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Liquidity Forecasting

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Liquidity Forecasting[1]

Abstract

Liquidity forecasting is a key part of a central bank's sound liquidity management framework. Liquidity forecasts enable the central bank to decide on how much liquidity to provide to or withdraw from the market on a day-to-day basis with the objective of smoothing undesirable fluctuations that could distort the implementation of monetary policy and result in excessive overall financial market volatility. Liquidity forecasting involves the centralization of a wide range of information on financial transactions which affect the main items of the central bank's balance sheet. In particular, the capability of the government to prepare accurate cash-flow projections and share them with the central bank on a timely basis is vital for overall liquidity projections, since variations in the net position of the government often account for the most significant changes in liquidity supply.

This paper explains what makes liquidity forecasting so important for liquidity management, it outlines how the main components of liquidity demand and supply can be projected, and discusses the possible difficulties that may be encountered in the liquidity forecasting process. Further, the paper considers how the daily forecasting of liquidity within the central bank could be organized and what cooperation with outside authorities and agencies is needed. Country practices of liquidity forecasting are also summarized.

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I. INTRODUCTION AND SUMMARY

Forecasting the banking system's liquidity situation is a key element of a central bank's liquidity management framework. This paper explains what makes liquidity forecasting so important for liquidity management, outlines how the main components of liquidity demand and supply can be projected, and discusses the possible difficulties that may be encountered in the liquidity forecasting process. Further, the paper considers how the daily forecasting of liquidity within the central bank could be organized and what cooperation with outside authorities and agencies is needed. Liquidity is defined as reserves of the banking system held with the central bank.[2] The terms "liquidity" and "bank reserves" will, therefore, be used interchangeably in this paper.

Objectives of liquidity forecasting

The main purpose of producing short-term liquidity forecasts is to create an information set which puts the central bank into a position to smooth changes in liquidity conditions. From the outset, it is important to distinguish the short-term, typically daily, liquidity forecasting exercise from financial programming, which encompasses a longer-term perspective, typically one year. The purpose of smoothing fluctuations in liquidity demand and supply is to create stable liquidity conditions and steer the central bank's operating target. These are preconditions to effectively conduct monetary policy, since they help market participants to clearly distinguish between changes in the monetary policy stance and temporary "noises." Distinctly signaling monetary policy changes reduces uncertainties that market participants might have about the central bank's policy intentions, thereby contributing to an efficient transmission of monetary policy. In the same vein, stable liquidity conditions facilitate banks' liquidity management. By moderating the volatility and uncertainty, liquidity management costs are reduced and settlement risks limited.

Liquidity forecasting is the process of centralizing all relevant information that determine the future stance of liquidity without central bank activities. Upon these projections central banks decide on how much liquidity they should add or withdraw from the system. Liquidity forecasting is, therefore, a process that precedes the implementation of liquidity management. This paper focuses entirely on the former, and does not try to provide guidance on how to find the optimal stock of liquidity or what instruments to use to achieve this. These are elements of the liquidity management rather than the forecasting process. It is important to note, however, that central banks will want to conduct liquidity forecasts no matter whether their operating target is an interest rate or a quantity (monetary base or bank reserves) target. The liquidity forecasting process is the same in both cases, but the use of the information, i.e., how a central banks utilizes its policy instruments, differs.[3]

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[2] To simplify, the present paper uses the term banking system for all financial institutions that have access to central bank credit or operate an account with the central bank.

[3] Most central banks have an interest rate operating target. For example, the U.S. Federal Reserve Bank sets a target for the federal funds rate, but nevertheless, to conduct open

Liquidity forecasting and monetary policy instruments

Central banks that conduct monetary policy through direct monetary policy instruments have no immediate need for liquidity forecasts. Without market forces at play, a central bank exerts direct control over the liquidity situation, typically by controlling interest rates, directing credit, setting bank-to-bank credit ceilings, or defining statutory liquidity ratios.[4] When moving from direct to market-based indirect monetary policy instruments, it is crucial to develop a thorough liquidity forecasting framework, including its institutional and organizational setup.

Certain indirect monetary policy instruments can contribute to reducing fluctuations in liquidity conditions. Reserve requirements with averaging provisions and standing facilities can limit interest rate volatility. Reserve averaging acts as a buffer to changing liquidity conditions by allowing banks to over- and underfulfill reserve requirements during the maintenance period. The interest rate elasticity of demand for reserves tends to by higher in systems with reserve averaging, thereby reducing the degree of fluctuations in money market rates from liquidity supply shocks.[5]

Interest rates on standing facilities (credit and deposit facilities) set an upper and lower boundary for interbank money market rates with the same maturity. A narrow corridor between the credit and deposit facility rate limits money market rate fluctuations and let the central bank precisely steer the money market rate, but such a policy has several disadvantages. Liquidity is injected or absorbed at the initiative of banks rather than at the initiative of the central bank. A too narrow interest rate corridor could discourage interbank activity with negative consequences for market development. And finally, a narrow corridor reduces the central bank's ability to extract information on liquidity conditions and banks' expectations from the activities in the interbank money market.[6] Most interest rate targeting central banks therefore conduct their main operations through a policy instrument which is at their initiative, and aim at an interest rate corridor that is wide enough to encourage interbank

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market operations with the objective of keeping the federal funds rate near its target level, it "uses estimates of liquidity needs, which include of projections of both reserve demand and reserve supply" (Partlan, 1998). In such a case, the purpose of these estimates is to give a first indication of the size of the operations the central bank would need to undertake to keep short-term interest rates within the target range.

[4] For a discussion on the transition from direct to indirect monetary policy instruments, see Alexander et al. (1995).

[5] See MAE Operational Paper by David Marston (1996) for more details on the role of reserve requirements.

[6] For a discussion on the trade-offs related to the frequency of central bank interventions and the width of a corridor set by standing facilities, see Hardy (1997a) and Laurens (1997).

transactions. Liquidity forecasting then serves to consolidate information on the expected liquidity conditions and to avoid unwarranted excessive volatility.

Liquidity forecasting and the payment system

Another factor relevant to the central bank's liquidity forecasting and liquidity management process is the payment system, the features of which affect the demand and the effective supply of bank reserves. If the payment system is undeveloped and inefficient, the banking system typically holds large, often highly volatile amounts of excess reserves. Moreover, in some cases an inefficient payment system goes along with large and unstable reserve floats. Both deficiencies complicate liquidity forecasting, can weaken the central bank's control on the liquidity supply, and hence hamper monetary management. The quality of liquidity forecasts will increase with the efficiency of the payment system.

Determinants of liquidity

The liquidity forecasting exercise involves an analysis of the projected changes in the main items of the central bank's balance sheet. The main components of banks' demand for liquidity and the autonomous supply of liquidity (i.e., all supply factors that are in the short-run beyond the control of the central bank) can be derived from the central bank balance sheet. Based on the projected gap between the liquidity demand and autonomous supply the central bank can decide on the appropriate level of liquidity to be added to or withdrawn from the market.

The autonomous factors of liquidity supply comprise: (i) net foreign assets, (ii) net position of the government with the central bank, (iii) currency in circulation, and (iv) other items net. Liquidity demand consists of demand for required and excess reserves. To forecast the demand and autonomous supply of liquidity, one has to identify their determinants and decide on the appropriate forecasting techniques. The predictability of these items depends critically on the institutional and regulatory environment of the economy.

Very often the net position of the government with the central bank accounts for the most significant changes in the autonomous liquidity supply. To ensure a high degree of overall forecast accuracy, it is therefore crucial that the government cooperates closely with the central bank in providing on a timely basis all information available on government transactions that affect the liquidity supply (i.e., cash flow projections on revenues, expenditures and funding instruments). In countries with heavily managed exchange rates and large and volatile capital flows, significant changes in liquidity supply can also result from changes in net foreign assets. In the very short run however, variations in net foreign assets are normally known with certainty, since settlements of foreign exchange typically lag transactions by two days. Currency projections can under certain circumstances also underlie large uncertainties—for example, after a period of high inflation.

Liquidity forecasting framework

A clear and efficient organization of the liquidity forecasting process is essential to produce accurate and timely projections. Liquidity forecasts should be arranged as a rolling process under which every new piece of information is promptly incorporated. A useful way to organize the liquidity forecasting process is to assign the forecasting responsibility to a specific division within the central bank's monetary operations department to ensure a close link between liquidity forecasting and liquidity management. The assignment of such a liquidity forecasting division should comprise: (i) communicating with the different information sources and ensuring the timely receipt of the data, (ii) supervising the consistency of the forecasted components, (iii) producing an overall liquidity projection which is regularly (daily) updated, and (iv) assessing forecasting errors. The optimal size of a liquidity forecasting division depends on the complexity, amount, and availability of data.

Liquidity forecasting horizons and forecasting intervals differ with institutional setups. In systems with reserve requirements, the forecasting horizon should comprise at least the current maintenance period; in systems without reserve requirements the horizon should comprise at least the time period between two discretionary monetary interventions. Optimally, liquidity forecasts should be at daily intervals. If data is not available at this frequency or operations take place less frequently, the central bank might initially start producing forecasts at weekly rather than daily intervals.

Organization of the paper

The remainder of the paper addresses how to set up an effective liquidity forecasting framework. In Section II, the main components of liquidity demand and supply are outlined. Section III explores how to identify the determinants of the liquidity supply and demand components and recommends ways to forecast them. The focus of this analysis is on the information required to produce accurate forecasts rather than the actual forecasting techniques themselves. Section IV, the final section, considers how the day-to-day practice of liquidity forecasting within the central bank can be organized and what cooperation is needed with outside authorities and agencies. A brief summary on different forecasting techniques can be found in Appendix I. Appendix II provides an overview of the main determinants of changes in the net liquidity position of the government and how they can be forecasted. A summary of the determinants affecting the autonomous supply of liquidity is given in Appendix III. Appendix IV describes how to use the variance decomposition method to determine the relative importance of factors affecting changes in bank reserves. The main elements of liquidity forecasting practices in 44 countries are summarized in Appendix V.

II. Conceptual Background

The demand and supply of liquidity can be derived from the balance sheet of the central bank. Simplifying a typical balance sheet, by netting the external position of the central bank (net foreign assets) and the position against the government (net position of the

government), as well as summarizing all other assets and liabilities (other items net) results in the following:

Stylized Balance Sheet of the Central Bank

Assets	Liabilities
• Net foreign assets • Net position of the government[7] • Lending to banks/open market operations • Other items net	• Currency in circulation • Bank reserves

The **demand for bank reserves** can be divided into the demand for required reserves and excess reserves:

Demand for bank reserves = Required reserves
+ excess reserves

The demand for bank reserves is primarily determined by the institutional relationship between the central bank and the banking system, the degree of interbank money market development, the variability and timeliness of payments, and the banking system's expectations about the central bank's liquidity management. Important components of the institutional relationship are the characteristics of reserve requirements, the design and efficiency of the payment system, and access to central bank credit (see Section III.A). It is important to note that identifying determinants for short-run fluctuations in liquidity demand is the main purpose of the day-to-day liquidity forecasting exercise. Institutional factors are more relevant for the long-run level of liquidity demand. They must, particularly, be taken into account in case of structural changes.

