Pitfalls and Opportunities for the Conduct of Monetary Policy in a World of High-Frequency Data

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Introduction

Financial market developments over the last decade have greatly increased interest in the properties of high-frequency data. Stimulated by the search for greater arbitrage opportunities, which have been created or facilitated by innovations in computer technology, central banks are now able to monitor and, if they choose, react daily to developments influencing financial markets in particular.

Central banks in several industrialized countries are responsible for maintaining some form of price stability. To do so, monetary policy-makers tend to use information that is released relatively infrequently (e.g., CPI inflation, GDP growth). Moreover, the lags on the effects of monetary policy are long, while those on other forms of central bank intervention in financial markets (e.g., changing the overnight interest rate band) are very short. As a result, there can be a conflict between being too concerned about daily developments in financial markets and attaining a specific monetary policy objective. This is a problem alluded to in Zelmer (1996) using case studies. The implication, then, is that there is a risk that monetary authorities may develop "myopia" or "tunnel vision" and overreact to what appear to be

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random or inexplicable events from the perspective of overall monetary policy objectives.

History is replete with examples of policy-makers who showed some form of short-sighted behaviour triggered by the misinterpretation or ignorance of the available evidence. Friedman (1992), for example, points out that innocuous policy moves whose full consequences were not considered can have disastrous economic effects. Taylor (1998) suggests that frequent changes in U.S. monetary policy regimes over the last century reflect a lack of understanding of what constitutes a set of rules consistent with “good” monetary policy. Other recent examples of myopia or tunnel vision include co-ordination failures throughout the 1970s among central banks and governments in the industrialized countries (Volcker and Gyohten 1992), and, arguably, the failure to anticipate the magnitude of the Mexican and Asian financial crises of the 1990s (General Accounting Office 1996; Fischer 1998). It should be pointed out, however, that authorities’ focusing on a specific event need not always be a symptom of bad policy-making or short-sightedness. For example, the U.S. Federal Reserve Board reacted to the stock market crash of 1987 with what are generally regarded as the right signals, even if the event was a singular one with unclear long-term consequences for monetary policy. What may seem like a myopic response to some may not be so from the broad macroeconomic perspective. This paper examines the pros and cons of monetary authorities’ short-sightedness when high-frequency information is available.

Certainly there is much interest in this topic, which makes exploring the information content in high-frequency data worthwhile. Recent research, such as Granger, Ding, and Spear (1997), reveals that high-frequency data show long memory[1] and other intriguing properties. However, it is unclear to what extent the testing procedure can explain the results—whether the available samples are too short, the statistics used to gauge the properties of the data are inappropriate, or the sampling frequency plays some role. As well, conventional measures of volatility or risk, such as variance, or generalized autoregressive conditional heteroscedasticity (GARCH), may actually proxy some of the hidden features or structure in the data (such as non-linearities), instead of the underlying risks in asset markets.

Policy-makers seeking to understand the implications of high-frequency data for the conduct of monetary policy are asking, Since information is supplied by the market apparently more frequently, should this necessarily elicit more frequent responses? Why should central bankers care about daily fluctuations in, say, the exchange rate, interest rates, or

1. In other words, current shocks to a variable will have long-lasting or permanent effects on the same variable in the distant future. See also Granger and Teräsvirta (1993).

stock prices, if these are unlikely to have permanent economic effects or thwart central bank policies?

I will suggest a couple of reasons for the tension between taking the long view on policy questions and the need to be seen as being responsive to frequent shocks that may, or may not, have lasting economic consequences. First, central banks are viewed as the guardians of the stability of the financial system and, as such, may be expected to react to news that might influence financial markets. Consequently, one would expect central bank announcements and interventions to be more precise and, therefore, less frequent, possibly to counter the “noise” of high-frequency information. A second explanation for central banks’ interest in high-frequency information is the fear that one small event, whether “rational” or not, can trigger a financial crisis and threaten the stability of the financial system (e.g., the “irrational exuberance” statement made by Alan Greenspan in December 1996). Policy-makers fear that one small event can be enough to warrant monitoring and responding to high-frequency data. Generating empirical evidence on this question is problematical, but I will present some suggestive evidence.

This paper surveys arguments in favour of or against central banks being overly concerned with day-to-day developments in financial markets, and is organized as follows. Section 1 defines types of central bank myopia and tunnel vision. Section 2 discusses the problem of whether and how often central banks should signal their intentions, as well as the consequences of their actions. Section 3 presents a smorgasbord of suggestive evidence about the information content of high-frequency data and discusses whether ignoring such data may have measurable consequences when focusing on lower-frequency economic information.

1 Varieties of Short-Sightedness in Monetary Policy

Central bankers show myopic behaviour when they become overwhelmed by high-frequency data and lose sight of the consequences of their actions. Alternatively, they can show tunnel vision when they focus exclusively on a particular problem and ignore the possible consequences of their actions. Both are types of short-sighted behaviour that manifest themselves in many different ways, not all necessarily linked to the existence of high-frequency data.

Myopic central bank policy focuses too much on day-to-day events that may not have a lasting effect on the overall objectives of monetary policy. For example, monetary policy objectives might be defined by an inflation-control target. Assuming that day-to-day news events have at most a temporary effect on price-level movements, a central bank that is overly reactive, intervening in some fashion too often, may be seen as being myopic. However, for a central bank that has not one explicit objective but several, perhaps *no* one reaction may be characterized as myopic.

It is clear from many central bank publications that the policy-makers' vision—and here I include the fiscal authorities as well—of what constitutes good monetary policy has narrowed considerably in the last few years. Inflation control is viewed as the ultimate role of the monetary authorities. Some (e.g., Fortin 1996) might interpret this as a form of tunnel vision, because they see the statutory mandate of the central bank as being much broader than just inflation control. They view inflation targets, for example, as a sign of a lack of concern for the real side of the economy. However, this presupposes some well-defined trade-off between the two. Needless to say, that is a controversial question.

If high-frequency data contain more up-to-date information about current and anticipated economic conditions (as claimed, for example, by Söderlind and Svensson 1997), then central banks would be excessively short-sighted if they ignored this type of information. Similarly, when institutions such as the International Monetary Fund or the Bank for International Settlements, partly as a result of their historical or perceived mandates, pressure or force policy-makers to pay too much attention to a specific aspect of economic performance, such as the current account balance, the budget deficit, or the capital adequacy of banks, this is also tantamount to tunnel-vision policy-making. Other warning signals that may be present in high-frequency data (e.g., the exchange rate) can easily be ignored or underestimated. Yet another manifestation of tunnel vision occurs when the central bank fails to consider the impact of policy shocks on large versus small firms. The extensive body of literature dealing with the channels of monetary policy is relevant here. There has been a revival of interest in this topic, as a result of greater experimentation with different types of monetary regimes (Mishkin 1995).[2]

Central banks may show tunnel vision or myopia by reacting too quickly to some news events, as opposed to too often, without allowing time for sober economic analysis to confirm whether the impact on some stated policy objective may be great enough to breach an inflation or other policy

2. Lucas (1989) is a good example of an analysis that raises this issue in examining the consequences of Canada's disinflation policy during the 1980s at the provincial level.

target.[3] However, central banks are more forward-looking than much of the empirical literature on central bank reaction functions gives them credit for being. And because they know about the inaccuracies and measurement biases inherent in several macroeconomic aggregates, central bankers do not mechanically apply simple rules to monetary policy. They rely on many proxies or leading economic indicators and informal information-gathering techniques. To generate inflation forecasts, they use a "portfolio" of models (see Longworth and Freedman 1995 for a Canadian illustration). The reason is that myopic behaviour can be less stabilizing than pure foresight. To see why this might be the case, assume, as in Johnson and Siklos (1996) and elsewhere, that monetary policy is governed by forward-looking behaviour of the following type:

$$R_t = \theta\,(E_t\pi_{t+k} - \pi^+), \tag{1}$$

where R is the policy instrument, here assumed to be a short-term interest rate, π is the inflation rate, π^+ is either the inflation forecast or the inflation target. Now, I will incorporate (1) into a simple macro model of the form:

$$\pi_t = E_t\pi_{t+1} + \Phi y_{t-1} + v_t, \tag{2}$$

$$y_t = -\delta(R_t - E_t\pi_{t+1}), \tag{3}$$

where y can represent either deviations from the natural rate of output (as in a Taylor-type rule; see Clarida, Gali, and Gertler 1997), or unemployment (as in Johnson and Siklos 1996). Equation (2) is a standard expectations-augmented Phillips curve. Together with (3), it forms a conventional aggregate demand–supply model of the economy. Consider first a policy rule or reaction function in which the monetary authorities are forward-looking[4] so that

$$\pi_t = E_t\pi_{t+1} + \delta\pi^* - \delta(\phi - 1)E_{t-1}\pi_t + v_t. \tag{4}$$

Assuming $\theta > 1$, this leads to a stable solution. The basic intuition is that, in the event of a positive shock (i.e., $v_t > 0$), the nominal interest rate increase

3. In this connection, the analysis by Orphanides (1997) is interesting, since he argues that more-reasonable assumptions about data availability lead to policy recommendations quite different from those obtained using final estimates. Of course, it has yet to be demonstrated, in an international setting, that the "Taylor" rule, which underpins Orphanides' analysis, adequately describes the policy-making process. Under this rule, a central bank sets a benchmark interest rate according to the output gap and changes in the inflation rate.

