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High-Frequency Real Economic Activity Indicator for Canada

by Gitanjali Kumar

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Abstract

I construct a weekly measure of real economic activity in Canada. Based on the work of Aruoba et al. (2009), the indicator is extracted as an unobserved component underlying the co-movement of four monthly observed real macroeconomic variables—employment, manufacturing sales, retail sales and GDP. The indicator has a number of applications in macroeconomics and finance—it can be used to measure macroeconomic news, to quantify the impact of news on financial asset prices, to study exchange rate movements and as an input in nowcasting and forecasting exercises.

JEL classification: C38, E32
Bank classification: Econometric and statistical methods; Business fluctuations and cycles

Résumé

L’auteur construit un indicateur hebdomadaire de l’activité économique réelle au Canada, inspiré de l’étude d’Aruoba et autres (2009). Cet indicateur représente une composante inobservable qui sous-tend l’évolution conjointe de quatre variables macroéconomiques observées à une fréquence mensuelle, à savoir l’emploi, les ventes manufacturières, les ventes au détail et le PIB. L’indicateur a de multiples applications en macroéconomie et en finance : il peut servir à mesurer l’effet d’annonces macroéconomiques inattendues, en particulier à quantifier leur incidence sur les prix des actifs financiers, à étudier les variations du taux de change, ou encore, à appuyer des prévisions pour la période en cours ou d’autres horizons.

Classification JEL : C38, E32
Classification de la Banque : Méthodes économétriques et statistiques; Cycles et fluctuations économiques

1 Introduction

Estimation and measurement of the business cycle in a timely manner is a useful monitoring tool for policy-makers. It is also a valuable input in the analysis and development of models in the fields of both macroeconomics and finance. However, the construction of indicators of real economic activity is challenged by a number of factors. First, macroeconomic data are measured at multiple, typically low frequencies. Second, data on macroeconomic variables are released with a long publication lag, which differs for various data series. Lastly, data may not be measured consistently over time. Combining macroeconomic variables into one index to obtain an overall view of economic activity is, therefore, challenging. Using the methodology proposed by Aruoba et al. (2009),[1] which overcomes these obstacles, I construct a high-frequency real activity indicator for Canada that reflects the evolution of real activity in Canada.

The indicator is extracted as an unobserved common factor underlying the movements of four key real macroeconomic variables observed at a monthly frequency—the level of employment, manufacturing sales, retail sales and GDP. The methodology underlying the construction of the indicator is customizable and has certain interesting features, such as the ability to incorporate missing observations and mixed-frequency data, and the ability to be updated in real time as data are released. Even though I follow the Aruoba et al. (2009) methodology quite closely, there are some points of departure that are crucial given the nature of Canadian data. First, the novel feature of the indicator is that it evolves weekly because the information underlying the construction of the indicator changes every week due to new data releases. Therefore, a high-frequency indicator is constructed even though there are no macroeconomic variables that are available at a weekly frequency in Canada. Second, the underlying variables are measured in year-on-year (YoY) growth rates, instead of month-on-month (MoM) growth rates used in the Aruoba-Diebold-Scotti (ADS) index, for better identification of the unobserved common component.

The indicator is useful in itself, but it has a variety of applications in macroeconomics and finance. Since the indicator is able to incorporate the most recently available data on core macroeconomic variables, it can be employed in nowcasting and forecasting other variables of interest, such as quarterly GDP. In addition, the high-frequency nature of the indicator makes possible its use in a variety of applications in finance and I provide two such examples. First, I show that the indicator is particularly useful for measuring macroeconomic

[1] The Aruoba, Diebold and Scotti index for the United States is maintained by the Federal Reserve Bank of Philadelphia and has been successful in providing timely information about the state of the U.S. economy.

news. Typically, asset prices react to the surprise or news component of macroeconomic data releases, i.e., the deviation of economic data from market expectations. So far, the literature has measured news as the difference between the data release and its forecast normalized by the standard deviation of this difference for ease of comparison across different data releases. As an alternative, the indicator can be used to measure news uniformly across data releases, expressed in terms of the unexpected change in current economic activity. This measure of news can then be used to analyze movements in asset prices on days of data releases.

As a second example, I show that the indicator for Canada can be used along with the ADS index for the United States to analyze weekly changes in the nominal Canadian-dollar exchange rate relative to the U.S. dollar. Given the tight link between the Canadian and U.S. economies, deviations in macroeconomic fundamentals between the two countries observed at high frequency should affect the CAD/USD exchange rate. The underlying idea is similar to the Taylor-rule-based exchange rate predictability demonstrated by Molodtsova and Papell (2009), but it is adapted to a high-frequency setting. The drawback is that at the weekly frequency, the simple regression model is constrained because there are no high-frequency indicators of inflation available for the two countries. Constructing such inflation indicators constitutes a useful avenue for future research.

Contributing to multi-country analyses, a few other papers have constructed an indicator for Canada using the dynamic factor model approach proposed by Aruoba et al. (2009). These indicators have been constructed at a monthly frequency, to maintain consistency across countries. For example, Aruoba et al. (2010) construct country-level indicators for the G-7 countries, which are then aggregated to obtain a measure of the global business cycle. Scotti (2012) also constructs country-level indicators for the United States, euro area, United Kingdom, Canada and Japan, as well as an aggregate indicator, which are subsequently used to construct surprise and uncertainty indices, but these indicators are also available at a monthly frequency. In contrast, I propose an indicator that evolves at a weekly frequency and provide examples that exploit the high-frequency aspect of the indicator.

