

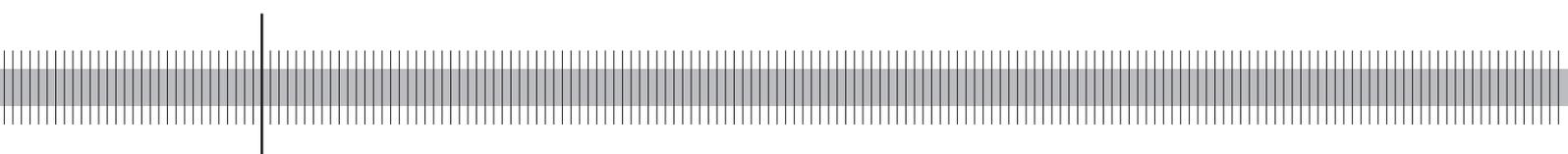
Forecasting national activity using lots of international predictors: an application to New Zealand

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Forecasting National Activity Using Lots of International Predictors: an Application to New Zealand*

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24 April 2009

Abstract:

We look at how large international datasets can improve forecasts of national activity. We use the case of New Zealand, an archetypal small open economy. We apply “data-rich” factor and shrinkage methods to tackle the problem of efficiently handling hundreds of predictor data series from many countries. The methods covered are principal components, targeted predictors, weighted principal components, partial least squares, elastic net and ridge regression. Using these methods, we assess the marginal predictive content of international data for New Zealand GDP growth. We find that exploiting a large number of international predictors can improve forecasts of our target variable, compared to more traditional models based on small datasets. This is in spite of New Zealand survey data capturing a substantial proportion of the predictive information in the international data. The largest forecasting accuracy gains from including international predictors are at longer forecast horizons. The forecasting performance achievable with the data-rich methods differs widely, with shrinkage methods and partial least squares performing best. We also assess the type of international data that contains the most predictive information for New Zealand growth over our sample.

Key words: Forecasting, factor models, shrinkage methods, principal components, targeted predictors, weighted principal components, partial least squares, ridge regression, elastic net, international business cycles

JEL classifications: C53, F47, C33

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Non-technical summary

We look at how large international datasets can improve forecasts of national activity. We use the case of New Zealand, an archetypal small open economy. We apply “data-rich” factor and shrinkage methods to tackle the problem of efficiently handling hundreds of predictor data series from many countries. The methods covered are principal components, targeted predictors, weighted principal components, partial least squares, elastic net and ridge regression. Factor methods summarise the information contained in large datasets into a few common factors which are then included in the forecasting equation. Shrinkage methods allow reduction of the variance of the coefficient estimates and, hence, direct regression of the target variable on the many regressors. Most of these methods have only been applied previously to US data, and not very often.

Using these methods, we assess the marginal predictive content of international data for New Zealand GDP growth. We find that exploiting a large number of international predictors can improve forecasts of our target variable, compared to more traditional models based on small datasets. This is in spite of New Zealand survey data capturing a substantial proportion of the predictive information in the international data. The largest forecasting accuracy gains from including international predictors are at longer forecast horizons.

The forecasting performance achievable with the data-rich methods differs widely. Shrinkage methods (ridge regression and elastic net) and partial least squares perform particularly well on our international dataset, whereas principal component-based methods perform poorly. One reason may be the rather weak factor structure and, more specifically, the low commonality of the international dataset. We suggest that this result would be relevant for other examples of forecasting using international datasets, since the international dataset we use here has comprehensive coverage of the economically major regions of the world. The factor structure of our national dataset, by contrast, is stronger, and principal components or variants of principal components work better as means of summarising the predictive content of this dataset. We suggest that the choice of technique in any particular application, and whether pre-selection or other weighting schemes should be used, should be guided by considerations of the strength of the factor structure, as illustrated in the paper.

Finally, we show how some of the data-rich techniques can fill a gap to some extent between structural econometric work and forecasting, by enabling assessment of the marginal predictive content of (economic and regional) subsets of international data, and calculation of historical contributions to GDP growth forecasts. This is important for policy makers, among others, who usually want to explain the forecasts in a consistent and accessible way as a basis for policy decisions.

Nicht-technische Zusammenfassung

Wir untersuchen am Beispiel Neuseelands, einer kleinen offenen Volkswirtschaft, inwiefern sich mit Hilfe umfangreicher internationaler Datensätze die Prognose der nationalen realwirtschaftlichen Aktivität verbessern lässt. Wir verwenden Methoden, die es erlauben, große Datenmengen zu berücksichtigen. Es handelt sich dabei um Faktormethoden (darunter Hauptkomponentenanalyse, gewichtete Varianten der Hauptkomponentenanalyse („targeted predictors“, „weighted principal components“) sowie „partial least squares“) und Shrinkagemethoden (darunter „elastic net“ und „ridge regression“ als ein Spezialfall von „elastic net“). Faktormethoden fassen die in großen Datensätzen enthaltene Information in wenigen Faktoren zusammen. Die Faktoren werden dann anstelle der vielen Zeitreihen in die Prognosegleichung einbezogen. Shrinkagemethoden reduzieren hingegen die Varianz der Koeffizientenschätzer und ermöglichen daher die direkte Regression der zu prognostizierenden Zielvariable auf die vielen Zeitreihen. Die Mehrheit dieser Methoden wurde zuvor nur selten und lediglich auf die Vereinigten Staaten angewandt.

Mit Hilfe dieser Methoden und auf Basis eines über 900 nationale und internationale Zeitreihen umfassenden Datensatzes untersuchen wir den marginalen Vorhersagegehalt internationaler Daten für den Zuwachs des neuseeländischen Bruttoinlandsprodukts. Wir finden, dass die Berücksichtigung einer Vielzahl internationaler Daten tatsächlich zu einer Verbesserung der Prognose unserer Zielvariable führen kann verglichen mit traditionelleren kleinen Modellen. Und dies, obwohl neuseeländische Umfragedaten, die ebenfalls in unserem nationalen Datensatz enthalten sind, bereits einen Teil der internationalen Entwicklungen abbilden. Die größten Prognosegewinne lassen sich für längere Prognosehorizonte erzielen.

Die Vorhersagequalität variiert jedoch stark über die Methoden. Angewandt auf unseren internationalen Datensatz schneiden Shrinkagemethoden und „partial least squares“ besonders gut ab, wohingegen Methoden, die auf Hauptkomponenten basieren, eher schlecht abschneiden. Dies könnte daran liegen, dass die Faktorstruktur in unserem internationalen Datensatz eher schwach ausgeprägt ist, was sich insbesondere in einem relativ niedrigen erklärten Anteil der gemeinsamen Faktoren an der Gesamtvarianz zeigt. Möglicherweise trifft das auch auf andere Anwendungen zu, welche mit Hilfe internationaler Datensätze nationale Prognosen erstellen. Die Faktorstruktur unseres nationalen Datensatzes ist hingegen stärker ausgeprägt, und folglich schneiden die Hauptkomponentenanalyse oder Varianten derselben besser ab.