4. To conserve space I will omit the case where policy-makers maintain a constant interest rate. In the very short run, this may be a possibility, but not a very interesting one.

is *greater* than the rise in inflation so that the *real* interest rate also rises. This, of course, leads to a dampening of future or *expected* inflation, offsetting the original positive shock. Now consider the case of the *myopic* policy-maker who reacts to *any* deviation from the stated or explicit inflation objective. Such a rule would be written:

$$R_t = \chi(\pi_t - \pi^+) . \tag{5}$$

This leads to the following reaction function, after rewriting (5) in reduced form:

$$\pi_t = E_t \pi_{t+1} - \delta\chi\pi_{t-1} + \delta E_{t-1}\pi_t + \delta\chi\pi^+ + \epsilon_t . \tag{6}$$

It can be shown[5] that there are two solutions in this case. One is the "bubble" or explosive solution; the other is the stable solution, but one that introduces oscillatory behaviour in the inflation process. Clearly, myopia is to be avoided under these circumstances. There is nothing in the foregoing example, of course, to suggest that myopia is the result of the presence of high-frequency information. However, a central bank that reacts as in (4) by frequently adjusting the target for, say, overnight interest rates may be showing short-sighted behaviour.[6]

Myopic behaviour might also be the outcome of a misunderstanding of, say, sources of price changes in a market economy. For example, some, such as Johnson and Keleher (1996), have argued that central banks should focus their attention almost exclusively on the behaviour of commodity prices as a reliable guide to inflationary pressures. Observations on these series are available more frequently than for the CPI, which again suggests that policy-makers are missing an opportunity to monitor high-frequency data. While central banks do not entirely ignore such information, it is doubtful that they are guided solely by movements in these prices. The relationship of these prices with the overall objectives of monetary policy are still not well understood, given that there are many other equally useful

5. Using the method of undetermined coefficients (McCallum 1989).

6. There may be a way for a central bank to act as in (5) and not *appear* myopic, since the arguments adopted here assume some type of formal intervention whenever $\pi \neq \pi^+$. Suppose that χ is a function of central bank announcements. In this case, deviations from the inflation targets need not prompt the central bank to actively rely on the interest rate instrument. A scheme of this kind is envisioned by Guthrie and Wright (1998), although their approach does not rely on a specific macro model.

signals of future inflation performance.[7] Hence, a form of myopia occurs when the central bank's information set is deliberately restrictive.

A variation on the restricted-information-set theme raises yet another form of myopia. Since policy objectives, formal or not, are stated in terms of the *levels* of some aggregate, the *volatility* of time series, more apparent in high-frequency data, may not be taken fully into account by policy-makers.[8] Part of the reason might be the difficulty of distinguishing "meteor showers" from "heat waves" (Engle, Ito, and Lin 1995). The latter originates from the impact of volatility outside of the domestic market, while the former effect is country- or market-specific. Another explanation is that perhaps the consequences of volatility are not well understood. [9]

2 When and How Much to Signal?

2.1 "Cheap talk" and its institutional fixes

The literature has for a long time been concerned with whether and how central banks should make their policy intentions known. The swelling, constant stream of data, complete with its own dangerous currents, provides an opportunity for central banks to "talk" to the public either more often, or less often but with more precision.

Interest has turned towards the question of how markets and the public should interpret signals emanating from central banks and central bankers. For example, Cukierman and Meltzer (1986) formulated a theory of ambiguity, which explains how central banks can exploit the output–inflation trade-off. Crawford and Sobel (1982) introduced the concept of cheap talk to illustrate how signals can be used or misused to achieve a certain objective in the

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7. In the sense that shocks arising from such markets are accommodated unless it is felt that there are permanent inflationary consequences. In inflation-targeting countries, this shows up in the focus on inflation performance net of certain caveats as an indicator of policy success. These caveats include indirect taxes, food, and energy price shocks. In the Canadian context, however, commodity prices have, at times, been carefully monitored as a source of change in the exchange rate. See, for example, Bank of Canada (1998a).

8. There is an implicit presumption here that volatility somehow has a negative connotation for economic performance. There is a large body of literature, for example, on the connection between inflation levels and inflation volatility, but the economic significance of that link is debatable for the industrial countries. Similarly, there is a debate about the consequences of exchange rate volatility. Central bankers have, at various times, drawn attention to the need to moderate volatility in financial markets even if research has not yet conclusively demonstrated a negative link between volatility and real economic outcomes.

9. Christoffersen and Diebold (1997) suggest, however, that volatility cannot be forecast beyond very short horizons, and so may not be as important in risk management as previously thought.

presence of asymmetric information.[10] This concept has been used to explain central bank behaviour and has been proposed as a justification for central bank secrecy (Stein 1989). Garfinkel and Oh (1995) suggest a different form of ambiguity in central bank announcements; monetary authorities can send “noisy” signals that can reveal private information they have, sometimes to relieve a credibility problem. Garfinkel and Oh’s approach implies that the central banks that speak more precisely are the ones less likely to speak at all. The “cheapness” of central bank talk is therefore a function of how precise it is. However, the authors provide no definition or examples of precision in central bank announcements. Nevertheless, they imply that there is a trade-off between central bank credibility and flexibility in the implementation of monetary policy.

A trade-off also arises when a central bank’s strategy is state-contingent. Under this pragmatic policy, the central bank is prepared to deviate from some target, if necessary. However, if the monetary authorities are not permitted to explain their reasons for such a departure, such as a fundamental change in the underlying state of the economy, pragmatism can lead to a loss of credibility.

Many central banks in the industrialized world have attempted to increase credibility by adopting measures intended to persuade financial markets and the public that their operations are more autonomous from political influences, more transparent, and more accountable. The prime example is inflation targets. Other central banks that appear equally successful, based on inflation performance, have opted not to follow this route. Part of the reason may be that these central banks did not feel the need to enhance their credibility, having already established a sufficiently good reputation for good monetary policy-making. These central banks could also be viewed as speaking infrequently without implying anything about the degree of precision with which they convey monetary policy signals. Instead, some central banks need not practise much, if any, cheap talk because economic agents are not predisposed to be skeptical of the motives or conduct of the monetary policy authorities. Assuming credible inflation targets and a reasonable amount of transparency and accountability, does cheap talk have any role to play in monetary policy-making? It does, if the purpose of central bank announcements is to communicate frequently, as opposed to more precisely, to the public the consistency with which the central bank aims to achieve its stated policy objectives.

Alternatively, does cheap talk, regardless of its form, improve or worsen the public’s perceptions about the stability of the financial system?

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10. Farrell and Rubin (1996, 103) define the term to mean “costless, non-binding, non-verifiable messages that may affect the listener’s beliefs.”

The arguments that follow suggest that institutional "fixes," such as inflation targets, monetary policy or inflation reports, and other such signals, are not sufficient to solve a central bank's credibility problem. Instead, central banks need to convince the public that adopting such "rules" goes hand in hand with an ability to communicate greater certainty about the central bank's understanding of the true state of the economy.

2.2 Implications for monetary policy

One difficulty facing central banks is that no matter how clear their objective (e.g., a specific inflation target), they worry that, by not reacting more frequently, financial markets may lose some faith in how well they conduct monetary policy. The likeliest source for this conflict is the greater availability, usage, and perhaps reliance on high-frequency data by financial markets and the public. Alternatively, financial markets, if they are bound by fixed trading rules,[11] look to the central bank, either for reassurance that the previous rules have been adhered to, or for signals that they should revise their interpretation of the current monetary policy. If actions do speak louder than words, then there are, on balance, more pitfalls than opportunities when central banks react frequently, unless they are trying to reduce uncertainty about the state of the economy.

Another difficulty for central banks arises when they try to set more-precise monetary policy objectives. They must watch some macroeconomic variables that change relatively slowly, or for which signals are transmitted to the markets and the public relatively infrequently. As Rich (1997) notes, there is a "fast" channel through which monetary policy affects domestic inflation (i.e., via the exchange rate) and a "slow" channel (i.e., via the long and variable monetary policy lags notion associated with Milton Friedman). The former may necessitate more-frequent central bank responses, while the latter calls for cautious and measured responses.[12]

These considerations might call into question the benefits of setting precise goals when frequent "noisy" information constantly pressures central banks to act in a way that may compromise the achievement of their stated objectives, or reduce their public credibility. So, central banks must weigh the consequences of fostering the perception that they act or react

11. There is considerable evidence that this is true in most financial markets. See Neely and Weller (1997), Neely (1997), and references within.

