Foreign Central Bank Approaches to Monetary Policy Implementation:

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Foreign Central Bank Approaches to Implementing Monetary Policy

The following material summarizes ten central banks' current approaches to implementing monetary policy. All but one target a one-day interest rate (but not always the overnight interbank interest rate); however, their methods for hitting the target are far from uniform. Their varying approaches illustrate a wide range of feasible choices about the key elements of monetary policy procedures and central bank payment systems: reserve requirements, remuneration of balances, market operations, standing facilities, and provision of daylight credit.[1]

Although the details of monetary policy systems vary widely from country to country, each system is defined by the relevant central bank's choice of settings for several core structural elements. Variations in the specifications for these core elements establish the defining characteristics of monetary policy implementation frameworks in each country. The settings of these core elements are important determinants of the demand for and supply of balances in accounts at the central bank, and thus of the behavior of interbank interest rates. Key points about the core elements include:

- Standing facilities establish upper and/or lower bounds on interbank rates; such bounds may be tight or loose.

- Constraints on the minimum—and sometimes the maximum—quantity of balances banks hold play an important role in allowing the central bank to estimate the demand for balances under some approaches. These constraints take the form of reserve requirements or contractual agreements to hold an average quantity of reserves over a specified period, with clearing bands or carryover provisions to provide some flexibility in reserve management.

- The maintenance period over which banks' must meet reserve requirements or other quantity constraints varies from one day to more than a month. Longer reserve maintenance periods can make the demand for balances more elastic and provide additional reserve management flexibility. Some central banks make the maintenance period coincide with the period between monetary policy meetings.

- Remunerating balances held to meet requirements or voluntary targets can largely eliminate distortions caused by the reserve "tax." Under some systems, it also affects the attractiveness of reserve requirements or targets, and could

[1] This summary was prepared by Steve Meyer (Research Department, Federal Reserve Bank of Philadelphia) as part of the work undertaken by the Interest on Reserves workgroup. It draws on material published by the foreign central banks listed below, and on material presented at the six-central-bank Workshop on Monetary Policy Implementation held at the Board of Governors on February 27 and 28, 2008. The author thanks Joe Gagnon for helpful comments.

affect banks' choice, at the margin, between holding reserves at the central bank versus lending in the interbank market.

- Targeting a term rate (as in Switzerland) rather than an overnight rate (as in the other countries) affects the behavior of the near-term yield curve when liquidity pressures arise in term interbank markets.

Table 1 summarizes the settings of these core structural elements in selected countries, including the United States.

Table 1: Key Structural Elements of Existing Monetary Policy Frameworks

	Bounds on Interbank Rates (basis points) (1)		Quantity Constraints (2)	Length of Maintenance Period (3)	Flexibility in Meeting Constraints (4)	Remuneration of Required Reserves (5)
	Upper	Lower				
U.S.	Currently target+25 (only partly effective)	0	Combination of Mandatory and Voluntary Requirements	14 Days or 7 Days	Carryover allowance and clearing balance band	Required reserve balances earn no interest; Contractual balances earn implicit interest
Japan	Target+25	0	Mandatory Requirement	Intermeeting period (one month)	None	None
ECB	Target+100	Target-100	Mandatory Requirement	Intermeeting period (one month)	None	Required balances earn main refinancing rate
Switzerland	Target+25	Target−25	Mandatory Requirement	One month	None	None
England	Target+100 (Target+25 at end of period)	Target-100 (Target-25 at end of period)	Voluntary Reserve Targets	Intermeeting period (5 to 6 weeks)	Clearing Band	Target balances earn Official Cash Rate
Australia	Target+25	Target-25	None	1 day	N/A	N/A
Canada	Target+25	Target-25	None	1 day	N/A	N/A
Sweden	Target+75	Target-75	None	1 day	N/A	N/A
Denmark	Target + 25 (effected via 7-day repo)	Target (effected via deposit facility)	None	1 day	N/A	N/A
New Zealand	Target+50	Target-50	Upper Bound	1 day	None	Balances up to upper bounds earn Official Cash Rate

As noted in the first row, the primary credit facility in the United States should establish an upper bound on interbank rates at the primary credit rate. Absent a redeposit facility or remuneration of reserves, the only lower bound on interbank rates in the United States is the zero bound on nominal interest rates. Many U.S. depository institutions face quantity constraints on the amount of balances they must maintain, though a majority do not. These quantity constraints include mandatory reserve requirements that banks must meet, on average, over a fourteen-day or seven-day maintenance period. In addition, some banks may establish voluntary requirements in the form of a contractual clearing balance that must be met, on average, over a fourteen-day maintenance period. The U.S. system allows some flexibility in meeting these constraints. A carryover allowance allows banks to carry forward surpluses or deficiencies up to 4 percent of their reserve requirements from the current maintenance period into the subsequent period. A narrow clearing band provides some flexibility in meeting contractual clearing balance requirements. Average balances within this band receive implicit interest in the form of earnings credits that may be applied against charges for Federal Reserve priced services. Average balances above this band earn no interest; a penalty is applied for any shortfall in average balances relative to the lower bound of the clearing balance band.