Schließlich zeigen wir, wie trotz des Umfangs der Datensätze die Prognose auch ökonomisch interpretiert werden kann. Wir unterteilen unseren internationalen Datensatz und ökonomische und regionale Teildatensätze und untersuchen den marginalen Vorhersagegehalt dieser Teildatensätze. Des Weiteren schätzen wir die Beiträge dieser Teildatensätze zum Zuwachs des Bruttoinlandsprodukts über die Zeit ab. Eine solche Analyse ist für die Politik besonders wichtig, denn sie muss ihre Prognosen als Basis für ihre Entscheidungen verständlich und konsistent kommunizieren.

Contents

1.	Introduction	1
2.	Related literature	3
3.	Methodology	4
3.1.	Forecasting setup	4
3.2.	Data-rich methods	5
3.2.1.	Shrinkage methods	5
3.2.2.	Factor methods	7
3.3.	Trade-weighting approaches to summarising international data	10
3.4.	Strength and weaknesses of the various approaches	10
4.	Data	12
4.1.	Characteristics of the dataset	13
5.	Forecasting results	15
5.1.	Forecasts using New Zealand data only	16
5.2.	Forecasts using international data only	16
5.3.	Forecasts using New Zealand and all international data	17
5.4.	Best forecasting models and summary of forecasting results	17
6.	The relevance of different classes of international data over the sample	18
6.1.	Impact of international subsets on forecasting accuracy	18
6.2.	Historical contributions to New Zealand GDP growth forecasts	19
6.3.	Do national surveys reflect international information?	21
7.	Conclusions	22
	References	24

Tables and Figures

Table 1:	International dataset – number of series in each class	27
Table 2:	Overview of specifications	27
Table 3:	Correlation between estimated factors and 1-quarter ahead New Zealand GDP growth	27
Table 4:	Relative RMSEs	28
Table 5:	Best five models by RMSE	29
Table A.1.:	International dataset	35
Table A.2.:	Forecast results for subsets of international data	40
Figure 1:	Characteristics of the New Zealand, international-only, and combined datasets	30
Figure 2:	Forecast results – international-only, and combined New Zealand-international, versus New Zealand-only	31
Figure 3:	Forecast results – data-rich methods versus trade-weighting	31
Figure 4:	Forecast results – New Zealand data only versus international data (regional and economic subsets)	32
Figure 5:	Contributions to forecasts – $RR(v_2 = N)$, New Zealand and international data	33
Figure 6:	Contributions to forecasts – $RR(v_2 = N)$, New Zealand excluding survey data and international data	34

1. INTRODUCTION

Exploiting information from large datasets has been shown to improve forecasts. Certain “data-rich” methods such as principal components (PC) are now widely used in economic forecasting and analysis by academics and practitioners. In this paper, we explore PC and other lesser-known data-rich methods using the case of New Zealand GDP growth forecasting. We focus in particular on whether data-rich methods are a useful way of handling effectively for forecasting purposes the large quantity (hundreds of series) and diversity (many countries and types) of available international data.

We use New Zealand as an example because it is an archetypal case of a small, open economy. New Zealand has many trading partners across the world, suggesting *a priori* that large international datasets and data-rich methods would be useful. Structural vector-autoregressive (SVAR) analyses of New Zealand macroeconomic fluctuations such as Buckle *et al.* (2007) and Dungey and Fry (2007) find that internationally sourced shocks contribute substantially to New Zealand GDP fluctuations. New Zealand’s economic profile suggests many channels for international influences on the national economy. Exports account for around 30 percent of New Zealand GDP, with a large proportion of these accounted for by agricultural commodity products. New Zealand is thus (along with Australia and Canada) often viewed as a “commodity economy” (Chen and Rogoff 2003). New Zealand also has strong international links through financial markets, with a net foreign liability position of around 100 percent of GDP and a largely foreign-owned banking system dependent on offshore capital markets for a large proportion of its funding (Bedford 2008).

Most data-rich applications use datasets that include some international variables, but not very many, compared to the number available. Surprisingly few explicitly assess the marginal predictive content of international data. None systematically examines how best to exploit international data for forecasting the domestic economy¹, or what these methods can reveal about the predictive content of different types of international data for forecasting purposes.

We ask three main questions, as follows. (i) By how much can the use of international data improve forecasts of New Zealand GDP growth? (ii) Are data-rich techniques a feasible and useful means of handling the large quantity and diversity of available international data manageably, while retaining predictive power? (iii) How can data-rich methods shed light on the economic types of international data and regions of the world that have most predictive content for New Zealand growth forecasting?

¹ An exception is Schumacher (2009) as we will note below.

For the first question, we look at the potential improvement in forecasting accuracy when a large number of international data are added to a predictor dataset containing national (in this case, New Zealand) data only. We also look at the forecasting performance of models based on international data only.

For the second question, we compare different data-rich approaches to capturing the predictive information in our international dataset. As noted, certain data-rich approaches have been shown to be useful in the context of essentially single-country datasets, but the dimensionality of the problem is an order of magnitude greater in the case of international datasets. The dataset we use here contains several hundred macroeconomic time series from 12 major trading partner economies of New Zealand, which together account for about three quarters of New Zealand's total trade in goods (exports and imports). These economies represent the three major world economic regions – North America and Europe (which each account for about 15 percent of goods trade) and Asia-Pacific (about half).²

Data-rich methods deal with large dimension datasets by shrinking the variance of parameters in estimated equations, by summarising the information contained in many data into a few common factors, or both. These approaches make forecasting using many predictors feasible. In addition to the familiar PC, we look at other data-rich methods that address some of the known limitations of PC when applied to forecasting in practice. Variants of PC are targeted predictors (TP) and weighted principal components (WPC). We also look at partial least squares (PLS), elastic net (EN) and ridge regression (RR; a special case of EN).

We compare forecasting accuracy using these data-rich approaches to the international data with that using trade-weighted aggregates. Trade-weighting is a much simpler approach to summarising international data often used by practitioners due to its simplicity and intuitive appeal. Obvious advantages of the data-rich methods, though, are that they can easily cope with a much greater number and diversity of data; they are agnostic about which series among a large number have the greatest predictive content; they can (implicitly) capture international transmission channels beyond direct trade linkages, such as indirect trade, financial markets, commodity prices, and confidence; and they (generally) derive weights from an explicit statistical optimisation problem, which is not usually the case for trade-weights.

For the third question, we construct broad subsets of the international dataset across two alternative dimensions – macroeconomic type, and region of origin. The economic types are

² North America is represented by the US and Canada, Europe by the euro area (measured as a single economy) and the UK, and Asia-Pacific by Australia, Japan, China, Singapore, Korea, Malaysia, Taiwan and Hong Kong.

real activity, prices, monetary and financial and commodity price data. The regions are North America, Europe, Asia and Australia. We then assess the marginal predictive content of these subsets and their historical contributions to forecasts over our sample. The subset exercise provides a sense of the explanatory power of the different types of international data and different regions for the variance in New Zealand GDP growth over the sample. This exercise also addresses to some degree the criticism, sometimes levelled at large forecasting models with little imposed economic structure, that they are “black boxes” (Forni *et al.* 2008) and that their output is difficult to interpret and communicate.

The rest of the paper is organised as follows. In section 2 we review related literature. In section 3 we outline our approach to assessing relative forecasting accuracy, and introduce and discuss the data-rich methods. In section 4 we describe the data. In section 5 we present our results on forecasting accuracy. In section 6 we look at how the partitioning exercise and data-rich techniques can illuminate the drivers of the forecasts. We conclude in section 7.

