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by Justin-Damien Guénette, Nicholas Labelle St-Pierre, Martin Leduc and Lori Rennison

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Abstract

Similar to those of other forecasters, the Bank of Canada's forecasts of global GDP growth have shown persistent negative errors over the past five years. This is in contrast to the pre-crisis period, when errors were consistently positive as global GDP surprised to the upside. All major regions have contributed to the forecast errors observed since 2011, although the United States has been the most persistent source of notable errors. In turn, the Bank of Canada's gauge of foreign demand for Canadian exports—the foreign activity measure—has been continuously revised down. Average forecast errors for Canadian GDP growth are also negative over this period, particularly at the one-year-ahead horizon. The most important contributors to this unexpected weakness are exports and business fixed investment, the effects of which were only partly offset by positive surprises on housing. We find that the one-year-ahead export errors can be linked in part to the unanticipated weakness in US growth. Canadian competitiveness may also have been weaker than assumed. The errors on business investment correlate with measures of firm sentiment and uncertainty, as well as with deviations in oil prices from the view in the Bank's baseline forecast. The possibility that a period of negative surprises in foreign and domestic output growth could continue over the coming years raises important questions for future study by central banks and policy-makers.

JEL Codes : E, E2, E27, E6, E66, F, F0, F01
Bank topics: Business fluctuations and cycles; Economic models; Potential output; International topics; Domestic demand and components; Uncertainty and monetary policy

Résumé

Les prévisions de la Banque du Canada concernant la croissance du PIB mondial, tout comme celles d'autres institutions, ont présenté des erreurs négatives persistantes ces cinq dernières années. Cette situation tranche avec la période d'avant-crise, durant laquelle les erreurs de prévision étaient systématiquement positives, la croissance du PIB mondial étant alors plus élevée qu'escompté. Si les erreurs prévisionnelles observées depuis 2011 sont attribuables à une surestimation de la croissance dans les principales régions du globe, les États-Unis ont été la source d'erreurs importantes la plus persistante. Par contrecoup, l'indicateur que la Banque du Canada utilise pour évaluer la demande étrangère d'exportations canadiennes, à savoir la mesure de l'activité étrangère, a continuellement été revu à la baisse. Sans surprise, les erreurs moyennes de prévision liées à la croissance du PIB du Canada sont également négatives au cours de cette période, surtout pour ce qui est des prévisions à l'horizon d'un an. Les principales composantes de la demande à l'origine de cette faiblesse inattendue sont les exportations et les investissements fixes des entreprises, dont la tenue n'a été que partiellement contrebalancée par la vigueur supérieure aux attentes du logement. Nous constatons que les erreurs de prévision une année à l'avance concernant les exportations peuvent être en partie liées à la faiblesse inattendue de la croissance de l'économie américaine. La compétitivité du Canada pourrait également avoir été plus faible qu'anticipé. Les erreurs relatives aux investissements des entreprises sont corrélées avec les mesures de la confiance et de l'incertitude des entreprises, ainsi qu'avec les écarts du cours du

pétrole par rapport à l'analyse de la prévision de référence de la Banque. La possibilité qu'une période de croissance inférieure aux attentes de la production étrangère et intérieure se poursuive au cours des prochaines années soulève d'importantes questions qui pourraient être étudiées par les banques centrales et les décideurs publics.

Classification JEL : E, E2, E27, E6, E66, F, F0, F01
Classification de la Banque : Cycles et fluctuations économiques; Modèles économiques; Production potentielle; Questions internationales; Demande intérieure et composantes; Incertitude et politique monétaire

1. Introduction

Forecasting output over the past 10 years has been challenging. Central banks and other forecasting institutions tended to underestimate growth before the global financial crisis, and they have overestimated growth since. Indeed, the post-crisis recovery has become known as a period of "serial disappointment," given that a repeatedly projected, sustained strengthening of global economic growth has failed to materialize.

This note reviews the Bank of Canada's forecasting performance with respect to global, US and Canadian GDP growth over the pre- and post-crisis periods. It provides a decomposition of the contribution to the errors by region and component of growth and reviews several factors that may have contributed to the serial disappointment. We then evaluate the spillovers from errors in projections of global growth to Canada and examine the extent to which other information available at the time of the forecast helps to explain the forecast errors. We conclude with a discussion of the policy implications.

2. The Bank's economic projections

The Bank of Canada's economic projections are provided in its quarterly *Monetary Policy Report*s (MPRs) that are published each January, April, July and October. In these reports, the Bank's Governing Council provides its outlook for economic activity and inflation and outlines the key risks around this outlook. The forecasts published in the reports are informed by the staff international and Canadian economic projections, which combine macroeconomic models of the global and Canadian economy with the latest intelligence on the near-term prospects for economic activity, and by the staff's best judgment on various issues.[1] The April Report is a useful benchmark for assessing forecasting performance, since official national accounts data have not yet been released to inform the current-year forecasts and the projection horizon is model- and judgment-driven.[2]

[1] See Macklem (2002) and Murray (2013) for a discussion of the monetary policy decision-making process at the Bank of Canada. The staff projection for Canada is based on a combination of outputs from the most recent macroeconomic models, such as LENS (see Gervais and Gosselin 2014) and ToTEM II (see Murchison and Rennison 2006 and Dorich et al. 2013) and staff judgment. For details on the models used to produce the staff international projection, see Blagrave et al. (forthcoming) and Gosselin and Lalonde (2005).

[2] At the time of the April MPR, some monthly indicators are available that provide information on economic activity over the first few months of the year.

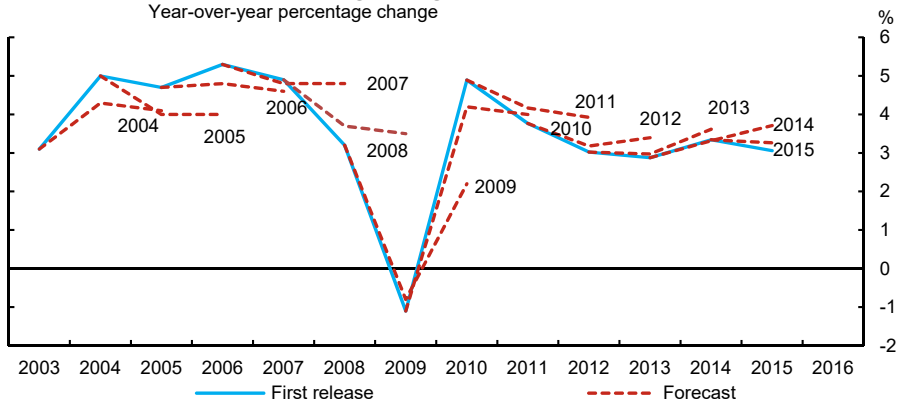
We calculate forecast errors as actual growth less forecast growth at each forecast horizon, where "actual" growth in any given year is taken from the April MPR in the following year.[3] The sample is the 2004–15 period because global forecasts began to be published in the MPR in 2004 (a longer history is available for the Canadian forecasts). Given this relatively short sample period, we focus on the current-year and one-year-ahead horizons.

