

# Implications of a Macro Stress Test on Financial Stability: Summary of the second census on stress tests

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# M R arket review

*The Financial Markets Department conducted its second census of stress tests to collect and analyse stress scenarios adopted by market participants. In a sense, the exercise was conceived as a market-wide "fire drill" assuming situations where serious shocks occur in financial markets. Through the census, it became evident that the following three points need to be duly taken into account in order to understand the mechanism through which stress develops: (1) the combined effects arising from changes in multiple risk factors, (2) the speed with which stress materialises and spreads through the market, and (3) the change in the resiliency of markets to stress caused by changes in economic and financial conditions and in market structure. In particular, when the effects of stress events evolve into a vicious circle involving the real economy, financial markets, and the banking sector, policy measures will become necessary to stem the movement. The aim of the exercise is to reinforce market resiliency to stress by sharing the results of the census with market participants, thereby facilitating the understanding of the mechanisms through which stress materialises and develops.*

## Introduction

Stress tests are defined as "tools used by financial firms to gauge their potential vulnerability to exceptional but plausible events." Recently, the Financial Markets Department conducted its second census of stress tests, directed at participants in Japanese financial markets. A census of stress tests can be regarded as a macro stress test by which the distribution of risk within markets may be identified. Macro stress testing is an intellectual exercise where various hypotheses are assumed as to how stress emerges and how it could be amplified by a "second-round effect" stemming from market participants' reactions to initial stress events. In this census, the Financial Markets Department collected stress scenarios that market participants adopted as of end-May 2002 together with information on possible measures they would take in the event of stressful events.<sup>1</sup>

Since the 1997 Asian crisis, Russian crisis and collapse of LTCM in 1998, the importance of stress testing as a risk management tool has been widely recognised by financial institutions. The Committee on the Global Financial System of the Bank for International Settlements has recognised the significance of providing for market-wide stress environments, and has conducted various studies.<sup>2</sup> Individual financial institutions also utilise stress tests as an opportunity to consider possible reactions to plausible future events on a firm-wide basis.

Releasing the results of the census would facilitate a common understanding among market participants on stress scenarios. Market participants might make use of such shared information to evaluate the extent of their concentration within some market segments and to envisage appropriate reactions to stress. This process may well prove to be an effective crisis prevention measure.

In the following sections, first, an outline of stress

scenarios that market participants adopted as of end-May 2002 will be introduced. Then, these scenarios and the resultant effects will be examined in more detail. Finally, the implications for financial stability derived from discussions with survey participants are discussed. Here, relevant issues are picked up to better understand the way stress develops.

## Outline of the Second Census on Stress Tests

### Extended Coverage of Participants

Ten financial institutions, including both banks and non-banks, participated in this census (seven banks participated in the last census).<sup>3</sup> The participants are engaged in various businesses in financial markets, which include financial intermediation and asset management, and hence their risk profile and risk-taking strategies differ. They are expected to react in different ways when stress events occur. By expanding the range of participants it became possible to collect wider views and thus to discuss from a realistic perspective the way stress develops.

### Extended Information Coverage

In the last census, stress scenarios were surveyed in terms of risk factors such as interest rates and equity prices. Namely, the extent to which such factors were expected to fluctuate were examined. In this census, surveyed items were extended to include information on what market participants regarded as sources of stress and on how they would react to these events, making it possible to estimate the second-round effects of stress events caused by market participants' reactions. A review of previous financial market crises reiterates how stress events spread entailing a vicious circle among the real economy, financial markets, and the banking sector. Taking into account this interaction, the mechanism through which stress

spreads is considered in this exercise from its origin to second-round effects (see Box).

