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ANALYTICAL NOTES

Technical appendix to

Down to business: Which QSBO measures are the best at forecasting?

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Data

Which variables do we forecast?

In this *Note,* we aim to find which *Quarterly Survey of Business Opinion* (QSBO) indicators are best for predicting four key variables, published by Stats NZ:

- quarterly growth in production GDP,
- quarterly growth in the number of employed from the *Household Labour Force Survey*,
- the change in the unemployment rate from the *Household Labour Force Survey,* and
- quarterly CPI inflation.

GDP data is subject to significant revisions when annual data are collected by Stats NZ. As a result, we evaluate the forecast performance of QSBO measures using both the most recently published GDP data and the first-release GDP data. For the final vintage data, we truncate the sample at 2018 Q3 as more-recent data has not yet been subject to the annual benchmarking process.

The 2010 increase in Goods and Services Tax (GST) caused a one-off spike in CPI inflation. For our forecast evaluation, we adjust the CPI to remove the impact of the GST increase from the series. All seasonal adjustments are made in real time in order to approximate the information set available in real time.

Our sample ranges from 1995 Q1 to 2020 Q1 and we begin our out-of-sample forecasts in 2010 Q3. For brevity, we only report the results for GDP, employment, and inflation in the main text.

QSBO variables tested

In this evaluation we focus on the QSBO. The QSBO provides industry breakdowns of each variable, however this note analyses the economy-wide versions of the QSBO series. Table 1 outlines the QSBO variables that are considered in this evaluation, including their definitions and which macroeconomic variables we use the QSBO variables to forecast.

Table 1: QSBO indicators used to forecast each macroeconomic variable

QSBO variable	Definition	GDP	Employment	Unemployment	Inflation
Domestic trading activity (past 3 months)	Excluding seasonal variations, what has been your firm's experience during the past three months in respect of output/sales (up, down, same)?	✓	✓	✓	
Domestic trading activity (next 3 months)	Excluding seasonal variations, what changes do you expect in your firm during the next three months in respect of output/sales (up, down, same)?	✓	✓	✓	
General Business situation	Do you expect the general business situation in New Zealand during the next six months to (improve, deteriorate, same)	✓			
Investment intention (building)	Do you expect new investment approvals (next 12 months compared with the last 12 months) to be (greater, same, less)	✓			
Investment intention (plant and machinery	Do you expect new investment approvals (next 12 months compared with the last 12 months) to be (greater, same, less)	✓			
Employment (past 3 months)	Excluding seasonal variations, what has been your firm's experience during the past three months in respect of numbers employed (up, down, same)?	✓	✓	✓	

Employment (next 3 months)	Excluding seasonal variations, what changes do you expect in your firm during the next three months in respect of numbers employed (up, down, same)?	✓	✓	✓	
Profitability (past 3 months)	Excluding seasonal variations, what has been your firm's experience during the past three months in respect of profitability (up, down, same)?	✓			✓
Profitability (next 3 months)	Excluding seasonal variations, what changes do you expect in your firm during the next three months in respect of profitability (up, down, same)?	✓			✓
Costs (past 3 months)	Excluding seasonal variations, what has been your firm's experience during the past three months in respect of average cost (up, down, same)?				✓
Costs (next 3 months)	Excluding seasonal variations, what changes do you expect in your firm during the next three months in respect of average cost (up, down, same)?				✓
Prices (past 3 months)	Excluding seasonal variations, what has been your firm's experience during the past three months in respect of selling prices (up, down, same)?				✓
Prices (next 3 months)	Excluding seasonal variations, what changes do you expect in your firm during the next three months in respect of selling prices (up, down, same)?				✓
Capacity pressure	Excluding seasonal factors, by how much is it currently practicable for you to increase your production from your existing plant and equipment without raising unit costs?		✓	✓	✓
Difficulty finding skilled labour	Finding the staff you want today compared with three months ago is (skilled/specialist – easier, same, harder)		✓	✓	
Difficulty finding un-skilled labour	Finding the staff you want today compared with three months ago is (unskilled/semi-skilled – easier, same, harder)		✓	✓	
Labour as a limiting factor	What single factor, if any, is most limiting your ability to increase your production? (Orders/sales, materials/components, finance, labour, capacity, other)		✓	✓	
Principal component	Principal component of the QSBO indicators used to predict each macroeconomic variable	✓	✓	✓	✓

Econometric methodology

This section outlines the econometric approach to the forecast evaluation reported in the *Note*. We consider which QSBO variables are best at forecasting quarterly production GDP growth, quarterly employment growth, quarterly changes in the unemployment rate, and quarterly CPI inflation.