The paper is organized as follows. The next section discusses the data. Section 3 covers the details of the econometric model and estimation, followed by the results in section 4. Section 5 presents the computation of macroeconomic news and quantifies the reaction of asset prices to news. Section 6 discusses the use of the indicator to study high-frequency exchange rate movements and section 7 concludes.

2 Data

Four monthly series—employment, manufacturing sales, retail sales and GDP—expressed in real terms are used to construct the indicator for Canada. These variables are chosen because they are key variables representing the Canadian macroeconomy and are similar to the variables used in the construction of the ADS index for the United States.[2] The four monthly series that are chosen to construct the indicator for Canada in this paper have the useful property that each variable is typically released in a different week of the month.[3] Hence, the amount of information available for the Canadian economy changes every week. Taking advantage of this publication lag, a weekly indicator is constructed because the information set changes every week.

However, to use information on publication lags, the history of exact release dates for each variable are required. Due to the non-availability of real-time data from Statistics Canada, the data were obtained from Bloomberg, since it provides pseudo real-time data. In particular, it provides the date on which the data are released, the original value of the data release and the current revised value of the data resulting from revisions to the data. The indicator is constructed from the current revised value of the data. For recent months, the current value is the same as the actual released value and, whenever there is a revision, it is reflected in the current value. Thus, the indicator is a pseudo real-time indicator because, historically, there is no information on when the data were revised, but from the current period onwards one can keep track of how the indicator changes in response to data revisions and new data releases. Ideally, if real-time data were available for Canada for the four macroeconomic variables used to construct the indicator, a real-time indicator using the methodology described below could be constructed for Canada.

Bloomberg also provides the mean and median forecast for every data release, obtained by conducting a survey of market participants before the release. This information is useful for constructing market expectations of the current state of the economy, as discussed in section 5.

Table 1 shows the macroeconomic variables used in the analysis, the approximate week in a month in which the data are typically released and the publication lag, along with an example of release dates and months to which the data correspond during June 2013.

The employment level is released in the first week of the month and has the shortest

[2] The economic variables underlying the construction of the ADS index are weekly initial jobless claims; monthly payroll employment, industrial production, personal income less transfer payments, manufacturing and trade sales; and quarterly real GDP. For Canada, there is no weekly macroeconomic indicator.

[3] For the analysis in this paper, a week ends on a Friday, i.e., a week is measured from Saturday to Friday.

Table 1: Information on variables used to construct the indicator

Variable	Week of release	Publication lag (weeks)	Example: June 2013	
			Release date	Reference month
Employment	1	1	7 June	May
Manufacturing shipments	2	6	14 June	April
Retail sales	3	7	21 June	April
GDP	4	8	28 June	April

publication lag. It provides the most recent information on the state of the economy. Data on manufacturing shipments, retail sales and GDP are released in subsequent weeks and have a longer lag of 6, 7 and 8 weeks, respectively. During the month of June 2013, employment data are released in the first week of the month and correspond to the month of May. Other variables are released in subsequent weeks and refer to the month of April. Thus, by the end of June, data on all four variables become available up to April, for May only employment data are observed and there is no macroeconomic information for the month of June.

3 Methodology

Construction of the real activity indicator in this paper follows the methodology described in Aruoba et al. (2009) and is adapted to the nature and availability of Canadian macroeconomic data. The indicator is derived from a dynamic factor model and is extracted using a Kalman filter and smoother.

3.1 Econometric model

Macroeconomic variables are typically measured at monthly or quarterly frequencies. However, to construct a high-frequency indicator, economic conditions are assumed to evolve at a weekly frequency in this paper.

Let x_t denote the unobserved state of the economy at week t, which evolves weekly with AR(1) dynamics:

$$x_t = \rho x_{t-1} + e_t, \tag{1}$$

where $e_t \sim N(0, 1)$. x_t is a scalar. Throughout this paper, subscript t denotes weeks.

Let $\tilde{y}_t^i$ denote the ith economic variable at week t, which depends linearly on x_t:

$$\tilde{y}_t^i = c^i + \beta^i x_t + \gamma^i \tilde{y}_{t-D}^i + u_t^i, \tag{2}$$

where D is the number of weeks in the month. u_t^i is contemporaneously and serially uncorrelated; it is also uncorrelated with e_t.

Even though economic variables are assumed to evolve at a weekly frequency, they are not observed at a weekly frequency. All the variables considered in this analysis are released at a monthly frequency and are measured in growth rates. Hence, the observed economic variables are flow variables that can be expressed as the sum of the weekly unobserved counterparts. The observed variable y_t^i can be written as

$$y_t^i = \begin{cases} \sum_{j=0}^{D-1} \tilde{y}_{t-j}^i & \text{in the last week of the reference month} \\ = \sum_{j=0}^{D-1} c^i + \beta^i \sum_{j=0}^{D-1} x_{t-j} + \gamma^i \sum_{j=0}^{D-1} \tilde{y}_{t-D-j}^i + \sum_{j=0}^{D-1} u_{t-j}^i & \\ NA & \text{otherwise,} \end{cases} \tag{3}$$

which can be rewritten as

$$y_t^i = \begin{cases} C^i + \beta^i \sum_{j=0}^{D-1} x_{t-j} + \gamma^i y_{t-D}^i + U_t^i & \text{in the last week of the reference month} \\ NA & \text{otherwise,} \end{cases} \tag{4}$$

where $C^i = \sum_{j=0}^{D-1} c^i$ and $U_t^i = \sum_{j=0}^{D-1} u_{t-j}^i$, and note that $\sum_{j=0}^{D-1} \tilde{y}_{t-D-j}^i = y_{t-D}^i$. D denotes the number of weeks in the reference month, which can be either four or five. So, D is time-varying but known and is not indexed for simpler notation.