12. Rich (1997) describes the introduction by the Swiss National Bank of a "medium-term" strategy for money-base growth, allowing that the strategy was not well understood at first but gained credibility later. Precisely how credibility was lost and then regained is, however, left unexplained. Did it reduce inflation-forecast errors? Was the volatility of exchange rate changes reduced?

more frequently because of high-frequency data against the costs of having financial markets and the public misinterpret their intentions. This might have negative implications for the successful conduct of monetary policy—as if we did not have enough trade-offs to worry about. It is important to understand that, even if the signals from central banks are "precise," there may still be negative consequences from trying to interpret or act more often because of high-frequency data. One reason is the assumption that high-frequency data contain "useful" information that has a bearing on the conduct of monetary policy. However, if there is considerable uncertainty in the marketplace about the content of high-frequency data, then no concerted effort at making precise announcements will suffice.[13]

Hence, if more-frequent responses because of high-frequency data are viewed as signalling increased uncertainty within central banks about the true state of the economy, such behaviour will likely make financial markets and the public more uncertain. It is therefore imperative that, in a world of high-frequency data, central banks signal greater certainty about their own knowledge of the state of the economy, especially since their goals are measured only infrequently. I will now discuss whether some of the recent developments in the conduct of monetary policy accomplish this objective.[14]

2.3 Signalling implications

If there are relatively few empirical regularities or stylized facts at high frequencies, more-frequent signalling by a central bank can damage the credibility of monetary policy, not only because of the potential noise or ambiguity in the signals themselves but also because of the uncertainty about whether current shocks are seen as permanent or temporary. A central bank may respond to the greater emphasis on monetary policy transparency and accountability by signalling too often or prematurely rather than more

13. "Information content" is usually assessed via some form of time-series analysis. Granger (1997) describes time-series analysis as being in a "confused" state because of the sheer number of different models that purport to specify the conditional mean or variance of time series.

14. Caplin and Leahy (1996) also begin with the notion of policy uncertainty. They argue that, as a result, policy actions should be "aggressive" if they are to generate the correct public reaction. Hence, gradualism is to be avoided in implementing monetary policies. Balvers and Cosimano (1994) point out, however, that there are costs associated with the volatility of economic outcomes. In their view, gradualism is to be preferred, because it helps the public learn about the monetary policy-making process. However, Caplin and Leahy (1996) were not concerned with perceptions about whether central banks are short-sighted. The uncertainty referred to here is of a different kind; it relates to what frequent "news events" signal about the true state of the economy when they occur at time intervals far smaller than the time interval used to evaluate success or failure of monetary policies as measured by conventional monetary aggregates.

precisely. In a world of high-frequency data, credibility is not just a function of the precision of monetary policy objectives; it is also determined by the information content of the devices the central bank uses to signal its intentions. The point is that observing data at higher frequencies does not mean that more information about monetary conditions can be extracted.[15] The Asian crisis of 1997, the Mexican crisis of 1994–95, or the 1987 stock market crash are one-time events; it does not matter how myopic the central bank is, unless all such crises have common features.[16] Unfortunately, the literature on currency crises, despite valiant attempts at locating common elements, is without consensus (Kaminsky, Lizondo, and Reinhart 1997; Kamin and Wood 1997; and Sachs, Tornell, and Velasco 1996).[17]

Even if the central bank has a clear set of signals to buttress its credibility, the markets, the public, or rather the media may exaggerate the significance of some event in a manner that could not have been anticipated.[18] Under these circumstances, it is probably best if central banks err on the side of caution in monetary policy activism.[19]

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15. Söderlind and Svensson (1997, 383) assume that high-frequency data "embody more accurate and up-to-date macroeconomic data … than is directly available to policy-makers." But they provide no empirical evidence to substantiate their view.

16. We know even less about predictability in how crises are transmitted across countries (Eichengreen, Rose, and Wyplosz 1996).

17. In an unpublished appendix, I illustrate how assumptions about signalling costs and credibility can explain the failure of institutional devices, such as granting more autonomy to the central bank, to translate into lower inflation. Credibility is defined as some aggregation of four factors: autonomy, transparency, accountability, and past policy successes. These signals may not convey meaningful information about the central bank's knowledge about the true state of the economy.

18. Alan Greenspan apparently confided to Louis Rukeyser that media coverage of the Fed regularly surprised him, as he never knew when a reporter would overreact to even the most routine statements. See *Louis Rukeyser's Wall Street* (January 1998). Perhaps the explanation has to do with the media's hunger for anything that approaches what appears to represent a "defining moment" for markets. See "From O.J. to Diana's Death, Impact is Often Exaggerated," *Wall Street Journal Interactive* 19 September 1997. Alternatively, the frequency of "news" events is influenced by the media's desire to convey a sense of being on the verge of "momentous change," regardless of whether this is true or not. See Clyde Haberman, "The Brink Isn't What It Once Was," *New York Times Week in Review* 19 April 1998, 5.

19. In reminiscing about his experiences in the U.S. government and at the Fed, Alan Blinder suggests that central banks need to be far-sighted to counter the tendency of politicians to be short-sighted. "Good policy decisions require patience and a long time horizon." (Blinder 1998, 118).

2.4 In the words of central bankers

As noted earlier, one of the signals available to central bankers is cheap talk or "moral suasion." The Asian crisis of 1997 illustrates both the opportunities and dangers of central bank myopia. Consider these statements by the Governor of the Bank of Canada and the Chairman of the Federal Reserve Board. "Let me reiterate that, in view of the uncertainties involved, it is difficult at this time to make precise assessments of the likely effects of the Asian crisis on the Canadian economy" (Thiessen 1998). "I do not believe we are as yet sufficiently knowledgeable of the full complex dynamics of our increasingly developing high-tech financial system" (Greenspan 1998).

Despite these statements, the same central bankers were at pains to point out that they understood the "critical mass of vulnerabilities" the Asian countries in particular were faced with, but that the "combination was not generally recognized as critical" nor were the implications for industrial countries well understood. These comments[20] suggest that some central bankers at least believe that myopia can itself trigger a crisis precisely because there are too many variables that can, in hindsight, explain such singular events. Some central bankers are concerned that a signalling function, in the form of speeches or other devices (see Section 3.4), that may appear to be myopic can produce unwanted consequences (Reserve Bank of New Zealand 1997).[21] For example, the frequency of "important articles and speeches by central bankers" has declined over the last few years, according to the Bank for International Settlements (see Section 3 for an important qualification on the data). Other examples are relying on changes in overnight interest rate bands to send a clear message about monetary policy intentions, and using the monetary conditions index (MCI) to signal the current stance of monetary policy.

Only one person suggested that the most recent crisis originated because central banks did not have sufficiently high-frequency data. The President of the Bundesbank suggested that monthly data on the size and maturity of foreign currency borrowing would be helpful (Chote and Münchau 1998).[22]

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20. Speeches by such diverse personalities as the Chief Executive of the Hong Kong Monetary Institute (Yam 1997), and the Governor of the Reserve Bank of Australia (MacFarlane 1997) reinforce this view.

21. Interestingly, this comment arose from a proposal to target the overnight interbank interest rate. The Reserve Bank of New Zealand instead chose to retain the technique of targeting settlement cash balances.

22. The Bank for International Settlements (BIS) releases information semi-annually in a publication entitled "The Maturity, Sectoral and Nationality Distribution of International Lending."

2.5 Signalling monetary conditions

Several central banks have begun reporting an MCI. Even, some private economic research firms construct such indexes and report on their development (e.g., J.P. Morgan's *World Financial Markets*). The advent of the MCI also illustrates the potential and pitfalls of indexes that can be computed at very high frequencies and based on different underlying assumptions. The danger is that such a signalling device can lead to myopic or tunnel-vision-like behaviour on the part of a central bank, especially if there is uncertainty about whether day-to-day fluctuations signal temporary or long-term changes in monetary conditions. Central banks may (see the Bank of Canada's *Monetary Policy Reports*) take pains to point out that the MCI should be used with care or supplemented with other information to determine whether some kind of intervention is necessary. However, the markets and the public may presume that central banks now have at their disposal a new tool that enables them to extract useful economic information at high frequency. But, if misused or misinterpreted, the same signal can easily heighten uncertainty about the circumstances under which the central bank will or will not respond to movement in the MCI.

Examples from New Zealand and Canada help underscore the point. By 1995, the Reserve Bank of New Zealand (RBNZ) began to focus more of its public statements on overall monetary conditions—namely, exchange rate and interest rate changes. But on at least one occasion that year, there was confusion in financial markets about whether the RBNZ was satisfied with monetary conditions, given a significant depreciation of the New Zealand dollar.[23] The market for a time believed that the RBNZ was signalling a fall in future inflation, thereby raising expectations of an easing of monetary conditions. In fact, this is not what the Bank intended. The RBNZ's attempt not to be myopic confused the private sector, which was focused on exchange rate developments (RBNZ 1995). In Canada, the recent depreciation of the Canadian dollar has produced similar tensions, and accusations that the central bank is myopic (Robson 1998). The Bank of Canada, meanwhile, has argued that monetary conditions warranted recent increases in the interest rate (Bank of Canada 1998b). While the Bank of Canada, for example, has made it clear that it does not "try to maintain a precise MCI level by adjusting interest rates in response to every exchange rate wiggle" (Bank of Canada 1995, 14), it has left that impression among some analysts (e.g., Little 1998; Robson 1998). As well, there has been confusion about the direction the MCI provides for monetary policy actions,

23. Part of the problem is that the RBNZ announces desired levels for the MCI every three months, while the actual MCI can change significantly in the intervening period. The Bank of Canada does not announce desired MCI levels.

as one of my discussants, Lloyd Atkinson, points out (see also Stinson 1998).[24]

Another form of high-frequency signalling used in Canada and elsewhere is to target the overnight market (e.g., Lundrigan and Toll 1998). Clearly, the signals this device provides offer a useful benchmark to indicate interest rate intentions of the central bank. But its availability at high frequency also provides an opportunity to create unintentional regularities in the spread between the overnight rate and other rates where none existed before. If this is the case, signals about monetary conditions, instead of being clearer and more transparent, can in fact become more opaque.[25] Again, empirical illustrations are provided in the following section.

