

**BANK FOR INTERNATIONAL SETTLEMENTS**

**Market Liquidity:**

**Research Findings and Selected Policy Implications**

Report of a Study Group established by the  
Committee on the Global Financial System  
of the central banks of the Group of Ten countries

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## Preface

Recent episodes of turbulence in global financial markets, as well as the ever-increasing importance of traded markets to financial intermediation, have focused the attention of policy-makers and academics on the determinants and dynamics of market liquidity. In December 1997, the Euro-currency Standing Committee (now the Committee on the Global Financial System) set up a study group of central bank researchers, under the chairmanship of the Bank of Japan, to examine some of the relevant issues. This work is in accordance with the Committee's mandate to engage in in-depth analysis of the functioning of financial markets and systems. This volume contains the papers that resulted from this effort, as well as an overview note drawing on the insights obtained from the papers and on the discussions of the study group. The papers, including the overview, represent the views of the authors and not necessarily those of the institutions with which they are affiliated, the Bank for International Settlements or the Committee on the Global Financial System.

As the group notes, an attempt to understand the mechanics of market liquidity is needed in order to inform public and private activities that either presume the existence of liquid markets or affect the extent to which markets are liquid. Liquidity in government bond markets is of particular interest to central banks, because of the relevance of these markets to monetary policy and to financial stability. For these reasons, the group decided to make a particular effort to understand what determines liquidity in these markets, at both the theoretical and empirical levels. As part of the study, staff from the central banks and/or government debt offices of all of the G-10 countries participated in a survey on the structure of government securities markets. This comparative analysis, in combination with the in-depth discussion of specific national markets, may offer useful guidance to authorities in other countries seeking to enhance liquidity in their respective government debt markets.

The Committee concurs with the group's observation that central bank activities inevitably have an impact on market liquidity, corresponding to the various roles that central banks perform in the financial system. The Committee decided to publish this volume in the hope that it will encourage further efforts to understand these very important issues.

Yutaka Yamaguchi

Chairman, Committee on the Global Financial System

Deputy Governor, Bank of Japan

## Executive Summary

### I. Goals and Motivations for the Study

This report is the result of a coordinated research effort by the central banks of Canada, Italy, Japan, the United Kingdom and the United States and the Bank for International Settlements on the determinants of market liquidity and on how central banks and other public authorities influence these determinants. Following a decision by the Euro-currency Standing Committee (now the Committee on the Global Financial System) in December 1997, a group of central bank economists and market analysts, under the chairmanship of the Bank of Japan, conducted this research from February 1998 to March 1999. As part of the study, staff from the central banks and/or government debt offices of all of the G-10 countries participated in a survey on the structure of government securities markets.

The ultimate goal for central banks in studying market liquidity is to develop knowledge about its determinants that can be employed by them in the conduct of monetary policy and in performing their other roles. As a first step towards this goal, the group examined a whole range of issues bearing on market liquidity, at both the theoretical and empirical levels. Of these issues, the group paid particularly close attention to those with relevance to the determinants and dynamics of the liquidity of government securities markets. This is because of the importance of these markets to key central bank functions, including the conduct of monetary policy, the maintenance of financial stability, and in some cases the management of government debt.

### II. Dynamics and Determinants of Market Liquidity

#### Definition, Dimensions and Dynamics of Market Liquidity

Market liquidity is an elusive concept, reflecting its multi-faceted nature. Having said this, a definition which seems to garner relatively wide support would be the following: a liquid market is a market where participants can rapidly execute large-volume transactions with a small impact on prices. The usual approach adopted in market microstructure research is to consider market liquidity according to at least one of three possible dimensions: tightness, depth and resiliency. *Tightness* is how far transaction prices diverge from mid-market prices, and can generally be measured by the bid-ask spread. *Depth* denotes either the volume of trades possible without affecting prevailing market prices, or the amount of orders on the order-books of market-makers at a given time. *Resiliency* refers to the speed with which price fluctuations resulting from trades are dissipated, or the speed with which imbalances in order flows are adjusted.

The sharp evaporation of liquidity from some markets and the spread of illiquid conditions to other, seemingly unrelated markets following the recent Asian and Russian crises have reminded observers that the determinants and dynamics of market liquidity have yet to be fully understood. Three phenomena, in particular, are of interest: the *concentration* of liquidity in specific markets or instruments, often at the expense of liquidity in closely related markets; the *evaporation* of liquidity from markets; and the *flight to liquidity*, with a rise in the premium investors are willing to pay to hold liquid assets.

#### Factors Affecting Market Liquidity in General

The group divided the factors affecting market liquidity into three broad categories: product design, market microstructure, and the behaviour of market participants. One reason *product design* is

important is because it affects the substitutability of market instruments. A high level of substitutability tends to lead to the concentration of liquidity in one out of a range of substitutable instruments. A prime example of this, discussed at several points in the overview paper and in a number of the individual papers, is the high degree of liquidity of benchmark government securities.

*Market microstructure* affects market liquidity as well. Although a number of broad patterns can be found relating the nature of traded instruments to their corresponding *trade execution systems* (including quote-driven and order-driven systems), these patterns may well change with the ongoing development of information technology and changes in market conditions. It is found that smaller *transaction costs* could enhance market liquidity, but the intensity of the effects varies depending on market conditions. One key theoretical finding is that imposing transaction costs could lead to an early exit of market-makers from a market in times of stress. Regarding *transparency of market data*, the effects are often more complex than they appear initially. On the one hand, broader observability of ex-ante price information (such as dealer quotes) should lead to narrower bid-ask spreads in dealer-type markets. On the other hand, it is found empirically that a move to anonymity of market-makers in the Italian government securities market led to improved market liquidity. A theoretical paper suggests that the effects of transparency on market liquidity depend on the underlying information structure, and particularly the degree to which different market participants can observe different kinds of information.

A key aspect of *market participants' behaviour*, which runs through many of the studies, is *self-fulfilling expectations*: often a market will become more liquid or less liquid simply because market expectations point in that direction. A paper using simulation techniques finds that market liquidity is also affected by traders' sensitivity to short-term price movements, their degree of risk aversion, and their confidence in their own forecasts about prices.

### III. Liquidity in Government Securities Markets

#### Liquidity Indicators across Countries

The group's survey of G-10 government securities markets and other recent central-bank research on these markets find that national markets have a great deal in common in terms of the characteristics of liquidity indicators. Narrow bid-ask spreads tend to accompany high market turnover and the benchmark status of an issue. Liquidity indicators (trading volume, price volatility, bid-ask spreads) tend to show distinct intraday and intraweek patterns. The indicators tend to be higher at the beginning and end of the day relative to mid-day; in the middle of the week relative to Monday and Friday; and around statistical announcements. Futures market prices tend to lead those in cash markets, though this is not necessarily true for all instruments and countries. This price relationship may be affected by the degree of market liquidity and substitutability between cash and futures instruments.

#### Comparison of Institutional Features

In the area of *product design* while most governments try to issue bonds at a variety of maturities in order to meet investors' varying demands, there has been a tendency to reduce the number of maturities in favour of issuing a greater amount at each key maturity. There has also been a tendency to try to concentrate liquidity in a few benchmark issues.

Regarding market microstructure, a majority of the surveyed countries have adopted *primary dealer systems*, in which the central bank or another authority confers on a certain group of dealers the right to participate in issuance process and/or central bank market operations in exchange for the obligation to make a market in secondary trading. With regard to *transparency*, cash customer markets for government securities tend to be the least transparent, futures markets the most, and cash interdealer markets somewhere in between. Most of the countries have *structures to facilitate short-sales* of

government securities, such as repo markets, delivery-fail rules, and securities lending or reopening of issues by authorities to prevent market manipulation.

#### **IV. Toward Deep and Liquid Markets**

The following conclusions derive from the study group members' research findings, the existing academic literature, and discussions within the group.

##### **Measures for the Enhancement of Market Liquidity**

First, *maintaining a competitive structure of trading* serves to heighten liquidity by creating pressure for narrower bid-ask spreads in over-the-counter (OTC) dealer markets. In the case of organised exchanges, intensified competition between exchanges or with OTC markets could help to lower trading costs and promote efficient information dissemination. Under such a competitive structure, market participants should enjoy the freedom to choose between markets of different characteristics, as long as over-fragmentation of markets does not reduce market liquidity.

Second, *taxes, if imposed, should be levied so as to minimise their impact on market liquidity*. The liquidity-impairing effects of a transaction tax should be counted against the revenue it might raise. The effects of withholding taxes become larger if imposed on marketable assets which change hands frequently, or on entities which are actively involved in trading.

Third, *transparency generally improves the functioning of markets*, by promoting reliable price discovery and efficient risk allocation. However, in a dealer market, while disseminating prevailing prices to the public would enhance market liquidity, disclosing information on specific orders, which reduces the anonymity of market participants, may in some cases prove counterproductive.

Fourth, *standardised trading and settlement practices mitigate market fragmentation and thus reduce transaction costs*. In this regard, the introduction of the euro should eventually lead to the alignment of coupon and principal payments for euro-denominated government securities and thus increase the liquidity of these securities. Broader application of settlement practices in the government securities markets, such as DVP and T+3 settlement, to the whole universe of fixed-income securities should improve liquidity, not least by facilitating arbitrage and hedging transactions.

Fifth, *heterogeneity in market participants' behaviour, reflecting different transaction needs and investment horizons, should enhance market liquidity*. In this regard, broader participation of non-residents in domestic markets could improve liquidity by increasing heterogeneity.

Finally, given the externalities and self-fulfilling nature of market liquidity, *core asset markets whose ample liquidity would benefit the whole financial system need to be identified*, and policy measures might be tailored to the characteristics of such markets.

Government securities provide a principal, but not the only, example of such a core asset class. In promoting government securities as a core asset, the following issues are important in addition to the above-mentioned points. First, filling demands for benchmark issues at "key maturities" seems to be a more effective strategy than seeking high levels of liquidity throughout the yield curve. To make the issue size of benchmarks in each zone sufficiently large, issuers can consider reducing issue frequency and or conducting several consecutive reopenings. Second, pre-announcement of issuance schedules should facilitate dealers' ability to make markets, by improving their ability to anticipate customer demands and thus decreasing their inventory risk. Third, improving the functioning of the repo and derivatives markets, including futures, could enhance liquidity in the cash market in government securities.

### **Issues for Further Study**

Central bank activities inevitably have an impact on market liquidity, corresponding to the various roles that central banks perform in the financial system. First, as policy makers, information announced by central banks, such as policy decisions, statistics, and notification of open market operations, is rapidly incorporated into financial market prices. Second, as large market participants, some central banks affect liquidity through their portfolio management policies. Third, given their interest (usually in conjunction with other agencies) in matters relating to financial stability, central banks closely monitor and analyse liquidity conditions in markets where liquidity could dry up under stress.

Given these different concerns, central banks can take a number of steps to promote further research into market liquidity, including research efforts by central bank researchers and academics.

## Introduction

This report is the result of a coordinated research effort by the central banks of Canada, Italy, Japan, the United Kingdom and the United States and the Bank for International Settlements on the determinants of market liquidity and on how central banks and other public authorities influence these determinants.<sup>1</sup> Following a decision by the Euro-currency Standing Committee (now the Committee on the Global Financial System) in December 1997, a group of central bank economists and market analysts, under the chairmanship of the Bank of Japan, conducted this research from February 1998 to March 1999. As part of the study, staff from the central banks and/or government debt offices of all of the G-10 countries participated in a survey on the structure of government securities markets.

The ultimate goal for central banks in studying market liquidity is to develop knowledge about its determinants that can be employed by them in the conduct of monetary policy and in performing their other roles. In this respect, the study group's efforts are an initial attempt towards this goal. The intention is to lay the groundwork for future work in this area by examining the basic mechanics of liquid markets and the determinants of market liquidity, and identifying areas for further study in the academic and policy spheres as well as possible policy implications. As such, the study group did not concentrate its efforts on one particular market, but examined a whole range of issues bearing on market liquidity. Nonetheless, government securities markets received relatively more attention than others, because central banks have a particular interest in the functioning of these markets. This is because of the relevance of government securities-market liquidity to issues of vital importance to central banks, including the conduct of monetary policy, the maintenance of financial stability, and (in some cases) the management of government debt.

These issues have received especially close attention in recent months, in the aftermath of the global financial markets crisis following Russia's virtual default in August 1998. The rapid spread of that crisis, and the sharp evaporation of liquidity in markets that seemingly had little to do with events in Russia or other emerging economies, have reminded observers that the determinants and dynamics of market liquidity remain to a large extent obscure and puzzling. The group therefore examines the determinants and characteristics of market liquidity both in "normal" times and in response to external shocks, from both the theoretical and empirical perspectives.

The report consists of an overview note (Part 1) and eighteen individual papers on various aspects of market liquidity (Part 2; see Table 1 for the titles and authors). The overview note is the result of extensive discussions among the members of the study group, taking into account insights obtained from the individual papers. These papers provide the theoretical and empirical bases for the discussions of the study group. However, any opinions expressed in the papers are those of the authors, and do not necessarily represent the views of the participating institutions or the Bank for International Settlements.

Chapter I of Part 1 outlines the motivations behind the study. The second chapter of Part I reviews the various definitions and measures of market liquidity, and summarises the results of individual studies and discussions of the group on the determinants and mechanics of market liquidity from a broad perspective. Chapter III looks more closely at the liquidity of government securities markets. Chapter IV explores implications for market participants and for central banks and other authorities on enhancing liquidity in financial markets and suggests avenues for further research. Part 1 contains a compendium of the results of the group's survey of characteristics of G-10 government security markets as an appendix.

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<sup>1</sup> See Section II.1 for the group's definition of market liquidity. Throughout the report, the term will be used in this sense, and not in its other common senses such as the degree of availability of liquid funds.

Table 1  
**List of individual research papers**

| <b>Institution</b>  | <b>Author</b>  | <b>Title</b>   |
|---|--|--|
| Bank of Canada  | Gravelle, Toni   | (a) Liquidity of the Government of Canada Securities Market: Stylized Facts and Some Market Structure Comparisons to the United States Treasury Market |
|   |  | (b) The Market Microstructure of Dealership Equity and Government Securities Markets: How They Differ  |
| Banca d'Italia  | Scalia, Antonio and Valerio Vacca                                | Does Market Transparency Matter? A Case Study  |
| Bank of Japan   | Higo, Hideaki  | The Change of Liquidity in the Life Cycle of Japanese Government Securities  |
|   | Inoue, Hiroataka   | (a) The Structure of Government Securities Markets in G10 Countries: Summary of Questionnaire Results  |
|   |  | (b) The Stylized Facts of Price Discovery Processes in Government Securities Markets: A Comparative Study  |
|   |  | (c) The Effects of Open Market Operations on the Price Discovery Process in the Japanese Government Securities Market: An Empirical Study              |
|   | Miyanoya, Atsushi  | Price Discovery Functions in the Corporate Bond Market in Japan: An Event Study on the Recent Financial Crisis of Fall 1997                            |
|   | Muranaga, Jun  | Dynamics of Market Liquidity of Japanese Stocks: An Analysis of Tick-by-Tick Data of the Tokyo Stock Exchange  |
|   | Muranaga, Jun and Tokiko Shimizu                                 | (a) Market Microstructure and Market Liquidity   |
| (b) Expectations and Market Microstructure When Liquidity is Lost |  |  |
| Bank of England   | Ui, Takashi  | Transparency and Liquidity in Securities Markets   |
|   | Clare, Andrew, Mark Johnson, James Proudman and Victoria Saporta | The Impact of UK Macroeconomic Announcements on the Market for Gilts   |
| Federal Reserve Board of Governors                                | Dupont, Dominique  | The Effect of Transaction Costs on Depth and Spread  |
| Federal Reserve Bank of New York                                  | Fleming, Michael and Asani Sarkar                                | Liquidity in U.S. Treasury Spot and Futures Markets  |
| Bank for International Settlements                                | Cohen, Benjamin  | Monetary Policy Procedures and Volatility Transmission along the Yield Curve   |
|   | McCauley, Robert   | The Euro and the Liquidity of European Fixed Income Markets  |
| Bank of Canada, FRB of New York and BIS                           | Fung, Ben Siu Cheong, Scott Mitnick, and Eli Remolona            | Inflation Expectations and Risks in a Two-Country Affine-Yield Model   |

# Part 1

## Overview

### I. Motivations for the Study

#### I.1 Why Should We Study Market Liquidity?

Market liquidity is often taken for granted when market participants price financial instruments and manage their portfolios and when central banks conduct their monetary policies. From time to time, however, the fragile nature of liquidity is demonstrated in dramatic fashion. For example, at certain points in the October 1987 crash of stock markets around the world, and in the more recent Asian and Russian financial crises, liquidity dried up suddenly and unexpectedly in many key markets worldwide, with negative implications for the smooth functioning of the broader financial system and, potentially, the economy as a whole. Even where convincing explanations for these sudden liquidity shortfalls can be found, such explanations are constantly being challenged by the rapid globalisation of financial markets and advances in information technology such as electronic trading.

An attempt to understand the mechanics of market liquidity is thus needed in order to inform public and private activities that either presume the existence of liquid markets or affect the extent to which markets are liquid. The growing body of academic work on “market microstructure theory”, which has tended to focus on equity markets, represents an important starting point for such an investigation, and has provided some of the central theoretical underpinnings for the discussions on market liquidity in this study group.

#### I.2 Why Should Central Banks Be Concerned about Market Liquidity?

Left to themselves, financial market participants have usually proved both adaptable and inventive in developing institutional arrangements to bring about liquid conditions in their respective markets, to the extent the size and other characteristics of a given market make this feasible. Yet the benefits that deep and liquid markets offer to the broader economy can be thought of as public goods, in the sense that, while all financial market participants (as well as the economy as a whole) enjoy these benefits, each of them individually on occasion lacks the proper incentives for behaviour that would maintain adequate liquidity in both good and bad times. This suggests a role for public authorities with respect to market liquidity.

Central banks have an interest in market liquidity because of their monetary policy responsibilities and because of their interest (usually in conjunction with other government agencies) in the stability of the financial system. For one thing, in a market with ample market liquidity, price determination will be more efficient, so prices will be more informative for monetary policy. A deeper and more liquid money market also contributes to a more effective transmission of the effects of central bank intervention from markets where central banks conduct their open-market operations to other financial markets.

Recent disruptions in the financial markets of emerging economies show that disruptions are amplified in markets where liquidity is low. Systemic risk in this sense – disruption of markets as opposed to bank “runs” – is becoming more important given the increasing importance of capital markets to economic activity.<sup>2</sup> A liquid market in normal times may enhance the confidence of market

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<sup>2</sup> BIS (1992) (the “Promisel Report”) offers the following definitions of systemic crisis and systemic risk: “A systemic crisis is a disturbance that severely impair the working of the financial system and, at the extreme, causes a complete

participants in its functioning and contribute to its resiliency against stress or shocks, thus lowering systemic risk.