The ADS index measures macroeconomic variables in terms of MoM growth rates. In this paper, for Canada, the four variables are measured in YoY growth rates instead. This point of departure from the ADS index's methodology is motivated by the fact that it is difficult to identify a common latent factor when MoM growth rates of these four variables are considered. A check using principal component analysis reveals that the first principal component of these four variables when measured in MoM growth rates does not explain a significant fraction of the variation in the data. When YoY growth rates are considered, the first principal component is able to explain 88% of the variation in the data, thus facilitating the identification of a common factor. However, $\tilde{y}_t$ does not have a clean interpretation when y_t is measured in YoY growth rates. Thus, $\tilde{y}_t$ has to be interpreted in a way that is consistent with equation (3). The state variable is not affected, since it is a latent factor without any units.

3.2 State-space representation

The model in state-space form can be written as

$$\alpha_{t+1} = F_t \alpha_t + \eta_t, \tag{5}$$

$$y_t = \begin{cases} H\alpha_t + A_t w_t + \mu_t & \text{in the last week of the reference month} \\ NA & \text{otherwise,} \end{cases} \tag{6}$$

where y_t is a vector of observed variables, α_t is a vector of state variables, w_t includes the constant term and lags of observed variables, $\eta_t \sim N(0, Q)$ is a vector of transition shocks and $\mu_t \sim N(0, R_t)$ is a vector of measurement shocks. Note that Q is an identity matrix following the identification assumption in equation (1), and R_t is a diagonal matrix following equation (2).

For easier computation, I use the cumulator variable described in the web updates to the ADS index.[4] Following Harvey (1991), a cumulator variable Z_t is used to summarize information for the aggregation of flow variables:

$$\begin{aligned} Z_t &= \xi_t Z_{t-1} + x_t \\ &= \xi_t Z_{t-1} + \rho x_{t-1} + e_t, \end{aligned}$$

where ξ_t is an indicator variable defined as

$$\xi_t = \begin{cases} 0 & \text{if } t \text{ is the first week of a month} \\ 1 & \text{otherwise.} \end{cases}$$

Using the cumulator variable, equation (4) can be rewritten as

$$y_t^i = \begin{cases} C^i + \beta^i Z_t + \gamma^i y_{t-D}^i + U_t^i & \text{in the last week of the reference month} \\ NA & \text{otherwise.} \end{cases}$$

[4]See "Updates on ADS Index Calculation" on the ADS index website, available at http://www.philadelphiafed.org/research-and-data/real-time-center/business-conditions-index.

The use of the cumulator variable makes the state vector two-dimensional, i.e., $\alpha_t = (Z_t, x_t)$. The full state-space representation corresponding to equations (5) and (6) is

$$\underbrace{\begin{bmatrix} Z_{t+1} \\ x_{t+1} \end{bmatrix}}_{\alpha_{t+1}} = \underbrace{\begin{bmatrix} \xi_{t+1} & \rho \\ 0 & \rho \end{bmatrix}}_{F_t} \underbrace{\begin{bmatrix} Z_t \\ x_t \end{bmatrix}}_{\alpha_t} + \underbrace{\begin{bmatrix} 1 \\ 1 \end{bmatrix} e_{t+1}}_{\eta_t},$$

$$\underbrace{\begin{bmatrix} y_t^1 \\ y_t^2 \\ y_t^3 \\ y_t^4 \end{bmatrix}}_{y_t} = \underbrace{\begin{bmatrix} \beta^1 & 0 \\ \beta^2 & 0 \\ \beta^3 & 0 \\ \beta^4 & 0 \end{bmatrix}}_{H} \underbrace{\begin{bmatrix} Z_t \\ x_t \end{bmatrix}}_{\alpha_t} + \underbrace{\begin{bmatrix} C^1 & \gamma^1 & 0 & 0 & 0 \\ C^2 & 0 & \gamma^2 & 0 & 0 \\ C^3 & 0 & 0 & \gamma^3 & 0 \\ C^4 & 0 & 0 & 0 & \gamma^4 \end{bmatrix}}_{A_t} \underbrace{\begin{bmatrix} 1 \\ y_{t-D}^1 \\ y_{t-D}^2 \\ y_{t-D}^3 \\ y_{t-D}^4 \end{bmatrix}}_{w_t} + \underbrace{\begin{bmatrix} U_t^1 \\ U_t^2 \\ U_t^3 \\ U_t^4 \end{bmatrix}}_{\mu_t}.$$

The above measurement equation assumes that all elements of y_t are known. However, due to publication lags, all elements of y_t will not be known, especially for recent periods, and the above measurement equation will have missing observations. To incorporate missing observations and update the indicator in real time, a selection matrix W_t is used for the measurement equation. If some elements of y_t are observed, the measurement equation is modified to

$$y_t^* = H^* \alpha_t + A_t^* w_t + \mu_t^*, \tag{7}$$

where $\mu_t^* \sim N(0, R_t^*)$. y_t^* is of smaller dimension than y_t and consists of variables that are observed, i.e., $y_t^* = W_t y_t$. Hence, W_t is an identity matrix, I_n, of dimension $n \leq 4$, which picks out the elements of y_t that are available at time t. All other starred variables and matrices are obtained by pre-multiplying their unstarred counterpart with W_t; for example, $A_t^* = W_t A_t$, and so on. The above modified measurement equation can be used in the Kalman filter in the usual way.