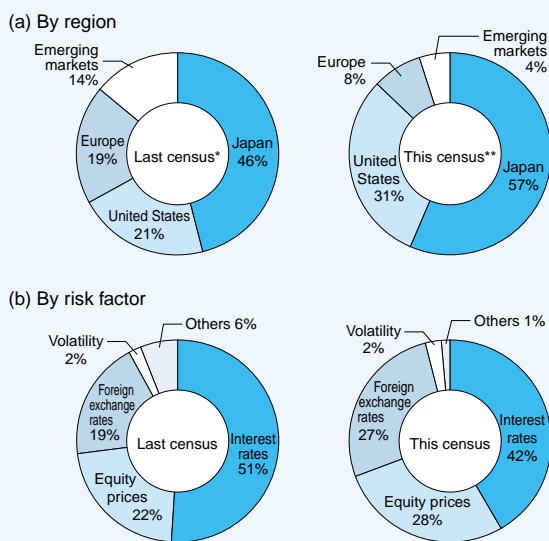
Stress scenarios used in stress tests can be divided into three categories. A sensitivity stress test refers to the impact of predefined changes in one or more risk factors on the value of portfolios. A historical scenario is based on the replication of significant past market events, and a hypothetical scenario is based on an assumed plausible market event. In the census, a total of 166 stress test scenarios, comprising 47 sensitivity stress tests, 58 historical scenarios, and 61 hypothetical scenarios, were reported by participants.

### Strong Focus on Japanese and US Economic Conditions

Looking at the historical and hypothetical scenarios by region, scenarios covering emerging markets were a common feature in the last census. This reflected the fact that it was conducted subsequent to the Asian and Russian currency crises which occurred in 1997 - 98.

In this census, scenarios tended to be more focussed on Japan and the United States in geographical terms than in the last census (Chart 1).

[Chart 1] Risk Scenarios



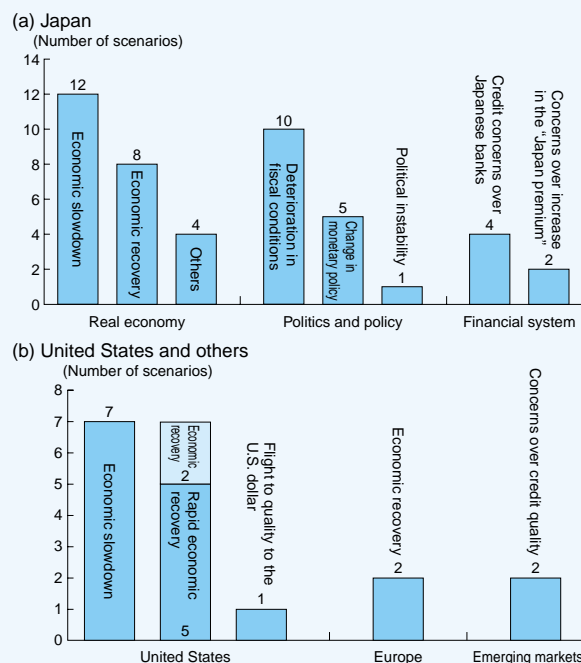
\* Participants in the last census: seven banks.  
 \*\* Participants in this census: six banks, one securities firm, two insurance companies, one cooperative institution.  
 Note: Sum of historical and hypothetical stress scenarios.

Chart 2 provides a more detailed view of the hypothetical scenarios which explain this increase in scenarios concerning Japan and the United States. An analysis of hypothetical scenarios reveals the factors that financial institutions consider as sources of stress, and which factors they pay more attention to.

As for Japan, most scenarios focussed on the downside risk of the Japanese economy.<sup>4</sup> This implies that the uncertainty over the future development of the real economy was strongly recognised as a risk factor when this census was undertaken. In addition, it is worth noting that market participants considered that changes in fiscal and monetary policy could result in drops in bond and equity prices, thus themselves becoming a source of stress.

As for the scenarios pertaining to the United States, the number of scenarios was evenly split between those assuming an upturn and those looking at the downside risks. This would imply that the

[Chart 2] Background to Hypothetical Scenarios



Note: "Flight to quality to the United States" is a scenario where increased demand for U.S. Treasuries would lead to a decline in dollar interest rates.

uncertainty over the recovery of the U.S. economy at end-May was not as strong as it is at present. This timing issue also applied to scenarios on Europe which assumed a rise in interest rates reflecting economic recovery. Emerging market scenarios mostly focussed on uncertainties surrounding credit quality.