Evaluating the forecast performance of the QSBO variables

Our research question is which QSBO measures are best at forecasting the variables outlined in section 1, at different forecast horizons? To answer this question, we first test whether the QSBO indicators can increase the accuracy of forecasts from a basic autoregressive model and then look at which indicators generated the largest improvement over different forecast horizons.

We use direct forecasting methods for three reasons. Firstly, this avoids the need to generate forecasts for our QSBO indicators. Secondly, this is closest to how these measures would actually be used in practice. And thirdly, direct forecasting methods are less susceptible to bias from model misspecification than iterative methods (Marcellino, Stock, and Watson, 2006).

Our baseline model, which we label as Model 1, is a simple autoregressive process:

$$y_{t+h,1} = \beta_0 + \beta_1 y_{t-1} + \varepsilon_t \qquad (1)$$

where $Y_{t+h,1}$ is our h-quarter-ahead forecast of variable Y_t, $h = 0,1,2,3$ (starting at zero because at time t , Y_t is unknown due to the delay in publishing official economic statistics).

We then add a QSBO indicator to equation 1:

$$y_{t+h,2} = \beta'_0 + \beta'_1 y_{t-1} + \beta'_2 QSBO_t + \epsilon'_t \quad (2)$$

The h-step-ahead forecast errors for each model are then given by:

$$\hat{e}_{t+h} = Y_{t+h} - \hat{Y}_{t+h} \qquad (3)$$

Note that the Model 1 is a restricted version of Model 2; in other words, Model 1 is nested in Model 2. Our objective is to test whether there is a difference in predictive accuracy between Models 1 and 2.

Comparing predictive accuracy

To test the difference in predictive accuracy, we need to generate forecasts from Models 1 and 2. We divide our sample into two. The first R observations are used to make our first set of predictions. We set R to cover the period 1995 Q1 to 2010 Q2. The last P observations are used for our forecast evaluation, in this case 2010 Q3 to 2020 Q1. This evaluation is carried out in real time. For the initial forecast, this means we only use data available in 2010 Q2 to generate our h quarter-ahead forecast. We can then use the actual data outturns to test how well our real-time forecasts are predicting our macroeconomic variables.

We begin our forecast evaluation after the GFC because in early versions of this paper the GFC completely dominated the results. We also exclude 2020 Q2, as the sheer magnitude of the drop in GDP growth would also be likely to inappropriately influence our results.

After we generate our initial set of predictions, we calculate the h quarter-ahead forecast errors for each model. Then, we add the next data point so that our second sample is 1995 Q1 to 2010 Q3 and generate a new set of predictions and forecast errors. We recursively expand the sample, collecting predictions and forecast errors each time, until we reach 2020 Q1. At the end of this process, we have a series of forecast errors for each model. Then, we test whether adding our QSBO variable to the autoregressive model yielded a significant reduction in mean square prediction error (MSPE).[1]

1 The MSPE for model i is $\hat{\sigma}_i^2 = \frac{\sum(Y_{t+h} - \hat{Y}_{t+h})^2}{P}$ where P = number of predictions in the forecast evaluation (Clark and West, 2007).

Model 1 is nested in Model 2. This can be seen by setting β_2 in equation 2 to zero. We therefore employ the test developed by Clark and West (2007), henceforth CW, which is designed to compare the relative predictive accuracy of nested models. This test compares the MSPE of the restricted model (Model 1) and the unrestricted model (model 2), with the null hypothesis that they have equal MSPE, and the alternative hypothesis that the restricted model has a larger MSPE. CW suggest an adjustment of the MSPE of the unrestricted model to account for the fact that even though $\beta_2 = 0$ under the null hypothesis, the sample MSPE from the parsimonious model is expected to be less than that of the extended model (see p. 298).

We follow the procedure outlined in CW, defining the following variable:[2]

$$\hat{f}_{t+h} = \left(Y_{t+h} - \hat{Y}_{t+h,1t}\right)^2 - \left[\left(Y_t - \hat{Y}_{t+h,2t}\right)^2 - \left(\hat{Y}_{t+h,1t} - \hat{Y}_{t+h,2t}\right)^2\right] \qquad (4)$$

Where $\hat{Y}_{t+h,it}$ is the h quarter-ahead prediction from model i and Y_{t+h} is the actual outturn. We then regress $\hat{f}_{t+h}$ against a constant and test whether the coefficient on the constant is statistically significant, using robust standard errors. Following CW, we calculate bootstrapped standard errors, using 1000 bootstrap samples, and use standard normal critical values to evaluate our test statistics.

