BANK OF CANADA
BANQUE DU CANADA

BANK OF CANADA REVIEW

Special issue on the renewal of the inflation target

Spring 2016

2016

Contents

1941 Newfoundland Cent

The purple pitcher (*sarracenia purpurea)* is a carnivorous wild flower found in boggy habitats of Canada and along the eastern seaboard of the United States. Designated as Newfoundland's provincial floral emblem in 1954, today it is featured on the province's advertisements, signage and licence plates. Between 1865 and 1947, the flower appeared on the reverse of provincial one-cent pieces. The original design was unpopular and replaced in 1938 with a more life-like rendition of the plant, designed by Royal Mint engraver Walter J. Newman. The piece was last struck in 1947 and continued in general use until Newfoundland entered confederation in 1949.

Members of the Editorial Board

The *Bank of Canada Review* is published twice a year. Articles undergo a thorough review process. The views expressed in the articles are those of the authors and do not necessarily reflect the views of the Bank.

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ISSN 1483-8303

Introduction

Sharon Kozicki, Guest Editor, and Don Coletti, Chair of the Editorial Board

In 2016, the Bank of Canada and the Government of Canada will renew the Agreement on the Inflation-Control Target, which was initially adopted in 1991. Since 1995, the inflation target has been at 2 per cent within a 1 to 3 per cent control band, with inflation measured by the consumer price index. Every five years, the inflation-control agreement is renewed. While the 2 per cent inflation target has served Canada well, before each renewal, the Bank and the Government take the opportunity to review and reassess important aspects of the framework.

The Bank focused on the following three questions for the 2016 renewal: What are the costs and benefits of raising the inflation target? How should core inflation be measured and used? To what extent should the conduct of monetary policy take into account financial stability considerations? This special issue of the Review summarizes some of the Bank's recent research on these questions. The first three articles in the issue provide analysis related to the first question, while the fourth provides insights for all three questions.

The question of whether the inflation target should be raised has been primarily motivated by potential constraints on the ability of monetary policy to ease in situations of weak demand and low inflation as well as with a lower estimated neutral real interest rate. A higher inflation target, and thus higher average level of nominal interest rates, would provide greater scope for easing before the effective lower bound (ELB) is reached.

In 2009, the Bank of Canada determined that the ELB on its key interest rate was 25 basis points (bps). However, recent international experience with negative interest rates, including negative policy rates in some countries, suggests that the ELB may be lower. Jonathan Witmer and Jing Yang review the analysis that underpins the Bank's latest estimate of the effective lower bound—around -50 bps. The article also examines the economics and practicalities of negative interest rates and touches on the theoretical considerations that could influence future thinking on the ELB.

A second motivation for considering a higher inflation target relates to the importance of impediments to downward adjustment of nominal wages in hindering economic adjustment to shocks. Robert Amano, Dany Brouillette, Stefano Gnocchi and Natalia Kyui provide evidence that the extent of downward nominal wage rigidity (DNWR) and its influence on average wage growth have increased in recent years. However, the authors also find that

even if DNWR is more important, its presence needs to be considered in the broader economic context because DNWR may not be sufficient to argue for a higher inflation target.

In the third article, Eric Santor and Lena Suchanek review the recent international experiences of central banks as their policy interest rates approached zero. The article assesses the effectiveness of alternative approaches to monetary policy stimulus and discusses the channels through which they operate. It also outlines issues to be considered when exiting from these policies.

Finally, Robert Fay and Kristina Hess provide insights into each of the three focal research questions of the 2016 renewal through an examination of the monetary policy frameworks in several advanced economies. They describe how central bank policies have evolved since the time of the 2011 renewal in the face of prolonged low inflation, weak demand, commodity price declines and financial stability concerns.

The section of the Bank's website titled "Renewing Canada's Inflation-Control Agreement" provides links to other Bank research on these questions. In addition, around the time of the joint statement of the Government of Canada and the Bank of Canada on the Renewal of the Inflation-Control Target, the Bank intends to release a background document that summarizes the key elements of Canada's inflation-targeting framework and presents the conclusions of the Bank's research program in the lead-up to the 2016 renewal.

Estimating Canada's Effective Lower Bound

Jonathan Witmer and Jing Yang, Financial Markets Department

- Savers have an incentive to switch from deposits to cash when nominal interest rates fall sufficiently below zero.
- The costs of storing and insuring cash dictate the effective lower bound in Canada, which is likely to be around -50 basis points.
- The pass-through of monetary policy changes to consumer and business borrowing rates may be only partial when rates are low or negative.
- The Bank's framework for the implementation of monetary policy can accommodate negative rates.

It has long been accepted that, in practical terms, nominal interest rates cannot fall below zero because investors can always earn a zero nominal return simply by holding cash. This concept has been termed the "zero lower bound" on nominal interest rates. Theoretically, the existence of this zero lower bound limits a central bank's ability to provide further stimulus to the economy through conventional decreases in policy rates below zero.

However, this conventional wisdom about the constraints imposed by the zero lower bound has been contradicted by recent international experience: interest rates have become negative in Sweden, Denmark, Switzerland, the euro area and Japan, suggesting that the effective lower bound (ELB) on central bank policy rates could be below zero, at least in those countries.

In 2009, the Bank of Canada determined that the ELB on its key policy interest rate was 25 basis points (bps). At the time, the Bank was concerned about the potential disruption that low rates might cause in some key funding markets. In December 2015, the Bank released an updated version of its *Framework for Conducting Monetary Policy at Low Interest Rates*, which includes the potential use of negative policy rates in Canada as part of the Bank's unconventional policy tool kit, and estimated Canada's ELB to be around -50 bps (Poloz 2015).

This article outlines the analysis that underpins the Bank's current estimate of the ELB, examines the economics and practicalities of negative interest rates, and touches on theoretical considerations that could influence further thinking on the ELB.

The Costs of Holding and Using Cash

The existence of cash serves as the main constraint on nominal interest rates falling below zero. If holding cash entailed no costs, interest rates on savings and investments could never go below zero because savers and

investors would simply switch to holding zero-yielding cash. But holding cash—especially in large quantities—does have costs. These costs, which are primarily for storage and insurance, mean that the effective return on holding cash is actually negative. How negative depends on the level of those associated costs as well as the inconvenience cost of using cash for large-value payments. In theory, the ELB can be reduced—or even eliminated—by altering the zero-yielding nature of cash (**Box 1**).

The negative return on holding cash is effectively negative after costs for storage and insurance are taken into account

We estimate the costs of holding cash using three sources:

(i) industry estimates for wholesale cash storage;

(ii) a comparison between wholesale cash storage costs and those for storing precious metals; and

(iii) costs associated with precious-metal-backed exchange-traded funds (ETFs), which are liquid financial instruments for investing in vault gold and silver.

Wholesale cash storage estimates suggest that the cost of holding cash (i.e., storage and handling) is fairly low. When insurance requirements are taken into account, cash storage costs for the $100 denomination, for example, can be up to 35 bps per year.[1] Dormant storage costs, excluding insurance, for cash that is stored and not handled or transported frequently could be less than 5 bps for the $5 denomination and less than 1 bp for

1 All the estimates of storage costs reported in this section are denoted in basis points per year to conform with the method of reporting policy interest rates. For example, a cost of 35 bps suggests it costs $3.50 to store $1,000 for one year.

Box 1

Further Reducing or Eliminating the Effective Lower Bound: Theoretical Considerations

The presence of an effective lower bound (ELB) is driven by the existence of an alternative: zero-yielding cash. In theory, the ELB can be reduced—or even eliminated—by increasing the cost of using and holding cash or by eliminating cash altogether. Adopting either of these alternative futures would be a significant change from the current practice. Such a change is not completely beyond the realm of possibility, however: a significant change in the monetary policy regime already occurred some time ago in the move away from the gold standard after the Great Depression (Agarwal and Kimball 2015).

The first group of ideas put forward to further reduce the ELB involves increasing the cost of holding cash. The earliest such proposal was by Gesell (1906), who suggested a stamp tax on money: to use a note as legal tender, holders of cash would be required to pay for the note to be stamped periodically. In a more recent proposal, holding cash could be made more expensive by introducing a time-varying exchange rate between cash and electronic money (Agarwal and Kimball 2015). To discourage holding cash, the exchange rate would need to be set at a level where the expected return from investing at the policy rate is greater than the expected return from holding cash.

A second group advocates for eliminating cash altogether (Buiter 2009; Rogoff 2015; Haldane 2015). The monetary policy transmission should continue to be effective, even if electronic payments replaced cash in all transactions (Woodford 2003). However, although the volume of cash in retail transactions is decreasing as a result of payment innovations, such as contactless credit cards (Fung, Huynh and Stuber 2015), the value of cash in retail transactions remains stable and the amount of currency in circulation in Canada continues to grow in line with GDP growth. It therefore seems unlikely that cash will naturally be replaced completely by electronic payments in the foreseeable future.

While these proposals are all theoretically feasible, they do present several practical challenges. First, reducing or eliminating the use of cash could create incentives for Canadians to use other currencies in their economic transactions. A widespread adoption of other currencies would undermine the effectiveness of negative interest rates as a tool for monetary policy. Second, some Canadians, such as those with low incomes and the elderly, have a stronger preference for cash (Fung, Huynh and Stuber 2015) and may be disproportionately affected by any proposals that eliminate or discourage its use.

the $100 denomination. As such, wholesale storage pricing is mainly driven by insurance requirements, not by the required physical space for storage. Contrary to a commonly held belief, this implies that denomination does not play an important role in overall cash storage costs. This notion is further confirmed when investigating the cost of storing precious metals.

Overall costs of a storing precious metals are of a similar magnitude to those for cash regardless of space requirements because insurance is a larger part of the cost

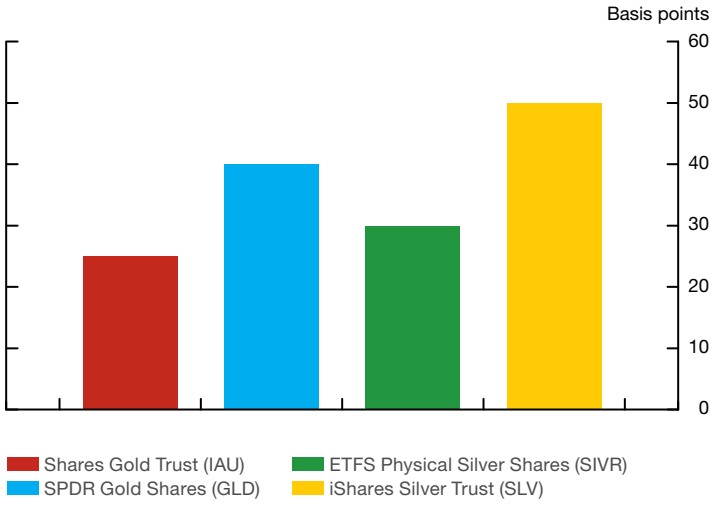
A reasonable estimate of the cost of storing cash can be obtained from a comparison with storage costs for precious metals such as gold and silver, which must also be stored in vaults and insured.[2] Despite a wide range of physical space requirements associated with storing different precious metals, overall costs are of similar magnitude to those for cash because insurance is a larger part of the cost. Publicly available estimates for storage costs, including insurance, range from 40 to 50 bps for silver and from 20 to 35 bps for gold, even though silver requires more than 100 times the storage space than the same value of gold.

Precious-metal-backed ETFs charge a fee that reflects the cost of storing and insuring the underlying precious metal as well as fund-management fees and expenses. We estimate that the pure storage and insurance costs of gold and silver likely range from 20 to 45 bps after fund-management fees and expenses are deducted (**Chart 1**). This is broadly consistent with the cost of storing gold and silver with companies that provide vaults.[3] Taken together, these estimates suggest that the cost of holding cash, including storage and insurance, is most likely between 25 and 50 bps, given that the space required to store a given value of cash in the $100 denomination sits between that for the same value of gold and silver.

Holding cash not only entails storage and insurance costs but also forgoes the convenience benefits of being able to make payments electronically. For commercial entities that frequently transfer large payments (e.g., payroll obligations), there would be a strong convenience benefit to using electronic payment methods associated with bank deposits. Based on industry

Chart 1: Gold and silver storage costs

Fees of exchange-traded funds



Source: etfdb.com

Last observation: 28 January 2016

2 Unlike cash, precious metals may have different properties (weight, flammability) that could affect theft and fire insurance premiums. We assume that these differences have a minimal impact on insurance and storage costs.

3 We assume that the fund-management fees and expenses are a small portion of the total fees, given that several equity ETFs have all-in ETF fees of between 5 and 10 bps.

estimates, cash transportation costs can be up to or even more than 1 bp per shipment, depending on the distance travelled and the value of the shipment. Although small, such a cost would become material if there was a need to settle large-value transactions frequently—even as seldom as twice a month for payroll settlements could add up to almost 25 bps per year. Thus, corporate customers may be willing to accept a small negative return on their deposits rather than switch to cash. For them, the convenience value could be large. Based on these considerations, we think a conservative estimate for the convenience value could be between 0 and 25 bps.[4]

Combining both the costs of holding and using cash, we estimate that the ELB in Canada is likely between -25 bps and -75 bps, with a midpoint estimate of -50 bps.

Of course, there is uncertainty around any point estimate. Some factors can push the ELB toward the low (more negative) end of our estimates, or further. First, our estimate of the ELB is for the target for the overnight rate (the Bank's policy rate). As such, it ignores the wedge between the overnight rate and prevailing commercial interest rates. Participants in the economy face interest rates that are generally higher than the overnight rate, and their decision to hold cash will be based on those interest rates, not on the overnight rate, which could therefore go below that suggested by the costs of holding and using cash without triggering an abnormal increase in the demand for cash. Second, the insurance costs of storing cash would likely increase in the event of a surge in the demand for such storage, reducing the lower bound further. Current industry practice suggests that there is a finite amount of cash that any individual insurance company is willing to insure. Third, there is uncertainty around our estimates, and the convenience value of making payments electronically could simply be higher than estimated.

Financial innovations may make the effective lower bound less negative by reducing costs of storing and using cash

In contrast, other factors could bring the ELB closer to the high (less negative) end of our estimates. For example, the decision to hold cash in significant amounts likely depends on both the level of interest rates and on how long the rates are expected to remain negative. If negative rates were to endure, financial innovations could develop over time to reduce the storage and usage costs associated with cash (Garbade and McAndrews 2012). An ETF physically backed by cash stored in a vault, for example, could help its investors achieve economies of scale, as such funds currently do for precious metals, yielding higher returns for investors than debt instruments with negative yields. A special-purpose bank that has only cash as an asset could also provide traditional banking services, such as chequing accounts and the ability to make electronic payments. Gold-backed payment cards have even been developed, allowing customers to make retail payments using gold stored in a vault.[5] Such financial innovations may make the ELB less negative by reducing costs of storing and using cash. All of this suggests that the lower bound becomes less negative as the expected duration of negative rates increases.

4 The fee charged on credit cards (1 to 3 per cent) has sometimes been used as a proxy for this convenience value. This figure may be an overestimate, given that the fee is charged on the value of the transaction, not on the total cash balance.

5 For more details, see www.bitgold.com.

Financial Market Frictions Associated with Negative Rates

The European experience with negative rates suggests that Canadian financial markets could also adapt to negative rates

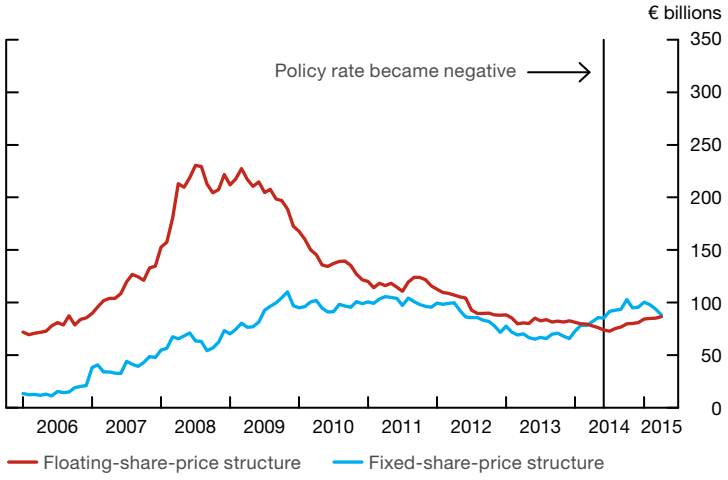
Market frictions exist in many financial contracts and products with payoffs that are explicitly or implicitly constrained from going below zero, including money market mutual funds (MMMFs), floating rate notes (FRNs) and repurchase agreements (or repos). Financial markets in European countries with negative interest rates continue to function reasonably well, suggesting that these market frictions have not posed any significant constraints on negative rates. Generally, affected market participants in Europe have used two methods to adapt to negative interest rates. Some have accepted a reduced profit margin or used other business lines to subsidize lower revenue or losses, while others have altered financial contracts by removing any implicit floor when interest rates became negative. This experience suggests that Canadian financial markets could also adapt to negative rates, although the relative importance of some of these markets differs for Canada and Europe. We discuss the potential effects of negative rates in Canada on each of the financial products noted above.