### **I.3 Central Banks and Market Liquidity in Government Securities Markets**

Central banks have an interest in matters affecting the liquidity of government securities markets, for the following reasons. First, outright purchases and repos of government securities are important instruments of monetary policy. If market liquidity is not sufficient, central banks might not be able to provide or absorb the necessary amount of funds smoothly through their open market operations, and such operations could produce unintended effects such as excessive price volatility.

Second, obtaining appropriate information, including the term structure of yields and implied inflation expectations, from prices in government securities markets is important for the conduct of monetary policy. Differences in liquidity across the term structure, or between fixed-coupon and inflation-linked bonds (where the latter exist), would distort the information that can be extracted from these different classes of securities.

Third, a high level of liquidity in government securities markets contributes to the promotion of financial efficiency and stability by providing benchmarks and hedging vehicles for other traded financial assets such as commercial paper, asset-backed securities, and corporate bonds. Such traded assets are assuming an increasingly important role in financial intermediation in most countries. Liquidity in government securities markets should thus make the financial intermediation process more efficient. In addition, liquidity in traded asset markets improves the ability of financial institutions to adjust their assets and liabilities rapidly in response to shocks.

Fourth, since many central banks act as agents for their governments in the issuance of government securities, they have a strong interest in aspects of the design of the issuing market, such as the types and maturities of securities offered, which affect secondary market liquidity. A liquid secondary market lowers funding costs for the government by reducing the liquidity premium demanded by purchasers of government securities in the primary market.

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breakdown in it. Systemic risks are those risks that have the potential to cause such a crisis. Systemic crises can originate in a variety of ways, but ultimately they will impair at least one of three key functions of the financial system: credit allocation, payments, and pricing of financial assets.”

## II. Dynamics and Determinants of Market Liquidity

### II.1 Definitions of Market Liquidity

Market liquidity is an elusive concept. While most observers would agree whether a given market is liquid or not, it is difficult to draw up precise definitions of market liquidity. This is because market liquidity is multi-faceted: the definition necessarily changes depending on what aspect one wishes to emphasise. The definition of market liquidity differs somewhat even among the individual research papers contained in this report. Having said this, a definition which seems to garner relatively wide support would be the following: a liquid market is a market where participants can rapidly execute large-volume transactions with a small impact on prices.

### II.2 Measuring Market Liquidity

#### II.2.1 Dimensions of Market Liquidity

The usual approach adopted in market microstructure research is to consider market liquidity according to at least one of three possible dimensions: tightness, depth and resiliency (Figure 1).<sup>3</sup> *Tightness* is how far transaction prices (i.e. bid or ask prices) diverge from the mid-market price, in other words the general costs incurred irrespective of the level of market prices. *Depth* denotes either the volume of trades possible without affecting prevailing market prices, or the amount of orders on the order books of market-makers<sup>4</sup> at a given time. In general, the greater the relative imbalance of buy or sell orders (measured on the horizontal axis of Figure 1), the farther the market price must diverge from the standard bid or ask price (measured on the vertical axis) for the imbalance to be cleared. Measures of depth attempt to capture the maximum backlog that can be accommodated before such a divergence takes place. Finally, *resiliency* refers either to the speed with which price fluctuations resulting from trades are dissipated, or the speed with which imbalances in order flows are adjusted.<sup>5</sup>

Many of the individual papers contained in this report attempt to measure market liquidity taking into account the three dimensions listed above. The data actually used to measure liquidity, however, vary greatly across the different papers, not least because of differences in underlying market structures. This points up a significant obstacle to comparisons of liquidity across markets: a given measure might be very informative about liquidity conditions in one market but meaningless or irrelevant about those in another.

Another difficulty is that the measures do not always point in the same direction, as is confirmed by some of the individual papers.<sup>6</sup> For example, *Muranaga and Shimizu (a)* find that an increase in a depth measure, volume of the order book, is accompanied by a worsening of tightness, as measured by the bid-ask spread, under certain assumptions about traders' access to order-book information.

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<sup>3</sup> Kyle (1985), Harris (1990). Figures can be found at the end of the paper.

<sup>4</sup> A market maker is an individual or institution that regularly gives customers both bid and ask price quotations for a given asset and trades with customers as a counterparty.

<sup>5</sup> Another commonly used concept is *immediacy*, defined as the time necessary to execute a trade of a certain size within a certain price range. Because immediacy incorporates elements of all three of the dimensions listed, it is not strictly speaking a separate dimension.

<sup>6</sup> *Fleming and Sarkar, Muranaga and Shimizu (a)*. Citations of individual papers prepared for this project show the author's name in italics; the full title of the paper can be found in Table 1. Citations of other papers are in normal type and refer to the Bibliography at the end of Part 1.

### II.2.2 Tightness

One of the most frequently used measures of tightness is the bid-ask spread. Bid-ask spreads can be measured in several possible ways, however, and each measured spread has a slightly different economic meaning. The *quoted spread* (which may be firm or indicative) is the gap between quoted bid and ask prices, and is observed before an actual transaction takes place. The *realised spread* is the gap between weighted averages of the bid and ask prices for executed trades over a period of time, using the transaction volumes at each price as the weights. The *effective spread* is based on the actual transaction price, rather than the quoted price; because it incorporates the change in the price between when it is quoted and when it is executed, the effective spread incorporates the direction of price movements. *Fleming and Sarkar*, who study the U.S. treasury securities market, attempt to measure tightness more precisely by looking into these different measures of bid-ask spreads (Figure 2). Methods have also been developed for estimating quoted bid-ask spreads when they cannot be measured directly. *Scalia and Vacca*, for example, estimate the fixed cost of trading associated with the existence of the spread by using the empirical model proposed by Foster and Viswanathan (1993).

### II.2.3 Depth

Depth can be measured by the amount of orders on order books, or by *market impact*,<sup>7</sup> which is the fluctuation in quotes or bid-ask spreads resulting from order executions. Average turnover figures for a given time period (such as daily or weekly) can sometimes act as proxies for depth, because they show the order flow a market tends to accommodate in “normal” times. While these measures of market depth capture actual order flows, a more accurate measure of market depth would measure both actual trades by market participants and potential trading needs that may arise from portfolio adjustments (this sum of actual and potential trading volume is sometimes called *effective supply and demand*).<sup>8</sup> Though there are few examples of research to date in this area, partly because information on order flows is difficult to obtain, *Muranaga and Shimizu (a)* investigate the dynamics of market depth by constructing simulated markets. *Muranaga* studies market impact by examining high-frequency data on transactions involving individual stocks listed on the Tokyo Stock Exchange. Other proxies for market depth include the size of trades that market makers are willing to accept<sup>9</sup> and the volume per trade.

### II.2.4 Resiliency

While there is still no consensus on the appropriate measure for *resiliency*, one approach is to examine the speed of the restoration of normal market conditions (such as the bid-ask spread and order volume) after trades.<sup>10</sup> Measuring market resiliency should be useful because it gives us a picture of potential market depth, which cannot be observed from prevailing order flows.<sup>11</sup>

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<sup>7</sup> While many securities traders and academics use the term “market impact” to refer to both market impact and market resiliency, the two concepts are distinguished in this volume in view of their different dynamics.

<sup>8</sup> *Gravelle (a),(b); Muranaga and Shimizu (a)*.

<sup>9</sup> *Dupont*.

<sup>10</sup> *Muranaga and Shimizu (a)*.

<sup>11</sup> Engle and Lange (1997).

### ***II.2.5 Other Measures***

Other measures, such as the number and volume of trades, trade frequency, turnover ratio<sup>12</sup>, price volatility<sup>13</sup>, and the number of market participants, are often regarded as readily observable proxies of market liquidity. Though these measures do not directly coincide with the three dimensions described above, they have also been employed as indicators of market liquidity in the work of the study group. *Muranaga*, for example, finds a positive correlation between some widely accepted measures of market liquidity and trade frequency, the relationship of which with market liquidity had been considered obscure.

## **II. 3 Dynamics of Market Liquidity**

### ***II.3.1 What Are the Dynamics?***

In addition to studying what determines the overall level of liquidity in various markets, the group also looked at why and how liquidity tends to change over time. In other words, the group studied both the static and dynamic aspects of market liquidity.

As advances in information technology and the globalisation of financial markets have accelerated, it has become easier both for trading activity to increase or decrease rapidly within a market, and for activity to shift rapidly among markets. This was especially apparent in the context of the events in global financial markets in August-October 1998, when illiquid conditions spread rapidly and unexpectedly across markets that are usually uncorrelated with each other and investor demand for liquid instruments rose dramatically. Insights into the dynamics of market liquidity are thus essential in understanding recent developments in international financial markets.

### ***II.3.2 Patterns in the Dynamics of Market Liquidity***

In this section, the dynamic aspects of market liquidity are explored by constructing stylised facts. Three phenomena are discussed in turn: the *concentration* of liquidity in specific markets or instruments, often at the expense of liquidity in closely related markets; the *evaporation* of liquidity from markets; and the *flight to liquidity* in which, because of a shift in investor preferences, the premia demanded for holding traditionally illiquid instruments rise relative to those attached to traditionally liquid ones.

#### ***II.3.2.1 Concentration of Market Liquidity***

In markets for assets that can act as substitutes for one another, liquidity is often concentrated in one or a small number of the assets. For example, while in a typical government securities market there are many issues, differing in maturities, coupon levels, etc., market liquidity is usually concentrated in relatively few specific issues. Similarly, in the case of futures markets, while there are multiple contracts listed, not all contracts enjoy the same degree of liquidity; the closest-to-delivery contracts are usually the most liquid.

Three of the research papers in Part 2 examine the concentration of liquidity in the government securities markets of the U.S., Japan and Europe. In the case of the U.S., “on-the-run” issues<sup>14</sup> in the

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<sup>12</sup> The turnover ratio is the ratio of the average trading volume over a given period of time to the outstanding volume of securities.

<sup>13</sup> If one assumes a constant level of “true” (i.e., fundamentals-based) prices, then volatility in observed prices could reflect the bid-ask spread, the market impact of trades, and/or the degree of resiliency. *Cohen* uses this concept to examine the liquidity of short-term money-markets. Specifically, he investigates the linkages between the volatility of various short-term interest rates under different monetary policy operating regimes for nine developed countries.

<sup>14</sup> On-the-run issues are most recently issued securities of a given maturity class. On-the-run issues become off-the-run when a new issue is created.

case of the cash market and closest-to-maturity contracts in the case of futures markets are the most actively traded (Figure 3).<sup>15</sup> In Japan, up until recently, a particular bond issue with a 10-year original maturity, a relatively large issue size and a remaining maturity of longer than seven years was regarded as the benchmark. Among the non-benchmark issues, “ex-benchmark” issues, i.e. issues which once held benchmark status, enjoy higher liquidity compared with other issues of similar maturity and issue size.<sup>16</sup>

In 1999, with the introduction of the euro, a partially integrated government securities market has emerged among the eleven member countries. The introduction of the euro has accelerated the concentration of futures market trading in the euro area in the 10-year German government *bund* futures. This heightened concentration of activity has accentuated the disproportion between the *bund*'s broad use in managing risk in the euro area and the relatively narrow basis of the underlying on-the-run cash bonds.<sup>17</sup>

While these studies suggest a high degree of persistence over time in the concentration of liquidity in specific instruments, liquidity can also shift rapidly among instruments over short time periods under certain conditions. For example, when there was excessive position taking in the *bund* future after the 1998 Russian shock, concerns over squeezes seemed to encourage market liquidity to migrate into the government securities markets of other developed countries.<sup>18</sup>

### *II.3.2.2 Evaporation of Market Liquidity*

Concentration of liquidity in one market could result in the evaporation of market liquidity from other markets. *Muranaga and Shimizu (b)* explore this topic using simulation techniques. They find that market liquidity can affect price discovery in times of stress in at least two different ways.

In one simulation, it is found that the loss of market liquidity in response to a market shock sometimes performs the function of a built-in stabiliser in the market, by preventing a precipitous secondary drop in prices that would not have been warranted by fundamentals.<sup>19</sup> As uncertainty increases in response to the shock, market participants become less willing to trade, and the decline in the number of orders generated, in turn, results in a loss of market liquidity. In other words, when market liquidity is low, price discovery is not conducted as often, so a crash in prices is less likely to lead to an endogenous (secondary) crash in prices that does not reflect fundamentals. In a sense, the withdrawal of liquidity breaks the self-reinforcing dynamics of market crashes and allows time for fundamentals to reassert themselves.

In a second simulation, however, resting on a somewhat different set of assumptions, conditions are found under which secondary crashes might develop. If market participants amend their expectations of future prices in response to a price shock and uncertainty remains low, order streams do not diminish but instead, reflecting sharply lower expected future prices, become one-way, resulting in secondary crashes.

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<sup>15</sup> *Fleming and Sarkar.*

<sup>16</sup> *Higo, Inoue (a).* See section III.3.1.3 for further discussion of benchmark effects.

<sup>17</sup> See *McCauley* for a discussion of the issues that this raises.

<sup>18</sup> At one point in the summer of 1998, the amount outstanding of September 1998 Bund futures contracts reached more than twice the total amount of securities deliverable.

<sup>19</sup> This result relies on the following key assumptions: first, that the degree of market liquidity does not affect the participants' expectations of future prices; second, that market participants do not amend their expectations on future price levels in response to a price shock; third, that in response to a price shock they become more uncertain over whether their expectations will be realised. Each modeled participant is given an expected future price, and expects that realized prices will fall within a statistical distribution around this expected future price. The increase in uncertainty is then modeled as an increase in the variance of this distribution.

### *II.3.2.3 Flight to liquidity*

A “flight to liquidity” can be regarded as a migration of activity into markets which are expected to continue to provide price quotes even in times of stress. During such an episode, participants are willing to pay a higher premium than usual to hold liquid assets. This usually happens as part of a broader “flight to quality”, when participants pay a higher premium for assets perceived to have low levels of all kinds of risk. While *activity* may move to more liquid markets, however, it is not clear that *liquidity* per se increases in them. For example, during August-October 1998, prices of risky assets of all types fell as investors shifted into the safest available assets, principally government securities. However, the liquidity premia on government securities did not necessarily increase (in price terms) for all issues and indeed, for “off-the-run” issues, they generally fell. Increased yield spreads between on-the-run and off-the-run issues reflected the fact that investors placed a higher value on the liquidity of on-the-run issues, rather than an actual increase in the liquidity of those issues.

## **II.4 Factors Bearing on Market Liquidity**

Factors affecting market liquidity are complicated and it is generally not possible to characterise how each factor works independently of the others. Therefore, the study group focuses on three sets of factors which seem to be both of particular importance in determining market liquidity and relatively easy to observe and compare across markets: product design, market microstructure, and the behaviour of market participants. For each of these categories, instead of a comprehensive treatment, what follows are general considerations and suggestions for future work.

### *II.4.1 Effects of Product Design*

One key element in considering the relations between product design and market liquidity is the substitutability of products. If the substitutability between a number of products is high, market liquidity might be concentrated in just one of them. For example, government securities are more homogeneous than corporate paper because there is only one issuer (the government) and because other features, such as coupon payment dates, embedded options and pricing conventions, are usually identical across issues. Such homogeneity should be especially high among securities with similar maturities, in which case there would be little reason to prefer one issue to another. If, for some reason, one issue becomes the preferred issue and its liquidity increases, liquidity might be all the more concentrated in such an issue because trading demand from market participants who have higher preference for more liquid securities would certainly increase. This offers an example of the “self-fulfilling” nature of market liquidity, which is discussed in greater detail below (see Section II.4.3.3). Alternatively, greater substitutability might increase the liquidity of similar issues, for example if it is easy to hedge a position in one security with a position in another.

### *II.4.2 Effects of Market Microstructure*

Differences in market microstructure can also affect market liquidity considerably. Market microstructure includes many elements, including trade execution systems, trading commissions, disclosure of contracted price and volume information, and market regulations, and these elements can be combined in many different ways across countries, products and markets. Over time, competition between different organised exchanges and between organised exchanges and OTC markets spur further changes in market microstructure, and should help to ensure that market structures eventually adopt whatever efficiency gains are made available by technological advances and globalisation.

#### *II.4.2.1 Trade Execution Systems*

Trade execution systems can be broadly categorised into *dealer markets* and *auction-agency markets*. In a dealer or “quote-driven” market, dealers quote bid and ask prices to traders, and the traders

choose whether to buy or sell at those prices. In an auction-agency or “order-driven” market, orders from traders are brought together on the order book of the auction agency, and those orders are matched according to predetermined rules.<sup>20</sup> Order-driven markets have been said to provide more efficient price discovery (that is, prices better reflect available information), while quote-driven markets are thought to provide greater immediacy (that is, trades can be executed more quickly at posted prices). Order-driven markets disseminate more information to market participants about order flows, allowing the participants to use this information in their trading decisions. Quote-driven markets give dealers a monopoly over information about the order flows that they handle, reducing the information available to the wider market but encouraging the dealers to trade even in uncertain market conditions. Although over-the-counter (OTC) markets tend to be quote-driven and the majority of organised exchanges are order-driven, there are exceptions to this pattern.

While some aspects of trade execution systems seem to be made necessary by characteristics of the product traded, other aspects vary from one market to another because of historical or institutional factors. For example, stocks of large companies are generally traded on organised exchanges, perhaps because the differences between issuers are so great that it would be difficult to match trades (or discover prices) bilaterally when order flows are dispersed, but exchanges are organised differently across countries.<sup>21</sup> In the case of foreign exchange markets, quote-driven OTC markets are dominant in most countries. This could be because the traded product is homogenous and price discovery is relatively easy, and also because order flows, from various parties dispersed around the globe, are ample even without artificially directing them to an exchange.<sup>22</sup>

As for fixed-income securities, quote-driven OTC systems seem to be fairly common, but in some countries trading also takes place in organised exchanges. Although fixed-income securities are not as homogeneous as foreign exchange, price discovery is easier for bonds than stocks because prices can be determined through arbitrage with benchmark government security yields. The price-discovery benefits of an organised exchange are therefore not always needed for bonds.

The correspondence between product characteristics and trade execution systems can sometimes shift because of market conditions. *Miyano* examines the sustainability of price discovery for the Japanese corporate bond market in the months following November 1997, when there were a series of failures of large financial institutions. He finds that, immediately following the turbulence, the trading volume of the bonds in the secondary market declined, while the issue of new bonds increased and continued at record levels for about half a year. He also finds that credit spreads in the primary market widened before those in the secondary market did (Figure 4). The paper concludes that the changes in activity levels may imply that the preferences of market participants shifted to a periodic-auction system, whose price discovery function might better withstand shocks.<sup>23</sup>

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<sup>20</sup> Dattels (1995). Order-driven systems can in turn be categorised as either periodic-auction or continuous-auction systems. In the former, orders are accumulated on the order book, and are matched periodically at certain times of the day. In the latter, orders are matched continuously on the order book according to certain standard procedures, such as a “best-price rule” and/or a “first-in rule”.