We carry out this forecast exercise for production GDP growth, employment growth, the change in the unemployment rate, and quarterly CPI inflation from one to four quarters ahead. For each dependent variable, we consider a range of QSBO variables that we expect should contain information useful for forecasting (detailed in table 1). In the next section we present the MSPE of Model 1 versus Model 2, with the superscripted stars denoting whether the CW test shows a statistically significant reduction in MSPE after adding the QSBO indicator to model 1.

2 As CW note, the sample average of $\hat{f}_{t+h}$ is equal to the MSPE of model 1, minus the adjusted MSPE of model 2.

Forecast evaluation results

Tables 2-6 show the results of the forecast evaluation for each dependent variable across different time horizons up to 1 year ahead. The numbers in the tables show the adjusted-MSPE of the unrestricted models, relative to the autoregressive baseline. A number less than one means the unrestricted model was better than the restricted autoregressive model, and the significance stars denote whether this difference was statistically significant. In addition to the individual QSBO indicators, we also include a principal component variable in each evaluation reported in Tables 2-6. This variable is simply the first principal component of all the indicators considered for each variable. We find that while the principal component does perform well at forecasting, it is never the best at any horizons.

Table 2: Real-time production GDP growth - MSPEs of unrestricted model relative to the autoregressive baseline

Horizon	Business confidence	Investment intentions (building)	Investment intentions (P&M)	Employment (past 3 months)	Employment (next 3 months)	Profitability (past 3 months)	Profitability (next 3 months)	Domestic trading activity (past 3 months)	Domestic trading activity (next 3 months)	QSBO Principal
1	0.73	0.81	0.68	0.84*	0.73	0.44**	0.30**	0.38***	0.36**	0.43*
2	0.92	0.89	0.83	1.00	0.99	0.75*	0.69*	0.76	0.86	0.79
3	0.94	0.96	0.96	0.97	1.06	0.80	0.75	0.88	0.96	0.93
4	0.76**	1.02	0.90*	0.99	1.01	0.78*	0.59**	0.86**	0.67**	0.85**

Note: Numbers are MSPEs of Model 2 (the autoregressive plus QSBO variable) relative to the baseline autoregressive model. Stars indicate the significance of the reduction in MSPE for the unrestricted model. Significance levels denoted by *** ≡ 1%, ** ≡ 5% * ≡ 10%. The test is for equal MSPE, using the Clark and West test with bootstrapped autocorrelation consistent standard errors. Time horizons are all quarterly.

Table 3.2: Final vintage production GDP growth - MSPEs of unrestricted model relative to the autoregressive baseline

Horizon	Business confidence	Investment intentions (building)	Investment intentions (P&M)	Employment (past 3 months)	Employment (next 3 months)	Profitability (past 3 months)	Profitability (next 3 months)	Domestic trading activity (past 3 months)	Domestic trading activity (next 3 months)	QSBO Principal
1	0.82	0.71	0.41*	0.62***	0.69*	0.30***	0.39*	0.21***	0.47*	0.31*
2	1.00	0.79	0.61*	0.89	0.89	0.90	0.66	0.75	0.79	0.69
3	1.04	0.84	0.58*	0.89**	0.85	0.63*	0.87	0.63*	0.86	0.69
4	0.56**	0.89**	0.71***	0.97	1.00	0.64**	0.54**	0.71***	0.55**	0.62***

Note: Numbers are MSPEs of Model 2 (the autoregressive plus QSBO variable) relative to the baseline autoregressive model. Stars indicate the significance of the reduction in MSPE for the unrestricted model. Significance levels denoted by *** ≡ 1%, ** ≡ 5% * ≡ 10%. The test is for equal MSPE, using the Clark and West test with bootstrapped autocorrelation consistent standard errors. Time horizons are all quarterly.

Table 4: CPI inflation – MSPEs of unrestricted model relative to the autoregressive baseline

Horizon	Costs (past 3 months)	Costs (next 3 months)	Prices (past 3 months)	Prices (next 3 months)	Profitability (past 3 months)	Profitability (next 3 months)	Capacity utilisation	QSBO Principal
1	0.99	0.90	0.97	0.89	0.90	0.90	1.00	0.96
2	1.02	1.04	1.08	1.02	0.89	0.84*	1.03	1.07
3	1.03	1.05	1.08	1.04	1.06	1.04	1.11	1.04
4	1.02	1.09	1.06	1.06	1.05	0.99	1.12	1.06

Note: Numbers are MSPEs of Model 2 (the autoregressive plus QSBO variable) relative to the baseline autoregressive model. Stars indicate the significance of the reduction in MSPE for the unrestricted model. Significance levels denoted by *** ≡ 1%, ** ≡ 5% * ≡ 10%. The test is for equal MSPE, using the Clark and West test with bootstrapped autocorrelation consistent standard errors. Time horizons are all quarterly.