3. Global forecast errors

The Bank's published annual growth forecasts have consistently overpredicted global real GDP growth in the years since the start of the recovery from the global financial crisis (**Chart 1** and **Tables A1.1** and **A1.2** in **Appendix 1**). The period of persistent negative errors over the past five years stands in contrast to the years leading up to the crisis, when global GDP growth was underestimated.

Chart 1: Bank of Canada's global growth outlook

Year-over-year percentage change



Source: Bank of Canada (April MPR) Last data plotted: 2015

Errors around the Bank's current-year and one-year-ahead annual forecasts of global growth have averaged -0.2 percentage points (p.p.) and -0.5 p.p., respectively, since 2011. The Bank's current-year forecast errors over 2011–15 were smaller than the IMF's errors but slightly larger than the private sector consensus errors (**Table A1.1**). For the year ahead, growth outcomes

[3] We focus on these "real-time" data as the most relevant consideration for monetary policy, since they represent the information available at the time monetary policy decisions are made. However, to the extent that initial data releases may be less reliable, particularly following shocks or at times of rapid changes in the economy (OECD 2014), we also calculated forecast errors using the most recent vintage of the data (recognizing that the last year in the sample period will be the same as for the initial release). The results discussed in this note hold for charts and tables based on the latest data vintage.

have been closer to the Bank's forecasts than to the private sector consensus forecast or to the International Monetary Fund (IMF) forecasts over this period (**Table A1.2**).[4]

GDP forecasts by major region and component of growth

All major regions have contributed to the errors in forecasts of global growth observed since 2011 (**Table 1**). In growth terms, the largest negative errors have been observed for advanced economies, with errors around the Bank's US forecast representing the most persistent source.[5]

With the exception of 2009, year-ahead errors around US growth have been consistently negative since 2005 (**Chart 2**). The United States is the only region among those forecast by the Bank to see such consistent negative errors. Errors have averaged a considerable -0.4 p.p. and -1.0 p.p. for current-year and one-year-ahead annual forecasts, respectively, since 2011; as such, they are generally larger than those of the consensus and the IMF (**Tables A1.3** and **A1.4**) but comparable with those of the Federal Reserve (**Tables A1.5** and **A1.6**).

Table 1: Average forecast errors of GDP growth projections by major region (percentage points)

Period	April projection for current year	April projection for one year ahead
Pre-crisis, 2004–06:		
Global GDP growth	0.6	1.0
United States	-0.3	-0.7
European Union	0.3	-0.3
Japan	0.2	0.5
China and Asian NIEs	1.5	2.6
Post-crisis, 2011–15:		
Global GDP growth	-0.2	-0.5
United States	-0.4	-1.0
Euro area	0.0	-0.6
Japan	-0.5	-1.1
China	-0.1	-0.4
Rest of world	-0.2	-0.5

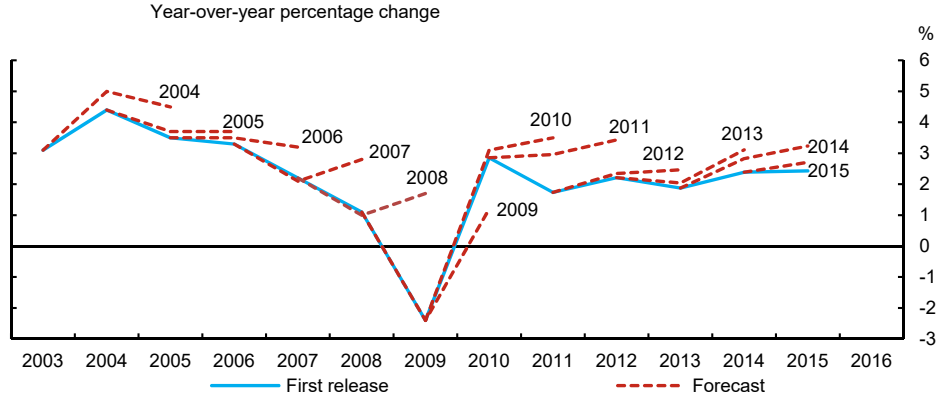
Notes: Errors are calculated as actual growth less forecast growth at each forecast horizon, where actual growth is the published value in the April MPR in the following year. Asian NIEs are newly industrialized economies. These include Hong Kong (Special Administrative Region), South Korea, Taiwan (Province of China) and Singapore. For the one-year-ahead forecast, the average for the 2004–06 period only uses 2005–06 data, since there were no one-year-ahead forecasts published for 2004.

[4] Since the definition of global GDP may differ across institutions, we compare each institution's forecast of global growth with its own estimate of realized global growth.

[5] The "rest of world" includes all economies outside the United States, the euro area, Japan and China, representing approximately 50 per cent of the world in purchasing-power-parity terms (PPP). While the growth errors are smaller on average for this category, its large weight in global growth implies that the category makes a large contribution to the global errors, together with the United States.

Chart 2: **Bank of Canada's outlook on US growth**

Year-over-year percentage change



Source: Bank of Canda (April MPR)

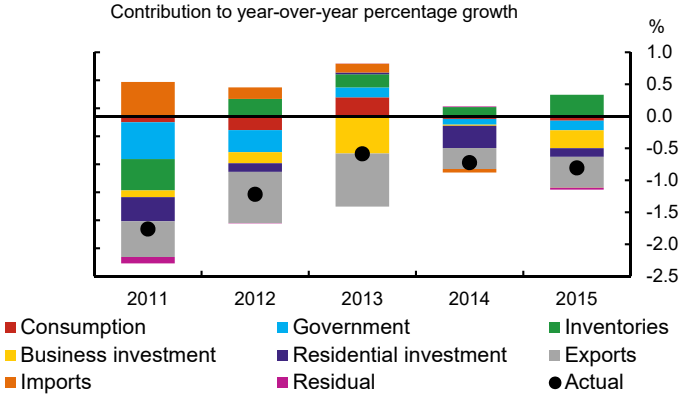
Last data plotted: 2015

Growth was significantly overestimated in the euro area in 2010 and 2011, but in more recent years it has come in largely in accordance with the Bank's forecasts. After significantly underestimating Chinese growth in the years leading up to the crisis, the Bank of Canada's forecast errors for China have been relatively modest over the past five years.[6] Weaker-than-expected growth in other emerging-market economies (EMEs) also contributed to the errors for the rest of world residual.

The components of demand driving the global and US forecast errors are particularly important in gauging the outlook for Canadian exports. The Bank's foreign activity measure (FAM) takes into account both the composition of demand in the United States and economic activity outside of the United States.[7]

Chart 3: **US growth forecast errors, by component, one year ahead**

Contribution to year-over-year percentage growth



Source: Bank of Canada (April MPR)

[6] The IMF's Spring WEO current-year (year-ahead) forecast errors for China over 2011–15 are 2.0 (2.4) times as large as those of the Bank of Canada when the root-mean-square errors are considered.