3 What, If Any, Empirical Regularities Exist in High-Frequency Data?

3.1 The message in the daily data

Table 1 provides a crude indicator of the danger signals inherent in five high-frequency time series for the G-7 countries.[26] Daily observations since 1979 for the rate of change in the exchange rate, the MCI, a proxy for the change in long-term and short-term interest rates, as well as stock market returns, exceeding three standard deviations from the mean are interpreted as being extreme observations and could serve as crisis indicators.[27] The number of outliers in the exchange rate is similar across the countries

24. Figures in an unpublished appendix show that the bulk of the variation in the MCI since 1994 has been in the exchange rate and not in interest rates but that, over a long period such as three months, there is a clear connection between the two variables that make up the index.

25. Balduzzi, Bertola, Foresi, and Kapper (1998) present empirical evidence for the United States that the volatility and persistence of the spread between the federal funds rate (FFR) and its target are an increasing function of the term to maturity. Thus, for example, the overnight spread is not autocorrelated, but there is significant autocorrelation at longer maturities. Moreover, while the persistence of the overnight spread of the FFR from its target has been reduced under the targeting regime, it is not at all clear that the outcome has translated into a clearer signal of Fed intentions, based on spreads at the longer end of the term structure.

26. A data appendix provides additional details about the data and the transformations used to interpret the results. Notes to the tables also provide pertinent information.

27. Balke and Fomby (1994) use a similar approach to identify "large" versus "small" shocks, and find evidence that large shocks are typical of U.S. macroeconomic time series. They rely, however, on data at lower sampling frequency (monthly and quarterly). Tsay (1988) suggests that one should estimate an ARMA(p,d,q) model prior to applying the three-standard-deviation rule. Otherwise, spurious shifts might be identified. The series in Table 1 are all ARMA(0,1,0). Estimates of various ARMA(p,q) models applied to the series did not, however, significantly alter the conclusions.

Table 1

Outlier Analysis of Key Financial Time Series, 1979 to 1997

Sample: 1979–1997	**Series and frequency of days deviations exceed three standard deviations from the mean (percentage of sample)**				
Country	**Exchange rate**	**Monetary conditions index**	**Long-term interest rate**	**Short-term interest rate**	**Stock returns**
Canada	61 (1.24)	0	8 (.16)	69 (1.40)	24 (1.16)
Germany	57 (1.16)	6 (.12)	47 (.95)	63 (1.28)	21 (1.02)
France	57 (1.16)	80 (1.62)	20 (.40)	0	na
Italy	55 (1.11)	6 (.12)	27 (.55)	84 (1.70)	na
Japan	63 (1.28)	28 (.57)	32 (.65)	87 (1.76)	22 (1.07)
United Kingdom	53 (1.08)	0	90 (1.83)	105 (2.13)	22 (1.07)
United States	na	16 (.32)	23 (.47)	104 (2.12)	27 (1.31)

Note: Data are at the daily frequency. Details about the construction of some series are contained in a separate appendix. All series are in first differences of the logarithm of the levels, except for interest rates, which are differences of the levels.

sampled, but the largest number of outliers is usually found in short-term interest rates, and the fewest are generally found in stock returns. There are, however, large differences in the number of danger signals when looking at either the MCI or long-term interest rates. Indeed, with the exception of France, the frequency of outliers is generally significantly lower in the MCI than in either of its constituent parts. Hence, zeroing in on the performance of the MCI can be a form of short-sightedness if underlying danger signals are attenuated. Alternatively, the MCI could be viewed as a useful means of preventing myopic behaviour if, by construction, the MCI retains only the most important sources of danger.

Table 2 presents evidence of how often danger signals in the exchange rate and the short-term interest rate are common for values of the time series two or more standard deviations away from the mean.[28] Shown in parentheses are the dates when the various outliers occurred simultaneously. For example, in the case of Canada, the 1980 Quebec Referendum, not surprisingly, stands out. Indeed, in many of the countries

28. A difficulty arises if there are significant changes in the mean of the time series under investigation. While such shifts cannot be ruled out entirely, selecting the appropriate subsamples is far from a simple matter.

Table 2

How Common are “Danger” Signals in Financial Asset Prices? (1979 to 1997)

	Frequency and dating of common deviations from the mean in the exchange rate and the short-term interest rate (daily data)		
Countries	**More than 4 SD**	**More than 3 SD but less than 4 SD**	**More than 2 SD but less than 3 SD**
Canada	1: (21/5/80)	1: (27/10/92)	5: (16/12/80, 19/12/80, 3/8/81, 9/8/82, 22/4/87)
Germany	3: (9/4/80, 20/2/81, 14/9/92)	2: (5/10/81, 28/12/81)	8: (17/3/80, 28/1/81, 17/2/81, 4/3/81, 19/4/81, 24/6/88, 18/1/89, 22/10/93
France	0	0	0
Italy	1: (14/9/92)	0	3: (25/8/81, 25/1/83, 20/7/92)
Japan	0	1: (30/12/80)	6: (13/7/79, 18/7/79, 29/2/80, 2/4/80, 23/7/80)
New Zealand	0	0	0
United Kingdom	4: (31/7/79, 21/3/85, 16/9/92, 16/10/92)	2: (15/9/81, 27/10/89)	4: (15/11/79, 11/3/85, 11/4/88, 3/1/92)
Country pairs		**Common cross-country deviations in the monetary conditions index**	
United States–Canada	0	0	30: (7/81 to 9/81)
United States–Australia	0	0	0
United States–New Zealand	0	0	0
Germany–France	0	0	62
Germany–Italy	0	6: (25 to 27/2/81, 3 to 6/3/81)	151
Germany–United Kingdom	0	0	0

(continued)

Table 2 (cont'd)

How Common are "Danger" Signals in Financial Asset Prices? (1979 to 1997)

Countries	**Frequency and dating of common deviations from the mean in the exchange rate and the short-term interest rate (daily data)**		
	More than 4 SD	**More than 3 SD but less than 4 SD**	**More than 2 SD but less than 3 SD**
Country pairs	**Common cross-country deviations in the short-term interest rate**		
United States–Canada	8: (7/5/80, 21/5/80, 22/12/80, 8/1/81, 22/1/81, 14/12/81, 15/12/81, 18/8/82)	4: (17/3/80, 4/12/80, 6/1/81, 21/1/81)	11
United States–Australia	0	0	0
United States–New Zealand	0	0	0
Germany–France	0	0	0
Germany–Italy	3: (24/7/80, 6/10/81, 14/9/92)	0	13
Germany–United Kingdom	0	0	14

Note: All variables are in first log differences except for the interest rate, which is in first differences. Details of the construction of the MCI are described in the data appendix. Where there were too many dates, only the number of common dates is shown. Sample is the same as shown in Table 1. Dates in d/m/y format are given in parenthesis.
SD = standard deviation.

sampled, many of the outliers take place early in the sample.[29] The results suggest that events that occur extremely infrequently or are clustered in time are not conducive to prediction, and should deter short-sighted behaviour on the part of monetary authorities.

Table 2 also asks whether and how often outliers in the change in the MCI are common across the G-7, as a rough indicator of contagion. Such common shocks are relatively rare, especially if danger signals are defined by the three-standard-deviation rule. Not surprisingly, they occur far more often between key European countries such as France and Germany, but only if the two-standard-deviations threshold is used.

Finally, the table examines how common large shocks are between countries, as measured by the short-term interest rate. As with the exchange rate, there is a clustering of outliers in the early portion of the sample while,

29. This may partly reflect failure to account for a changing mean although this problem need not permeate all of the series considered. Allowance for alternative definitions of what constitutes an outlier also helps mitigate the problem.

as with some European countries, the large shocks occurred at the time of the last European Monetary System crisis in September 1992.[30]

We can also obtain some insights into the potential for short-sighted central bank behaviour by examining the autocorrelation in deviations of the short and long rates from the overnight target in daily data from 12 April 1994 to 14 November 1997 (data not shown). There is some significant short-run persistence in the overnight–target differential, lasting up to three days, as well as possible longer-run persistence (e.g., at lags of 20, 25, 30, and 35). However, there is virtually no correlation between the overnight–target spread and the long-rate–target spread. As in the U.S. experience, this calls into question the signalling property of the overnight market about the overall stance of monetary policy.[31]

Table 3 attempts to more systematically identify the "sources" of crises at high frequencies by estimating the "probability" of a crisis. The dependent variable is the series of outliers reported in Table 1.[32] It is treated as being censored, because we observe only "crises" that have taken place. Moreover, the chosen crisis indicator is, by necessity, imperfect. The vector of explanatory variables includes the following: news events, stock market returns, the rate of change in the exchange rate, the slope of the yield curve, and, where relevant, a dummy variable for the period when inflation is formally targeted. Evidence is presented only for Canada, Germany, and the United Kingdom, as the estimates seem to be representative of the G-7 experience. Separate estimates are presented as a function of the horizon over which some of the independent variables (such as stock returns, exchange rate fluctuations, and the yield curve) are evaluated. Thus, what is of interest is whether the likelihood of a crisis is influenced by, say, stock returns when these are estimated over intervals of a day, three months, or one year. The news events are classified according to whether the news is "good" or "bad." Good news is expected to reduce the probability of a crisis, while the latter obviously carries the opposite expectation. The news variables take on values of +1 or –1 depending on the nature of the event.