### Increased Focus on Equity Prices and Foreign Exchange Rates and Less on Interest Rate Changes

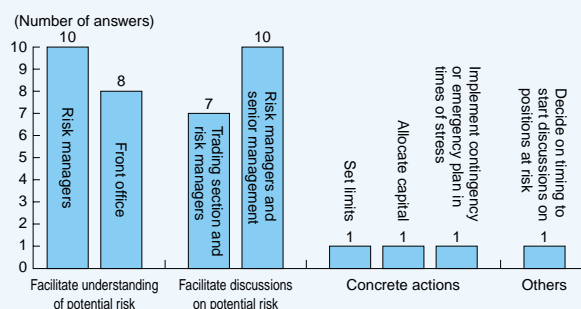
Next, we look at the risk factor breakdowns of historical and hypothetical scenarios in Chart 1. In this census, as in the last one, the order of participants' interest was "interest rates," "equities," and "foreign exchange rates." However, in this census, the weight of "equities" and "foreign exchange rates" rose while that for "interest rates" declined. Scenarios focussing on "equities" may have risen as a result of increased uncertainty over future prospects for the economy, as they are considered as more closely linked to economic fundamentals. The increase may also have reflected concerns over the prospects for U.S. equity prices. Scenarios relating to "foreign exchange rates" may have increased, as they are directly connected with export-led economic recovery scenarios. On the other hand, the weight of "interest rate"-related scenarios decreased, probably because many participants took it for granted that interest rates will remain stable at a low level for the foreseeable future.

### Stress Tests as a Communication Tool

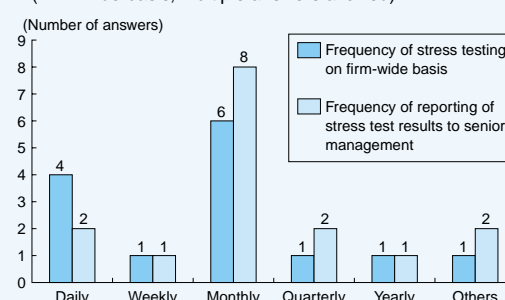
In the census, as in the last one, participants were asked how they use stress test results. It turned out that stress tests tended to be used to facilitate understanding of risk profiles and communication between risk managers and a front office as well as with senior management. Few participants linked stress tests results with risk management action (Chart 3). These observations tend to be applicable not only to financial institutions in Japan, but also to those in G10 countries in general. All census participants responded "No" to the question, "Have the results of stress tests ever directly led your firm to hedge or unwind a position?"<sup>5</sup>

### [Chart 3] Questionnaire Results on Stress Test Practices

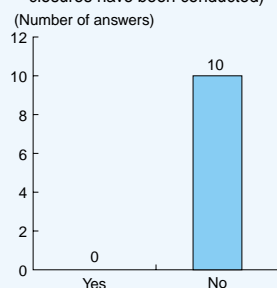
(1) Uses of stress tests (Multiple answers allowed)



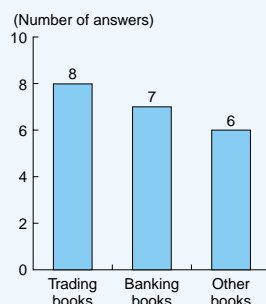
(3) Frequency of stress testing and reporting to senior management (Firm-wide basis, multiple answers allowed)



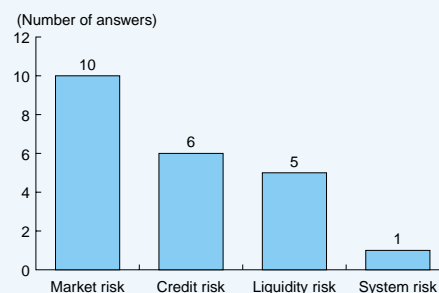
(2) Uses of stress test results (whether hedge operations or position closures have been conducted)



(4) Business lines covered by stress tests



(5) Types of risks expected to arise from changes in market conditions (Multiple answers allowed)



If stress were defined as an unforeseen change in market conditions, by definition one could not predict it *a priori*. This means that the information collected through a census of stress tests cannot be used to predict future stress events, but rather to facilitate information sharing among risk managers, a front office, and senior management.