3.3 Estimation

The Kalman filter and smoother are used to extract the common state using the above state-space representation. The parameters are estimated by maximizing the log-likelihood derived from the Kalman filter equations. The parameter estimates are used to compute the filtered estimate of the state of the economy, which is further passed through the Kalman smoother to obtain the optimal latent state of the economy.

Due to the non-availability of real-time data for the entire history of variables considered in this analysis, two data samples are used to construct the indicator. A longer time-series from January 1982 to May 2012, available from Statistics Canada, is used to estimate the parameters of the state-space representation, and it consists of revisions up to July 2012. For the estimation, the log-likelihood is derived from the state-space representation described in equations (5) and (6), without imposing the publication lag of these variables. Thus, there is no real-time element in the estimation of the parameters. The parameters are estimated only once, and this is comparable to the standard method of estimating parameters for the Kalman filter. However, the state-space is not standard, because the state evolves at a higher frequency than the underlying data.

A smaller sample containing pseudo real-time information, available from Bloomberg, is used to construct the indicator, which begins in February 1999 and ends July 2013. Bloomberg does not provide all vintages of the data. It provides only the original release value and the most recent revised value for each of the data series. The indicator is constructed using the current revised value but imposing the publication lag for all series, resulting in an indicator that can be updated in real time every week since February 1999. This approach assumes that the current revised value coincides with the original released value for any data point, which implies that the indicator is based on more information than is available at the release date.

Use of the current revised value is justified for two reasons. First, revisions to monthly values do not translate into large revisions for YoY growth rates, and hence the values being used to construct the indicator should not be significantly affected whether revised or original release values are used. Second, for more recent periods, the current revised value and the original released value are identical because revisions have not taken place. Therefore, the indicator reflects real-time information. As a robustness check, for historical dates, the indicator can first be updated using the actual release value and then it can be updated using the current revised value to determine how much revisions affect the indicator.

4 Results

Figure 1 shows the indicator based on data releases up to the end of July 2013. The average value of the indicator is zero, by construction. The indicator is consistent with patterns observed for the Canadian business cycle. For example, the indicator shows a mild slowdown during 2000–01 when the U.S. economy was in a recession, and the large drop in the indicator between October 2008 and January 2009 coincides with the onslaught of the financial crisis in the rest of the world. One way to interpret the value of the indicator is to compare its average value (which is zero) with the average annual GDP growth rate for Canada, which is 2.5% over the sample. Positive values of the indicator imply a better-than-average state of real activity, whereas negative values imply worse-than-average economic performance.

The level of the indicator can be used to figure out whether the economy is going into a recession by observing the historical value of the indicator at the start of past recessions. Figure 2 shows the long-run evolution of the indicator over the sample period that has been used to estimate the parameters, ranging from January 1982 to May 2012. This is the indicator obtained without imposing the publication lag. Since this period covers two recessions, one in the early 90s and the other in the late 2000s, the value of the indicator at the start of these recessions can help anticipate whether the economy is headed into a recession. However, the period of time for which the indicator has been below the recession threshold is also a significant factor in determining the severity of the contraction.

Figure 3 shows the indicator along with the 95 percent confidence bands as of 31 July 2013. In the last two months of the sample, the bands become wider, implying greater uncertainty. There are two reasons for the widening bands. First, no data have been observed for the month of July 2013, so the indicator is following only the weekly AR(1) process implied by equation (5). Second, even for the month of June 2013, information on only one series, the employment level, has been incorporated in the indicator because other series have not been released.

Since the indicator is updated every week as new data are released, it is informative, particularly for policy-makers, to track the changing nature of the state of the Canadian economy. Figure 4 shows the evolution of the indicator due to new data releases during January and February 2009, when the financial crisis was spilling over to the real economy. Updating the indicator with new data changes the indicator, not only for the time period to which the data correspond but for surrounding dates as well, due to the Kalman smoother. There are some weeks in which there are no new data releases, in which case the indicator coincides with that of the previous week. In the figure, the weeks ending 16 January and 13 February had no data releases. For these weeks, the indicator is represented by dotted lines and it overlaps the previous week's values.

The performance of the indicator can be assessed by comparing it with the observed variables that are used in the construction of the indicator. Table 2 shows the correlation coefficient between the observed variable and the estimated indicator. For this exercise, since the macroeconomic variables are observed at a monthly frequency, the indicator is also converted to a monthly frequency by picking the value for the last week of the month.[5] The indicator shows a high degree of correlation with all of the observed variables.

Table 2: Correlation of the indicator with observed variables

Variable (in YoY growth rates)	Correlation coefficient
Retail sales	0.73
GDP	0.70
Employment	0.51
Manufacturing sales	0.70

Figure 5 compares the indicator at a weekly frequency with quarterly GDP growth obtained from the quarterly GDP series. The indicator leads the quarterly GDP series due to its high-frequency nature, and highlights the turning points of the business cycle sooner.

An alternative way of summarizing many data series is to use principal components analysis in which the first principal component accounts for the largest common variation in the underlying data. However, the first principal component is limited to the frequency at which the data evolve, which is monthly for the variables used in this paper. Figure 6 shows that the indicator at the weekly frequency leads the first principal component of the observed variables at the monthly frequency. Thus, the indicator is able to provide timely, high-frequency information that is not captured by the first principal component.

5 Measuring Macroeconomic News

The indicator constructed in this paper is updated whenever data on the four macroeconomic variables used to construct the indicator are released. However, market participants are typically interested in the surprise component of macroeconomic data releases, i.e., the deviation of the data release from the market expectation for that particular announcement. This is because asset prices reflect changes in macroeconomic fundamentals and positive (negative) data surprises would lead to a correction in asset prices, since markets would become more optimistic (pessimistic) about the state of the economy. This section shows that the methodology used in the construction of the indicator can also be used to construct a measure of macroeconomic news.