30. A different perspective on the issue can be gained by examining selected simple correlation coefficients between the outliers, again defined as three standard deviations or more in the rate of change in the exchange rate (not shown). Not surprisingly, the correlations are highest between the countries with linked exchange rates (i.e., the European Monetary System countries), or geographical proximity. There is, however, little evidence from this analysis that "contagion" effects are more easily extracted from the analysis of high-frequency data than at lower-frequency data.

31. One must be cautious about inferences based on simple correlations because the time series properties of the various spreads, while broadly stationary, reveal persistent "swings" over the sample considered.

32. Unlike Table 1, however, a two-standard-deviation threshold was used.

Table 3

The Determinants of a Financial “Crisis,” 1979 to 1997

	Dependent variable: “danger signal” in the short-term interest rate								
	Canada			Germany			United Kingdom		
	Horizon			Horizon			Horizon		
Independent variables	**1-day**	**3-month**	**1-year**	**1-day**	**3-month**	**1-year**	**1-day**	**3-month**	**1-year**
Domestic “bad” news	.36	.12	.22	–.62	.68	–.58	–2.66	–2.23	–1.90
	(.54)	(.53)	(.53)	(.49)	(.49)	(.49)	(.75)+	(.77)+	(.74)+
Domestic “good” news	.50	.41	.32	.60	.69	.62	1.34	1.15	1.48
	(.29)@	(.30)	(.29)	(.40)	(.39)@	(.39)	(.55)*	(.55)*	(.53)+
Stock return	.07	–.07	–.04	.20	.22	.19	–.03	.02	–.06
	(.16)	(.02)+	(.01)+	(.12)	(.12)@	(.12)	(.19)	(.03)	(.02)+
Exchange rate	.45	.21	.20	–.40	.08	.18	–.03	–.02	–.001
	(.33)	(.05)+	(.03)	(.39)	(.16)	(.09)*	(.05)	(.05)	(.04)
IT dummy	–.08	–1.08	–1.24	na	na	na	3.33	3.14	3.21
	(.53)	(.56)+	(.57)*				(.88)+	(.89)+	(.89)+
Domestic–international	.40	.21	.05	.22	.25	.21	1.12	1.09	.98
interest rate differential	(.06)+	(.06)+	(.08)	(.05)+	(.05)+	(.05)+	(.22)+	(.22)+	(.22)+
Constant	–3.23	–2.00	–1.75	50.43	–15.64	–28.21	–15.04	–13.42	–10.33
	(.59)+	(.60)	(.54)	(54.08)	(22.59)	(11.8)*	(5.13)+	(4.60)+	(3.97)+
No. Left censored	1,539	1,440	1,439	1,554	1,545	1,538	1,596	1,488	1,488
No. Uncensored	199	184	185	96	97	100	60	60	62

Note: Sample is the same as in Table 1. Horizon refers to the period over which rates of change are calculated. For example, at the 1-day horizon, the daily rate of change in stock prices appears as an independent variable; at the 1-year horizon it is the annual rate of change in stock prices which is used. The same procedure is used to evaluate the rate of change in the exchange rate. The dependent variable is equal to 1 if the demeaned change in the short-term interest rate (three-month maturity) exceeds 3 standard deviations. Otherwise the dependent variable is set to zero. The Tobit estimation procedure was used to obtain coefficient estimates. Standard errors in parenthesis.

@ signifies statistical significance at the 10-per-cent, * 5 per cent, and + at the 1 per cent level.

The IT dummy is equal to 1 when inflation is targeted in the relevant countries and 0 otherwise.

The domestic–international interest rates differential is for short-term interest rates. News events dummies are active on the day of the event and five days following the event.

na = not applicable.

News is defined as an event thought to have the potential to influence interest rates or exchange rates (see Robinson and Siklos 1998 for details).

As for the results, with the exception of the yield curve, few variables can significantly explain the probability of a crisis. In every case, a rise in the term spread raises the likelihood of a crisis.[33] The domestic–international interest rate differential seems to provide some useful high-frequency information, whereas variations in other asset markets do not.[34] At longer horizons, however, rising stock market returns significantly reduce the likelihood of a crisis, except in Germany. A change in the rate of depreciation of the exchange rate increases the probability of a large shock in the short-term interest rate.

News events also affect the probability of a crisis. For U.K. data, “bad” news raises the probability of a crisis at all horizons. For Canada and Germany, only “good” news has a significant effect, although the sign is counter-intuitive, an indication perhaps of the difficulty in effectively distinguishing between good and bad news events, or in interpreting how day-to-day events might influence the onset of a crisis.[35] Thus, it appears difficult to uncover a set of “stylized” facts based on high-frequency data.[36]

A different perspective on the information content of high-frequency data or the potential for central bank myopia can be gleaned from the determinants on short-term interest rate changes. Presumably, the direction of change can be influenced by central bank policies. Table 4 presents evidence based on a simple model of interest rate determination of the form:

$$\Delta R_t = X_t \beta + \eta \ IT_t + \in_t \tag{7}$$

$$\sigma_t^2 = \kappa + \Sigma_{i=1}^{q} \alpha_i \in_{t-1}^2 + \Sigma_{j=1}^{p} \zeta \sigma_{t-j}^2 + Z_t \Pi . \tag{8}$$

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33. The coefficients do not have the usual interpretation as in a conventional regression, that is, they do not represent the marginal effect of a change in the regressor on the dependent variable.

34. The situation is somewhat different if we truncate the sample so that, for example, the dependent variable is observed only when it exceeds a threshold. The yield curve is then almost never a statistically significant variable in the regression. Indeed, regardless of the length of the horizon over which asset prices are calculated, very few of the explanatory variables explain the likelihood of a crisis.

35. When good and bad news events were combined, these were found generally to have an insignificant effect. Also, when the sample was truncated in the manner described in the previous note, news events also became generally insignificant.

36. Essentially, the same conclusion was reached when outliers in exchange rate fluctuations were used to proxy the likelihood of a crisis.

Equations (7) and (8) represent a GARCH(*p*,*q*) model in which the conditional variance of a time series is modelled explicitly.[37] The vector X_t consists of the domestic–U.S. short-term interest rate differential and the rate of change in the exchange rate, while *IT* is a dummy variable, used where applicable, to identify the period of formal inflation targeting. The variance equation (8) assumes that lagged volatility, estimated from (7), lagged forecast variances, and exogenous regressors (Z_t),[38] explain the conditional variance σ^2. To capture the flavour of "meteor shower" effects, I added separate dummies for good and bad domestic news. Potential "heat waves" are captured by adding the good and bad U.S. news dummies.[39] GARCH models of up to order 3 were estimated prior to arriving at the most parsimonious specifications presented in Table 4. Daily data since 1979 for the G-7 except Japan[40] were used, the specifications were estimated using maximum likelihood, and the significance of the coefficients was based on the estimation of robust standard errors.[41]

The results reveal that "heat waves" dominate the conditional variance of short-term interest rates for Canada and the United Kingdom while meteor showers can be used to explain U.S. data. For France and Germany, there is evidence of both meteor-shower- and heat-wave-type influences, while in Italy no news effects significantly influence the conditional variance of short-term interest rate changes. Examining estimates of the conditional mean, we find that interest rate changes have, on average, been higher in inflation-targeting countries. The inflation-targeting countries in our sample include: Canada, Sweden, New Zealand, the United Kingdom, and Australia. These results could be sample-specific or reflect

37. Balke and Fomby (1994) note that there is less evidence of GARCH effects when "outliers" are omitted. I also found this to be the case in the present data set. But this presumes that such outliers are a "nuisance" which, of course, need not be the case. Whether they are is something central bankers are keenly interested in.

38. For U.S. data, $Z_t = 0$, and a proxy for "world" news is used in the place of U.S. news.

39. Technically, the terms "meteor showers" and "heat waves" refer to *intra*-daily effects, but data limitations prevented me from conducting the relevant estimation. In addition, I considered a specification in which the news variables enter (equation 9) but found the coefficients to be highly insignificant in all cases considered. These results parallel those of Hogan and Melvin (1994), who perform a similar test but examine the behaviour of exchange rates and consider only the announcement effects of the U.S. trade balance, not news more generally.

40. I was unable to include a news series for Japan.

41. Dummies to capture the effects of holidays and weekends were also added, but these too were usually found to be insignificant and were dropped from the final specification. Andersen and Bollerslev (1998) argue that ignoring news or announcement effects imparts more bias in explaining excess volatility in asset markets such as foreign exchange.