The frequency with which stress test results are reported to senior management was at least monthly, with some items such as trading book results being reported as often as daily. Coverage increased from the last census and included not only trading books but also banking books and strategic long-term equity holdings. The range of risks covered also expanded. The last census results indicated that the covered risks centred on market risks, but the results of this census showed that market-related credit risk, such as credit spreads, and liquidity risk were also taken into account by participants.

### The Magnitude of Stress

In this section we look at the potential magnitude of stress in the three sectors, i.e. financial markets, real economy, and the banking sector, where the effect of stress events propagates.

### Stress in Financial and Capital Markets

The average, maximum, and minimum values of changes in the main risk factors covered in the hypothetical scenarios are summarised in Chart 4. In order to better gauge the magnitude of these values, they were compared with those that materialised under actual stress events in the past.<sup>6</sup> As for equity prices, the average of the reported decline was -18% which was comparable to the one-day TOPIX loss in 1987 on Black Monday (-15%). The maximum increase in long-term yen interest rates in the census, 129bp, was a little larger than the 105bp rise in 10-year JGB rates over a roughly one-month period subsequent to the Trust

Fund Bureau shock in December 1998.<sup>7</sup> Average changes in the U.S. dollar/yen exchange rate in the census were 10% dollar appreciation and 11% depreciation. This was slightly smaller than the 16% change which had materialised during a one-month period subsequent to the collapse of LTCM in 1998. Looking at credit spreads of corporate bonds to government bonds, the maximum rise of 200bp (for low rated bonds) provided by participants was almost equivalent to the 200bp rise in the credit premium for BB bonds, which had materialised in the six months prior to end-March 2001 subsequent to the default of Mycal (a large retailer) in September 2001.

### Stress in the Real Economy<sup>8</sup>

Many participants expressed the view that stress in financial markets, described in the above section, might well be caused by a further economic downturn

[Chart 4] Changes in main risk factors covered in hypothetical scenarios

(Changes as from end-May 2002)

Risk factors	Change	Average	
Equity prices	Japan	+11% to -36%	+ 9% -18%
	United States	+12% to -28%	+12% -16%
	Europe	+12% to -26%	+12% -19%
Interest rates	Long-term yen interest rate	+129bp to -120bp	+56bp -51bp
	Long-term U.S. dollar interest rate	+150bp to -150bp	+76bp -64bp
Foreign exchange rates	U.S. dollar / Yen	+17% to -23%	+10% -11%
	Euro / Yen	+17% to -17%	+12% -6%
Credit risk premium	High-rated bonds	+40 to +60bp	+50bp
	Low-rated bonds	+90 to +200bp	+145bp

Note: Upper and lower rows in "Average" column indicate average value of positive and negative changes respectively.

or increased expectation of further deterioration. The most commonly expressed scenario by census participants was the continued slowdown of the Japanese economy.

We now examine the possible changes in external conditions that cause stress in the real economy and the magnitude of such stress. Participants reported declines in exports brought about by a global economic slowdown as the most likely change in external conditions that may cause such stress scenarios. To grasp the quantitative impact on the real economy in such a scenario, we assumed, though rather extreme, global economic contraction at a rate that is equivalent to that experienced by Asian countries during the Asian Crisis in 1997. The effect on the real economy was estimated using the Bank of Japan's macroeconomic model.<sup>9</sup> The results show that the nominal GDP growth rate for the Japanese economy would, with this external shock, decline by 2% year-on-year for two consecutive years. This result is severer than the government forecast of -0.9% for FY2002, and market participants' forecast of -1.3% for CY2002 and +0.2% for CY2003.<sup>10</sup>

Though needless to say, the figures derived from the macroeconomic model should not be understood as "forecasts," but rather as data that can be used in an intellectual exercise to provide for future stress. Analyses using the macroeconomic model tell us the mechanism through which the effects of stress events spread to various economic sectors. In the census, the decline in private consumption and the poor performance of firms were pointed out as components of stress in the real economy. Again, to obtain a quantitative view, possible impacts on demand components under the aforementioned scenario were simulated, and the results show that estimated nominal growth in private consumption was lower than the +0.1% growth actually experienced in FY1997. The estimated decline in fixed investment was also large, matching the largest decline of the 1990s, -12% in FY1993.