Money market mutual funds

MMMFs have a fixed share price and pay their shareholders a non-negative dividend that is roughly equal to a prevailing money market interest rate less management fees. Should money market interest rates become negative, MMMFs with a fixed share price would become unprofitable. Indeed, the immediate response of many euro-denominated MMMFs to negative rates was to waive their expense fees and absorb the losses rather than passing them on to their investors. Some euro-denominated MMMFs have prepared for a more persistent negative rate environment by converting from a structure with a fixed share price to one with a floating share price.[6] Overall, however, evidence in Europe indicates that negative rates have generally had minor effects on MMMFs, which have not experienced abnormal redemptions during the current episode (**Chart 2**).[7] While similar behaviour could

Chart 2: Euro-denominated money market mutual fund assets

Assets under management of MMMFs domiciled in Luxembourg and Ireland



Source: Morningstar

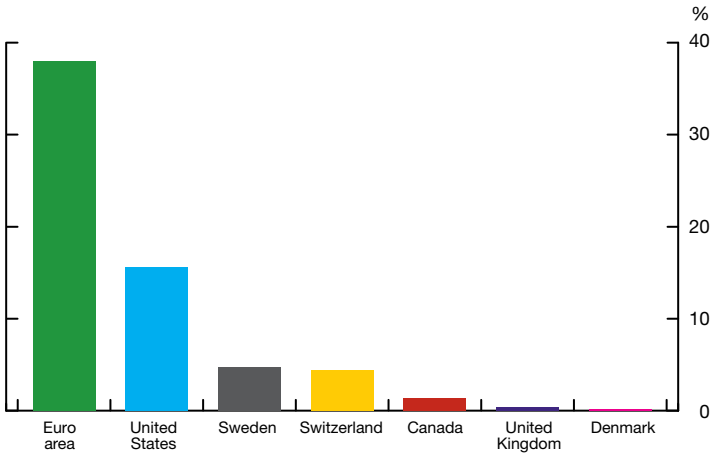
Last observation: April 2015

6 See http://www.bloomberg.com/news/articles/2012-10-19/jpmorgan-readies-clients-for-negative-euro-money-yields.

7 When negative rates were introduced in Japan, some Japanese fund managers announced that they would close their money market funds.

Chart 3: Market size of money market mutual funds by region

Money market fund assets as a share of GDP



Sources: Investment Company Institute (ICI) and Central Intelligence Agency (CIA) World Factbook

Last observation: 31 December 2014

be expected in Canada, MMMFs are a relatively small part of the financial system, and the impact of any potential disruption in this sector on the functioning of the financial system as a whole would therefore be limited (**Chart 3**).

Floating rate notes

Issuers of FRNs pay coupons to their bondholders based on a short-term, floating rate.[8] Several FRNs have explicit clauses preventing interest rate payments from falling below zero. For those that do not have such a clause, investors have perceived an implicit floor of zero.[9] Thus, in principle, FRN issuers are constrained from accessing funding at negative rates. In European FRN markets, coupon rates have not fallen below zero, even though the 3-month Euro Interbank Offered Rate (EURIBOR) has been negative since April 2015. Issuers of FRNs have also adapted, however, issuing FRNs at a price above par, which in turn implies a wider coupon spread to EURIBOR to reduce the possibility that actual coupon payments approach negative territory. It is not inconceivable that Canadian FRN issuers may also respond to negative rates in a similar way.

Repos

When rates become negative, the securities borrower in a repo transaction incurs a smaller penalty for failing to return the borrowed security, potentially resulting in more frequent failures to deliver securities in repo transactions. Conceptually, this could lead to disruptions in the overnight repo market, which could impair the Bank's ability to guide the overnight rate toward its target.[10] In Europe, the general collateral (GC) repo market has continued to function normally despite repo rates being very close to zero from

8 FRNs are securities with a coupon payment based on a short-term benchmark interest rate, such as the Euro Interbank Offered Rate (EURIBOR) in Europe or the Canadian Dollar Offered Rate (CDOR) in Canada. FRNs outstanding in Canada represent about $170 billion, or about 10 per cent, of total non-Government of Canada bonds outstanding.

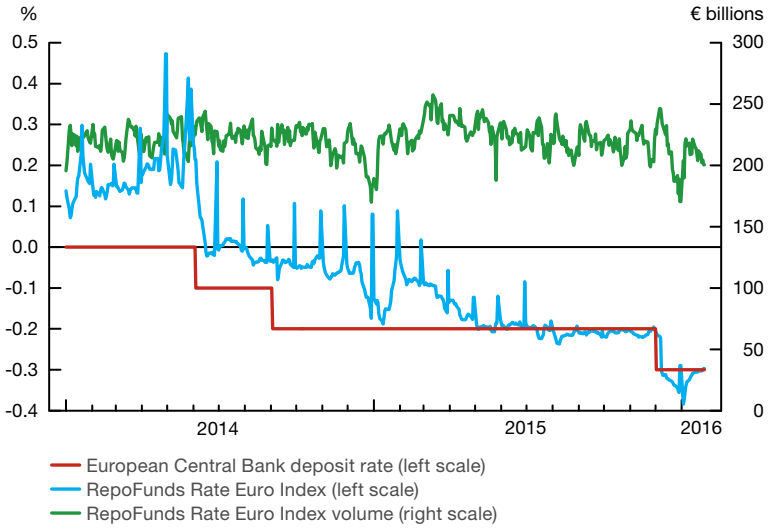
9 For example, European investors are now seeking contractual guarantees that they are not liable to borrowers when floating rates become negative. "Box 1: The Financial System Implications of Negative Interest Rates," Bank of Canada *Financial System Review* (June 2015): 7.

10 General collateral (GC) repo markets are important for the implementation of monetary policy in Canada, since, unlike other jurisdictions, our target is the overnight (i.e., 1-day) GC repo rate of interest.

2012 to 2014 and persistently negative since 2014. Repo volumes have been steady over this period (**Chart 4**), and there is no evidence of market disruption or increased fail rates.[11] The lack of settlement failures in Europe could also indicate non-negligible reputational costs associated with settlement failures.

While negative rates could lead to more settlement failures in the repo market, this problem is not insurmountable. After US rates were reduced to their ELB during the financial crisis, for example, chronic settlement failures of US Treasury transactions led the US Treasury Market Practices Group (2009) to adopt an industry-wide fail fee, which reduced settlement failures in the repo market substantially.

Chart 4: Trading volumes in the euro area core funding markets



Source: Bloomberg

Last observation: 29 January 2016

The Economics of Implementing Negative Rates

The Bank of Canada operates a corridor system with no reserve requirements. Its target for the overnight rate is at the midpoint of a 50-basis-point corridor. Participants in the Large Value Transfer System are charged the rate at the upper limit of the corridor (the Bank Rate) for overdraft loans from the Bank. Participants with end-of-day excess balances with the Bank are compensated at the rate at the lower limit of the corridor (the deposit rate).[12] Participants thus have economic incentives to trade within the operating band and close to the target rate. Since it is a closed system, participants with a short cash position know that there is at least one other participant with a long (extra) cash position.

Incentives to trade near target remain the same whether the target policy rate is zero or negative

The incentives to trade near the target rate remain the same when the target policy rate is zero or negative: participants are better off trading with each other at interest rates inside the operating band than with the Bank at the limits of the operating band. If the target rate were -25 bps, for example, participants' long money at the end of the day would receive a

11 "Box 1: The Financial System Implications of Negative Interest Rates," Bank of Canada *Financial System Review* (June 2015): 7.

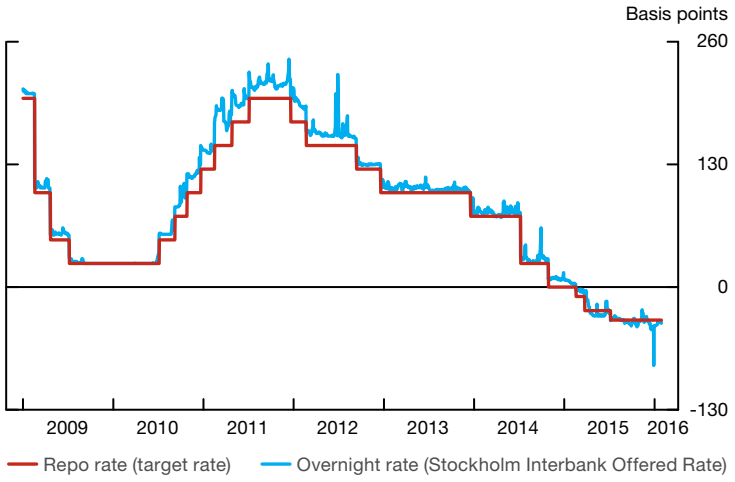
12 For more details, see http://www.bankofcanada.ca/markets/market-operations-liquidity-provision/framework-market-operations-liquidity-provision.

lower-than-market rate of -50 bps on such balances deposited at the Bank. Similarly, participants that are short money at the end of the day would pay a higher-than-market rate of 0 bps on overdraft loans from the Bank. Participants would therefore be better off trading with each other within the band and would generally negotiate a rate near the target rate of -25 bps. The Bank's operating framework should therefore continue to function effectively with the target rate below zero.

Some jurisdictions with large reserve surpluses have tailored their monetary policy framework to the negative interest rate environment. Switzerland and Japan, for example, have exempted a significant portion of banks' deposits at the central bank from being subject to negative rates. Such a system of tiered negative rates serves to limit the impact of negative interest rates on banks' profit margins. In Canada, however, banks do not have significant deposits with the Bank of Canada; hence, a negative deposit rate does not have the same adverse effect on the profit margins of Canadian banks.

When rates are below zero, the Bank is able to maintain the overnight rate near the target rate, provided that markets are functioning well and participants are not hoarding cash, which is likely to be the case if the target is at or above the Bank's estimated ELB. Indeed, in European jurisdictions, monetary policy has continued to function well even with overnight rates below our, perhaps conservative, estimated ELB of -50 bps. In Sweden and Switzerland, market interest rates continue to trade near the target rate for these jurisdictions, even though the rates are set below -50 bps (**Chart 5** and **Chart 6**).

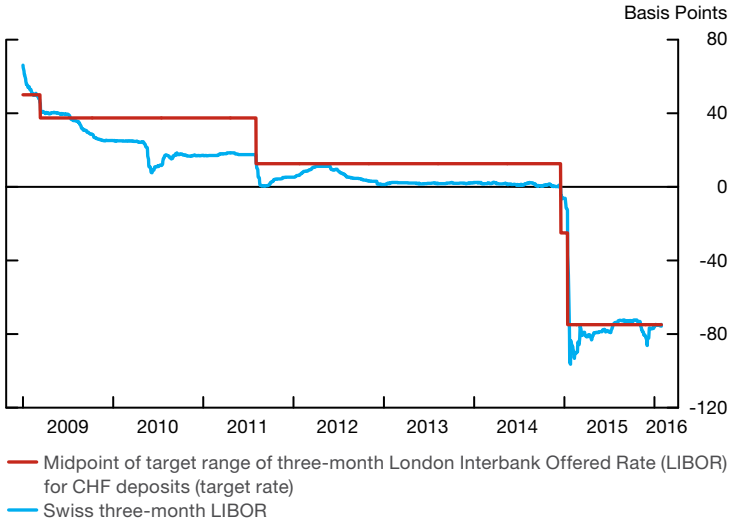
Chart 5: Swedish overnight rates relative to target



Sources: Sveriges Riksbank, Datastream and Bloomberg

Last observation: 29 January 2016

Chart 6: Swiss three-month rates relative to target



Sources: Swiss National Bank, Datastream and Bloomberg Last observation: 29 January 2016

Monetary Policy Transmission at Low or Negative Rates

In theory, negative interest rates do not fundamentally alter the monetary policy transmission mechanism. They are expected to stimulate the economy by affecting market interest rates, bank lending, asset prices and exchange rates.[13] Empirical observations, however, suggest that the monetary policy transmission mechanism may have become weaker at low or negative rates.

Transmission of changes to monetary policy through the bank lending channel may be less effective when rates become negative. In the euro area, the pass-through of policy rate cuts to retail deposit rates has been shown to be weaker when rates are already low but still positive (Paries et al. 2014). A similar pattern is observed when rates are negative. In Switzerland, Denmark and Sweden, retail deposit rates for commercial banks have not declined to the same extent as central bank target rates and remain in positive territory. Swiss and Danish banks, however, have largely passed on the negative rate cuts to their large corporate deposit accounts. A recent survey suggests that many depositors are likely to withdraw their deposits from banks and/or change their saving behaviours when faced with negative rates.[14]

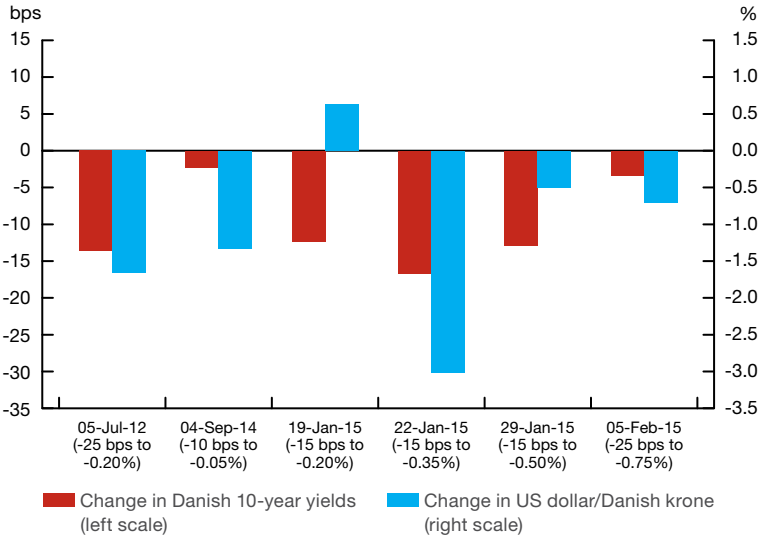
The transmission of further policy rate cuts in the negative zone through bank lending rates has been diminishing. Banks are reluctant to pass on negative rates to their retail depositors, which limits the extent to which banks can reduce their lending rates without sacrificing profitability (Jensen and Spange 2015). In fact, some critics relate the recent weak performance of some European banks to concerns over a decline in their profitability, which is seen to be associated with negative rates. Some even argue that if the negative effect on bank profitability persists, it may lead to a tightening of financial conditions, reducing the effect of monetary stimulus. Swiss banks, for example, increased their mortgage lending rates following the introduction of negative interest rates (Bech and Malkhozov 2016).

13 Buiter and Panigirtzoglou (2003) provide an early analysis of this rationale in a New Keynesian model.

14 In a survey of 13,000 consumers commissioned by ING, about three-quarters of the respondents said they would withdraw funds from their savings accounts, and 10 per cent responded that they would save more if rates were negative (Cliffe 2016).

Chart 7: Danish yield and currency reactions to rate cuts below the zero lower bound

Changes from day before announcement to day after announcement



Sources: Bloomberg and Datastream

As expected, negative rates are being transmitted to long-term benchmark yields

There is evidence, however, that negative rates are being transmitted to long-term benchmark yields, as expected. It is well understood that monetary policy does not have total control over long-term rates but can affect long-term yields through changing expectations for future short-term rates. This is consistent with the recent experiences of Denmark and Sweden. Denmark, a small, open economy like Canada, is a good example of how negative rates transmit to longer-term yields. The Danish central bank has reduced the overnight policy rate deeper into negative territory on six occasions. For each policy rate announcement, we found that Danish 10-year yields dropped by as much as 15 bps (**Chart 7**).[15] Swedish announcements of negative rates have had a similar effect on 10-year yields (**Chart 8**).[16] The magnitude of the effects is broadly consistent with that of a rate cut when rates are positive.

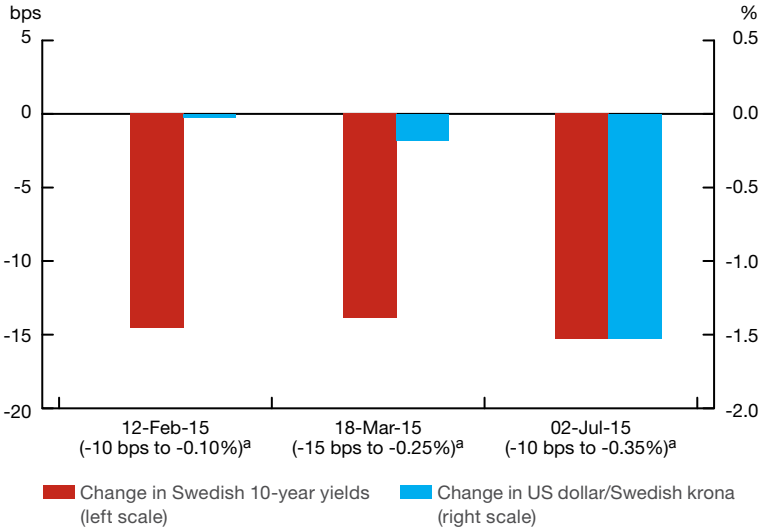
Moreover, there are indications that the transmission of monetary policy through the exchange rate channel continues to function when rates are negative. Exchange rates seem to have responded to a reduction in interest rates in Europe. Both Sweden and Denmark introduced negative rates in response to capital inflows and appreciation pressures. Our empirical analysis suggests that Swedish and Danish exchange rates have depreciated following most of their negative rate announcements. The Swedish krona depreciated with every announcement of a rate cut. The Danish krone depreciated on five out of six dates when rate cuts were announced, with the largest depreciation (3 per cent) in January 2015 (**Chart 7** and **Chart 8**). In the euro area, since the ECB deposit rate became negative in July 2014, the euro/US$ exchange rate had depreciated by almost 20 per cent by the end of 2015; this depreciation may also be attributable to the ECB's quantitative easing program and the divergence of its monetary policy from policy in the United States, among other factors.

15 The effect of the 29 January 2015 announcement shown in Chart 7 may be due to a combination of the negative rate announcement and the announcement by the Danish Ministry of Finance on 30 January 2015 that it would suspend the issuance of government bonds to offset an appreciation of the krone.

16 Since the Swedish announcements also included changes to its quantitative easing program, it is difficult to clearly separate the effect of quantitative easing from that of negative rates.

Chart 8: Swedish yield and currency reactions to rate cuts below the zero lower bound

Changes from day before announcement to day after announcement



a. Quantitative easing was announced simultaneously with a cut to the policy rate.

Sources: Bloomberg and Datastream

Conclusion

We do not know with certainty where the ELB for the Bank of Canada policy rate is, nor do we know precisely how long it could stay negative without causing disruptions to the financial system or a surge in the demand for cash. We do know that the ELB in Canada is lower than the earlier estimate of 25 basis points. Based on our analysis of international experience as well as the costs of holding and using cash, and taking into account Canadian market circumstances, our current best estimate is between -25 bps and -75 bps, with a median estimate of -50 bps. The experience in Europe demonstrates that markets have adapted reasonably well to the challenges associated with negative interest rates. Given uncertainty over the precise level of the lower bound, the Bank will continue to monitor both market functioning and the demand for cash in other countries to identify signals that their policy rates are approaching their lower bound. This will continue to inform Bank estimates of the potential ELB in Canada, should negative rates ever be deemed appropriate.