The liability side comprises the two uses of base money—currency and bank reserves—which are mirrored by the four sources of base money creation on the asset side. The **supply of bank reserves** can thus be derived as:

Supply of bank reserves =	Net foreign assets	}	Autonomous liquidity position
+	net position of the government		
+	other items net		
–	currency in circulation		
+	lending to banks/OMOs	}	Policy position

[7] In countries where the central bank is not allowed to provide direct credit to the government, the net position of the government will typically appear on the liability side.

The first four items contain all factors that are beyond the control of the central bank in the very short run or—more generally—not related to monetary policy actions. These items are, therefore, called the "autonomous liquidity position."[8] In contrast, the central bank's "policy position" which comprises central bank direct lending to banks and net lending through open market operations (OMOs) is under the immediate control of the central bank. The supply of bank reserves is defined as the sum of the autonomous liquidity position and the policy position. To steer the supply of liquidity according to its objectives, a central bank needs to have sufficient information on the autonomous factors of liquidity supply (see Section III.B).

By comparing the forecasted demand and the projected autonomous factors of the supply of bank reserves, the central bank receives an estimate of the excess supply of (or excess demand for) liquidity that results if the central bank does not intervene. Based on this estimate, the central bank decides how to adjust its net policy position to achieve the desired liquidity conditions. The net policy position accounts for policy operations that have been carried out in the past and come into effect later like the redemption of repurchase or reverse repurchase agreements, maturing refinance credit and the like.

In general, the way in which a central bank adjusts its policy position to disequilibria depends on the underlying operating target, which can be a quantity target (reserve money or bank reserves) or an interest rate target. In addition, the time horizon of the operating target needs to be considered. A central bank can, for example, target the overnight rate or reserve money on a daily basis or aim at a certain weekly or monthly path and allow for daily deviations from the target path.

If the central bank targets the overnight interest rate, it nevertheless still uses the projected daily excess supply or demand reserves to define the amount it has to withdraw or inject daily into the market. The relationship is less strict if the central bank steers the overnight interest rate within a corridor or has reserve requirements with averaging provisions in place. Then, the central bank only has to react to cumulated disequilibria over the entire maintenance period, since the system of reserve requirements works as a stabilizer. In contrast, if the central bank operates without reserve requirements, or without reserve averaging, it may then need to manage liquidity conditions more on a day-to-day basis.

In the case of quantitative (reserve money or bank reserves) operating targets, the central bank in principle adjusts the supply of bank reserves so that it confirms with the target level. For all remaining excess demand or supply, the central bank would allow the interbank money market rate to adjust. However, if the demand for bank reserves is interest inelastic, as

[8] Net foreign assets (NFA) are categorized as an autonomous item regardless of the exchange rate regime. This assumes that under flexible exchange rates the central bank does not intervene in the very short run and NFA are, therefore, constant. On the other hand, under fixed exchange rates NFA changes are outside the control of the central bank as it is committed to intervene to hold the exchange rate stable.

might be the case at the end of the reserve period, the central bank would have to accommodate the demand to avoid disturbances within the financial system even if this leads to short-term deviations from the quantitative operating target.

III. Forecasting the Different Components of Liquidity Needs

The preparation of liquidity forecasts can be divided into two steps. The first step is to identify the factors that determine the components of the demand and the autonomous supply of liquidity. The second step is to decide upon the appropriate forecasting techniques and apply these to project the demand and supply components. In the subsequent sections, both steps will be described. While the liquidity forecasting exercise concentrates mainly on identifying what leads to day-to-day rather than long-term fluctuations, it is also important for the central bank to get a clear understanding of the longer-run and structural determinants, some of which the central bank might be able to model econometrically, and to be aware of the underlying factors that may be causing shifts in these longer-term structural relationships. These considerations form the bases for projections of longer-term changes and help determine how banks can adjust their demand to supply shocks in the given institutional environment. Econometric issues on alternative forecasting techniques are summarized in Appendix I.

A. Demand for Bank Reserves

Bank reserves are held, in principle, for two purposes—fulfilling reserve requirements (if imposed by central banks) and meeting settlement obligations. Consequently, the factors underlying the demand for bank reserves are either those that reflect the reserve requirement regime or that contribute to the uncertainty of meeting settlement obligations, such as the variability of payments and the efficiency of the payment system. Some of these elements are of institutional or structural nature and do not change on a day-to-day basis. The following sections describe both the main institutional and the short-term elements for the demand for bank reserves. The fact that most of the elements are interlinked makes the analysis rather complex.

For liquidity forecasting purposes a central bank is interested in the overall liquidity demand of the banking system, not that of individual banks, unless money markets are segmented. Whether shifts in the banking system's demand result in fluctuations of the overall stock of bank reserves depends on how the central bank manages liquidity. As the monopolistic supplier of base money, it determines the overall level of liquidity in the system. If demand shifts are not accommodated by the central bank, they will consequently be reflected in interest rate fluctuations. The level and variability of banks' demand for bank reserves, therefore, also reflects to some extend the supply conditions determined by the central bank and banks' expectations hereon.

When a central bank operates with reserve requirements, the demand for bank reserves can be split into a demand for required reserves and a demand for excess reserves, in

case. In this case, excess reserves are defined as all deviations from the required level of reserve holdings. Excess reserves can be positive or negative in systems where reserve averaging is allowed. In systems without reserve requirements or where required reserves are blocked in a special account, excess reserves are always positive, unless banks can overdraw their accounts with the central bank.

Required reserves

Forecasting the demand for required reserves only becomes an issue if the reserve (maintenance) period is contemporaneous or partially lagged. With an entirely lagged reserve period and sufficient reporting time for the banking system, the central bank knows the level of reserve requirement with certainty. In this case, all fluctuations in the overall bank reserve demand result from changes in excess reserves.

To forecast the demand for required reserves, the central bank needs to project the development of the reserve base. Domestic currency or foreign currency deposits typically form the reserve base. Consequently, forecasting the required reserve demand entails forecasting the underlying eligible deposits. This is somewhat easier in case of uniform reserve ratios, since only the overall deposit amount needs to be projected. With differentiated ratios, the amount of each deposit type has to be projected taking into account possible shifts between the different types of deposits. The approach to forecast either overall deposits or the deposit components is similar to projecting short-run money demand functions. They can be captured in time series and structural models, which should, in particular, account for seasonal peculiarities. In addition, forecasting required reserves needs to address special factors, such as changes in the tax system, that might cause shifts between different deposit types some of which might not be subject to reserve requirements.

Excess reserves

While the timing of the reserve period impacts on the ability to forecast the demand for required reserves, as explained above, all other characteristics of the reserve requirement system (e.g., averaging provisions or the length of the reserve period) affect the demand for excess reserves and its predictability. This will be analyzed in the sections below. Projecting the demand for excess reserves should become a combination of an econometric and an institutional procedure. An estimated time series or structural model, based on historical data, should be complemented by information about the institutional setup that is difficult to model econometrically and judgments about the developments of liquidity needs.[9]

[9] The U.S. Federal Reserve Bank, for example, estimates the demand for excess reserves as a single equation model with the following main explanatory variables: lagged values of excess reserves, the overnight interest rates, dummy variables for bank holidays, and the amount of reserves banks are permitted to move between adjacent reserve periods. Moreover, it monitors daily how banks are meeting reserve requirements, as the maintenance period evolves (Partlan, 1998).

Impact of the reserve requirement regime[10]

The main characteristics to be considered are as follows:

- averaging provisions versus daily fulfillment of reserve requirements;
- the length of the reserve requirement period;
- cost of reserve shortfalls; and
- the eligibility of vault cash as a reserve asset.

In practice, reserve requirements are characterized by different combinations of these features, which may operate in the same or opposite directions with regard to the predictability of reserve demand. How different combinations of these elements affect the demand for excess reserves is summarized in Table 1.

With **averaging provisions** in place, banks can on certain days "overfulfill" (hold positive excess reserves) and on other days "underfulfill" (hold negative excess reserves) their reserve requirements, provided they maintain at all times a positive balance on their account with the central bank. Nevertheless, on a system wide basis, there are constraints for deviations from the average balances which are set by the degree with which the central bank accommodates demand shifts. In principle, averaging provisions can result in larger fluctuations of the *ex ante* demand for excess reserves, and consequently the overall demand for reserves, than if reserve requirements were to be fulfilled daily.[11] On the other hand, averaging provisions provide banks with flexibility to react to liquidity supply shocks and adjust their *ex post* demand accordingly. This buffer function tends to stabilize liquidity conditions in case of supply shocks and requires a less active monetary policy.

Reserve averaging also plays an important role when banks anticipate the stance of monetary policy to change. An expected increase in central bank rates is likely to raise the demand for excess reserves before the interest rise is expected to take place. Such behavior aims at acquiring bank reserves at the existing low rates and using the excess reserves to temporary overfill reserve requirements, thereby trying to avoid higher borrowing rates at later points in time during the reserve period. Thus, the demand for bank reserves tends to fluctuate more strongly at times when adjustments in central bank rates are anticipated. In systems without reserve averaging, on the other hand, the responsiveness of the demand for excess reserves to expected interest rate changes is fairly low since holding positive excess reserves is much more costly. Averaging limits and high penalties for reserve shortfalls also

[10] For a general discussion on the use of reserve requirements as a monetary policy instrument and an overview of country practices see Hardy (1997b) and MAE Operational Papers by Marston (1996) and Ize (1995).

[11] This phenomenon has, for example, been experienced in Finland where the volatility of the money market liquidity and the overnight rate increased as a result of the introduction of reserve averaging (see Välimäki, 1998).

tend to reduce the responsiveness to anticipated adjustments in central bank rates. Especially toward the end of the maintenance period, the demand for excess reserves becomes fairly interest inelastic.[12]

Table 1. Determinants of the demand for bank reserves

	Increases (+)/ reduces (-) demand for bank reserves	Makes reserve demand more (+)/ less (-) volatile
Demand for required reserves		
Maintenance period		
Contemporaneous	0	+
Lagged	Demand for required reserves is known with certainty.	
Level of reserve base	+	0
Variability of reserve base	+	+
Demand for excess reserves 1/		
Value of payments	+	+
Variability of payments	+	+
Efficiency of payment system	-	-
Averaging provision for reserve requirements	0	+ 2/
Required reserves may be used for payment settlements	-	+
Length of maintenance period		
Short	0	- 2/
Long	0	+ 2/
Access to central bank credit		
At average market costs	-	+
At above market costs	+	-
Costly sanctions for reserve shortfalls	+	-
Eligibility of vault cash as a reserve asset	-	+
Expected interest rate changes	0	+
Possibility for interbank operations after settlement positions are known	-	-

1/ Average over the maintenance period.