The availability of release dates from Bloomberg as well as the forecasts of data releases permits the calculation of a "market-implied" state of the economy that represents market

[5]The results do not change significantly if monthly averages are used instead.

expectations about the current state of real activity. Let y_t^{iF} denote the forecast for the data release of the variable y_t^i. Then, assuming that the forecasts obtained from Bloomberg's survey of market participants follow the same data-generating process as the actual macroeconomic variable,[6] the measurement equation (7) can be rewritten as

$$y_t^{*F} = H^* \alpha_t + A_t^* w_t + \mu_t^*, \tag{8}$$

where y_t^{*F} consists of the forecast of the variable that is being released in week t. Using the Kalman filter, before every data release, the state of the economy can be updated by the Bloomberg forecast for that particular data release to obtain the market-expected state of the economy denoted as x_t^F. Subsequently, when the data are released, the state is updated by the actual data release instead, using measurement equation (7), to obtain the actual state of the economy, x_t. At the end of week t, the difference between the market-expected state of the economy and the actual state of the economy constitutes a measure of surprise:

$$news_t = x_t - x_t^F.$$

Figure 7 compares the market-expected state of the economy with the actual state on 6 February 2009. This release date is chosen because it corresponds to the first data release for January 2009, the month in which real activity declined sharply during the financial crisis. Being the first Friday of the month, the employment-level data were released for the month of January. The median forecast for the change in the employment level was -40K, which translates into a nearly flat YoY growth rate of 0.09%. However, the actual data release was -135.8K, implying a YoY growth rate of -0.5%. Thus, markets were surprised to the downside. The solid black line in Figure 7 is the result of updating the indicator in the previous week (dashed blue line) with the employment data release: it moves substantially downward compared to the week before. Market expectations about the state of the economy are represented by the dotted red line, obtained by updating the state in the previous week by the median forecast of market participants. It shows that markets were expecting almost the same level of slowdown in the economy as the week before, not the large extent implied by the data release. The difference between the end points of the solid black line and the dotted red line on 6 February 2009 constitutes a measure of news about the state of the economy for that week.

[6] This is a strong assumption, but it serves as a good starting point, since no re-estimation of parameters is required. Alternatively, one could re-estimate the parameters using forecasts in the measurement equation.

5.1 Reaction of asset prices to macroeconomic news

As discussed above, the difference between the expected state of economic activity and the actual state constitutes a measure of macroeconomic news that captures the surprise component of various data releases. Past studies have suggested that the unexpected component of data releases has a significant impact on asset prices. The measure of news used in the literature is the difference between the actual data release and the expected value for the data release, normalized by the standard deviation for comparison across different data releases. In contrast, using the methodology described in the previous section, the indicator helps measure macroeconomic news expressed in terms of unexpected changes to the current state of the economy. This eliminates those data releases where expectations of the release might deviate from the actual release but the deviations do not constitute new information regarding the state of the economy, and should therefore already be incorporated in current asset prices.

To study the impact of news on asset prices, changes in the Canadian 10-year bond yield and changes in the CAD/USD nominal exchange rate are obtained for days on which data on any of the four macroeconomic variables used to construct the indicator are released. Correspondingly, a measure of news is constructed for the weeks in which those dates lie. Even though news is measured over the week, it corresponds to the particular data release during that week because, typically, there is only one data release per week. Observations corresponding to weeks in which there are two data releases are dropped. To quantify the impact of news, the following two equations are estimated using OLS:

$$\Delta i_{d,10y} = \beta_0 + \beta_1 news_t + \mu_t,$$

$$\Delta CAD_d = \delta_0 + \delta_1 news_t + \nu_t,$$

where subscript d refers to the day of the data release such that d lies in week t. The estimated coefficients are shown in Table 3. Heteroskedasticity and autocorrelation consistent (HAC) standard errors are reported in parentheses.

The coefficient on news is statistically significant in both regressions. The R^2 is 4.5% for yields and 2.9% for the exchange rate. The positive coefficient on news implies that positive surprises about the state of the economy lead to an increase in the 10-year yield as well as an appreciation of the Canadian-dollar exchange rate. Quantitatively, the estimated coefficient can be multiplied with the average value of the news variable to obtain the contribution of news to average changes in yields or the Canadian dollar. Thus, on average, yields change

Table 3: Regression of daily changes in 10-year yields and CAD changes on news

	$news_t$	$constant$	N	Adj. R^2
$\Delta i_{t,10y}$	0.0219***	-0.0075***	659	0.045
	(0.004)	(0.0018)		
ΔCAD_t	0.193***	-0.024	659	0.029
	(0.058)	(0.022)		

*** indicates significance at 1%.

by 4 bps and news can explain about 0.7 bps of that change. Similarly, on average, the Canadian dollar changes by 0.4 cents, and news can explain about 0.07 cents of that change.

The regression shows that the measure of news calculated using the indicator, which captures only real activity, contributes to movements in asset prices. It has a higher R^2 than similar studies that use the conventional measure of news for both real and nominal variables for Canada (see Gravelle and Moessner (2001)).