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The Micro and Macro of Downward Nominal Wage Rigidity

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- Evidence indicates that employers and employees are, in general, reluctant to reduce nominal wages when economic conditions would normally imply such an adjustment. In such a context, one solution that might be desirable would be a higher inflation target, which would lower real wages without necessitating nominal wage cuts. While the decision to change the inflation target is affected by many other considerations, this article focuses on downward nominal wage rigidity (DNWR) as an argument in favour of a higher inflation target, given its prominence in the literature.
- This article presents new evidence suggesting that in recent years the extent of downward nominal wage rigidity and its influence on average wage growth have increased in the Canadian labour market.
- Even if DNWR is important in the Canadian labour market, its presence alone is not sufficient to argue for a higher inflation target as long as the current target adequately addresses concerns that policy-makers have regarding the effective lower bound.

Some economists have long conjectured that, for a variety of reasons, employees and some employers are unwilling to decrease their nominal wage even when economic conditions justify a reduction. As a reason for their reluctance, employers often cite the impact that a cut in the nominal wage could have on worker morale and, hence, productivity. More-formal analysis of individual-level wage changes suggests that there are a large number of zero nominal wage changes and few nominal wage cuts relative to increases. Keynes (1936) and Tobin (1972) argue that the downward nominal wage rigidity (DNWR) demonstrated by employees and employers plays an important role in labour market dynamics and therefore has significant implications for macroeconomic policy. One implication central to monetary policy is that the presence of DNWR can lead to a long-run trade-off between inflation and unemployment when inflation is low.

The intuition for this trade-off starts with the notion that, in a low-inflation environment, the reductions in real wages that are required to offset the effects of a negative shock can only be achieved through nominal wage cuts. If employers are unwilling or unable to reduce nominal wages, their only recourse is to lay off workers, leading to an increase in the number of unemployed. One way to mitigate the adverse effects of DNWR on employment is higher inflation, which can lower real wages without a corresponding reduction in the nominal wage. When the inflation target is higher, DNWR

is less likely to prevent a decline in the real wage necessary to facilitate economic adjustment over a given time horizon. In other words, workers are assumed to suffer from "money illusion"; that is, they do not recognize the effect that inflation has in reducing the real value of their wages and so accept real wage cuts that they would not accept otherwise.[1] Proponents of this view, such as Akerlof, Dickens and Perry (1996) and Fortin (2013) regard inflation as "grease" that can aid labour market adjustments.

In the Canadian labour market, the extent of downward nominal wage rigidity and its influence on average wage growth have increased in recent years

Since one of the core questions associated with the 2016 renewal of the inflation-control target is whether to change the target, the Bank of Canada undertook work to examine the prevalence and implications of DNWR for Canada.[2] Brouillette, Kostyshyna and Kyui (forthcoming), extending Crawford and Wright's earlier analyses (2001 and 2004), re-examine whether DNWR is present in the Canadian labour market using two sources of Canadian micro-data representing the firm and worker levels and find evidence consistent with the presence of DNWR. They find that the extent of downward nominal wage rigidity and its influence on average wage growth have increased in recent years. Studies for other countries, such as the United States and Europe, also find evidence of the presence of DNWR in labour markets (Fallick, Lettau and Wascher 2016; Deelen and Verbeek 2015; Babecký et al. 2010; Dickens et al. 2007; and Fehr and Goette 2005).

At the same time, Amano and Gnocchi (forthcoming) take DNWR as a given and explore its implications for monetary policy in a macroeconomic model that includes an effective lower bound (ELB) on nominal interest rates. Preliminary results from their model support the finding that when DNWR and the ELB are each considered in isolation, they tend to favour a higher inflation target, in line with previous results from the literature. In fact, and similar to the case of DNWR, the ELB also provides a rationale for a positive inflation target, as discussed by Witmer and Yang (2016). At first glance, this might create expectations that introducing both frictions into a common framework would lead to an even higher optimal inflation target. However, the authors find that this is not the case. More specifically, adding DNWR to a model that already incorporates the ELB does not raise the optimal inflation target because firms' anticipation of DNWR dampens declines in prices, wages and, ultimately, interest rates. This effect, in turn, reduces both the frequency and the severity of ELB episodes for any given level of the inflation target.

Results by Amano and Gnocchi (forthcoming) and Brouillette, Kostyshyna and Kyui (forthcoming) exclude several factors that would be considered in a decision to change the inflation target. First, a higher inflation target may not help in the presence of downward real wage rigidity, which may even increase with inflation. Second, other real labour market frictions, such as a lack of flexibility in adjusting hours or the level of employment, might amplify the costs of DNWR and result in a higher inflation target than found in this article. Third, the findings hinge on the assumption that monetary policy follows a simple interest rate rule. However, unconventional monetary policy, such as quantitative easing, forward guidance and negative nominal interest rates, might completely eliminate the occurrence of ELB episodes

1 The assumption of money illusion is not essential for our argument. As an alternative, and to the extent that debt obligations are not indexed to inflation, workers might value DNWR because it reduces uncertainty about their future nominal income. If this is the case, they would accept a real wage cut triggered by a rise in inflation that would also reduce their real debt burden.

2 As part of its mandate to promote the economic and financial welfare of Canada, the Bank uses monetary policy to achieve a 2 per cent inflation-control target, within a target range of 1 to 3 per cent. This target is renewed every five years by the Government and the Bank of Canada. The next renewal is scheduled for the end of 2016.

and restore the traditional argument by Keynes (1936) and Tobin (1972) regarding the role of DNWR in labour market dynamics and macroeconomic policy (see page 15). Moreover, labour market policies implemented by the government may be more effective in addressing labour market frictions and may eliminate the need to grease the wheels of the economy through higher inflation. Finally, since the theoretical model is calibrated, the quantitative results should be taken as suggestive, although they seem qualitatively robust to changes in the calibration of key variables. With all these caveats in mind, the findings still qualify Tobin's conclusions and emphasize that DNWR is not sufficient by itself to justify an increase in the inflation target.

Evidence for Canada Based on Firm and Worker Data

To assess the extent of DNWR, changes in wages over time are usually examined, either at the job level (for a given position) or at the worker level (for persons keeping the same job). Recent work by Brouillette, Kostyshyna and Kyui (forthcoming) combines both types of microdata. The authors analyze changes in hourly wages using the Major Wage Settlement (MWS) data set and the Survey of Labour and Income Dynamics (SLID) data for Canadian employees.[3] The MWS data set contains reliable administrative data and covers a long period (January 1978 to May 2015) but only for unionized firms with more than 500 employees.[4, 5] The SLID data set consists of a representative sample of the entire Canadian working-age population from 1993 to 2011 but includes self-reported information, which may likely be subject to reporting errors. With MWS, the first-year change in the base pay is analyzed in a period when a wage negotiation took place; therefore, changes in wages that occur in a particular year but that were negotiated in previous years are not included in the sample.[6] With SLID, the individual hourly wage used in the analysis is derived from self-reported total hours worked and wage income, which includes tips, commissions and bonuses. Combining both sources of information allows for a more extensive analysis of DNWR in the Canadian labour market.

Measuring downward nominal wage rigidity

One way to measure DNWR is to analyze the distribution of the changes in hourly wages from one period to another (e.g., annually). For example, firms adjust wages following changes in the demand for their products or in the face of technological or productivity shocks. In the case of a negative demand shock, firms may need to reduce wages and may even lay off workers. But wage reductions could be prevented by DNWR. How would this be reflected in the distribution of the observed wage changes? **Chart 1** shows two possible wage distributions—with and without DNWR. Assume, for example, that 25 per cent of firms experience a negative demand shock following an adverse commodity price shock and want to reduce wages. Firms in other sectors are much less affected and either freeze wages (40 per cent) or increase wages (35 per cent).[7] In the absence of DNWR, wages are fully flexible and all firms wanting to reduce wages (25 per cent)

3 SLID was a survey conducted by Statistics Canada. MWS data are collected by the Labour Program at Employment and Social Development Canada.

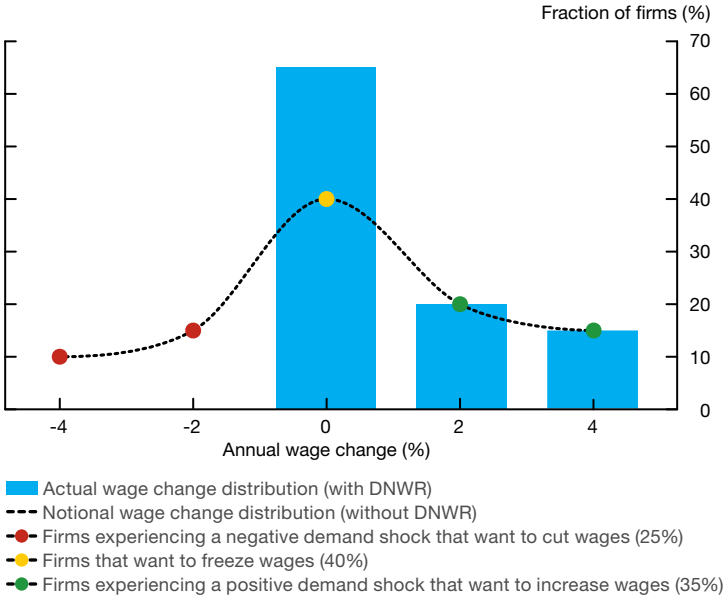
4 The term "firms" here refers to both public sector organizations and private sector firms.

5 According to Crawford and Harrison (1998), the wage distribution of the MWS data is not significantly different from some other data sources (e.g., the annual compensation survey of Sobeco Ernst and Young for 1989–96).

6 An important caveat here is that the resulting data set covers only those large unionized firms that negotiate a wage change in a reference year.

7 All the numbers cited in the example are hypothetical.

Chart 1: Hypothetical example of the distribution of wage changes with and without downward nominal wage rigidity (DNWR)



Note: All numbers are hypothetical.
Source: Authors' calculations

can do so. The distribution of wage changes without DNWR—the notional wage change distribution—is depicted in **Chart 1** by coloured dots on the dotted line. In the presence of DNWR, however, desired wage cuts turn partially or fully into wage freezes. In this simple example, assuming that all wage cuts are turned into wage freezes, 65 per cent of firms overall would freeze wages, compared with 40 per cent when DNWR is not present. The actual, or observed, wage distribution in the presence of DNWR is shown by the blue bars. An increase in the percentage of freezes in hourly wages may therefore be an indicator of the growing importance of DNWR. Estimates of the impact of DNWR can then be derived by comparing the notional and observed distributions of changes in hourly wages.

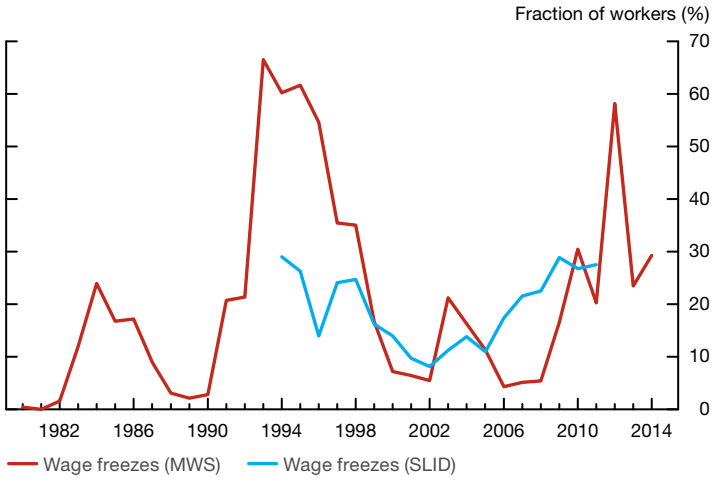
Downward nominal wage rigidity in Canada

The increase in the share of workers experiencing wage freezes is driven not only by lower inflation but also by the weakness in aggregate demand

Data from both MWS and SLID provide evidence that the effect of DNWR may have increased in recent years. **Chart 2** depicts the proportion of wage freezes observed in both the MWS and SLID data (red and blue lines, respectively).[8] As suggested by the MWS data, the proportion of freezes in hourly wages increased from 5 per cent in 2008 to almost 58 per cent in 2012. The percentage of wage freezes, however, dropped to about 25 per cent in 2013 and 2014. SLID data also show an increase in the percentage of wage freezes from 2008 to 2011, although this increase was smaller. Interestingly, a similar level of wage freezes was observed in the MWS data in the early 1990s, when the inflation level and the inflation-control target were higher. This suggests that the increase in the share of workers experiencing wage freezes is driven not only by lower inflation but also by the weakness in aggregate demand.

8 In the SLID data, the analysis is restricted to job-stayers, defined as workers having a job tenure of at least 24 months, who had only one paid job (self-employed workers and those working at non-paid jobs are excluded from the analysis). The change in average annual wage in the SLID data is taken into account here. In the MWS data, the unit of observation is a firm negotiating a change in the base pay in a given year.

Chart 2: Observed wage freezes in Canada



Sources: Major Wage Settlement database, Survey of Labour and Income Dynamics data and Bank of Canada calculations

Last observations: MWS, 2014; SLID, 2011

The average wage change decreased substantially over the entire period, from about 13 per cent in the early 1980s to 1.5 per cent in 2014, in line with the lower level of inflation observed in Canada after the introduction of the inflation-control target. The variance of wage changes also declined after the early 1980s. Following the Great Recession, over the period from 2008 to 2012, the average wage change decreased from 3.4 per cent to 1.6 per cent.

The percentage of hourly wage freezes cannot by itself identify the extent of DNWR because some workers might have experienced hourly wage freezes even in the absence of DNWR, as discussed in the simple example described above. More extensive empirical analysis is necessary to identify the percentage of hourly wage freezes driven by DNWR. The main hurdle is the estimation of the notional distribution of hourly wage changes, which, by definition, is not observed. Assumptions need to be made on the properties of the distribution, and results may be sensitive to these assumptions.

Extending the analytical framework of Crawford and Wright (2001), Brouillette, Kostyshyna and Kyui (forthcoming) estimate the underlying notional distribution of changes in hourly wages. The authors then quantify the impact of DNWR on average wage growth (i.e., by how much DNWR inflated average wage growth because its presence prevented some wage cuts). Their empirical analysis using MWS data suggests that the effects of DNWR have become slightly more important since the Great Recession. For example, annual wage growth of workers in large unionized firms was inflated by about 0.2 percentage points (pp), on average, during the 2010–15 period because of the presence of DNWR, while the average impact between 2006 and 2008 was less than 0.1 pp.[9] Estimates using MWS data are presented here because MWS was the main source of data historically used to study DNWR in Canada, despite its limited coverage. Estimation results using the SLID data are qualitatively similar in the sense that these data also suggest that the effects of DNWR have increased since the 2009 recession. Quantitatively, the results from the SLID data also suggest that the effects of DNWR might be larger for smaller firms than for bigger firms.

9 It is noteworthy that the impact of DNWR also increased in the wake of the 1991 recession, although to a larger extent, from less than 0.1 pp (1986–91) to 0.7 pp (1992–97).

Our results are in line with the findings in the empirical literature for Canada and other countries—that DNWR is present. We should be cautious, however, before concluding that our results imply that DNWR has real macroeconomic effects on, for example, long-run employment. This is especially true considering that the analysis excludes other types of labour market frictions that could affect unemployment in the absence of DNWR.[10] Some previous studies analyzing DNWR in Canada (e.g., Fortin 2013; Simpson, Cameron and Hum 1998) find that the combination of DNWR and low inflation pushed unemployment above the level it would have been in the absence of DNWR, suggesting that real wage erosion through inflation takes more time when inflation is low. In contrast, Farès and Lemieux (2001), Faruqui (2000) and Farès and Hogan (2000) find that DNWR had no long-term effect on unemployment. Overall, the presence of DNWR is not by itself sufficient to support the inference that the natural rate of unemployment may be higher than it would be in the absence of DNWR.

The presence of downward nominal wage rigidity (DNWR) is not by itself sufficient to support the inference that the natural rate of unemployment may be higher than it would in the absence of DNWR

The Macroeconomics of Downward Nominal Wage Rigidity

Modelling downward nominal wage rigidity and the effective lower bound

In addition to DNWR, the recent experiences of central banks operating at or near the ELB have also raised the question of whether a higher inflation target would provide policy-makers with a potentially useful buffer against this lower bound (see Blanchard, Dell'Ariccia and Mauro 2010). While these two issues have been studied separately with respect to their implications for the inflation target, relatively little work has been done on their interaction. In an effort to fill this important gap, Amano and Gnocchi (forthcoming) construct several variants of a standard New Keynesian model with different combinations of DNWR and the ELB.[11] In particular, they start with a standard New Keynesian model in which price and wage adjustment entails costs that increase disproportionately to the size of the adjustments. The model is calibrated such that nominal prices and wages adjust every two and four quarters, respectively. Nominal price rigidity generates a New Keynesian Phillips curve that positively links price inflation to the unit labour cost. Monetary policy is represented by a Taylor rule, with a 1.2 weight on inflation's deviations from target, a 0.07 weight on GDP fluctuations and a 0.4 weight on the lagged interest rate.[12] Conditional on this rule and a set of demand and supply shocks, the model is simulated over a series of inflation targets that range from zero to five. The optimal rate of inflation is then computed as the one that maximizes households' welfare.[13] The quantitative results should only be taken as suggestive. However, these results are qualitatively robust to changes in the calibration of key variables, including the length of nominal contracts, the sensitivity of monetary policy to deviations

10 An issue not investigated in this analysis is the presence of downward real wage rigidity (DRWR). A higher inflation target may not be desirable if it generates more DRWR, making the real wage adjustment even more difficult. In such a case, other labour market policy (e.g., a policy introducing more flexibility in hours worked) may be needed to facilitate the labour market adjustment.

11 In this article, we focus on the case of a zero lower bound for both the nominal interest rate and nominal wage growth.

12 The calibration of the Taylor rule is borrowed from Kim and Ruge-Murcia (2009), who study optimal monetary policy in the presence of DNWR without taking into account the ELB constraint.