2/ The volatility of the *ex ante* demand for excess reserves is likely to rise. However, taking fluctuations in the autonomous supply of bank reserves into account, the *ex post* demand for excess reserves might be less volatile, the longer the maintenance period. 0 = no effect.

The **length of the reserve requirement period** can influence the variability of excess reserve demand and affect the pattern of reserve holdings over the reserve period. The longer

[12] For a graphical presentation of the demand for bank reserves under alternative scenarios see Borio (1997).

the reserve requirement period, the more banks can make use of averaging provisions and the more likely are fluctuations in the demand for excess reserves during the holding cycle. In addition, the longer the reserve requirement period, the higher is the deviation from reserve requirements that can be accumulated over time. The demand for excess reserves on the last day of the reserve period will have to offset these accumulations. For example, if the maintenance period comprises five days and required reserves amount to 100 million currency units, banks could, in principle, have negative excess reserves of -100 million on the first four days and would have to compensate this by holding +500 million on the last day to achieve an average of 100 million. With a 10 days maintenance period, they could even accumulate a "deficit" of -900 million. Most central banks have a good idea of "normal" patterns of reserve holdings over the reserve period. These depend not only on the length of the reserve period, but also on how and when central banks "normally" provide and absorb liquidity. For example, the Bundesbank tended to provide ample liquidity at the beginning of the reserve period and held the system rather short later on. Consequently, banks accumulated positive excess reserves early in the reserve period. In France and Japan the reserve patterns were reversed.[13]

The demand for excess reserves is also affected by the **cost of reserve shortfalls**. When reserve shortfalls are highly penalized by the central bank, the banking system is less likely to deviate from the average required reserve holdings. The demand for excess reserves, therefore, tends to be more stable and better predictable.

In systems in which **vault cash** can partly or fully be deducted from reserve requirements, fluctuations in the demand for excess reserves can also result from adjustments in the demand for vault cash. The latter responds to a precautionary motive of meeting unforeseen cash demands of bank customers. As the level and variability of cash demand is related to the amount and variability of payments, analyzing these underlying typical seasonal patterns can serve as the basis to forecast the demand for vault cash and consequently the demand for excess reserves.

Payments and payment systems

Uncertainties about the daily clearing outcome and the risk of incurring costs from the inability to meet settlement obligations cause banks to hold unremunerated reserves with the central bank. The degree of uncertainty varies with the level of large-value payments and the efficiency of the payment system and interbank money markets. The cost of holding too few settlement balances can take the form of high interbank money market rates, above market rates to be paid for access to central bank facilities, and directly levied penalties. A repetitive failure to meet obligations can result in further sanctions through the central bank and market segmentation. On a day-to-day basis, it is mostly fluctuations in large-value

[13] See Borio (1997) for an overview of patterns of reserve accumulation in industrial countries.

payments that can shift the demand for excess reserves, while all other factors rather determine the long-run demand.

The demand for excess reserves is, in principle, positively related to the number of large-value transactions and their volatility. At the same time, a negative relation exists between bank reserve demand and the efficiency of payment systems or interbank money markets. Inefficient payment system, regardless of their design as real-time gross settlement systems (RTGS) or net deferred-settlement systems, are often characterized by multiple rather than centralized settlement accounts, processing errors and delays due to inadequate processing capacity, or transportation delays in paper-based systems. These inefficiencies can result in increased payment system risk and large and volatile reserve float which directly impact the autonomous supply of liquidity (see Section III.B). As a result, banks tend to hold higher bank reserves. This is particularly the case, if the short-term access to bank reserves is limited because the central bank does not operate an overdraft facility or the interbank money market is segmented or illiquid.[14]

On the other hand, in more efficient payment systems, unaccommodated fluctuations in liquidity demand can have larger impacts on market rates, since bank reserve holdings tend to be much lower than in inefficient payment systems. This calls for a particular vigilant liquidity management by the central bank.

The timing of clearing and settlement is another institutional feature that affects the demand for excess reserves. Allowing for pre-settlement rounds to take place before money markets close and in which central banks can intervene as needed, would lower the demand for excess reserves and moderate fluctuations. Such arrangements provide banks and the central bank with information before adjustments in liquidity become final and thereby facilitate their liquidity management (Freedman, 1990).

Distribution of reserves

The distribution of reserves among banks might reveal useful information to the central bank on the liquidity situation in case interbank markets are not entirely efficient. Market segmentation is a phenomenon often observed especially in emerging market economies. With segmented markets because of financial difficulties in some banks,[15] the overall liquidity in the system would not provide an appropriate picture of liquidity

[14] For more details on payment systems and the impact on the demand for bank reserves and ways to increase the functioning of payment systems see MAE Operational Paper by Hilbers and Roberts (1998). For an overview on the discussion on bank reserves demand in RTGS versus deferred net settlement systems see Fry (1999).

[15] More generally, in business cycle downturns that go along with deteriorations of the loan portfolio quality, banks may wish to hold more liquid assets, which could also raise the demand for excess reserves.

conditions, since some banks' access to liquidity on the interbank money market is restricted. In principle, the central bank would then have to forecast and assess the liquidity conditions for each of the different market segments.

The distribution of reserves is also of importance, in case of market dominance. For example, if a large bank with market power holds positive excess reserves while most other banks are in deficiency, this could lead to stronger pressures on the overnight rate than if a large number of banks was in surplus and a large number of banks in deficit. Consequently, if interbank markets are inefficient or segmented, the central bank will need to closely monitor the situation of individual banks or market segments, and take this information into account when deciding on discretionary monetary intervention. This may only be feasible when either the entire system is very small or is dominated by a small number of banks. In practice, some central banks contact large commercial banks directly to inquire about their short-term liquidity needs (e.g., the Bank of Canada).

B. Autonomous Factors of the Supply of Bank Reserves

As seen in Section II, four main autonomous factors of liquidity supply can be distinguished: (i) net position of the government with the central bank, (ii) net foreign assets, (iii) currency in circulation, and (iv) other items net. The predictability of these items depends critically on the institutional and regulatory environment of the economy. Surveys performed by the Bank for International Settlements for several industrial and emerging market economies, published in Borio (1997) and Van't dack (1999), show that in most cases the net position of the government poses the greatest difficulty to forecast. On the other hand, in countries with exchange rate pegs and large foreign exchange interventions, net foreign assets can be very volatile and likewise be difficult to predict. Similar challenges can be posed for currency projections, when a country is on the path of remonetization after a period of high inflation.

Net position of the government at the central bank

The capability of the government to accurately prepare cash flow projections and to share them with the central bank on a timely basis is vital for dependable overall liquidity projections. This can best be achieved by establishing formal communication channels between the relevant divisions in the respective ministries of finance (or other government agencies) and the central bank's liquidity forecasting division. Providing such information is in the government's own interest, since accurate liquidity forecasts will also facilitate the daily implementation of debt management policies. In particular, putting in place a reliable calendar of government issues will facilitate the placement of government securities and may reduce the overall costs of government borrowing. Ultimately, accurate forecasts will facilitate the central bank's liquidity management function, limit financial market volatility, and help to achieve the macroeconomic objectives of monetary and economic policies.

Institutional arrangements with regard to government accounts play an important role for the liquidity forecasting exercise.[16] In countries where the government maintains banking relations exclusively with deposit money banks, variations in the net liquidity position of the government have no impact on the overall level of bank reserves. The liquidity situation may, however, be indirectly affected, if government transactions change the distribution of reserves within the banking system and inefficient money markets prevent a smooth redistribution of reserves. On the other hand, when the government holds its deposits exclusively with the central bank, changes in its net position have a full impact on bank reserves. A difficulty is added to liquidity forecasting if the government holds deposits at both the central bank and deposit money banks, with the freedom to move its deposits between the two.

Under these circumstances, specific institutional arrangements can help to reduce uncertainties. The central bank could remunerate government deposits over a certain threshold value at below market rates to provide an incentive to hold all deposits below that threshold level with the banking system, as in the case of France. The initiative to shift deposits between the government's central bank and deposit bank accounts could be given to the central bank, as is the case in Canada. The central bank could set a deadline relatively early in the day, when the government must complete its transactions to allow the central bank to react to unforeseen changes.[17] Another alternative would be to require the government to hold a certain average balance on its central bank account, as in the case of Singapore.[18]

The net position of the government with the central bank is affected by the government's expenditures (including servicing of government debt) and revenues (including

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[16] For the implications of government deposits on monetary policy operations and an overview of country practices see the MAE Operational Paper by Almuiña (1999).

[17] Mexico and Canada have set up a one day and one week notice provision on large expenditure so as to facilitate liquidity forecasting.

[18] Institutional differences in the euro area have had the effect that the size and volatility of governments activities differ among the member countries (European Central Bank, 1999). In one group, consisting of Belgium, Germany, Luxembourg, the Netherlands, Austria, and Finland, overnight balances on the government's account with the central bank are low or close to zero. In a second group (Ireland and Portugal), some volatility occurs which is, however, of limited scale. The liquidity effects from government transactions of a third group (France, Italy, and Spain) have been considerable with the largest effect resulting from the Italian tax collection scheduled on the 23rd of each month, which absorbs liquidity. Since the 23rd is also the last day of the reserve maintenance period, these effects need to be carefully assessed. Some volatility has been eliminated since May 1999, since the French Treasury holdings with the Banque de France over a certain threshold value will now be remunerated below the market rate, which is an incentive to keep the holdings below this threshold.

grants), and new borrowing from the market. How much the government needs to borrow from the central bank—in cases where the central bank is allowed to provide direct credit to the government—or will be able to build up deposit balances with the central bank can be derived as the difference between positive and negative cash flows. The change in the net position of the government with the central bank can be summarized as follows:[19]

Change in net position with central bank = Current expenditure
+ Servicing of debt
– Revenue and grants
Non-central bank lending { – New domestic bank borrowing
– New issuance of government papers
– New foreign financing

New borrowing from the market (i.e., new domestic bank borrowing, new issuance of government paper and new foreign financing) is subject to the government's discretion and information on it should be readily available. In countries where the government has access to central bank credit, the projected change in the net position with the central bank, as defined above, provides an indication of the volume of new central bank lending needed for the government to be able to finance its operations.