2. RELATED LITERATURE

In a number of seminal papers, Stock and Watson (2002a, 2002b, 2004) show the benefits of factor-model approaches for economic forecasting. Eickmeier and Ziegler (2008)’s recent meta-analysis overviews 52 studies (including one, Matheson (2006), for New Zealand) that predict output growth and inflation using factor models and compare the factor-based forecasts with forecasts based on alternative methods. Most of the studies are based on PC estimates of the factors. They find that, in general, factor models outperformed small-scale models (though gains were sometimes small or not robust across specifications), but that other data-rich methods tend to outperform factor models.

These other methods are much less widely applied. Most of them use US data. Boivin and Ng (2006) and Bai and Ng (2008) apply WPC and TP, respectively. TP is applied by Schumacher (2009) to German data. De Mol *et al.* (2008) produce their forecasts based on RR and LASSO, another special case of EN. Groen and Kapetanios (2008) and Lin and Tsay (2006) apply RR as well as PLS.

Although most papers using data-rich methods include a small set of foreign variables, very few explicitly investigate the information content of foreign data. Banerjee *et al.* (2006) investigate the importance of euro-area data for central and east European countries (CEECs). Gosselin and Tkacz (2001), Cheung and Demers (2007) and Brisson *et al.* (2003) assess the predictive content of US variables for Canadian real economic activity and inflation. Brisson

et al. (2003) include other countries' data as well as US data. Finally, Schumacher (2009) uses G7-country data for German GDP forecasts.

All these studies compare forecasts based on factors extracted from national datasets with those based on factors estimated either from datasets containing both national and foreign variables, or containing foreign variables only. Banerjee *et al.* (2006), in addition, use in their forecasting equation distinct national and international factors, i.e. factors estimated separately from national and international datasets, as well as factors estimated from the entire dataset. The forecasting accuracy results are qualitatively similar. The Banerjee *et al.* (2006) study finds that euro-area information is of limited value in forecasting the CEECs, and attribute this result to the phase of low correlation between the CEECs and the euro area during convergence. In the studies for Canada, US variables generally appear to contain information beyond that in Canadian data. Brisson *et al.* (2003) find that data from countries outside North America provide useful information for forecasting Canadian inflation, but not Canadian GDP growth. Schumacher (2009) finds that international data is useful only when TP, but not simple PC, is applied to a joint national and international dataset.

There have been few data-rich approaches taken to New Zealand data in a forecasting context. Matheson (2006) estimates factors from a dataset of almost 400 variables to predict GDP and other variables. Most variables in this dataset are domestic variables, but there are a handful of international variables as well, including trade-weighted foreign aggregates. Bloor and Matheson (2008) use a large Bayesian VAR featuring almost one hundred variables to forecast GDP and other variables, finding its forecasting accuracy to be quite favourable for GDP and some other variables, compared to smaller models such as small- or medium-sized VARs. The large Bayesian VAR includes similar international variables to Matheson (2006). However, the predictive content of the international variables for domestic forecasting is systematically examined in neither of these studies.

3. METHODOLOGY

3.1 Forecasting setup

Our benchmark forecasting model for our target variable $y_{t+h,t}$ is the univariate model:

$$y_{t+h,t} = \mathbf{a}'\mathbf{W}_t + \mathbf{e}_{t+h,t}, \quad (1)$$

where $y_{t+h,t} = y_{t+h} - y_t$, the log difference of New Zealand GDP between period $t+h$ and t and \mathbf{W}_t is 1 or $\begin{bmatrix} 1 & y_{t,t-1} & \cdots & y_{t-p,t-p-1} \end{bmatrix}'$ with $y_{t,t-1} = y_t - y_{t-1}$, and \mathbf{a} is the scalar or the $(p+1) \times 1$ vector of associated parameter(s).

Our target variable may also be influenced by other variables, summarised in the $N \times 1$ vector X_t . Introducing X_t in equation (1) yields

$$y_{t+h,t} = \mathbf{a}'W_t + \Gamma'X_t + e_{t+h,t}, \quad (2)$$

where $\Gamma = [\Gamma_1 \ \dots \ \Gamma_N]'$ has dimension $N \times 1$. If N is large, the forecast is not efficient because the sampling variability increases with N . If $N > T$, forecasting with standard least squares (LS) methods is not even feasible. To deal with large N , data-rich techniques either shrink the Γ parameters to or towards zero, or summarise X_t in a few common factors, or both.

We consider forecasts based on X_t where X_t contains only national data, only international data, and both national and international data. To keep the number of results manageable, we do not estimate separate “national” and “international” factors from the respective datasets for inclusion in equation (2).

Our forecasting setup is as follows. We produce direct, recursive out-of-sample forecasts for horizons 1, 2, 4 and 8 quarters. We compute root mean squared errors (RMSE) between $y_{t+h,t}$ and its forecast $\hat{y}_{t+h,t} = \hat{\mathbf{a}}'W_t + \hat{\Gamma}'X_t$, where ‘^’ indicates here and in what follows estimates, and compare them across models. To make RMSEs comparable across horizons, we divide them by \sqrt{h} . In the case where W_t contains current and lagged GDP growth, we consider up to 4 lags, i.e. $p = 0, \dots, 3$. For each horizon and each p , we compute the corresponding RMSE over the forecast evaluation period and choose the lag length which yields the minimal RMSE for each horizon.³ We start the forecast evaluation period in 2000Q1.

3.2 Data-rich methods

As noted, data-rich methods either directly regress the target variable on the predictors where the parameters are shrunk towards or to zero (subsection 3.2.1), or summarise the information in a few common factors and regress the target variable on those factors (subsection 3.2.2). When presenting the data-rich methods here, we drop W_t for clarity, but account for it at each recursion by exploiting the Frisch-Waugh-Lovell theorem.

3.2.1 Shrinkage methods

The EN and the RR directly regress the target variable on the predictors.

³ Of course, this does not correspond to a real-time forecast situation. In real time, one would need to choose the lag length optimally for each recursion (which is usually done applying information criteria). This would, however, greatly lengthen the computation time, and is not the focus of our analysis. We adopt instead a performance-based approach where we pick the lag length that minimises the RMSE over the whole sample period. For a thorough discussion on performance-based criteria versus information criteria see Schumacher (2007).

Ridge regression

The ridge estimator solves the penalised regression problem

$$\min_{\Gamma} \mathbf{RSS} + \nu \sum_{i=1}^N \Gamma_i^2 \quad (3)$$

and is given by

$$\hat{\Gamma}_h^{RR} = (\mathbf{X}'\mathbf{X} + \nu \mathbf{I}_N)^{-1} \mathbf{X}'\mathbf{y}^h, \quad (4)$$

where $\mathbf{X} = [\mathbf{X}_1 \ \cdots \ \mathbf{X}_{T-h}]'$, $\mathbf{y}^h = [\mathbf{y}_{h+1,1} \ \cdots \ \mathbf{y}_{T,T-h}]'$, Γ_i is an element of Γ , and ν is the scalar ridge or shrinkage parameter.⁴ The RR estimator penalises large parameter estimates and shrinks the LS estimator towards (but not to) zero, thus reducing the variance of the estimates. With RR, all variables enter the forecasting equation. We produce forecasts for $\nu = 0.25$, N , $5N$ and $10N$, following Groen and Kapetanios (2008). $\nu = 0.25$ imposes much less shrinkage, but is consistent with the parameterisation for EN chosen below and by previous work.