13 The theoretical model assumes that the economy is closed to international trade and thus does not account for the loss of competitiveness that DNWR would impose on exporters in the event of an adverse productivity or foreign demand shock. However, the model captures these costs in an ad hoc fashion through domestic supply shocks. In fact, these shocks harm the economy if prices and nominal wages are not perfectly flexible and call for a positive inflation target, even in this setup, as in Tobin's original argument.

in inflation and output, the relative size of the demand and supply shocks, the interest rate elasticity of consumption demand, and the level at which the ELB is imposed.

The results are summarized in **Table 1**. In the model, a positive inflation target increases relative price dispersion because of price and wage rigidity and leads to an inefficient allocation of resources (Woodford 2003), making fluctuations in inflation costlier as the trend level of inflation rises (Coibion, Gorodnichenko and Wieland 2012). In fact, as relative price dispersion grows larger, households and firms increasingly dislike uncertainty about the level of price dispersion and inflation. For the baseline case with no DNWR or ELB, inflation does not have any benefit but only entails welfare costs, and the optimal inflation target is found to be zero, consistent with previous literature (Woodford 2003).

Table 1: The impact of the effective lower bound and downward nominal wage rigidity on the optimal inflation target

Version of model	Optimal inflation target (per cent)
No ELB or DNWR	0.0
ELB	4.5
DNWR	1.0
ELB and DNWR	1.5

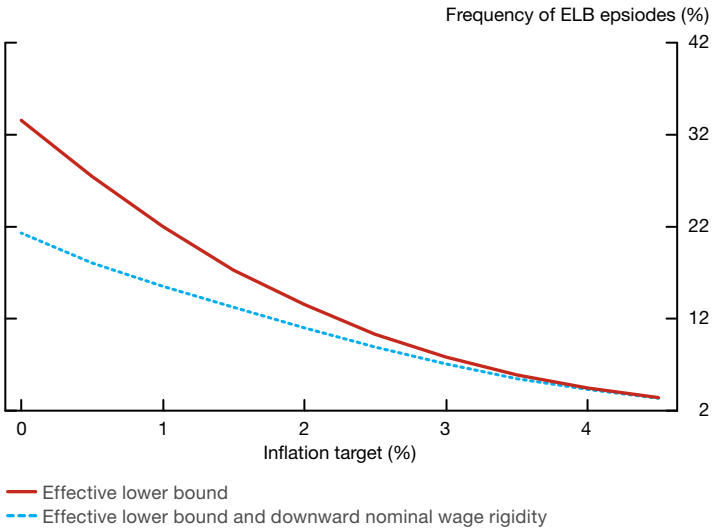
Source: Authors' calculations

In a second version of the model (the ELB model), the ELB is imposed at 0 basis points, and the model is simulated using the same calibration as for the baseline case. As shown in **Table 1**, this causes the optimal inflation target to rise from 0 to 4.5 per cent. Positive trend inflation provides the economy with a buffer against ELB episodes, during which volatility in inflation and output spikes. On the other hand, a higher inflation target magnifies inflation volatility in normal times, generating larger inefficiencies. This trade-off explains why the optimal level of the inflation target is not large enough to eliminate ELB episodes completely, which occur with a frequency of roughly 3.5 per cent in the case of a 4.5 per cent inflation target (**Chart 3**), as opposed to a frequency of 33 per cent in the case of a zero inflation target.

A third version includes DNWR but not the ELB. DNWR is modelled by placing a zero lower bound on the growth of nominal wages, thus capturing the notion that firms may face greater frictions when contemplating nominal wage decreases relative to increases of the same magnitude. This allows the model to capture the effects of DNWR without appealing to the traditional assumption of money illusion. As shown in **Table 1**, this version of the model places the optimal inflation target at 1 per cent, given that higher inflation helps to "grease the wheels" of real wage and labour market adjustments.

Chart 4 provides a comparison of the dynamic responses of the DNWR model with the baseline model (with no DNWR or ELB), when the models are perturbed by a negative demand shock and the inflation target is set at 2 per cent. Wage inflation, which is initially at its 2 per cent trend level, decreases by 2 pp after the shock and hits its lower bound in the DNWR model. Since DNWR prevents nominal wages from falling further than in the baseline model, inflation and nominal interest rates also tend to react by less. Hence, for a given interest rate rule, DNWR diminishes the accommodation provided by monetary policy and causes employment to decline by more than it would otherwise, depressing consumption.

Chart 3: The effect of downward nominal wage rigidity on the frequency of effective lower bound episodes



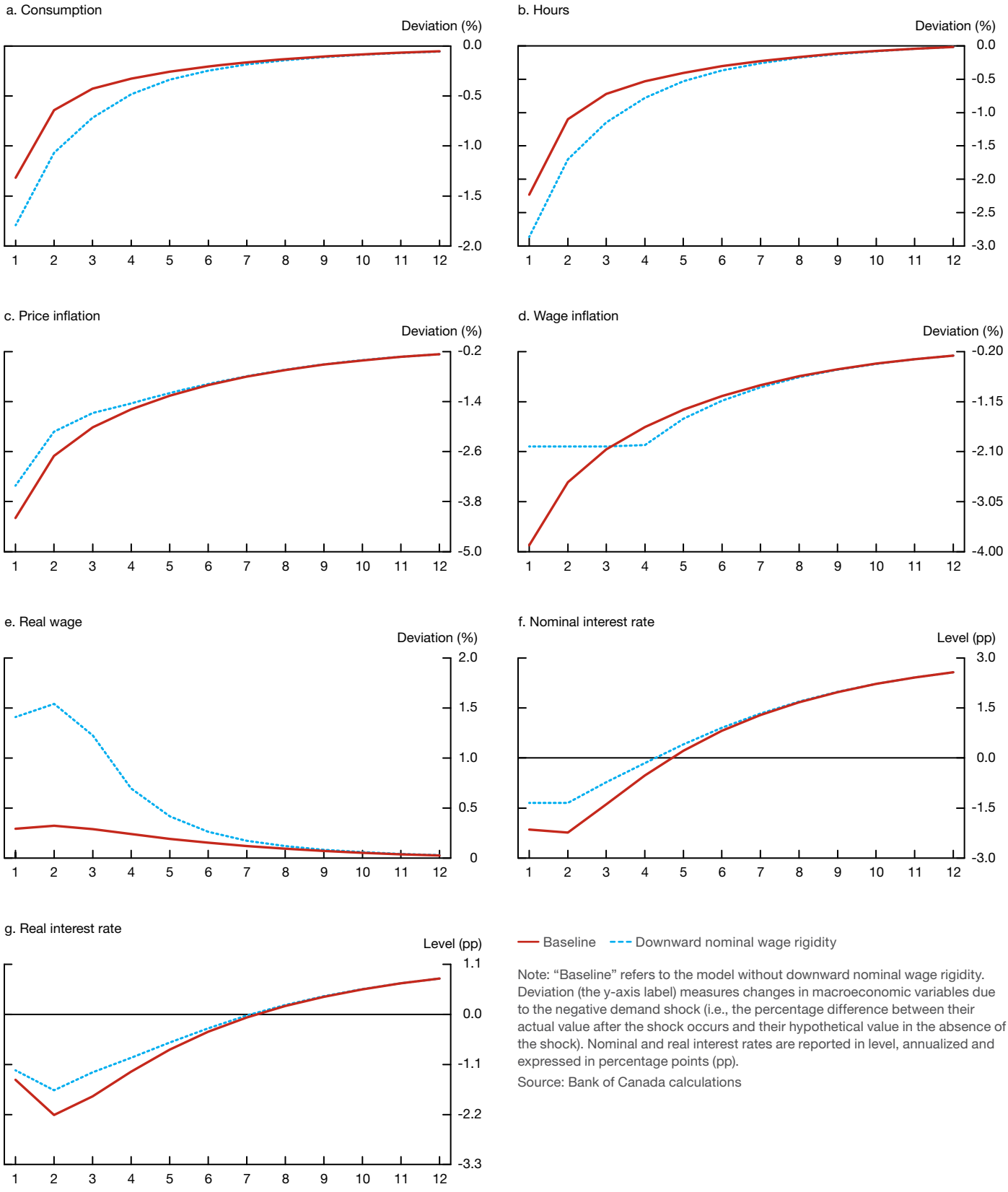
Source: Bank of Canada calculations

Downward nominal wage rigidity moderates declines in nominal wages and, subsequently, in prices and interest rates. This dampening effect then reduces the frequency of episodes of the effective lower bound for any given inflation target

The final version of the model incorporates DNWR and the ELB simultaneously (the ELB-DNWR model). As mentioned above, one might initially think that these two frictions would jointly drive the optimal inflation target above the 4.5 per cent prescription delivered by the ELB-only version. However, our results suggest otherwise. Indeed, relative to the ELB-only model, the optimal inflation target when DNWR is included falls to 1.5 per cent. The principal reason for this drop is that DNWR moderates declines in nominal wages and, subsequently, in prices and interest rates. This dampening effect then reduces the frequency of ELB episodes for any given inflation target. **Chart 3** illustrates the magnitude of this effect. In this chart, the frequency of ELB episodes (vertical axis) is plotted against the inflation target (horizontal axis). The solid line corresponds to the ELB-only model, while the dashed line corresponds to the model with both frictions. When policymakers target zero inflation, we see that the introduction of DNWR causes the frequency of ELB episodes to fall from 33 per cent to 20 per cent, approximately. However, as the inflation target rises, the effect of DNWR on the frequency of ELB episodes weakens, especially once the inflation target exceeds 3 per cent. A similar picture emerges with respect to the average duration of ELB episodes. For example, our baseline calibration predicts that the introduction of DNWR should reduce the average duration of ELB episodes by 40 per cent when the inflation target is at zero, but by only 20 per cent when the inflation target is at 2 per cent.

Chart 5 demonstrates these effects by comparing the response of the ELB-only model (solid line) with that of the ELB-DNWR model (dashed line) following a demand shock that forces the nominal interest rate to its ELB. From this chart, we see that DNWR has the conventional effect of placing upward pressure on real wages. In isolation, this effect would tend to favour lower employment. However, **Chart 5** also makes it clear that the response of price inflation in the ELB-DNWR model is substantially diminished relative to that in the ELB model. In particular, price inflation falls by only 4 per cent in the ELB-DNWR model, whereas inflation in the ELB model declines by more than 8 per cent and remains lower for more than one year. Since

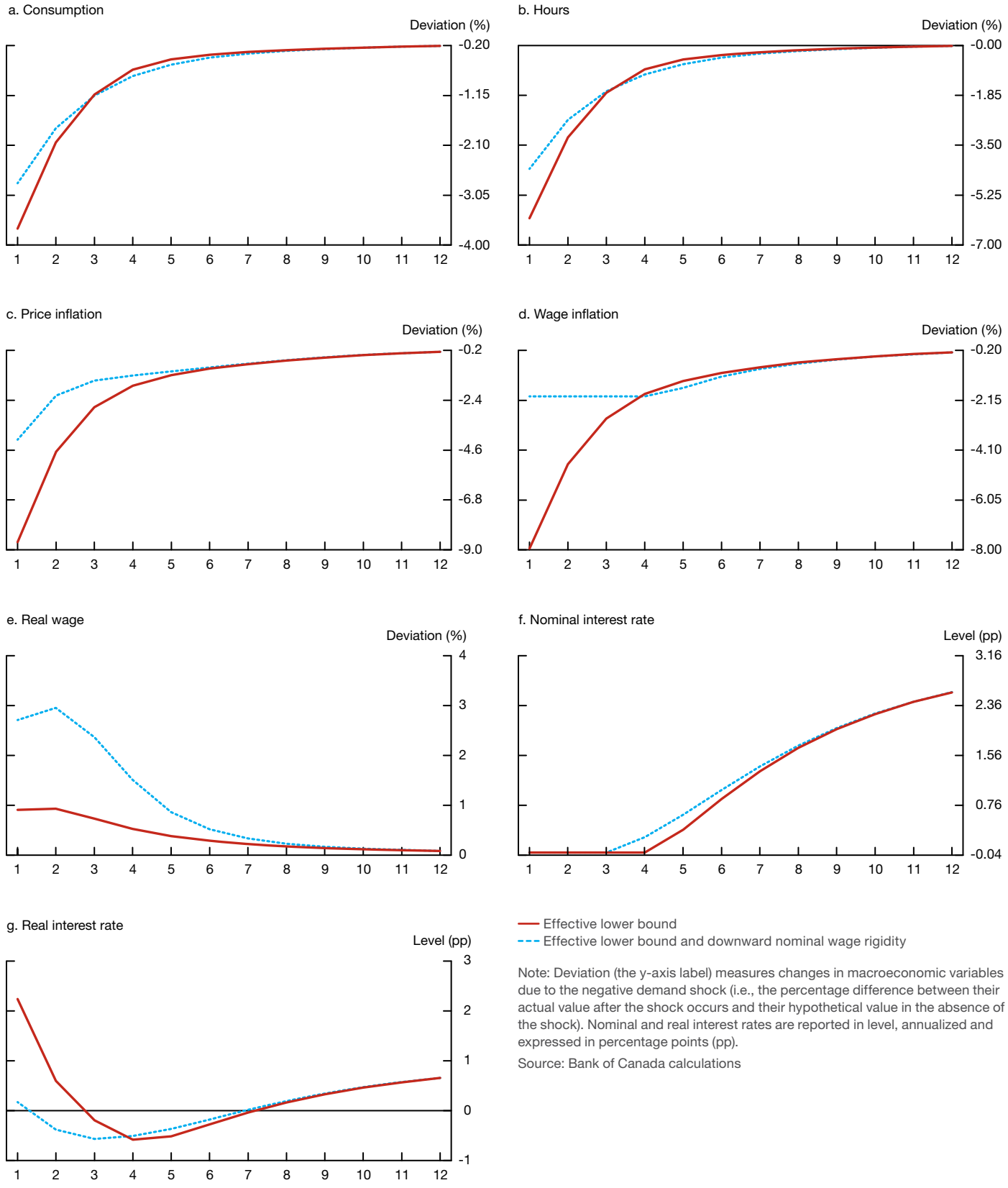
Chart 4: Effect of a negative demand shock on macroeconomic variables in the absence of the effective lower bound
Quarters after the shock



Note: "Baseline" refers to the model without downward nominal wage rigidity. Deviation (the y-axis label) measures changes in macroeconomic variables due to the negative demand shock (i.e., the percentage difference between their actual value after the shock occurs and their hypothetical value in the absence of the shock). Nominal and real interest rates are reported in level, annualized and expressed in percentage points (pp).

Source: Bank of Canada calculations

Chart 5: Effect of a negative demand shock on macroeconomic variables when the effective lower bound is taken into account
Quarters after the shock



Note: Deviation (the y-axis label) measures changes in macroeconomic variables due to the negative demand shock (i.e., the percentage difference between their actual value after the shock occurs and their hypothetical value in the absence of the shock). Nominal and real interest rates are reported in level, annualized and expressed in percentage points (pp).

Source: Bank of Canada calculations

higher inflation translates into lower real interest rates due to the ELB, the ELB-DNWR model thus delivers lower real rates in response to the demand shock. In isolation, these lower real rates would tend to favour higher aggregate demand and, in turn, higher employment. The net impact of DNWR on employment thus depends on how the benefits associated with lower real rates balance against the costs associated with higher real wages. From **Chart 5**, we see that the former dominates, with the ELB-DNWR model ultimately delivering higher employment, higher consumption and a lower duration for the ELB episode.[14]

Overall, combining DNWR with the ELB reduces the frequency, duration and welfare cost of ELB episodes relative to the ELB-only case. This suggests that previous literature focusing exclusively on the ELB may have overestimated the optimal inflation target.

Theory of the second best

The result that the ELB and DNWR combined does not lead to a higher inflation target than the ELB alone may, at first, seem a little surprising. However, the result has an analogy in the public finance literature and the theory of the "second best." The ELB and DNWR are both undesirable constraints because each of them considered in isolation prevents the economy from efficiently responding to aggregate shocks. Combined, however, they partially offset each other so that DNWR is desirable when the ELB is binding, similar to a fiscal subsidy that counteracts the negative effects of a distortionary tax, a case often discussed in the literature of public finance. For example, Bénabou (2002) and Bovenberg and Jacobs (2005) show that subsidizing education improves welfare because progressive income taxation discourages the accumulation of human capital by lowering expected returns from schooling. This example, like our finding, is an application of the theory of the second best, first formalized by Lipsey and Lancaster (1956–57): in economies where it is impossible to perfectly correct a particular distortion, introducing a second distortion may mitigate the first one and lead to a more efficient outcome. As a result, the second best might counterintuitively differ from efficiency.

According to the findings by Amano and Gnocchi (forthcoming), DNWR acts as both a complement and a substitute for monetary policy when the ELB is taken into account. On the one hand, DNWR works with a positive inflation target in reducing the risk of monetary policy becoming constrained by the ELB. On the other hand, when such a risk materializes, DNWR takes over the role of the policy rate—which cannot be further decreased—in supporting aggregate demand.

Downward nominal wage rigidity acts as both a complement and a substitute for monetary policy when the effective lower bound is taken into account

Conclusion

This article discusses two recent studies, Brouillette, Kostyshyna and Kyui (forthcoming) and Amano and Gnocchi (forthcoming), which analyze the extent of DNWR in the Canadian labour market and its implications for the conduct of monetary policy. One manifestation of DNWR should be an increase in the incidence of wage freezes in the distribution of wage changes as wage cuts become more difficult to implement. Microdata evidence shows that this has been the case in Canada since the mid-2000s,

14 Consumption is equal to the sum of wage income and firms' profits, net of price and wage adjustment costs. In the ELB-DNWR model, inflation is lower than in the ELB model and adjustment costs are smaller. As a result, percentage differences in consumption across models cannot be explained entirely by percentage differences in labour income.

which suggests that the effect of DNWR has increased. This conclusion is supported by the results of Brouillette, Kostyshyna and Kyui's empirical analysis that finds that the effects of DNWR on average wage growth have become stronger in recent years. For example, average wage growth was about 0.2 percentage points higher between 2010 and 2015, owing to the presence of DNWR among large unionized firms that negotiated wage changes during this period.