Net foreign assets

In the very short run, variations in net foreign assets are known with certainty if settlements of foreign exchange lag transactions by a few days. The typical lag period is two days. Given such delays, and considering that the central bank may well be provided with monetary policy instruments that can be adjusted daily, unwanted fluctuations in the supply of bank reserves resulting from changes in net foreign assets can be compensated. However, if policy instruments are used less frequently, or, if settlements are not lagged, forecasting changes in net foreign assets becomes an important task with regard to liquidity management.[20]

Changes in NFA result from central bank interventions on the foreign exchange market. On a day-to-day basis, it is mainly short-term capital flows which can create an excess demand or supply for the currency and are the most relevant for short-run liquidity forecasting purposes. The more integrated an economy is into the world economy, the larger

[19] For an overview on the main determinants of changes in the net position of the government at the central bank and how to forecast them see Appendix II.

[20] Korea, for example, experienced large unforeseen liquidity effects from foreign exchange interventions in times of unstable foreign exchange markets, because settlement was on the same day. To reduce this uncertainty, in 1994, the majority of transactions was changed from "value today" to either "value tomorrow" or "value spot" as part of the foreign exchange market liberalization (Kim and Kim, 1999).

and more volatile the flows can become. Short-term capital flows depend crucially on interest rate differentials and market participants' exchange rate expectations as well as their assessment of the country risk. These have to feed into liquidity forecasts, for example, by inserting them into estimated functions for short-term capital flows. But since expectations can quickly turn around, estimating short-term capital flows remains an extremely difficult task of the liquidity forecasting exercise.

For longer liquidity forecasting horizons, it can be useful to also prepare cash balance of payments projections. These can best be accomplished by disaggregating the balance of payments into its main components (trade account, service balance, income account, current transfers, capital and financial accounts), identifying the determinants of these components and projecting them individually before merging them into an overall forecast for changes in net foreign assets (see Appendix III).

Currency in circulation

Currency in circulation is defined as all notes and coins held outside the central bank and made available or removed by debiting or crediting the banking system's reserve accounts with the central bank. An increase in currency demand reduces the availability of liquidity supply, while a reduction in currency demand increases it.[21] In the short-run, the demand for currency is mostly affected by recurring seasonal factors such as payroll dates, weekends, or holidays and exceptional events such as retrospective pay increases. The central bank needs to identify these patterns from historical data and collect all information that could lead to exceptional deviations. Obtaining the most recent data on currency in circulation can be delayed depending on the degree of computerization and the organization of the reporting system between the central bank and its regional and local units that administer the supply of currency in circulation throughout the country.[22] This might complicate currency forecasts and lead to delays in discovering forecasts errors and their sources.

Long-run determinants of currency demand include scaling variable such as GDP or private consumption and opportunity cost variables such as interest rates, inflation, and the exchange rate. Even though these are unlikely to result in day-to-day fluctuations in currency demand, it is important to have an estimation on how changes in these variables will affect currency demand over time. Currency demand functions can be estimated as structural models which explicitly account for seasonal patterns. In case of exceptional events, these

[21] Variations in currency only affect the supply of bank reserves, but leave the monetary base unchanged.

[22] Another possibility to improve the quality of short-term forecasts currency demand, is to complement the central bank's projections with the banking sector's forecasts. The Bank of Canada requires all banks to give daily notice with respect to forecasted withdrawals of the next day.

forecasts need to be adjusted accordingly.[23] The predictability of the demand for currency, can, however, be weakened by a number of factors. They can make forecasting currency in circulation, even for a longer-term horizon, to a judgmental exercise:

- Technological and financial innovations such as the introduction of ATMs, electronic banking or interest paying checking deposits can change the long-term currency demand functions. When such innovations are introduced, forecasts become more difficult.

- Shifts in monetary regimes, such as shifts from high or hyper-inflation periods to low inflation, often result in a breakdown of currency demand functions. Historical data are then only of limited use. When disinflating, the central bank must assess how fast it can regain credibility to predict the speed with which the economy will remonetize. The experience of countries which have faced similar situations can be used as benchmarks.[24]

- The use of a parallel currency (i.e., currency substitution) can increase the volatility of currency demand as a result of shifts between the domestic and foreign currency. These shifts may be motivated by political instabilities or changes in exchange rate expectations. Of course, such currency fluctuations are also borne by the country that issues the parallel currency. The disturbances might be considerable, since, as in the case of the United States or Germany respectively, about two-thirds and one-third of the total currency stock is held abroad. In general, however, the effect for the country that issues the parallel currency is on a much smaller scale than the effect for the country that uses the parallel currency, since only a small fraction of its currency is affected.[25]

- In monetary unions with regional central banks, instabilities in currency demand in one or more member states can spill over to other member countries as substitution effects. In addition, technical problems with regard to the sorting process of banknotes at the regional central banks can complicate forecasts and delay the availability of actual data on the currency in circulation in each member country.

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[23] For a recent survey on the theoretical and empirical literature on the demand for money, including the demand for currency, see Siram (1999). The paper includes extensive references to the major papers concerned with money demand issues.

[24] For country examples see DeBroeck et al. (1997) and Stone (1998).

[25] For an overview on currency substitution see Calvo and Végh (1992) and Baliño et al. (1999). The perspective of the country that issues the parallel currency is dealt with in Porter and Judson (1996) and Seitz (1995).

Other items net

All other assets and liabilities of the autonomous liquidity position are summarized as "other items net" including the central bank's capital and reserves and the revaluation accounts. However, fluctuations in the revaluation accounts do not impact liquidity because they have their counter position in changes in capital. Hence, only a few of those accounts have liquidity implications. Among these, many transactions are normally known considerably in advance such as the transfer of the central bank profits to the treasury. Even this transaction would have no immediate liquidity impact, unless the treasury holds its accounts with the banking system or withdraws its deposits with the central bank for payments.

Depending on the institutional setup of the economy, the so-called "reserve float" can matter for liquidity forecasting purposes. A reserve float arises if the payor's and payee's accounts with the central bank are not credited and debited on the same day. If the payor's account is debited before the payee's account is credited, the supply of liquidity is reduced and vice versa. The impact on the liquidity supply is reversed as soon as the lagging accounting is carried out. The major sources of floats are lack of operating standards in the processing of payments, inadequate rules and regulations on clearing procedures and settlement methods, holdovers and backlogs of payments, delays in transportation and delivery of payment information, the existence of decentralized accounts of commercial banks in branches of the central bank, and processing errors (Veale and Price 1994). These problems, resulting in high and volatile reserve floats, have often occurred in the early stages of transition economies (Baliño et al., 1994, Sundararajan and Sensenbrenner 1994). The problems were often due to processing delays because of cumbersome procedures and multiple settlement accounts (with the central bank and its regional branches) as well as transportation delays which had serious impacts since most systems were initially largely paper-based. The more sophisticated and more efficient payment systems become, the less important is the problem of the reserve float. But with a portion of payments in most systems continuing to be paper-based, there also remains the possibility of reserve float resulting from processing errors and transportation delays. The best approach to forecast the reserve float is to extrapolate historical data and assess the float's specific economic and noneconomic determinants, such as tax and payroll dates as well as specific factors contributing to transportation delays.

IV. THE PRACTICE OF LIQUIDITY FORECASTING

A clear and efficient organization of the liquidity forecasting process is essential to produce accurate and timely projections. Typical organizational features and issues regarding the day-to-day implementation of liquidity forecasting are discussed below. Country practices are summarized in Appendix V.

A. Forecasting Horizon and Interval

Liquidity forecasts should be arranged as a rolling process under which every new piece of information is immediately incorporated. In systems with reserve requirements, the forecasting horizon should comprise at least the current maintenance period; in system without reserve requirements it should comprise the interval between two discretionary monetary interventions. For example, if the central bank operates mainly through weekly repurchase agreements, the minimum liquidity forecasting horizon should also operate on the basis of one week.

The interval for liquidity forecasts should be at least at the frequency with which central banks can carry out discretionary monetary operations with daily intervals providing the highest degree of information. If the data does not allow for daily intervals and also the central bank cannot react to expected daily disequilibria, since it operates its instruments less frequently, lower forecasting intervals, e.g., weekly, might initially be sufficient. For instance, daily liquidity effects over one week could cancel out. They would consequently not be relevant for central banks carrying out their operations on a weekly rather than a daily basis.

B. Tasks and Organization of a Liquidity Forecasting Division

A useful way to organize the liquidity forecasting process is to assign the forecasting responsibility to a specific division within the central bank's monetary operations department. This is to ensure, on the one hand, a close link between liquidity forecasting and liquidity management and, on the other hand, establish a clear accountability for the forecasting exercise. The forecasting division is the "center" in which the information about the demand and supply components of bank reserves come together. The information has to be provided by different sources within and outside the central bank (e.g., the Ministry of Finance, the central bank's the foreign exchange operations and research department). The main task of the liquidity forecasting division should be to coordinate and supervise these inputs rather than estimating the liquidity individual components. Such a division of labor, can help in avoiding a misallocation of resources or duplication of duties.

The assignment of a liquidity forecasting division would thus comprise:
(i) communicating with the different information sources and ensuring the timely receipt of the data, (ii) supervising the consistency of the forecasted components, (iii) preparing an overall liquidity projection to be updated on a daily (or regular) basis, and (iv) assessing forecasting errors. The central bank's capability to produce accurate liquidity forecasts depends crucially on the information it receives from the individual data providers with the government playing a key role. Resources should be allocated such that emphasis is given to forecasting the items which have the largest impact on liquidity. The optimal size of a liquidity forecasting division will depend on the complexity, amount and availability of data. While much effort and resources are needed to build up or initially improve the liquidity

forecasting process, operating an established forecasting framework when information channels have been established and become reliable typically requires less resources.[26]

Communication with data providers

As the analysis of the demand and autonomous supply of bank reserves in Section III has shown, numerous agents are involved in the transactions which affect liquidity. It is essential to identify the main sources that can provide the relevant information in a timely and accurate fashion and establish regular communication with them. The central bank's liquidity forecasting division needs to contact all data providers daily—preferably according to a preset timetable—to develop a standard procedure with fixed deadlines.

The government should provide daily all available information on government cash flow projections to the central bank preferably through one single government source, most likely located in the Ministry of Finance. Even in an environment where government activities are decentralized and individual government departments have discretion to disburse funds, the centralization of information should be undertaken by a government agency. Only in situations in which centralized information from the government is not available, should the central bank directly contact the largest spending departments to be daily informed about their disbursements and produce its own estimate of government cash flows.[27] A Liquidity Management Committee, composed of representatives of the central bank and the Ministry of Finance, can be useful to help improve the quality of the government's cash flow projections by developing forecasting methodologies, systematically assessing forecast errors, and increasing the efficiency of communication between both agencies.