<sup>21</sup> For example, some stock exchanges are order-driven (e.g., the Tokyo Stock Exchange) while others are quote driven (e.g., the London Stock Exchange). The New York Stock Exchange operates under a “specialist system” which has features of both order-driven and quote-driven markets. The specialists match buy and sell-orders on their order books, but are obligated to provide liquidity to the market as market makers when orders disappear from one side of the order book.

<sup>22</sup> An increasing fraction of foreign exchange trading takes place on electronic deal-matching (“electronic broking”) systems, which facilitate the trading process without imposing the overhead costs (such as clearing services and the identification of authorised dealers) that characterise an organised exchange.

<sup>23</sup> While the secondary market in Japanese corporate bonds is an OTC, quote-driven market, the paper regards the price discovery function in the primary market as that of an order-driven system with periodic auctions.

#### II.4.2.2 Effects of Transaction Costs

*Transaction costs* include all factors that may affect the ease of executing transactions. Explicit transaction costs include commissions for trade and transaction taxes. Implicit transaction costs can take several different forms, including the temporary divergence of transaction prices from their market-clearing levels. Implicit costs often involve a tradeoff between the cash cost of trading at a bad price and the opportunity cost of not being able to trade at the desired time. For example, if one tries to minimise the price impact of a large-scale portfolio adjustment by conducting multiple small-lot transactions, one incurs the risk that the market price will change before the desired adjustment is completed, as well as the opportunity cost of the time a trader must devote to planning and executing the trades.

*Dupont* investigates how a transaction cost, for example a tax, could affect market liquidity by using a model where a dealer faces an “informed trader” and a “liquidity trader”.<sup>24</sup> If market conditions are unfavourable to the dealer, in the sense that information asymmetry is high or demand for liquidity is weak, an increase in the transaction cost drastically reduces market liquidity: the widening of the bid-ask spread is larger than the increase in the transaction cost and the quoted depth falls. In contrast, favourable market conditions mitigate the impact of an increase in the transaction cost.<sup>25</sup> These findings imply that reducing explicit transaction costs could be effective in enhancing market liquidity, although the strength of such effects depends on market conditions, while an increase in transaction costs could aggravate liquidity loss in periods of market stress and possibly cause an earlier exit of market-makers from the market.

*Muranaga* studies the effects on market liquidity of “tick size”, i.e. the minimum allowable change of prices from one trade to the next. Tick size can be considered a determinant of transaction costs in the sense that it determines the lower bound of the bid-ask spread. Despite the burden of this cost, most markets have some standard tick size, whether established by explicit rules or by convention, because of the need to facilitate the exchange and recording of price quotations. It was found that, after a reduction in tick size on the Tokyo Stock Exchange in April 1998, market liquidity indicators such as bid-ask spreads and the number of order flows improved (Figure 5). The earlier, larger tick size appears to have suppressed potential trading demand, which subsequently materialized when tick size was reduced.

#### II.4.2.3 Transparency of Markets

For purposes of the analysis of market microstructure, *market transparency* is usually defined as the ability of market participants to observe the information in the trading process<sup>26</sup>. The theoretical literature suggests that if transparency decreases: a) informed traders<sup>27</sup> become better off while uninformed traders become worse off, because the former can better exploit their private information; b) traders tend to delay their transactions in order to gather information from the trading activity of other participants. *Scalia and Vacca* test these hypotheses, using transaction data before and after a reform that reduced the degree of transparency of the *Mercato Telematico dei Titoli di Stato* (MTS), the electronic inter-dealer market for Italian government securities. With the reform of July 1997 the identity of the market makers behind each quote became unknown to the rest of the market. The study

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<sup>24</sup> A trader is considered informed if he/she knows more about fundamental asset values than other traders. A liquidity trader is defined as a trader who knows only the price process, not the underlying value of the asset, and trades for reasons unrelated to the underlying value. In this model, the dealer has no prior information about the true value of the asset.

<sup>25</sup> This study approaches market liquidity by focusing on the depth of the market (the volume a market maker is willing to accept at one time) and bid-ask spreads.

<sup>26</sup> O'Hara (1995). “Information” in this context is usually categorised as either public (available to all market participants, e.g. publicly announced statistics) or private (not available to all market participants, including both “inside” information about fundamentals and information on order flow or customer behaviour available only to dealers).

<sup>27</sup> See footnote 24 for a definition of informed traders.

finds that both hypotheses are supported by the empirical evidence. Finally, the study finds that the decrease in transparency is associated with a reduction in trading costs and volatility and with an increase in market efficiency. This finding suggests that the relationship between transparency and market efficiency is non-linear: transparency may improve efficiency up to a point, but full transparency appears to be sub-optimal.

The relationship between market transparency and price volatility is also explored by *Ui*, who uses a theoretical model. The paper focuses on transparency with respect to information about the orders of liquidity traders, and distinguishes between transparency regarding public and private information. In the model, a market is considered more transparent with respect to public information, the larger the fraction of the total order flow observed in common by all informed traders. It is considered more transparent with respect to private information, the larger the fraction of the total order flow observed by any given individual informed trader (without being revealed to the other traders). It is found that, when the orders of liquidity traders are sufficiently volatile, increasing the transparency of *public* information reduces price volatility up to a point, but increases price volatility thereafter. This is because two different effects are at work: first, knowledge about order flow allows traders to place orders to offset transitory shocks; and second, knowledge about order flow may decrease the price-responsiveness of traders' demands, thereby leading to larger price movements in response to liquidity-demand shocks. When transparency about order flows is low, the first effect dominates, so more knowledge about order flow leads to less volatile prices. When transparency about order flows is high, the second effect dominates, so more knowledge about order flow leads to more volatile prices. On the other hand, under the same conditions, an increase in the transparency of *private* information always reduces price volatility. This is because different traders always have different knowledge about order flow, which limits the second effect.

These results suggest that one should not automatically equate greater market transparency with greater efficiency. In general, regarding the transparency of ex-ante price information in OTC-dealer markets, the market microstructure literature suggests that greater transparency would contribute to higher market liquidity, since it tends to increase (uninformed) investor activity.<sup>28</sup> However, the effects on efficiency seem to depend in subtle ways on the underlying information structure. If there is little inherent information in trade flows (as may often be the case in government security markets), greater transparency may not necessarily improve efficiency. In some cases, greater transparency can be a disincentive for market makers to take on large open positions. Indeed, if a market is already highly transparent, decreasing certain kinds of transparency can sometimes be beneficial.

### ***II.4.3 Effects of Market Participants' Behaviour***

#### ***II.4.3.1 The importance of market participants' behaviour***

The behaviour of market participants also affects market liquidity. *Muranaga and Shimizu (b)* show through simulations that time horizons for transactions, the degree of risk aversion, traders' confidence in their own expectations<sup>29</sup> and sensitivities to market information all affect market liquidity (Figure 6). As regards the time horizon for transactions, an increase in the ratio of market participants basing their behaviour on the direction of short-term market price movements ("momentum-traders") is found to lead to an increase in the number of trades in general but a decrease in the volume of accumulated order flows up to a certain point. When market participants become on the average more risk-averse, market liquidity decreases. A sharp decrease in market liquidity also results when market participants lose confidence in their expectations regarding future prices. Finally, the authors find that

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<sup>28</sup> See section III.3.2.2 for a discussion of the relationship between the observability of ex-ante prices and market liquidity in government securities markets.

<sup>29</sup> In the paper, "confidence" is defined as the inverse of the expected standard deviation of the sum of the traders' expectations for the asset's fundamental value. Thus, a decrease in confidence means an increase in the average trader's estimation of the risk he/she would take on by submitting an order.

changes in the sensitivities of traders to market information affect market liquidity, but the various market liquidity indicators do not necessarily move in the same direction.

The behaviour of participants in turn reflects the institutional setting. Corporate governance practices, capital rules and disclosure requirements are all elements of this setting at the corporate level, while compensation systems and the ability to access information play a role at the level of individual traders. As suggested by the simulation exercises, the relationship between institutional structure and trading behaviour is both important and complicated, and a worthy area for empirical study.

#### *II.4.3.2 Heterogeneity of Market Participants*

The degree of heterogeneity of participants can by itself affect market liquidity, by increasing the number of participants who are willing to trade on their differing perceptions of the value of an asset. *Gravelle (a)* suggests that the entry of non-residents into the Canadian government securities market led to an increase in market liquidity (Figure 7). This effect could result from the differing portfolio demands and risk exposures of foreign as compared with domestic participants.

A more heterogeneous customer base might also work to improve market liquidity by providing a dealer with more risk-sharing services than a more homogeneous customer base. This is because a more diverse set of customers, assuming this corresponds to a more diverse set of portfolio strategies and endowments, is less likely to present a dealer with a “one-way” trading session that would force the dealer to increase its inventory to an unacceptably risky level. In other words, as customer heterogeneity increases, dealers become more confident that they can offset a temporary surge in orders in one direction with an equal amount of orders in the opposite direction, so they are less likely to try to reduce liquidity (by increasing the bid-ask spread, for example) to dampen such surges.

#### *II.4.3.3 Self-fulfilling Expectations*

During the course of its discussions, the study group looked at the relevance to market liquidity of self-fulfilling expectation mechanisms, whereby the fact that market participants regard a market as highly liquid helps it to become and remain highly liquid. One area where this is thought to be relevant is in the concentration of liquidity in one of a group of otherwise identical, highly substitutable instruments. As noted earlier (section II.3.2.1), the observation that, in the Japanese government securities market, “ex-benchmark” bonds enjoy higher liquidity relative to other issues of similar issue size offers an example of such a self-fulfilling mechanism.

### **III. Liquidity in Government Securities Markets**

Despite the relevance of government securities market liquidity to central bank policies and to broader market functioning, the determinants and mechanics of liquidity in these markets have received relatively scant attention from academic theorists. Market microstructure research has to date focused mainly on equity markets and more recently on foreign exchange markets, but not on fixed-income securities markets.<sup>30</sup> Thus, in view of the underdeveloped state of research and the relevance of such research to central banks, the study group decided to pay particular attention to understanding the liquidity of government securities markets. The discussion in this Chapter derives from the individual papers in the study group touching on this subject, the results of the Group's survey on the structure of government securities markets in the G-10 countries, and a comparative study of stylized facts on price discovery processes based on earlier research by member central banks.

#### **III.1 Common Characteristics of Government Securities**

Perhaps the most important characteristic of industrial-country government securities as an asset class is that they are considered to be virtually free from credit risk. For this reason, government bonds of a given currency and remaining maturity are treated as essentially homogeneous by market participants for many purposes. Homogeneity and the virtual absence of credit risk, in turn, underlie the following aspects shared by government securities markets in most industrial countries:

- (a) Prices are considered to be primarily driven by public information, rather than private information.<sup>31</sup>
- (b) Government securities often serve as benchmarks for other securities and financial claims. Therefore, they are used in pricing a wide range of instruments and as a primary tool for hedging interest-rate risk.
- (c) Government securities are broadly used as underlying or reference assets and as collateral by repo, futures, and options markets.
- (d) Liquidity tends to be concentrated in specific issues at certain maturities.
- (e) Cash government securities markets tend to take the form of quote-driven dealer markets, though in some cases interdealer brokers provide services to match specific orders between dealers.

#### **III.2 Patterns of Liquidity in Government Securities Markets**

##### ***III.2.1 Liquidity in the Cash Market***

Since few existing studies have performed detailed comparisons of liquidity indicators across major government securities markets, the study group decided to compile data on some of the typical indicators, such as bid-ask spread and turnover ratio, through a questionnaire of government securities market characteristics (see Appendix 2 and *Inoue [a]*). Besides the five countries represented on the study group, the other six G-10 countries also completed this questionnaire.

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<sup>30</sup> *Gravelle (b)*. O'Hara (1995) offers a useful overview of this literature.

<sup>31</sup> However, participants often differ on the interpretation of public information, and trade on these differences. In addition, over the very short term, prices may be driven by private information on order flow (see *Scalia [1998(b)]*).

A comparison of a few key liquidity indicators (Table 2) suggests the following initial observations:

- (a) Measures of market liquidity differ considerably across countries.
- (b) The national markets with large outstanding volumes are not necessarily those with narrow bid-ask spreads. For example, in Japan, the outstanding volume is quite large, but the spread is not very narrow. This stands in contrast with the tendency for outstanding volume and the bid-ask spread to be inversely correlated both across issues within a given national market, and over time for a single maturity in a given national market (see *Gravelle (a)* for Canada).
- (c) Higher turnover ratios (the ratio of trading volume to the amount outstanding) tend to go hand-in-hand with a narrower bid-ask spread. An exception is the UK, where a narrow bid-ask spread accompanies a relatively low turnover ratio.
- (d) Longer maturity is generally accompanied by wider bid-ask spreads. This may be a reflection of the greater inherent price variability of securities with longer remaining maturities.<sup>32</sup>

Table 2  
Comparison of basic market liquidity measures

|  | Canada | Italy | Japan           | U.K.  | U.S.   |
|--|--------|-------|-----------------|-------|--------|
| Bid-ask spread:                        |        |       |                 |       |        |
| Fixed coupon <sup>1</sup>              |        |       |                 |       |        |
| 2 years                                | 2      | 3     | 5               | 3     | 1.6    |
| 5 years                                | 5      | 5     | 9 <sup>4</sup>  | 4     | 1.6    |
| 10 years                               | 5      | 6     | 7               | 4     | 3.1    |
| 30 years                               | 10     | 14    | 16 <sup>5</sup> | 8     | 3.1    |
| Volume outstanding (a) <sup>2</sup>    | 285    | 1,100 | 1,919           | 458   | 3,457  |
| Yearly trading volume (b) <sup>3</sup> | 6,243  | 8,419 | 13,282          | 3,222 | 75,901 |
| Turnover ratio (b/a)                   | 21.9   | 7.7   | 6.9             | 7.0   | 22.0   |

Notes: For detailed notes, see Inoue (a).

<sup>1</sup> The table shows the bid-ask spreads of on-the-run issues, given in one-hundredth of a currency unit for the face amount of 100 currency units. <sup>2</sup> The figures are as of end-1997, in billion U.S. dollars, converted at the exchange rates of end-1997 (US\$1 = C\$1.43 = ITL1770 = ¥130, £1 = \$1.65). <sup>3</sup> The figures are for the 1997 calendar year, on a two-way basis.

<sup>4</sup> 6-year bonds. <sup>5</sup> 20-year bonds.

The discussion in Chapter II suggests that market liquidity tends to be concentrated in a specific product when similar products are traded. Bid-ask spreads for on-the-run issues are usually much narrower than those for off-the-run issues, indicating that the degree of market liquidity is higher for on-the-run issues (Table 3).<sup>33</sup> As a result of investors' preference for on-the-run issues, the yield on these issues tends to be lower than that on issues of comparable maturity. The resulting yield differential, called the benchmark premium, varies from time to time. When a flight to quality or liquidity occurs, this premium tends to widen, reflecting an increased preference for on-the-run issues (Figure 8). This was the experience in the August-October 1998 flight-to-quality episode, particularly in the US bond market.

<sup>32</sup> *Gravelle (a)* finds that, in the Canadian market, the bid-ask spread tends to widen when the market is more volatile.

<sup>33</sup> In the futures market for government securities, liquidity tends to be most heavily concentrated in the contracts closest to expiration. *Fleming and Sarkar* find that the degree to which futures trading is concentrated in nearby-expiration issues exceeds the degree to which cash-market trading is concentrated in on-the-run issues.

Table 3  
**Comparison of bid-ask spreads for on-the-run and off-the-run issues**

|  |          | Canada |      | Italy |     | Japan           |                 | U.K. |     | U.S. |      |
|--|----------|--------|------|-------|-----|-----------------|-----------------|------|-----|------|------|
| On-the-run or off-the-run                    |          | On     | Off  | On    | Off | On              | Off             | On   | Off | On   | Off  |
| Bid-ask spread,<br>by remaining<br>maturity: |          |        |      |       |     |                 |                 |      |     |      |      |
|  | 5 years  | 5      | 12.5 | 5     | 8   | 9 <sup>1</sup>  | 11 <sup>1</sup> | 4    | 4   | 1.6  | 6.3  |
|  | 10 years | 5      | 15.5 | 6     | 8   | 7               | 7               | 4    | 4   | 3.1  | 6.3  |
|  | 30 years | 10     | 18.5 | 14    | 14  | 16 <sup>2</sup> | 19 <sup>2</sup> | 8    | 12  | 3.1  | 12.5 |

The table compares the bid-ask spreads of on-the-run and just off-the-run issues having similar remaining maturity. For detailed notes, see *Inoue (a)*. Some of the spreads are indicative rather than definitive.

<sup>1</sup> 6-year bonds. <sup>2</sup> 20-year bonds.

### III.2.2 Comparing Liquidity in the Cash and Futures Markets

An issue of great importance to both market participants and public authorities is the relationship of market liquidity between the cash and futures markets. On the one hand, one might expect liquidity in the two markets to be positively correlated, because heavy trading in the cash market may lead to more trading, for hedging purposes, in the futures market. In other words, trading in the two instruments might be complements. On the other hand, cash issues (especially benchmarks) and futures contracts may act as substitutes for one another, because they both reflect the same underlying risks, and hence market liquidity in both markets may be inversely correlated.

Trading volumes are higher in the cash market than in the futures markets in Canada, Italy and the US, roughly equal in the UK, and lower in Japan (Table 4). However, the comparability of these figures across countries is limited, given the numerous differences in their national markets. For example, the range of maturities covered by futures contracts differs across countries.

Table 4  
**Yearly trading volume in cash and futures markets**

|                            | Canada | Italy | Japan  | U.K.  | U.S.   |
|----------------------------|--------|-------|--------|-------|--------|
| Cash trading volume (a)    | 6,243  | 8,419 | 13,282 | 3,222 | 75,901 |
| Futures trading volume (b) | 185    | 2,036 | 18,453 | 3,294 | 27,928 |
| Cash/futures ratio (a/b)   | 33.7   | 4.1   | 0.7    | 1.0   | 2.7    |

Figures are for the 1997 calendar year, in billion U.S. dollars, converted at the exchange rates of end-1997. Figures are "two-way", i.e. each transaction is counted twice. For detailed notes, see *Inoue (a)*.

When cash and futures trading are compared within individual countries, evidence is found for both the substitution and complementarity effects. *Fleming and Sarkar* compare liquidity for cash and futures trading at each maturity segment in the U.S. government securities market. They find that, in the 30-year segment, trading volume is larger for the futures market than for the cash market, but in the other segments, the reverse is true (Table 5). Cash-market volume tends to decline and futures-market volume to rise as maturity increases. In Japan, after the establishment of a futures market on the Tokyo Stock Exchange, short-term trading needs were said to have shifted from the benchmark 10-year bond to the corresponding futures contracts. Reflecting this shift, the trading volume of the futures market soon exceeded that of the cash market. *Gravelle (a)*, however, finds volume measures to be positively correlated over time for Canadian bonds and futures.