[7] The Bank introduced the US activity index in 2009 as a measure of demand for Canadian exports. The methodology was refined in Morel (2012) to (i) take into account the composition of US demand; (ii) estimate coefficients over the 1981–2009 period, controlling for the effects of changes in relative prices; and (iii) more accurately forecast Canadian exports.

Chart 3 shows that the forecast errors on US GDP growth after 2011 have been largely driven by three components: persistently weaker-than-expected exports; a recovery in residential investment that was more protracted than expected; and persistently weaker-than-expected business investment.[8] Based on the estimated coefficients used in the construction of the FAM, residential and business investment represent about two-thirds of the FAM. Given the errors on these components of demand and, to a lesser extent, those on activity outside the United States, the FAM has been weaker than forecast since 2011 over the one-year-ahead horizon.

4. Factors contributing to global forecast errors

Persistently negative forecast errors over the one-year-ahead horizon can be tied in part to the effects of a succession of one-sided negative shocks, some of which proved over time to be larger and more structural in nature than initially expected. At the same time, the financial crisis has had longer-lasting effects than anticipated. Slow global growth and heightened economic uncertainty have weighed on business investment globally in the post-crisis period (Leboeuf and Fay 2016). Structural adjustments have been under way that were not (and in some cases are still not) well understood. Unobserved concepts such as potential output are difficult to capture in real time and to predict over the monetary policy horizon, and central bank macro models may not have had sufficient channels to capture the salient features of the post-crisis recovery. These factors are discussed below.

One-sided negative shocks

Fiscal consolidation across the G20 while the recovery was still at an early stage, including in the United States and Europe, was unexpected and weighed significantly on growth in 2011–12. The euro-area crisis, compounded by unexpected monetary policy tightening, resulted in large negative forecast errors for the euro area in 2011 and 2012. More recently, growth disappointed in several emerging markets, including Brazil (fiscal crisis) and Ukraine (war). These events followed other shocks earlier in the recovery, such as the natural disaster in Japan in 2011 that severely affected its economic activity and created short-term disruptions to supply chains in advanced economies.

[8] The decomposition of the forecast errors on US growth shown in Chart 5 is based on the internal staff projection.

Larger-than-expected drags on growth

In the case of the United States, the unexpected appreciation of the US dollar starting in 2011 was a large drag on exports and investment growth.[9] At the global level, the supply-driven oil price shock that began in 2014 was initially expected to provide a considerable boost to global output; the latest assessments by the IMF and the ECB suggest that the impact to date has instead been a small net negative.[10]

Structural adjustments in the post-crisis period

Potential output growth in the United States slowed markedly through the 2000s, led by a deceleration in the growth of total factor productivity (TFP). Contrary to the Bank's expectations in 2011, US productivity and potential output growth failed to recover and continued to decline throughout most of the post-crisis period. Some of the weakness in potential output can be linked to hysteresis effects caused by the financial crisis and subsequent deleveraging needs, as well as persistently weaker business investment in the face of inadequate private domestic demand.[11] A similar pattern of slower potential growth, driven by a slowdown in productivity growth, was observed at the global level. A part of this slowdown may reflect fading productivity spillovers from trade following the dramatic slowing of world trade in the post-crisis period.[12] The persistence of the headwinds described above and their impact on potential and actual output became more apparent over time.[13]

Based on a cross-country forecast assessment of the 2007–12 period, the Organisation for Economic Co-operation and Development (OECD 2014) finds that growth was comparatively

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[9] In the post-crisis period, staff expected a sustained depreciation of the US real effective exchange rate. This assumption reflected the need to rebalance global demand as outlined in the G20's Framework for Strong, Sustainable and Balanced Growth (see Murray 2012 for a detailed discussion). According to this framework, countries with large current account deficits, such as the United States, were expected to experience large real effective exchange rate depreciations.

[10] See the IMF *World Economic Outlook* (April 2016); ECB *Economic Bulletin* (June 2016).

[11] As discussed in Reza and Sarker (2015), the persistently weak growth in advanced economies in the post-crisis period can be linked to headwinds from demographics, technological factors and financial deleveraging, as well as the structural inadequacy of demand, which has led to a long-lasting liquidity trap. Also, see Mourougane (2015) for a review of quantitative estimates of the impact of hysteresis from past financial crises on potential output.

[12] A large part of the weakness in global trade remains unexplained and may reflect the fading benefits of the globalization process. See Francis and Morel (2015) and Poloz (2016) for a detailed discussion of the slowdown in global trade.

[13] Martin, Munyan and Wilson (2015) find that output deviates persistently from trend for all recessions, especially the severe ones. They show that contrary to the assumption that output grows rapidly after recessions to close the output gap, the gap is also closed through revisions to potential output. These downward revisions to potential are found to take place only gradually, raising the policy question as to whether policy-makers wait too long to make downward revisions.

weaker and forecast errors higher in countries that are more open to external developments and exposed to shocks from other countries and that had more-stringent pre-crisis labour and product market regulations, as well as impaired banking systems and weak confidence. Other pre-crisis imbalances (i.e., house price increases and growth of private credit) were not found to be correlated with forecast errors, since they were already incorporated sufficiently through the OECD staff judgment.

A review of IMF forecasting errors by Genberg and Martinez (2014) suggests that in addition to economic factors, institutional factors can also influence the speed with which forecasters adjust their outlooks in response to recent global developments. For example, the need to justify why an organization's forecasts are different from those of other forecasters has been shown to introduce a bias toward the private sector mean. To the extent that private sector forecasts lack incentives to forecast recessions (Juhn and Lougani 2002), this practice could lead to serially correlated errors.

Lessons learned

Many of the global developments and puzzles at play over the post-crisis period were incorporated to some degree into the Bank's forecast judgments and were discussed in the MPR. The Bank downgraded growth prospects in the euro area following its sovereign debt crisis, anticipated a gradual slowdown in potential output growth in China and tempered model-based forecasts for global trade. The Bank adjusted its estimates of the drag from fiscal consolidation in the United States after 2011, and as a result, the fiscal-policy-related forecast errors that resulted from the fiscal cliff and sequestration over 2013–15 were relatively small. Nonetheless, as the Bank and other forecasters were drawing on models and judgment to understand and incorporate the negative surprises of the post-crisis period into their forecasts, new shocks kept hitting the economy, and some unfolded in ways contrary to historical experience, suggesting that structural forces were at play. Estimates of potential output were gradually revised down across regions. The experience of persistent negative errors amid shifting global trends is leading forecasters and central banks to examine model assumptions and ensure that macroeconomic models capture channels that appear more relevant in the post-crisis context. This work is under way and will inform our knowledge on the extent to which some errors could have been better anticipated.