Elastic net

EN is more general than RR and performs shrinkage and variable selection at the same time – i.e. unlike with RR, some parameters may be shrunk to zero (Zou and Hastie 2005).⁵ It solves

$$\min_{\Gamma} \mathbf{RSS} + \nu_1 \sum_{i=1}^N |\Gamma_i| + \nu_2 \sum_{i=1}^N \Gamma_i^2. \quad (5)$$

The EN estimator can be found iteratively with least angle regression (LARS), which efficiently solves the optimization problem (5). For details, see Efron *et al.* (2004). Following Bai and Ng (2008), we set ν_2 to 0.25. As in their application, our results do not change much when we set ν_2 to 0.5 or even to 1.⁶ Choosing ν_1 is equivalent to choosing the

⁴ The ridge regression can be interpreted as a Bayesian regression with a Gaussian prior – see De Mol *et al.* (2008).

⁵ EN combines the shrinkage achieved by RR, and the variable selection achieved by LASSO, a method we do not use here. In contrast to EN, the optimization problem in LASSO considers only the first penalisation term of equation (5). While LASSO “tends to select only one variable from the group and does not care which one is selected” (Zou and Hastie 2005), the EN has the advantage that, under certain parameter constellations, it can select groups of (similar) variables. This is the case if $\nu_2 / (\nu_1 + \nu_2) > 0$, i.e. if the EN penalty is a strict convex combination of the LASSO and the RR penalty terms. We have made sure that this is indeed the case for our choices of ν_2 and of the number of variables we keep in our datasets. EN should also select similar variables at each point in time, unlike LASSO. This makes results easier to interpret than with LASSO, and is the main reason why we use the EN here and not LASSO.

⁶ A small value for ν_2 reflects the idea that with EN, the focus lies on variable selection (and LASSO shrinkage). We also set ν_2 to N or values larger than N , as for the RR case. In this case, the ridge penalty term in equation (5) obtains a very large weight relative to the first (LASSO) penalty term. No noticeable

number of variables with non-zero coefficients which we set to 30, 100 and 200 for our forecasts.

3.2.2 Factor methods

Approximate factor models (Chamberlain and Rothschild 1983, Stock and Watson 2002a, Forni *et al.* 2000, Bai and Ng 2002, Bai 2003) assume that the (typically large number of) variables in the $N \times 1$ vector $X_t = [x_{1t} \ \cdots \ x_{Nt}]'$ can be described as

$$X_t = \Lambda F_t + \Xi_t. \quad (6)$$

$\Lambda = [\lambda_1' \ \cdots \ \lambda_N']'$ is the $N \times r$ matrix of factor loadings and Ξ_t is the $N \times 1$ vector of idiosyncratic components which can be weakly mutually and serially correlated in the sense of Bai and Ng (2002). F_t is the $r \times 1$ vector of common factors, and r , the number of common factors, is typically small.

In all the factor methods, the factors are used to replace the original predictor variables in the forecasting equation.

Principal components estimation

Estimation of F_t and Λ with PC involves solving the following optimization problem

$$\min_{\Lambda, F} \frac{1}{NT} \sum_{i=1}^N \sum_{t=1}^T (x_{it} - \lambda_i' F_t)^2 \quad (7)$$

subject to $\sum_{t=1}^T F_t F_t' / T = I_r$ and $\Lambda' \Lambda$ being diagonal. This is equivalent to searching for the linear combinations of the data that maximise the share of the total variance explained for each number of combinations up to N . A solution to this problem can be found by an eigenvalue-eigenvector decomposition of $\sum_{t=1}^T X_t' X_t / T$. PC estimates for Λ and F_t are given by

$$\hat{\Lambda} = \hat{V}, \quad (8)$$

and

$$\hat{F}_t^{PC} = \hat{V}' X_t, \quad (9)$$

where \hat{V} is the $N \times r$ matrix of eigenvectors corresponding to the r largest eigenvalues of $\sum_{t=1}^T X_t' X_t / T$. We introduce \hat{F}_t^{PC} in equation (1) and estimate the LS regression

$$y_{t+h,t} = b' \hat{F}_t^{PC} + e_{t+h,t}. \quad (10)$$

forecast improvements can be obtained compared to the RR case with larger shrinkage parameters, and, hence, we do not present results for EN with large values of \mathbf{V}_2 here.

Our factor-model-based forecasts use a fixed $r = 1, 2, 3$ and 5 . $r = 5$ is suggested by the Bai and Ng (2002) information criterion IC_{p1} for all three (New Zealand, international and combined New Zealand and international) datasets when applied to the whole sample period. In addition, we consider smaller numbers of (up to 3) factors, because previous studies have found that forecasts based on very few factors – often only a single factor – tend to yield better results than less sparsely parameterised factor models.

Weighted principal components

Factor forecasting based on PC factors is not always successful in practice. For instance, the PC estimator does not perform well when idiosyncratic components are highly cross-correlated and explain a large part of the variation in the data. To handle this problem, we use Rule 1c suggested by Boivin and Ng (2006) (WPCBN). This involves removing variables from the set that, if included in the PC estimate, would be characterised by highly cross-correlated idiosyncratic components and a low commonality, i.e. the variance explained by the common factors relative to the total variance. With this rule applied here, weights are either zero or one, i.e. variables are either in or out.

In the rule's first step, we estimate by common and idiosyncratic components by PC, using alternately $r = 1, 2, 3$ and 5 . In the second step, we look at each series $i = 1, \dots, N$ in turn and drop the series j from the rest of the dataset whose idiosyncratic component is most correlated with the idiosyncratic component of series i . If the idiosyncratic components of series i and j are most correlated with each other, the series with the lower commonality is selected for dropping. The PCs are then re-estimated from the reduced dataset and included in the forecasting equation.

As we show below, with our dataset WPCBN reduces the amount of cross-correlation in the idiosyncratic components, but does not succeed in increasing commonality. We therefore consider an additional rule (rule SWa as described in Boivin and Ng 2006, WPCSW) that lowers the weight on variables with large idiosyncratic components, as follows. We first estimate with PC the common and idiosyncratic components of X_t , again alternately using $r = 1, 2, 3$ and 5 . We then multiply each series by the inverse of its idiosyncratic component's standard deviation, and re-estimate the PCs from the weighted series.

Targeted predictors

Another problem of simple or weighted PC for forecasting is that they find the linear combinations of variables that maximise the variance of the total dataset, without directly relating the factors to the target variable. Hence, they do not necessarily improve forecasts of the target variable. TP, by contrast, takes into account the relation between the target variable

and the predictors. In TP, PCs are estimated from a reduced set of variables that contains only variables closely related to the target variable. These PCs are then used in the forecasting equation. TP thus combines variable selection and PC. Following Bai and Ng (2008), we select the variables in two ways.

Hard thresholding (TPH) uses a statistical criterion to decide which variables to exclude from the active set. The target variable is regressed on each predictor individually, and only predictors with an absolute t -statistic exceeding a specified threshold are retained in the set.⁷ We set a threshold of 1.65, the critical value of the two-sided 5% significance level. One weakness of TPH is that it does not take into account the other predictors when deciding whether a variable is included or not. Consequently, TPH may end up selecting “too similar” variables, and we know that pooling over variables is effective only if they have mutually distinct information content.