Among the other central banks listed in Table 1, the Bank of Japan, the ECB, the Swiss National Bank, and the Bank of England, all operate with systems based on quantity constraints that must be met over a multi-day maintenance period. These constraints are voluntary (contractual) for the Bank of England while the ECB, SNB, and Bank of Japan rely on mandatory reserve requirements. The remaining countries operate without average balance requirements and instead allow banks to choose each day the quantity of reserves they wish to hold. Most of the countries included in Table 1 establish upper and lower bounds for interbank rates by maintaining standing lending and deposit facilities. (The U.S. and Japan are the exceptions; neither has a deposit facility.) In most cases, the central bank's target rate is midway between the upper and lower bounds for interbank interest rates. New Zealand presents an interesting case in which the lower bound for interbank rates is established at the central bank's "Official Cash Rate." As described in more detail below, the Reserve Bank of New Zealand supplies ample reserves, enough to drive interbank rates down close to this lower bound every day. To guard against situations in which an individual bank may wish to hold a very large quantity of reserves, the Reserve Bank of New Zealand establishes a generous upper bound on the quantity of balances on which each bank can earn the official cash rate.

Table 1 illustrates one important stylized fact about alternative monetary policy frameworks. Establishing reserve requirements that must be met over multi-day periods is one method, but not the only method, that central banks employ to stabilize interbank rates. Standing facilities and the remuneration of reserves are another way of stabilizing interbank rates within a band or "channel." In general,

central banks that rely upon quantity constraints and reserve averaging to stabilize the funds rate tend to have a rather wide gap between the upper and lower bounds on interbank rates associated with standing facilities. In contrast, central banks that employ systems in which banking institutions are largely free to choose any desired daily balance also tend to establish a relatively narrow channel for interest rates through standing facilities or the remuneration of interest on reserves. In systems with reserve averaging, the wider channel for interbank rates established by standing facilities provides incentives for banks to trade reserves and strengthens the role of arbitrage across days of the maintenance period in stabilizing overnight interest rates. In systems without requirements and reserve averaging, daily demands for reserves may be volatile and central banks have found it necessary to establish a relatively narrow channel for interest rates through standing facilities and the remuneration of reserves. Central banks that have adopted systems without reserve requirements or contractual balances also generally have implemented tools that allow them to adjust the supply of reserve balances more than once per day.

Nine of the countries listed in Table 1 target an overnight or one-day interest rate; many of them saw term interbank rates rise relative to their target rates during the period of market turmoil that began in August 2007. Some responded by cutting their target for the overnight rate or by taking special steps to supply term funds to the banking system. In contrast, Switzerland, which targets a 3-month interbank rate, saw the overnight interest rate fall as it responded to upward pressure on the 3-month rate by increasing the supply of central bank balances.

Federal Reserve: The Federal Reserve's current approach can be characterized as an asymmetric tunnel with an upper bound that currently is 25 basis points above the target rate and a lower bound at zero. The Federal Reserve imposes avoidable reserve requirements: reserve requirements apply only to end-of-day balances in transactions accounts; the Federal Reserve allows depository institutions to largely eliminate their reserve requirements by "sweeping" balances out of transactions accounts, into linked accounts that are not considered transactions accounts, just before the end of the day. The Federal Reserve does not pay interest on balances held to meet reserve requirements (or on excess reserves), so banks have a strong incentive to "sweep" balances out of reservable accounts. Moreover, the Federal Reserve allows banks to satisfy all or part of their reserve requirements by holding vault cash. A large majority of banks meet their entire reserve requirement by holding vault cash; hence the level of required reserve balances is quite small, averaging less than $7 billion in recent years. Key features of the Federal Reserve's current approach include:

- Interest rate target. The Federal Reserve targets the federal funds rate, which is the interest rate on one-day, uncollateralized, interbank loans.
- Reserve requirements. The Federal Reserve imposes reserve requirements equal to 3 percent of the amount of each depository institution's net transaction deposits deposits between $9.3 million and $43.9 million, plus 10

percent of the amount of each DI's net transactions deposits in excess of $43.9 million.
    - Each DI's reserve requirement is based on its average deposits during a one- or two-week reserve calculation period.
    - The average of the DI's end-of-day holdings of vault cash over the computation period and reserve balances during subsequent one- or two-week reserve maintenance periods must be large enough to meet its reserve requirement.
    - If a DI's vault cash falls short of its reserve requirement, it must hold a required reserve balance in its account at a Federal Reserve Bank (or in its account at a correspondent bank, which holds the balance in its account at a Federal Reserve Bank).
    - But "sweep accounts" allow DIs to transform checkable deposits into non-transactions deposits at the end of the day and thus avoid, to a large extent, holding more balances than they need to make and settle payments.
- DIs earn no interest on balances held to meet reserve requirements.
- There is no deposit facility and excess reserves earn no interest.
- Contractual clearing balances. The Fed allows DIs to hold "contractual clearing balances" when they need or wish to hold more balances than they need to hold to meet reserve requirements. Once a DI contracts to hold a target level of clearing balances, it is obliged to hold that amount in addition to any balances it must hold to meet its reserve requirement
    - The Fed imputes "earnings credits" on contractual clearing balances (in the form of credits against fees DIs incur by using the Fed's payment services) at a floating rate that is below, short-term market rates.
- Each day, Federal Reserve staff forecast the quantity of balances (required plus contractual plus excess balances) DIs would demand if the federal funds rate were equal to the target rate; staff also forecast autonomous factors (such as the Treasury balance) that affect the supply of balances.
    - The forecasts of demand for, and autonomous factors affecting the supply of, balances inform decisions about open market operations.
    - The Open Market Desk conducts occasional outright purchases of U.S. Treasury securities, along with term repurchase agreements (RPs) against Treasury and other securities to provide a base of reserve deposits that normally is slightly smaller than the projected demand.
    - Almost every business day, the Desk engages in RPs (occasionally reverse RPs) with maturities of one to several days to make that day's projected supply of reserve balances equal to the day's projected demand at the target fed funds rate. With rare exceptions, the Federal Reserve conducts market operations only during the morning.
- The Federal Reserve maintains a standing lending facility (the primary credit

facility) from which sound DIs can borrow at a rate above the target fed funds rate, against a wide range of collateral and on a "no-questions-asked" basis.