Table 5  
Daily trading volume in the U.S. Treasury market

|                            | 2-year | 5-year | 10-year | 30-year |
|----------------------------|--------|--------|---------|---------|
| Cash trading volume (a)    | 14,139 | 15,361 | 8,236   | 2,407   |
| Futures trading volume (b) | 420    | 3,212  | 6,546   | 31,394  |
| Cash/futures ratio (a/b)   | 33.7   | 4.8    | 1.3     | 0.1     |

Source: *Fleming and Sarkar*. Figures are for the 1993 calendar year, in millions of US dollars.

### III.2.3 Price Discovery in Government Securities Markets

*Price discovery* refers to the process by which information about an asset's fundamental value becomes incorporated into its price. A primary benefit of a liquid market is that it facilitates rapid price discovery. The study group explored what is known about the price discovery processes in government securities markets, using studies that have been conducted in the recent past by the member central banks.<sup>34</sup> This section reviews the key stylised facts that were identified. (See *Inoue [b]* for details.)

#### III.2.3.1 Intraday and Intra-week Patterns of Market Liquidity

The arrival of new information is one of the most important sources of trading activity. In today's global economy, new information relevant to securities prices arrives twenty-four hours a day, seven days a week. However, it is virtually impossible for the participants in a given national market to actively trade such long hours. This gap may cause changes in the degree of liquidity of a given market in the course of a typical day and week, creating distinct intraday and intra-week patterns in the measures of market liquidity.

At the *intraday* level, trading volume, price volatility, and the bid-ask spread tend to follow U-shaped patterns, where the parameters are high just after the opening and just before closing, and low during the rest of the trading session (Figure 9).<sup>35</sup> Other studies have found similar patterns in equity markets.

The first surge in trading volume and price volatility may be explained in the following way. Just after opening, market participants have an incentive to trade based on the accumulated information and client orders that may have been received after the market close on the previous day. The morning surge may also reflect the timing of statistical data releases, which tend to occur before or just after the market opening in local time.<sup>36</sup> In such a situation, market participants' expectations of equilibrium prices tend to be dispersed. These dispersed expectations gradually converge through trading activities, until equilibrium prices are reached. In the process, trading volume and price volatility tend to be positively correlated. The second surge in trading volume, in the late afternoon, may be explained by the position-adjusting behaviour of market participants to control price risk during market closure. In addition, the closing of the futures market at certain times in the afternoon may affect the second surge in some markets by cutting off hedging opportunities. In Europe, the afternoon surge in trading may also reflect morning data releases in the U.S.

Bid-ask spreads also show U-shaped intraday patterns although, except in Japan, the timing of the two surges is slightly different from those for trading volume and price volatility. One reason that bid-ask

<sup>34</sup> The comparative study is primarily based on the following existing papers: Scalia (1998a, 1998b) and *Scalia and Vacca* for Italy; Miyanoya, Inoue, and Higo (1999) for Japan; Proudman (1995) and *Clare, Johnson, Proudman and Saporta* for the U.K.; and Fleming (1997) and Fleming and Remolona (1997a, 1997b, 1998) for the U.S.

<sup>35</sup> In Japan, the parameters surge somewhat before and after the lunch break, creating "W-shaped" patterns.

<sup>36</sup> The patterns of trading volume and volatility around statistical announcements are examined more closely in the next section.

spreads and price volatility are *positively* correlated could be that market-makers widen the spread in order to compensate for increased inventory risk from volatile prices. However, one might also expect a *negative* correlation between bid-ask spreads and trading volume, since a large trading volume makes it easier for market-makers to adjust their inventory and these lower inventory costs, in a competitive dealer market, will be reflected in a tighter bid-ask spread. Instead, it is observed that bid-ask spreads and volume surge in the same direction both in the morning and in the afternoon. Perhaps the need to compensate for the volatility inherent in the price-discovery process overwhelms the lower inventory-adjustment costs. Alternatively, dealers may have some oligopolistic power and charge larger spreads at times of trading pressure.

In Japan, the U.K., and the U.S., figures for daily trading volumes exhibit a hump-shaped *intra-week* pattern (Figure 10). Price volatility figures for Japan also show this pattern. This is similar to the pattern for equities, though equity volumes do not seem to fall off quite as far on Fridays (Figure 11).

The differences between intraday and intraweek patterns, as well as the differences between government securities and equities markets, represent something of a puzzle. For example, if intraday liquidity indicators are U-shaped because of the uncertainty introduced by overnight events, one might expect weekends to introduce a similar U-shaped pattern at the intra-week level. These patterns are, however, both large and persistent, and seem to derive from the timing of data releases as well as differences in the participation and price-response behaviour of informed traders, liquidity traders and market-makers.

### III.2.3.2 *The Role of Public Information*

As noted in Section III.1, because their promised future cash flows are fixed and credit risk is virtually absent, fundamental values in industrial-country government securities markets ought primarily to reflect publicly available information, such as statistical announcements and central bank policy actions. Material information about these fundamental values is almost always available to the public, though some market participants may be (or are perceived to be) better able to interpret information than others and, over the very short run, dealers may have private information about order flows. In this sense government securities markets differ from corporate bond and equities markets, in which there will always be traders with superior or (despite the best efforts of regulators) “inside” information about such matters as credit risk and earnings prospects. This enables researchers to analyse relatively cleanly the process through which new information is incorporated into government securities prices, by examining trading volume and price volatility patterns around the times when new public information is announced.

The evidence in Japan, the U.K. and the U.S. indicate that both trading volume and price volatility are generally larger for days when statistical announcements are made than days when they are not (Figure 12).<sup>37</sup> In the U.S. and Japanese markets, price volatility spikes at the moment of announcement, but decreases after a few minutes (Figure 13). Trading volume spikes after an appreciable lag relative to price volatility, but the increase persists longer. One reason behind these features could be dispersed expectations regarding equilibrium prices caused by the statistical announcements. These dispersed expectations cause an immediate spike in price volatility, which decreases once the equilibrium price is arrived at. After the decrease in price volatility, liquidity traders still need to trade in order to rebalance their portfolios, resulting in a persistent surge in trading volume.<sup>38</sup> It is also found that, in the US, the degree of “surprise” (the absolute value of the difference between the forecast and actual figure) is positively correlated with the increase in trading volume and price volatility that follows the announcement. For the UK, *Clare, Johnson, Proudman and Saporta* find an asymmetric response to statistical announcements, namely that volatility increases more and

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<sup>37</sup> According to *Scalia and Vacca*, U.S. statistical announcements may also contribute to the intraday spikes in the bid-ask spread in the Italian government securities market.

<sup>38</sup> Fleming and Remolona (1997a).

remains high for longer in response to “unfavourable” surprises (figures showing higher inflation, higher unemployment, or lower output than expected) than “favourable” surprises.

*Inoue (c)* examines the impact of the notification of official purchases of government securities on intraday trading volume and price volatility in the Japanese government securities market. Notification of open market operations can affect the market in two possible ways: by conveying information about the central bank’s policy intentions, and as a large buy/sell order *per se*. Inoue finds that the notification of an outright purchase by the Bank of Japan leads to an immediate spike in trading volume and price volatility. However, the notification of a temporary operation (a purchase with a sell-back agreement) or the notification of a BOJ purchase of securities as the agent of the Government does not affect trading volume or price volatility.<sup>39</sup> He also finds that an unexpected change in the purchase amount and notification time may lead to an immediate increase in price volatility. This would seem to suggest that the informational content of a central bank operation – in this case, its monetary-policy relevance, the time-horizon of the purchase (outright or temporary) and the degree to which it conforms to market expectations – is a vital component of the operation’s effect on market liquidity.

### *III.2.3.3 Leads and Lags in Pricing between Cash and Futures Markets*

Most existing studies show that futures prices tend to lead cash prices. For example, this has been found to be the case for the 10-year segment in Japan and the 30-year segment in the U.S.<sup>40</sup> Given the different microstructure and liquidity characteristics of cash and futures markets, as discussed above, it may be worthwhile to ask whether liquidity plays a role in this relationship.

Faster price discovery in the futures markets is said to be caused by the standardised nature of futures contracts and by the greater accessibility of the futures market due to its relatively small margin requirements.<sup>41</sup> In the case of Japan, additional factors such as the difference in trade execution mechanism (telephone for the cash market, electronic for futures) and in taxation (lower transaction tax in the futures market) may also play a role.<sup>42</sup>

However, the leading role of futures markets in price discovery does not always hold. For example, for the 5 and 10-year segments in the U.S., no clear leads/lags relationship is observed.<sup>43</sup> This corresponds with the fact that futures trading is more active than cash trading in the 30-year segment, while the reverse is the case in the 5 and 10-year segments (Table 5). *Scalia and Vacca* empirically test the lead-lag price relationship between the cash market for Italian 10-year government bonds and the corresponding futures contract traded on the London International Financial Futures and Options Exchange (LIFFE). They find that after the MTS reform of July 1997 indicators of a lead of futures prices over cash prices become weaker, whereas indicators of contemporaneous correlation or a cash-price lead become stronger. This phenomenon seems related to the improvement in the efficiency of the cash market.

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<sup>39</sup> In Japan, the government (the Trust Fund Bureau of the Ministry of Finance) purchases government securities, where the Bank of Japan serves as the agent of the government. The Trust Fund Bureau invests the funds raised mainly through the Postal Savings and Insurance and the Public Pension Funds.

<sup>40</sup> Miyanoya, Inoue, and Higo (1999).

<sup>41</sup> Holland and Vila (1998).

<sup>42</sup> The transaction tax in Japan was eliminated at end-March 1999.

<sup>43</sup> Miyanoya, Inoue, and Higo (1999).

### III.3 Institutional Features Affecting Liquidity in Government Securities Markets

This section reviews the institutional aspects of G-10 government securities markets, relying heavily on the results of the study group's survey of market characteristics. Two categories of factors are addressed: first, factors related to product design, specifically issue size, maturity distribution, and benchmark effects; and second, factors related to market structure, specifically the primary dealer system, transparency of markets, structures facilitating short-sales, and taxation. (See Appendix 2 and *Inoue [a]* for details.)

#### III.3.1 Product Design

##### III.3.1.1 Issue Size

Since any trade of government securities is conducted for a specific issue, rather than for the total outstanding volume at a given maturity, issue size may be particularly relevant to market liquidity. According to *Gravelle (a)*, turnover ratios in Canada seemed to increase after the issue size of fixed-coupon benchmark securities was increased in 1992. Table 6 compares issue sizes and bid-ask spreads for on-the-run issues. The table suggests that a larger issue size tends to be accompanied by a narrower bid-ask spread.

Table 6  
Issue size and bid-ask spread for on-the-run ten-year fixed-coupon securities

|   | Canada | Italy | Japan | U.K.  | U.S. |
|---|--------|-------|-------|-------|------|
| Average issue size in 1997 (\$ billion) | 6.7    | 12.3  | 7.7   | 18.2* | 17.5 |
| Bid-ask spread                          | 5      | 6     | 7     | 4     | 3.1  |

|   | Bel. | France | Ger. | Neth. | Swe. | Switz. |
|---|------|--------|------|-------|------|--------|
| Average issue size in 1997 (\$ billion) | 8.9* | 2.8    | 8.3  | 6.2*  | 3.8* | 2.5*   |
| Bid-ask spread                          | 5    | 10     | 4    | na    | 15   | 10     |

Source: Questionnaire, except as noted. For detailed notes, see *Inoue (a)*

\* Issue-size data for these countries are not available from the questionnaire. Instead, the following issues were used: UK, 7.25% due 12/2007. Bel., 6.25% due 3/2007. Neth., 5.75% due 2/2007. Swe., 6.5% due 5/2008. Switz., 4.25% due 1/2008.

##### III.3.1.2 Maturity Distribution

The choice of the maturity distribution of new bond issues involves a trade-off. On the one hand, if a government does not offer securities at the maturities desired by investors, the latter will demand an extra yield premium as compensation, thereby increasing the government's funding costs. On the other hand, if bonds are issued at too many original maturities, the size of each issue will be less, reducing liquidity. The liquidity premium demanded by investors will also increase government funding costs.

The G-10 countries seem to have followed broadly similar paths in this respect. Each country issues bonds at from five to twelve original maturities, and most countries attempt to spread issuance more or less evenly among four maturity zones: short (one year or less), medium (one to five years), long (five to ten years), and super-long (more than ten years) (Table 7). The trend in recent years, as deficit and debt levels have fallen in many countries, has been to reduce the number of maturities and increase average issue size. For example, since 1992, Canada has concentrated the issuance of fixed-coupon

bonds in four key maturities (2, 5, 10, and 30 years) and has increased the issue size of benchmarks for each original maturity.<sup>44</sup> The U.S. recently stopped issuing 3-year bonds in response to a decline in financing needs, instead of reducing issue amount evenly across all maturities. Most countries have moved to create larger benchmarks by periodically “reopening” existing issues, i.e. issuing additional securities with the same maturity, coupon, and other terms and conditions as existing ones.

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<sup>44</sup> *Gravelle (a)*

Table 7  
Features of the maturity distribution

|  | Canada                          | Italy                                      | Japan                              | U.K.                    | U.S.                            |     |
|--|---------------------------------|--|------------------------------------|-------------------------|---------------------------------|-----|
| Number of original maturities                  | 7                               | 10   | 8                                  | 5                       | 7                               |     |
| Original maturities<br>(M=month, Y=year)       | 3, 6-M; 1,<br>2, 5, 10,<br>30-Y | 3, 6-M; 1,<br>1.5, 2, 3, 5,<br>7, 10, 30-Y | 3, 6-M; 2,<br>4, 5, 6, 10,<br>20-Y | 3-M; 5, 10,<br>20, 30-Y | 3, 6-M; 1,<br>2, 5, 10,<br>30-Y |     |
| Distribution by original maturity <sup>1</sup> | 1 Y and under                   | 32%  | 17%                                | 5%                      | 7% <sup>2</sup>                 | 21% |
|  | 1 – 5 Y                         | 29%  | 32%                                | 8%                      | 29% <sup>2</sup>                | 62% |
|  | 5 – 10 Y                        | 27%  | 48%                                | 78%                     | 34% <sup>2</sup>                |     |
|  | Over 10 Y                       | 12%  | 3%                                 | 9%                      | 30% <sup>2</sup>                | 17% |
| Number of benchmarks                           | 7                               | 5  | 1                                  | 3                       | 7                               |     |

|  | Bel.                             | France                                 | Ger.                         | Neth.                         | Swe. | Switz.   |     |
|--|----------------------------------|--|------------------------------|-------------------------------|------|--|-----|
| Number of original maturities                  | 7                                | 8                                      | 6                            | 6                             | n.a. | 12   |     |
| Original maturities<br>(M=month, Y=year)       | 3, 6-M;<br>1, 5, 10,<br>15, 30-Y | 3, 6-M;<br>1, 2, 5,<br>10, 15,<br>30-Y | 6-M; 2,<br>4, 5, 10,<br>30-Y | 3-, 6-M;<br>1, 5, 10,<br>30-Y | n.a. | 3, 6-M;<br>5, 7, 9,<br>10, 11,<br>12, 13,<br>14, 15,<br>20-Y |     |
| Distribution by original maturity <sup>1</sup> | 1 Y and under                    | 19%                                    | 10%                          | 2%                            | 4%   | n.a.   | 27% |
|  | 1 – 5 Y                          | 6%                                     | 27%                          | 32%                           | 10%  |  | 23% |
|  | 5 – 10 Y                         | 43%                                    | 53%                          | 61%                           | 74%  |  | 13% |
|  | Over 10 Y                        | 32%                                    | 10%                          | 5%                            | 12%  |  | 37% |
| Number of benchmarks                           | 2                                | 7                                      | 4                            | 2                             | 12   | 7  |     |

For detailed notes, see *Inoue (a)*.

<sup>1</sup> Distribution as a percentage of volume outstanding, excluding older issues out of the regular issuance cycle and index-linked securities. <sup>2</sup> Distribution by remaining maturity.

### III.3.1.3 Benchmark issues

In all of the countries surveyed, one or more on-the-run issues for key maturities are regarded as *benchmarks*, that is, issues whose yields are widely followed as macroeconomic indicators and used for pricing related securities. Market participants tend to prefer on-the-run issues for hedging and short-term trading because coupon rates of on-the-run issues tend to be close to the market rate, and thus the prices are almost at par. This simplifies the calculation of bond duration and the separation of flows into “principal” and “interest” for tax and accounting purposes. In addition, a significant portion of the issue size tends to be in the hands of active traders such as dealers, rather than investors who follow buy-and-hold strategies, since on-the-run issues are, by definition, issued quite recently. The preference for on-the-run issues can also be thought of as a kind of market convention: by mutually agreeing to treat such issues as benchmarks, and to concentrate their trading activity in these issues

rather than others, market participants solve a coordination problem and assure that a liquid market will usually exist for these issues.

However, in Japan, until recently only one issue of 10-year securities with a large issue size was regarded as the benchmark. Given the absence of benchmarks at other maturities, it may be interesting to investigate on which issues market liquidity tends to concentrate. *Higo* finds that, among Japanese government securities with original maturities of ten years and remaining maturities of less than seven years, turnover ratios are highest not for the issues with largest issue size, but for the issues which were once benchmarks (ex-benchmarks). This could be interpreted in the following way. Market participants usually do not know how much of a given issue is held by dealers and how much of it is held by investors who take buy-and-hold strategies. However, they easily know which issues are ex-benchmarks, and being an ex-benchmark may imply that the issue is in the hands of relatively active traders. The expectation of an active market therefore increases the willingness of market participants to trade ex-benchmarks. This finding offers yet another example of the self-fulfilling nature of market liquidity.

### **III.3.2 Market Structure**<sup>45</sup>

#### *III.3.2.1 Primary Dealer System*

In cash markets for government securities, more than half of the surveyed countries have adopted primary dealer systems. Typically, the central bank or other authorities confer on a group of dealers the right to participate in primary auctions and central bank market operations, in exchange for the obligation to make a market (i.e., at some level, guarantee liquidity) in secondary trading of government securities. As described above, dealer markets are the dominant structure in government securities markets. When the competition between dealers intensifies, the bid-ask spread becomes narrower, which improves market liquidity. However, excessive competition would harm their profitability by putting downward pressure on the bid-ask spread, which may reduce the market making function provided by dealers. The monopoly rent provided to primary dealers in the primary market is thus essentially a subsidy for liquidity-provision in the secondary market, which as an externality might otherwise not be provided at the socially optimal level. In this way, the design of a primary dealer system attempts to balance the benefits of competition between dealers with the need to maintain the market-making function.

#### *III.3.2.2 Transparency*

Market information on government securities markets has various dimensions: the substance of the information (usually price or volume); whether it is pre-trade information (quoted price and order size) or post-trade information (contracted price and trading volume); whether the information is available to dealers or the public; and the frequency and time lag with which the information is released (on a real-time basis or periodically). Typically, cash customer markets are the least transparent according to all of these dimensions, futures markets are the most, and cash inter-dealer markets are somewhere in between.

