresidents' holdings				-1.75***					
Change in nonresidents' holdings after September 2006				1.61***					
Nonresidents' swap shekel-dollar transactions						-0.22			
Nonresidents' swap shekel-dollar transactions after September 2006						0.41*			
AR(1)	0.27***	0.36***	0.57***		0.44***	0.25**	0.38***	0.37***	0.54***
R-squared	0.74	0.46	0.69	0.77	0.78	0.39	0.77	0.67	0.50
Adjusted R-squared	0.73	0.43	0.67	0.74	0.76	0.33	0.76	0.65	0.47
DW	2.07	2.06	2.09	1.81	2.06	2.00	2.05	2.01	2.07

° * Denotes coefficient at a level of significance (p value) less than 0.1

** Denotes coefficient at a level of significance (p value) less than 0.05

*** Denotes coefficient at a level of significance (p value) less than 0.01

The issued capital serves as an explanatory variable for all the liquidity measures other than turnover rate and turnover rate excluding transactions by the TASE market makers. The latter two are in any case standardized for issued capital, so that the effect of the issued capital on them is not significant (the estimation that includes the issued capital is not shown). In the context of the reform, there are two positive effects on the relation between total issued capital and the liquidity measures. The effect of total issued capital on the spread and on YI before the reform does not differ significantly from 0, but after the reform, a rise in total issued capital has a significant negative impact on these measures, i.e. it has a positive effect on the liquidity level.

The sensitivity tests that include omitting the observations from the beginning of the sample period or from its end, omitting turnover of the TASE market makers as an explanatory variable, and omitting time windows around the start date of the reform (the omission of two time windows was checked: June 1–December 31, 2006 and April 1–September 30, 2006) produced similar effects of the reform on the liquidity indices, except for estimation of the effect on YI, in which some of the tests of the reform's effect preserve a similar or slightly higher estimate, but the estimate becomes significant at a 10 percent level of significance.

The sensitivity to the variable representing the reform, turnover in the MTS system, was checked by replacing the MTS turnover and TASE market makers turnover variables by dummy variables for the reform. The results of this sensitivity test show that the rise in turnover rate following the reform originates in an increased effect of volatility, while the effect of the reform was not found to be significant. The effect of the dummy variable for the reform on CRT was found to be positive and significant, while the effect on average transaction size was not found to be significant, in contrast to the positive effect found in the main estimation. A significant negative effect on the quoted quantity was also found, in contrast to no change in the main estimation. On the other hand, the positive effect of the reform on the spread in the main estimation became insignificant in the estimation with a dummy variable for the reform, and a negative connection was estimated for trading frequency (an improvement in trading frequency), in contrast to in insignificant connection in the main estimation. In other words, the sensitivity test did not indicate that the reform had improved liquidity on the bond market, except for an improvement in trading frequency. This

estimation was also checked with the omission of the two time windows noted above, and similar results were obtained, although turnover rate in the first window rose significantly.[23]

8.3. Possible Explanations for the Results

The results of the estimation show that the reform contributed on the whole to an improvement in the level of market activity. Market depth was probably not affected, although it appears that following the reform, the large transactions became even larger. The reform had a negative impact on the cost of liquidity, which was consequently pushed upwards. Nevertheless, of the cost measures, only the reform's effect on the spread was significantly positive, although in some of the sensitivity tests, it was found that even this measure was insignificant.[24]

In any case, it can be concluded from the results that the reform did not contribute to improving liquidity in the nominal government bond market on the TASE. This result requires an explanation, given the variety of measures employed in the reform that were designed to improve liquidity in this market. As noted, a shortage in aggregate liquidity in the market as a whole is eventually channeled to the primary dealers, who turn to other primary dealers on the MTS or the Ministry of Finance's lending facility of domestic Government bonds for trading when necessary. Trading between primary dealers balances the demand for liquidity in the market, contributes to stability in market depth, and therefore also pushes down the cost of liquidity. As noted, however, the functioning of this mechanism will support liquidity in the secondary market on the TASE only if the cost of liquidity on the MTS is equal to or lower than the cost in the secondary market itself (the TASE); otherwise, it will not be worthwhile at all for the various suppliers of liquidity on the secondary market to turn to the primary dealers. Data for the cost of liquidity—the spread—in the MTS system are

[23] In principle, a situation can be conceived in which a drop in the liquidity level increases the viability of the market makers serving as financial intermediaries, with turnover on the MTS system increasing as a result. The existence of such a connection, in which the liquidity measure affects MTS turnover, provides grounds for concern about endogenous in the equations for the main estimation. However, as with the result of the main estimation, it was not found in the above-mentioned sensitivity test that the reform had improved liquidity. It therefore appears that the main estimation results were not affected by consequences of the concern about endogeneity.