6 Implications for the Canadian Dollar

The high-frequency real activity indicator constructed for Canada can be used in conjunction with the ADS index for the United States to study weekly movements in the nominal Canadian-dollar exchange rate relative to the U.S. dollar. The idea behind the exercise is to examine whether the divergence in the performance of the Canadian and U.S. economies, as measured by the divergence between the high-frequency indicators for both Canada and the United States, can explain high-frequency movements in the Canadian dollar. This is explored via a simple model that relates changes in the nominal Canadian-dollar exchange rate to changes in the difference between the real activity indicators for Canada and the United States, both normalized to have unit variance, controlling for changes in the interest rate differential between the two countries. The model considered here is similar to the idea behind Taylor-rule-based exchange rate predictability described in Molodtsova and Papell (2009), and is given by the following equation:

$$\Delta CAD_t = \beta_0 + \beta_1 \Delta(x_t^{CAN} - x_t^{US}) + \beta_2 \Delta(i_{t,3m}^{CAN} - i_{t,3m}^{US}) + \epsilon_t,$$

where x with the superscript CAN and US refers to the real activity indicators for the two countries. i with the superscript CAN and US represents the 3-month T-bill rate for each country.

The model is estimated using OLS. An implicit assumption made here is that the real activity indicator is unlikely to respond to changes in the Canadian dollar at a weekly frequency. The results from the OLS regression are shown in Table 4. Estimated coefficients for changes in the indicator differential and the interest rate differential are statistically significant. HAC standard errors are reported in parentheses and the R^2 is 3.34%.

Table 4: Regression of weekly CAD changes on the changes in the indicators and other controls

	Δx_t	Δi_t	N	Adj. R^2
ΔCAD_t	1.128**	1.185***	738	0.0334
	(0.57)	(0.45)		

*** and ** indicate significance at 1% and 5%, respectively.

The significant positive coefficient on the change in the difference between the two real activity indicators suggests that a relative improvement in Canadian economic activity leads to an appreciation of the exchange rate. It also shows that, beyond interest rate differentials, macroeconomic fundamentals are important for explaining changes in the Canadian-dollar spot rate. The inclusion of high-frequency indicators on inflation in the two countries should improve the performance of the model. However, such indicators are not available yet and their development is an interesting area for future research.

7 Conclusion

A weekly real activity indicator for Canada is derived as the common component underlying the co-movement of select macroeconomic variables. The indicator is coincident and tracks changes in the Canadian economy as data are released. The novel aspect of the indicator is its high-frequency nature, which widens its applicability to a variety of topics in macroeconomics and finance. In this paper, I give two examples that illustrate the use of the indicator beyond standard applications. One example demonstrates how the indicator can be used to measure macroeconomic news and its quantitative implications for asset prices. The second example relates high-frequency changes in macroeconomic fundamentals measured by the indicator to high-frequency movements in exchange rates. These examples suggest that the real activity indicator at a high frequency offers insights into movements in financial asset prices. However, complementary high-frequency indicators of nominal variables such as inflation are required for a more complete analysis.

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Figure 1: Real activity indicator for the Canadian economy on 31 July 2013

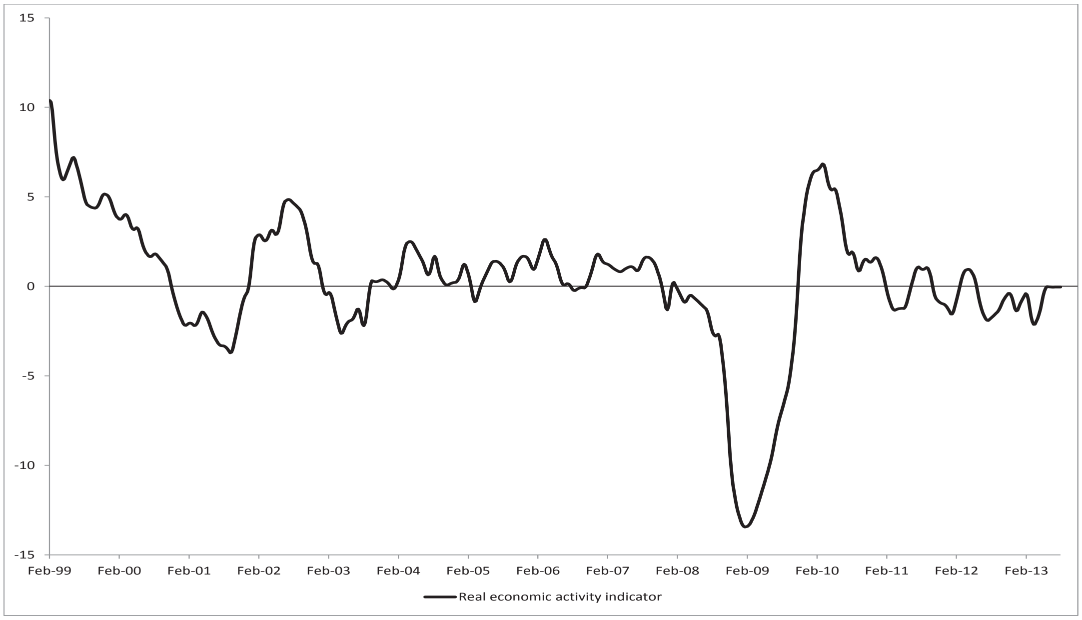

Figure 2: Long-run evolution of the indicator (without imposing publication lags)

