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Abstract

Housing starts and building permits data are commonly used as leading indicators of economic activity. In British Columbia, all new homes must be registered with the Homeowner Protection Office, a branch of BC Housing, before the issuance of building permits and the start of construction. Data on new housing registrations (NHR) could thus potentially be used as an even earlier leading indicator of economic activity. This study assesses whether NHR data have significant predictive power for economic activity in British Columbia. The authors find that quarterly increases in new registrations for single detached homes have statistically significant predictive content for growth in real GDP over the next one to three quarters, and provide stronger signals compared to housing starts and building permits over this forecast horizon. These signals remain significant for growth in real GDP over the next two quarters even in the presence of other leading indicators in the equations. However, forecasts using quarterly NHR data with other leading indicators are not able to outperform simple benchmark forecasts in an out-of-sample forecasting exercise. Nonetheless, adding the NHR variable to an AR(1) equation does produce forecasts that are superior to a simple AR(1) and that at one quarter ahead also outperform an AR(1) augmented with building permits.

JEL classification: C13, C53, E32, E37
Bank classification: Business fluctuations and cycles; Housing; Regional economic developments

Résumé

Les données relatives aux logements mis en chantier et aux permis de bâtir servent souvent d'indicateurs avancés de l'activité économique. En Colombie-Britannique, tous les logements neufs doivent être enregistrés auprès du Bureau de la protection des propriétaires (Homeowner Protection Office), une division de BC Housing, avant la délivrance des permis de bâtir et le début des travaux. Les données sur les enregistrements de logements neufs pourraient donc éventuellement être utilisées comme un indicateur avancé encore plus précoce de l'activité économique. Dans la présente étude, les auteurs évaluent si ces données permettent de prédire l'activité économique en Colombie-Britannique. Ils constatent que les augmentations trimestrielles des nouveaux enregistrements concernant les maisons individuelles ont une valeur prédictive statistiquement significative de la croissance du PIB réel sur une période de un à trois trimestres et fournissent des indications plus claires comparativement aux données sur les logements mis en chantier et les permis de bâtir au cours de cette même période de prévision. Ces indications demeurent significatives pour ce qui est de la croissance du

PIB réel sur les deux prochains trimestres, même en présence d'autres indicateurs avancés dans les équations. Toutefois, les prévisions faisant appel aux données trimestrielles sur les enregistrements de logements neufs et à d'autres indicateurs avancés donnent de moins bons résultats que les prévisions effectuées grâce à un modèle de référence simple dans le cadre d'un exercice de prévision hors échantillon. Ajouter la variable des enregistrements de logements neufs à une équation du processus autorégressif d'ordre 1, noté AR(1), produit néanmoins des prévisions qui sont supérieures à celles d'un simple modèle AR(1) et qui, pour un horizon d'un trimestre, obtiennent également de meilleurs résultats qu'un processus AR(1) intégrant les données sur les permis de bâtir.

Classification JEL : C13, C53, E32, E37
Classification de la Banque : Cycles et fluctuations économiques; Logement; Évolution économique régionale

1. Introduction

Housing starts and building permits data are commonly used as leading indicators of cyclical activity in an economy. For example, Statistics Canada includes housing starts among the ten components used to construct its Canadian Composite Leading Indicator. In the United States, the Conference Board includes building permits in its Index of Leading Economic Indicators, used to predict the direction of the US economy. In British Columbia, all new homes must be registered with the Homeowner Protection Office, a branch of BC Housing. Because this registration process occurs before the issuance of building permits and the start of construction, data on new housing registrations could potentially be used as an even earlier leading indicator of economic activity. BC Housing has been collecting data on all new housing registrations (NHR) across the province and has made available monthly time series beginning in 2000.[1] The data are released seven to nine business days after the reference month; this compares with six to seven business days for the release of housing starts data and about 27 business days for building permits.

This study assesses whether NHR data have significant predictive power for economic activity in British Columbia, and over what time horizons the series would be most useful as a leading indicator. We find that quarterly increases in NHR for single detached homes add significant information content for predicting real GDP growth over the next two quarters beyond that provided by other leading indicators. However, they perform poorly in out-of-sample forecasts. In section 2, we discuss various indicators used to represent BC economic activity at different frequencies, and potential challenges with using each. Section 3 sets up the forecasting equation and the approach for assessing predictive content. Section 4 discusses the results, and section 5 concludes.

2. Determining a Measure of BC Economic Activity

An effective leading indicator provides advance signals on the state of the economy, and may even predict turning points in the business cycle. Given that Statistics Canada only releases provincial GDP data at an annual frequency and with long time lags, we cannot observe the state of the BC economy at higher frequencies and must therefore employ a proxy measure. This involves a first step of selecting or constructing a more timely indicator that best represents overall macroeconomic conditions in British Columbia.