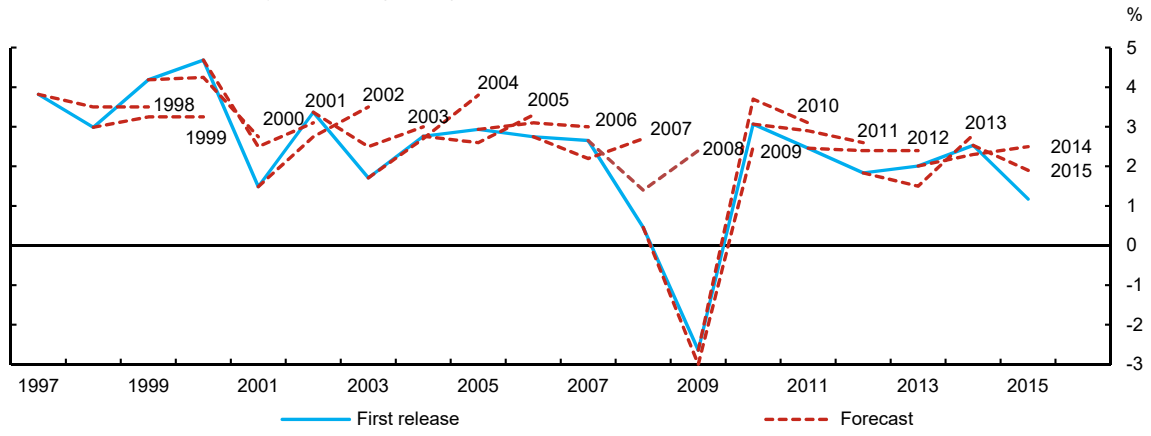
5. Canadian forecast errors

The evolution of the Bank's outlook for Canadian real GDP growth exhibits a similar pattern to that for US growth (**Chart 4**).[14] When the Bank published its outlook in the April MPR over the past five years, the data available at the time suggested, on average, weaker growth than forecast in the previous year. Forecast errors average -0.2 and -0.7 p.p. for the current-year and one-year-ahead horizons, respectively, between 2011 and 2015 (**Tables A1.7** and **A1.8**). The Bank's forecast errors for Canadian GDP growth were comparable to those of the IMF and the consensus for the current-year horizon, whereas the IMF fared slightly better than the Bank and the consensus for the one-year-ahead horizon on average. However, forecasts of Canadian inflation have performed somewhat better relative to those of the IMF over 2004–15.[15]

Chart 5 and **Table A1.9** show the contribution to the forecast errors from each component of growth. On average, exports and business investment have been the main drivers of the disappointments in GDP growth since 2011, while residential investment has been stronger than predicted. After a stronger-than-expected rebound from the recession in 2010, business investment has been particularly disappointing since 2012. Year-ahead forecast errors for exports in the past 10 years have been negative in all but two years (2010 and 2014).

Chart 4: **Bank of Canada's outlook for Canada**

Year-over-year percentage change



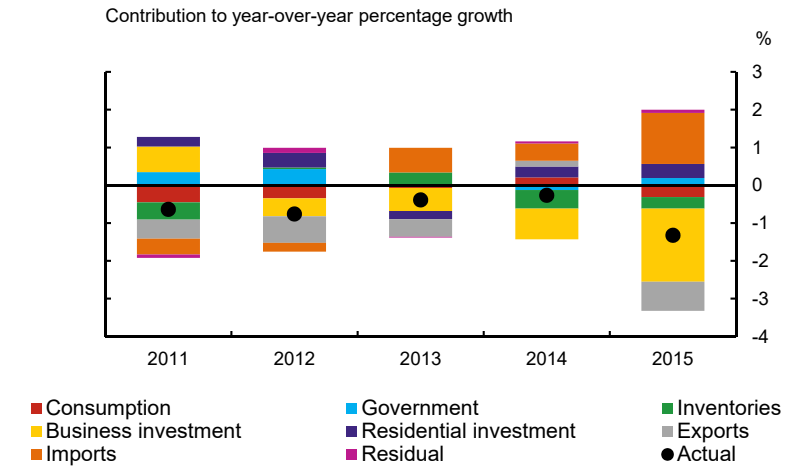
Source: Bank of Canda (April MPR)

Last data plotted: 2015

[14] The Bank's forecast errors have been negative at the one-year-ahead horizon each year since 2004 for both the United States and Canada, with the exception of 2010. Current-year errors for the United States have been negative each year since 2004, except for the years from 2007 to 2009. Current-year errors for Canada do not show a similar negative bias.

[15] The IMF's Spring WEO current-year (year-ahead) forecast errors for annual CPI inflation over 2004–15 are 1.3 (1.2) times as large as those in the Bank of Canada's April MPR when the root-mean-square errors are considered.

Chart 5: Canada growth forecast errors, by component, one year ahead



Source: Bank of Canada (April MPR)

The assessment of forecast errors in the post-crisis period is complicated by substantial revisions to the national accounts in 2012 and 2014. Even when calculating forecast errors based on real-time data (the growth outcome at the time of the April MPR in the following year), these kinds of conceptual changes affect the realized forecast error for Canada and the world, but less so for the United States, over the period from 2011 to 2015.[16] If we calculate the errors using the latest vintage (which also takes into account the historical revisions), the data revisions in the post-crisis period bring the data closer to the Bank's initial forecast. Nonetheless, even using the latest vintage, forecast errors remain sizable at the one-year-ahead horizon.

6. Impact of global factors on Canadian forecast errors

Global disappointments could feed through to the Canadian outlook through trade, financial or confidence channels. We focus on the role of errors in the Bank's measure of foreign demand for Canadian exports, commodity prices and the exchange rate. We also investigate whether other information available at the time the forecasts are published is correlated with the

[16] For example, the 2014 forecast for export growth went from 2.9 per cent in the July 2014 MPR to 5.0 per cent in the October 2014 MPR, after a 2 per cent increase in the level of GDP in the data release of September 2014. The first release for export growth came in at 5.4 per cent in March 2015. Similarly, data revisions in the rest of world residual related to updates of the purchasing-power-parity weights. As well, large national account revisions in several emerging markets (e.g., India) noticeably boosted initial estimates of output growth and thus reduced staff forecast errors for this region and the world as a whole. In the case of the United States, however, national account revisions did not significantly affect the balance of forecast errors over the post-crisis period.

realized errors. Given that exports and business investment were the most important contributors to the unexpected weakness, we focus our analysis on these two components.