- To facilitate the flow of interbank payments, the Federal Reserve grants sound DIs ready access to uncollateralized daylight credit via overdrafts in their reserve accounts. DIs pay a modest fee when they use daylight credit.

In combination, the features summarized above generate a small (relative to the size of banking system assets or the flow of payments through Fedwire) but reasonably predictable demand for reserve balances. The demand varies from day to day, rising on days that have unusually large payments flows. The fact that averaging is allowed over the reserve maintenance period makes the demand for reserve balances fairly elastic, except on the last day of the reserve maintenance period when the combination of limited carryover provisions and no remuneration of excess reserves makes the demand for reserve balances quite inelastic. Hence small misses in forecasting the demand for or supply of reserve balances on any given day generally do not cause large movements in the federal funds rate – except when the miss occurs on the last day of a reserve maintenance period. The primary credit facility restrains (but does not cap) upward movements in the federal funds rate; though sound DIs are free to borrow from the primary credit facility and lend in the federal funds market whenever the funds rate rises above the primary credit rate, in practice all but a few appear reluctant to do so. The federal funds rate can fall well below target—even to zero—when there is a substantial excess supply of reserve balances on the last day of a reserve maintenance period. Such outcomes are unusual.

Bank of Japan: The Bank of Japan's operating model (now, as well as before the zero-interest-rate, "quantitative-easing" period) is similar to the U.S. approach in some respects, but quite different in other respects. One key difference is that the Bank of Japan imposes very low required reserve ratios (1.2 percent or less) against virtually all liabilities of banks and bank-like institutions. Like the U.S. approach, Japan's approach can be characterized as an asymmetric tunnel with a lower bound at zero; in Japan's case, a standing lending facility routinely makes the upper bound of the tunnel 0.25 percentage point above the target rate. Key features include:

- Interest Rate target. The Bank of Japan targets the call money rate, which is the interest rate for uncollateralized, one-day, interbank loans.
- Required Reserves. The Bank of Japan imposes a very low required reserve ratio (one percent or less) on virtually all deposits and some short-term non-deposit liabilities of banks and bank-like firms.
    - Japan uses partly lagged reserve accounting. The reserve computation period is the calendar month; the maintenance period is the 16th of the month to the 15th of the next month so the level of required reserves is pre-determined during the last two weeks of the maintenance period.
    - The reserve maintenance period coincides with the period between

monetary policy meetings.
    - The long maintenance period allows substantial averaging.
    - Required reserves earn no interest. Excess reserves earn no interest.
- The BOJ conducts daily open market operations (sometimes more than once per day) to make the supply of reserve deposits equal to projected demand and thus hit its target for the interbank rate.
    - The BOJ does outright purchases/sales of Japanese government securities as well as repurchase agreements/reverse repurchase agreements in Japanese government securities.
    - The BOJ sometimes issues its own paper (BOJ bills) at mid-day, for same-day settlement, when necessary to absorb liquidity.
- The BOJ lends freely to banking institutions on an overnight basis, against eligible collateral, at a rate (currently) 25 basis points above the target rate.
- Account-holders are allowed free daylight credit (via overdrafts in their accounts at the BOJ) against acceptable collateral.

In combination, these features give Japanese depository institutions little opportunity to avoid reserve requirements and little need to hold excess reserves for clearing purposes, but a potentially significant incentive to avoid holding substantial excess reserves (at least when the interbank rate is significantly above zero); thus they imply a predictable demand for reserves. The long reserve maintenance period allows a large amount of averaging and thus makes the demand for reserves quite elastic until the end of the maintenance period, when it becomes inelastic. The overnight lending facility keeps the interbank rate from going significantly above the target but there is no facility that limits downside movements in the interbank rate.

European Central Bank: The European Central Bank and national central banks of the Eurozone countries maintain a symmetric tunnel system with a very large quantity of remunerated required reserves. Key features of the ECB's approach include:

- Interest rate target. The ECB targets EONIA, the Euro area Overnight Index average, which is an average of the interest rates for uncollateralized, overnight, interbank loans in the Euro area.
- Reserve Requirement. The ECB imposes a flat 2 percent reserve requirement on all liabilities (deposits and debt securities) with initial maturities of 2 years or less issued by "credit institutions" (banks and bank-like institutions), except that interbank liabilities are not subject to reserve requirements and the first €50 million of each institution's liabilities are exempt.
    - Each credit institution's required reserves are determined by its liabilities on the last banking day of the calendar month.
    - The reserve maintenance period begins a week or two later, on the settlement day for the first "main refinancing operation" that follows the next ECB Governing Council meeting; it ends on the day before the corresponding settlement day in the next month.