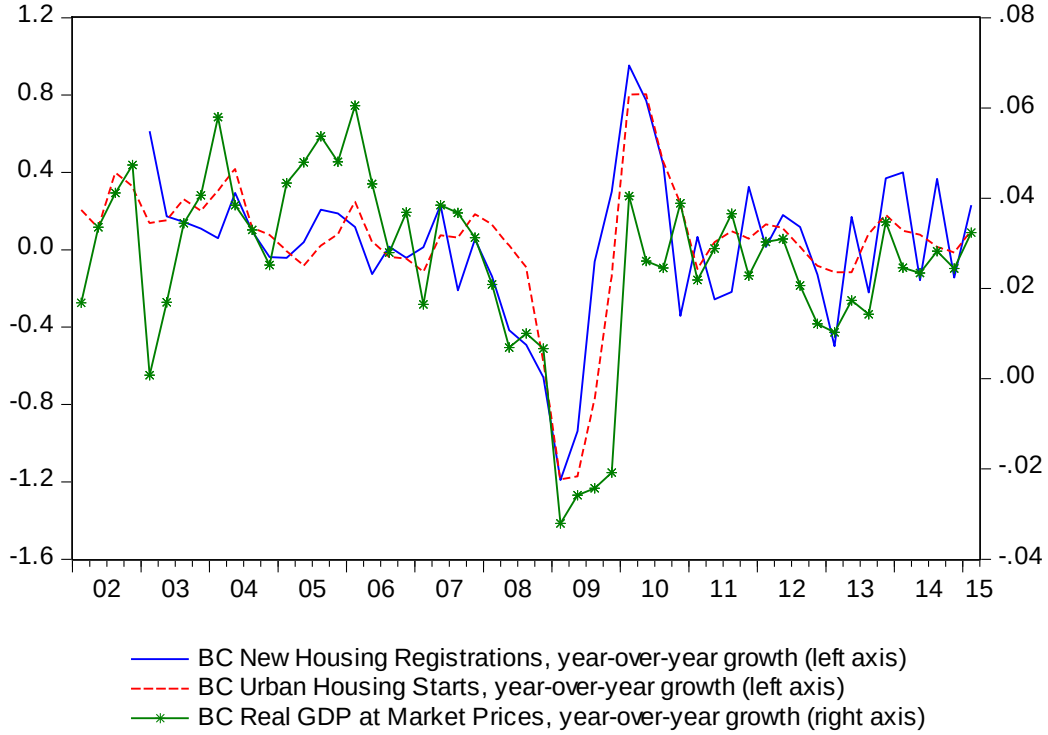
At the quarterly frequency, the Conference Board of Canada provides estimates of provincial GDP for British Columbia.[2] Figure 1 compares year-over-year growth in NHR against that of housing starts and estimates of real GDP for British Columbia (from the Conference Board of Canada). Although it may be difficult to tell from the figure, a simple regression of quarterly growth in real GDP on leads and lags of growth in NHR suggests a significant correlation between quarterly growth in NHR and real GDP growth two quarters ahead. Meanwhile, a similar regression on growth in housing starts suggests that its correlation with real GDP growth appears strongest contemporaneously.

[1] BC Housing provided to the Bank of Canada monthly time series for new housing registrations starting from 2000 for single detached homes and multi-unit buildings, and from 2002 for rental units exempted from home warranty insurance. These time-series data are available to the public upon request.

[2] The Conference Board constructs these estimates based on Statistics Canada's annual provincial GDP estimates (which are released with a one-year lag), combined with quarterly national accounts data for Canada, as well as a variety of other monthly data available for British Columbia such as building permits and manufacturing shipments.

Specifying a forecasting equation in quarterly terms would involve aggregating the monthly NHR series into quarterly averages, which has the advantage of smoothing excess noise and volatility in the monthly data that may not be representative of the underlying state of the economy.

Figure 1. BC new housing registrations, housing starts and real GDP



Sources: BC Housing, Canada Mortgage and Housing Corporation and the Conference Board of Canada

However, using a monthly indicator of BC economic activity may be desirable from a practical standpoint, since it would allow us to extract more timely signals about the economy with each monthly NHR data release. To select a monthly indicator, we consider 48 monthly series most relevant to the BC economy that are available at the provincial level and with a sufficiently long history. Details on these variables are provided in Table A2.[3] Given its strong correlation with the business cycle, the unemployment rate may be the best existing monthly indicator to represent the state of the BC economy. We also construct a composite indicator for underlying economic activity in British Columbia in order to exploit all of the information content from the 48 variables. To do this, we use static factor or principal component analysis (PCA), following the methodology of Stock and Watson (1999) and which is used to construct the Chicago Fed National Activity Index.[4] Factor analysis extracts the common signal from a wide variety of variables by removing any idiosyncratic movements. This methodology allows us

[3] Almost all data are specific to British Columbia, except for the six commodity price series and the US Coincident Economic Activity Index constructed by the Federal Reserve Bank of Philadelphia, referred to as the USPHCI.
[4] For details, see the "Background on the Chicago Fed National Activity Index" report available at https://chicagofed.org/publications/cfnai/index.

to capture the co-movement among a broader set of data series and thus derive a more comprehensive measure of macroeconomic conditions than any one single indicator could accomplish. Details on how the PCA was conducted are provided in the Technical Appendix.

3. Constructing a Forecasting Equation

To assess the predictive content of NHR for BC economic activity, we follow a simple and widely used approach to construct the basic forecasting equation. Since the NHR series is non-stationary, the methodology involves regressing cumulative changes in future BC economic activity on the one-period change in the logged new housing registration series (*NHR)* at time *t*. At the quarterly frequency, the equation is

$$Y_t^q = \beta_0 + \beta_1 \Delta NHR_t + \beta_2 Z_t + \varepsilon_t \,, \qquad (1a)$$

$$Y_t^q = y_{t+q} - y_t,$$

where y_{t+q} represents the log of real GDP (using the Conference Board of Canada estimate) in quarter *t+q,* and Y_t^q represents the cumulative growth in real GDP over the *next q* quarters. *ΔNHR* is the *current* quarterly change in the log of new housing registrations at time *t,* and *Z* is a set of other exogenous variables that might be leading indicators of real output in British Columbia. The equation is estimated for horizons of *q* = 1, 2, 3 and 4 quarters ahead. For example, at *q* =3, a statistically significant parameter estimate for $\beta_1$would suggest that, over history, quarterly changes in NHR have predictive content for changes in BC economic activity over the next three quarters.