Table 4

News and the Volatility of Short-Term Interest Rate Changes, 1979 to 1997

Independent variables	Dependent variable: change in short-term interest rate (daily data)					
Mean equation	**Canada**	**France**	**Germany**	**Italy**	**U.K.**	**U.S.**
IT dummy	.07 (.03)	na	na	na	.015 (.008)$^{@}$	na
Domestic–international interest rate differential	.0002 (.001)	–.0007 (.0007)	–.0007 (.0004)$^{@}$	.002 (.001)	–.0009 (.001)	na
Exchange rate	.08 (.02)	.006 (.003)$^{@}$	.007 (.002)$^{+}$	–.0004 (.005)	.01 (.003)*	na
Constant	–.08 (.03)	–.0003 (.001)	–.003 (.001)*	–.015 (.005)$^{+}$	–.013 (.009)	–.001 (.0006)*
Variance equation						
Constant	.0003 (.0001)	.003 (.004)$^{+}$	.003 (.00001)$^{+}$	.0006 (.0003)*	.00001 (.00004)	.0001 (.00004)$^{+}$
$\in_{t-1}2$	.35 (.09)$^{+}$	.167 (.05)$^{+}$	.095 (.02)$^{+}$	.128 (.03)$^{+}$	.218 (.059)*	.134 (.02)$^{+}$
$\in_{t-1}2$	–.26 (.08)$^{+}$	.156 (.045)$^{+}$	–	–	.213 (.059)*	–
$\sigma_{t-1}2$	.89 (.03)$^{+}$	–.149 (.023)$^{+}$	.807 (.031)$^{+}$	.195 (.139)	.028 (.343)	.816 (.029)*
$\sigma_{t-1}2$	–	.696 (.041)$^{+}$	–	.653 (.141)$^{+}$	.594 (.279)*	–

(continued)

Table 4 (cont'd)

News and the Volatility of Short-term Interest Rate Changes, 1979 to 1997

Independent variables	Dependent variable: change in short-term interest rate (daily data)					
Mean equation	**Canada**	**France**	**Germany**	**Italy**	**U.K.**	**U.S.**
Domestic "bad" news	−.0002 (.0005)	−.017 (.004)$^{+}$	.0002 (.00001)$^{+}$	−.003 (.002)	−.001 (.001)	−.0002 (.00001)$^{+}$
Domestic "good" news	−.0001 (.0003)	.001 (.0007)*	.0005 (.0003)$^{@}$	.0008 (.001)	.0005 (.0006)	−.0002 (.00004)$^{+}$
U.S. "bad" news	−.0005 (.0003)$^{@}$	.002 (.0008)*	−.0001 (.00001)$^{+}$	−.00001 (.0007)	−.0006 (.0003)*	−.00006 (.00008)
U.S. "good" news	-.0004 (.0002)$^{@}$	.002 (.0007)*	−.0003 (.00001)$^{+}$	−.0007 (.0008)	−.00003 (.0001)	−.00003 (.00006)

Note: Sample is the same as in Table 1. See Table 6 for variable definitions.
Equations were estimated via maximum likelihood. Bollerslev-Wooldridge robust standard errors are in parenthesis.
The terms $\in$ and σ are defined in the text in equations (7 and 8).
Significance levels (@, *, +) are as in Table 3.
na = not applicable.

the transitional phase of inflation-targeting policies. Generally, exchange-rate depreciation raises interest rates in all countries except Italy. However, a steeper yield curve is not found to generate positive short-term interest rate changes, except in Germany, and possibly Italy. If news events increase the conditional volatility of interest rate changes in the manner described, then contagion effects are clearly possible. However, the measurable contagion effects originate from the United States, not from the rest of the world. A specification that also contains "world news," meant to capture news events that might have an impact on all countries simultaneously, was also considered and later discarded, as the variables proved to be highly insignificant. Hence, it is likely that contagion effects, other than the ones already mentioned, are difficult to quantify.[42] In Canada and France, the meteor-shower and heat-wave effects appear to offset each other, while in other countries, such as the United Kingdom, only "bad" news from the United States appears to contribute to conditional variance. There is certainly strong evidence that myopic behaviour that ignores the "virulence" of contagion effects can significantly influence domestic monetary policy. Perhaps the most important contribution of high-frequency data is the useful information these data contain about volatility in financial markets, an aspect of policy-making given little attention in a world where central bank credibility is usually evaluated on the basis on the performance of aggregates such as the CPI inflation rate.

3.2 Taking the "long view"

A possible counter-argument for being overly concerned with high-frequency events is that if inflation contains a substantial long memory component monetary policy reflects expectations that the central bank will not accommodate higher inflation—at least not for long. A statistical expression of that long view is the presumption that the time series of interest to central bankers contain a long-memory component. While evidence was cited above that many financial time series do in fact have such a property, an examination of daily exchange rate, interest rate, and stock price data for the G-7 does not overwhelmingly support this result (results

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42. Again, the absence of contagion effects, as in, say, the Mexican or Asian crises, might actually reflect myopic behaviour on the part of policy-makers who succeeded in neutralizing the possibility of a global crisis in spite of news. Even if we control for the sample selectivity bias referred to earlier, inferences from the estimated models are unaffected. It should also be added that inference about conditional variances may also be affected by how well the conditional mean equation is specified. Watt (1997) considers a variety of interest rate models and finds that interest rate levels significantly affect volatility. He also reports that it is difficult to find an empirically satisfactory model of short-term interest rate dynamics using Canadian data.

not shown).[43] One can certainly imagine that if central banks intervene to smooth high-frequency fluctuations in key financial time series (e.g., the overnight interest rate or the exchange rate) the noise component should be dominant, and any long-memory feature in the data would be difficult to extract. More interesting perhaps is whether inflation exhibits long-memory properties. Although some empirical evidence of this phenomenon exists (see Hassler and Wolters 1995; Gagnon 1996) based on long-horizon regressions, an alternative approach is to explore the long-memory property of inflation series by examining the autocorrelation function. Granger and Marmol (1997) show that long-memory processes have autocorrelations that decay at a rate proportional to $k^{-\alpha}$, where k represents the lag in the autocorrelation function. Indeed, they show that a useful device to detect long-memory properties in a time series is to examine the so-called log–log correlogram, which shows the relationship between $\log(\rho(k))$ and $\log(k)$. They use a regression of the form

$$\log(\rho(k)) = \mu + \alpha\log(k) + \tau_k, \tag{9}$$

where $\rho(k)$ is the autocorrelation of a time series at lag k. The coefficient α is expected to be negative. The smaller the value of α, in absolute value, the greater the long-memory component in the time series. Table 5 gives estimates of α for the full available sample shown, as well as for the period since 1991, when the central banks of the G-7 countries were more focused on inflation control, whether explicitly or not. While a relatively long span of data is required for a powerful test of the long-memory property, the results are nevertheless suggestive. For example, Germany's inflation rate shows the strongest indications of the long-memory property, but the estimate of α rises substantially after 1991, no doubt due in large part to the consequences of German monetary union. Italy's inflation rate has the smallest long-memory component, but the component noticeably improves in the 1990s. For Canada, the estimates hardly change at all, but the component is now ranked second in the 1990s, as opposed to fifth for the period since 1960. In general, inflation displays shorter memory in most of the G-7 countries since the beginning of the 1990s. To the extent that the

43. The absolute deviations from the mean in the returns of the assets in question tend to display a lack of autocorrelation save at lag 1. The autocorrelations in the demeaned absolute returns are greater than the demeaned autocorrelations in the squared returns, but the marginal distribution of the absolute demeaned returns are not exponential. If we measure the return on an asset at time t as $r_t = \log(P_t) - \log(P_{t-1})$, and the mean return as m, then the demeaned return is $r_t - m = \text{sign}(r_t - m)\ |r_t - m|$, where sign $r_t = 1$ if $r > 0$, $= 0$ if $r = 0$, and $= -1$ if $r < 0$. For example, in the case of exchange rates the distribution of rates of change tends to be excessively negatively skewed (i.e., less than the theoretically expected value of 2), and there is insufficient kurtosis (i.e., less than the theoretically expected value of 9) relative to the properties of a long memory process.

Table 5

Long Memory in Inflation, 1960 to 1996

Country	Full sample	Post-1991
	Monthly data	
Germany	−.02 (.19)	−.19 (.29)
Canada	−.31 (.21)	−.29 (.19)
France	−.34 (.20)	−.91 (.41)
Italy	−.76 (.31)	−.45 (.29)
Japan	−.23 (.14)	.06 (.24)
United Kingdom	−.24 (.14)	−.38 (.18)
United States	−.24 (.14)	−.42 (.23)

Note: Estimates of α as in equation (10) with standard errors in parenthesis. Monthly data is for annual inflation in the CPI for the sample 1960:01 to 1996:12, before differencing. Annual inflation is the log difference in the CPI (i.e., $\log P_t - \log P_{t-12}$).

change represents the adoption of a new monetary policy, the results imply that inflation is now more sensitive to temporary shocks, which is roughly consistent with a monetary regime that uses an inflation-control target range, whether implicit or explicit. Under such circumstances, monetary policy-making becomes more difficult, and one can therefore understand why financial markets search for clues in high-frequency data. However, it should be stressed that economists still have no adequate explanation for the long-memory component, especially in financial time series, and we know even less about distinguishing long- from short-memory components in time series such as inflation.

3.3 Short-sightedness and private sector inflation forecasts

One manifestation of central bank myopia occurs when the central bank misunderstands how the private sector forecasts key variables such as inflation. Croushore (1996) reports that private sector forecasts in the United States have improved over the last few years but that forecasters do not seem to take sufficient account of changes in monetary policy. Moreover, until the early 1990s, forecasters under-predicted inflation. The situation has improved substantially since then, no doubt because inflation is both lower and less volatile than in the 1980s.[44] After dismissing arguments such as poor forecasting ability, an economy too complex to model, and inability to extract available information, the gist of Croushore's explanation for private sector forecasting performance centres around the lack of "credibility" in monetary policy. If private sector forecasters are myopic, then the problem may not be whether the central bank is in danger of becoming short-sighted but how it communicates its knowledge of economic conditions. It is, therefore, of interest to determine what types of signals, whether from the market or the central bank, private-sector forecasters use to either revise their expectations or explain forecast errors.