[24] It is important to note that while the sensitivity test showed no effect of the reform on the spread, the same test also indicated a negative impact on market depth during the period following the start of the reform.

unavailable. However, the trading rules on the MTS stipulate maximum spreads, in terms of basis points, that are binding on the primary dealers. Table 4 shows the actual averages of the spread in basis points in TASE trading in nominal government bonds, divided according to years to maturity during the sample period, and the maximum spreads established in the MTS rules.[25]

Table 4: The Actual Spread on the TASE and the Maximum Spread on the MTS in Basis Points During the Sample Period by Years to Maturity

	Up to 3 Years to Maturity	3–6 Years to Maturity	6–13.5 Years to Maturity	13.5+ Years to Maturity
Average	2.4	5.6	9.6	18.1
Median	2.2	5.3	9.7	17.0
Maximum	6.7	12.0	23.8	31.1
Minimum	1.1	2.7	3.8	8.0
Maximum spread on MTS	10.0	15.0	25.0	50.0
Minimum spread on MTS for bonds defined as on-the-run	10.0	15.0	20.0	50.0

The significant differences between the actual spreads in TASE trading and the maximum spreads established in the MTS are evident. Basically, the maximum spreads established in the MTS rules are sometimes significantly higher even than the corresponding maximum spread actually measured on the TASE. Turnovers on the MTS, which are low in comparison with TASE turnovers, also support the existence of a wider spread on the MTS. If the actual spreads on the MTS system indeed tend more towards the established maximum spreads, the incentive to turn to primary dealers in a liquidity shortage is lost. As a result, MTS turnover will decline, as was indeed observed in practice, and this is therefore a possible explanation of the results obtained.[26] Furthermore, wide spreads in trading between primary dealers are also liable to trickle into the secondary market, due to the volume of holdings by the market makers and their share of the Ministry of Finance tenders (a possible explanation of the increase in the spread in TASE trading).

[25] During the period in which the reform was initiated, the maximum spreads established in the MTS rules were even higher.

[26] Obviously, the maximum spread is for each principal market maker himself. Over the MTS system, it is possible that gathering the quotations of all the primary dealers together will yield a very narrow spread, even if all of them quoted the maximum spread. In such a case, the proposed explanation is invalid.

The relatively high turnovers in the period immediately following the launching of the reform can be attributed to the existence of a relatively narrow spread in the MTS system in its initial months of activity. Later, in the same way, a rise in the spread towards the maximum possible spread could have caused the decrease recorded in turnovers on the MTS. Another reason for relatively high turnovers in the first months following the launch of the MTS system could be initial enthusiasm about the system, leading to relatively high turnover, which later subsided, at which point turnovers declined. These two reasons—separately or combined—could explain the high turnovers when the MTS system was launched.

Actually, the reform would have successfully improved liquidity in the government bond market on the TASE, had it motivated the primary dealers on the TASE to supply liquidity through market making, i.e. by simultaneously injecting limit orders for the purchase of bonds and the sale of bonds. If it is found that the primary dealers had indeed performed market making on the TASE, then the reform really should have improved liquidity.

In essence, market making is a simultaneous quotation of limit orders on the buying side and on the selling side. A market maker manages his inventory (i.e. makes sure that the quantity of inventory that he possesses does not fall below a certain threshold, so that he can supply securities to the market, and does not rise above a certain threshold, in order to limit the risk of price changes) by injecting limit orders. For example, in a buyers' market, the quantity of inventory possessed by the market maker rapidly decreases. The market maker responds by raising the price of the selling limit orders, so that he distances himself from the best price, and the volume of his sale transactions drops. On the other hand, the market maker will want to increase the quantity of his inventory, distancing it from the bottom threshold, and he will therefore inject buying limit orders at higher prices. In this way, the market price rises, and the existence of the market makers makes it possible to maintain a reasonable spread, even in a buyers' market, even if the spread widens slightly. Such behavior enables the market maker to both manage his inventory and meet his market making commitments, while producing profits in the form of the spread. In this way, the market maker should not inject market orders, which constitute consumption of liquidity, at all, except in a few unusual cases.