With soft-thresholding (TPS), other predictors are taken into account. We select 30, 100 and 200 variables for PC factor estimates by solving the EN problem with LARS. Our choice of a minimum of 30 is based on work by Boivin and Ng (2006) who show in simulations that factors can be estimated precisely from datasets containing 30 variables or more, and Bai and Ng (2008) also base their analysis on 30 variables. The parameter ν_2 is set to 0.25, consistent with our parameterisation for EN.

Partial least squares

PLS (Wold, 1982) factors are linear combinations of the predictors with weights derived from the covariance of the predictors with the target variable, while being mutually orthogonal.⁸ We use the following algorithm to estimate the PLS factors⁹:

- i. Set $\mathbf{u}_t = \mathbf{y}_{t+h,t}$ and $\mathbf{v}_i = \mathbf{x}_i$, $i = 1, \dots, N$. Set $j = 1$.
- ii. Determine the $N \times 1$ vector of indicator variable weights or loadings $\boldsymbol{\omega}_j = [\boldsymbol{\omega}_{1j} \ \dots \ \boldsymbol{\omega}_{Nj}]'$ by computing individual covariances: $\boldsymbol{\omega}_{ij} = \text{Cov}(\mathbf{u}_t, \mathbf{v}_i)$, $i = 1, \dots, N$. Construct the j th PLS factor by taking the linear combination given by $\boldsymbol{\omega}_j' \mathbf{v}_i$ and denote this factor by $\hat{\mathbf{f}}_{jt}^{PLS}$.
- iii. Regress \mathbf{u}_t and \mathbf{v}_i , $i = 1, \dots, N$ on $\hat{\mathbf{f}}_{jt}^{PLS}$. Denote the residuals of these regressions by $\tilde{\mathbf{u}}_t$ and $\tilde{\mathbf{v}}_i$, respectively.

⁷ When we analyse the subsets of the international data, in a few cases, t -statistics associated with fewer than r variables exceed the critical values, and we cannot estimate r principal components. In these cases, we include the r variables with the largest t -statistics in the active set.

⁸ PLS has become prominent in natural sciences such as chemical engineering and chemometrics.

⁹ A good overview is given in Groen and Kapetanios (2008), and we follow the authors closely.

- iv. If $j = k$, where k is the number of PLS factors, stop, else set $u_t = \tilde{u}_t$ and $v_{it} = \tilde{v}_{it}$, $i = 1, \dots, N$ and $j = j + 1$ and go to step ii.

$\hat{F}_t^{PLS,h} = [\hat{f}_{1t}^{PLS} \quad \dots \quad \hat{f}_{kt}^{PLS}]'$ is the $k \times 1$ matrix of estimated common PLS factors for horizon h , that are included in the forecasting equation (1). We set k to 1, 2, 3 and 5.

3.3 Trade-weighting approaches to summarising international data

We also look at trade-weighted aggregates of foreign variables as an approach to capturing international data for forecasting purposes. Trade-weighting is often used by practitioners, and, interestingly, also in applications of Pesaran *et al.*'s (2004) Global VAR approach to handling large datasets for modelling international business cycles. In these applications, foreign factors are constructed as trade-weighted aggregates of observable variables before inclusion in a VAR (e.g. Déés *et al.* 2007).

We use two variants of trade-weighted aggregates. In both, we use total merchandise trade (the sum of export and import value) weights for constructing foreign GDP, CPI and interest rate variables, following the Global VAR application. Foreign GDP and CPI are calculated using trade weights on all 12 major trading partners. Foreign long- and short-term interest rates use trade weights for Australia, US, UK, Japan and the euro area (a subset of the 12 trading partners due to data availability). In the first variant, the trade weights are fixed at the average over the entire sample. In the second variant the weights are two-year moving averages.

Table 2 gives an overview of the forecast methods applied here.

3.4 Strengths and weaknesses of the various approaches

It is not clear *a priori* which of the approaches adopted in this paper to handling large amounts of data will lead to the best forecasting results. Each method has its strengths and weaknesses, and the success of each method will depend on the particular forecasting problem at hand, and on the particular characteristics of the data.

Trade-weighting versus data-rich approaches

The data-rich approaches to handling the international data have several advantages over the trade-weighted (and other simple weighted-average) aggregation methods. An obvious advantage is that data-rich methods can easily cope with a much greater number and diversity of data compared to the trade-weighting approach. In our international dataset, for example, we include alongside GDP many other real economic variables, such as productivity, capacity

utilization, consumption, investment and industrial production. These series may have greater predictive content for New Zealand activity than foreign GDP. The data-rich methods allow for this possibility, while being agnostic about which series among a large number have the greatest predictive content.

A second advantage is that data-rich methods can (implicitly) capture international transmission channels beyond direct trade linkages, such as indirect trade, financial markets, commodity prices and confidence. Those linkages are more difficult to measure directly: data are either not available, or they are very volatile (in the case of financial data), or it is not obvious how to translate them into weights.

Third, the data-rich methods (generally) derive weights from an explicit statistical optimisation problem, which is not usually the case for trade-weights.

However, trade-weighted aggregates also have their appeal. They are often preferred by practitioners, since they provide an intuitive summary of foreign data and may thus make communication with the users of forecasts easier (Robertson 2000, Drew and Frith 1998). In contrast to the data-rich methods (as applied here), trade-weighting can accommodate changing weights, whereas PC and variants of PC as well as PLS, RR and EN approaches are based on constant factor loadings and/or weights.¹⁰ This may be important given changes in trade and financial market integration patterns across time.

Relative strengths of data-rich methods

Among the data-rich methods, a disadvantage of PC and WPC compared to other methods is that PC and WPC do not take into account the relationship between the predictors and the target variable. This may be one reason why PC, despite of its ability to use lots of data, does not systematically outperform small-scale models and why other data-rich methods that take the predictors' relationship with the target variable into account tend to outperform factor models (Boivin and Ng 2006, Eickmeier and Ziegler 2008).

Whether pre-selection of the data (EN, TP and WPCBN) or not (PC, WPCSW, PLS and RR) improves performance depends on whether some coefficients are actually exactly zero, i.e. whether some predictors are in fact irrelevant. If this is the case, including all variables in the forecasting model increases sampling uncertainty, but will not improve forecasts, and forecasters may be better off setting these coefficients to zero. Key, of course, is knowing or inferring which coefficients are, or are not, exactly zero.

¹⁰ Del Negro and Otrok (2008) suggest a factor model with time-varying loadings which is, however, computationally more demanding than the non-parametric constant parameter factor approaches.