Table 5: Employment growth – MSPEs of unrestricted model relative to the autoregressive baseline

Horizon	Difficulty finding skilled labour	Difficulty finding unskilled labour	Labour limiting factor	Employment (past 3 months)	Employment (next 3 months)	Domestic trading activity (past 3 months)	Domestic trading activity (next 3 months)	Capacity utilisation	QSBO Principal
1	1.05	1.05	0.92	0.81	0.79*	0.73**	0.70***	0.89	0.85
2	1.03	1.01	1.00	0.93	0.98	0.86	0.97	0.84	0.92
3	0.95	0.93	0.89	0.90	0.91	0.75***	0.83*	0.80	0.88
4	1.04	1.10	1.03	0.95	0.88	0.86**	0.86	0.84	0.94

Note: Numbers are MSPEs of Model 2 (the autoregressive plus QSBO variable) relative to the baseline autoregressive model. Stars indicate the significance of the reduction in MSPE for the unrestricted model. Significance levels denoted by *** ≡ 1%, ** ≡ 5% * ≡ 10%. The test is for equal MSPE, using the Clark and West test with bootstrapped autocorrelation consistent standard errors. Time horizons are all quarterly.

Table 6: Change in the unemployment rate – MSPEs of unrestricted model relative to the autoregressive baseline

Horizon	Difficulty finding skilled labour	Difficulty finding unskilled labour	Labour limiting factor	Employment (past 3 months)	Employment (next 3 months)	Domestic trading activity (past 3 months)	Domestic trading activity (next 3 months)	Capacity utilisation	QSBO Principal
1	1.30	1.21	1.06	1.10	1.15	0.98	0.88	1.03	1.13
2	0.59**	0.60**	0.57**	0.62*	0.59**	0.61**	0.67*	0.55**	0.60**
3	0.90	0.94	0.94	0.81*	0.82	0.78	0.76	0.95	0.85
4	0.85*	0.83**	0.78**	0.82*	0.80*	0.96	0.88	0.82**	0.88

Note: Numbers are MSPEs of Model 2 (the autoregressive plus QSBO variable) relative to the baseline autoregressive model. Stars indicate the significance of the reduction in MSPE for the unrestricted model. Significance levels denoted by *** ≡ 1%, ** ≡ 5% * ≡ 10%. The test is for equal MSPE, using the Clark and West test with bootstrapped autocorrelation consistent standard errors. Time horizons are all quarterly.

Robustness results

In this section we summarise the results of some additional evaluations we carried out. These evaluations were done to check how sensitive our results were to the choice of sample and baseline model.

Pre-GFC sample

To check the consistency of our results across time, we re-run our forecast evaluation using a sub-sample of 1995 Q1 to 2007 Q4. We find our results changed substantially for employment, unemployment, and CPI inflation. This indicates that the forecast performance of the QBSO measures is not constant across time and therefore should be continually monitored. Our quantitative results changed for GDP growth, but domestic trading activity and profitability performed consistently well compared to other indicators.

For employment growth, we find the QSBO measures offered larger reductions in MSPE using the pre-GFC sample. In addition, while the domestic trading activity (forward- and backward-looking) were the best one-quarter-ahead measures in our baseline results, they were poor predictors of employment growth before the GFC. Difficulty finding skilled and unskilled labour, and employment (forward- and backward-looking) performed best for one and two quarter-ahead forecasts in the pre-GFC period.

For the change in the unemployment rate, the indicators were not able to provide a statistically significant reduction in MSPE compared to the autoregressive model. The only exception was for one year ahead, where both domestic trading activity measures offered reductions that were significant, but only at the ten percent significance level.

In the baseline results for CPI inflation, the only significant reduction in MSPE came from profitability (next three months), at the two quarter forecast horizon. This changes using the pre-GFC sample. Costs, prices, and profitability (forward- and backward-looking) offer large and statistically significant reductions in MSPE for one quarter ahead forecasts of CPI inflation.

Finally turning to predicting real-time GDP growth, we find the qualitative results are similar. That is, in our pre- and post-GFC samples, profitability and domestic trading activity (forward- and backward-looking) off the largest and most significant reductions in MSPE.

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