The results described in this article have a number of potential implications. First, DNWR may be an important piece of the "missing disinflation" puzzle of why advanced economies did not experience disinflations of the magnitude normally associated with the large output gaps witnessed during the Great Recession. That is, DNWR may play a role in stabilizing prices during periods of persistently high unemployment. Second, the presence of DNWR may suggest that nominal wages will lag the economic recovery because firms were unable to reduce their wages as much as they would have liked during the recession. Third, and perhaps most significant from the perspective of the 2016 renewal of the inflation-control target, the results suggest that DNWR is no reason to increase the Bank's inflation target if policy-makers are satisfied that the current target adequately accommodates their concerns about the ELB.

Downward nominal wage rigidity is no reason to increase the Bank's inflation target if policy-makers are satisfied that the current target adequately accommodates their concerns about the effective lower bound

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A New Era of Central Banking: Unconventional Monetary Policies

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- When conventional monetary policies come close to their limit, central banks can provide additional easing with unconventional policies.
- The international experience has been largely positive. Costs associated with these measures could, however, rise with extensive and prolonged use.
- When used simultaneously, unconventional measures can often be mutually reinforcing but can also lower the effectiveness of individual measures in some cases.
- Another challenge major central banks need to carefully plan for, manage and communicate is how and when to exit from such measures.

Over the past decade, central banks acted aggressively to counter the adverse effects of the global financial crisis and its aftermath, operating in uncharted waters as they implemented "unconventional monetary policies" (UMPs) such as quantitative easing (QE) and, more recently, negative policy interest rates.[1] While these interventions and many others introduced since the 2007–09 global financial crisis were initially thought to be temporary, some are expected to remain in place for longer than expected.[2] The unconventional is increasingly becoming conventional, and UMPs have established themselves as part of any modern central bank's tool kit.

A thorough assessment of their effectiveness and potential implications is essential for the sound conduct of monetary policy.[3] This is all the more pertinent as the neutral rate of interest—the rate of interest that would prevail with full employment and stable inflation in the medium term—has likely declined both in Canada (Mendes 2014) and abroad (Hamilton et al. 2015). This implies that, all else being equal, central banks will reach the limits of conventional monetary policy easing more often and the use of UMPs could become more likely than in the past. Yet, policies that have

1 This article uses the terms QE and large-scale asset purchases (LSAPs) interchangeably. The term "conventional monetary policy" refers to adjusting the key policy rate (Bank of Canada 2015), whereas the term "unconventional monetary policies" or, interchangeably, "non-standard measures" includes, but is not limited to, QE and negative interest rates.

2 Other measures include, but are not limited to, liquidity facilities (involving the provision of liquidity by central banks to address elevated pressures in term funding markets), credit facilities (measures aimed at restoring the functioning of a particular credit market and promoting bank lending), and forward guidance (central bank communication regarding the future path of the policy rate).

3 UMPs are deemed effective if they are able to support economic activity and inflation by providing further easing of financial and monetary conditions.

been introduced to improve the resilience of the financial system reduce the future likelihood of financial crises (Côté 2014) and potentially the need for implementing UMPs.

This article reviews the international experience with UMPs, focusing on QE, and briefly discusses negative interest rates.[4] It first discusses the channels through which these measures work and evidence of their effectiveness. It then examines the potential costs and the limits of these tools. This is followed by a discussion of the simultaneous use of multiple UMPs. A brief assessment of exit considerations is followed by a discussion of the broader implications for monetary policy.

The International Experience

Current measures

Central banks have introduced a wide range of measures that have evolved over time (see Reza, Santor and Suchanek [2015] for a summary). In each case, the measures were tailored in their nature, size and vigour to conditions specific to the country in which they are being implemented. Recently, monetary policy stances have begun to diverge: policy normalization has started in the United States with the Federal Reserve raising the policy rate late last year, and the Bank of England continues to prepare market participants for an eventual increase as well. They have nevertheless maintained the level of asset holdings and thus the size of their balance sheets in both cases. In contrast, the Bank of Japan, the European Central Bank (ECB) and some other European central banks (such as the Swedish Riksbank) have continued to expand their respective asset purchase programs to provide further monetary accommodation (**Chart 1**).

In addition, several central banks have lowered policy rates into negative territory (**Chart 2**). The ECB, for example, lowered its deposit rate below zero in June 2014 and cut it further three times, most recently to -0.4 per cent in March 2016. The policy rates at the central banks of Japan, Denmark, Switzerland and Sweden have also all gone negative.

Transmission channels and effectiveness

There are multiple channels through which lower market interest rates are expected to improve domestic financial and economic conditions

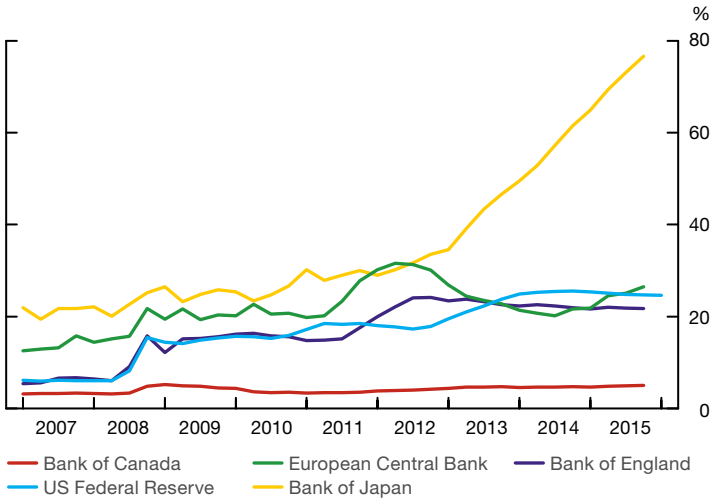
The channels through which asset purchases affect financial markets and transmit to the real economy, as well as evidence of their effectiveness, have been widely discussed (Poloz 2015; Reza, Santor and Suchanek 2015). QE pushes up the price of, and reduces the yield on, the purchased assets, thereby flattening the yield curve of the purchased asset class (**Chart 3**). There are multiple channels through which lower market interest rates are expected to improve domestic financial and economic conditions. Financing costs of firms and households are reduced, with lower interest rates providing incentives to increase borrowing.[5] At the same time, lower interest rates are lifting asset prices as investors are encouraged to shift out of government bonds into riskier assets. Higher asset prices can in turn create a

4 This article concentrates on the international experience with non-standard policy measures. For a discussion of options in the Canadian context, see the recently published *Framework for Conducting Monetary Policy at Low Interest Rates* (Bank of Canada 2015) and a speech by the Governor of the Bank of Canada (Poloz 2015).

5 QE may also have more indirect effects on private sector borrowing through balance sheet effects. If firms are able to borrow at a lower rate to pay off a debt that carries a higher rate, for example, their balance sheet position would improve, which could imply more investment spending at the margin in the future. Similarly, households may refinance mortgages at lower rates, improving their balance sheet position.

Chart 1: Total assets on central bank balance sheets

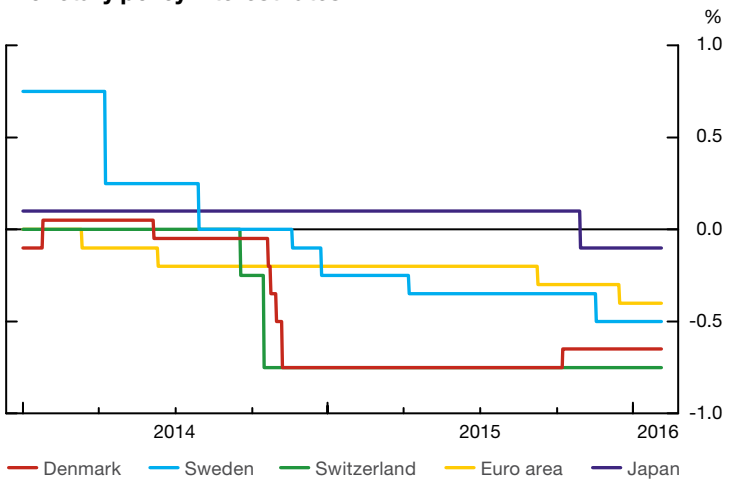
As a percentage of GDP, quarterly data



Sources: Statistics Canada; US Federal Reserve, US Bureau of Economic Analysis; European Central Bank; Bank of Japan, Cabinet Office of Japan; Bank of England, Office for National Statistics; and Bank of Canada calculations

Last observations: United States, 2016Q1; all others, 2015Q4

Chart 2: Monetary policy interest rates



Notes: Denmark—certificate of deposit rate; Sweden—repo rate/rate of interest on Riksbank certificates; euro area—deposit rate; Switzerland—midpoint of target range for three-month London Interbank Offered Rate; Japan—rate on outstanding balance of financial institution's current account

Sources: Danmarks Nationalbank, Sveriges Riksbank, Swiss National Bank, European Central Bank

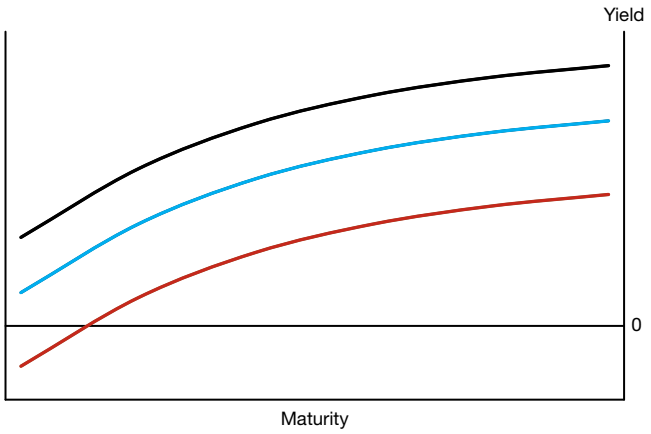
Last observation: 5 May 2016

wealth effect that boosts spending and confidence. And finally, by affecting expected interest rate differentials, QE puts downward pressure on the exchange rate, providing impetus to aggregate demand through improved price competitiveness of domestic production.

International evidence to date provides policy-makers with reasonable confidence that QE has served its purpose of providing significant monetary and financial easing. In particular, numerous studies have found that QE has lowered the interest rates not only on purchased assets but also on other

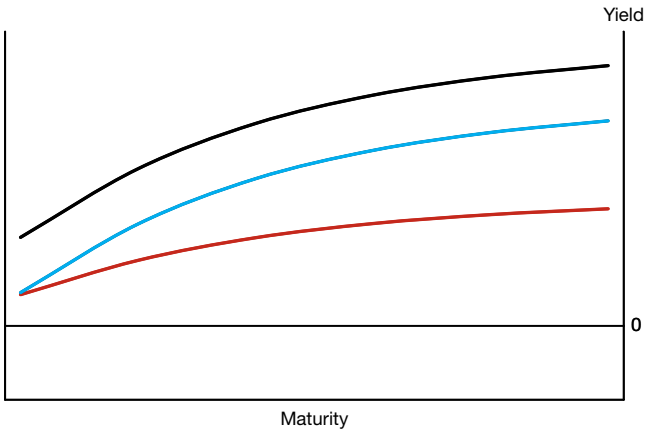
Chart 3: Effect of UMPs on yield curve (illustrative example)

a. Negative interest rates shift the yield curve down at all maturities



- Baseline
- Baseline + conventional monetary easing
- Baseline + conventional monetary easing + negative interest rates

b. Quantitative easing (and forward guidance) flatten the yield curve



- Baseline
- Baseline + conventional monetary easing
- Baseline + conventional monetary easing + quantitative easing (or forward guidance)

types of debt.[6] While more difficult to measure, researchers have also estimated the macroeconomic impacts of QE using a variety of models and methods and have concluded that asset purchases by major central banks had a sizable impact on GDP growth and inflation,[7] ultimately helping central banks achieve their mandated objectives. QE may thus be seen as a substitute for conventional monetary policy when policy rates are close to the effective lower bound (ELB).

Turning to negative interest rates, the channels of transmission are similar to those of conventional easing (Jackson 2015; Hannoun 2015), shifting the yield curve down at all maturities (**Chart 3**), rather than primarily at longer maturities as is the case with QE. While the experience is much more limited than with QE, the evidence is encouraging: short-term money market rates have declined and easing has been transmitted to assets of longer maturity (**Chart 4**). In jurisdictions that went negative, a significant proportion of the outstanding marketable government debt is now trading at negative interest rates. Yet, the pass-through of negative rates to market rates has been incomplete, suggesting that the monetary policy transmission mechanism may have become weaker (Witmer and Yang 2016). Moreover, the degree to which negative rates will be able to boost economic growth and support inflation has yet to be seen.

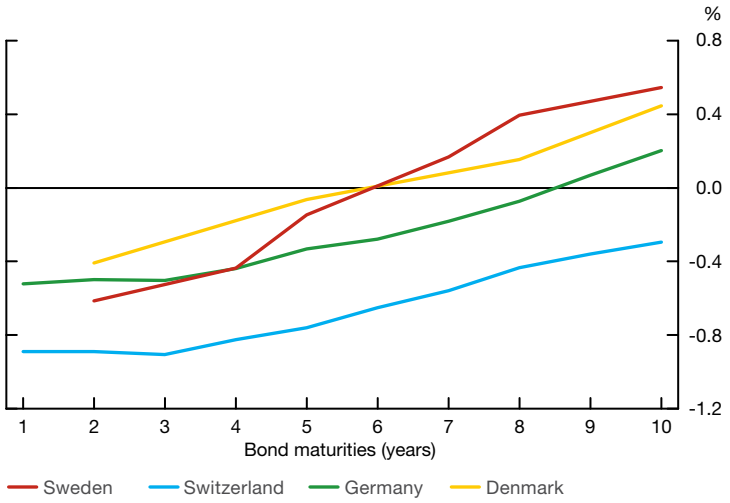
Quantitative easing may be seen as a substitute for conventional monetary policy when policy rates are close to the effective lower bound

6 For a review of empirical evidence, see IMF (2013) and Reza, Santor and Suchanek (2015). In particular, studies estimate the cumulative effects of the QE programs by the US Federal Reserve between 90 basis points (bps) and 200 bps. In the United Kingdom, estimated cumulative effects range from 45 bps to 160 bps. In Japan, the IMF (2013) estimates that purchases of government bonds under the policies of comprehensive monetary easing and quantitative and qualitative monetary easing reduced 10-year yields by about 30 bps. One common caveat, however, is that evidence of lower interest rates is usually based on the yields on existing debt, rather than on funding costs of firms for new borrowing. Thus, if access to credit is constrained and the borrower cannot take advantage of lower yields or rates, the transmission may not be as effective if borrowers do not benefit from lower market rates.

7 Researchers have constructed counterfactual scenarios using structural dynamic stochastic general-equilibrium models, as well as semi-structural or reduced-form econometric models, for instance (IMF 2013; Reza, Santor and Suchanek 2015). There is, however, an important uncertainty around the estimated macroeconomic effects of QE and conclusions from these studies should be viewed with caution.

Chart 4: Government bond yield curves

As at 4 May 2016



Source: Bloomberg

Challenges Ahead

There are many potential costs associated with unconventional monetary policy measures

Despite the rapidly growing evidence on the mechanics, effects and implications of UMPs, important issues remain. Specifically, there are many potential costs to such measures. While some of these costs are associated with prolonged monetary easing more generally, in what follows, we concentrate on the risks specifically related to UMPs such as QE.

Unintended consequences of unconventional monetary policies

Critical observers have noted that extraordinary policy measures can lead and have led, in certain cases, to distressed market functioning and have contributed to increased risk in the financial system. In the case of QE, market functioning may be affected for two main reasons.

First, QE decreases availability of safe assets that provide important services, such as collateral. In particular, long-term government bonds provide a money-like safe-haven service to certain investors, such as institutional investors (which have to hold these high-quality liquid assets to comply with regulatory requirements). Moreover, the same assets can be used as collateral multiple times in a chain of financial transactions, amplifying their role for liquidity in the financial system (Claessens et al. 2012). Because QE removes a fraction of the safe assets from the financial system, QE may be detrimental to market functioning (Stein 2012) and even reduce welfare (Krishnamurthy and Vissing-Jorgensen 2013).

Second, if the central bank's asset holdings constituted a significant share of outstanding supply, price discovery could be compromised and liquidity premiums would increase. While such impairment to financial market functioning could, if prolonged, hamper real economic activity, it is unclear at this time whether existing QE programs have led to the perceived shortage of safe collateral or whether this is the result of a host of other factors, such as enhanced liquidity and capital requirements under Basel III and changes in bank business models (CGFS 2013).

Similarly, there are some concerns about the impact of negative interest rates on financial market functioning, in particular for financial assets with payoffs that are explicitly or implicitly constrained from going below zero (for a more detailed discussion, see Witmer and Yang 2016). Others have voiced concerns that reduced bank profitability as a result of negative interest rates could compromise the soundness of the banking system. While such frictions on their own may not limit the pass-through of negative nominal policy rates to the real economy, the combination of several of them may well do so (Alsterlind et al. 2015), potentially hampering the economic recovery (McAndrews 2015, Cœuré 2014).

A more general concern about UMPs aimed at reducing long-term yields is that they lead investors to increase their exposure to risky assets, as well as to interest rate risk, in their search for yield (Hannoun 2015).[8] While this is a key channel through which both QE and negative interest rates are designed to work, prolonged periods of excessive risk taking can contribute to financial imbalances through asset price over-valuation and weak credit standards.

Factors influencing the effectiveness of unconventional monetary policies

It is important to acknowledge that the economic context influences how well UMPs function, implying that the experience to date is an imperfect guide to anticipate the effectiveness of such policies in the future. In other words, their success is state-dependent. For example, many of the UMPs implemented during the crisis when financial markets were impaired have had important effects on bond yields, but these effects would likely become smaller as liquidity improves (Rogers, Scotti and Wright 2014). Similarly, the effectiveness of QE might be more limited in small open economies because government bond yields are highly correlated with international bond yields through global term premiums.[9] The impact of QE may moreover be context-dependent in the sense that the transmission through the bank lending channel depends on the structure of financial markets (Butt et al. 2014).