Producing short-term projections on changes in net foreign assets resulting from intervention should be responsibility of the central bank's foreign exchange operations department. The forecasts with a long horizon are typically produced by the research department. The coordination process between these two divisions should be iterative to account for as much useful information from both sources as possible. In countries with a few large exporters and importers, the central bank should also communicate frequently with these enterprises and the relevant customs authorities to learn about the settlement dates as early as possible.

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[26] In New Zealand, for example, the initial liquidity forecasting team consisted of a team of seven, but has since been reduced to effectively two people.

[27] New Zealand is an example where the central bank receives in the morning a fax from the eight largest spending departments estimating their expenditures for each day of the following week and receives in the afternoon an estimation of their expenditure for the following day.

Especially in times of large uncertainties, it might also prove valuable to directly contact banks to inquire about their short-term liquidity needs, which is a common practice in several countries, but also has some caveats. First, banks are not in a position to assess the impact on overall bank reserves of transactions initiated by the central bank or the government. Here, the central bank has a clear comparative advantage. Second, in highly developed financial systems with a large number of banks, surveys can prove to be very resource-intensive. Third, such surveys may be subject to a moral hazard problem. Banks might, for example, exaggerate their liquidity needs to induce additional central bank liquidity injections. In the long run, this problem can, however, be considered as less prominent, since the central bank can learn from the bank's behavior in the past.

Supervising the consistency of the forecasted components

Even though the liquidity forecasting division may not be concerned with the technical issues of producing its own estimates of the liquidity components, it has to be able to assess the projections it receives from the various central bank and government sources. Understanding the factors determining the liquidity components and the underlying patterns are crucial to check their consistency. Therefore, when divisions and agencies transmit their forecasts they have to complement them with a summary of the underlying assumptions. One example of a consistency check would involve the question whether wage and salary payments for civil servants are also reflected in the projected currency demand, or whether maturing government debt and new issues are taken into account. If the liquidity forecasting division finds systematic inconsistencies for certain liquidity components, it has to advise the responsible data provider to address them accordingly.

Producing an overall forecast of liquidity needs

The main task of the liquidity forecasting division is to provide the central bank's operating division with a daily overall liquidity forecast that puts together the individual projections of the different liquidity components. A computerized operating sheet similar to the one presented in Table 2, which is based on the balance sheet items discussed in Section III, may be used. For more detailed information, equivalent worksheets with a lesser degree of aggregation can be produced. All working tables should be updated daily as soon as additional information becomes available.

Table 2. Bank Reserve Projections (Changes)

(In currency units)	Projections for Forecasting Period (e.g., 10 days)			
	Day t	……..	Day t+10	Total
Autonomous supply of reserves (A=a+b+c+d)				
Changes in net position of government (a) Revenue (-) Expenditure (+) Maturing government debt (+) New issues of government debt (-) Others Changes in net foreign assets (b) Purchases (+) Sales (-) Changes in currency in circulation (c) Increase (-) Decrease (+) Changes in other items net (d)				
Demand for bank reserves (B=e+f)				
Changes in required reserves (e) Changes in excess reserves (f)				
Projected excess supply (+) or demand (-) (C=A-B)				
Supply (+) or withdrawal (-) of liquidity by the central bank (policy position) (D=g+h+i+j+k+l+m+n)				
Repos (g) Maturing repos (-) New repos (+) Reverse repos (h) Maturing reverse repos (+) New reverse repos (-) Credit auctions (i) Maturing (-) New (+) Deposit auctions (j) Maturing (+) New (-) Outright open market operations (k) Purchases (+) Sales (-) Maturing refinance standing facility (-) (l) 1/ Maturing deposit standing facility (+) (m) 1/ Other operations net (n)				
Final position (E=C+D)				

Stock of reserve holdings after central bank interventions

"Spot" reserves (stock) ($F_t=F_{t-1}+E_t$)				
Average "cumulated" reserves (stock) ($G_t=1/t\cdot$ ÓF_t)				

(+) = liquidity injection; (-) = liquidity withdrawal

1/ Refinance and deposit standing facilities are under the discretion of banks; only maturing operations can be forecasted.

Assessing forecasting errors

To ensure the quality of the projections, forecasting errors have to be carefully assessed. Comparing the actual outcomes with the daily liquidity forecasts is crucial to identify the sources of mistakes and draw on this information to improve future projections. In that sense, the liquidity forecasting division carries out the function of an internal control division which assesses the input it receives from the data providers. Four types of errors can be distinguished. First, errors can result from a different timing in flows than expected, for example, when the government postpones certain disbursements. Second, forecasting errors can be due to mistakes in the data input and data submission. Such errors need to be addressed by the relevant data processor and provider. Third, the forecasting process might not use all available relevant information or use suboptimal seasonal adjustment patterns. Including more information or revising the seasonal pattern will help to reduce the fourth type of forecasting error, the residual error or unexplained error.

When establishing a liquidity forecasting framework, the quality of projections might at the beginning be low. Discretionary monetary operations should not be based on liquidity forecasts as long as they would add rather than reduce volatility. As this stage, liquidity forecasts should nevertheless be regularly undertaken to build the relevant expertise and, step-by-step, improve upon the quality. As soon as the quality of liquidity forecasts is such that they add information to the liquidity management process, i.e., they provide better information than that used in a random-walk process and reduce volatility, they should become fully operative. In statistical terms, a quality threshold for liquidity forecasts is reached when the standard deviation of the forecast error is smaller than the absolute change in liquidity.

C. The Day-to-Day Practice of Liquidity Forecasting

Central banks should follow a preset timetable to produce liquidity forecasts. The timetable should set forth certain items such as when to contact the different data providers to gather new information, when to produce or revise the overall liquidity forecast, and when to transmit the final projections to the central bank's management. The concrete setup of such a timetable will be country specific depending on features like the settlement times for interbank operations, the closing times for certain government and central bank operations, the government's readiness to provide information, and the degree of computerization.

The timing of the forecasting process itself underlies a trade-off. On the one hand, the forecast accuracy can be improved by assessing as much information as possible. On the other hand, efficient liquidity management requires the central bank's decision-making body to receive the projections sufficiently in advance. In practice, liquidity projections are typically completed at the end of the day or early in the day. Together with the most recent observations of the situation on the interbank market, they form the basis for decisions on discretionary monetary operations. Depending on country specific circumstances, these decisions are either taken by the central bank's monetary operations department or the executive management of the central bank. When the central bank monetary policy

framework and its given operating target is clearly formulated and the set of instruments well-defined and working, liquidity smoothing operations can become a routine. In that case, it might not be necessary to involve the central bank's executive management in the daily decision making process, but rather limit its involvement to strategical decisions, such as changes in the stance of monetary policy.

The typical steps involved in the day-to-day implementation of liquidity forecasting are summarized in Box 1.

D. Publication of Liquidity Forecasts

While some central banks (e.g., Mexico, and the United States) publish their operating targets, only few central banks disclose their liquidity forecasts (e.g., Australia, Japan, New Zealand, and the United Kingdom).[28] Both are ways of revealing the central bank's assessment of the liquidity situation and communicating the central bank's intention to intervene in the market.

Disclosing central banks' liquidity forecasts can help the banking sector to form expectations on the overall liquidity situation by distinguishing more clearly between the central bank's short-term liquidity management actions and its longer-term policy intentions. This can facilitate banks' liquidity management and contribute to stabilizing liquidity conditions. Transparency, not only with regard to the ultimate objectives, the monetary policy framework, and changes in the monetary policy stance, but also with regard to the central bank's short-term liquidity management process can be a potential means to increase the effectiveness of monetary policy.[29] Since banks are mostly interested in the central bank's assessment of the overall liquidity situation rather than forecasts of the individual supply and demand components, the publication of liquidity forecasts should concentrate on an aggregate indicator, for example, the projected excess liquidity supply or demand without central bank intervention. The more often such liquidity forecasts are updated, the more new information is provided to the public, facilitating banks liquidity management. However, the updates of liquidity forecasts might also be linked to the frequency of monetary operations since the latter is the frequency with which the overall level of liquidity can be adjusted.

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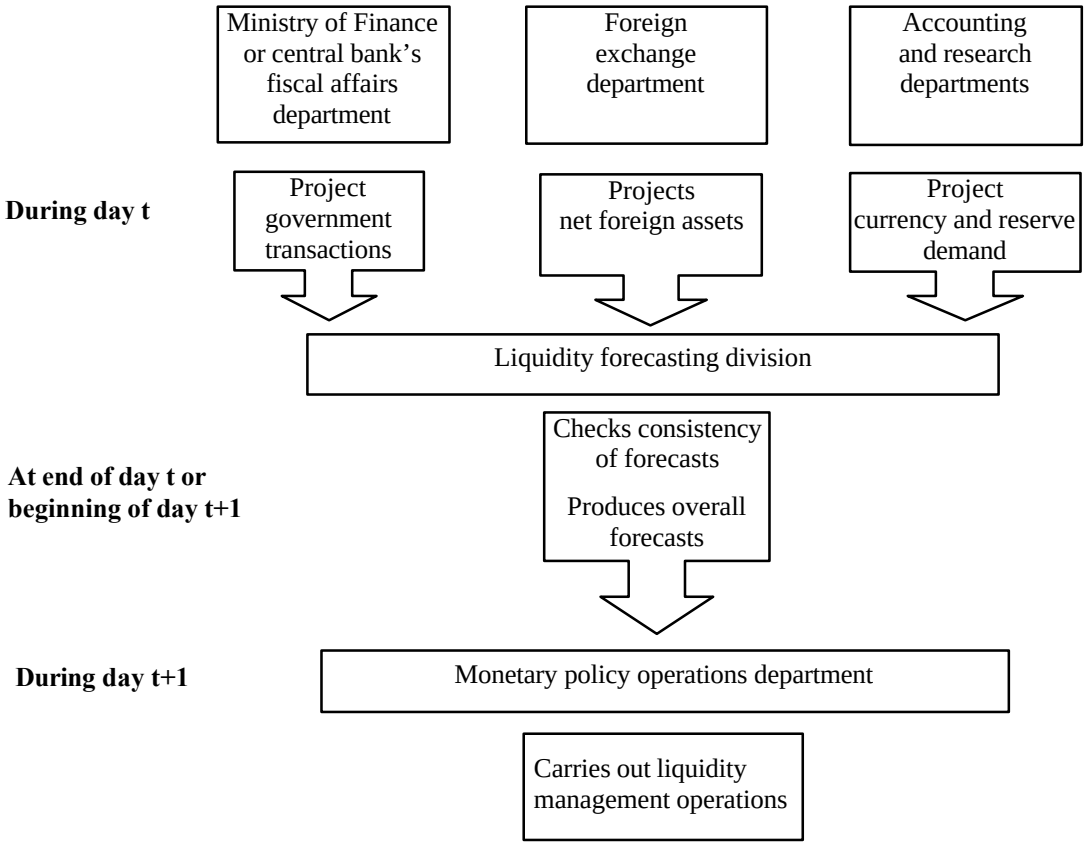
[28] The Bank of Japan's Financial Markets Department, for example, publishes daily the "projection of the reserve balance that exceeds (or falls below) remaining required reserves" (see Bank of Japan website). Individual projected components comprise changes in banknotes, treasury funds and others, and Bank of Japan loans and market operations. The published projections are compared with the actual outcomes.