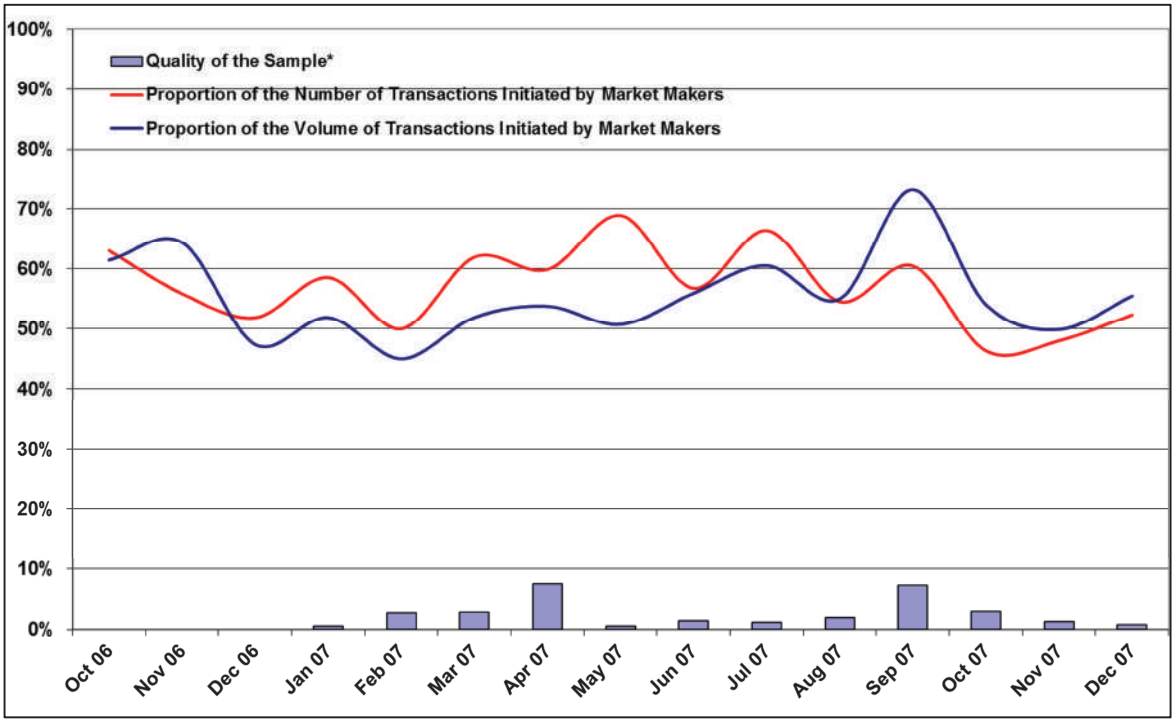
Five of the primary dealers were also appointed by the TASE as TASE market makers. Since the TASE marks transactions in which a market maker participated, and whether the market maker bought or sold, the character of these five market makers' activity can be described. The data for transactions in which the TASE market makers took part were cross-referenced with the intraday data, thereby making it possible to characterize each transaction by a market maker—whether they initiated the transaction, meaning that they were consumers of liquidity, or injected limit orders, meaning that they supplied liquidity.

Figure 14 describes what proportion of all the transactions in which a market maker was one of the parties was initiated by the market maker. Since the transaction data for market makers did not include unique transaction identifier, cross-referencing the data for 2007 produced data with a partial correlation varying between 3 percent and 42 percent, and the data in the graph were calculated on the basis of this sample. At the same time, an examination of the sample shows it to be of high quality. In comparing the proportion of all the transactions each month in the population in which the market makers participated with the same ratio in the sample, it was found that the differences were extremely small, with the largest such difference being only 7 percent. Furthermore, the sample was dispersed over the entire trading month, and during different hours of the trading day. The sample can therefore be regarded as representative.