However, the model does not take into account the negative feedback effects of a downturn in the global economy, which could arise in the financial markets, e.g. changes in equity prices, foreign exchange rates, and interest rates. Therefore, it needs to be noted that the -2% growth in nominal GDP could occur even without such a large downturn as assumed above in the global economy if such negative feedback effects through financial and loan markets are taken into consideration.

### **Stress in the Banking Sector**

We now consider the possible stress in the banking sector, the remaining one of the three sectors, if stress events were to occur in financial markets and the real economy. This would likely materialise through changes in the values of banks' various assets and thus would affect bank behaviour. Equity holdings by the four major banking groups, which participated in the census, totalled 21 trillion yen at end-March 2002. Using the sensitivity figures disclosed by a leading bank, a rough estimate of the effect on the equity holdings of the four groups to changes in equity prices was calculated. The result was that a 10-point decline in TOPIX would result in approximately a 0.2 trillion yen decline in the value of equities they held. The economic value of their loan assets, which amounted to 218 trillion yen at end-March 2002, would also decline with the widening of credit risk premiums. In addition,

if fiscal spending were to be raised to counter this economic situation and were to be financed by increased government bond issuance, long-term interest rates might also rise. This would, in turn, negatively affect the value of bond holdings by banks, which amounted to 38 trillion yen at end-March 2002.

## **Important Issues in Understanding Stress Situations**

The Financial Markets Department had discussions with participants on the results of this census with a view to developing it into a sort of "fire drill." Through the discussions, some key issues in considering stress situations were identified. In the sections below, these issues will be discussed from three perspectives: scenario construction, market participant behaviour, and central bank perspectives.

### **Issues Involved in Constructing Stress Scenarios**

Three issues were identified in the construction of stress scenarios, i.e. the importance of (a) scenarios reflecting the combined effects of multiple risk factors, (b) an appropriate time horizon, and (c) recognising sources of stress. Below, we will look at each of these in more detail.

#### **Importance of Scenarios Reflecting the Combined Effects of Multiple Risk Factors**

In constructing scenarios, it is important to take into account the combined effects of various risk factors. That is, when stress materialises, it is common that not only a single risk factor but multiple factors change simultaneously. For example, bond and equity prices generally move in opposite directions under normal conditions, and so banks can normally expect to offset, at least partially, losses incurred in one of these instruments with gains in the other. However, in times of stress, these risk factors may change in the same direction, so that banks' positions in both markets could be impaired. Census participants acknowledged that they had enough capacity to absorb stress pertaining to changes in a single risk factor, but that they would have more difficulties in dealing with stress resulting from changes in multiple factors. It is not realistic, however, to assume a simple "worst case scenario," in which all risk factors mechanically move in unfavourable directions. It is necessary to construct plausible scenarios reflecting the combined effects of multiple factors. Such scenarios should incorporate possible correlation among risk factors in times of stress. A better understanding of the mechanism in which the effects of stress spread is indispensable for constructing plausible scenarios.

#### **Importance of an Appropriate Time Horizon**

In addition, in discussing the development of stress and its effects, it was recognised that the time horizon over which stress materialises was a key element in constructing stress scenarios. In other words, if stress materialises gradually over a protracted period of time, market participants would be able to implement countermeasures. It was noted as a result of the discussions, however, that if stress occurs suddenly and in multiple risk factors, the existing capital capacity at individual institutions and market liquidity may not suffice to absorb the shock.<sup>11</sup> As will be discussed in more detail later, some market participants were of the view that crisis management policy responses would be called for when stress occurs in a short period of time and in a concentrated manner.