To assess the predictive power of NHR on a monthly basis, the equation becomes

$$BCEA\_p_t^k = \beta_0 + \beta_1 \Delta NHR_t + \beta_2 Z_t + \varepsilon_t \,, \qquad (1b)$$

where *ΔNHR* now represents the month-over-month rate of change in the number of new home registrations at current time *t.* $BCEA\_p_t^k$ is defined as the cumulative growth in BC economic activity over the next *k* months. The regression is performed for values of *k* = 1, 3, 6 and 12. To construct the composite indicator $BCEA\_p_t^1$, we first transform the *p* series into I(0) growth rates from month *t* to month *t*+1, and then take the first principal component and normalize it (see the Technical Appendix for details).[5] Then for *k* = 3, the cumulative growth in BC economic activity over the next three months is constructed as the sum of $BCEA\_p_t^1$, $BCEA\_p_{t+1}^1$ and $BCEA\_p_{t+2}^1$. This is similarly done for *k* = 6 and 12.

[5] In cases where the underlying series are a ratio (e.g., the employment rate), they are transformed into month-over-month changes, rather than growth rates. There were nine series found to be I(0) in (log) level terms. The analyses were also performed where these nine variables were included instead in log-level terms. This produced fairly similar results, but the resulting measure of BC economic activity had a slightly lower correlation with real GDP growth at the quarterly frequency.

4. Results

4.1 Predictive content at monthly frequency

We next test the significance of BC Housing's NHR data for predicting cumulative changes in BC economic activity over the next 1, 3, 6 and 12 months. Because the NHR data are less reliable before 2002, we limit our sample to the period 2002m1–2015m3, allowing for 157 observations (after adjustments) to conduct regressions. The NHR data are available for three dwelling types: single detached, multi-unit buildings, and "rentals exempted," which refers to new homes in purpose-built rental buildings and includes social housing.

We test the significance of *current* monthly growth in NHR for predicting *future* growth in the BC economy based on regressions of equation (1b), using two constructed measures of economic activity from our principal component analysis: (i) *BCEA_48,* which captures the common signal from all 48 monthly variables, and (ii) *BCEA_8*, which is the common factor from a subset of eight variables that appear to be coincident indicators of real output growth in British Columbia, rather than leading or lagging indicators. Details on how these eight variables are selected are provided in the Technical Appendix.

Because these measures are constructed and may thus be subject to some error, we also test the predictive power of NHR for future changes in the unemployment rate, since it is a measure we can directly observe. We first test the significance of the total NHR, and then that of each of the individual dwelling types. We find that both the NHR for multi-family homes (*NHR_multi)* and rentals exempted are statistically insignificant in most of the regressions. The NHR for single detached homes (*NHR*_single) tends to perform better in all regressions than either the *NHR_multi* variable or the total NHR variable that includes all dwelling types. We therefore report only the results of using the *NHR_single* series.[6]

The greater statistical significance of the singles versus multiples series may reflect, in part, differences in the way that Statistics Canada uses singles and multiples starts data to construct GDP estimates.[7] In particular, to construct estimates of housing investment, Statistics Canada distributes values of singles starts over the current and next two quarters, whereas for multiples they spread the values over the current and next four quarters. Consequently, in any given month or quarter, new construction of multi-family units may provide weaker signals for the economy relative to singles. In addition, Baumohl (2012) suggests that, for the United States, the performance of single-family dwelling starts is a far more reliable leading indicator of the economy than multi-family starts: construction of singles depends more on consumer confidence and demand, whereas that of multiples can be subject to the whims of speculative real estate investors and changes in the tax code. However, it is possible that this may evolve in the future, since new home construction in British Columbia has shifted increasingly toward multi-family units as a result of rising land development constraints.

[6] Results reported are for the non-seasonally-adjusted NHR series, since seasonally adjusting the series did not improve upon the results.

[7] Statistics Canada uses data on units of housing starts combined with values from building permits to construct estimates of work-put-in-place, which then constitutes almost half of housing investment in the national accounts.

We first test equation (1b) including only current monthly changes in *NHR_single*, but excluding any other potential leading indicators from the equation; these results are reported in Table 1.[8] To compare the signalling power of NHR with other housing indicators, Table 1 also reports the results when we replace *NHR_single* in the equation with housing starts for single detached dwellings ($\Delta STARTS\_single$), as well as with building permits for singles (Δ*Bldg_perm_single*).

We find that monthly changes in *NHR_single* are not significant for signalling future changes in our two constructed measures of BC economic activity over any horizon up to 12 months ahead. However, it is not clear whether this result reflects that NHR is a bad predictor or whether our constructed *BCEA* indicators are poor measures of economic activity. Meanwhile, growth in *NHR_single* in the current month does appear to be a statistically significant leading indicator of changes in the unemployment rate over the next three months. The results suggest, for example, that all else equal a 1 percentage point increase in the growth rate of *NHR_single* this month would be associated with a 0.006 percentage point decline in the unemployment rate over the next three months. However, the results find little evidence that NHR are superior or earlier leading indicators of the BC economy compared to housing starts or building permits.

[8] Because we are forecasting cumulative changes in activity, this introduces a moving-average component into the error terms of the regressions. We therefore adjust the standard errors using heteroscedasticity and autocorrelation consistent (HAC) Newey-West estimators.

Table 1. Predictive content of new housing registrations vs. housing starts and building permits for future changes in BC economic activity (monthly measure)