The Bank's outlook for exports is influenced by the expected growth of foreign activity (based on the Bank's foreign activity measure, or FAM) as well as competitiveness[17] and trade openness (i.e., the import propensities of trading partners). In the post-crisis period, the year-ahead forecast errors around the Bank's export growth profile have been smaller on average than those for the FAM (**Table 2**). This is partly explained by the Bank's consideration of structural factors, such as changes in competitiveness and trade openness, in the post-crisis period. Some of Canada's observed loss of market share following the crisis started to seem persistent and structural. Moreover, trade openness did not resume its pre-crisis upward trend, as had previously been expected. The composition of exports also helped in some years, since commodity exports helped offset some of the errors made on non-commodity exports. In addition, the depreciation of the Canadian dollar that started in 2012 provided unexpected stimulus relative to the Bank's assumption of a flat dollar.

Table 2: Year-ahead forecast errors of the growth in the foreign activity measure (FAM) and the growth in Canadian exports (percentage points)

Period	Growth in FAM	Growth in Canadian exports
2011	-3.8	-0.7
2012	-0.4	-1.2
2013	-2.8	-1.1
2014	-2.4	0.5
2015	-1.9	-2.2
Average of the errors (2011–15)	-2.3	-1.0

Note: Errors are calculated as actual growth less forecast growth at each forecast horizon, where actual growth is the published value in the April MPR in the following year.

Regression analysis can help to identify variables whose errors are correlated with the errors made on exports (see **Appendix 2** for more details). We start the analysis in 2004 (when the Bank began publishing its global and US forecasts) in order to have a sufficiently large sample for statistically significant results. Over this period, forecast errors made on the contribution to growth (CTG) of exports are not found to be correlated with the errors on the assumptions for oil prices and the dollar. However, the year-ahead forecast errors are correlated with the errors around US total GDP growth. Underestimating US GDP growth by 1 p.p. is associated with a

[17] Competitiveness can be assessed by considering factors such as relative prices (including the exchange rate) and market shares.

year-ahead forecast error on the CTG of exports of -0.3 p.p. We also calculate a series equivalent to the FAM (the FAM equivalent) using the weights for the components of US private demand.[18] Errors around the FAM-equivalent series are also significant, but the effect is smaller (-0.1 p.p.) than for total US growth, suggesting that the export errors may be linked in part to the errors on US exports. This may reflect to some extent the high Canadian import content of US exports[19] or, indirectly, the role of general global weakness.

In the case of business investment, the regression results suggest that the forecast errors can be linked to uncertainty and oil prices. We examine whether the investment forecast errors can be linked to information available at the time of the forecast from the Business Outlook Survey, using the BOS underlying indicator as a proxy, and find a link with the current-year forecast errors (see **Appendix 2**).[20] We also found a link with the uncertainty index of Jo and Sekkel (2016). Year-ahead forecast errors on the CTG of investment are found to be correlated with errors on realized oil prices.[21] Underestimating the price of West Texas Intermediate (WTI) by US$10 is associated with an error of about -0.2 p.p. on the CTG of investment. Errors on the exchange rate are not found to be correlated with the investment errors over either horizon.

Lessons learned

Some of the possible explanations for repeated growth disappointments at the global level (such as weaker-than-expected potential output growth and the inability of models to accurately reflect the post-crisis period) can provide useful insights into the negative forecast errors for Canada. The Bank did lower its outlook for potential output growth over the period of serial disappointment; in each annual reassessment since 2012, the outlook for potential output growth over the projection horizon was lower than it was the year before (**Table A1.10** in **Appendix 1**). Even though the Bank took into account changes in competitiveness through the judgment on its export profile, the persistent errors could be consistent with a more-marked deterioration than assumed. The disappointments in Canadian business investment and export growth were shared with other countries such as the United States, suggesting that common global factors, including persistently weak aggregate demand and the slowdown in

[18] As mentioned in footnote 7, the Bank introduced the FAM in 2012. The FAM equivalent can be calculated over the whole sample (i.e., back to 2004).
[19] The OECD (2016) estimates that about 40 per cent of US exports contain imports from other countries. Canada is one of the top three countries from which the United States imports, with China and Mexico.
[20] See Pichette and Rennison (2011) for details on the BOS underlying indicator.
[21] In the April 2014 MPR, the Bank changed its working assumption for the profile of energy prices and started to assume that energy prices would remain near their current levels. Previously, the Bank had assumed that energy prices would follow the futures curve.

global trade, may also play a role. These common factors, if persistent, have implications for future growth prospects.

The correlation between information from the BOS and current-year errors on business investment supports the role of business intelligence in helping to identify the near-term risks around the Bank's outlook for business investment, as well as informing the Bank's view on longer-term trends and structural issues.[22]

7. How closely do the forecast errors align with the published risks?

Since 2011, the Bank has considered the risks to the projected path for inflation to be roughly balanced. **Table 3** shows the risks to the outlook cited in the MPR over the 2011–15 period. Broadly speaking, the pattern of Canadian GDP forecast errors shown in **Chart 5** suggests that many downside risks materialized to varying degrees (notably those shaded in **Table 3**), while few of the upside risks have come to pass.

The possibility of weaker-than-expected investment and exports has been mentioned as a downside risk in the MPR every year between 2011 and 2015. This was counterbalanced by a repeated upside risk that US private domestic demand could be stronger than anticipated and thus Canadian exports could be stronger than expected. While the growth of US private domestic demand remained solid in the face of weak global demand over this period, it did not materially strengthen, and this upside risk did not materialize. Instead, the Bank was consistently negatively surprised by the pace of US growth and exports. In addition, the commodity-price shock was larger and the adjustment more front-loaded than initially anticipated.

The upside risk of stronger-than-anticipated household spending has been mentioned in many MPRs since 2011, and, indeed, positive forecast errors on residential investment have helped to offset the negative surprises on Canadian exports and investment. Lower imports have also surprised on the upside, in line with lower exports and investment.

Regarding the global outlook, at the time of the 2011 projection the Bank flagged the risk that global potential output could be weaker than projected (the Bank expected it to strengthen) and could lead to more-persistent global inflationary pressures. Higher global inflation did not materialize; rather, inflation has remained well below inflation targets in advanced economies

[22] The findings of the Bank of Canada's 2013 *Firm Strategy Survey* suggest that, in a slow-growth environment amid strong competition and uncertainty regarding the timing of a strengthening in demand, Canadian firms focus on short-term strategies rather than investing in longer-term competitiveness (Rennison, Novin and Verstraete 2014).

since the start of the financial crisis, notwithstanding ongoing and, in several cases, exceptional support from monetary policy over this period. The Bank's latest assessment shows a significant broad-based slowing in global potential output growth in the post-crisis period. Weaker-than-expected global potential output growth in the face of persistently weak global inflation indicates that demand-side weakness has been the more important factor in explaining the serial disappointment.