[29] Desirable transparency practices for central banks in their conduct of monetary policy are set out in the International Monetary Fund's *Code for Good Practices on the Transparency in Monetary and Financial Polices*.

Publishing liquidity forecasts might not contribute to stabilizing liquidity conditions if liquidity projections are subject to significant error. A similar problem arises, when interbank money markets are inefficient and segmented. Then, it becomes difficult for banks to interpret the central bank's overall assessment of the liquidity situation since the distribution rather than the level of reserves is relevant. In such cases, it would be preferable to first improve the forecast quality and develop an efficient interbank money market before considering to publish the central bank's liquidity forecasts.

Box 1. Summary of a Stylized Day-to-Day Liquidity Forecasting Process



Simple Forecasting Techniques[30]

In principle, three main approaches are available to forecast the different components of liquidity supply and demand. *Time series* models make use only of the historical path of the variable to project. They are therefore also called atheoretical models. *Structural models* use all relevant information that explain the variable and are formulated either as a single or multi-equation model. Both methods are based on the assumption that the underlying relationships are stable. In times of regime or policy shifts or other instabilities, it might therefore be necessary to conduct discretionary *judgmental estimations*. The most common forecasting practice is to supplement the time series or structural approach with judgmental factors.[31] In any case, for monthly, weekly or daily projections, it is essential to adjust the forecasts according to the typical seasonal or calendar characteristics.

A. Time Series Models

Deterministic models

In deterministic time series models, simple extrapolation techniques are used to forecast the variable *y*. Trend models are one approach. They can either be linear, exponential or auto regressive. In the first two cases, the value of *y* is extrapolated as a function of time (*t*), while in the autoregressive model *y* depends on its value of the previous period:

$$y_{t+1} = a_0 + a_1(t+1) \qquad \text{Linear trend model} \qquad (1)$$

$$y_{t+1} = \alpha_0 e^{\alpha_1(t+1)} \quad \text{or} \quad \log y_{t+1} = \log \alpha_0 + \alpha_1(t+1) \qquad \text{Exponential trend model} \qquad (2)$$

$$y_{t+1} = a_0 + a_1 y_t \qquad \text{Autoregressive trend model} \qquad (3)$$

Moving average models are a second type of deterministic models are, in which *y* is formulated as a weighted moving average of historical observations with the weights either being constant, decreasing or increasing with the lag length.

$$y_{t+1} = \alpha_0 y_t + \alpha_1 y_{t-1} + \ldots + \alpha_n y_{t-n}; \ \sum_{i=0}^{n} \alpha_i = 1 \qquad \text{Moving average model} \qquad (4)$$

[30] More details on the forecasting techniques presented here can be found in most Econometrics textbooks e.g., Enders (1995) or Pindyck and Rubinfeld (1991).

[31] For a short survey on these different types of models and the Bank of England's practice of economic modeling see Price (1996).

Stochastic models

It is now assumed that the observations of the variable *y* are generated by a stochastic process. One distinguishes again between autoregressive and moving average models. In autoregressive models the process depends on the weighted sum of previous observations and a random error term (e_t):

$$y_{t+1} = a_0 + a_1 y_t + a_2 y_{t-1} + ... + a_n y_{t-n} + e_{t+1} \quad (5)$$

In moving average models, the process is described as the weighted sum of lagged disturbances and the current stochastic term:

$$y_{t+1} = b_0 + b_1 e_t + b_2 e_{t-1} + ... + b_n e_{t-n} + e_{t+1} \quad (6)$$

Autoregressive and moving average models can also be combined in the so-called ARMA models (7). If the data are non-stationary, that is the mean, variance, and covariance of the series change over time, the series needs to be differenced to produce stationary data. The model is then called an autoregressive integrated moving average (ARIMA) model. The number of times a series has to be differenced to become stationary, is thereby called its degree of integration.

$$y_{t+1} = a_0 + a_1 y_t + a_2 y_{t-1} + ... + a_n y_{t-n} + e_{t+1} + b_1 e_{t+1} + b_2 e_{t+1} + ... + b_n e_{t+n} \quad (7)$$

The disadvantage of the above described time series models is not only that they are formulated in a completely atheoretical way, but also that they might leave out relevant information. Structural models try to remedy both defects.

B. Structural Models

In structural models, the variable *y* is explained by structural (economic and non-economic) factors (x_i) and lagged values of *y*, as derived from the underlying theory (8). If the explanatory variables are endogenous variables, the structural model might also consist of several rather than one equation.

$$y_{t+1} = a_0 + a_1 y_t + \sum_{i=1}^{r} b_i x_{i,t+1} + ... + \sum_{n=1}^{r} g_n x_{t-n} + e_{t+1} \quad (8)$$

C. Judgmental Estimations

Prerequisites for applying time series or structural models as forecasting methods are the availability of historical data and the stability of the relations being modeled. In countries with a weak data base or in times of economic transition, introduction of new policy measures or restructuring of the economy these conditions are not fulfilled. Forecasts will have to rely mainly

on judgmental factors. In less extreme situations, time series and structural models may serve as the basis for first estimates, but are refined by accounting for specific unsystematic factors, which are difficult to model. For example, projections for the government's borrowing needs may be based on historical data, but are adjusted when the central bank learns that certain payments will be delayed.

D. Adjusting for Seasonal and Calendar Effects

In the case of very short-run forecasting horizons (daily, weekly, or monthly), not only the trend-cycle and the irregular component need to be captured, as described above, but also recurring patterns, seasonal and calendar effects, have to be modeled. Liquidity needs, for instance, are greatly influenced by certain payment dates (e.g., salaries, pensions, and taxes). Demand for currency typically increases before holidays or the weekend. Variations in the calendar can have similar effects for example as the number of working days within a month differs from the previous year. To apply the seasonality pattern observed over the past, several methods are available. One simple approach is to estimate seasonal indices as moving averages. The first step of this approach is to decompose the variable y_t into its trend-cycle (T_t), its seasonal (S_t), and its irregular (I_t) components.[32]

$$y_t = T_t \cdot S_t \cdot I_t \tag{9}$$

The trend-cyclical element can be estimated as a moving average (in the following example a 12-month moving average to obtain monthly seasonal indices):

$$\hat{T}_t = \frac{1}{12}\sum_{i=0}^{11} T_{t-i} \quad \text{or} \quad \hat{T}_t = 1/12\,(T_{t+6} + ... + T_t + ... + T_{t-5}) \tag{10}$$

Dividing equation (9) by (10) gives an estimate for the combined seasonal and irregular factors.

$$y_t / T_t = \hat{S}_t \cdot \hat{I}_t = z_t \tag{11}$$

Eliminating the irregular component by for example calculating the average values of the same months, i.e., all January values (z_1) over n years, all February values (z_2) etc. gives the 12 seasonal indices.

[32] Sometimes the trend-cycle component itself is decomposed into a long-term secular trend and a cyclical trend. In addition to the seasonal element, one might also isolate an explicit calendar component. The model can be multiplicative or additive.

$$\bar{z}_1 = \frac{1}{n+1}\left(z_{1,t} + z_{1,t-12} + z_{1,t-24} + ... + z_{1,t-12n}\right)$$
$$\text{.....} \qquad (12)$$
$$\bar{z}_{12} = \frac{1}{n+1}\left(z_{12,t} + z_{12,t-12} + z_{12,t-24} + ... + z_{12,t-12n}\right)$$

These indices are then multiplied with the trend (seasonally adjusted) forecasts for a specific month to adjust for month-specific information. Seasonal indices can likewise be calculated for other frequencies (weeks, days).

A more sophisticated and in industrial countries widely used approach, to adjust for seasonality is the **X-11 method** developed by the U.S. Bureau of the Census, which is also based on the basic steps described above. However, this method is only applicable for quarterly and monthly data and a full data set of at least four years needs to be available. Recently the method has been enhanced by the Bureau of the Census to the **X-12-ARIMA method**, which is also being used by the European Central Bank.[33]

[33] Both methods are described by the U.S. Department of Commerce, Bureau of the Census (1965, 1999). For a brief comparison of the two approaches see Deutsche Bundesbank (1999).

Main Determinants of the Net Position of the Government with the Central Bank

The following sections provide an overview on the main determinants of changes in the net position of the government with the central bank and how these can be forecasted.[34]

A. Expenditures and Net Lending[35]

Annual forecasts for **total expenditure** can be based on the government's annual budget adjusted by the predicted execution rate (over- or under-spending). Historical data on the execution rate as well as realized and expected institutional changes are information to be used for estimating the budget execution rate. For day-to-day liquidity forecasting purposes, the annual expenditure has to be broken down into higher frequencies. This is only possible, apart from splitting the budget amount evenly over the 12-month or 52-week period, if additional information on expenditure and net lending is available. This information could, for example, comprise payments dates (e.g., payroll dates), seasonal patterns (e.g., hiring temporary workers for public enterprises in the high season) or observed regularities in budget execution (e.g., low budget execution at the beginning of the fiscal year). Moreover, by comparing the calculated expenditure based on the annual budget with the actual outlays one can derive useful information for short-term expected expenditure.

To account for specific information on expenditure components, total expenditure should be broken down into its major categories. Among the different ways to categorize the components of government expenditure, one approach is to separate the components by function or purpose, such as education, health, defense, transportation, economic affairs, and other. Another way is to split expenditure into current and capital expenditure, which is then further divided by economic type.[36] The main categories of current expenditure are interest payments, wages and salaries, subsidies and transfers, and other current expenditure. The main categories of capital expenditure are purchases of fixed capital assets, stocks, land and intangible assets, and capital transfers.

The type of categorization should not affect the forecast accuracy of government expenditure, since the available information is simply arranged and presented in different ways.

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[34] For an example on how public finances over the medium term are forecasted in practice see the articles by Pike and Savage (1998) and Sentance et al. (1998) on the United Kingdom. For issues concerning public sector forecasting in developing countries see Schroeber and Wasylenko (1989).

[35] Net lending is defined as the difference between new policy loans made by the government (e.g., subsidized credits to farmers) and repayments of these loans.

[36] For these two types of categorizations, see IMF *Government Finance Statistics*.

However, it is normally easiest to work with the categories in which the data are collected.[37] In the following sections, it is assumed that the data are collected according to economic type.