$$BCEA\_p_t^k = \beta_0 + \beta_1 \Delta NHR_t + \varepsilon_t$$

Sample: 2002m1–2015m2			**Horizon (change over next *k* months)**			
Monthly Measure of BC Economic Activity	RHS variable		*k* = 1	*k* = 3	*k* = 6	*k* = 12
BCEA_48^k	ΔNHR_single_t	$\hat{\beta}_1$	0.510 (0.493)	2.392 (0.216)	3.205 (0.266)	3.776 (0.221)
		Adj-R^2	0.009	0.037	0.021	0.011
	$\Delta STARTS\_single_t$	$\hat{\beta}_1$	1.981 (0.301)	6.254* (0.078)	8.561 (0.118)	9.484 (0.109)
		Adj-R^2	0.045	0.082	0.050	0.023
	$\Delta Bldg\_perm\_single_t$	$\hat{\beta}_1$	2.733 (0.328)	10.452* (0.094)	16.312* (0.097)	18.876 (0.125)
		Adj-R^2	0.050	0.133	0.106	0.053
BCEA_8^k	ΔNHR_single_t	$\hat{\beta}_1$	0.369 (0.602)	2.206 (0.222)	3.566 (0.250)	2.456 (0.339)
		Adj-R^2	0.005	0.046	0.043	0.007
	$\Delta STARTS\_single_t$	$\hat{\beta}_1$	1.979 (0.308	5.748** (0.034)	6.859 (0.107)	5.004* (0.077)
		Adj-R^2	0.041	0.099	0.052	0.011
	$\Delta Bldg\_perm\_single_t$	$\hat{\beta}_1$	0.687 (0.766)	8.484 (0.122)	12.885 (0.116)	9.759 (0.273)
		Adj-R^2	0.003	0.126	0.105	0.026
$UNEMP_{t+k} - UNEMP_t$	ΔNHR_single_t	$\hat{\beta}_1$	-0.129 (0.388)	-0.591** (0.037)	-0.788 (0.106)	-0.732 (0.218)
		Adj-R^2	0.001	0.023	0.010	0.000
	$\Delta STARTS\_single_t$	$\hat{\beta}_1$	-0.534 (0.108)	-1.139 (0.134)	-1.912* (0.048)	-2.427 (0.125)
		Adj-R^2	0.022	0.030	0.040	0.014
	$\Delta Bldg\_perm\_single_t$	$\hat{\beta}_1$	-0.543 (0.227)	-1.718 (0.128)	-2.926* (0.093)	-3.927 (0.144)
		Adj-R^2	0.012	0.043	0.062	0.035

1. p-values in parentheses. Standard errors are adjusted using HAC Newey-West estimators, with the maximum number of lags set to be one greater than *k.*
2. *,**, *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

4.2 Predictive content at quarterly frequency

We next test the predictive power of the same variables for the BC economy at quarterly frequencies, using the Conference Board of Canada estimates of real GDP growth. Quarterly aggregates are constructed for each monthly variable by averaging their monthly values. Changes in the log of real GDP over the next *q* = 1 to 4 quarters ahead are regressed on current quarterly changes in the log of NHR for single detached homes. The results are shown in Table 2, and compared against results when we substitute for single-family housing starts or building permits.

Table 2. Predictive content of new housing registrations vs. housing starts and building permits for future changes in BC real GDP (quarterly measure)

$$Y_t^q = \beta_0 + \beta_1 \Delta NHR_t + \varepsilon_t$$

Sample: 2002Q1–2015Q1			**Horizon (change over next *q* quarters)**			
Quarterly Measure of BC Economic Activity	RHS variable		*q* = 1	*q* = 2	*q* = 3	*q* = 4
Real GDP at Market Prices	ΔNHR_single_t	$\hat{\beta}_1$	0.020** (0.034)	0.033** (0.011)	0.0199* (0.064)	0.013* (0.120)
		Adj-R^2	0.142	0.244	0.053	0.006
	$\Delta STARTS\_single_t$	$\hat{\beta}_1$	0.012 (0.232)	0.011 (0.333)	0.018 (0.222)	0.012 (0.386)
		Adj-R^2	0.008	0.000	0.007	0.000
	$\Delta Bldg\_perm\_single_t$	$\hat{\beta}_1$	0.031* (0.065)	0.038* (0.065)	0.037 (0.144)	0.033* (0.072)
		Adj-R^2	0.079	0.079	0.050	0.027

1. p-values in parentheses. Standard errors are adjusted using HAC Newey-West estimators, with the maximum number of lags set to be one greater than *q*.
2. *,**, *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

The results improve substantially at the quarterly frequency, in that the Δ*NHR_single* variable has significant predictive content for growth in real GDP over the next one to four quarters. It also significantly outperforms both $\Delta STARTS\_single$ and Δ*Bldg_perm_single* as a leading indicator for future growth in real GDP over the next one to three quarters. The superior results at the quarterly frequency may indicate that smoothing out excess volatility in the monthly fluctuations strengthens the signalling power of the NHR variable significantly, or alternatively that our monthly *BCEA* measures did not capture economic activity effectively. However, building permits for singles provide stronger signalling power (based on higher adjusted R^2) for changes in real GDP over the next four quarters.

Given that the estimations described above excluded Z_t – other variables that could be leading indicators of BC economic activity – it is possible that the coefficient on the *NHR_singles* variable could be biased upward because of omitted variables. We thus test whether the *NHR_singles* variable remains significant when other possible leading indicators are included in equation (1a). We identify 15 possible leading indicators (Table A2) after assessing all variables based on regressions of the following equation:

$$\Delta GDP_t = \alpha + \sum_{j=-4}^{4} \gamma' x_{t-j} + \varepsilon_t, \quad (2)$$

where GDP is the natural logarithm of the Conference Board of Canada estimate of real GDP at market prices at the quarterly frequency, and x is the indicator suitably transformed to be I(0). Variables were identified as leading indicators if any of their lags were found to be statistically significant and all leads were insignificant.

Tests are then performed using a general-to-specific method, first including all 15 variables, and sequentially eliminating the least significant variables to reach a specification that maximizes overall equation fit. These specifications are reported in Table 3. The results suggest that even when other leading indicators are included, the *NHR_single* retains significant predictive content for changes in real GDP growth over the next two quarters. For growth in real GDP over the next three and four quarters, other housing variables appear to be superior leading indicators, including changes in Multiple Listing Service (MLS) home sales and home prices, and changes in residential building permits.