Table 3: The Bank's characterization of risks to its projection for Canadian inflation, 2011–15

Year*	Upside	Downside
2011	Stronger global economy	Weaker exports (strong dollar, productivity)
	Stronger global inflationary pressure (if strong demand or weaker potential in advanced economies)	Imbalances in the household sector with spillovers/sharp deceleration in spending
	Stronger household spending	Failure to contain euro-area crisis
	Lower Canadian potential output	US recession
2012	Higher global inflationary pressure (if stronger commodity prices or weaker global potential output)	Re-intensification of euro-area crisis
	Stronger exports if exporters improve their competitiveness faster	Slower growth in EMEs
	Stronger US private demand and smaller-than-expected fiscal drag	Weaker Canadian exports
	Stronger household spending and residential investment	Imbalances in household sector; spillovers
2013	Stronger US private sector demand	Failure to contain euro-area crisis
	Stronger exports if exporters improve their competitiveness faster	Weaker exports and business investment
	Stronger residential investment	Imbalances in household sector; spillovers
	Stronger growth—advanced economies	Weaker growth in China and EMEs
	Stronger exports and business investment (uncertainty unwinds; natural sequence)	More-protracted and difficult euro-area recovery
2014	Stronger US private sector demand	Weaker exports and business investment
	Global uncertainty dissipates, boosting global investment	Severe tightening in credit conditions in EMEs; weaker growth in EMEs
	Higher commodity prices	Imbalances in household sector; spillovers
	Continued strength in housing and consumption	Further disappointment in global growth
2015	Stronger US private sector demand	Slower growth in EMEs
	Higher non-energy prices	Weaker exports and business investment
		Greater impact of oil price decline
		Imbalances in household sector; spillovers
		Financial market stress in EMEs

*Risks cited in *Monetary Policy Report*s in this year for Canadian inflation over the monetary policy horizon. Upside and downside risks that materialized to varying degrees are shaded.

8. Conclusions

The Bank and other forecasting institutions have observed repeated growth disappointments since 2011. All regions have contributed, but errors around the Bank's forecasts for US growth have been a persistent source of notable errors. Moreover, these errors have taken place around a lower level of growth globally than in the pre-crisis period and in the context of exceptionally accommodative monetary policy. Canadian GDP growth has also disappointed. In both the United States and Canada, business investment and exports have most often been the sources of the forecast errors.

The period of "serial disappointment" appears to reflect a series of one-sided negative shocks against a backdrop of persistent uncertainty and shifting structural forces weighing on actual and potential output. Efforts to take these shifts into account in real time were often made through judgment (since existing tools and models frequently offered insufficient channels) in an environment of considerable uncertainty around when pre-crisis trends would reassert themselves. Forecasts of actual and potential output were being revised down at both the global and Canadian levels, but slowly, and growth continued to disappoint.

Statistically, the disappointments in the components of US growth that the Bank has considered most relevant for Canadian exports (residential investment, business investment, consumer spending) can be linked (using correlations) to the sustained overprediction of Canadian exports. By reducing the need for inputs from Canada, the unexpected weakness in US exports over the post-crisis period may have also played a role. The errors on business investment correlate with measures of uncertainty and deviations in oil prices from the view in the Bank's baseline forecast.

Notwithstanding the recent forecast downgrades, the Bank's global forecasts still rest on some key assumptions: labour productivity growth (particularly in the United States) is expected to pick up; global trade and investment are expected to strengthen; and structural reforms are expected to drive higher growth in emerging-market economies. Moreover, the Bank's outlook for Canada still calls for non-commodity exports to strengthen and for this to lead to increased investment. If the non-commodity sector is not sufficiently competitive following the period of prolonged uncertainty and persistent underinvestment by firms, or in the absence of a faster pace of firm creation or greater focus on innovation, there is potential for the pattern of negative errors in investment and exports to continue.

Monetary policy is conducted in an environment of uncertainty at the best of times, but the repeated growth disappointments of the past several years leave some important questions for further reflection by central bank forecasters as they seek to achieve their mandated objectives.

APPENDIX 1 | Forecast errors for the world, the United States and Canada

Table A1.1: Forecast errors of world GDP growth projections (current-year, p.p.)

Period	Bank	IMF	Consensus
2010	0.7	0.8	0.9
2011	-0.3	-0.6	-0.3
2012	-0.2	-0.4	-0.2
2013	-0.1	-0.3	-0.2
2014	0.0	-0.2	0.0
2015	-0.2	-0.4	0.0
Full period of published forecasts: 2004–15*	0.1 (1.0)	0.1 (1.1)	0.3 (1.6)
Subperiods			
Pre-crisis (2004–07)*	0.5 (1.0)	0.4 (0.8)	0.9 (1.8)
2004–06*	0.6 (1.0)	0.5 (0.8)	1.1 (1.8)
2007–10*	0.0 (1.0)	0.3 (1.3)	0.1 (1.4)
2011–15*	-0.2 (1.0)	-0.4 (2.0)	-0.1 (1.0)

Note: Errors are calculated as actual growth less forecast growth at each forecast horizon, where actual growth is the published value in the April MPR in the following year. We compare with the International Monetary Fund's Spring *World Economic Outlook* forecasts and the April consensus from Consensus Economics.

* Average errors over the sample period are shown on the left. Root-mean-square errors (RMSE) over the sample period are shown on the right in parentheses relative to the Bank of Canada (which always has a value of 1.0). Lower RMSE is better and higher is worse.

Table A1.2: Forecast errors of world GDP growth projections (year-ahead, p.p.)

Period	Bank	IMF	Consensus
2010	2.7	3.1	2.3
2011	-0.2	-0.5	-0.3
2012	-0.9	-1.4	-1.3
2013	-0.5	-1.1	-0.7
2014	-0.3	-0.7	-0.4
2015	-0.6	-0.8	-0.5
Full period of published forecasts: 2004–15*	-0.2 (1.0)	-0.4 (1.0)	-0.2 (1.1)
Subperiods			
Pre-crisis (2004–07)*	0.8 (1.0)	0.7 (0.8)	1.2 (1.4)
2004–06*	1.0 (1.0)	0.8 (0.8)	1.2 (1.3)
2007–10*	-0.8 (1.0)	-0.7 (1.0)	-0.8 (1.0)
2011–15*	-0.5 (1.0)	-0.9 (1.7)	-0.6 (1.3)

Note: Errors are calculated as actual growth less forecast growth at each forecast horizon, where actual growth is the published value in the April MPR in the following year. We compare with the International Monetary Fund's Spring *World Economic Outlook* forecasts and the April consensus from Consensus Economics.

* Average errors over the sample period are shown on the left. Root-mean-square errors (RMSE) over the sample period are shown on the right in parentheses relative to the Bank of Canada (which always has a value of 1.0). Lower RMSE is better and higher is worse.

Table A1.3: Forecast errors of US GDP growth projections (current-year, p.p.)