Table 6 reports several regression results that ask how changes in private sector inflation forecasts respond to a variety of macroeconomic indicators, and whether forecast errors respond to essentially the same set of indicators. The data set consists of the "Monthly Poll of Forecasters" published each month in *The Economist* magazine since 1991. The regression results were pooled across time and across blocks of countries; hence, for example, Canadian forecasts were pooled with U.S. forecasts. In addition, because of the small number of observations in any given year, the forecasts were "stacked" year by year so that changes in inflation forecasts over the period 1991 to 1996, inclusive, were related to the time series of interest. The estimated regression is of the form

$$\Delta\pi^{f}_{it}\Big|_{m-1,\,t} = \mu_{it} + \zeta[X_{it}|I_{m-1}] + \lambda_{it} \tag{10}$$

$$[\pi^{f}_{it} - \pi_{it}]\Big|_{m-1,\,t} = \mu^{*}_{it} + \zeta[X_{it}|I_{m-1}] + \lambda^{*}_{it}, \tag{11}$$

where π^{f}_{it} represents the inflation forecast for country *i* for year *t*, and $[\pi^{f}_{it} - \pi_{it}]$ is the forecast error for country *i*, at time *t*. Each forecast is assumed to be conditional on information in the previous month (i.e., $m-1$). X is a vector of variables believed to influence either the actual forecast or the forecast error, μ can stand either for a common intercept or fixed effects—that is, separate forecast year and country effects in the intercept term, and λ is the residual. The vector of explanatory variables includes: last period's forecast or forecast error, to capture potential persistence in forecasting; the slope of the yield curve; the number of speeches by senior central bank officials (see Table 7); the change in the MCI; and stock market returns.

44. Siklos (1997a) shows that forecasters in inflation-targeting countries *over*-predicted inflation once the inflation control parameters were in place but that, subsequently, they began to under-predict inflation. Also, see Johnson (1998) in this connection.

Table 6

The Determinants of Private Sector Inflation Forecasts and Forecast Errors, 1991 to 1996

Independent variables	Dependent variables *Odd* columns: monthly change in inflation forecasts *Even* columns: inflation forecast errors (monthly data) Country blocks											
	(1) Canada–U.S.	**(2) Canada–U.S.**	**(3) Japan–U.S.**	**(4) Japan–U.S.**	**(5) Germany–U.S.**	**(6) Germany–U.S.**	**(7) Europe**	**(8) Europe**	**(9) IT countries**	**(10) IT countries**	**(11) IT countries**	**(12) IT countries**
Constant	–.03 (.02)	–.008 (.059)+	–.01 (.02)	–.06 (.06)	.025 (.02)	–.064 (.051)	–.029 (.014)*	.013 (.019)	**NZ:**.10, .10, –.02, –.08, –.16, –.08 **UK:** –.07, –.14, –.15, –.07, –.10 **CAN:** –.17, –.03, –.005, .02, –.09 **AUS:** –.09, –.09, –.12,. –.18, –.17	**UK:** –.32 .34, –.10, –.23 **CAN:** .94, –.48, –.31, –.23, –.42	.011 (.023)	–.20 (–.08)*

(continued)

Table 6 (cont'd)

The Determinants of Private Sector Inflation Forecasts and Forecast Errors, 1991 to 1996

Dependent variables
***Odd* columns: monthly change in inflation forecasts**
***Even* columns: inflation forecast errors**
(monthly data)

Country blocks

Independent variables	(1) Canada–U.S.	(2) Canada–U.S.	(3) Japan–U.S.	(4) Japan–U.S.	(5) Germany–U.S.	(6) Germany–U.S.	(7) Europe	(8) Europe	(9) IT countries	(10) IT countries	(11) IT countries	(12) IT countries
$\Delta\pi_{t-1}^{f}$ or	–.007	–.007	.018	.72	–.078	.91	.123	.98	–.06	.66	.013	.93
$(\pi-\pi^{f})_{t-1}$	(.09)	(.059)	(.09)	(.06)*	(.09)	(.05)*	(.059)*	(.009)*	(.06)	(.07)*	(.047)	(.03)*
Yield curve	–.006	.013	.0003	.01	–.012	.018	–.0001	.018	.01	.07	–.012	.043
	(.01)	(.010)	(.008)	(.03)	(.005)*	(.013)	(.005)	(.007)*	(.02)	(.05)	(.011)	(.027)
Speeches	.002	.006	–.003	.02	–.003	.003	.003	–.011	.003	–.009	–.008	.009
	(.003)	(.019)	(.003)	(.01)	(.0008)	(.007)	(.004)	(.004)*	(.009)	(.012)	(.007)	(.013)
"Bad" news	.006	.004	.0009	na	.001	–.011	–.002	–.0009	na	na	na	na
	(.005)	(.004)	(.0006)@		(.004)	(.011)	(.004)	(.006)				
"Good" news	.007	.002	na	na	.0006	–.002	.0004	–.01	na	na	na	na
	(.005)	(.015)			(.004)	(.011)	(.004)	(.005)				
Stock return	–.004	.004	na	.003	–.0008	–.0004	na	na	–.00001	–.0004	–.0003	.005
	(.001)	(.004)		(.002)@	(.0008)	(.002)			(.0006)	(.004)	(.005)	(.003)*
Monetary	–	–	–	–	–	–	–	–	.021	–.171	–.014	–.143
conditions index									(.030)	(.065)+	(.024)	(.056)+
Deviation	–	–	–	–	–	–	–	–	.007	–.298	.003	.093
from IT									(.026)+	(.085)+	(.011)	(.033)+

(continued)

Table 6 (cont'd)

The Determinants of Private Sector Inflation Forecasts and Forecast Errors, 1991 to 1996

Independent variables	Dependent variables *Odd* columns: monthly change in inflation forecasts *Even* columns: inflation forecast errors (monthly data) Country blocks											
	(1) Canada–U.S.	(2) Canada–U.S.	(3) Japan–U.S.	(4) Japan–U.S.	(5) Germany–U.S.	(6) Germany–U.S.	(7) Europe	(8) Europe	(9) IT countries	(10) IT countries	(11) IT countries	(12) IT countries
Φ'_m	–	–	–	–	–	–	–	–	–	–	–.36 (.154)	.745 (.438)@
R^2	.03	.70	.033	.59	.062	.80	.02	.97	.19	.88	.04	.83
F-statistic	.56 (.76)	40.2 (.00)	.98 (.42)	42.1 (.00)	1.17 (.33)	70.7 (.00)	1.10 (.36)	–	5.28 (.00)	42.5 (.00)	1.70 (.12)	–

Notes: Sample is 1991:01 to 1996:12 (monthly).

Common intercept assumed, except in columns (9) and (10).

Least-squares estimates except for column (8), which is estimated via the seemingly unrelated regression technique

@, *, and + refer to statistically significant coefficients at the 10-per-cent, 5-per-cent, and 1-per-cent levels, respectively.

Standard errors in parenthesis.

Speeches are the number of speeches by senior central bankers per month, as reported in the BIS *Review* and as defined in Table 7.

R^2 is the simple coefficient of determination for the odd columns and the adjusted R^2 for the even columns; *p*-value for *F*-statistic is given in parenthesis. All other variables defined in previous tables.

na = not applicable.

Deviation from IT is actual inflation less the mid-point of the specified target range.

– No coefficient was estimated for these variables.

The problem then is how to incorporate these missing information indicators, that is, information in daily data, at the monthly frequency.[45] Two proxies are considered. First, individual news events described in earlier regressions were aggregated by adding the number of events that took place each month. The basic hypothesis is that the greater the frequency of such events the more likely that inflation forecasts will be affected; thus high-frequency data influence private sector expectations. If the effects are significant only in the regression explaining forecast errors, then, within a month, news events are interpreted as being ignored by the private sector. As before, I distinguish between good and bad news events.

A second set of missing indicators was also incorporated in an attempt to capture information that might be contained in daily short-term interest rate data. Two measures of "risk" to future inflation stemming from daily interest rate changes—namely, absolute deviations from mean interest rates and the conditional variance in short-term interest rates, were summed within the month.[46]

Table 6 provides the pooled regression estimates for different blocks of countries. For the Canada–U.S. block, none of the variables can statistically explain changes in inflation forecasts (the MCI was included but was found to be not significant), while there does appear to be some persistence in forecast errors as seen in column (2). Columns (3) and (4) are for the Japan–U.S. block. Again, the available data suggest that, at the 5-percent level, none of the chosen variables can explain changes in inflation forecasts. However, there appears to be significant persistence in forecast errors. The MCI also did not significantly explain either changes in inflation forecasts or forecast errors (not shown). In the German–U.S. case in columns (5) and (6), only the yield curve significantly explains changes in inflation forecasts in the sense that a tighter monetary policy, in the form of a

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45. Curiously, while there has been interest recently in creating higher-frequency data from information sampled at lower frequencies (e.g., GDP), there has been little research on how to use high-frequency information in models where data are sampled at lower frequencies.