Nevertheless, the equations perform poorly when forecasting out of sample over the period 2012Q1–2015Q1. Root-mean-squared forecast errors (RMSFE) are calculated from the specifications that perform best at $q = 1$ and $q = 2$ (i.e., the first two columns of Table 3) and compared against RMSFEs from a simple benchmark forecast derived from an autoregressive equation. In Table 4 we show results from the specification that performs best, which cannot outperform a simple AR(1) model forecast. Nonetheless, we do find that augmenting an AR(1) equation with the Δ*NHR_single* variable reduces forecast errors relative to a simple AR(1) forecast at all horizons up to four quarters ahead. This is also true when we augment an AR(1) equation with the Δ*Bldg_perm_single* variable, though not when we use Δ*STARTS_single*. However, the forecast performance at one quarter ahead is best when we include the NHR singles variable. At greater horizons, inclusion of the building permit variable produces superior out-of-sample forecast performance.

Table 3. Predictive content of new housing registrations vs. other leading indicators for BC economic activity

$$Y_t^q = \beta_0 + \beta_1 \Delta NHR_t + \beta_2 Z_t + \varepsilon_t$$

Sample: 2002Q1–2015Q1	**Horizon (change over next *q* quarters)**			
	q = 1	*q* = 2	*q* = 3	*q* = 4
ΔNHR_Single_t	0.013** (0.035)	0.026*** (0.008)	0.006 (0.273)	0.001 (0.885)
$\Delta MLS\_Home\_Sales_t$		0.026** (0.050)	0.045*** (0.002)	
$\Delta MLS\_Avg\_Home\_Price_t$		0.116* (0.070)	0.112*** (0.004)	0.180*** (0.000)
$\Delta Bldg\_perm\_res_t$	0.020** (0.06034)			0.020*** (0.001)
$\Delta Unemployment_t$	-0.005* (0.06076)	-0.028** (0.021)	-0.009*** (0.000)	-0.030** (0.038)
C	0.005*** (0.0010)	0.012*** (0.000)	0.016*** (0.000)	
Adj-R^2	0.261	0.261	0.205	0.095

1. p-values in parentheses. Standard errors are adjusted using HAC Newey-West estimators, with the maximum number of lags set to be one greater than *q*.
2. *,**, *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 4. Out-of-sample forecast performance relative to AR(1)

	1- to 4-step-ahead forecasts			
	1	2	3	4
Best Equation RMSFE	1.10	1.11	1.11	1.08
AR(1) + Δ*NHR_single*	0.968	0.941	0.915	0.887
AR(1) + Δ*STARTS_single*	1.099	1.051	1.019	1.016
AR(1) + Δ*Bldg_perm_single*	0.976	0.932	0.885	0.877

5. Conclusion

This study assesses whether NHR data have significant predictive power for economic activity in British Columbia, and over what time horizons the series would be most useful as a leading indicator. We evaluate the statistical significance of NHR at the quarterly frequency for forecasting real GDP growth up to four quarters ahead, and compare this with the signalling power of housing starts and building permits. We do the same at the monthly frequency using (i) the unemployment rate as a measure of the economic cycle, and (ii) two composite indicators that we construct using principal component analysis on a wider set of monthly variables. Our main findings are that NHR for single detached homes are significant leading indicators of the BC economy when aggregated to quarterly frequency. Quarterly increases in NHR for singles have statistically significant predictive content for growth in real GDP over the next one to three quarters, and provide stronger signals compared to housing starts and building permits over this forecast horizon. These signals remain significant for growth in real GDP over the next two quarters even in the presence of other leading indicators in the equations. At monthly frequencies, changes in NHR have weak signalling power, but may be useful for predicting changes in the unemployment rate over the next three months. However, forecasts using quarterly NHR data with other leading indicators are not able to outperform simple benchmark forecasts in an out-of-sample forecasting exercise. Nonetheless, adding the NHR variable to an AR(1) equation does reduce forecast errors relative to a simple AR(1) forecast at all horizons up to four quarters ahead. Relative to housing starts and building permits, adding the NHR singles variable to an AR(1) equation produces the best out-of-sample forecast performance at one quarter ahead. At greater horizons, inclusion of the building permit variable produces superior out-of-sample forecast performance.

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Technical Appendix

Using Principal Component Analysis to Construct Monthly Measures of BC Economic Activity

Given a vector $X^p = [x_1, x_2, ...x_p]$ of *p* variables, each indicator *x* is first transformed as necessary to be I(0), and normalized to have a mean of zero and standard deviation of one. The common factor is taken to be the first principal component corresponding to the largest eigenvalue computed from the sample variance-covariance matrix $\sum^p$ of X^p. This first principal component is essentially a weighted average of the *p* series, where the vector of weights is the eigenvector associated with the largest eigenvalue. These weights are fixed over time and reflect the importance of each variable's historical contribution to the overall co-movement among the *p* indicators. This common factor is then renormalized with a mean of zero and standard deviation of one to construct our monthly proxy for economic activity in British Columbia, which we call *BCEA_p*. In this way, the indicator is constructed as a measure of growth relative to some average rate of economic growth, where positive values signify growth above trend, and vice versa for negative values.

In estimating the common factor, an important consideration is the dimension *p*. On the one hand, Stock and Watson (2002) and Bai and Ng (2002) show that factor estimates achieve consistency as the number of variables approaches infinity. On the other hand, including variables that contain no additional information but have idiosyncratic errors that are highly correlated with others in the set can reduce the efficiency and accuracy of factor estimates (Boivin and Ng 2006).