Finally, if the conditions that guarantee consistent estimation of the factor space in approximate factor models are not satisfied, PC-based methods may tend to perform poorly compared to methods whose success does not depend on the factor structure in the data, such as RR and EN. Consistent estimation with PC requires the factor loadings to remain non-trivial as the number of time series becomes large (so called “strong” factors)¹¹ and weak serial and cross-correlation of the idiosyncratic components (e.g. Boivin and Ng 2006). In addition, Boivin and Ng (2006) have shown that PC factor estimates become worse as the cross-sectional dispersion of commonality increases. Groen and Kapetanios (2008) have demonstrated in Monte Carlo simulations that PC is outperformed by PLS and RR if factors are “weak”. These issues may be particularly relevant for our international dataset, which may contain regional as well as global cycles. This would lead to highly correlated idiosyncratic components and small factor loadings if some countries’ variables have substantial correlation with variables from only a subset of other countries.¹²

4. DATA

We use quarterly data from 1990Q1 to 2007Q4. Our target variable is New Zealand GDP growth. Both the New Zealand and the international datasets are large. Most of our 446 New Zealand series are taken from Matheson (2006).¹³ Our international dataset contains 434 series from the US, Canada, euro area, UK, Australia, China, Singapore, Hong Kong, Malaysia, Taiwan, Korea and Japan. The breakdown of our international dataset is shown in Table 1. The set comprises roughly 100 North American, 100 European, 200 Asian, and 42 Australian series. There are 206 real activity, 108 price and 130 monetary and financial series. The real block includes national accounts data, industrial production, productivity and labor market variables, new orders, retail trade, and survey-based expectations about real economic activity. The price block contains consumer prices, producer prices, the GDP deflator and deflators of the main GDP components, unit labor costs and house prices. The monetary and financial variables block includes interest rates, money and credit aggregates, exchange rates and stock prices. In addition, 38 commodity price series (in US dollar terms) are included in the dataset. In building the dataset, we attempted to roughly balance the numbers of series from each region and across the economic types, subject of course to availability.

¹¹ Formally, Onatski (2007) defines “weak factors” as factors that have bounded, instead of increasing with N , cumulative effects on the cross-sectional units.

¹² See Kose *et al.* (2008) for evidence of global divergence and regional convergence.

¹³ For details on the national dataset see Matheson (2006).

All data are seasonally adjusted and made stationary by differencing where necessary. Following Stock and Watson (2005), we remove outliers.¹⁴ We standardise the predictors to have zero mean and unit variance at each recursion. This is needed for the factor methods, so we apply it for the other data-rich methods also for comparability. A detailed overview of the international data and their treatment is given in Table A.1.

4.1. Characteristics of the dataset

Here we summarise the statistical characteristics of our dataset, to illuminate some of the issues relating to the factor structure as discussed above.

First, we compute correlations between the target variable $y_{t+1,t}$ and each predictor x_{it} contained in our New Zealand and international datasets. We show in Figure 1, panel (a) box plots of absolute correlations for the full New Zealand, international and combined (New Zealand and international) datasets as well as for datasets that were reduced by either hard- or soft-thresholding.

New Zealand variables tend to be more highly correlated with $y_{t+1,t}$ than international variables. The figure also illustrates the effect of pre-selection based on both hard- and soft-thresholding: the share of variables that are highly correlated with the target variable rises in most cases. Hard thresholding and soft thresholding with 30 variables kept in the active set are most successful in increasing the correlation between the predictors and the target variable, whereas, somewhat surprisingly, the correlation does not change much with soft thresholding with 100 or 200 variables. The dispersion of individual variables' correlations with $y_{t+1,t}$ is smallest with hard-thresholding, which probably reflects that it tends to select rather similar variables.

We next fit factor models to the New Zealand, the international and the combined datasets and look at the first five factors. In Table 3, we report the correlations between the factors extracted from X_t and the target variable $y_{t+1,t}$. Three observations are worth highlighting.

First, the first PC is meaningfully correlated with $y_{t+1,t}$ when extracted from the national and the combined datasets, with correlation coefficients of 0.5 in each case, whereas the correlation coefficient is lower, at 0.3, when the factors are estimated from the international data only.

¹⁴ In this approach outliers are defined as observations of the stationary data with absolute deviations from the median larger than 6 times the interquartile range, replacing them with the median value of the preceding 5 observations.

Second, the correlation does not decline monotonically as the rank of the PC drops. For example, the third PC of the international dataset is most highly correlated with $y_{t+1,t}$ (correlation coefficient: 0.32), followed by the first (0.28) and the fourth PCs (0.27). This is because the PC optimisation problem does not take into account the relationship between target and predictors.

Third, pre-selection unsurprisingly helps to extract factors that are more closely linked to the target variable. For all datasets, the correlations of the first PC with the target variable estimated with TPH exceed those estimated with simple PC, and correlations increase further when variable selection is made with TPS and 30 variables. As noted before, TPS with 100 or 200 variables is less successful in raising the correlation. Correlations based on TPS and 30 variables are comparable with, or even larger than, correlations between the first PLS factors and the target variable.¹⁵

We then decompose each variable into a common component and an idiosyncratic component based on PC with $r = 5$ and examine, along the lines of Boivin and Ng (2006), the extent to which the assumptions of the approximate factor model are satisfied for our datasets.¹⁶ We first examine whether cross-correlation between the idiosyncratic components could be a problem. We follow Boivin and Ng (2006) and estimate, for each variable, the correlation of its idiosyncratic component with the other variable's idiosyncratic components. Distributions of the maximum absolute correlations are shown in Figure 1, panel (b). We also show in Figure 1, panel (b) the sums over all absolute correlations. There are more variables with highly cross-correlated errors in the international and combined datasets than in the New Zealand dataset. Moreover, WPCBN clearly reduces the amount of cross-correlation in the errors.

We next assess the commonality. Average commonality ratios of our international data are at 32 percent (based on 3 factors) and 42 percent (based on 5 factors) and are, thus, comparable with those reported in other international business cycle papers (e.g. Eickmeier 2008, Marcellino *et al.* 2000). Figure 1, panel (c) shows box plots of commonalities of all individual variables. There are more variables with low commonality in the international dataset than in the New Zealand dataset. However, the dispersion of the commonality ratios is larger for the New Zealand than for the international dataset, and Boivin and Ng (2006)

¹⁵ At first sight, it seems surprising that the correlation between the target variable and PLS factors does not decline monotonically with lower-ranked factors. The reason is twofold. First, we look at correlations here, and not at covariances. The latter are used in the optimisation. Second, the PLS algorithm uses the covariance between the target variable and the predictors for the first PLS factor, but for subsequent factors it uses the covariance between the residual from regressing of the target variable on the previous PLS factor(s).

¹⁶ We also did this analysis for $r = 3$ and the results were very similar.

have shown that this worsens factor estimates. Interestingly, WPCBN does not increase the commonality when applied to our dataset. The reason may be the hierarchical way WPCBN proceeds: it considers only variables with highly cross-correlated errors for elimination. If the common component in eliminated variables is not smaller than the average, WPCBN will not improve the average commonality in the remaining series.

Overall, pre-selection appears to relieve most potential difficulties relating to weak factor structure in the dataset, except for the low and dispersed commonality of many variables in our dataset. We consider WPCSW as a means to deal with this latter potential problem.

5. FORECASTING RESULTS

In this section, we look at the predictive content of the international data. We first summarise in subsection 5.1 our forecasting results for New Zealand GDP growth based on data-rich methods exploiting only New Zealand data. This allows a broad comparison with Matheson's (2006) results, using a very similar dataset. We then present in subsection 5.2 our forecast results based on only international data, and then in subsection 5.3 a combined dataset with both New Zealand and international data. These results are shown in Table 4, in the form of RMSEs relative to univariate benchmark models for different horizons. Relative RMSEs below 1 indicate that the univariate benchmark model is outperformed.