## Importance of Recognising Sources of Stress

In the census, declines in credit ratings and changes in public policy were noted as possible sources of stress. Credit downgrades occur in jumps even while credit risk premiums change more continuously. Therefore, the effects of a downgrade could abruptly surface in the markets. Clauses, under which contract conditions may be modified unfavourably vis-à-vis borrowers subject to a rating downgrade, are being more often embedded in contracts. If such conditional clauses were to be suddenly triggered on a wide scale, borrowers would be faced with difficulty in obtaining liquidity, which might have systemic implications. In recent years, events such as the Enron shock have prompted the global financial community to pay more attention to the issue of how this type of stress may materialise. Census participants responded that they were braced for such shocks because they were aware of this type of risk from experiences in the recent past and assumed, in their stress tests, situations in which they were downgraded.

## Market Participants' Behaviour in Times of Stress

In this census, emphasis was put on trying to understand the dynamics of how stress situations develop. Discussions with market participants also focussed on the actions they would take in cases of stress. These discussions revealed that it was necessary to take into account (a) business cycles and changes in surrounding conditions such as technological advances, and (b) the macro aggregated effect of the behaviour of individual market participants.

## How Business Cycles and Changes in Surrounding Conditions such as Structural Changes and Technological Advances are Reflected in Stress Scenarios

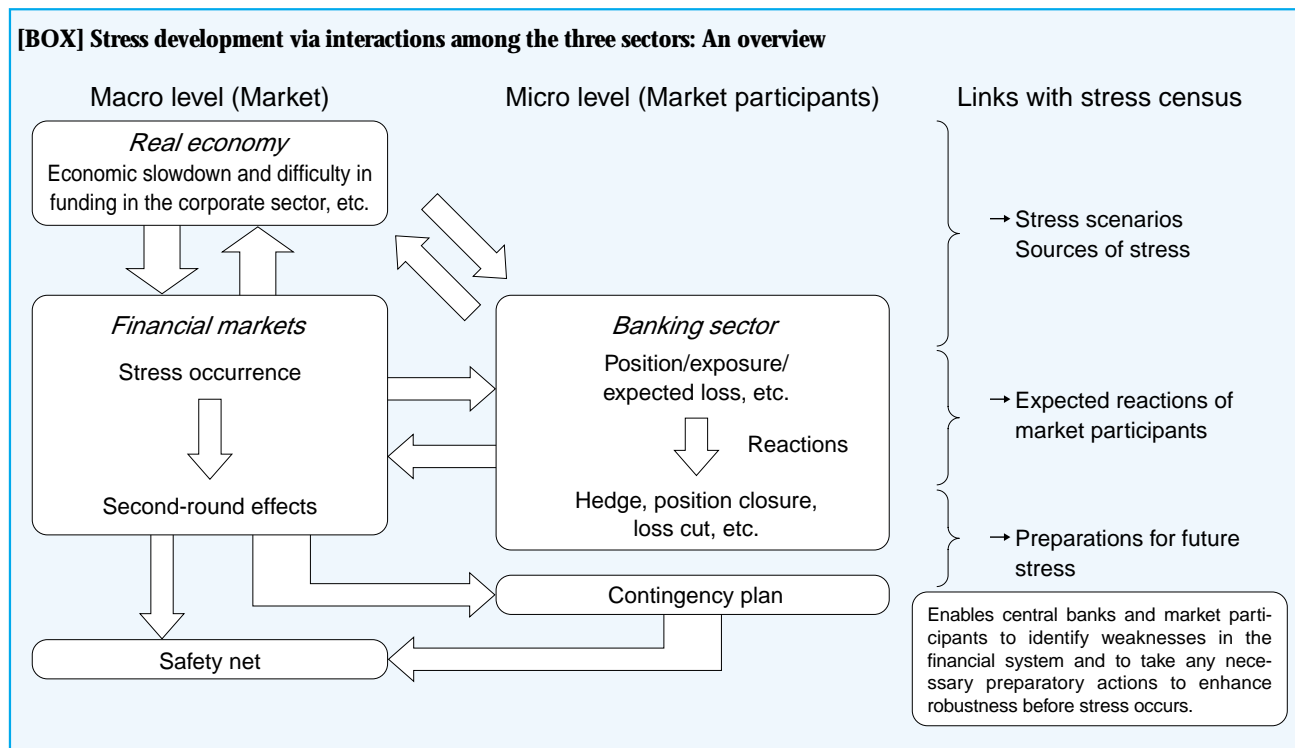
Even when a stress event of the same magnitude as a past incident should occur, market participants may not react in the same way because surrounding conditions are not necessarily identical. Its effect on