46. The following equations summarize the various missing information indicators:

$$\Phi_m = \Sigma_{d=1}^{l} \left| r_{3m} - \mu \right|_d$$
$$(\Phi_m^{/} = \Sigma_{d=1}^{l} \sigma_d^2)$$
$$(\Phi_m^{*} = \Sigma_{d=1}^{l} NEWS_d^{+})$$
$$(\Phi_m^{**} = \Sigma_{d=1}^{l} NEWS_d^{-}) .$$

The variables Φ are defined in terms of the news variables (*NEWS*$^+$ meaning "good" news, *NEWS*$^-$ signifying "bad" news), the demeaned short-term interest rate ($r_{3m} - \mu$, in absolute values), or the conditional variance of short-term interest rates (σ^2). All are summed over the days (d) of the month.

smaller long–short spread, leads to a downward revision in future inflation. If changes in the yield curve represent a rough proxy for monetary policy credibility, then Germany and the United States are idiosyncratic compared with the remaining groups of countries examined. There is, as before, substantial persistence in the forecast errors, shown in column (6), but none of the other variables is capable of explaining private sector expectational errors. Columns (7) and (8) consider all the available European countries as a group, namely, Germany, France, the United Kingdom, and Italy. Taken together there is evidence of persistence in changes of inflation forecasts, but no other monetary or news variable appears to significantly explain movements in inflation expectations.

Forecast errors show the persistence noted for the other blocks of countries considered so far. However, they are also significantly affected by the term structure and the number of speeches by senior central bank officials. A tightening of monetary policy, for example, increases inflation-forecast errors. This may reflect the private sector's belief that higher short-term interest rates presage higher short-term inflation over the forecasting horizon, when the objective, of course, is to reduce inflation and expectations of inflation. Alternatively, the higher forecast errors may reflect an additional source of persistence other than their lagged values. If we assume that central bank speeches typically reflect the message of inflation control over the sample in question, the frequency of speeches may reflect an attempt to use moral suasion or cheap talk to reduce inflationary expectations. Columns (9) and (10) present estimates for the block of inflation-targeting countries. Note that, of all the covariates, only the size of deviations from the targeted inflation rate significantly explains changes in inflation forecasts. In the forecast errors, persistence remains a factor.

However, changes in the MCI have a significant effect on inflation forecasts. While presumably larger than anticipated deviations from the inflation target, they also help reduce forecast errors. Interestingly, the missing information indicators are often either insignificant, or their significance is highly sensitive to the choice of estimation technique or to the estimation of fixed effects. One important exception in columns (11) and (12) reveals that, in inflation-targeting countries, the cumulative variance in daily short-term interest rates within the forecasting interval has the effect of lowering inflation forecasts, while the same missing information indicator has the effect of increasing forecast errors. If there is potentially useful high-frequency information for inflation forecasting, it makes accurate forecasting more difficult. This underlines how important it is that central banks convey the proper signals, at least to those who forecast inflation.

Table 7

How Much Cheap Talk?

Country	Number of "important speeches and articles," 1980–1996	Number of "important speeches and articles," 1991–1996
	Annual averages (rounded to nearest integer)	
Canada	10	6
Germany	67	51
New Zealand	3	2
United Kingdom	32	24
Australia	17	15
United States	74	57
France	25	18

Note: Data were compiled from the *BIS Review*, which collects "important speeches and articles by senior central bankers." The information is supplied to the Bank for International Settlements by central banks. The title of "senior central bankers" refers to the president, governor, or deputy-governor of a central bank. However, in the case of the United States and Germany, speeches by some members of the Board of Governors of the Federal Reserve System and the Board of the Bundesbank are also recorded. It is unclear whether the definition of an "important speech" has remained unchanged since 1980. In addition, central banks' reporting requirements can differ and have changed through time (e.g., Humphrey-Hawkins testimony in the United States, or the release of inflation reports in the U.K., New Zealand, and Canada) which may affect the number of speeches given. The data do not represent the *total* number of speeches given by central bankers.

3.4 Cheap talk

Table 7 presents data about the average number of important articles and speeches given by senior central bankers since 1980.[47] Separate data for the period since 1990, or when selected countries adopted inflation-control targets, is also shown. The average number of speeches has decreased in every country listed in the table, though the differences are not always statistically significant. The largest drop in cheap talk tends to occur in the inflation-targeting countries. A possible explanation is that cheap talk is relatively less effective in inflation-targeting countries. It is also interesting that the number of speeches by German and U.S. central bankers is

47. The notes to Table 7 provide important qualifications for the data. In particular, the BIS collects information selectively provided by central banks. Moreover, what is considered to be "important," is left undefined. Hence, the data do not reflect the *total* number of speeches which, according to the central bankers who attended the conference at which this paper was given, assure me has risen substantially over the past few years.

considerably higher than those by central bankers from the other countries shown in the table, perhaps because the German and U.S. central banks are more prone to cheap talk. It would be interesting to examine whether the more-frequent speeches of German and U.S. central bankers are more precisely directed towards monetary policy as opposed to other issues, and whether this direction is connected to their relatively good reputation. Research along these lines is in progress.

Conclusions

There is a danger that central banks can become short-sighted if they rely too heavily on high-frequency data. The notion that markets every day provide timely information about underlying macroeconomic conditions is not supported by the empirical results reported in this study. To be sure, there is useful information in high-frequency data, but there is little evidence that news events have a predictable impact on important financial-asset prices. If the objective of more-timely or more-frequent data is to reduce the risk of a financial crisis, then it must be demonstrated that such data help predict the onset of a crisis. (They may be useful in responding to crises.) Moreover, identifying the "fundamentals" that can give clues to central banks and the private sector about the current conduct of monetary policy and the future course for the economy is difficult, especially at high frequencies. Some central bank signals, such as the MCI, appear to smooth some high-frequency information present in the series that constitute the index. Private sector forecasts of inflation either have already incorporated such information or ignore it altogether, as it appears to be difficult to pin down either how private sector forecasts change or which economic variables can explain forecast errors. However, there is considerable evidence of persistence in inflation-forecast errors. There is also more evidence that high-frequency information is used by inflation-targeting central banks in revising inflation forecasts, but that such information also increases forecasting errors. Given the state of our knowledge about the properties of high-frequency data, the long view is what should dictate monetary policy actions and the behaviour of central bank officials.

Data Appendix

Daily data are from the Bank of Canada and the Reserve Bank of New Zealand.

Short-term interest rates are three-month euro-currency rates (Series R3). Long-term interest rates are yields on 10-year government obligations (Series R10). The slope of the yield curve is the difference between the long and short rates (R10–R3). All foreign exchange data (Series FX) are in

Canadian cents per unit of the foreign currency. The original data were then converted into units of the foreign currency in terms of the U.S. dollar.

The stock market indices used are as follows:

Canada	TSE300
United States	Dow Jones Industrial Average
United Kingdom	FT100
Germany	Frankfurt DAX
Japan	Nikkei
Australia	Sydney all ordinaries
New Zealand	ASECT

The daily nominal MCI for Canada was obtained from the Bank of Canada. For comparability, a daily nominal MCI for all countries was constructed along the lines of the one reported in J.P. Morgan *World Financial Markets*. The weight of the exchange rate is determined by "the importance of a country's foreign trade sector relative to the rest of the economy (i.e., the higher the value of trade relative to the rest of the economy, the greater the exchange rate's weight)." Initially, I imposed constant weights in a five-year span using the fraction of exports and imports to GDP. Year-to-year variations were generally found to be small enough to ignore, so the final MCI proxies were evaluated on the basis of trade figures for 1979, 1989, and 1996. In all cases, the bilateral U.S.–foreign currency exchange rate was used, not a nominal effective exchange rate. For Canada, the resulting estimates were comparable to the official nominal MCI from the Bank of Canada. The MCI was set equal to zero at 2 January 1979.

The samples during which inflation is formally targeted in some countries is as follows:

Australia	1 January 1993
Canada	26 February 1991
New Zealand	2 March 1990
Sweden	15 January 1993
United Kingdom	8 October 1992

The news variables are defined as in Robinson and Siklos (1998). Specifically, events were compiled from the *New York Times Index* under the key words "banks and banking," "currency," "world trade," and "finance," as well as under the name of each country.

To illustrate the good news versus bad news dichotomy, consider the following case:

Date	Event	Value
13 September 1994	Parti Québécois wins provincial elections in Quebec	−1
10 June 1995	Conservative government elected in Ontario	+1

Bad news suggests that interest rates will rise or the exchange rate will depreciate, or possibly both. Good news implies the opposite. Dummy variables created on the basis of such news events are active for the length of time indicated in the relevant tables. The above represent examples considered to be purely domestic events. U.S. news and events in other countries were defined in a similar fashion.

Inflation data were constructed from *OECD Main Economic Indicators: Historical Statistics*, and updated from recent issues of *OECD Main Economic Indicators*, or from the International Monetary Fund's *International Financial Statistics* CD-ROM.

Inflation forecasts are from *The Economist* poll of forecasters, available monthly since 1991. The poll is released in the second or third week of each month, and represents an average forecast of inflation made in the month for the current calendar year and the subsequent year. Current calendar-year forecasts from throughout the year were used to generate the results reported in Table 6.

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