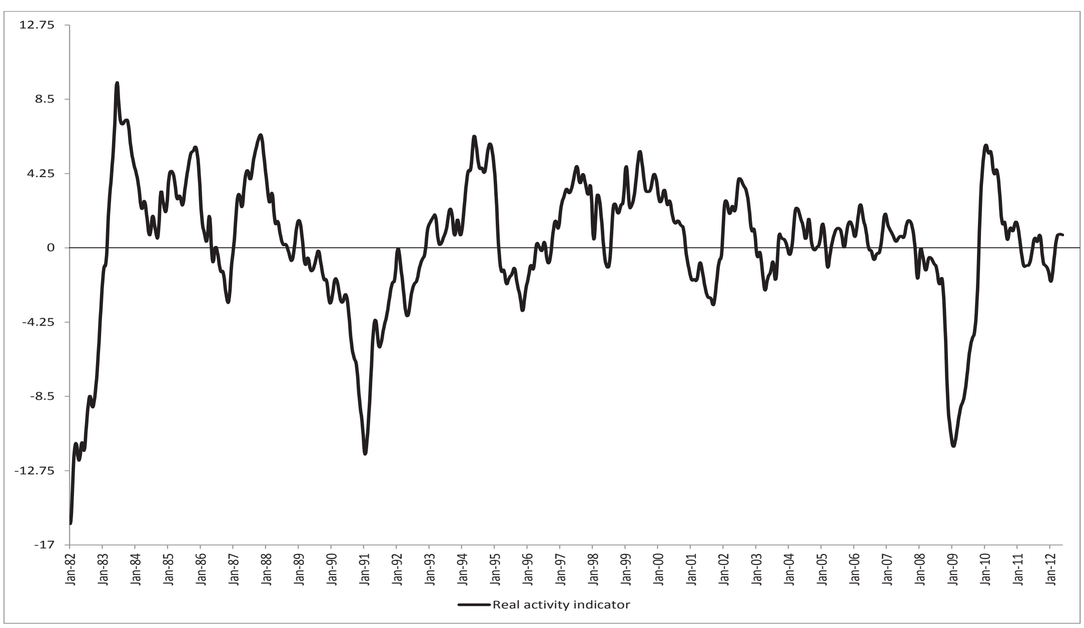

Figure 3: 95% confidence interval for the indicator as of 31 July 2013

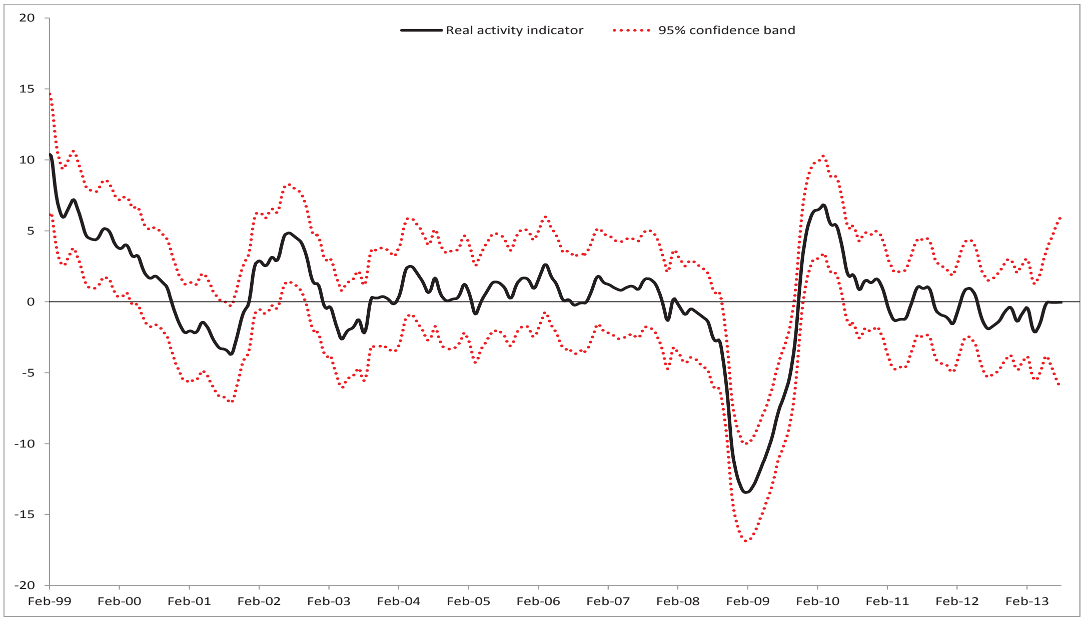

Figure 4: Weekly evolution of the indicator during January and February 2009

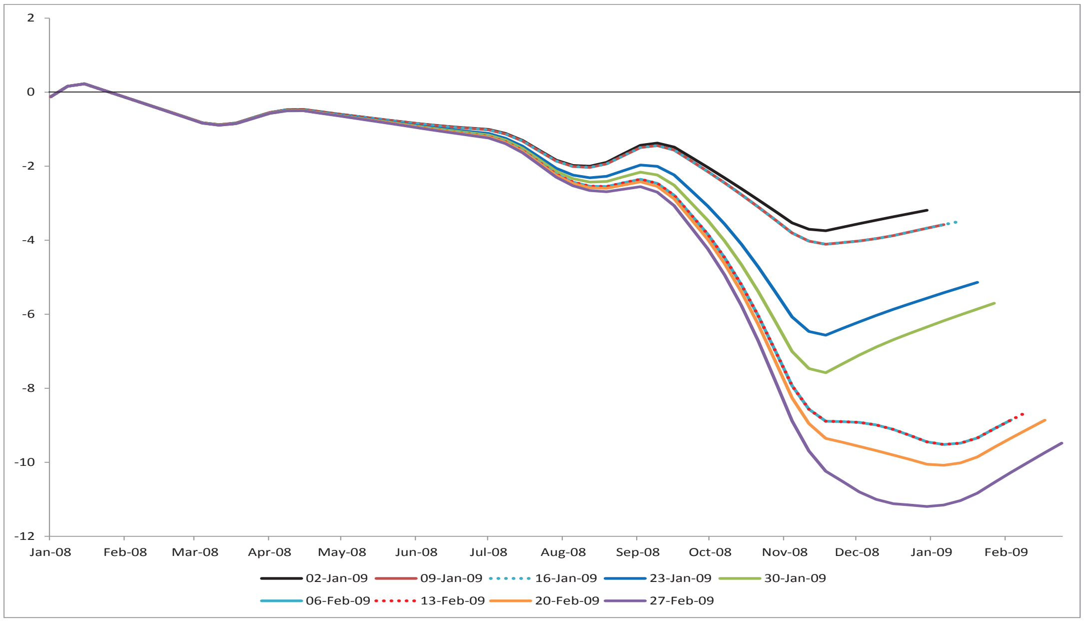

Figure 5: Comparison of the indicator (weekly) with quarterly GDP growth