*Gravelle (b)* identifies two key aspects of government securities market transparency which have implications for their liquidity characteristics. One is the fact that order-flow information is not necessarily public information. In particular, with the exception of Italy and the U.S., little information on volume is publicly available in the cash customer markets. This may be related to competitive conditions and the dealers' profitability: dealers use the information they obtain from the incoming customer order flows to adjust their bid-ask quotations in order to make profits from trading, because they lack other reliable sources of profitability (such as "inside" information) from their market-

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<sup>45</sup> See also section *II.4.2.1* for details of different trade execution mechanisms.

making activities.<sup>46</sup> A second key transparency aspect identified by Gravelle is the fact that dealer quotations are not generally available to the public in consolidated format. Instead, customers must “shop around” for the best available price. This “shopping around” reduces the ability of the dealer who eventually trades with a given customer to share his/her inventory risks via inter-dealer trading. If the customer did not shop around the trade, the dealer would then not be subject to greater inventory risk and as such would be able to offer lower spreads to investors. Therefore, higher transparency regarding the prevailing market price could be one factor exerting downward pressure on bid-ask spreads.

In contrast with cash markets, futures markets almost everywhere boast a generally high level of transparency with respect to information about prices and volumes. This reflects the fact that futures are traded on authorised exchanges, where collecting and disseminating information is relatively easy.

A distinct but related set of issues concerns transparency in the primary markets. In all countries surveyed, auction schedules and issuance conditions are announced several days or more in advance. In these countries, *when-if-issued* trading is often active.<sup>47</sup> Such trading permits market makers to manage their inventory risk by enabling them to gauge the likely demand for a given bond issue. It also enables them to anticipate the prevailing market price more easily, which may help promote efficient price determination in the primary auction. This may in turn lead to enhanced market liquidity in the secondary market following the auction, since it may be easier for market makers to provide tight bid-ask quotations if the true value of the new issues has been tested in the market.

### *III.3.2.3 Structures Facilitating Short Sales*

The ability of market participants to sell securities short facilitates a liquid market in those securities. When traders have a short position, they have to obtain the required securities before the settlement time. If traders expect that it may be difficult to obtain the securities when needed, they will be hesitant to take short positions in the first place. The unwillingness of dealers to take short positions may in turn decrease market liquidity. One reason for this is that dealers’ ability to make markets may be hindered if they can only sell the issues in their inventory: they would be forced either to keep an excessive number of issues in inventory, which drives up the cost of market-making, or to delay their response to customer buy-orders until they have obtained the issues in the market, which reduces immediacy.

Because of these considerations, all of the countries surveyed have structures and policies to facilitate short sales of government securities (Table 8). For one thing, repo and/or securities lending markets exist in all of the countries. Dealers are able to obtain needed securities by borrowing or by reverse-repos, without an undesirable effect on their inventory management. Second, in most countries, rules and practices for delivery “fails” enable a dealer to postpone the delivery of the securities with some penalty payments, if the dealer cannot deliver the securities.<sup>48</sup> Third, the authorities in most countries can provide the market with securities that are in short supply, either by reopening the issue, or by lending out the securities at short term.

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<sup>46</sup> *Scalia and Vacca.*

<sup>47</sup> When-if-issued trading is the trading of claims on securities whose issuance has been announced but has not yet taken place. It is conducted between the auction announcement, which is usually several days before auction, and the auction itself.

<sup>48</sup> The rules and practices for delivery fails usually apply only to inter-dealer trading rather than customer trading.

Table 8  
Structures facilitating short-sales

|   | Canada           | Italy            | Japan | U.K.             | U.S.             |
|---|------------------|------------------|-------|------------------|------------------|
| Repo/securities lending market present                          | Yes              | Yes              | Yes   | Yes              | Yes              |
| Rules/practices for fails                                       | Yes <sup>1</sup> | Yes <sup>1</sup> | No    | Yes              | Yes <sup>1</sup> |
| Reopening to prevent market manipulation                        | Yes              | Yes              | No    | Yes              | Yes              |
| Repos/securities lending program to prevent market manipulation | No               | Yes              | No    | Yes <sup>2</sup> | Yes              |

|   | Bel. | France | Ger. | Neth. | Swe. | Switz. |
|---|------|--------|------|-------|------|--------|
| Repo/securities lending market present                          | Yes  | Yes    | Yes  | Yes   | Yes  | Yes    |
| Rules/practices for fails                                       | Yes  | Yes    | No   | Yes   | Yes  | Yes    |
| Reopening to prevent market manipulation                        | Yes  | No     | No   | No    | No   | No     |
| Repos/securities lending program to prevent market manipulation | Yes  | No     | Yes  | No    | Yes  | No     |

<sup>1</sup> While official rules for delivery fails do not exist, clear practices have been established among market players.

<sup>2</sup> The U.K. has the capability to engage in such a program. However, this has only been used once and the authorities make no commitment to use it in any particular case.

### III.3.2.4 Taxation

Transaction taxes, such as stamp duties, are an explicit transaction cost and thus can be expected to have a negative impact on market liquidity.<sup>49</sup> Such taxes were found to be either entirely absent, about to be abolished, or narrowly applied in the government securities markets of the countries surveyed.<sup>50</sup> This exemption of the government securities market may indicate recognition by authorities of the social benefits of a high degree of liquidity in this market, as discussed above.<sup>51</sup> The exemption can also be seen as part of a broader process whereby cross-border competition among financial centres discourages authorities from placing burdens on financial activity that are not present in the leading centres.

While direct transaction taxes are rare, withholding taxes on interest exist in seven of the eleven countries surveyed. Such taxes sometimes add to transaction costs in complex ways. For example, when withholding taxes are levied on government securities which frequently change hands, a tax

<sup>49</sup> However, as discussed in Chapter II, the extent of the effects depends on market conditions, such as the degree of information asymmetry and participants' demand for liquidity. See *Dupont*.

<sup>50</sup> At the time of the survey, transaction taxes existed in Japan, Belgium, and Switzerland. However, in Japan, the transaction tax was abolished at the end of March 1999. In Belgium, the tax is applicable only to individuals. In Switzerland, dealing books of traders are exempted from the tax.

<sup>51</sup> Furthermore, at least part of the burden of transaction taxes falls on the government as the issuer of public debt: the higher liquidity premia incorporated into bond yields at issuance may wind up costing the government as much in increased funding costs as it collects in revenue from the tax.

adjustment on the accrued interest is necessary between the seller and the buyer. This adjustment incurs transaction costs in the form of operational costs and the opportunity cost of interest on the accrued interest. If there is a difference in treatment between taxable entities and non-taxable entities, the market may be fragmented between the two types of entities, resulting in different pricing for the securities held by each type.<sup>52</sup> Perhaps in view of these negative effects on market liquidity, a majority of the seven countries that impose withholding tax restrict it to individuals, who are not considered to be active traders.

### III. 4 Market Liquidity and Information Extraction

In order to allow policy-makers and market participants to extract information from the yield curve, the government securities market must be sufficiently liquid so as to ensure that the information content of bond yields is high. This information, however, is obscured when different issues along the curve have different degrees of liquidity.

In particular, differences in liquidity premia between benchmark and non-benchmark issues may reduce the smoothness of the yield curve. Even for securities with similar remaining maturities, differences in coupon rates and other issue-specific parameters often create different preferences by market participants, deriving from institutional factors such as regulations, taxes, and accounting rules. These different preferences are reflected in divergent yields for securities with similar maturities. This in turn reduces the informativeness of the yield curve regarding inflation and interest rate expectations. However, useful information can still be extracted from the yield curve if liquidity effects are explicitly understood and accounted for. For example, *Fung, Mitnick and Remolona* measure expected inflation rates and risk premia in Canada and the US, using the yield curves for both countries. In order to generate meaningful zero-coupon yields for the two countries, the authors rely only on off-the-run issues, on the grounds that liquidity premia for these issues are roughly similar.

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<sup>52</sup> Consider a non-taxable entity (such as a dealer) that sells certain securities to a taxable entity. The buyer receives an amount equivalent to the withholding tax on the accrued interest corresponding to the holding period of the dealer. If the dealer cannot deduct this amount when it pays income tax, the tax cost for the dealer increases. Because of this problem, in Japan, dealers are said to widen bid-ask spreads on transactions in securities held by taxable entities.

## **IV. Toward Deep and Liquid Markets**

In this chapter, we suggest possible measures which could contribute to the enhancement of market liquidity, from the point of view of market participants and public authorities. The group hopes that the points raised in this chapter will contribute to efforts to understand market liquidity and to future examination of these issues by authorities and market participants.

The chapter discusses, in turn: the enhancement of market liquidity in general; issues of particular relevance to government securities markets; and a few suggestions for the encouragement of future study in this area in the academic and policy spheres.

### **IV.1 Measures for the Enhancement of Market Liquidity**

#### ***IV.1.1 Competitive Structure for Trading Activities***

As discussed in Section II.4.2.1, market liquidity is provided by market-makers and/or by the matching of orders at an exchange. In either case, maintaining a competitive structure is important for enhancing market liquidity. Competition among market makers serves to heighten market liquidity by creating pressure for the narrowing of bid-ask spreads. In the case of exchanges, it is generally observed that trading of a particular product tends to be heavily concentrated in just one exchange. Nevertheless dynamic competition between exchanges or markets, including that between an organised exchange and the OTC market, all could help to lower trading costs and promote efficient information dissemination, thus enhancing market liquidity. Competitive pressures can work to enhance market liquidity as long as the market for market-making services is “contestable” – that is, as long as it would be profitable for a rival to enter the market if the dominant player behaves in a monopolistic way.

Under such a competitive structure, market participants would ideally be accorded the freedom to choose between markets of different characteristics: a market with more favourable prices but less immediacy and vice versa, a market with relatively high transaction costs but high capacity for trading volume, etc. This would help to assure that the different aspects of markets in which participants are interested are available as and when needed. At the same time, too much fragmentation may reduce market liquidity. As discussed below, a certain “critical mass” of trading activity and a degree of heterogeneity among traders are also important factors contributing to market liquidity, so there is an endogenous limit to the feasible level of market fragmentation.

#### ***IV.1.2 Minimising the Liquidity-Impairing Effects of Taxation***

Transaction taxes are an explicit cost of trading and hence normally decrease market liquidity, as discussed in Chapter II. This means that such taxes, if any, should be levied so as to minimise their impact on market liquidity, and that authorities should count their liquidity-impairing effects against any revenue they might raise. Withholding taxes on the interest of marketable assets offer an example of a more indirect route through which taxes can affect market liquidity. Since such assets tend to change hands frequently, imposing withholding taxes may lead to an increase in transaction costs, such as the need to calculate and adjust for accrued interest. This effect might be reduced (but not eliminated) if withholding taxes are limited to entities which do not frequently trade the assets.

#### ***IV.1.3 Transparency of Trading Information***

Transparency in financial markets is usually discussed in terms of information about the issuers of financial assets, particularly their credit standing. However, transparency of trading information is also important for the proper functioning of markets, specifically for the promotion of reliable price discovery and efficient risk allocation. As observed in Chapter II, the content of an appropriate information set would differ from one market to another, depending on characteristics of the market. Generally speaking, in a dealer market, the dissemination of prevailing prices in the market to the

broader trading community would help to enhance market liquidity.<sup>53</sup> On the other hand, disclosure of information on specific orders, including the size of the order and the names of dealers posting the orders, which reduces the anonymity of market participants, would require careful consideration, because such disclosure could have detrimental effects on market liquidity. This is because too immediate (e.g. real-time) dissemination of this information to the market may reduce the incentive for dealers to make markets. The optimal timing and extent of disclosure of ex-post trade-volume information may thus be a worthwhile area for further study

#### ***IV.1.4 Standardising Trading Conventions and Settlement Practices***

Standardised trading and settlement practices should enhance liquidity by mitigating market fragmentation, thus reducing transaction costs and increasing effective supply without having negative effects on heterogeneity. For example, the introduction of the euro from the beginning of 1999 could create incentives for euro area governments to align their terms, such as coupon levels, payment dates and maturity. This policy could render bonds issued by different governments of similar credit quality more interchangeable in cash and futures trading and thus more liquid, thereby lowering debt costs. Regarding settlement practices, delivery versus payment (DVP) and settlement within three days of a trade (T+3) have become the norm in the government securities markets of developed countries in the last ten years. Other fixed-income markets, however, have not necessarily enjoyed the same degree of standardisation in settlement practices. If such practices become more standardised over the whole universe of fixed-income securities, potential demands for arbitrage and hedging transactions could manifest themselves, thus improving market liquidity.

#### ***IV.1.5 Heterogeneity of Market Participants***

A market with diverse participants, with a variety of transaction needs and investment horizons, is also important in enhancing market liquidity. Increasing the heterogeneity of participation in a market need not lead to its fragmentation. For example, liquidity would be enhanced by the lifting of regulations which prevent particular investors from participating in a market, including restrictions on the ability of non-residents to hold domestic assets and vice versa. Speculators can also provide market liquidity, by taking positions which smooth supply and demand shocks. The diversity of market participants reflects institutional aspects of different markets, such as accounting practices, risk management practices and dealer compensation schemes at individual institutions. Thus, it is important to understand the relationship between market liquidity and such institutional arrangements, as well as to examine the effect on heterogeneity of public policies and private behaviour.

#### ***IV.1.6 Identifying Core Assets***

Even if the steps described so far are taken, differences in liquidity across markets or instruments would still arise, due to the preferences of market participants. These preferences, combined with the externalities of market liquidity, typically result in a concentration of market liquidity, i.e. a self-fulfilling process whereby liquid markets become more liquid and illiquid markets less liquid.

Given this self-fulfilling process, it would be unrealistic to try to enhance the liquidity of every market segment, nor would it be possible to adopt a “one-size-fits-all” approach for enhancing liquidity. Instead, it would be more effective to identify core asset markets whose ample liquidity would benefit the whole financial system, and to tailor policy measures to the characteristics of these markets. The development of market conventions, settlement practices and derivative instruments for these core assets would then help to enhance market liquidity for a broader range of assets. In this regard, government securities usually play the role of core assets because they can serve as benchmarks in the pricing for other financial assets and are accompanied by related markets such as repos and futures. In

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<sup>53</sup> In the U.S., real-time trading information on the government securities market, such as the best available bid and ask prices, is now available to dealers as well as investors through a screen-based system.

some cases, a sufficiently homogeneous private-sector market could perform this function as well as or better than the government securities market. Some have suggested that this may turn out to be the case for the interest-rate swap curve in the euro area, although it seems premature to predict such an outcome at this stage.<sup>54</sup>

## **IV.2 Promotion of a Liquid Government Securities Market as a Core Asset Market**

### ***IV.2.1 Filling Demands for Benchmarks of Key Maturities***

Government securities provide investors with saving and hedging vehicles virtually free from credit risk. To address investors' different time horizons, government securities should be issued at key maturities in each maturity zone – short (one year or less), medium (one to five years), long (five to ten years) and super-long (more than ten years). In order to ensure adequate liquidity in each of these zones, it would be preferable that amounts outstanding in each zone be large enough (at least to the extent that these amounts match investor preferences) and that the issue size of benchmarks be sufficiently large. To ensure the creation of large benchmarks, it may be useful, for example, to limit the number of new issues per year, or to conduct several reopenings of existing issues.

### ***IV.2.2 Pre-announcement of Issue Schedules***

Pre-announcement of issue schedules and auction conditions can reduce market-makers' and traders' uncertainty about prospective supply and demand in both the primary and secondary markets. It is also one of the prerequisites for conducting when-if-issued trading. The existence of when-if-issued trading may enhance market liquidity, especially just after issuance, by reducing bidders' inventory risk at the primary auction and enabling security prices to be tested in the market.

### ***IV.2.3 Improving the functioning of the repo and derivatives markets***

The functioning of repo and derivatives markets, including futures markets, can both enhance and be enhanced by liquidity in the cash market for government securities.<sup>55</sup> Repo transactions enable bond market dealers to finance long positions and to create short positions, allowing them to respond to customer needs quickly. A well-structured futures market reduces participants' hedge costs, and thus makes it easier to take cash-market positions. Facilitating the taking of short positions improves the supply of tradable securities and makes markets more liquid, by reducing the possibility that a "one-way" market might emerge. Liquid cash markets, in turn, are vital to the efficient functioning of repos and futures markets.

However, the development of repo and futures market may also provide some participants with opportunities for "squeezing" the cash market. As noted above, most G-10 authorities have responded to this risk by monitoring cash, repo and futures markets closely and entering the markets as necessary to prevent squeezes, through such measures as the lending or reopening of securities issues in short supply.

## **IV.3 Issues for Further Study**

Central bank activities inevitably have an impact on market liquidity, corresponding to the various roles that central banks perform in the financial system. First, as policy makers, information announced by central banks, such as policy decisions, statistics, and notification of open market

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<sup>54</sup> *McCauley*. Considering the recent trend towards fiscal consolidation and public debt retirement in many countries, private-sector instruments may acquire core-asset functions elsewhere as well.

<sup>55</sup> BIS (1999).

operations, is rapidly incorporated into financial market prices. Second, as large market participants, central banks may affect liquidity through their portfolio management policies. In addition, given their interest (usually in conjunction with other agencies) in matters relating to financial stability, central banks closely monitor liquidity conditions in markets where liquidity has been known to dry up under stress. Given these concerns, it is in the interest of central banks to promote further research in this field.

Though the body of empirical and academic literature concerning market liquidity has been growing in recent years, there are still many areas that need to be investigated. In view of this situation, the study group wishes to make the following recommendations with a view to developing a clearer understanding of market liquidity and of the appropriate steps for enhancing market liquidity.

#### ***IV.3.1 Continued Efforts to Study the Determinants and Mechanics of Market Liquidity***

Research into the mechanics of market stress and the roles played by market liquidity, such as the relationship between market liquidity and credit risk, is still in its early stages. Central banks should pursue efforts to understand market dynamics and to act as a catalyst for investigations into these issues by researchers elsewhere. The long-term goal of this program of study should be to enhance the ability to judge the state of market liquidity promptly and accurately, taking into account the linkages between various domestic and overseas markets.

In this regard, there are several options that could be taken up by central banks. One is to encourage research efforts by central bank researchers, academics and the private sector on market liquidity. For example, the research conferences on systemic risk, which have been organised by interested central banks and the Bank for International Settlements, might adopt an agenda in which the examination of market liquidity would play a central role.<sup>56</sup> Secondly, interested central banks could conduct studies of past instances of extreme market stress, such as occurred in the summer/fall of 1998.