Current expenditure

Interest payments and principle repayment are the only items of current expenditure that may be known with certainty considerably in advance. The data are available to the central bank when it operates as the government's fiscal agent. Otherwise, the information needs to be transmitted by the government debt management agency to the central bank.

Also, **wages and salaries** should be predictable with a high degree of accuracy, since the payment dates are normally preset. In addition to the timing of wage and salary payments, the amounts due, including specific payments like retroactive salary increases or one-time benefits, should be known at least a week in advance from the accounting and filing system operated by the Ministry of Finance. Such files should contain all relevant data on civil servants and public service employees including changes in net recruitment. Since hiring, firing, and retirements typically take effect only after some notice period, these changes can be taken into account when forecasting short-term changes in expenditures. A crucial precondition, however, is that the government operates an encompassing personnel data base that is frequently updated.

Subsidies and transfers are another important economic type of expenditure. They are defined as government assistance to producers or consumers for which the government receives no compensation in return. Granting subsidies and transfers is a political decision that should be implemented in the government's annual budget. Parts of the actual payments, however, can be very volatile, since they are often granted to support agents whose production or consumption is affected by exogenous shocks. Examples are subsidies for the production or consumption of agricultural products or raw materials that can be distorted by weather conditions or variations in world market prices. For short-term forecasts, it is therefore crucial that the central bank closely follows these exogenous developments and cooperates with the government that needs to provide information on outstanding subsidies.

Forecasting **other current expenditures** underlies the same problems as the categories above. It can become particularly difficult when outlays occur infrequently. It is then essential to extract information on payment patterns from historical data, to use information on the institutional setups like pay dates for the suppliers of utilities and materials, and to assess all exceptional factors for which timely information from government authorities is required.

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[37] Assume, for example, that the government has weekly data on the sectors of education, health and defense, because they are collected by the relevant ministries. But the government has only monthly and quarterly data on all other sectors. Then it would be preferable to work with the categorization by function and purpose, because regrouping the weekly data for each of the three sectors into economic types like wages and salaries or transfers and subsidies would be time consuming and would delay forecasts.

Capital expenditure

In contrast to current expenditure, capital expenditure aims to maintain or increase the government's capital stock. Capital expenditure comprises purchases of fixed capital assets, stocks, land and intangible assets, and capital transfers. All of the transactions are primarily subject to political decisions. Consequently, forecasts should rely on information provided by the government.

B. Revenue and Grants

The approach to forecast government revenue and grants is essentially the same as the one to predict expenditure and net lending. The main revenue categories need to be distinguished, the major determinants of each category identified, and the most appropriate forecasting technique chosen. Projections should be based on the annual budget broken down into higher frequencies and should take into account the experiences with revenue contributions in the past as well as additional specific information.

One usually distinguishes between tax, nontax, and capital revenue. **Tax revenue** comprises corporate, personal, value added, international, and other taxes. Payment dates for tax revenue are normally fixed and therefore known in advance. Personal taxes are typically paid once a month while corporate taxes are paid less frequently (e.g., every quarter). To forecast the amount of tax payments, one must consider the overall macroeconomic situation, including employment, national income, international competitiveness, and the balance of payments. In addition, strong seasonal patterns have to be taken into account when forecasting tax revenue. For example, employment fluctuations need to be considered when projecting personal taxes.

Nontax revenue consists of customs duties, interest income, dividend and other contributions from state enterprises, licenses and fees, central bank profit transfers, and other revenues. As for tax revenue, the macroeconomic situation influences strongly the level of nontax revenue. Examples are the profit situation of public enterprises or exports and imports of goods and services on which customs duties are levied. The latter might also depend on the tourist season or harvest periods when agricultural products constitute a major part of external trade. In contrast to tax revenue payments, the payment dates for nontax revenue are more irregular and not necessarily known in advance which requires close cooperation between the central bank and the relevant customs or government authorities.

Capital revenue is the counterpart to capital expenditure described above and comprises sales of fixed capital assets, stocks, land and intangible assets, and receipt of capital transfers. Similar to capital expenditure, all capital revenue transactions normally require political decisions. To estimate the liquidity impact, the central bank therefore needs to be informed in time by the government. The same applies to **grants** to be received by the governments.

C. Non-Central Bank Financing

To finance the fiscal deficit, the government has three options apart from borrowing from the central bank: domestic bank borrowing, issuance of government paper, and foreign borrowing. How much the government borrows through each channel depends on its debt management strategy which aims primarily at minimizing borrowing costs, but can also attain secondary targets like the development of a domestic debt market. However, not all of the three financing channels might be accessible to the government. For example, high political or exchange rate risks might make foreign financing too costly.

For a central bank's liquidity forecasts, it makes no difference in the short run how the government deficit is financed. The liquidity effect is determined by the overall amount. In the long run however, the type of financing can have an impact on the liquidity supply. If one or more of the channels are not accessible to the government and no adjustment efforts are undertaken to reduce the fiscal deficit, it becomes more likely that the government will borrow from the central bank. Moreover, the monetary policy stance set by the central bank affects the government's borrowing costs and thereby also the overall government borrowing needs. Consequently, the liquidity forecast must be embedded in a macroeconomic forecast.

In case the central bank decides to act as the debt manager or the fiscal agent for the government, it would be informed about the net issuance of government securities, including elements like the timing, size, and length of the borrowing period. This information is not only crucial for liquidity forecasting purposes, but also for the central bank's liquidity management if it conducts open market operations. Moreover, a central bank might issue its own securities. To avoid competition for resources between the central bank and the government, communication and a clear legal framework that defines the roles of both institutions is critical. The institutional relationship between monetary and fiscal operations should also be publicly disclosed.[38]
Forecasting the Autonomous Supply of Liquidity Position

[38] This is also an element of the IMF's *Code of Good Practices on Transparency in Monetary and Financial Policies*.

Main Determinants of the Net Position of the Government with the Central Bank

	Main Determinants		Data Source	Main Forecasting Method
	Short-run	Long-run		
Government transactions				
Expenditure and net lending				
Current expenditure				
Interest payments	Interest payment schedule	Debt management strategy	Government debt management agency; Central Bank; or Ministry of Finance	Combination of TS and SM adjusted by JE
Wages, salaries, and pensions	Payment dates; major recruitment/retiring dates	Annual budget and monthly cash flow plans	Civil service data base, Ministry of Finance	Combination of TS and SM adjusted by JE
Subsidies and transfers	Payment dates; institutional factors; exogenous factors like world market price fluctuations	Annual budget and monthly cash flow plans	Ministry of Finance	TS adjusted by JE
Other	Payment dates; institutional factors	Annual budget and monthly cash flow plans	Ministry of Finance	TS adjusted by JE
Capital expenditure				
Purchases of fixed capital assets, stocks, land and intangible assets, and capital transfers	Political decisions	Annual budget and monthly cash flow plans	Ministry of Finance	JE
Net lending	Payment schedule; political decisions	Annual budget and monthly cash flow plans	Ministry of Finance	JE
Revenue and grants				
Tax revenue				
Corporate tax	Payment dates; institutional factors; information on individual enterprises; seasonal factors	Profit expectations; competitiveness indicators for the economy	Tax office	Combination of TS and SM adjusted by JE
Personal tax	Payment dates; employment data; seasonal factors	Nominal GDP growth, employment trend	Tax office	Combination of TS and SM adjusted by JE
Value added tax	Payment dates; institutional factors; seasonal factors	Private consumption	Tax office	Combination of TS and SM adjusted by JE
International tax	Payment dates of large transactions; developments in partner countries; seasonal factors	Import and exports growth; nominal GDP growth; external competitiveness	Tax office	Combination of TS and SM adjusted by JE
Other	Payment dates; institutional factors; seasonal factors	Trend of tax base	Tax office	TS adjusted by JE

TS = Time series models; SM = Structural models; JE = Judgmental estimations.

	Main Determinants		Data Source	Main Forecasting Method
	Short-run	Long-run		
Nontax revenue				
Social security contributions	Payment dates; institutional factors; seasonal factors	Employment trend; nominal GDP growth; profit projections	Social security fund	TS adjusted by JE
Customs duties	Payment dates of large transactions; developments in partner countries; seasonal factors	Import and exports volume growth	Customs office	Combination of TS and SM adjusted by JE
Interest income	Interest payment schedule	Interest payment schedule	Government debt management agency; Central Bank; or Ministry of Finance	TS adjusted by JE
Dividends and other state enterprise contributions	Income statements; payment dates; information on individual enterprises	Profit expectations; information on individual enterprises; competitiveness indicators	Public enterprise agency	TS adjusted by JE
Other nontax revenue	Payment dates; institutional factors	Trend of revenue base	Relevant agencies	TS adjusted by JE
Capital revenue				
Purchases of fixed capital assets, stocks, land and intangible assets, and capital transfers	Political decisions	Annual budget and monthly cash flow plans	Ministry of Finance	JE
Grants	Political climate; political decisions	Annual budget and monthly cash flow plans	Ministry of Finance	JE
Non-central bank financing				
Domestic bank borrowing, net issuance of government papers, foreign financing	Short-term borrowing requirement; debt management strategy; interest rates; exchange rate	Debt management strategy; interest rates; exchange rate	Government debt management agency; Central Bank; or Ministry of Finance	Combination of TS and SM adjusted by JE
Net foreign assets				
Trade account	Payment dates of large transactions; developments in partner countries; weather conditions; other seasonal factors	GDP growth; GDP growth of trade partners; real exchange rate; production capacity in export sector; large investment projects	Customs office; Statistics Institute; or Central Bank	Combination of TS and SM adjusted by JE
Service balance				
Transportation	Payment dates of large transactions; developments in partner countries	Trade account	Statistics Institute or Central Bank	Combination of TS and SM adjusted by JE TS adjusted by JE
Travel	Seasonal factors; weather conditions; political and security situation	GDP growth and GDP growth of partners; competitiveness; security situation	Statistics Institute or Central Bank	TS adjusted by JE