A related observation is that subsequent rounds of QE had smaller effects on financial conditions compared with the first round of purchases, which is indicative of decreasing returns to scale (Krishnamurthy and Vissing-Jorgensen 2013; Goodhart and Ashworth 2012). Simply, monetary stimulus through a compression of the term premium may have a relatively smaller effect on investment than that provided through a lower expected path of future short-term rates. As shown in **Chart 3**, QE flattens the yield curve (rather than shifting it downward as the result of, for instance, conventional policy easing and forward guidance). With the term premium substantially compressed or even negative, firms might then be inclined to issue cheaper long-term bonds and, rather than investing the finances raised from issuing long-term bonds, use them to retire or buy back their more expensive outstanding short-term bonds. In other words, cheaper long-term interest rates may induce a change in financing behaviour without affecting investment behaviour.[10] This implies that effectiveness through the lending channel becomes more limited the more the term premium is already compressed (Stein 2012).

8 This discussion includes the risks from "low for long," such as (i) disincentives for governments, businesses and households to reduce their debt, thereby delaying necessary balance sheet adjustment, (ii) concerns about financial stability and (iii) asymmetric or distributional effects that benefit borrowers and punish savers (Reza, Santor and Suchanek 2015).

9 The Riksbank's experience shows, however, that QE may lower not only bond yields but also yield differentials in relation to German bunds (De Rezende, Kjellberg and Tysklind 2015). Moreover, in an open economy, the effect of LSAPs may be felt more through the exchange rate, thus boosting the country's economy through increased net trade (Reza, Santor and Suchanek 2015).

10 Some evidence of this can be seen in the data: a large fraction of the strong non-financial corporate bond issuance in 2012 was devoted to refinancing and not to new capital spending (Stein 2012).

Similarly, concerns about diminishing returns apply to the use of negative interest rates. Indeed, there is evidence that the effect of a reduction in interest rates in negative territory is more modest than a similar-sized cut that leaves rates in positive territory because of incomplete pass-through to deposit and lending rates (Bean 2013). Moreover, the mechanism through which monetary policy is transmitted may become weaker as the expected duration of negative interest rates increases because the incentive to switch to cash rises (Jackson 2015) and markets innovate to adapt (Witmer and Yang 2016). And finally, amid household deleveraging and uncertainty about the strength of global growth, the response of borrowing behaviour to a change in interest rates may be weaker.

Unconventional monetary policies have limits too

Unconventional policies also have limits in terms of operational bounds and efficacy

There are possible limits to UMPs because of their potential costs, and there is a point when their benefits may not outweigh their costs (Reza, Santor and Suchanek 2015).[11] UMPs can also hit operational limits. For large-scale asset purchases (LSAPs), significant purchases can impair market functioning by deteriorating liquidity in the market.[12] While an ample supply of public and private assets in the United States has allowed the Federal Reserve to purchase massive amounts of government debt and mortgage securities without seemingly coming close to such limits, other major central banks might actually be closer to their limits (**Table 1**). In the euro area, loans to corporations and households are generally extended through banks and thus the pool of assets the central bank can buy is smaller than it is in the United States. Simply, there may be an "effective quantitative bound" (EQB)—the point at which the costs outweigh the benefits of further UMPs and it is not worthwhile to continue with asset purchases. It is not our opinion, however, that the EQB has been reached in any of the central banks discussed in this article.

In turn, the use of negative policy rates is limited by the ELB. Recent studies and international evidence suggest that the ELB is around -0.25 to -1.0 per cent depending on the country (Jackson 2015; Witmer and Yang 2016). If policy rates were to be lowered further or persist at exceptionally low levels over a longer time span, financial intermediation could become impaired as frictions in financial markets accumulate and the transmission of monetary policy could weaken so that, ultimately, the costs of using negative rates to stimulate the economy would outweigh the benefits.

Finally, there are some more general potential costs to consider. Some observers have argued that QE could undermine central bank independence and credibility if it were perceived to be aimed at monetizing large fiscal deficits through inflation. None of the respective central banks are currently suffering from this problem (Reza, Santor and Suchanek 2015). Others claim that QE may make it harder for central banks to raise rates when it becomes necessary.[13] The experience until now has been encouraging: by paying interest on reserves, the Federal Reserve was able to raise rates despite its still-sizable balance sheet. Still others argue that QE in advanced economies has spilled over to emerging-market economies (EMEs) in the form of capital

11 This is complicated by the fact that quantifying the costs and benefits of UMPs is challenging, and today's analytical frameworks might be underestimating the risks of monetary policy to financial stability (Fischer 2016).

12 If the UK experience is a guide, central bank holdings of close to 40 per cent of the government bond market should not be expected to cause significant market impairment.

13 Indeed, central bank balance sheets have ballooned as a result of LSAP programs and are expected to take many years to return to their pre-crisis size and composition. If the central bank failed to adequately manage its balance sheet, this could lead to overly accommodative monetary conditions. Balance sheet risk management also raises issues of the extent to which, and the means by which, the central bank should be held accountable if losses were to occur.

Table 1: Central bank holdings of government debt as a share of total outstanding

As at 2015Q4		Total outstanding (in billions, domestic currency)	Central bank holdings	
			Amount (in billions, domestic currency)	As a share of total outstanding (in per cent)
United States	Marketable government debt held by the public (Treasuries)[a]	13,422	2,461	18
	Agency debt and mortgage-backed securities	6,470	1,780	28
United Kingdom	Government bonds denominated in pounds sterling (Gilts)[a]	1,220	385	32
Japan	Japanese government bonds	902,201	325,002	36
Euro area	Government debt securities denominated in euros	7,421	1,562[b]	21
Sweden	Swedish nominal government debt securities denominated in Swedish krona	992	166	17

a. As at 2016Q1

b. National central bank holdings of general government debt plus ECB holdings under its asset purchase programs including the Covered bond purchase programmes 1-3, the Asset-backed securities purchase programme, the public sector purchase programme, and the Securities Markets Programme.

Sources: International Monetary Fund—International Financial Statistics, US Treasury, US Federal Reserve Board, UK Debt Management Office, Bank of England, Ministry of Finance Japan, Bank of Japan, European Central Bank, and Sveriges Riksbank

flows and upward pressure on asset prices and exchange rates (Lavigne, Sarker and Vasishtha 2014).[14] The overall impact of QE on EMEs was likely positive, however, because of the beneficial trade and confidence effects stemming from stronger economic activity in the countries adopting QE.

The Interaction of Multiple Unconventional Monetary Policies

Large-scale asset purchases can strengthen the credibility of announced guidance about low future rates

One topic that has received little attention so far is the effectiveness of using multiple UMPs simultaneously. Various measures can be mutually reinforcing when used in combination (Bank of Canada 2015; Poloz 2015). In the United States, for example, QE programs likely boosted the credibility, and hence effectiveness, of the forward guidance by conveying to financial market participants that the Federal Open Market Committee was determined to provide persistent and aggressive easing (Engen, Laubach and Reifschneider 2015). In a similar vein, LSAPs by the ECB likely mitigated possible credibility or commitment problems associated with providing forward guidance. De Graeve and Lindé (2015) argue that because LSAPs extend the duration and size of the central bank's portfolio, starting to raise the policy rate early may result in capital losses. LSAPs can thus strengthen the credibility of announced guidance about low future rates because market participants believe that the central bank would want or need to avoid capital losses.

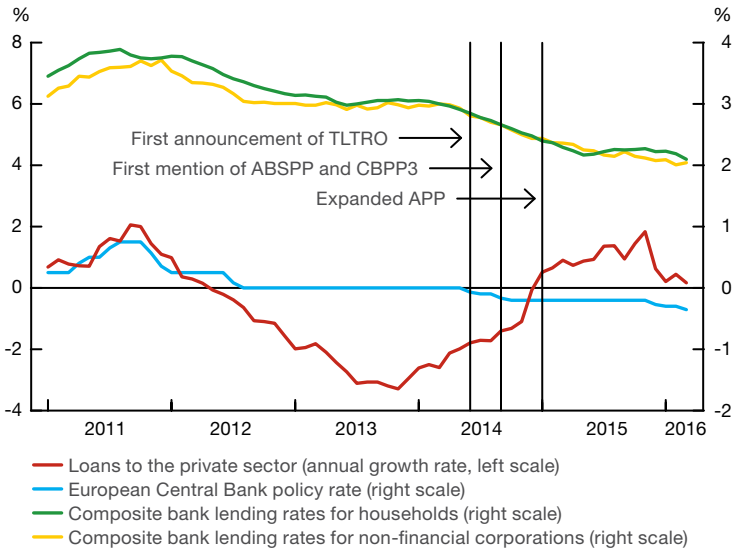
14 Glick and Leduc (2015) find that the US dollar depreciated by more in response to QE relative to conventional policy.

Technical or legal limits might even require the simultaneous implementation of such policies. The ECB's decision to expand its asset-purchase program in late 2015 was facilitated by the simultaneous further cut of the interest rate on the deposit facility to -0.3 per cent: according to ECB's own rules, bonds with yields lower than the deposit rate cannot be part of the QE scheme. This ruled out an important share of otherwise eligible bonds, such as German government debt securities at short- to medium-term maturities. In this environment, cutting the deposit rate further into negative territory likely widened the amount of permitted securities.[15]

Also, credit easing may enhance the transmission of the lower interest rates resulting from non-standard measures to all parts of the economy. A prominent example is the large-scale purchases of mortgage-backed securities by the US Federal Reserve (the Fed) as the liquidity in this market dried up in 2008. As the Fed stepped in, the resulting improvement in market functioning also enhanced the transmission of lower policy rates to other asset classes. In particular, there is evidence that corporate rates also declined and assets, such as stocks, rose during the program (Rosengren 2012).

Similarly, while measures in the euro area before June 2014 led to a substantial easing of banks' funding conditions, little was transmitted to the borrowing costs faced by households and firms in many vulnerable member states. The credit-easing package introduced later that year appears to have significantly improved the pass-through of monetary policy measures to bank lending rates (Praet 2015; ECB 2016), the latter declining by more than market reference rates since the ECB's credit-easing package was announced in June 2014 (**Chart 5**). Asset purchases were subsequently expanded, most recently to include corporate sector bonds with the aim of

Chart 5: Interaction of policy measures



Note: The indicator for the composite bank lending rates is calculated by aggregating short- and long-term rates using a 24-month moving average of new business volumes. TLTRO stands for targeted longer-term refinancing operations. ABSPP and CBPP3 denote two asset-backed securities purchase programs, i.e., the asset-backed securities purchase program and the third covered bond purchase program. APP stands for asset purchase program.

Sources: Haver Analytics and European Central Bank Last observation: March 2016

15 Conversely, some observers argue that pushing yields below the new deposit rate again only perpetuates the ineligibility problem of some bonds as European markets price in another rate cut.

further strengthening the pass-through of the Eurosystem's asset purchases to the financing conditions of the real economy. This is yet another example of the complementarity of unconventional tools.

In some cases, the effects of simultaneous UMPs may not be cumulative or they may imply new challenges

The simultaneous implementation of UMPs may pose important challenges, or, simply, the effects may not be cumulative. For example, instruments such as negative deposit rates and asset purchases may not be implemented together consistently (Noyer 2016): LSAPs lead banks to hold important excess reserves with the central bank. If negative interest rates are implemented simultaneously, banks need to pay interest on these reserves. As a result, banks might be encouraged to grant new loans or buy assets rather than holding excess reserves. But this extra liquidity in the financial system ultimately needs to be deposited on bank accounts as well. Unless banks impose negative rates on depositors, their margins will be squeezed. If they respond by increasing their credit margins or curtailing loans altogether, credit conditions would tighten and thereby dampen the effectiveness of monetary policy. Alternatively, if banks absorb the losses, this would weaken the banking system, which could, in the extreme, also impede proper monetary policy transmission.

Similarly, combining the introduction of negative rates with forward guidance might reduce the overall effectiveness of these policies. The use of negative interest rates in isolation may well be perceived to be temporary and thus not induce major changes in behaviour as agents choose to absorb any costs. In this case, strategies to avoid negative deposit rates, for example, would not be necessary or viable. But, if negative interest rates were implemented in combination with forward guidance, this clearly implies that policy rates will remain negative for a long time, inciting agents to search for options to circumvent or contain related costs rather quickly. To avoid paying interest rates on deposits, agents could rapidly invest in safe storage of cash. This would effectively increase the ELB and limit the power of the additional stimulus that negative rates can provide.

Exit Strategies

Central bank exit strategies should be specified before they are implemented to help keep inflation expectations well anchored

While the unwinding of UMPs is not imminent in most advanced economies, policy normalization has begun in the United States. To keep inflation expectations well anchored, central bank exit strategies should be specified before they are implemented. Exit strategies will necessarily depend on country-specific circumstances, including decisions on the sequencing of tightening when various measures are in place.

With respect to QE, central banks may simply allow purchased assets to mature, which would result in a gradual normalization of the size of its balance sheet over several years (Carpenter et al. 2015).[16] Importantly, the ability of central banks to pay interest on reserves allows them to raise policy rates despite having large balance sheets and thus provides additional flexibility in formulating exit strategies (Kozicki, Santor and Suchanek 2011).[17] In turn, the exit from negative interest rates should, in theory, be similar to monetary

16 In the case of the US Federal Reserve, a decision to not replace decreased mortgage-backed securities (MBS) holdings resulting from prepayments would nevertheless be insufficient (in the absence of outright sales) to return to a pre-crisis composition of its balance sheet. A scenario including outright sales of MBS is, however, rather unlikely at this point (Carpenter et al. 2015).

17 In the case of the US Federal Reserve, for instance, the Federal Open Market Committee announced it would cease or begin phasing out reinvestments of central bank holdings acquired under its LSAP programs only *after* it begins increasing the target range for the federal funds rate. Yet, while communication about the intended sequence, pace and timing of exit is important to guide market participants, central banks should remain flexible to adjust their approach to policy normalization in light of economic and financial developments.

policy tightening from low but positive rates. The central banks may make use of changes to the corridor, allowing for additional flexibility (Kozicki, Santor and Suchanek 2011).

Several challenges arise when considering the exit from unconventional monetary policy. First, policy-makers need to allow for the possibility that concurrently raising policy rates and draining reserves might alter the usual transmission mechanism. A typical policy rate increase, for example, could prove less contractionary than usual in the presence of substantial excess liquidity in light of expanded balance sheets. Second, if the central bank needs to sell assets, it could incur losses. To preserve policy credibility and independence to ensure the effectiveness of future policy, it needs to clearly state accountability in the context of the exit. In the case of the Bank of England, the British government provides an indemnity to cover any losses arising from the asset purchase facility. The US Federal Reserve, meanwhile, would stop remittances to the US Treasury should it incur losses and would need to offset losses with future remittances. While such losses could draw undue attention to the central bank, there is no evidence that they would impair the ability of the central bank to achieve its mandate.

Conclusion

The international experience of UMPs has shown that central banks have not run out of solutions when the policy rate is close to the ELB. Given the limits and potential costs of such measures, however, rather than being "perfect" substitutes for conventional monetary policy, they appear to be an "adequate" tool at the disposal of central banks.

Central banks have not run out of solutions when the policy rate is close to the effective lower bound

The adverse effects of these measures so far appear small, but making these measures permanent, or even using them on a larger scale, will likely amplify the potential for negative externalities. Their use thus requires a solid understanding of unintended consequences and limits so that central banks can seek, to the extent possible, to minimize them or raise awareness. In this way, mitigating or corrective action can be taken by other relevant authorities (Draghi 2015). Indeed, the simultaneous implementation of macro-prudential regulation can help to mitigate or even offset financial risks and distortions resulting from a low-for-long environment.[18]

Central banks, moreover, need to continue adapting the modelling and analytical frameworks they use to analyze the challenges of modern central banking tools. As central banks are faced with questions on the simultaneous implementation of UMPs, they need to carefully evaluate and anticipate the interaction of such measures. While researchers have tended to map the estimated impact of UMPs into an equivalent conventional interest rate cut in order to evaluate the impact on economic growth and inflation, the assessment of several simultaneous measures is likely more complicated. A simple addition of the effects into a single interest rate estimate risks ignoring any interdependencies of such measures and thus needs to be qualitatively assessed or modified. In addition, models need to be adapted to account for non-linearities of UMPs given the evidence of decreasing returns to scale for both QE and negative interest rates discussed above.

Sound communication in implementing extraordinary tools is primordial to ensure that market participants and the public understand the purpose as well as important aspects of their intended transmission. This may be

18 In addition, policy-makers need to be aware the UMPs cannot offset structural sources of weakness, compensate for a lack of fiscal stimulus or offset the effects of fiscal consolidation.

particularly challenging when innovative tools such as negative interest rates are introduced. Central banks therefore need to clearly communicate their decisions and repeatedly relate them to their mandated objectives (Santor and Suchanek 2013).

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Monetary Policy Frameworks: Recent International Developments

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- Central banks in advanced economies have faced significant challenges in recent years, with prolonged low inflation occurring against a background of rising financial stability concerns in some economies.
- While few advanced economies have made significant changes to their inflation-targeting frameworks since 2012, the tools that central banks have employed to meet their inflation targets have evolved.
- In particular, several central banks have announced or expanded asset purchase programs, moved policy rates below zero or taken on greater roles in contributing to financial stability.
- Some central banks have modified their set of preferred core inflation measures and continue to make use of them to monitor underlying trends in total inflation.

In 2016, the federal government and the Bank of Canada will renew their inflation-control target agreement for a further five years. In support of the renewal process in the past, the Bank has reviewed inflation-targeting (IT) frameworks in other countries (e.g., Paulin 2006; Lavigne, Mendes and Sarker 2012). This article provides an overview of developments in IT frameworks in 10 advanced economies since the previous renewal, which took place in 2011.[1] In particular, it highlights developments related to the three areas of research the Bank is focusing on during its review:

- the level of the inflation target,
- the measurement of core inflation and
- financial stability considerations in the formulation of monetary policy.

In the Spring 2012 issue of the *Bank of Canada Review*, Lavigne, Mendes and Sarker (henceforth Spring 2012 Review article) noted that monetary policy frameworks had faced significant challenges, particularly following the 2007–09 global financial crisis. These challenges have continued to evolve: considerable excess supply persists in several economies and, following the plummet in oil prices that began in 2014, total rates of inflation declined substantially in some economies. In some cases, this has

1 The central banks reviewed here are the Reserve Bank of Australia, the Bank of Canada, the European Central Bank, the Bank of Japan, the Reserve Bank of New Zealand, Norges Bank, the Swedish Riksbank, the Swiss National Bank, the Bank of England and the US Federal Reserve.

compounded existing and prolonged low underlying inflation. Against this background, in some economies there have also been ongoing concerns about financial stability in an era of low interest rates.