#### ***IV.3.2 More Comprehensive Exchange of Information***

Recent advances in communications and information technology have resulted in profound and rapid changes in trade execution mechanisms in financial markets. Central banks need to keep abreast of these changes. To this end, it is proposed to develop contacts, such as through occasional ad hoc meetings (perhaps at the BIS), among central bank experts and market participants responsible for monitoring markets with a view to exchanging information on structural developments.

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<sup>56</sup> The central banks of Japan, the U.K. and the U.S., together with the Bank for International Settlements have so far organised two research conferences on systemic risk (Board of Governors of the Federal Reserve System [1996]; Bank of Japan [1999]). At the second conference held in November 1998 at the Bank of Japan, the mechanics of stress in financial markets and the appropriate central bank responses were discussed in detail. Contagion of systemic disruptions was noted as a particularly important area requiring further research.

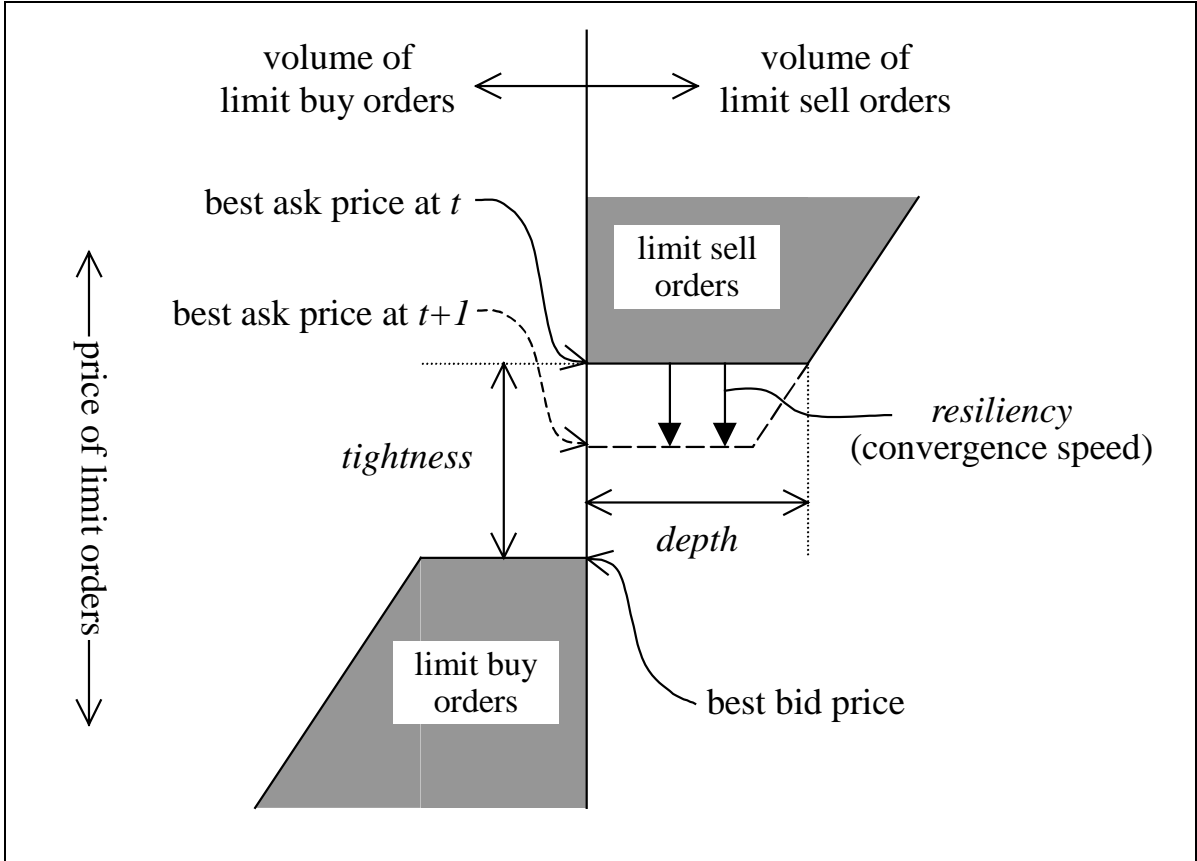
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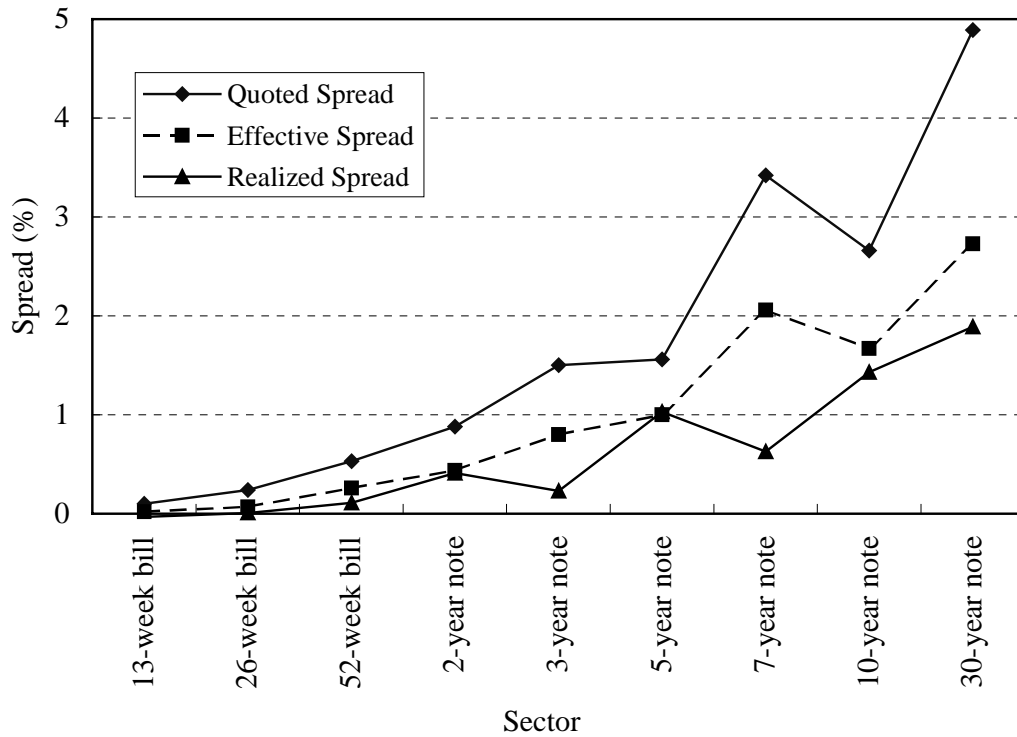
## **Members of the Study Group on Market Liquidity**

|  |  |
|--|--|
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| Bank of Canada                                   | Mr Toni Gravelle   |
| Banca d'Italia                                   | Mr Antonio Scalia<br>Mr Valerio Vacca  |
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| Bank of England                                  | Mr Graeme Danton<br>Mr James Proudman<br>Mr John Spicer  |
| Federal Reserve Bank of New York                 | Mr Michael Fleming<br>Mr John Kambhu<br>Mr Eli Remolona<br>Mr Asani Sarkar   |
| Board of Governors of the Federal Reserve System | Mr Dominique Dupont<br>Mr Vincent Reinhart   |
| Bank for International Settlements               | Mr Benjamin Cohen<br>Mr Robert McCauley  |

**Figure 1 Three Dimensions of Market Liquidity**



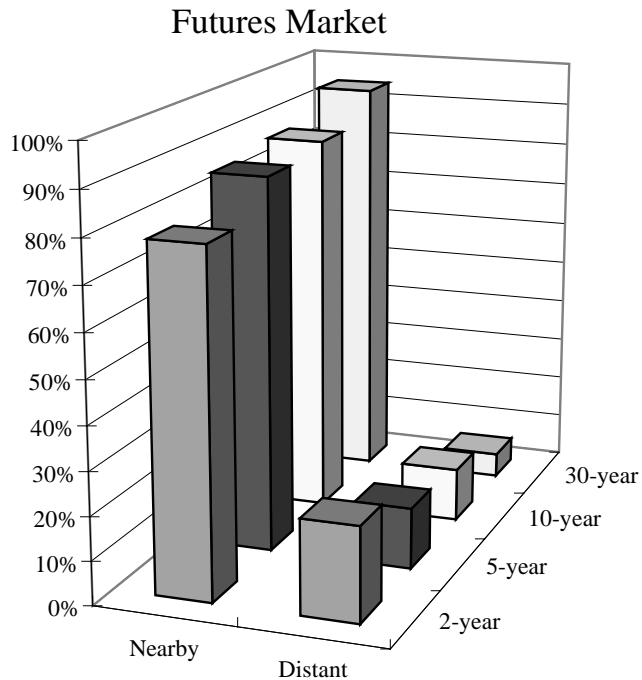
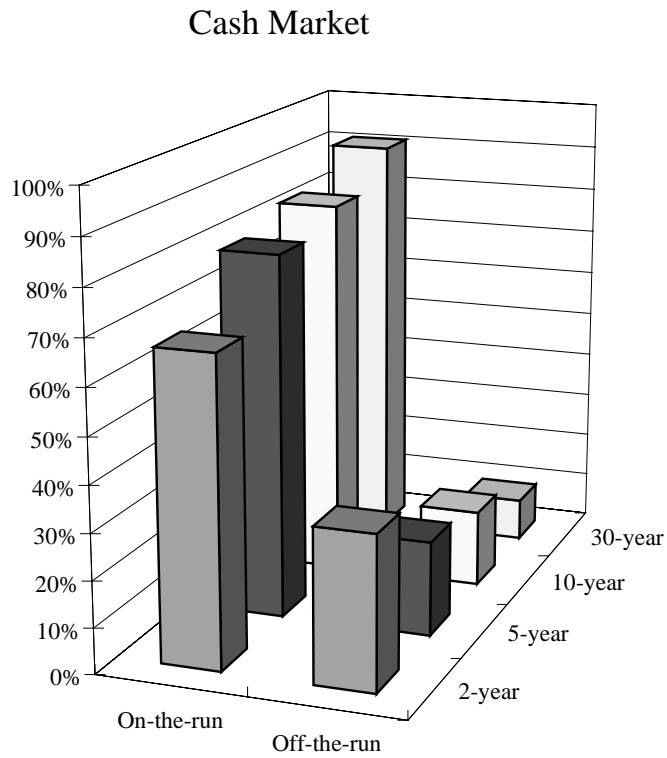
**Figure 2 Bid-Ask Spreads in the U.S. Treasury Market**



Source: *Fleming and Sarkar*

Notes: Quoted spread is the difference between the best bid and the best ask quotes. Effective spread measures the difference between the buy price and the ask price for purchases, and between the sell price and the bid price for sales. Realized spread is the difference between the daily volume-weighted buy price and the daily volume-weighted sell price.

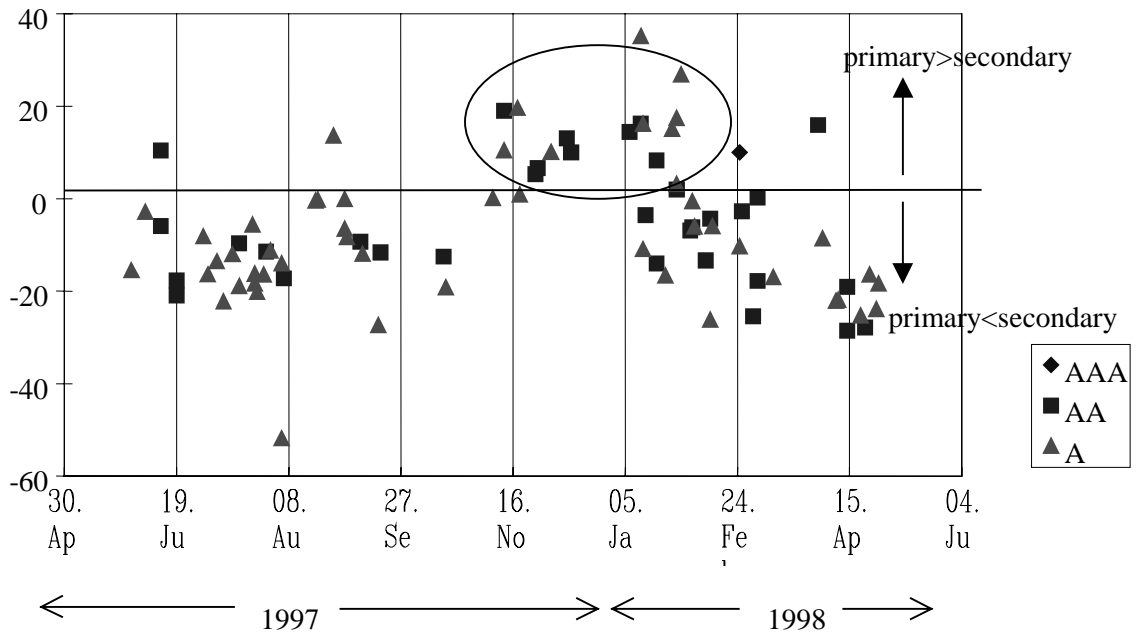
**Figure 3 Trading Volume in the U.S. Treasury Cash and Futures Markets**



Source: *Fleming and Sarkar*

Notes: The graphs show the breakdown of trading volume between on-the-run and off-the-run issues for the cash market, and nearby and distant contracts for the futures market.

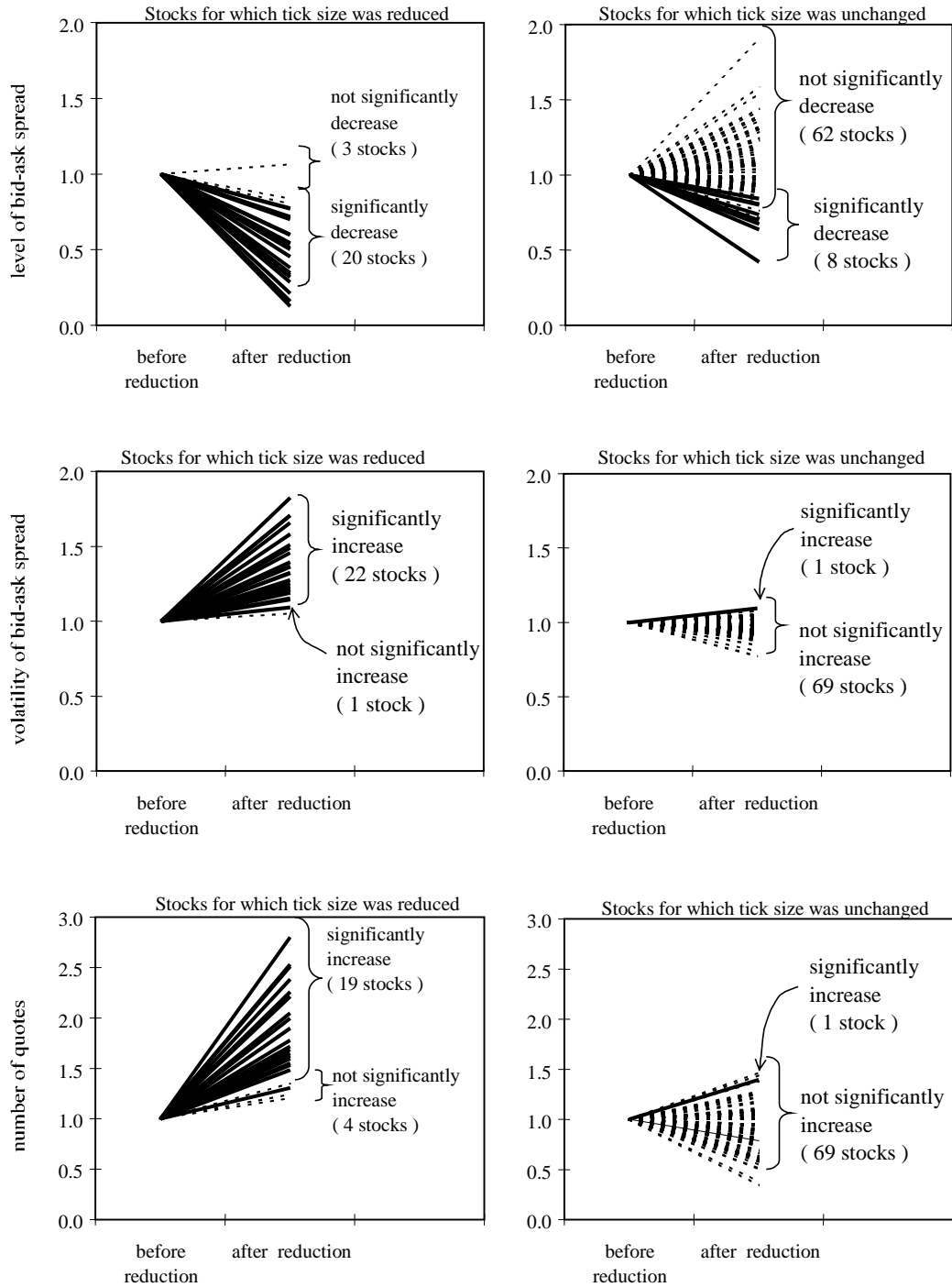
**Figure 4 Credit Spreads for 5-year Corporate Bonds in the Primary and Secondary Markets**



Source: *Miyanoya*

Notes: The credit spreads in the primary market are the spreads between coupons of newly issued 5-year corporate bonds and yields of government bonds. The credit spreads in the secondary market are the yield spreads between the same issuer's corporate bonds quoted in the secondary market and government bonds, both with remaining life of 4-6 years. The graph shows differences between these two spreads for selected matched pairs of bond issues at selected dates during the time period shown.

**Figure 5 Effects of Tick Size Reduction in the Japanese Equity Market**

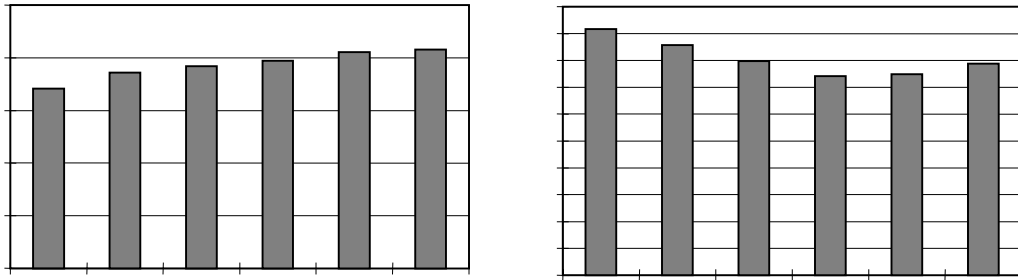


Source: *Muranaga*

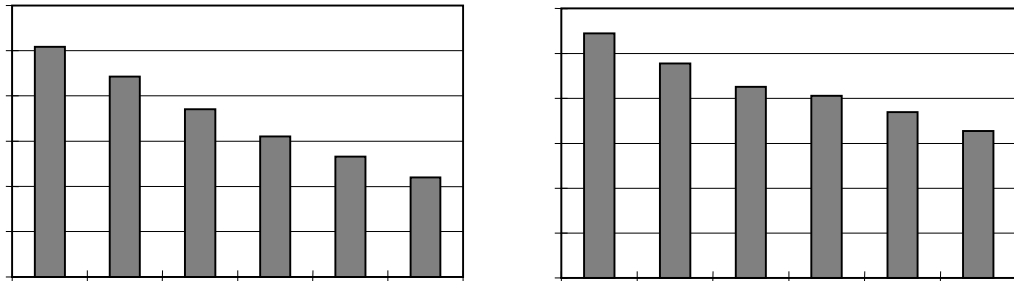
Notes: Vertical axes show how the indicators of market liquidity changed after the reduction of tick size, as a proportion of their level before the reduction of tick size, e.g., 1.5 denotes that the indicator increased by 50%. "Significantly" means that the null hypothesis "The reduction of tick size did not affect the level of the indicator" is rejected at the 1% level of significance.