markets is also likely to differ. Financial institutions in Japan may currently be less resilient to stress, as their financial strength has been undermined having had to deal with the issue of non-performing loans over a protracted period of time.

On the other hand, risk management techniques at individual financial institutions have been improved, including their increased ability to recognise risk earlier. Putting these together could mean that financial institutions might take action earlier than in the past to deal with stress situations. In addition, resilience to stress of both individual market participants and markets may have been strengthened by measures taken to improve the financial infrastructure. For example, in February 1994, a circuit breaker system was introduced in the Tokyo Stock Exchange. This system allows trading to be temporarily halted (for 15 minutes) when movements in futures markets become too volatile. This is thought to be contributing to reducing the anxiety of market participants and limiting the effects of stress in the market.

## Influence of Monetary Easing

During financial disruption in Japan in 1997 and 1998, two kinds of crises occurred simultaneously. One was a liquidity crisis, where even large banks had difficulty in obtaining funds, and the other was a solvency crisis, under which some banks faced difficulty in maintaining capital adequacy ratios above 8%.<sup>12</sup> Faced with this situation, some banks shed their assets dramatically in order to overcome the crises on two fronts. Learning from this experience, however, Japanese banks have significantly reduced their foreign exposure. Ample liquidity is provided to the markets under the current easy monetary policy. Under these circumstances, it is unlikely that a liquidity crisis will repeat itself anytime soon. It was pointed out by census participants that liquidity conditions in the market may influence the way stress occurs and how market participants react to it.



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## Relationship Between Micro and Macro Perspectives

In considering how action taken by individual market participants at the micro level would affect macro performance, the possibility of feedback effect needs to be taken into account. When a market participant responds to stress, it needs to take into account possible action by other market participants. Otherwise its action may become ineffective. For example, if market participants simultaneously and collectively start to reduce their assets, in order to prevent a decline in their capital adequacy ratios, they face a new risk of a deterioration in the market value of assets. Thus, rational as the strategy may be from an individual standpoint, they may not be able to achieve their initial objective. To construct stress scenarios covering such feedback effects, a wealth of knowledge covering advanced theoretical and empirical aspects might be needed. An effective information sharing mechanism in the market is also necessary. At this stage, it seems to be increasingly recognised that such scenarios as incorporating feedback effects are necessary, although they are not yet commonly adopted.

## Issues for Central Banks

In this census, stress scenarios covering feedback effects of stress on three sectors, i.e. the real economy, financial markets, and the banking sector, were examined. The census results suggest that careful consideration is required for situations when stress materialises abruptly and in a combined manner. It was also recognised that the feedback effects are anticipated to be more acute than in the past as the financial strength of the banking sector has weakened. On the other hand, it should also be noted that the resilience to stress of market participants and markets may have been reinforced. On the part of market participants, their risk management skills have improved. The overall stress resilience of the financial system has been strengthened through improved market infrastructure, a robust safety net, and sufficient liquidity positions on the part of market participants.

Some voiced a view that some kind of "circuit breaker" mechanism would be necessary when a vicious circle emerges among the three sectors. In particular, policy action aimed at preventing liquidity concerns from spreading was thought to be essential. Of course, more fundamentally, it is essential that policies to improve economic fundamentals are implemented, which will be reflected in overall financial market conditions and in the soundness of bank assets.

At the same time, it may be worth noting that policy aimed at breaking the vicious circle among the three sectors might, in itself, prompt unintended side effects by causing another round of reaction in markets. Market participants have already begun to take this kind of side-effect of policy action into consideration and have started to take necessary measures.