    - A bank meets its reserve requirement if the average of its end-of-day reserve balances during the maintenance period equals or exceeds its requirement. Vault cash does not satisfy the requirement.
- Required reserves are remunerated at the ECB's "main refinancing rate" (the auction-determined rate at which it conducts term repos), which normally is quite close to the ECB's target rate.
    - Excess reserves are not remunerated, but are tiny. Banking institutions can transfer any excess reserves into a standing deposit facility that pays 1 percentage point below the target rate. (In practice, banks typically hold no more than small amounts in the deposit facility.)
- The ECB employs a variety of market operations to manage the supply of reserve balances in an effort to offset movements in autonomous factors and match the projected demand at the target rate. Market operations include:
    - Weekly, one-week repos ("main refinancing operations");
    - Monthly three-month repos ("longer-term refinancing operations");
    - "Structural operations," including outright purchases or sales of eligible securities (including issuance of ECB paper). These are "infrequent."
    - "Fine-tuning operations" of any maturity, when necessary.
    - Eligible collateral for the ECB's market operations include a wide range of marketable and non-marketable debt instruments.
- The ECB has the legal authority to issue its own debt instruments to drain reserve balances, but has never done so.
- The national central banks in the Eurozone allow fully collateralized daylight overdrafts and do not charge for the use of daylight credit.
- The national central banks do not allow overnight overdrafts; they do, however, maintain standing lending facilities with a lending rate 1 percentage point above target rate.
    - Overnight loans, like daylight overdrafts, must be fully collateralized.

The Eurozone's lagged reserve requirement makes required reserves predetermined. The large quantity of required reserves plus ready access to free collateralized daylight credit means that banks and other credit institutions rarely hold excess reserves. The combination makes the average demand for reserves during a maintenance period predictable. The ability to average reserve balances over a long reserve maintenance period makes the demand for reserve balances highly interest elastic, so mismatches between the demand for and supply of reserves on any given day will have little effect on the interbank rate (it will stay close to the target rate) unless they occur at the end of the reserve maintenance period. The ECB can use "fine tuning operations" to adjust the supply of reserves on the last day of the maintenance period, or within the maintenance period if there is a large and unexpected swing in the demand for or supply of reserve balances. (Fine-tuning operations have been used only twice per year, on average; the ECB generally adjusts the supply of balances once per week.) If the ECB does not make the supply of reserve balances equal to the quantity

demanded at the official rate on the last day of the maintenance period, the standing facilities keep the interbank rate within 100 basis points of the target rate.

From mid-August through the end of 2007, deviations of EONIA from the ECB's target rate were larger and more frequent than usual, and the ECB engaged in multiple fine-tuning operations in an effort to keep the supply of balances in line with quantity demanded. Perhaps as a result of the fine-tuning operations, EONIA remained within + or − 50 basis points of the unchanged target rate; it did not hit the top or bottom of the + or − 100 basis point tunnel defined by standing facilities. Deviations were distributed roughly evenly above and below target.

Swiss National Bank: The SNB is unique in targeting a three-month uncollateralized interest rate rather than an overnight interest rate. Specifically, the SNB targets three-month Swiss franc libor, which it considers "the most important interest rate for short-term Swiss franc investments." The SNB announces a one-percentage-point-wide target range for 3-month Swiss franc libor rather than a point target, and then generally steers the rate toward the center of the target range by conducting frequent repo or reverse repo transactions with banks that hold accounts at the SNB. (At times, however, the SNB appears to have allowed the 3-month rate to remain persistently near the top or bottom of the range without announcing a change in the stance of monetary policy.) In other respects, the SNB's approach is similar to (but not identical to) that adopted by the ECB. Key features of the SNB's approach to implementing monetary policy include:

- Reserve Requirements. The SNB imposes a 2.5 percent reserve requirement on "sight liabilities and other liabilities with a residual maturity not exceeding three months," plus and 0.5 percent requirement on "liabilities to customers in the form of savings or investments."
    - Each bank meets its "minimum requirement" by holding, each month, average amounts of vault cash and deposits at the SNB that, when added together, equal or exceed its requirement. A bank's minimum requirement is based on its average deposits three months earlier.
    - On average, banks operating in Switzerland hold vault cash equal to roughly 60 percent of their reserve requirements; they also hold balances at the SNB equal to about 60 percent of their requirements, implying that they hold excess reserve balances equal to roughly 20 percent of their minimum requirements.
    - Banks earn no interest on balances they hold at the SNB.
- The SNB attempts to keep the supply of balances equal to the quantity the banking system demands by conducting frequent repo or reverse repo transactions with the banks that maintain accounts at the SNB. The SNB sets the quantity of securities it wishes to buy or sell, the rate is set by an auction.
    - The SNB executes main refinancing operations (repos) almost every morning. Maturities can range from one day to several months; the

SNB generally enters into seven-day repos.
- The SNB often conducts "fine-tuning operations" in the afternoon; these are bilateral repo or reverse repo transactions that the SNB executes directly with banks that have reserve deficiencies or surpluses; they are conducted at interest rates 25 basis points above (for repo) or below (for reverse repo) the rate set in the morning operation.
- These fine-tuning operations implicitly define a 50-basis–point-wide tunnel within the official one-percentage-point-wide target range.
- The SNB accepts as collateral a wide range of securities issued by the Swiss or other European governments; the securities may be denominated in Swiss francs, euros, dollars, sterling, kroner, or kronor.

In practice, three-month Swiss franc libor generally remains close to the midpoint of the SNB's target band except when markets anticipate a change in the target rate; at such times, that three-month rate tends to move up or down in the target range, moving toward the expected new target rate. Day-to-day variation in the three-month rate usually is small, with movements on the order of 5 or fewer basis points. Volatility increased during the summer of 2007; day-to-day changes of 10 to 20 basis points became common. In addition, the three-month rate, which had been near the middle of the SNB's target range during the Spring, rose into the upper quarter of the target range during the summer. At the same time, the overnight Swiss franc repo rate declined.