We therefore test two alternative approaches in constructing the monthly proxy. In the first approach, we include all 48 available monthly indicators in the PCA. In the second approach, we choose to include only a subset of variables that appear to be coincident indicators of real output growth in British Columbia, rather than leading or lagging indicators. Since the purpose of this research is to assess whether NHR data are a leading indicator of the BC economy, ideally our proxy would not in itself be a leading indicator of the business cycle. Using the Conference Board of Canada quarterly GDP estimates to represent the actual state of the BC economy, each monthly indicator is assessed by evaluating the following regression at the quarterly frequency:

$$\Delta GDP_t = \alpha + \sum_{j=-4}^{4} \gamma' x_{t-j} + \varepsilon_t, \qquad \text{(A1)}$$

where GDP is the natural logarithm of the Conference Board's estimate of real GDP at market prices at the quarterly frequency, and x is the quarterly aggregate of the monthly indicator suitably transformed to be I(0). Variables were identified as coincident indicators if they were found to be statistically significant contemporaneously at $t = 0$. Furthermore, in cases where several variables contain similar information and are likely to be highly correlated (such as total employment, full-time employment and the employment rate), only the variable with the best statistical fit was included in this second approach.

The effectiveness of each alternative monthly proxy for BC economic activity is then assessed by evaluating how closely its quarterly aggregate correlates with the quarterly GDP estimates and how well it tracks turning points.

In constructing the indicators, we prefer to exclude fluctuations related to seasonal factors, and thus employ seasonally adjusted (SA) variables, using the E-views X12 procedure where necessary.[9] Under the first approach, which includes all 48 monthly indicators, PCA is performed over the common sample across all series, from 1997m1 to 2015m3. Table A2 provides details on the stationarity properties of each series.

Beginning with $k = 1$, we construct the indicator of the one-month change in BC economic activity. The first principal component is found to account for only 10 per cent of the variance in the full data set, which is perhaps unsurprising given the volatility of monthly data and the high degree of noise in each of the 48 variables. To see how well *BCEA_48* tracks the BC economy, we convert the series to a quarterly aggregate and plot it against real GDP growth (standardized to have mean zero and standard deviation of one), as shown in Figure A1. The *BCEA_48* measure appears to track deviations of real GDP growth from trend reasonably well since 1997. However, at certain points in history, the measure seems to have acted more as a leading indicator rather than a coincident indicator, such as during the 2009 economic downturn. Simple regression results (Table A1) suggest that a quarterly aggregate of *BCEA_48* can explain just under 12 per cent of the variation in real GDP growth relative to its trend since 1997.

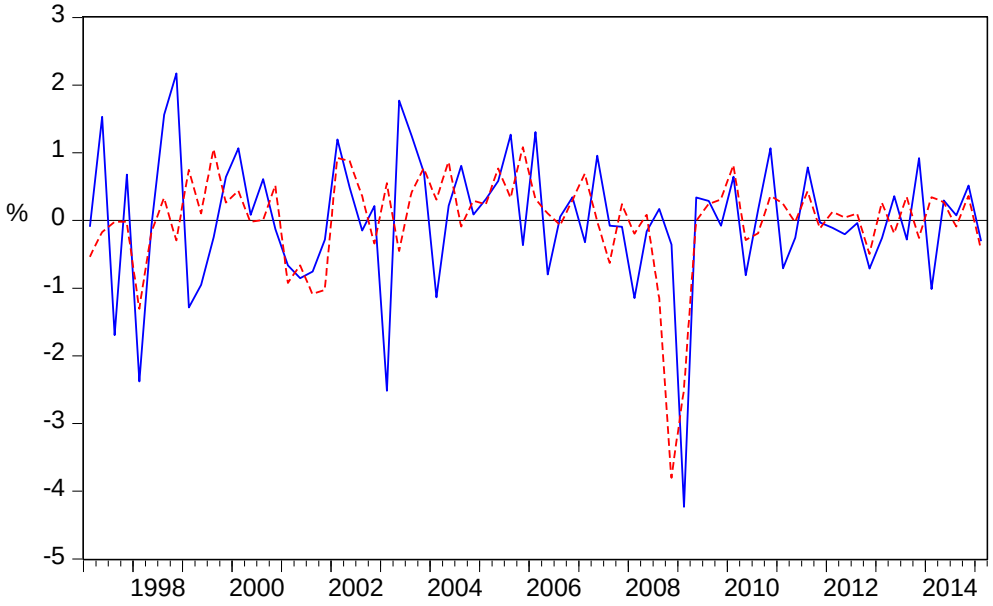
In the second approach, we construct a measure of BC economic activity from principal component analysis on a smaller subset of monthly variables limited to only those found to be coincident indicators of quarterly real GDP growth. Regressions of equation (A1) are used to select these variables. Based on the 48-variable measure's tendency to lead real GDP growth at certain points in history, indicators were selected only if they were statistically significant contemporaneously at $t = 0$, and if none of their leads or lags were found to be significant. By this method, we identify eight coincident indicators to include in the principal component analysis: manufacturers' sales, full-time employment, merchandise exports, the new housing price index, the consumer confidence index, building permits for singles, lumber production and electric power consumption.

This 8-variable measure, *BCEA_8,* also appears to track deviations from trend GDP growth fairly well since 1997, as shown in Figure A2. Compared to the 48-variable measure*, BCEA_8* appears to capture the 2009 economic downturn with less of a lead, but is less accurate on the magnitude of the contraction. A simple regression reveals that *BCEA_8* has a slightly higher correlation and explains a larger share of movements in real GDP compared to *BCEA_48* (Table A1).[10] For the sake of comparison, we also include the change in unemployment rate in Table A1 as a measure of the BC economic cycle, and can see that it explains a similar share of the variation in real GDP growth to *BCEA_48*.

[9] Principal component analysis is also performed on the non-seasonally adjusted (NSA) series, but because the resulting measure does not correlate as well to the real GDP series (which is seasonally adjusted), it is more difficult to assess how well it tracks the underlying economic cycle.