Central banks need to closely monitor the markets for signs of stress initiated in a vicious circle among the three sectors. Meanwhile, market participants constantly revise their stress scenarios in response to changes in the financial environment. This implies that it would be worthwhile to periodically conduct macro stress tests. In addition, it would also be of value to conduct theoretical and empirical analyses on how changes in surrounding conditions affect the transmission mechanism of stress. The Bank of Japan

will work to reinforce the resiliency of the market to stress by sharing the results of the census with market participants and by facilitating their better understanding of the mechanisms by which stress materialises and develops.

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<sup>1</sup> The last census of stress tests at global financial institutions was conducted in May 2000. Banks in G10 countries – Japan, Canada, France, Germany, Italy, the Netherlands, Sweden, Switzerland, the United Kingdom, and the United States – took part in this exercise, which was conducted as a project under the auspices of the Committee on the Global Financial System at the Bank for International Settlements. For more details, see "A Survey of Stress Tests and Current Practice at Major Financial Institutions," April 2001, by BIS and Market Review 2001-J-4 (in Japanese) published by the Bank of Japan. This census, described in this article, was conducted only in Japan.

<sup>2</sup> For example, see BIS "Stress Testing by Large Financial Institutions: Current Practice and Aggregation Issues," April 2000.

<sup>3</sup> Participants: Daiwa Securities SMBC, Mizuho Bank, Mizuho Corporate Bank, Mizuho Holdings, Nippon Life Insurance, The Norinchukin Bank, Sumitomo Mitsui Banking Corporation, Tokio Marine and Fire Insurance, Bank of Tokyo-Mitsubishi, and UFJ Bank.

<sup>4</sup> Stress events that participants anticipated were not necessarily limited to economic slowdowns. For those market participants holding long positions in bonds, interest rate increases resulting from a pickup in the economy was also a risk. Scenarios for Japan included twelve that assumed an economic downturn and eight that assumed a pickup in the economy. For the United States, there were seven of each.

<sup>5</sup> Loss-cutting rules are activated at front offices as a daily risk management exercise separately from stress tests when losses accumulate.

<sup>6</sup> In hypothetical scenarios, the period of time within which fluctuations in risk factors are assumed is selected by participants. It is not possible, therefore, to directly compare the magnitude of change in risk factors with those in the past. The comparisons made here are intended to give an idea as to the magnitude of assumed stress in hypothetical scenarios.

<sup>7</sup> In December 1998, the Finance Minister commented that the suspension of government bond purchases by the Trust Fund Bureau was not a particularly serious matter.

<sup>8</sup> Measuring quantitatively the effects of stress (either present or expected in the future) in the real economy on financial markets is technically difficult and remains an aim for future work. In the census, external conditions under which stress events could materialise and past stress events are referred to in order to gauge the potential effects of stress in the real economy on financial markets.

<sup>9</sup> From the second quarter of 2002, GDP figures are estimated by a new method. In this paper, on the other hand, final figures and simulated figures are based on old estimation method. It should also be noted that the macroeconomic model which was used is based on certain assumptions such as stable economic structure.

<sup>10</sup> These forecasts are based on the old estimation method.

<sup>11</sup> The period of time during which financial institutions expect to be required to unwind their positions is another important element to be considered. Census results showed that various time horizons were assumed in risk scenarios for identical stress events (therefore, the anticipated changes in risk factors would also vary). For highly liquid markets, short-term stress scenarios would be sufficient, but for markets where a longer period would be required for liquidity to recover to normal levels, it would be necessary to take into account the effects incurred by stress situations that may last longer.

<sup>12</sup> Financial institutions may, when faced with difficulty in obtaining funds for payment and settlement purposes, resort to selling their assets. In addition, when there is a risk that their capital adequacy ratio will fall below 8%, financial institutions may decide to reduce their asset holdings (in effect sell them in the market) to bring down their risk assets, i.e. the denominator in the capital adequacy ratio equation.

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