Bank of England: In June of 2006, the Bank of England implemented a symmetric tunnel with remunerated contractual (voluntary) reserves and other innovations. The floor and ceiling of the tunnel normally are 1 percentage point above and below the official Bank Rate, respectively, but the tunnel narrows to ± 0.25 percentage point on the last day of the maintenance period. (The Bank Rate is the rate at which the BOE conducts fixed-rate repurchase agreements to supply reserve balances and also the rate at which the BOE remunerates contractual balances.) The BOE does not formally target an interbank interest rate; nonetheless, its operating procedures ensure that the overnight rate for uncollateralized, sterling-denominated, interbank transactions (SONIA) typically is less than 10 basis points above the Bank Rate. But SONIA does sometimes rise well above, or fall below, the Bank Rate. The current British model includes:

- A 0.15 percent unremunerated, lagged reserve requirement on each banking firm's sterling deposits (except interbank deposits) in excess of £500 million.
  - The BOE finances its operations with earnings on the unremunerated reserves; this reserve requirement has no monetary policy role.
- Remunerated contractual balances for monetary policy purposes.
  - Banking institutions may choose a target level of remunerated balances up to a maximum of 2 percent of their sterling deposits.
  - Banking institutions may choose a different level of contractual balances each maintenance period; they must choose the amount they

will hold before the beginning of the reserve maintenance period.
    - A bank meets its balance "requirement" if the average of its end-of-day balances over the five to six weeks between meetings of the BOE's Policy Committee is within ± 30 percent of the bank's contractual target.
    - Contractual balances are remunerated at the BOE's official "Bank Rate" so long as the DI's average balance in its clearing account is within ± 30 percent of its contractual target.
    - A shortfall or excess larger than 30 percent of the bank's target balance is penalized. (Banks are charged the Bank Rate on such a shortfall or excess, rather than paid the Bank Rate.)
    - N.B. Before the period of market turmoil that began in August of 2007, banks average end-of-day balances had to be within ± 1 percent of their contractual targets to satisfy their contractual commitments and earn interest. The BOE widened the clearing band to as much as ± 60 percent in September to give banks greater flexibility in managing their balances and to reduce upward or downward pressure on the interbank rate at the end of the maintenance period. In October, the BOE narrowed the clearing band to ± 30 percent, its current width.
- The BOE does daily open market operations (both outright purchases/sales and repurchase agreements/reverse repurchase agreements), based on daily reserves projections, to make the day's projected supply of reserves equal to the projected demand and at its target for the interbank rate. Typically the BOE conducts fixed-rate repos at the official Bank Rate and allocates its intended quantity across bidders *pro rata*.
- The BOE maintains an overnight lending facility with a rate 1 percentage point above the target rate. The BOE also maintains an overnight deposit facility with a rate 1 percentage point below the target rate. Banks are free to transfer any excess balance in their main account to the deposit facility.
    - On last day of the maintenance period, rates on the standing facilities narrow to 25 basis points above/below the target rate effectively limiting end-of-maintenance period movements in the interbank rate.
- Clearing banks are allowed interest-free daylight overdrafts against collateral; daylight overdrafts trigger automatic intra-day repos against eligible collateral.
    - Any daylight overdraft that is not repaid by the end of the business day becomes a collateralized overnight overdraft; overnight overdrafts are charged a penalty rate well above the overnight lending rate.

The BOE's lending and deposit facilities define a tunnel centered on the Bank Rate; the tunnel normally is 200 basis points wide but it narrows to 50 basis points on the last day of the maintenance period. The combination of remunerated contractual balances and the penalties imposed when a bank misses its reserves target gives banks a strong incentive to hit their reserve targets and thus makes the demand for reserves

predictable, especially at the end of the maintenance period. Averaging over a month and paying interest at the target rate makes the daily demand for balances very elastic, except possibly at the end of the maintenance period. At the end of the maintenance period, the demand for reserves seems likely to be very close to flat over the + or – 30 percent clearing band but quite steep beyond that range.

The BOE uses daily open market operations to make the supply of nonborrowed reserves equal or close to the projected demand for balances. Errors in projecting autonomous factors that affect the supply of reserves will cause actual balances to deviate from the intended supply; such deviations, if they occur before the end of the reserve maintenance period, will have little effect on the interbank rate because the demand for reserve balances is highly elastic until the end of the maintenance period. If the BOE puts the supply of reserves within the clearing band on the last day, the interbank rate will again be very close to the official Bank Rate. (Note that if average balances are close to required plus contractual balances on the next-to-last day, the BOE will have a very wide margin of error on the last day.) If the BOE fails to put the supply of reserves within the clearing band on the last day of the maintenance period, some banks will try to borrow (lend) in the interbank market until the interbank rate rises (falls) to the BOE's lending (deposit) rate, at which point those banks will have a strong incentive to make up a deficiency by using the BOE's lending facility (or to get rid of excess balances by shifting them to the BOE's deposit facility). Thus if the BOE does not put the supply of reserves within the clearing band on the last day, the interbank rate seems likely to jump to the floor or ceiling of the (narrower) tunnel. In practice, the overnight rate in the UK was much less volatile between June 2006 and July 2007 than before, but the rate did occasionally spike up or down.

As in other countries, the overnight interbank rate became more volatile during the period of market turmoil in 2007, especially during August and early September before the BOE widened the clearing band. In contrast to the United States deviations from target were concentrated on the high side of the target rate.