The appropriate response of central banks to such challenges has been the topic of debate. For example, in light of concerns about persistently low inflation, there have been some calls for central banks to increase inflation targets (Blanchard, Dell'Ariccia and Mauro 2010; Ball 2014), while others have raised concerns that doing so would risk central bank credibility and consequently make it harder to stabilize inflation around a higher target (e.g., Mishkin 2011). There is also ongoing debate over the appropriate degree to which monetary policy should account for financial stability concerns, from those who argue that monetary policy should remain focused on price stability (e.g., Svensson 2014) to those who call for monetary policy to play a greater role in accounting for financial cycles (e.g., Stein 2013 and Borio 2014).

Central banks have responded to evolving challenges in many different ways, depending on their circumstances

In practice, central banks have responded to these challenges in many different ways, depending on their circumstances: announcing or enhancing asset purchase programs; breaking through the zero lower bound on interest rates as central bank deposit and policy rates moved below zero in some economies; and more explicitly addressing financial stability concerns in the conduct of monetary policy. Exploratory analysis suggests little change in the basket of core inflation measures used at most central banks. In some instances, however, there has been a slight shift in emphasis from a preferred "focal" measure of core inflation to a broader set of alternative measures of underlying trends in inflation.

Inflation-Targeting Frameworks During a Period of Prolonged Low Inflation

There have been few changes to either the numerical inflation target or the target variable in advanced economies since the Spring 2012 Review article (**Table 1**). All of these targets are defined in terms of total consumer price inflation, ranging from around 2.0 to 2.5 per cent, although some central banks frequently reference a measure of consumer price inflation that excludes certain volatile components when they communicate their monetary policy analysis (e.g., the Riksbank, Bank of Japan and, to a lesser extent, the Bank of Canada and Norges Bank).

Only Japan has changed the level of its inflation target since the Spring 2012 Review article, raising its target from 1 to 2 per cent in January 2013, which brought it in line with the targets in most advanced economies. When introducing the change, the Bank of Japan cited the need to anchor a sustainable rate of inflation and argued that the inflation rate consistent with price stability on a sustainable basis would rise following efforts to strengthen competitiveness and growth potential. The other main change has been the Reserve Bank of New Zealand (RBNZ)'s new focus on keeping future average inflation near the 2 per cent midpoint of its 1 to 3 per cent inflation-target range, introduced in its *Policy Targets Agreement for 2012* with the government.[2] Subsequent RBNZ commentary has suggested that this explicit focus on the midpoint helps to anchor expectations near 2 per cent, making the outlook more resilient to

2 The previous *Policy Targets Agreement for 2008* had indicated that the RBNZ would target inflation outcomes between 1 per cent and 3 per cent on average, without specifying a focus on the midpoint. The range and level of the RBNZ's inflation-target band has changed several times in the past with the signing of new policy target agreements.

Table 1: Monetary policy frameworks in selected advanced economies

Central bank	Date inflation targeting adopted	Current inflation target	Target variable	Changes since Spring 2012 Review article (May 2012)
Reserve Bank of New Zealand	March 1990	2 per cent midpoint (since 2012) in 1–3 per cent range (since 2002; several previous adjustments)	Consumer price index (CPI)	Inflation target focuses on the 2 per cent midpoint (since September 2012)
Bank of Canada	February 1991	2 per cent midpoint in 1–3 per cent range (since end of 1995, following a transition period from 1991)	CPI (operationally use core CPI)	No significant changes
Bank of England	October 1992	2 per cent (since 2004, following previous adjustments) (±1 percentage point, but not a target range)	CPI	No significant changes
Swedish Riksbank	January 1993	2 per cent (since 1995, following a transition period) (±1 percentage point tolerance interval removed in 2010)	CPI (emphasis on underlying measures of inflation)	No significant changes
Reserve Bank of Australia	March 1993	2–3 per cent, on average, over the business cycle (since initial adoption in 1993 and formal endorsement in 1996)	CPI	No significant changes
European Central Bank[a]	January 1999	Below, but close to, 2 per cent (since initial announcement in 1999 and confirmation in 2003)	Harmonised Index of Consumer Prices (HICP)	No significant changes
Swiss National Bank[a]	January 2000	Less than 2 per cent (since 2000)	CPI	No significant changes
Norges Bank	March 2001	Approximately 2.5 per cent (since 2001) (±1 percentage point, but not a target range)	CPI (emphasis on a core measure of the CPI)	No significant changes
US Federal Reserve[b]	January 2012	2 per cent (since January 2012)	Personal consumption expenditure price index (PCEPI)	No significant changes
Bank of Japan	February 2012	2 per cent target (since January 2013)	CPI (emphasis on a measure of CPI that excludes fresh food)	Target introduced January 2013; previously 1 per cent goal since February 2012; previously undefined but generally interpreted to be 0 per cent

a. The European Central Bank and the Swiss National Bank do not consider inflation targeting the goal of their monetary policy regimes.

b. The Federal Reserve does not use the word "target" to describe its inflation objective. Rather, it has stated that 2 per cent inflation is "most consistent over the longer run with the Federal Reserve's mandate for price stability and maximum employment."

Sources: Lavigne, Mendes and Sarker (2012); central bank websites

temporary deviations of inflation from the target band and helping to avoid inflation expectations becoming biased at either end of the target range (Ford, Kendall and Richardson 2015).[3]

Evolution of the monetary policy toolbox since 2012

Although inflation targets have remained more or less unchanged, central banks have introduced many different and innovative policy measures to implement their IT frameworks, such as asset purchase programs (also known as quantitative easing), negative interest rates, forward guidance and exchange rate policies.[4] These new tools were introduced in the context of inflation well below target in many advanced economies and with deviations from target that have increased since 2012 (**Chart 1**).

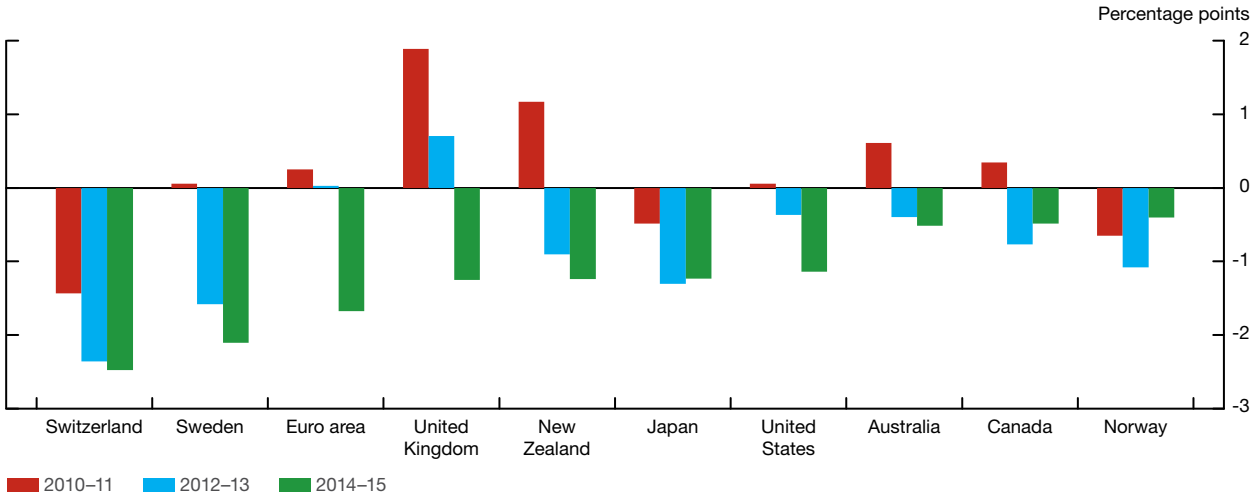
Although inflation targets have remained more or less unchanged, central banks have introduced many different and innovative policy measures to implement their inflation-targeting frameworks

3 RBNZ analysis finds that long-run inflation expectations have indeed shifted lower toward the 2 per cent midpoint since the increased focus on the midpoint of the target range was introduced in 2012 (Lewis 2016).

4 Since 2012, the Bank of England, the Bank of Japan and the European Central Bank have also launched targeted loan programs to help ease credit conditions and assist in improving the monetary policy transmission mechanism.

Chart 1: Deviation of total inflation from target in advanced economies

Average of monthly data



Note: Deviation of total inflation is calculated based on personal consumption expenditures inflation for the United States, Harmonised Index of Consumer Prices inflation for the euro area and CPI inflation for all other countries. A time-varying inflation target is used in the calculations for Japan (i.e., a 2 per cent target since January 2013, a 1 per cent target from February to December 2012, and a 0 per cent target before February 2012).

Sources: National sources via Haver Analytics

Last observation: December 2015

Faced with both the zero lower bound and prolonged low inflation, the European Central Bank (ECB), the Bank of Japan and the Swedish Riksbank introduced asset purchase programs, while the Bank of England expanded its asset purchase program (**Table 2**). How central banks approach asset purchase programs differs along a number of dimensions, including their size and whether other measures are implemented (e.g., negative policy rates). In all of these cases, however, achieving the inflation target in the current economic context was cited as a key reason for introducing the asset purchase programs. An analysis of the effectiveness and potential limitations of such programs is provided separately in this issue (Santor and Suchanek 2016).

The Federal Reserve introduced aggressive large-scale asset purchases earlier than many other central banks. Partly reflecting this action, inflation expectations and labour market conditions recovered more quickly than they did in many other advanced economies. The Federal Reserve was in a position to begin tapering off asset purchases beginning in December 2013, at a time when other central banks were still expanding such programs. The final asset purchase was conducted by the Federal Reserve in October 2014.

Negative interest rates, another type of unconventional monetary policy, have been introduced by many central banks since mid-2014.[5] This includes negative deposit rates charged by the central banks of Switzerland, Sweden, the euro area and Japan as well as negative targets for the key policy rate in Sweden and Switzerland.[6] As discussed in Jackson (2015), the reasons for implementing negative interest rates have varied across central

5 This was not the first time that negative policy interest rates had been used. The Riksbank's deposit rate was negative from July 2009 to September 2010, for example, and Danmarks Nationalbank's deposit rate was negative from July 2012 to April 2014.

6 The Danish central bank, Danmarks Nationalbank, also introduced a negative deposit rate in September 2014. In this article, because we focus on inflation-targeting central banks, we do not include Danmarks Nationalbank in our main review.

Table 2: Key changes to asset purchase programs since the Spring 2012 Review article

Central bank	Date implemented	Change to asset purchase program (APP)	Motivation[a]
Bank of England	July 2012	Increased the size of the APP	To balance the risks to inflation around the 2 per cent target in the medium term
Bank of Japan	April 2013	Quantitative and qualitative monetary easing program launched (the pace and average maturity of asset purchases have since been increased)	To achieve and maintain the price stability target
US Federal Reserve	December 2013–October 2014	Gradual reduction of APP	To make progress toward maximum employment, ongoing improvement in labour market conditions and inflation moving back closer to its longer-run objective
European Central Bank	October 2014	Initiated APP	To underpin the firm anchoring of medium- to long-term inflation expectations
	March 2015, March 2016	Expanded APP	To promote a sustained adjustment in the path of inflation that is consistent with the inflation target
		List of eligible assets expanded to include public sector assets (March 2015) and investment-grade euro-denominated bonds issued by non-bank corporations established in the euro area (March 2016)	To contribute to an easing of financial conditions of the real economy
Swedish Riksbank	February 2015	Introduced APP (the size of the program has since been expanded gradually)	To safeguard the role of the inflation target as a nominal anchor for price setting and wage formation

a. "Motivation" summarizes the objective provided by central banks in their press statements when their unconventional monetary policy measures were announced.
Sources: Central bank press releases and websites

banks. In many cases, however, central banks cited the need to increase inflation and achieve their inflation targets. An analysis of the economics and practicalities of negative interest rates is provided separately in this issue (Witmer and Yang 2016).

Forward guidance, in which central banks provide explicit statements about the future path of interest rates, is another policy tool that has been used to provide additional monetary stimulus. Different types and durations of forward guidance have been implemented since 2012, including by the central banks of the United States, the euro area, Japan, the United Kingdom and Sweden.[7] In reviewing this international experience, Charbonneau and Rennison (2015) find that forward guidance can be an effective tool when clearly communicated and perceived as credible, although these benefits need to be weighed against the associated costs.

Some central banks have also made changes to their exchange rate policies. The Swiss National Bank (SNB), for example, introduced a minimum exchange rate in 2011 in response to the threat of deflation resulting from an overvaluation of the Swiss franc. In January 2015, the SNB discontinued its exchange rate floor after it was assessed to be unsustainable, given the weakening of the euro. The SNB indicated that it will continue to consider the exchange rate when formulating its monetary policy.[8] In January 2016, the Executive Board of the Swedish Riksbank assumed the ability to instantly intervene in foreign exchange markets as necessary to complement other monetary policy measures supporting inflation.

7 Some of these central banks had also used forward guidance before 2012, in addition to the Bank of Canada, which had provided forward guidance from April 2009 to April 2010.

8 Since November 2013, the Czech National Bank has also maintained an exchange rate floor of 27 CZK/EUR as an additional monetary policy tool. The stated intention of weakening the exchange rate was to attain the inflation target and avert the threat of deflation rather than concern over exchange rate volatility.

Measuring and Communicating Core Inflation

There will always be sharp movements in total CPI, driven by volatile price changes in a small number of goods and services. As a result, many central banks often use measures of core inflation that reflect underlying price pressures (or "underlying inflation") as an operational guide for monetary policy. The most commonly used measures are those that exclude items with the most volatile price movements, which in many cases include energy and food products, from the CPI (**Table 3**). The use of such measures has become particularly relevant in assessing and explaining shocks to total inflation in recent years in light of large movements in energy prices and exchange rates.

Many central banks often use measures of core inflation that reflect underlying price pressures (or "underlying inflation") as an operational guide for monetary policy

Few substantial changes have been made to the basket of core measures used at most central banks since 2012. Some central banks (e.g., Canada, the United Kingdom, the euro area and Japan) have shifted their emphasis slightly, however, from a focal measure to a set of measures, while the reverse is true for other central banks (e.g., Norway and Australia). In many cases, central banks do not explicitly announce or explain these changes, and it is unclear whether the shifts are intended to be permanent. **Table 3** therefore focuses on central banks' observed selection of core inflation measures, rather than assessing possible reasons for the use of particular measures.

Table 3: Core inflation measures at selected central banks in advanced economies

Central bank	Types of measures (focal measures underlined)[a]	Changes since Spring 2012 Review article
Reserve Bank of New Zealand	Model-based measure (sectoral factor model), trimmed mean, weighted median	The sectoral factor model was modified in 2013. A recurring graph of alternative measures in its *Monetary Policy Statement* was dropped at the end of 2014.
Bank of Canada	Exclusion-based CPIX (CPI excluding eight of the most volatile components), trimmed mean, volatility-weighted, weighted mean, factor model	Since April 2012, many monetary policy reports (MPRs) have featured a chart comparing alternative core inflation measures, which have featured a common component measure since late 2013. More general references to "underlying inflation" increased over 2014 until around mid-2015.
Bank of England	Exclusion-based	Core inflation has been increasingly noted in inflation reports (IRs) and monetary policy minutes since mid-2014. The August 2015 IR reported a broader set of measures, but these are not yet a regular feature of communications.
Swedish Riksbank	Exclusion-based CPIF (CPI with fixed mortgage interest rates), trimmed mean, volatility-weighted	"CPIF excluding energy" has been increasingly emphasized since early 2015. The term "underlying inflation" (referring to the lasting inflation rate or inflation trend) has been increasingly used since 2014.
Reserve Bank of Australia	Trimmed mean, exclusion-based, weighted median	The general concept of underlying inflation or a range of measures is typically referenced. The trimmed mean has received some additional emphasis in statements on monetary policy since mid-2013.
European Central Bank	Exclusion-based HICPX (HICP excluding food and energy) is often used to gauge underlying developments in inflation	The December 2013 *Monthly Bulletin* assessed subindexes of the HICP, stating that they provided information on "underlying dynamics of headline inflation developments" but were not official measures of core or underlying inflation. The July 2015 *Economic Bulletin* reported a broader set of measures in a discussion of underlying inflation, but these are not yet a regular feature of communications.
Swiss National Bank	Exclusion-based, trimmed mean	Somewhat less discussion of individual core inflation measures since 2012.
Norges Bank	Exclusion-based CPI-ATE (CPI adjusted for tax changes and excluding energy products), trimmed mean, weighted median	MPRs have emphasized CPI-ATE slightly more than alternative measures, particularly since around mid-2013.
US Federal Reserve	Exclusion-based "Core PCEPI," trimmed mean, weighted median, factor model	No major changes observed since 2012. Monetary policy reports to Congress occasionally mention core inflation measure in addition to core PCEPI (e.g., core CPI, trimmed mean), but these are not a regular feature of the reports.
Bank of Japan	Exclusion-based (CPI, all items less fresh food), trimmed mean	Alternative measures have received additional emphasis in the past year, including a new weighted median (*Outlook Report*, October 2015; not yet clear if this will be a regular feature of communications).

a. Based on an assessment by Khan, Morel and Sabourin (2015) of core inflation measures most commonly reported in central bank communications. The relative emphasis given to focal measures varies across central banks.

Sources: Khan, Morel and Sabourin (2015); central bank websites

One method to gauge the shift in emphasis is to analyze the incidence of terms related to core inflation that central banks use (**Box 1**). This approach is common in social media analysis and is sometimes referred to as "keyword density analysis." This type of analysis is a subset of broader textual analysis that is increasingly being applied in the economic and financial literature. While our application of this textual analysis is both simple and exploratory, it suggests a number of findings:[9]

(i) Word counts of specific terms used in the monetary policy reports (MPRs) of individual central banks suggest that considerable differences have persisted in the frequency of core inflation terms, the relative emphasis given to a focal measure of core inflation and how this has changed over time (**Chart 2**). In general, core inflation appears to be discussed at a relatively high frequency in the MPRs of small open economies (e.g., Canada, Sweden, Norway and, to a lesser extent, Australia and New Zealand) as well as, particularly recently, Japan. This may relate to the exposure of small open economies to foreign shocks, including those that affect headline inflation. Exploring this link further could be an area for future analysis.