Period	Bank	IMF	Consensus
2010	-0.2	-0.3	-0.3
2011	-1.3	-1.0	-1.2
2012	-0.1	0.1	-0.1
2013	-0.1	0.0	-0.2
2014	-0.4	-0.4	-0.3
2015	-0.3	-0.7	-0.5
Full period of published forecasts: 2004–15*	-0.3 (1.0)	-0.1 (1.0)	-0.3 (0.9)
Subperiods			
Pre-crisis (2004–07)*	-0.2 (1.0)	-0.1 (0.4)	-0.1 (0.4)
2004–06*	-0.3 (1.0)	-0.1 (0.4)	-0.1 (0.4)
2007–10*	0.0 (1.0)	0.2 (2.9)	-0.1 (2.0)
2011–15*	-0.4 (1.0)	-0.4 (0.9)	-0.5 (1.0)

Note: Errors are calculated as actual growth less forecast growth at each forecast horizon, where actual growth is the published value in the April MPR in the following year. We compare with the International Monetary Fund's Spring *World Economic Outlook* forecasts and the April consensus from Consensus Economics.
* Average errors over the sample period are shown on the left. Root-mean-square errors (RMSE) over the sample period are shown on the right in parentheses relative to the Bank of Canada (which always has a value of 1.0). Lower RMSE is better and higher is worse.

Table A1.4: Forecast errors of US GDP growth projections (year-ahead, p.p.)

Period	Bank	IMF	Consensus
2010	1.7	2.9	1.1
2011	-1.8	-0.8	-1.4
2012	-1.0	-0.7	-1.1
2013	-0.6	-0.5	-0.6
2014	-0.7	-0.6	-0.3
2015	-0.8	-0.5	-0.6
Full period of published forecasts: 2004–15*	-0.9 (1.0)	-0.5 (0.9)	-0.8 (1.0)
Subperiods			
Pre-crisis (2004–07)*	-0.5 (1.0)	-0.3 (1.0)	-0.1 (0.7)
2004–06*	-0.3 (1.0)	0.0 (0.8)	0.2 (0.7)
2007–10*	-1.3 (1.0)	-0.7 (1.0)	-1.5 (1.0)
2011–15*	-1.0 (1.0)	-0.6 (0.6)	-0.8 (0.8)

Note: Errors are calculated as actual growth less forecast growth at each forecast horizon, where actual growth is the published value in the April MPR in the following year. We compare with the International Monetary Fund's Spring *World Economic Outlook* forecasts and the April consensus from Consensus Economics.
* Average errors over the sample period are shown on the left. Root-mean-square errors (RMSE) over the sample period are shown on the right in parentheses relative to the Bank of Canada (which always has a value of 1.0). Lower RMSE is better and higher is worse.

Table A1.5: Forecast errors of US GDP growth projections (current-year, p.p.)

Period	Bank (April)	Bank (July)	Fed (July)
2010	-0.2	0.0	-0.5
2011	-1.3	-0.7	-1.2
2012	-0.1	0.3	-0.5
2013	-0.1	0.2	0.1
2014	-0.4	0.8	0.2
2015	-0.3	0.1	-0.6
Full period of published forecasts: 2004–15*	-0.3 (1.0)	n/a	-0.4 (1.9)
Subperiods			
Pre-crisis (2004–07)*	-0.2 (1.0)	n/a	-0.3 (1.2)
2004–06*	-0.3 (1.0)	n/a	-0.4 (1.2)
2007–10*	0.0 (1.0)	n/a	-0.3 (10.5)
2011–15*	-0.4 (1.0)	0.1 (0.8)	-0.4 (1.0)

Note: Errors are calculated as actual growth less forecast growth at each forecast horizon, where actual growth is the published value in the April MPR in the following year. We compare with the Fed's July *Monetary Policy Report*. Errors for the Fed are based on the growth from the fourth quarter of the previous year to the fourth quarter of the year indicated.
* Average errors over the sample period are shown on the left. Root-mean-square errors (RMSE) over the sample period are shown on the right in parentheses relative to the Bank of Canada's April MPR (which always has a value of 1.0). Lower RMSE is better and higher is worse.

Table A1.6: Forecast errors of US GDP growth projections (year-ahead, p.p.)

Period	Bank (April)	Bank (July)	Fed (July)
2010	1.7	1.5	0.1
2011	-1.8	-1.3	-2.2
2012	-1.0	-1.0	-1.8
2013	-0.6	-0.2	0.1
2014	-0.7	-0.7	-0.9
2015	-0.8	-0.7	-1.1
Full period of published forecasts: 2005–15*	-0.9 (1.0)	n/a	n/a
Subperiods			
Pre-crisis (2005–07)*	-0.5 (1.0)	n/a	n/a
2005–06*	-0.3 (1.0)	n/a	n/a
2007–10*	-1.3 (1.0)	n/a	-1.6 (0.9)
2011–15*	-1.0 (1.0)	-0.8 (0.8)	-1.2 (1.3)

Note: Errors are calculated as actual growth less forecast growth at each forecast horizon, where actual growth is the published value in the April MPR in the following year. We compare with the Fed's July *Monetary Policy Report*. Errors for the Fed are based on the growth from the fourth quarter of the previous year to the fourth quarter of the year indicated.
* Average errors over the sample period are shown on the left. Root-mean-square errors (RMSE) over the sample period are shown on the right in parentheses relative to the Bank of Canada's April MPR (which always has a value of 1.0). Lower RMSE is better and higher is worse.

Table A1.7: Forecast errors of Canadian GDP growth projections (current-year, p.p.)

Period	Bank	IMF	Consensus
2010	-0.6	-0.1	-0.1
2011	-0.4	-0.3	-0.4
2012	-0.6	-0.2	-0.3
2013	0.5	0.5	0.4
2014	0.2	0.2	0.3
2015	-0.7	-1.0	-0.8
Full period of published forecasts: 2004–15*	-0.1 (1.0)	-0.1 (0.9)	-0.1 (0.9)
Subperiods			
Pre-crisis (2004–07)*	0.1 (1.0)	0.0 (0.7)	0.1 (0.9)
2004–06*	0.0 (1.0)	0.0 (0.8)	0.1 (1.0)
2007–10*	-0.2 (1.0)	-0.2 (0.7)	-0.3 (0.8)
2011–15*	-0.2 (1.0)	-0.1 (1.0)	-0.1 (0.9)

Note: Errors are calculated as actual growth less forecast growth at each forecast horizon, where actual growth is the published value in the April MPR in the following year. We compare with the International Monetary Fund's Spring *World Economic Outlook* forecasts and the April consensus from Consensus Economics.
* Average errors over the sample period are shown on the left. Root-mean-square errors (RMSE) over the sample period are shown on the right in parentheses relative to the Bank of Canada (which always has a value of 1.0). Lower RMSE is better and higher is worse.

Table A1.8: Forecast errors of Canadian GDP growth projections (year-ahead, p.p.)