Reserve Bank of Australia: The RBA maintains a system with zero required or contractual reserves and a narrow symmetric tunnel around its target for the overnight rate for uncollateralized interbank loans. Key features include:

- The RBA sets a target for the "cash rate," which is the interest rate for Australian-dollar-denominated, overnight, uncollateralized, interbank loans.
- The RBA imposes no reserve requirements.
- The RBA publishes its projection of the banking system's net position *vis à vis* the RBA (for that day) each morning and simultaneously announces its "dealing intentions" (whether it plans to buy or sell securities and its preferred maturity for repos). Banks then have 15 minutes to submit bids or offers.
    - To a large extent, the daily fluctuations in the banking system's net

position *vis à vis* the RBA result from flows between the banking system and the government.

- The RBA conducts market operations almost every morning (usually repos to add funds, occasionally reverse repos to drain funds) in an effort to make the supply of reserve balances equal to the modest (approximately A$750 million) demand for end-of-day balances.
    - The RBA may do a second round of market operations later in the day, but these are rare.
- The RBA also uses FX swaps, typically for terms of 3 months, to lay down about one third of the supply of balances.
- The RBA remunerates overnight balances at 25 basis points below the target rate. The RBA also maintains a standing overnight lending facility; it lends (via repos against acceptable collateral) at 25 basis points above its target rate.
- The RBA allows free collateralized daylight overdrafts via intra-day repos at a zero interest rate; it allows no overnight overdrafts.

The main features of the Australian model generate a small demand for end of day balances (approximately A$750 million) as banks seek to hold some balances to reduce the risk of end-of-day overdrafts that would have to be covered by borrowing from the overnight lending facility. The absence of averaging, in conjunction with the costs banks bear when they use the standing facilities, seem likely to make the demand for reserves somewhat inelastic (but not highly inelastic, given that the costs of using the standing facilities are not all that large). In practice, the RBA appears to do a good job of equating the supply of reserve balances with demand; the mean absolute deviation of the interbank rate from target is less than one basis point.

Bank of Canada: The Bank of Canada targets the interest rate on collateralized overnight loans in the Canadian money market (the overnight repo rate) and maintains a narrow symmetric tunnel; the top and bottom of the tunnel are 25 basis points above and below the target rate. The Bank of Canada operates with neither required reserves nor contractual balances. Nonetheless, the overnight rate rarely deviates from target by more than a few basis points, in part because the Bank of Canada can adjust the daily supply of reserve balances late in the day to ensure it matches the quantity demanded, and also because the small number of banks that hold accounts at the Bank of Canada makes it easy for banks to adjust their balances via pair-wise trades late in the day. Key features of the Canadian system include:

- No reserve requirement.
- A tiny demand for end of day balances (normally about C$50 million).
- The BOC does overnight Repos at mid-day if the interbank rate is high relative to the target rate; it does overnight reverse Repos at mid-day if the overnight repo rate is low relative to the target rate. If the interbank rate is at or close to the target, the BOC does not intervene.
    - The BOC typically aims to supply about C$50 million of end-of-day

balances to match the perceived demand, but supplies more "when technical pressures occur," as during the summer of 2007.

- The BOC auctions government deposits to the banking system twice daily, at 9:15 a.m. and 4:15 p.m.; the quantity of government deposits auctioned is chosen to offset the day's net flow of payments from the banking system to the government.
- The BOC targets the overnight repo rate and maintains overnight lending and deposit facilities with rates 25 basis points above/below the target rate.
- The BOC operates the Canadian Large Value Transfer System (LVTS), a payment system that incorporates netting features. The BOC guarantees payments finality and requires that participants in the LVTS post collateral with the BOC to mitigate the credit risk it would otherwise bear.
    - The BOC allows free collateralized daylight overdrafts but no uncollateralized overdrafts; any overdrafts remaining at 6:30 p.m. are automatically turned into collateralized overnight loans at a rate 25 basis points above the target rate.
    - The final half hour that the LVTS is open each day (from 6:00 to 6:30 p.m.) is reserved for LVTS participants (the large banks) to do pair-wise trades to square positions among themselves and with the BOC.

With zero reserve requirements, the demand for reserve balances is driven by banks' need for working balances to clear payments and to avoid overdrafts that could result from unanticipated debits to their reserve accounts. Because the BOC supplies free daylight credit (against collateral), banks' precautionary demand for balances stems from their desire to avoid the modest interest-rate penalty incurred by end-of-day overdrafts. The last-half-hour period for position-squaring (in an environment in which there are a small number of large banks), plus the Bank of Canada's use of its ability to shift government deposits between the government's account at the BOC and accounts at banks late in the day to avoid a reserve shortfall for the banking system as a whole, means each DI faces only a small probability that it will have an end-of-day overdraft that it cannot cover with a bilateral transaction at a rate close to the target rate. Moreover, when that outcome occurs, the cost borne by a DI that finds itself short is small, because the BOC's lending rate is just 25 basis points above its target rate. Hence, the demand for reserve balances is both small and inelastic. But the BOC's ability to move government deposits into or out of the banking system late in the day gives it the ability to finely control the supply of reserves and thus keep the overnight rate close to the target rate.

During the period of market turmoil in the second half of 2007, Canadian banks' demand for reserve balances increased substantially relative to its normal magnitude; the Bank of Canada supplied amounts between C$250 million and C$500 million between mid-August and the end of the year. The overnight rate generally traded low relative to the target rate from mid-August to mid-September, but rarely by more

than 10 basis points. From late-September through year-end, the overnight rate never deviated from target by more than 5 basis points.