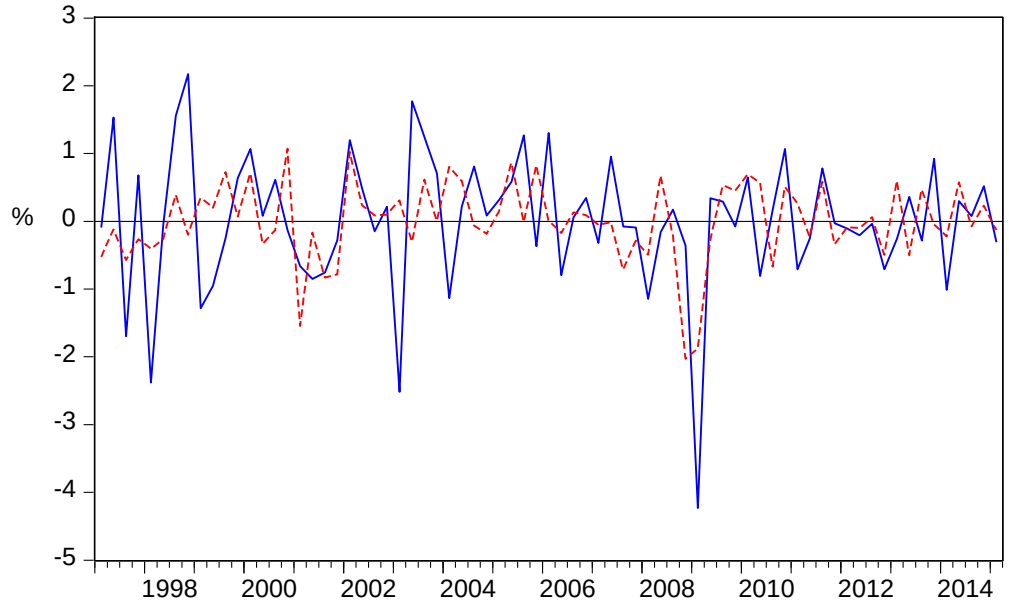
[10] In this case, the first principal component accounts for 20 per cent of the variance of the data set, which still suggests that using it would leave a large share of the co-movement among the eight indicators unexploited. In an attempt to capture the remaining 80 per cent of the variance, we constructed a third alternative measure that takes a weighted average of the eight principal components, where the weights correspond to the share of total variance that each principal component explains. The resulting measure performed worse, however, in tracking real GDP growth than *BCEA_48* and *BCEA_8*.

Figure A1. Measure of BC economic activity constructed from 48 monthly indicators



Sources: Conference Board of Canada and Bank of Canada calculations

Figure A2. Measure of BC economic activity constructed from 8 monthly coincident indicators



Sources: Conference Board of Canada and Bank of Canada calculations

Table A1. Correlations of various measures of BC economic activity with normalized real GDP growth at quarterly frequency

Measure of BC Economic Activity	Coefficient	Adjusted R^2 from simple regression
BCEA_48	0.47*** (0.003)	0.119
BCEA_8	0.59*** (0.002)	0.153
ΔUnemployment rate	-0.67*** (0.003)	0.116

1. p-values in parentheses
2. *,**, *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table A2. Data sources and description

Measure	Frequency	Source	CANSIM Table #, Famemart mnemonic	Stochastic process	Leading/Coincident/Lagging Real GDP growth	SA or NSA
Real GDP at Market Prices (GDP_MARKET_PRICES)	Quarterly	Conference Board	rygdpkb	I(1)	-	SA
Retail Sales (Value) (RETAIL_SALES_SA/NSA)	Monthly	Statcan	080-0020 (v52367245) 080-0020 (v52367244)	I(1)	Leading	SA NSA
Wholesale Trade (WHOLESALE_TRADE_SA/NSA)	Monthly	Statcan	081-0011 (v52367737) 081-0011 (v52367736)	I(1)	Coincident, Leading, Lagging	SA NSA
New Motor Vehicle Sales (units) (MV_SALES_UNITS_NSA/SA)	Monthly	Statcan	079-0003 (V42169969)	I(1)	Coincident	NSA SA using EViews X-12
New Motor Vehicle Sales (dollars) (MV_SALES_DOLLARS_NSA/SA)	Monthly	Statcan	079-0003 (V42169971)	I(1)	Coincident	NSA SA using EViews X-12
Housing Starts (Urban Areas) (HOUSING_STA_URB_NSA/SA)	Monthly	CMHC	b830073	I(1)	Coincident	NSA SA using EViews X-12
Housing Starts – Single Detached (STARTS_SINGLE_SA)	Monthly	CMHC	v52299969	I(1)	Coincident	SA
Manufacturers' Sales (MAN_SALES_SA/NSA)	Monthly	Statcan	304-0015 (v807928) 304-0015 (v807503)	I(1)	Coincident	SA NSA
Manufacturers' Sales (durables) (MAN_SALES_DUR_SA/NSA)	Monthly	Statcan	304-0015 (v807941) 304-0015 (v807700)	I(1)	Coincident	SA NSA
Manufacturers' Sales (non-durables) MAN_SALES_NONDUR_SA/NSA	Monthly	Statcan	304-0015 (v807929) 304-0015 (v807504)	I(1)	Coincident	SA NSA
Population (WORKAGE_POPULATION)	Monthly	Statcan	282-0087 (v2064699)	I(1)	No	N/A
Employment Rate (EMPLOYMENT_RATE_SA/NSA)	Monthly	Statcan	282-0087 (v2064707) 282-0087 (v2066786)	I(1)	Leading, Coincident, Lagging	SA NSA
Total Employment (TOT_EMP_SA/NSA)	Monthly	Statcan	282-0087 (v2064701) 282-0087 (v2066780)	I(1)	Leading, Coincident, Lagging	SA NSA
Full-time Employment (FT_EMP_SA/NSA)	Monthly	Statcan	282-0087 (v2064702) 282-0087 (v2066781)	I(1)	Coincident, Lagging	SA NSA
Part-time Employment (PT_EMP_SA/NSA)	Monthly	Statcan	282-0087 (v2064703) 282-0087 (v2066782)	I(1)	No	SA NSA
Public Sector Employment (PUB_SEC_EMP_SA/NSA)	Monthly	Statcan	282-0089 (v2067019) 282-0089 (v2067184)	I(1)	No	SA NSA