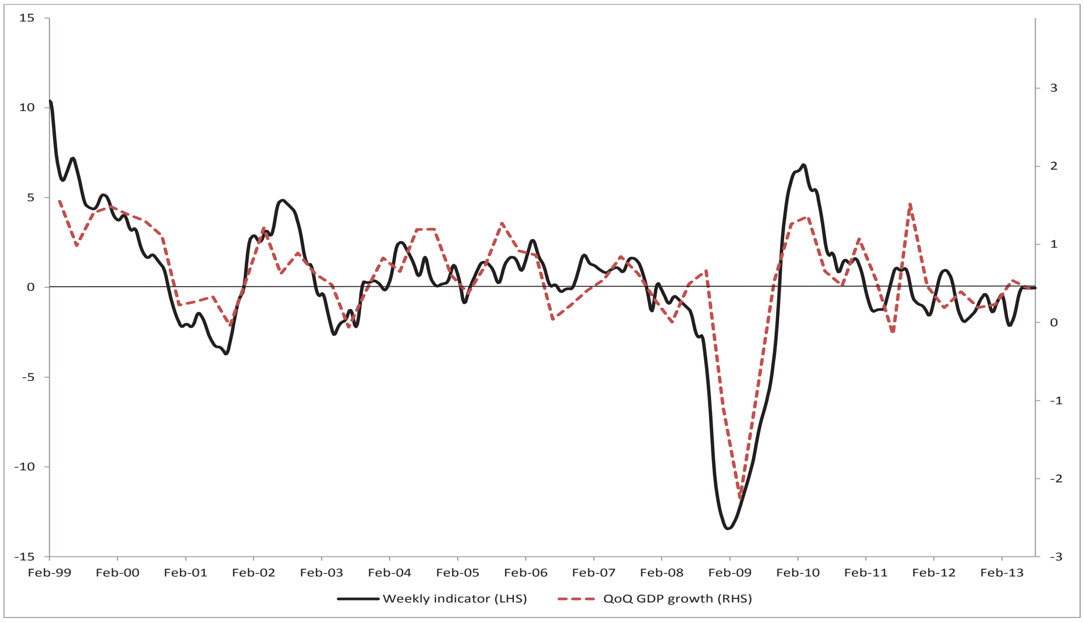

Figure 6: Comparison of the indicator with the first principal component of the underlying data (at monthly frequency)

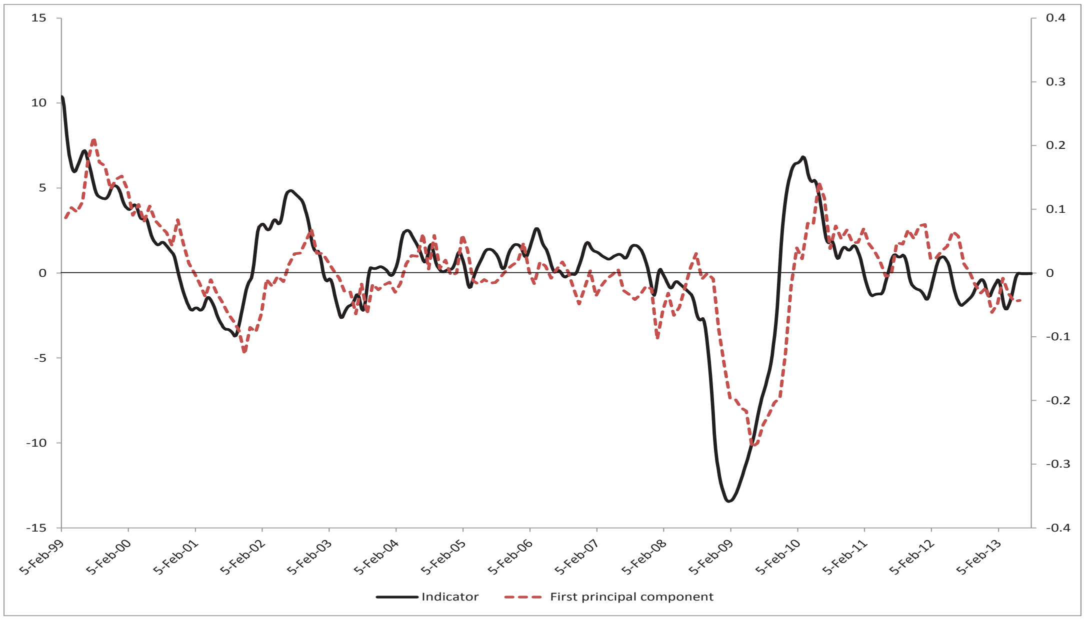

Figure 7: Measuring unexpected change in real activity for the week ending 6 February 2009