Swedish Riksbank: The Riksbank has implemented a symmetric tunnel with no reserve requirement. Though the demand for reserve deposits is both small and inelastic (steep) in such a system, the Riksbank keeps the interbank rate close to its target rate, and thus close to the center of the tunnel, by conducting both morning open market operations and end-of-day "fine tuning" operations. The key features of the Swedish approach are:

- No reserve requirements.
- The Riksbank conducts weekly 7-day Repos to get the supply of balances close to projected average demand for the week. (If the weekly operation requires draining, the Riksbank issues it own paper.)
    - The Riksbank sets the size of the RP and also sets the rate at the official target rate.
    - Banks submit bids for how much they want to borrow from (or lend to) the Riksbank at the official rate; the Riksbank allocates its intended quantity *pro rata*.
- Late in the afternoon each day, the Riksbank knows each bank's net position *vis a vis* Riksbank (and thus knows the banking system's net position); when necessary, the Riksbank does an end-of-day "fine tuning operation" to bring the banking systems' net position *vis a vis* the Riksbank to zero.
    - If banking system as a whole is short *vis a vis* the Riksbank (overdrawn), the Riksbank allows the banks that are short to borrow overnight, against collateral, at 10 basis points above target rate.
    - If the banking system as a whole is long *vis a vis* the Riksbank, the Riksbank allows the banks that are long to deposit excess funds at the Riksbank at 10 basis points below the target rate.
    - But the Riksbank does not allow both borrowing and depositing on same day, and the total amount borrowed or deposited can be no larger the banking system's net position. The effect is to force banks that are short or long vis a vis the Riksbank to borrow and lend among themselves to try to get to zero balances at Riksbank.
- The Riksbank maintains standing overnight lending and deposit facilities with rates 75 basis points above/below the target rate.
- Banks may use free collateralized intra-day credit, but the Riksbank allows no overnight overdrafts.

The standing deposit and lending facilities define a tunnel with a ceiling 75 basis points above the target rate and floor 75 basis points below the target rate. The end-of-day "fine tuning operations" effectively define a much narrower lane within the tunnel; that lane is just 20 basis points wide. The end-of-day operations make the marginal cost of reserves for the banking system as a whole just 10 basis points

higher than the Riksbank's stated target rate, and make the marginal rate of return on excess reserves just 10 basis points lower than the target rate. In effect, the end-of-day operations are a way of paying interest on excess reserves at a rate close to the target rate (required reserves are zero, so any overnight balances are excess reserves).

The main features of the Swedish approach (zero required reserves, no averaging, ready access to free daylight credit), in combination with the availability of the end-of-day operations to fund any late-in-the-day overdrafts, seem likely to make the demand for reserve balances both small and inelastic. Hence, the narrow corridor within the wider tunnel would seem crucial to keeping the interbank rate close to the target rate whenever the Riksbank's morning operations leave the banking system as a whole with smaller or larger balances than banks wish to hold in the aggregate.

National Bank of Denmark: Denmark maintains a unique system. The Danmarks Nationalbank (DNB) adjusts its policy rates to maintain a fixed exchange rate *vis à vis* the euro. In recent years, that has meant keeping the interbank rate in Denmark equal to the euro interbank rate. At first glance, the Danish system appears to be a collapsed tunnel (or "single-point channel") with the floor (deposit) and ceiling (lending) rates both equal to the target rate. The details of the system are more complicated; it is not really a single point channel. Key aspects of the Danish approach include:

- Zero reserve requirements.
- The Nationalbank employs a unique method to supply and absorb reserve balances. It does not buy and sell securities, nor does it conduct open market operations via auctions. (The Nationalbank does hold some bonds, but it does not routinely buy and sell bonds to manage the supply of reserve deposits.) Instead, the DNB conducts "market operations" as follows:
  - On the last banking day of each week, the Nationalbank offers private-sector banks the opportunity to borrow for a fixed 7-day term at a fixed rate. These loans are structured as 7-day repos conducted at the administered "lending rate" (currently 4.25 percent); because they are structured as repos, they cannot be repaid early. Private-sector banks may borrow any amount they wish, so long as they post collateral.
  - On the same day, the Nationalbank offers private-sector banks the opportunity to deposit funds at the Nationalbank at the administered "certificate of deposit rate." The "certificate of deposit rate" is set equal to the "lending rate." Private-sector banks may place whatever amount of funds they wish at the central bank for the fixed 7-day term. The resulting certificates of deposit can be sold to another bank, but cannot be redeemed before maturity.
  - By making its 7-day lending and deposit rates identical, the Nationalbank makes it possible for banks in Denmark to hold a base of reserve balances at zero opportunity cost.

- Private sector banks also have the opportunity to hold overnight "current account" deposits at the Nationalbank; such deposits can be transferred freely. Current account deposits earn a fixed rate that usually is 25 basis points below the "lending" and "certificate of deposit" rates. (The "current account deposit rate" is now 4 percent, equal to the ECB's "main refinancing rate.") This facility makes the marginal cost of balances 25 basis points.
    - The Nationalbank imposes an upper limit on the amount of current account deposits each bank may hold. The limits sum to slightly more than 25 billion krone. In practice, the limits do not appear to bind.
- The Nationalbank does not offer an overnight lending facility; neither does it allow overnight overdrafts. However the Nationalbank will open for special "market operations" if total current account deposits at the close of the day are negative, zero, or positive but close to zero; that is the Nationalbank will increase the supply of balances, late in the day, if changes in autonomous factors make the supply of balances fall short of normal demand.
- The Nationalbank allows unlimited collateralized daylight overdrafts (via intra-day Repos at a zero interest rate) to enable participants in the LVTS to make payments in a timely manner.