## Figure 6 Simulation Results

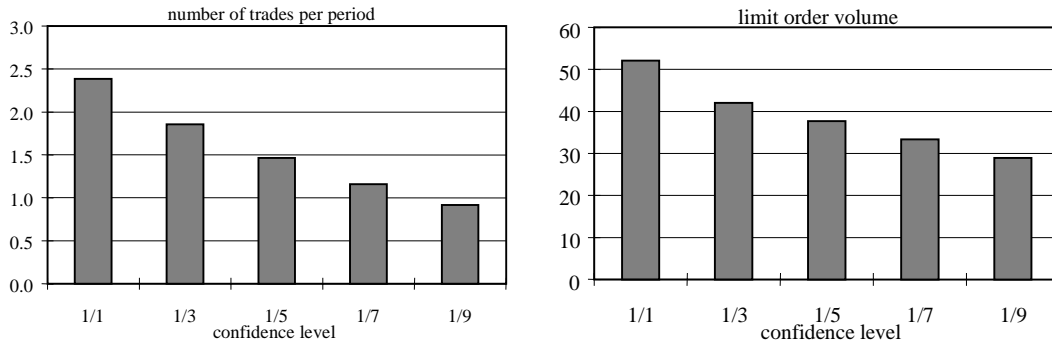
### Effect of time horizon for transactions



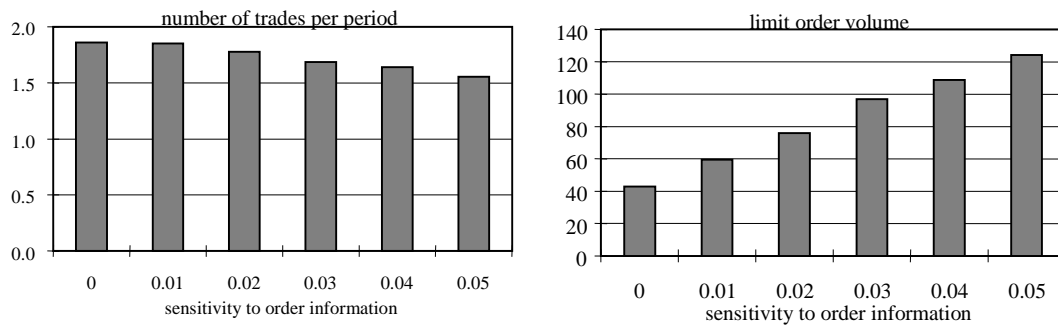
### Effect of degree of risk aversion



### Effect of confidence level

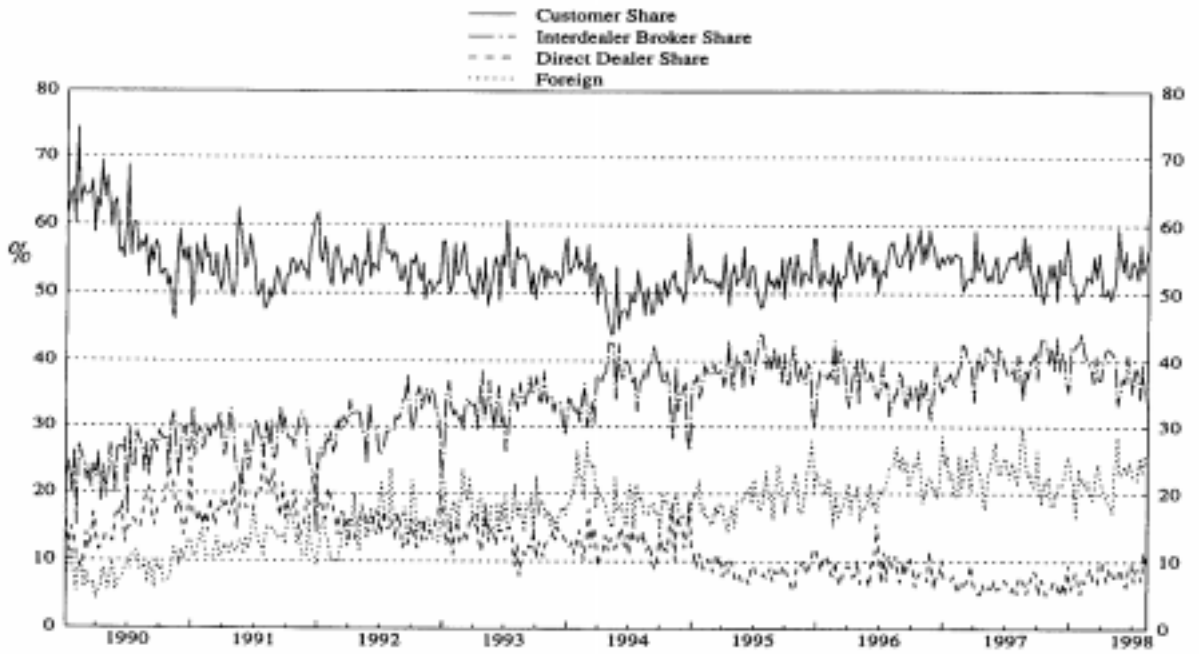


### Effect of sensitivity to order information



Source: *Muranaga and Shimizu (a)*

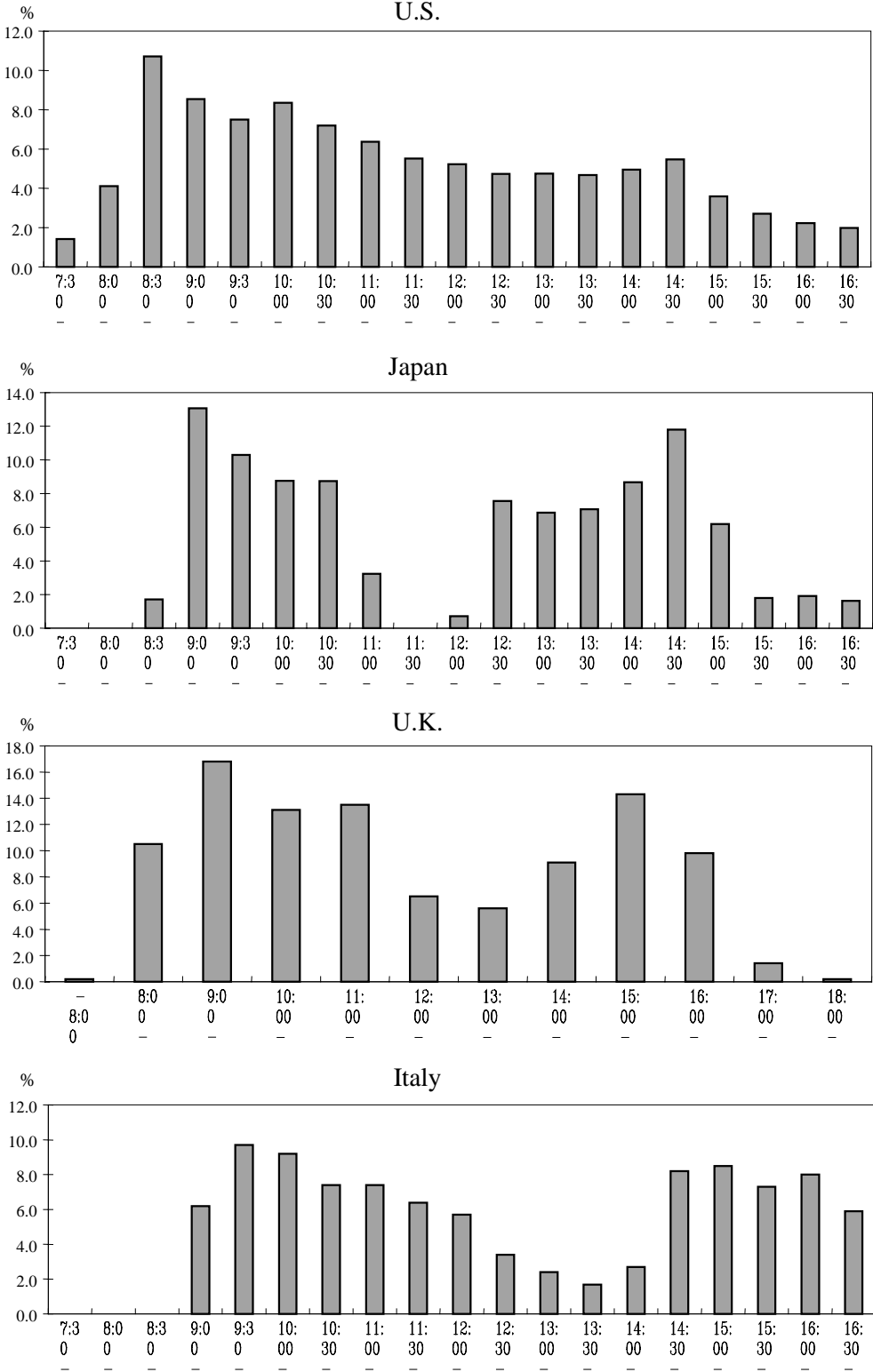
**Figure 7 Share of Government of Canada Bond Trading Volume, by Class of Customer**





**Figure 9 Intraday Patterns of Trading Volume, Price Volatility, and Bid-ask Spread in Selected Government Securities Markets**

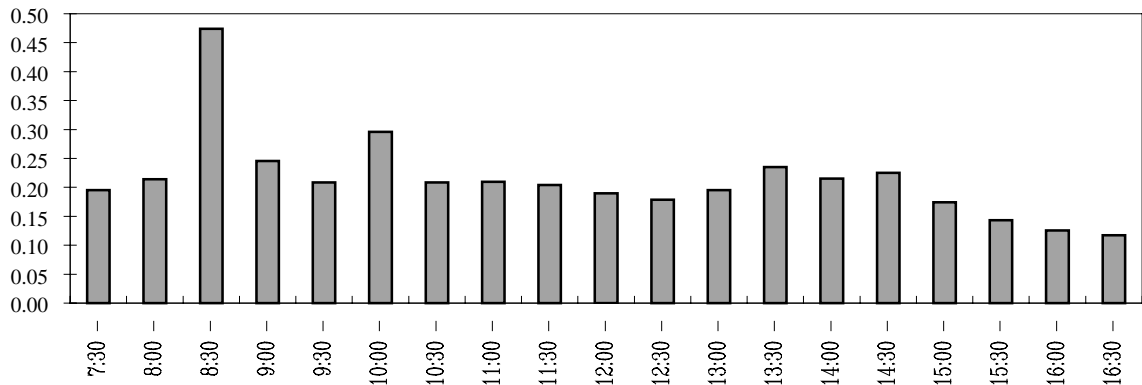
Trading volume



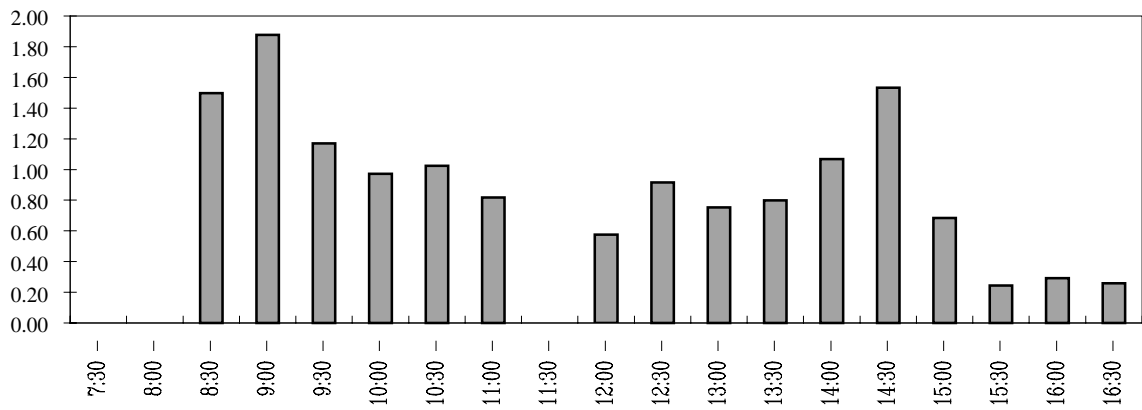
**Figure 9 (cont.)**

Price volatility

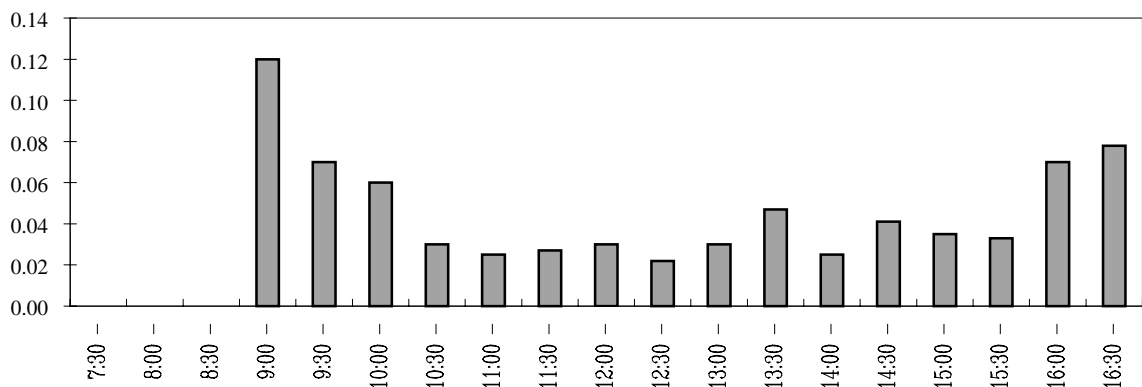
U.S.



Japan



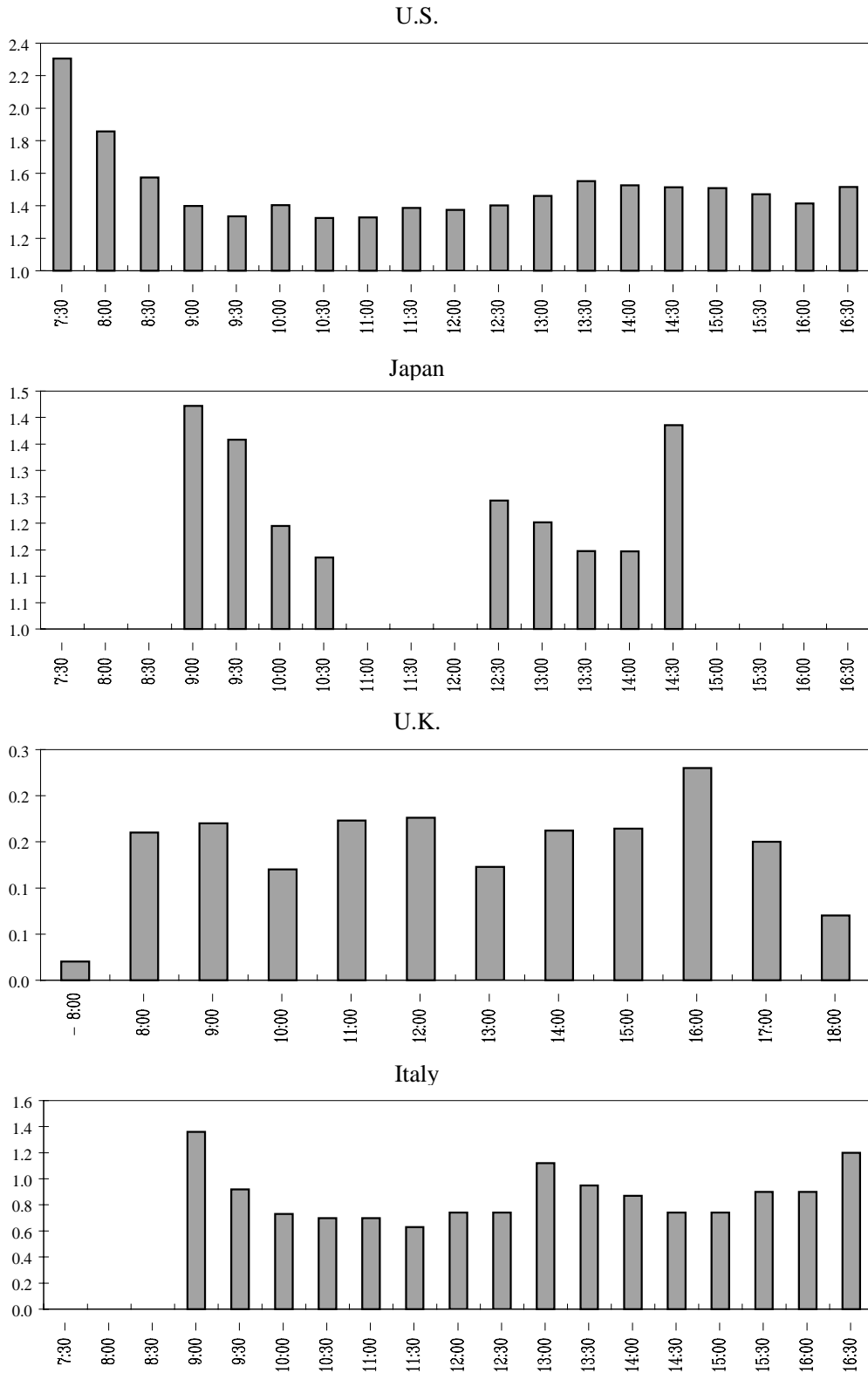
Italy



Note: Data for UK not available.