(continued)

Private Sector Employment (PRI_SEC_EMP_SA/NSA)	Monthly	Statcan	282-0089 (v2067020) 282-0089 (v2067185)	I(1)	Leading, Lagging	SA NSA
Self-Employment (SELF_EMP_SA/NSA)	Monthly	Statcan	282-0089 (v2067021) 282-0089 (v2067186)	I(1)	Coincident	SA NSA
Total Unemployment (TOT_UNEMP_SA/NSA)	Monthly	Statcan	282-0087 (v2064704) 282-0087 (v2066783)	I(1)	Leading	SA NSA
Unemployment Rate (UNEMP_RATE_SA/NSA)	Monthly	Statcan	282-0087 (v2064705) 282-0087 (v2066784)	I(1)	Leading, Coincident	SA NSA
Participation Rate PART_RATE_SA/NSA	Monthly	Statcan	282-0087 (v2064706) 282-0087 (v2066785)	I(1)	No	SA NSA
Average Hourly Earnings (AVG_HOURLY_EARN_NSA/SA)	Monthly	Statcan	281-0039 (v1606354)	I(1)	No	NSA SA using EViews X-12
Average Weekly Hours Worked AVG_WK_HRS_WORK_NSA/SA	Monthly	Statcan	281-0032 (v1594956) 281-0004 (v311635) 281-0004 (v734226)	I(0)	No	NSA NSA SA
Employment Insurance Beneficiaries EMP_INS_BENEF_SA/NSA	Monthly	Statcan	276-0022 (v64549480) 276-0020 (v64540928)	I(0)	No	SA NSA
CPI (CPI)	Monthly	Statcan	326-0020 (v41692462)	I(1)	No	N/A
Merchandise Trade – Domestic Exports (DOM_EXPORTS_NSA/SA)	Monthly	Statcan	228-0060 (v54057690)	I(0)	Coincident, Lagging	NSA SA using EViews X-12
Merchandise Trade – Total Imports (MERCH_IMP_NSA/SA)	Monthly	Statcan	228-0060 (v54057676)	I(1)	Leading	NSA SA using EViews X-12
NHPI (NHPI)	Monthly	Statscan	327-0046 (v53600515)	I(1)	Coincident	N/A
MLS Average Home Price MLS_AVG_HOME_PRICE	Monthly	MLS	MLS100015	I(1)	Leading	N/A
MLS Home Sales MLS_HOME_SALES	Monthly	MLS	MLS100013	I(1)	Leading	N/A
Consumer Confidence Index (CCI_INTER)	Monthly	Conference Board	bcbi_m Linearly interpolated	I(1)	Coincident	N/A
Consumer Bankruptcies CONS_BANK	Monthly	OSBC	-	I(1)	No	N/A
Building Permits (BUILDING_PERM_SA/NSA)	Monthly	Statcan	026-0006 (v42142)	I(1)	Leading, Coincident	SA NSA
Building Permits – Residential BLDG_PERM_RES_SA	Monthly	Statcan	026-0006 (v42143)	I(1)	Leading, Coincident	SA
Building Permits – Singles (units) BLDG_PERM_SINGLE_SA	Monthly	Statcan	026-0006 (v42188)	I(1)	Coincident, Lagging	SA
Building Permits – Non Residential BLDG_PERMITS_NONRES_SA	Monthly	Statcan	026-0006 (v42144)	I(0)	Coincident, Lagging	SA
Electric Power Consumption ELEC_CONSUMPTION_SA/NSA	Monthly	Statcan	Elavlbcs Elavlbc	I(0)	Coincident	SA NSA

(continued)

Tourist Entries (TOURIST_ENTRIES_SA/NSA)	Monthly	Statcan	427-0004 (v32214275) 427-0004 (v32214274)	I(0)	Lagging	SA NSA
NHR in Multi-unit Buildings (NHR_MULTI_NSA)	Monthly	BC Housing	-	I(1)	No	NSA
NHR in Single Detached Homes (NHR_SINGLE_NSA)	Monthly	BC Housing	-	I(1)	Leading	NSA
BoC Commodity Price Index COMM_PRICE_INDEX	Monthly	Bank of Canada	V52673496	I(1)	No	N/A
Lumber Price (LUMBER_PRICE)	Monthly	Famemart	lmbr	I(0)	No	N/A
Coal Price (COAL_PRICE)	Monthly	Famemart	coal	I(1)	No	N/A
Natural Gas Price (NAT_GAS_PRICE)	Monthly	Famemart	ngas	I(0)	No	N/A
Copper Price (COPPER_PRICE)	Monthly	Famemart	copr	I(1)	No	N/A
Zinc Price (ZINC_PRICE)	Monthly	Famemart	zinc	I(1)	No	N/A
Lumber Production (LUMBER_PROD_NSA/SA)	Monthly	Statcan	303-0064 (v55086626) Interpolated using Canadian series	I(1)	Coincident, Lagging	NSA SA using EViews X-12
Coal Production (COAL_PRODUCTION)	Monthly	Statcan	135-0002 (v43973959) 303-0016 (v192)	I(0)	No	NSA NSA
Natural Gas Production (NAT_GAS_PROD)	Monthly	Statcan	131-0001 (v17896)	I(1)	No	NSA SA using EViews X-12
Natural Gas Exports (NAT_GAS_EXPORTS)	Monthly	Statcan	131-0001 (v17913)	I(1)	Leading	NSA SA using EViews X-12
US Coincident Economic Activity Index (USPHCI)	Monthly	US Federal Reserve	-	I(1)	No	NSA

Note: SA = seasonally adjusted; NSA = non-seasonally adjusted