In subsection 5.4 we document the models that yield the best outcome, and show with basic summary statistics how the data-rich methods perform compared to models incorporating trade-weighted aggregates of foreign data, as well as whether models using international data outperform models based on New Zealand data only. For this subsection, as well as using datasets including all international data, we also use our subsets of the international dataset, by region and economic type. We replace the international dataset in the data-rich methods with each of the subsets in turn (for the subsets by type we include the relevant trade-weighted aggregate only). Since the international subsets are much smaller than the full international dataset, we consider for EN and TPS only 30, not 100 or 200 variables. Results are reported in Table A.2. of the appendix.

Results obtained based on the subsets of international data are then, in section 6, also used to assess the marginal predictive content of each subset, and for our examination of the regions and types of international data that are most relevant for New Zealand activity forecasting over the sample period. Using subsets of variables amounts to judgemental preselection, and

we are interested in whether including or excluding particular classes of variables *a priori* is warranted or not on the basis of their impact on the forecasts.

5.1. Forecasts using New Zealand data only

Using New Zealand data only, we find that univariate models deliver forecasts that, in general, are difficult to beat. Their average absolute forecast errors (i.e. RMSEs) lie between 0.6 and 0.7 percentage points. No data-rich method outperforms the univariate model at horizon 8.

The quality of forecasts based on data-rich methods differs widely. Of the factor models, simple PC performs well for short horizons (1 and 2). Preselection only helps in some cases: TPH yields lower RMSEs than simple PC for the one-year horizon, while TPS with 100 or 200 selected variables beats the benchmark at shorter horizons. It is noticeable that in our setup (and unlike in the US setup of Bai and Ng, 2008), more than 30 variables are necessary for TPS to outperform simple PC, and even the univariate benchmark model. WPCSW is quite successful, and WPCSW with 3 and 5 factors yields the best model for the one-year horizon of all the data-rich methods with the New Zealand dataset. PLS also performs well at shorter horizons, and yields the best model at the six-month horizon, with a reduction of the RMSE by 21 percent.

Of the shrinkage methods, RR with larger shrinkage parameters ($\nu_2 = N, 5N$ and $10N$) beats the benchmark at horizons 1, 2 and 4 quarters. RR with $\nu_2 = 0.25$ tends to produce worse forecasts than benchmark. EN with 30 variables (and $\nu_2 = 0.25$) generally outperforms RR with $\nu = 0.25$, but relative RMSEs still exceed 1 in most cases. EN with a larger number of variables having non-zero coefficients is worse than benchmark at all except one horizon.

These results are roughly consistent with Matheson (2006), who found that PC on a mostly New Zealand dataset was more successful for forecasting New Zealand GDP at longer horizons. In that study, variable selection prior to PC estimation improved forecast accuracy at a few longer horizons, but for shorter horizons it was better to exploit all variables.

5.2. Forecasts using international data only

Table 4 also shows results with only international data used as predictors – both in trade-weighted aggregate form and with the data-rich methods. This is to test whether the trade-weighted aggregates are clearly outperformed by the data-rich methods, i.e. whether there is sufficient additional predictive power offered by the latter to outweigh the additional complexity of using a large number of international variables. Using only international data

also tests whether the data-rich methods on the international-only dataset do better in terms of predictive power relative to using New Zealand data only. Our prior was that a New Zealand-only dataset would outperform an international-only dataset, but this turned out not to be true for longer horizons.

The models with trade-weighted aggregates outperform the benchmark only at the one-quarter-ahead horizon. Models based on time-varying trade weights outperform models based on constant trade weights, but the gains are very small. However, the best data-rich methods – the shrinkage methods and PLS – tend to outperform both the benchmark and the models with trade-weighted aggregates. PLS and RR yield the best models for three of the four horizons.

Performance differs strongly across the data-rich methods. One reason for factor methods to perform less well compared to shrinkage methods (and PLS) may be that, as discussed in subsection 4.5., the commonality is rather low in the international dataset, at least compared to that in the national dataset. This would also be consistent with the finding by Groen and Kapetanios (2008) that when there is little factor structure in the data, PLS outperforms PC.¹⁷

5.3. Forecasts using New Zealand and all international data

Finally, Table 4 shows forecast results based on the combined dataset of New Zealand and international data. Augmenting the New Zealand dataset with international data generally improves the forecasting performance. The relative forecasting performance results across the data-rich methods are similar as for the international-only dataset, with shrinkage methods and PLS performing very well. For shorter horizons simple PC and TPH also work fairly well, and for horizons up to 4 quarters TPS with 200 variables now outperforms the benchmark.

5.4. Best forecasting models and summary of forecasting results

Table 5 reports the best five forecasting models for each horizon out of all models we have considered, including models based on subsets of the international dataset. Consistent with previous results, PLS performs very well: 9 out of the 20 best models were estimated with PLS. RR, EN and PC are also quite successful (3 out of the 20 best models were estimated with each of these methods), followed by WPCBN. Unsurprisingly, models using only New

¹⁷ Although EN was outperformed by RR and PLS on the international-only dataset, it was marginally better than benchmark. Looking at the variables that EN selected most frequently (not shown), the results were quite stable over recursions, and most make intuitive sense as containing leading information for New Zealand growth. World commodity prices and foreign business and consumer confidence measures are frequently selected.

Zealand data do not appear in the set of best models for any horizon. Indeed, 13 out of the 20 best models exploit only international, but no national data, and the remaining 7 best models exploit both New Zealand and international data. Interestingly, 18 out of the 20 best models exploit only subsets of international data (in some cases along with national data). The finding that forecast models using only international data, or subsets of the international data, can dominate in forecasting performance is rather surprising at first sight. One might have supposed that more data would be better, or at least no worse, in terms of forecasting accuracy – and that using New Zealand data only would capture the most relevant information for forecasting national activity. These results suggest that there is noise in the New Zealand data that can adversely affect forecasting performance.

Figure 2 compares models exploiting international data with models exploiting only New Zealand data, looking at the best models of each category, the average over the best five models and the average over all models for each horizon. The two upper bar graphs show that it can be worth exploiting international information. The gains are particularly large for long horizons, suggesting that spillovers from international events to the New Zealand economy take some time to materialise. In some cases, it is better to exploit international information only, in some cases international information along with national information. The lower graph shows that on average over all models, results are less clear-cut. Forecast errors differ widely over models, suggesting that careful model selection and specification is crucial for obtaining good forecast results.

It is clear from Figure 3 that forecasts based on data-rich methods outperform forecasts based on trade-weighted aggregates (based on models using international data only).