The National Bank of Denmark engages in occasional foreign exchange intervention when necessary to maintain the fixed exchange rate. It also is the government's banker. Thus the autonomous factors that change the supply of reserve deposits include differences between the government's payments and its receipts as well as changes in the National Bank's foreign exchange reserves and currency in circulation.

Private-sector banks use the 7-day deposit and lending facilities to offset anticipated changes in the supply of reserve balances that result from autonomous factors. Banks hold current account deposits to reduce the risk that they will find themselves facing an end-of-day overdraft that they will have to cover by borrowing in the interbank market at a time when the interbank rate is elevated, but they hold limited amounts of current account deposits because they carry a 25 basis point opportunity costs relative to 7-day deposits. Banks that find themselves with more current account deposits than they wish to hold on any given day normally will lend the excess in the interbank market so long as the interbank rate exceeds the current account deposit rate; banks that find themselves holding fewer current account deposits than they wish will borrow in the interbank market.

With Denmark's scheme, the daily demand for current account deposits seems likely to be fairly elastic over a range that stretches from zero or slightly positive to the upper limit on total current account deposits. Hence the equilibrium interbank rate seems likely to lie somewhat above the current account deposit rate, and unanticipated changes in autonomous factors that do not push current account deposits to zero or the upper limit seem likely to generate small variations in the

interbank rate. But unanticipated changes that push current account deposits to zero or the upper limit could generate spikes up or down in the interbank rate unless the National Bank acts to offset those unanticipated changes. In fact, the interbank rate in Denmark typically lies within the 25 basis point range defined by the current account rate and the 7-day lending rate. Occasionally, however, the interbank rate spikes much higher; on a few days, it has fallen below the current account deposit rate. The National Bank notes that such fluctuations in the overnight interbank rate "do not affect the more long-term money-market interest rates, which are the most important in relation to capital movements and the krone (exchange) rate, and which are therefore the focus of monetary policy."

Reserve Bank of New Zealand: In 2006, the Reserve Bank of New Zealand (RBNZ) implemented an asymmetric tunnel system with features that seem designed to keep the overnight interbank rate close to the floor of the tunnel. The tunnel's floor is the Official Cash Rate (the interest rate the RBNZ pays on reserve balances); the ceiling is 50 basis points above the Official Cash Rate. A unique feature of the RBNZ's current approach is that the RBNZ provides no daylight credit, though it does provide collateralized overnight credit in the event that a depository faces difficulty obtaining funds in the market. Key features of New Zealand's current approach include:

- No reserve requirement.
- No daylight overdrafts.
- The RBNZ supplies enough balances, via term repos and FX swaps, to meet the banking system's intraday need for funds to clear payments
    - New Zealand's Large Value Transfer System (LVTS) has automated netting/offsetting features to reduce participants' need for liquidity during daylight hours.
- Balances a bank holds overnight earn the "Official Cash Rate," which is set by the RBNZ, so long as they do not exceed a high upper limit.
    - The RBNZ sets the upper limit for each bank; the limits are more than large enough to accommodate the greatest amount of working balances each bank could need.
    - If a bank hold balances in excess of its upper limit, those balances earn the Official cash rate minus 100 basis points.
- The RBNZ offers collateralized overnight credit via overnight repos against eligible securities, at a rate 50 basis points above the target rate, to banks that wish to borrow. The banks initiate any overnight borrowing.
    - Banks can borrow at any time up to 10 minutes before the LVTS closes; settlement occurs at the close.
    - Banks that enter into an overnight repo with the RBNZ can sell back the securities (repay the loan) the same day they borrow, but they still incur one day's interest. Loans are automatically repaid 10 minutes before the LVTS closes the next day, unless the borrower repays early.

In effect, the RBNZ provides a large enough supply of reserve deposits to meet the banking systems' need for clearing balances during the day. Though there is no reserve requirement, the absence of daylight credit generates a large demand for balances. But because there is no reserve requirement, the entire stock of reserves becomes excess reserves at the end of the day. The RBNZ remunerates those balances at its "Official Cash Rate," thus setting a floor on the overnight interbank rate. Though the RBNZ supplies a large enough base of reserves to meet the need for clearing balances in the banking system taken as a whole, on any given day some banks may find themselves needing additional balances to clear transactions expeditiously while others will have larger balances than they need. Hence, there is an interbank market. In that market, banks that find themselves short are willing to pay more than the official cash rate to obtain funds in order to avoid the need to borrow from the RBNZ at 50 basis points above the official cash rate, but generally are not willing to pay more than the RBNZ's lending rate. Banks that find themselves with larger balances than they need for clearing purposes normally are willing to lend in the interbank market rather than hold the extra balances so long as the interbank rate is above the official cash rate.

In a formal sense, the RBNZ has no target for the interbank rate; the Official Cash Rate is its policy rate. In practice, the interbank rate typically is 15 to 20 basis points above the official cash rate, but it occasionally rises farther above, or falls below, the Official Cash Rate. The RBNZ could flood the banking system with enough reserves to ensure that no bank would ever find itself short of clearing balances by more than a negligible amount; if it did so, the RBNZ could make the interbank rate equal or very close to the Official Cash Rate, but evidently the RBNZ chooses not to do so.

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