	Main Determinants		Data Source	Main Forecasting Method
	Short-run	Long-run		
Other (insurance, financial, consultancy etc.)	Payment dates	GDP growth and GDP growth of partners; real exchange rate; financial sector development	Statistics Institute or Central Bank	Combination of TS and SM adjusted by JE
Income account	Interest and exchange rates and expectations	Amount of net foreign lending; level of net foreign direct investment; interest rates and exchange rate	Ministry of Finance and Statistics Institute or Central Bank	Combination of TS and SM adjusted by JE
Current transfers				
Private	Seasonal factors	Number of nonresident workers; exchange rate; tax factors; political and economic climate	Statistics Institute or Central Bank	TS adjusted by JE
Public	Political decisions	Political decisions	Ministry of Finance and Central Bank	Transactions known in advance
Capital and financial account				
Direct investment	Payment dates; political and security situation	Long-term profit expectations; investment climate	Statistics Institute or Central Bank	Combination of TS and SM adjusted by JE
Portfolio investment	Exchange rate and interest rate expectations; political and security situation	Exchange rate and interest rate expectations; economic and political situation; government financing needs	Central Bank	Combination of TS and SM adjusted by JE
Other	Political decisions; exchange and interest rates	Political decisions; exchange and interest rates	Ministry of Finance and Central Bank	TS adjusted by JE
Reserve assets				
Gold, SDRs, position in the IMF, other	Dates for transactions are usually known to central bank in advance	Political decisions; balance of payments financing needs	Ministry of Finance and Central Bank	Dates for transactions are usually known to central bank in advance
Currency in circulation				
	Payment dates; seasonal factors (holidays, weekends)	Transaction variable (GDP, private consumption); opportunity costs and expectations; technological changes	Central Bank	Combination of TS and SM adjusted by JE
Other items net				
Capital and reserves	Transactions known in advance	Political decision; Central Bank Act	Central Bank	Transactions known in advance
Reserve float	Payment dates; payment system; interest rates	Payment system; technological changes	Central Bank and Banking System	TS adjusted by JE

Relative Importance of Factors Determining Changes in Bank Reserves

The predictability of factors determining the autonomous supply and the demand for liquidity is often related to their volatility. For liquidity forecasting purposes, it is therefore useful to carefully assess the degree of volatility, its sources, and the relative importance of liquidity components. Common indicators to measure the degree of volatility are the component's standard deviations and variation coefficients. An adequate method to assess the sources and relative importance of the liquidity components is a variance decomposition. Decomposing the variance of the changes in bank reserve yields each components percentage contribution to the variance.

By definition, changes in banks' reserve holdings with the central bank (Ä*R*) reflect changes in net foreign assets (Ä*NFA*), the net position of the government with the central bank (Ä*NPG*), lending to banks and open market operations (Ä*L*), currency in circulation (Ä*C*), and other items net (Ä*OIN*) (equation 1).[39]

$$\ddot{A}R = \ddot{A}NFA + \ddot{A}NPG + \ddot{A}L - \ddot{A}C + \ddot{A}OIN \quad (1)$$

The variance of bank reserves is equivalent to the sum of the covariances of each component with bank reserves.

$$\begin{aligned} \text{Var}(\ddot{A}R) = {} & \text{Cov}(\ddot{A}NFA,\ddot{A}R) + \text{Cov}(\ddot{A}NPG,\ddot{A}R) + \text{Cov}(\ddot{A}L,\ddot{A}R) \\ & - \text{Cov}(\ddot{A}C,\ddot{A}R) + \text{Cov}(\ddot{A}OIN,\ddot{A}R) \end{aligned} \quad (2)$$

The percentage contribution of each component to the variance in bank reserves can be obtained by dividing equation (2) by Var(Ä*R*):

$$\begin{aligned} 1 = {} & \text{Cov}(\ddot{A}NFA, \ddot{A}R)/\text{Var}(\ddot{A}R) + \text{Cov}(\ddot{A}NPG, \ddot{A}R)/\text{Var}(\ddot{A}R) + \text{Cov}(\ddot{A}L, \ddot{A}R)/\text{Var}(\ddot{A}R) \\ & - \text{Cov}(\ddot{A}C, \ddot{A}R)/\text{Var}(\ddot{A}R) + \text{Cov}(\ddot{A}OIN, \ddot{A}R)/\text{Var}(\ddot{A}R) \end{aligned} \quad (3)$$

The following steps explain how equation (2) can be derived. Apply the expectations operator to equation (1):

$$\text{E}(\ddot{A}R) = \text{E}(\ddot{A}NFA) + \text{E}(\ddot{A}NPG) + \text{E}(\ddot{A}L) - \text{E}(\ddot{A}C) + \text{E}(\ddot{A}OIN) \quad (4)$$

Subtract equation (4) from (1):

$$\begin{aligned} [\ddot{A}R\text{-E}(\ddot{A}R)] = {} & [\ddot{A}NFA\text{-E}(\ddot{A}NFA)] + [\ddot{A}NPG\text{-E}(\ddot{A}NPG)] + [\ddot{A}L\text{-E}(\ddot{A}L)] \\ & - [\ddot{A}C\text{-E}(\ddot{A}C)] + [\ddot{A}OIN\text{-E}(\ddot{A}OIN)] \end{aligned} \quad (5)$$

Multiply both sides by [Ä*R*-E(Ä*R*)] and apply the expectations operator:

[39] See Section II for the underlying stylized balance sheet of the central bank.

$$E\{[\Delta R - E(\Delta R)]\,[\Delta R - E(\Delta R)]\} = E\{[\Delta NFA - E(\Delta NFA)]\,[\Delta R - E(\Delta R)]\} \quad (6)$$
$$+ E\{[\Delta NPG - E(\Delta NPG)]\,[\Delta R - E(\Delta R)]\} + E\{[\Delta L - E(\Delta L)]\,[\Delta R - E(\Delta R)]\}$$
$$- E\{[\Delta C - E(\Delta C)]\,[\Delta R - E(\Delta R)]\} + E\{[\Delta OIN - E(\Delta OIN)]\,[\Delta R - E(\Delta R)]\}$$

Equation (6) is equivalent to equation (2).

Examples of variance decompositions for bank reserves are summarized in the table below. The calculations for El Salvador are based on daily data for 1999. The data shows that the largest part of the variance in bank reserves (33 percent) is explained by the volatility of the net government position with the central bank. The calculations for the Kyrgyz Republic are for weekly 1998 data. Mostly currency contributes to explaining the variance in bank reserves (51 percent).

Examples for Variance Decompositions of Bank Reserves
(In percent)

	Currency	Net foreign assets	Net position of the government	Lending to banks	Central bank bills	Other items net	Total
El Salvador	22.7	3.0	32.9	4.8	30.2	7.8	100.0
Kyrgyz Republic	50.6	41.0	-29.1	12.0	-	25.4	100.0

Source: IMF staff calculations.

Country Practices of Liquidity Forecasting

Country	Forecasting Horizon	Reserve Requirement Period	Forecasting Interval	Frequency of Revisions	Most Unpredictable Item
Algeria	1 month	..	1 day	..	Currency
Armenia	14 days	14 days	1 day	Weekly	NCG, Currency
Australia 1/ 4/	2 months	1 day	1 day	Intraday	NCG
Austria 1/ 2/	1 month	1 month	1 day	Daily	..
Belgium 1/ 2/	10 days	1 day	1 day	Daily	Currency
Bolivia	..	2 weeks	1 day	..	NCG, demand for bank reserves
Brazil 3/	1 month	1 week	..	..	NFA
Bulgaria	..	1 month	1 day	Daily	..
Canada 1/	3 months	No reserve requirements	1 day	Daily	..
Chile 3/	1 month	1 month	..	Daily	NFA
Colombia 3/	1 week	2 weeks	1 day	Weekly	Demand for bank reserves
European Central Bank 5/	1 month	1 month	1 day	Daily	NCG (Italy and Spain), Float
Finland 2/ 4/	2 weeks/ 4 weeks	1 month	1 day	Daily/ weekly	Currency
Former Yugoslav Republic of Macedonia	1 month	1 month	1 day	Weekly	NCG
France 1/ 2/	1 day/ 8 days	1 month	1 day	Daily	Float
Gambia	3 months	2 weeks	3 months	Weekly	NCG
Georgia 4/	1 week	1 month	1 week	Weekly	NCG, Currency
Germany 1/ 2/	2 month	1 month	1 day	Daily	Currency
Ghana	..	..	1 week	Weekly	NCG
Hong Kong 3/	2 days	..	..	Daily	NFA
India 3/	2 weeks	2 weeks	..	..	NCG
Indonesia 3/	1 week	1 week	..	..	NFA
Israel 3/	1 month	1 month	..	Daily	NFA
Italy 1/ 2/	2 months	1 month	1 day	Daily	NCG
Japan 1/ 4/	1 day	1 month	1 day/ 1 month	Intraday	NCG, Currency
Jordan	1 month	1 week	1 day	Bi-weekly	NFA, NCG
Korea 3/	Half-month	Half-month	..	..	NCG, Currency
Kyrgyz Republic	1 week/ 1 month	Half-month	1 week	Monthly	NCG
Malawi	1 month, 3 months	1 month	1 month	Monthly	NCG
Malaysia 3/	1 day	2 weeks	..	..	NCG, Currency

Country	Forecasting Horizon	Reserve Requirement Period	Forecasting Interval	Frequency of Revisions	Most Unpredictable Item
Malta	1 week (only intervention day)	1 month	1 week	Weekly	NCG
Mexico 3/	1 day	4 weeks	..	..	..
Netherlands 1/ 2/	1 day/ 3 months	3 months	1 day	Daily	NCG
Nicaragua	1 month	15 working days	1 week	Weekly	Demand for bank reserves
Peru 3/	1 month/ 1 day	1 month	..	..	NCG
Poland 3/	2 days/ 2 weeks/ 1 month/ 3 months	1 month	1 day	..	NCG, NFA
Romania	1 month	Half-month	1 day	Daily	..
South Africa 3/	1-6 months	1 month	..	..	..
Spain 1/ 2/	1 day/ 60-80 days	10 days	1 day	Every 10 days	NCG
Sweden 1/	1 week	1 day	1 day	Daily	NCG, Currency
Switzerland 1/	5 days	1 month	1 day	Daily	NCG
Thailand 3/	1 month/ 1-2 days	2 weeks	..	..	NCG
Turkmenistan	1 year	1 month	1 month, 1 year	Monthly	NCG
Uganda	1 month	1 week	1 month	Weekly	..
United Kingdom 1/ 4/	1 day/ 13 weeks	1 day	1 day	Daily	NCG, Currency
United States 1/	2 weeks	2 weeks	1 day	Daily	NCG, Currency
Zimbabwe	..	2 weeks	1 day	..	..

NCG = Net credit to the government; NFA = Net foreign assets.

1/ Basic information from Borio (1997, p. 60f.), revisions made where applicable.

2/ Before European Monetary Union. Since January 1, 1999 forecasting horizons, maintenance period, forecast interval, and frequency of revisions have been synchronized in all EMU member countries. National central banks in the EMU continue to forecast liquidity needs for the banking sector in their country, while the European Central Bank puts the national projections together to an overall liquidity forecast for the euro area.

3/ Information from Van't dack (1999, p. 28), revisions made where applicable.

4/ Liquidity forecasts are published by the central bank.

5/ The European Central Bank puts together the liquidity forecasts from each national central bank in the European Monetary Union.

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