Period	Bank	IMF	Consensus
2010	0.6	1.9	1.0
2011	-0.6	-0.7	-0.6
2012	-0.8	-0.8	-0.9
2013	-0.4	-0.2	-0.3
2014	-0.3	0.1	0.2
2015	-1.3	-1.2	-1.3
Full period of published forecasts: 2004–15*	-1.0 (1.0)	-0.8 (1.0)	-0.9 (1.0)
Subperiods			
Pre-crisis (2004–07)*	-0.5 (1.0)	-0.3 (0.6)	-0.3 (0.7)
2004–06*	-0.6 (1.0)	-0.3 (0.5)	-0.4 (0.7)
2007–10*	-1.8 (1.0)	-1.4 (1.0)	-1.6 (1.0)
2011–15*	-0.7 (1.0)	-0.5 (0.9)	-0.6 (1.0)

Note: Errors are calculated as actual growth less forecast growth at each forecast horizon, where actual growth is the published value in the April MPR in the following year. We compare with the International Monetary Fund's Spring *World Economic Outlook* forecasts and the April consensus from Consensus Economics.
* Average errors over the sample period are shown on the left. Root-mean-square errors (RMSE) over the sample period are shown on the right in parentheses relative to the Bank of Canada (which always has a value of 1.0). Lower RMSE is better and higher is worse.

Table A1.9: Forecast errors of the Bank of Canada's Canadian GDP growth projections, by component

Current year (one-year ahead) forecasts errors on the contribution to growth

p.p.	GDP	Consumption	Business investment	Residential investment	Inventories	Government	Exports	Imports
2008	-0.9 (-2.2)	-0.9 (0.0)	-0.2 (-0.3)	-0.3 (-0.1)	-0.1 (-0.2)	-0.1 (0.1)	-0.4 (-3.0)	0.9 (1.1)
2009	0.4 (-5.0)	0.9 (-2.2)	-0.6 (-2.6)	0.6 (-0.4)	0.2 (-1.3)	-0.1 (0.4)	-0.1 (-4.8)	-1.0 (5.4)
2010	-0.6 (0.6)	0.1 (1.0)	0.4 (0.9)	0.1 (0.5)	0.4 (0.2)	0.0 (0.0)	-0.3 (0.2)	-1.0 (-1.9)
2011	-0.4 (-0.6)	-0.4 (-0.5)	-0.1 (0.7)	0.3 (0.3)	0.3 (-0.5)	0.3 (0.3)	-1.2 (-0.5)	0.4 (-0.4)
2012	-0.6 (-0.8)	-0.2 (-0.3)	-0.3 (-0.5)	0.1 (0.4)	0.5 (0.0)	-0.2 (0.4)	-1.2 (-0.7)	0.6 (-0.2)
2013	0.5 (-0.4)	0.0 (-0.1)	-0.3 (-0.6)	0.2 (-0.2)	0.4 (0.3)	0.0 (0.0)	-0.1 (-0.5)	0.3 (0.7)
2014	0.2 (-0.3)	0.1 (0.2)	-0.2 (-0.8)	0.2 (0.3)	-0.3 (-0.5)	-0.1 (-0.1)	1.2 (0.2)	-0.6 (0.5)
2015	-0.7 (-1.3)	0.0 (-0.3)	-0.5 (-1.9)	0.3 (0.4)	-0.5 (-0.3)	0.2 (0.2)	-0.5 (-0.8)	0.3 (1.4)
Avg. 2011–15	-0.2 (-0.7)	-0.1 (-0.2)	-0.3 (-0.6)	0.2 (0.2)	0.1 (-0.2)	0.0 (0.2)	-0.4 (-0.5)	0.2 (0.4)

Note: Errors are calculated as actual growth less forecast growth at each forecast horizon, where actual growth is the published value in the April MPR in the following year.

Table A1.10: Forecast errors of Canadian GDP growth and potential growth projections (year-ahead, p.p.)

Period	Growth	Potential output
2011	-0.6	-0.3
2012	-0.8	0.0
2013	-0.4	-0.2
2014	-0.3	-0.1
2015	-1.3	-0.4
2011–15 average	-0.7	-0.2

Note: Errors are calculated as actual growth less forecast growth, where actual growth is the published value in the April MPR in the following year. Potential output errors are calculated as revised potential output growth less forecast growth at each horizon, where revised potential output growth is the Bank's revised forecast for potential output in the following year.

APPENDIX 2 | The impact of global factors on Canadian forecast errors: Evidence from regressions

We used statistical regressions to check the presence of correlations between forecast errors. We conducted regressions for current-year and year-ahead forecast errors of all the quarterly *Monetary Policy Report*s (MPRs) from April 2004 to January 2016. For instance, the series for the current-year error on the contribution to growth from exports on 2014Q2 would be the error made for 2014 in the April 2014 MPR. To control for the autocorrelation of the error terms between MPRs for a given year, we added dummy variables for the month of the MPR, included lag terms, and used Newey-West t-statistics. We also checked our results on a weighted sum of current-year and year-ahead forecast errors, in line with the "fixed horizon forecast" of Dovern, Fritsche and Slacalek (2012), to further control for the autocorrelation of annual forecast errors updated every quarter.[23] **Table A2.1** summarizes the main results.

Table A2.1: Summary of regression results

Variable, contribution to growth (CTG)	Current-year error	Year-ahead error
Exports	• No significant results: errors on the exchange rate and oil prices do not help to explain the CTG of exports.	• Overestimating US GDP growth by 1 p.p. implies overestimating the CTG of exports by 0.3 p.p.*** • Overestimating the growth of the FAM-equivalent by 1 p.p. implies overestimating the CTG of exports by 0.1 p.p.* • Overestimating the CTG of US exports by 1 p.p. implies overestimating the CTG of exports by 0.2 p.p.**
Business investment	• Errors on the exchange rate and oil prices do not help to explain the CTG of business investment. • A Business Outlook Survey underlying indicator of -1 would explain an error on the CTG of investment of -4 basis points,*** using the latest vintage. • The uncertainty index based on US private sector forecast errors developed by Jo and Sekkel (2016) also helps explain errors on the CTG of investment: an increase in the index of one standard deviation (0.3 over 1968Q4–2015Q1) would be linked to an error of –0.2 p.p.,*** using the latest vintage of the index (2015Q1). The average CTG of investment over 2000–15 has been 0.3 p.p. (or 0.2 p.p. over 2011–15). • When the BOS indicator and the uncertainty index are both included in the regression, the BOS indicator is not found to contain additional information beyond that contained in the US uncertainty measure.	• An error on the price of oil of US$10 would be accompanied by an error of 0.2 p.p.** on the CTG of investment.

Notes: * = significant at 10 per cent, ** = significant at 5 per cent, *** = significant at 1 per cent

[23] Dovern, Fritsche and Slacalek (2012) approximate a fixed horizon forecast as a weighted sum of the current-year and year-ahead forecasts based on the information available for a given period. For example, given that the four quarters for the current year are unknown in April, the fixed horizon forecast would put a weight of 1 on the current-year forecast and 0 on the year-ahead forecast. Using this logic, the current-year forecast would receive a weight of 0.75 in July, 0.50 in October and 0.25 in January.

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