(ii) In several cases, prominent spikes in the data reported in **Chart 2** can be attributed to explanatory boxes in MPRs. These boxes cover a variety of topics related to core inflation, including the effect of exchange rate pass-through (e.g., Bank of Canada in July 2015), energy prices (e.g., ECB in July 2015, which mentioned oil price movements among

9 The terms used to refer to core inflation vary across central banks. Unless otherwise noted, we use the term "core inflation" to refer to related concepts, including underlying inflation and specific measures of core inflation used by different central banks.

Box 1

Analyzing Communications on Core Inflation: Methodology

We conduct a simple version of the text-search approach by calculating the frequency with which terms related to core inflation appear in the monetary policy reports (MPRs) published by central banks.[1, 2] We focus on MPRs because they provide analytic detail of economic conditions. These communications would therefore be expected to reflect changes in a central bank's calculations of, and discussions about, core inflation over time. We selected a set of search terms related to core inflation that refer to the focal measure used at each central bank.[3] We erred on the side of being more conservative in our definition of a focal measure when it was unclear whether a central bank was referring to its focal measure in particular or core inflation in general. See **Chart 2** for the results of this exercise.

This approach has limitations. The text search does not identify indirect references to the concept of core inflation. The trade-off in expanding the set of search terms is to introduce a greater element of judgment in assessing what should be considered a relevant reference to core inflation. In addition, the text search does not distinguish between domestic and foreign developments in core inflation, both of which are included in MPRs published by several central banks. Furthermore, it does not fully capture the context of the core inflation terms and therefore does not reflect more nuanced changes in how core inflation is discussed in monetary policy communications over time.

1 Several studies have assessed the topics covered by central bank communications, using a range of statistical approaches. For example, some use the "latent semantic analysis" technique to identify common themes across texts (e.g., Hendry and Madeley 2010; Boukus and Rosenberg 2006), while others include a simple word count of terms of interest (e.g., Peek, Rosengren and Tootell 2015; Berger, de Haan and Sturm 2011).

2 Our search removed punctuation and capitalization from the texts and identified the following terms and stems: underlying inflation, core inflation, core CPI, core PCE, factor model, trimmed mean, weighted median, CPI EX, CPI ATE, CPI AT, CPI AE, CPIM, CPI FW, CPIF, und24, trim85, tm15, sfso1, sfso2, CPIX, CPIXFET, CPIW, meanstd, common component, component weights in CPI, sticky CPI components, diffusion index, HICP inflation ex, HICP ex, HICPX, CPI less, less fresh food, less food and energy, excluding food and energy, median CPI, underlying price, underlying trend in prices, underlying trend in inflation, underlying trend of inflation.

3 We used the following search terms for each central bank's focal measure: RBA (trimmed mean), Bank of Canada (CPIX, core CPI), ECB (HICPX, HICP ex, HICP inflation ex), Bank of Japan (less fresh food, core CPI), RBNZ (factor model), Norges Bank (CPI ATE), Riksbank (CPIF), SNB (core inflation rate 1, SFSO1, trimmed mean, TM15), Bank of England (core CPI), US Federal Reserve (core PCE, core personal, excluding food and energy).

several drivers of underlying inflation developments) and excess supply (e.g., Bank of Canada in April 2014), and comparing alternative measures of core inflation (e.g., ECB in December 2013, Bank of Japan in October 2015). Note, however, that in some case these topics are discussed in central banks' MPRs even when they are not observable as spikes in the data.

(iii) The frequency with which terms related to core inflation appear in monetary policy communications seems to have been relatively constant at most central banks since 2012, despite the experience with prolonged low inflation and various commodity price shocks in many advanced economies during this period (**Chart 2**). One exception is Norges Bank, where discussion of core inflation measures other than its focal measure, CPI-ATE (CPI adjusted for tax changes and excluding energy products), has gradually decreased since 2012.[10] Another exception is the Bank of Japan, which discussed both its focal measure and other measures of core inflation more frequently over 2015. This was partly driven by increased discussion of core inflation excluding energy prices, which was higher than headline inflation because of the impact of declining energy prices.[11] Other central banks have increased the frequency with which they refer to "underlying inflation" in addition to, or instead of, a specific measure (e.g., Riksbank in 2014 and the Bank of Canada from 2014 to around mid-2015).[12]

(iv) In cases where the focal measure includes energy prices (the Riksbank, Bank of Japan), versions of the measures that exclude energy have been increasingly discussed in monetary policy communications over the past year. In view of the large changes in energy prices over the past two years, such core measures can be helpful in distinguishing between the impact of a temporary relative price shock (such as the commodity price shock) and a more fundamental shock to the underlying inflationary pressures.

Financial Stability Considerations

All central banks contribute to the stability of the financial system to some extent through vulnerability assessments and risk analysis as well as crisis resolution, in their role as lender of last resort, for example. Five of the ten central banks reviewed here also have an explicit financial stability objective in their legal mandate.

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The majority of the 10 central banks publish a financial stability report (FSR), or equivalent document, in which they review and analyze developments in and risks to the financial system. The only exception is in the United States, where an FSR-type document has been published as an annual report of the Financial Stability Oversight Council (of which the US Federal Reserve is a member) since 2011.

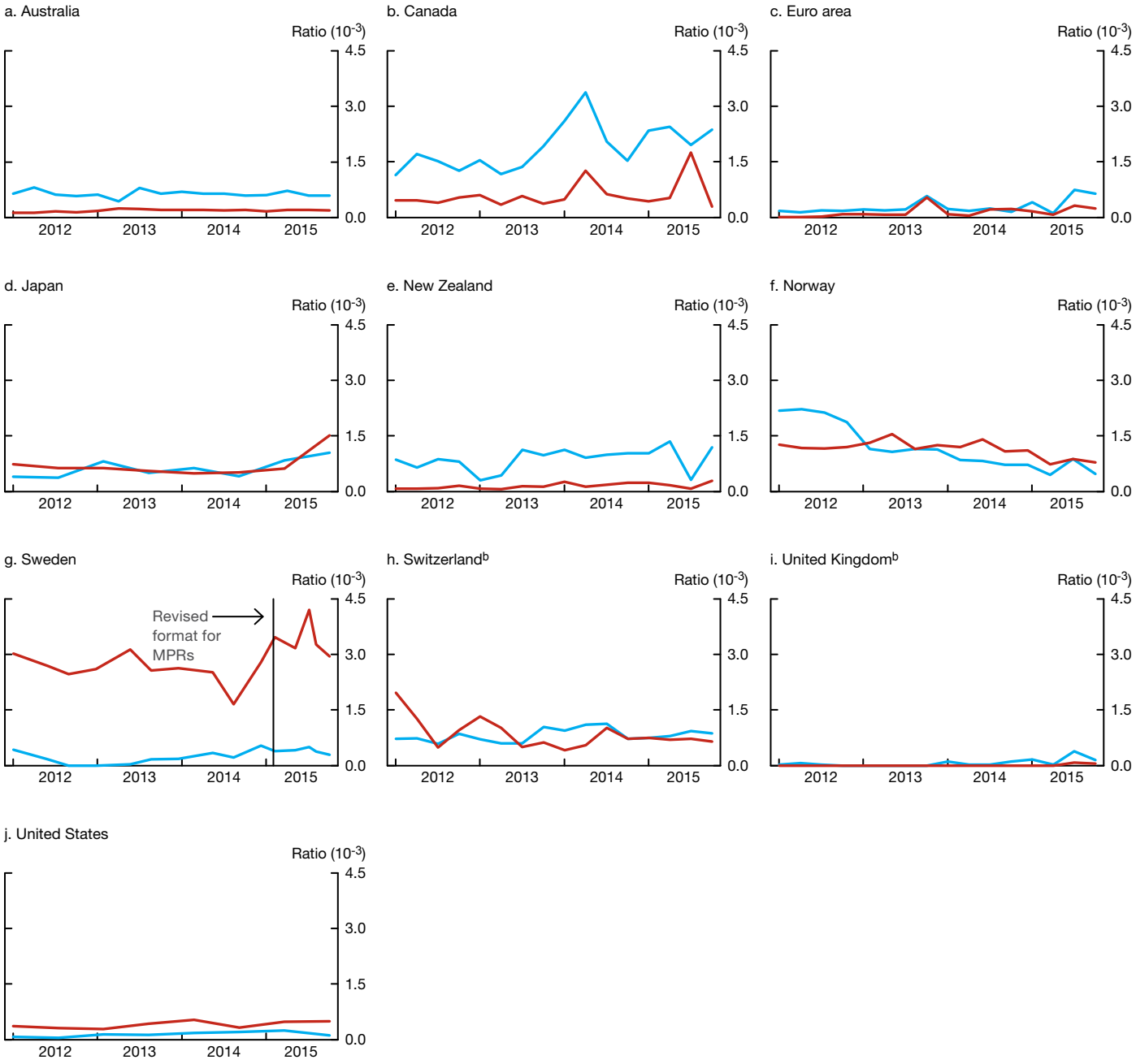
10 The main alternative to CPI-ATE is CPIXE (CPI adjusted for tax changes and excluding temporary changes in energy prices). CPIXE was introduced in 2008, in response to CPI-ATE's underestimation of overall inflation as a result of the persistent trend of rising energy prices (Nordbø 2008). The shift in emphasis from CPIXE to CPI-ATE in mid-2013 coincided with methodological revisions to reduce the volatility of CPIXE calculations, but it is unclear to what extent these developments are related.

11 The Bank of Japan's core inflation word count also rose in 2015 due to an Outlook Report box discussing developments in underlying inflation.

12 In the case of the Bank of Canada, the term "underlying inflation" has been used in the discussion of the transitory effects of exchange rate depreciation and some sector-specific factors, which could influence measures of core inflation.

Chart 2: Core inflation terms in central bank monetary policy reports,[a] 2012–15

Ratio of core inflation terms relative to total word count; focal measure and frequency vary by central bank



a. Monetary policy reports have been shortened to exclude front- and back-end material, special articles, statistical reports, etc.
b. For central banks that do not define a focal measure, we searched for commonly used terms. See footnotes 2 and 3 in Box 1 for a list of search terms for all central banks.

Note: See Box 1 for more detail on the methodology used to calculate the frequency of core inflation terms.

Sources: Bank of Canada analysis of monetary policy reports published by central banks: RBA (*Statement on Monetary Policy*), Bank of Canada (*Monetary Policy Report*), ECB (the March, June, September and December releases of the *Monthly Bulletin* 2012–14 and *Economic Bulletin* 2015), Bank of Japan (*Outlook Report*), RBNZ (*Monetary Policy Statement*), Norges Bank (*Monetary Policy Report*), Riksbank (*Monetary Policy Report*; we do not include *Monetary Policy Updates* because the word counts are not comparable to the longer reports), SNB (*Quarterly Bulletin*), Bank of England (*Inflation Report*) and US Federal Reserve (*Monetary Policy Report to Congress*).

Last observation: December 2015

In addition, several central banks contribute to financial stability through their involvement in micro- and macroprudential policy. This includes some central banks that have assumed primary responsibility for macroprudential policy (e.g., the Bank of England and the RBNZ in 2013), and others that have been assigned specific roles in contributing to financial stability in cases where responsibility for macroprudential policy is shared across multiple institutions (e.g., Norges Bank was assigned responsibility for issuing advice on the countercyclical capital buffer level in 2013, and the ECB assumed responsibility for the supervision of large euro-area banks when the Single Supervisory Mechanism came into force in November 2014).

Incorporating financial stability considerations into monetary policy decisions

Central banks may also use monetary policy itself to respond to financial stability concerns—that is, setting policy rates to take into account the buildup of financial imbalances. Work by the Bank for International Settlements supports this approach on the basis that monetary policy frameworks should take financial cycles into account more systematically, given the impact of monetary policy on financial stability (e.g., Borio 2014). The Spring 2012 Review article provided an overview of central banks that had made provisions for financial stability considerations in the conduct of monetary policy, and we highlight some examples of subsequent developments below.

In practice, Norges Bank presented one of the most explicit frameworks for incorporating financial stability considerations into monetary policy in its March 2012 *Monetary Policy Report*, when it published adjusted criteria for an appropriate interest rate path and a corresponding adjusted loss function to account for the potential contribution of low interest rates to the buildup of financial imbalances. The Bank of England also explicitly linked its conduct of monetary policy with financial stability for a finite period.[13] Its August 2013 Monetary Policy Committee (MPC) statement included three "knockout" conditions, one of which was that the policy rate could have been raised if the monetary policy stance was deemed to pose a significant threat to financial stability that could not be contained by regulatory actions.

Other central banks have monetary policy frameworks that account for financial stability considerations to varying degrees and have described this relationship through speeches and other monetary policy communications. The Bank of Japan, for example, has explained that its monetary policy is conducted within a framework in which it examines risk factors related to financial imbalances, among other factors, and macroeconomic developments (Sato 2014). At the Bank of Canada, monetary policy is conducted using a risk-management framework in which different sets of risks—including those related to financial stability—are balanced against risks to price stability. When the flexibility in returning inflation to target within a reasonable time frame permits, monetary policy tactics can be chosen to mitigate any potential adverse effects on financial stability (Poloz 2014).

Press releases accompanying monetary policy decisions have also been used to note instances where financial stability concerns were considered in the monetary policy decision. Since late 2012, for example, the Bank of Canada's monetary policy press releases regularly noted household imbalances and other risks to financial stability among other economic

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13 In subsequent periods, the Bank of England has also outlined ways in which coordinated use of its policy tools can mitigate risks to monetary and financial stability (e.g., Carney 2014).

conditions that had been taken into consideration in that context. Another notable example is the Riksbank, which has used its monetary policy press releases to note developments in household indebtedness fairly consistently since late 2012. The majority of other central banks have also discussed financial stability risks to some extent in their monetary policy press releases at various occasions in recent years.[14]

Even in cases where monetary policy decisions do not directly incorporate financial stability risks, speeches and monetary policy communications have been used to direct attention and, in some cases, suggest possible policy responses to these issues. For example, past speeches by US Federal Reserve officials have indicated that monetary policy was not deviating from a primary focus on price and output stability to address financial stability (Yellen 2014) but that it might do so in the future if financial imbalances grew rapidly (Brainard 2014). Speeches by the Reserve Bank of Australia (RBA) have been used to draw public attention to financial stability concerns and the role of the RBA in responding to these concerns (e.g., Ellis 2014, Edey 2013). Since 2014, the Riksbank has used many of its MPRs to assess and recommend macroprudential measures taken by the financial supervisory authority (FSA); in MPRs since October 2015, it has also called on the government to clarify the FSA's mandate for macroprudential policy. The ECB has argued that monetary policy must remain focused on price stability and rely on macroprudential policy to address financial stability risks (Constâncio 2015).

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In some cases, how central banks interpret and communicate the interaction between financial stability and monetary policy closely reflects the development of its role in contributing to financial stability overall. In May 2013, for example, the RBNZ published a position paper indicating that it would take into account the interactions between monetary policy and macroprudential policy adjustments when making its policy decisions, following the signing of a five-year memorandum of understanding with the Minister of Finance defining the RBNZ's operating guidelines and governance arrangements for macroprudential policy.

Like the Bank of Canada, several other central banks conduct or commission regular reviews of their monetary policy frameworks.[15] Such reviews indicate that financial stability considerations are playing a greater role in how central banks interpret their monetary policy frameworks.[16] An evaluation of the Riksbank's monetary policy from 2010 to 2015 concluded that, by 2012, financial stability concerns had led the Riksbank to set its repo rate at a higher level than was justified by strict inflation targeting. The argument was made that this reflected in part the lack of clearly assigned responsibility for financial stability and macroprudential policy among Swedish authorities, and it was recommended that the government establish a macroprudential policy framework and clarify the Riksbank's contribution to the framework and to financial stability more generally (Goodfriend and King 2015).[17]

14 We cannot directly compare the discussion of financial stability concerns in the monetary policy press releases across central banks because of the varying length, detail and frequency of these press releases.

15 See Table 1 of Lavigne, Mendes and Sarker (2012) for a review of renewal frameworks across central banks.

16 Financial stability concerns had been incorporated into some of these reviews by 2012 (e.g., the Bank of Canada's 2006 and 2011 reviews, the RBA's 2010 and 2013 Statements on the Conduct of Monetary Policy with the Government, and the RBNZ's September 2012 Policy Targets Agreement with the Government).

17 The Riksbank's role in promoting financial stability had also been reviewed in its previous 2005–10 evaluation.

Conclusion

There have been almost no changes to inflation targets in advanced economies over the past few years; indeed, only the Bank of Japan changed its numeric inflation target since 2012—and that change brought the Bank of Japan's inflation target in line with international practice. However, other aspects of the monetary policy framework have evolved in response to the challenges facing central banks. Central banks have, for example, been innovative when introducing unconventional monetary policy measures into their policy tool kits to assist them in meeting their targets in the face of persistent disinflationary pressure. In some cases, these measures were introduced individually and, in others, as part of a package. This variation will help to provide further evidence on the effectiveness of unconventional tools.

Given the context of low inflation and large amounts of monetary stimulus, some central banks have also played a greater role in the area of financial stability since 2012 by taking on greater authority over micro- and macroprudential policy, as well as by giving greater emphasis to financial stability considerations in their implementation of monetary policy.

Core inflation is an important element of the monetary policy frameworks of most central banks. There appears to have been little change in the basket of core inflation measures used by central banks or in their selection of a preferred, or focal, measure. Preliminary analysis suggests, however, that central banks have varied how they refer to core inflation over time, either with respect to their focal measure or the use of other measures to help explain inflationary developments. The analysis presented here can be expanded in many different ways to more formally test the information content of these changes.

Under flexible inflation targeting, central banks seek to return inflation to its medium-term target while mitigating volatility of other key economic and financial variables. The experience over the past few years has also highlighted the need for versatility in the tool kit used by central banks in achieving this objective, something that has been amply demonstrated by many central banks.

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