The graph displays two versions of the ratio. One is based on the ratio between the numbers of transactions, so that the ratio reflects the number of market transactions carried out, while the second is based on the volume of the transactions in par value, so that the ratio reflects the volume of market transactions carried out. For both versions, it was found that the ratio was usually over 50 percent, meaning that market makers initiated half of the transactions that they carried out on the TASE, with a tendency to a ratio greater than one-half.[27] This contrasts with the expectation that market makers will carry out mainly limit orders. This result shows that in practice, market makers did not engage in market making, and consumed liquidity to the same degree as they supplied it, and perhaps to a greater degree.

[27] We emphasize that by definition, when we look at all the players in the market together, we see that exactly half of the transactions are market transactions, and half are limit transactions.

Figure 14: Character of TASE Market Makers' Activity – The Proportion of Market Transactions Among All the Market Makers' Transactions, October 2006-December 2007



* The quality of the sample is expressed in the difference between the proportion of transactions in the population in which the market makers took part and the same proportion in the sample: The closer the difference is to 0, the better the quality of the sample.

The failure of TASE market makers, all of whom are also primary dealers and who constitute one-third of all the primary dealers, to engage in market making, is a reasonable explanation of the results, according to which the reform did not improve liquidity, particularly in the market depth and cost of liquidity aspects. Market activity, on which the estimation results show that the reform had a positive impact, is consistent with the data for transactions by the market makers. These data show that the market makers participated in some 40 percent of the transactions conducted up until the end of 2007, and it is possible that additional players entered the market after them. At the same time, it should be recalled that the market makers' activity featured more consumption of liquidity than supply of liquidity, to a greater degree than among the market players as a whole. The market makers' proportion of the market is large—a situation capable of detracting from the level of liquidity in the market by widening the spread or by decreasing market depth.

9. Summary and Conclusions

The market makers reform, which was launched at the beginning of the second half of 2006 and completed in early September 2006, is a comprehensive reform in the management of government debt and organizing trading in government bonds. The main elements of the reform involve only nominal government bonds, and have not yet been applied to the other types of government bonds. Therefore, before extending the reform to other types of bonds, it is very important to assess its various elements, and to examine whether its goals have been achieved. This study examines whether the reform succeeded in achieving one of its goals—bolstering liquidity in the secondary market. For this purpose, initial fundamentals were assumed for measuring liquidity in the Israeli bond markets through calculation of a group of liquidity measures, based on an intraday database of transactions and orders on the TASE.

Measuring the effect of the reform in a sophisticated and open market that is subject to many variables is not simple. In any case, it can be stated that an evaluation of the development over time of the various liquidity measures, together with estimation of the effect of the reform on the liquidity measures, show that it is very probable that the reform improved the level of market activity, but did not improve the cost of liquidity or market depth. Two possible explanations were suggested for the absence of a positive impact by the reform on liquidity: an excessively wide spread in the MTS system—an explanation supported by a comparison between the maximum MTS spreads binding on the primary dealers and the actual spreads on the TASE—and the activity of the TASE market makers, which shows that they are not functioning as suppliers of liquidity.

Further research is required to support these two possible explanations of the results. Such research should examine the width of the spreads on the MTS, in comparison with those on the TASE, and the effect of the difference between them on activity on the MTS and on the TASE liquidity level. The activity of the primary dealers and other market makers on the TASE should be characterized more precisely. If it is found that they are the causes of the reform's lack of success in improving liquidity on the TASE, measures should be taken to set effective—i.e. lower—maximum spreads on the MTS, and to regulate the action of market makers on the TASE to ensure that they supply liquidity to the market, for example by restricting their submitting of market orders.

It is important to note that this study examined only one of the many goals that the reform was designed to achieve.[28] Some of them—such as foreign investment banks' activity as primary dealers—were achieved as soon as the reform was launched. The achievement of other goals—including bringing foreign investors and investment banks to the Israeli market, lowering the cost of raising capital for the government, and enhancing transparency—were not examined here. Some of these are measurable, and there is room for further research to assess whether they were achieved.

[28] Other research conducted by Zvi Wiener, Eugene Kandel, Orly Sade, and Roy Stein (not yet published) found that the reform caused TASE spreads in nominal government bonds to narrow on the days preceding an additional issue of those bonds.

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