**Figure 9 (cont.)**

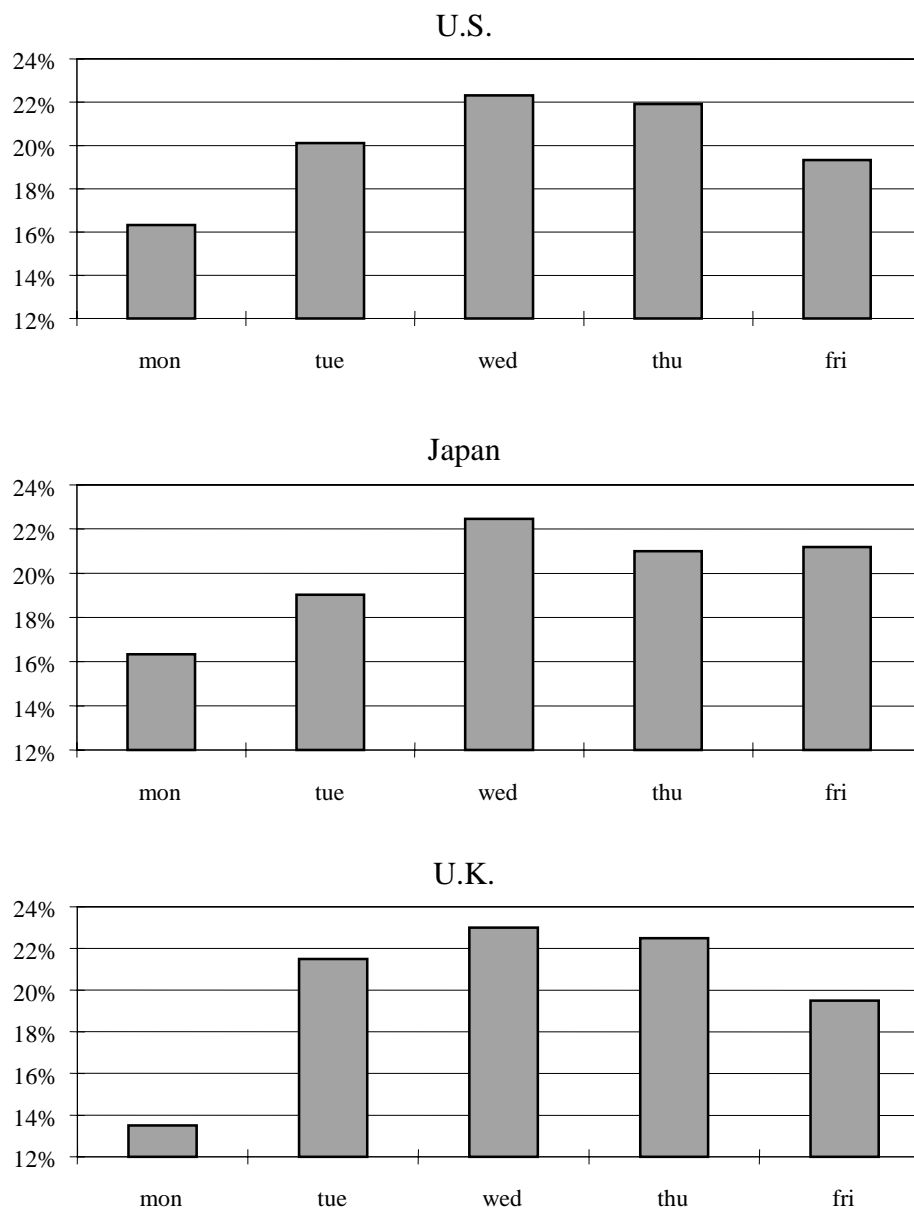
**Bid-ask spread**



Source: *Inoue (b)*. See text for further details.

Notes: The graphs show intraday patterns in trading volume, price volatility, and bid-ask spread for each 30-minute (1-hour for the UK) segment. See text for further details.

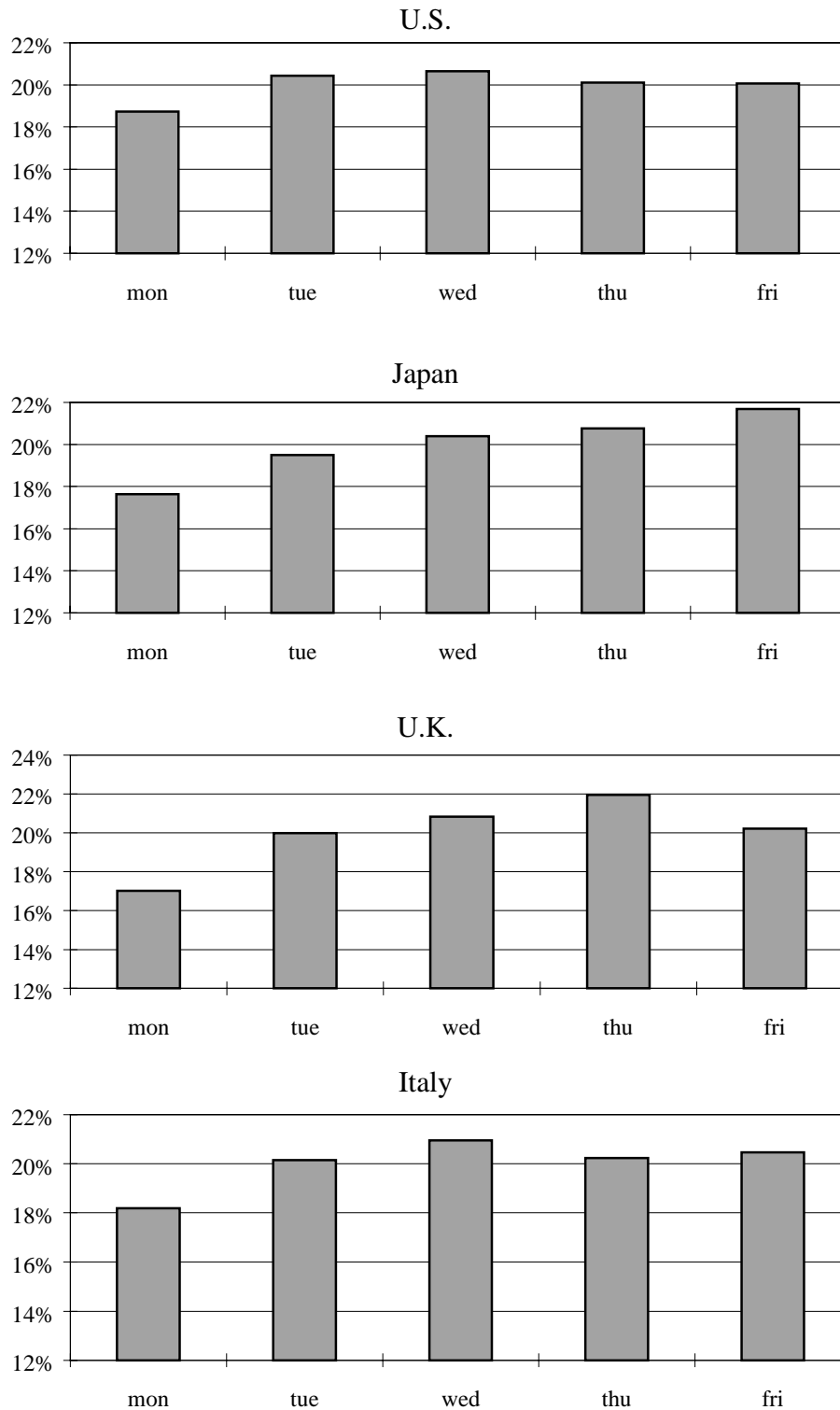
**Figure 10 Intraweek Patterns of Trading Volume in Selected Government Securities Markets**



Sources: *Inoue (b)*

Notes: The graphs show the percentage of weekly trading volume that takes place on each day of the week. See text for further details.

**Figure 11 Intraweek Patterns of Trading Volume in Selected Equity Markets**



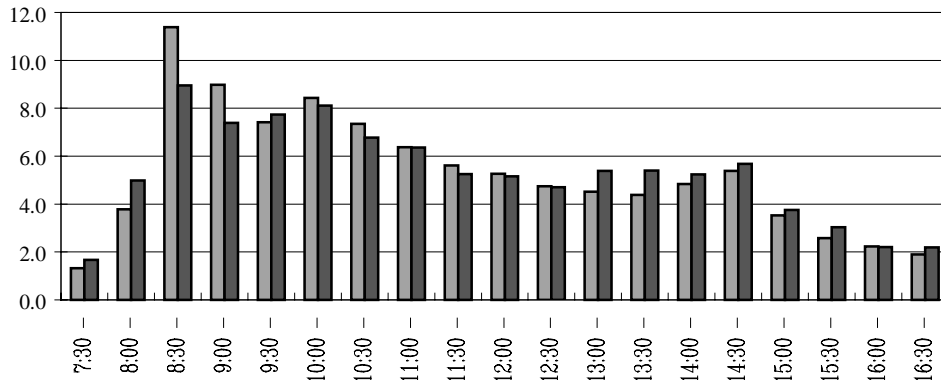
Sources: *Inoue (b)*

Notes: The graphs show the percentage of weekly trading volume that takes place on each day of the week. See text for further details.

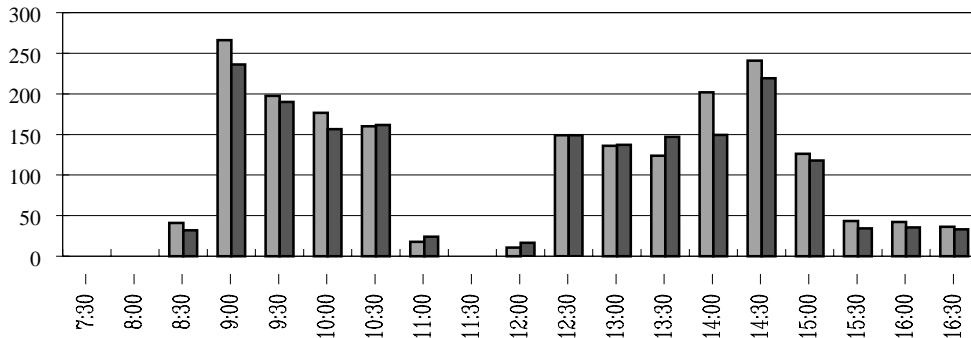
**Figure 12 Effect of Statistical Announcements on Intraday Patterns of Trading Volume and Price Volatility**

Trading volume

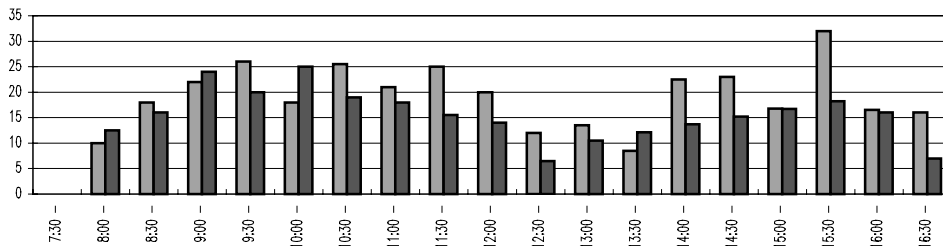
U.S.



Japan



U.K.

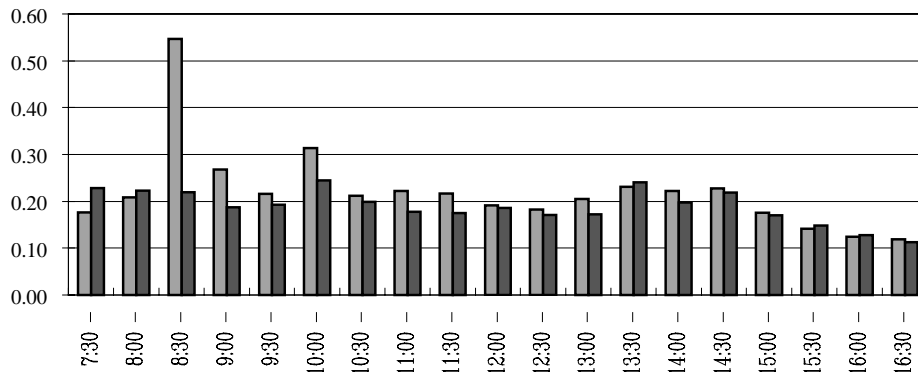


■ announcement day ■ non-announcement day

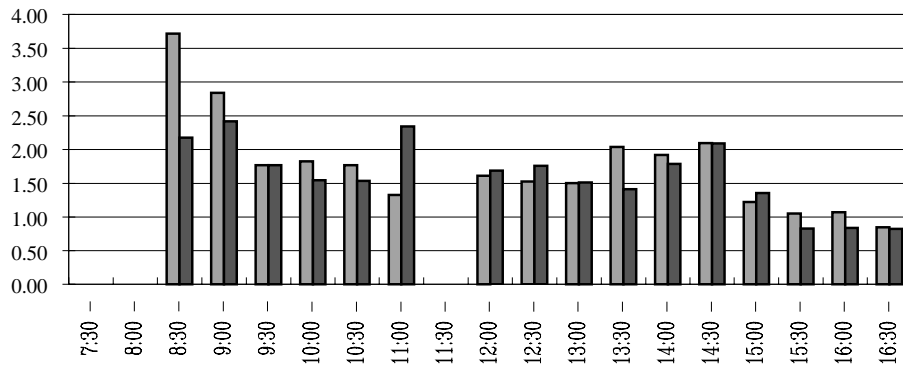
**Figure 12 (cont.)**

Price volatility

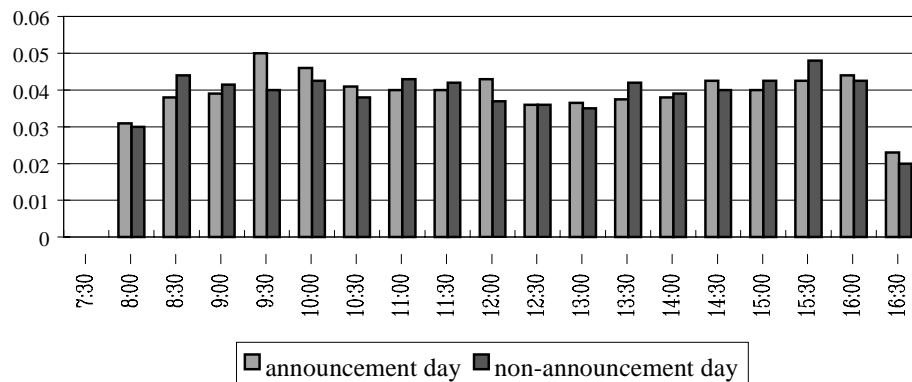
U.S.



Japan



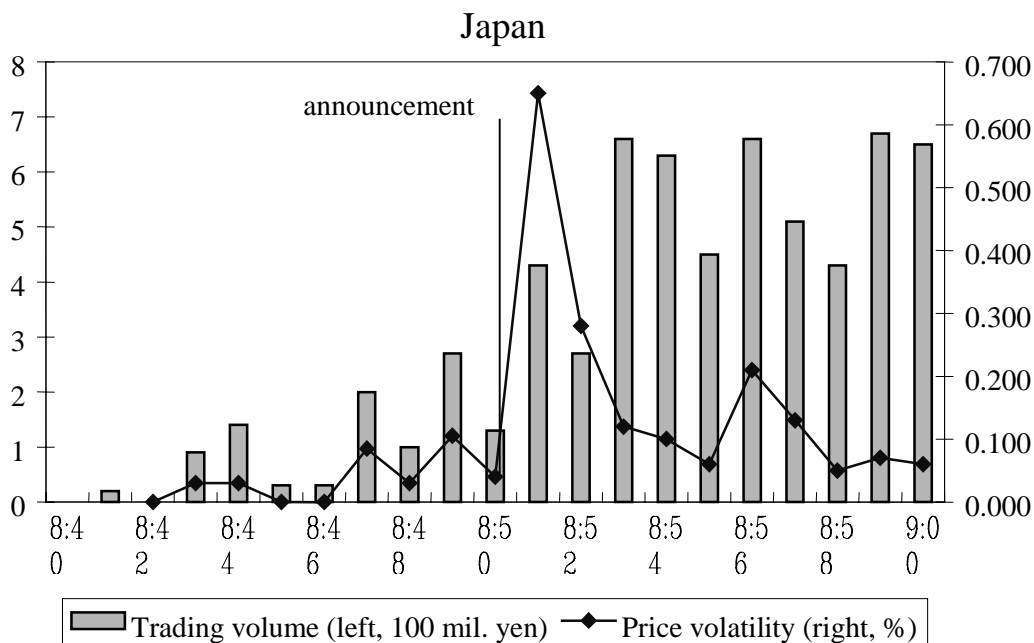
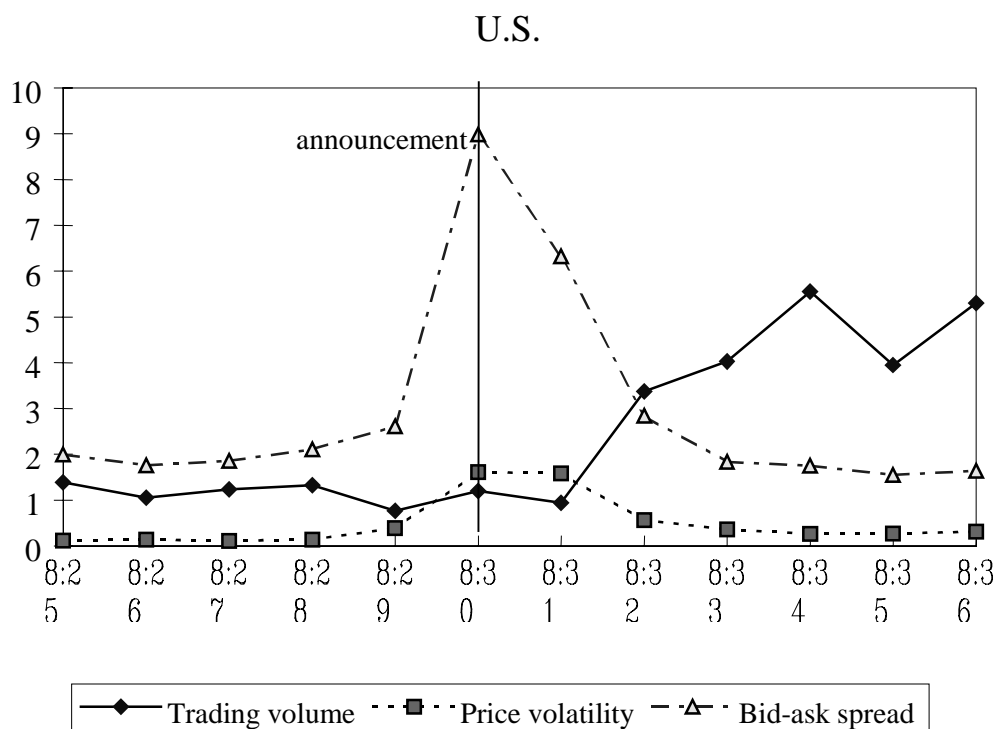
U.K.



Source: *Inoue (b), Clare, Johnson, Proudman and Saporta.*

Notes: The graphs show the intraday patterns of trading volume and price volatility on the days when official statistics are announced and on days when they are not. See text for further details.

**Figure 13 Liquidity Indicators Around Statistical Announcements**



Source: *Inoue (b)*

Notes: The graphs show the trading volume and price volatility (and bid-ask spread in the US) around statistical announcements. See text for further details.

## **Appendix: Table of Questionnaire Results**