6. THE RELEVANCE OF DIFFERENT CLASSES OF INTERNATIONAL DATA OVER THE SAMPLE

6.1. Impact of international subsets on forecasting accuracy

Based on Figure 4, we can assess which class of international data yields the greatest improvement over forecasting models using New Zealand data only. Gains can be obtained by including North American, European, Asian, and Australian data (panel (a)). Gains from including Australian data are particularly large at the one-quarter horizon, probably reflecting strong direct linkages between New Zealand and Australia. The quite large improvement that can be achieved by including European data (relative to data from other regions) is surprising. Europe is a less important trading partner by pure value of trade with New

Zealand than Asia or Australia, and the conventional wisdom is that fast-moving international financial and confidence shocks typically emanate from the US rather than Europe. One interpretation would be that the New Zealand survey data proxy to some degree for international – particularly North American – information. This may reflect the dominance of the US in global financial markets and its perceived role as a locomotive for the world economy (e.g. Osborn *et al.* 2005, Déés and Vansteenkiste 2007, Déés and Saint-Guilhem 2009). We will test this explanation in subsection 6.3. Contributions from world commodity prices are generally smaller and positive only for horizon 8.

Turning to the split by economic type of data (panel (b)), gains can be achieved by including international real, price and monetary and financial data (except for horizon 2 where only real data seem to help reducing the forecast error). Gains are surprisingly large from including international price data (at horizons 1, 4 and 8) relative to real and monetary and financial data. Again, given the focus on financial markets in the press, information on financial developments might be captured by proxy (or with a better signal/noise ratio) in New Zealand survey data.

6.2. Historical contributions to New Zealand GDP growth forecasts

We use $RR(\mathbf{v}_2 = N)$, which performed very well in terms of forecasting accuracy, to look at the contributions of each subset of the international data to the forecasts, when all data are used.¹⁸ This allows us to interpret the series of forecasts in terms of the predictive content of the different classes of international data, and as a plausibility check on the forecasts. This is particularly important for policy making institutions, as the forecasts need to be communicated clearly and credibly, both to decision makers and to the public. We note that, by construction, RR yields biased estimates of the parameters. Although the forecasts can be decomposed into the contributing variable groups, the bias suggests caution in interpreting the absolute and relative magnitudes of the contributions. To check robustness with respect to the data-rich methods, we also computed historical forecast contributions for PC (which also yields biased parameter estimates). Results were similar to those based on RR (not shown, but available upon request).

We discuss in this section the contributions of each subset of the international data to the forecasts, and whether the contributions make sense in terms of the stylised facts of the period. In some cases, the contributions are hard to explain, prompting us to ask in subsection 6.3 whether New Zealand business survey data may be proxying for international information, and whether this may affect our results.

¹⁸ We are grateful to Troy Matheson for suggesting this exercise to us.

Figure 5 shows the 1-quarter ahead forecasts of New Zealand GDP growth (as deviations from the mean) and the contributions of national and international variables.¹⁹ Looking first at the results for the contribution of New Zealand versus international variables, the relative contribution of national variables (dark blue bars) is quite substantial over the early period from 2001 to 2004. This result seems quite plausible in light of the documentation in RBNZ (2007) that New Zealand recovered from the developed world recession of 2000-2001 quite early relative to other countries, for a range of reasons idiosyncratic to New Zealand. In particular, there was a large influx of migrants and returning New Zealanders over this period, partly reflecting terrorism and personal security fears leading expatriate New Zealanders to return home. At the same time, coincidentally, there was a large influx of foreign students of English language. These two factors combined to add strength to the local housing market upturn, which began one or two years earlier than in other countries. Later in the sample, around 2005-2006, the New Zealand economy began slowing, probably dominated by a cooling local housing market and very dry weather conditions adversely affecting farm output.²⁰

Looking at the contributions of the international variables by regional subset (panel (a)), we see that the international contribution to growth forecasts early in the sample (2000-2003) is dominated by Asia, offsetting to some degree the negative contributions of North America at this time. The US contribution becomes positive from mid-2003 to 2005. The contribution of Australia is surprisingly small, given its large trade weight. Interestingly (and consistent with the previous subsection), through the whole period, the contribution of fluctuations in the European data is quite substantial. World commodity price fluctuations are, on average, slightly less important than contributions from Australia, North America or Europe.

Looking at the international subsets by economic type (panel (b)) also produces interesting results. The pattern of real contributions is not surprising, and appears to coincide with the overall cycle in world activity. The prices pattern resembles the world business cycle and the cycle in oil prices on international markets. The financial variables' contributions are strongly positive through the entire sample – a striking result, lending credence to the view that there is generally a strong signal available in financial prices for forecasting purposes. Over the sample, the financial prices may be capturing predictive information relating to the

¹⁹ The optimal model contains 1 lag of the target variable. We take into account that lags of the target variable are explained by past predictors of the large dataset. Differences between the forecasts (black line in figures 5 and 7) and the sums of the contributions (bars in figures 5 and 7) are the sums of GDP growth in the first period and the contribution of the forecast equation's residuals.

²⁰ Weather is captured by the Southern Oscillation Index (SOI) in our dataset. The SOI Southern Oscillation Index (SOI) is derived from the air pressure difference between Tahiti and Darwin, Australia. Bloor and Matheson (2008) found that migration and climate shocks matter for New Zealand GDP.

worldwide “savings glut” that emerged after the recovery from the 2000-2001 world recession.

6.3 Do national surveys reflect international information?

The presence of business and consumer survey data in the New Zealand dataset bears more discussion, in light of the surprisingly large contributions of the European and price data relative to those of North American and Australian data. One possibility is that the respondents to the surveys pay attention to US and Australian, and real and monetary, developments in accordance with their true signal value for forecasting national activity, whereas they mistakenly downweight European developments and foreign price developments. The data-rich techniques thus pick up the signal in the latter developments directly from the data.

To look at this question a little more formally, we extract $r = 5$ PCs from the New Zealand survey data, the other New Zealand data, the international data combined, and the subsets of international data as defined above.²¹ We compute the trace R^2 statistics for the factors extracted from the survey data against those extracted from the other New Zealand data and those extracted from the international data. The trace R^2 is a multivariate correlation measure defined as the sum of the variances of projections of the variables in one set on the variables in another set, divided by the sum of the variances of the variables in the latter set (Stock and Watson, 1998). The trace R^2 lies between 0 and 1.

The New Zealand survey data indeed do seem to reflect international as much as national information. The trace R^2 statistic for the survey factors against the international factors is 0.47, a little higher than the 0.43 for the survey factors against the factors extracted from the other New Zealand data. New Zealand survey factors were most highly correlated with North American factors (0.48) followed by Asian (0.47), European (0.42) and Australian factors (0.36). Moreover, they seem to capture international monetary and financial information (0.49) more than foreign real economic activity (0.41) and prices (0.40). The survey factors’ correlation with world commodity price factors is very low (0.08). This result is a little surprising for a “commodity economy” such as New Zealand, but is robust when a smaller number of factors is considered and when leads and lags are introduced between the survey factors and the commodity price factors. Overall, this pattern of results supports our conjecture that the surveys effectively capture much of the relevant information in North American and monetary and financial data.

²¹ Results were very similar for 3 factors.

We also test more indirectly the extent to which survey data mask international influences on New Zealand activity by removing survey data from the New Zealand dataset and re-estimating the marginal predictive contents (not shown but available upon request) and the forecast contributions of subgroups of international data (shown in Figure 6). The results suggest that the survey data proxy for North American and Asian data, especially at longer horizons, because when the survey data are dropped, the marginal predictive content of North American and Asian data appears to increase relative to that of European and Australian data. The relative contributions to the forecasts also appear to shift somewhat in the direction of the real international data and away from the price data. International data in general have a more important predictive role after the removal of New Zealand business survey data from the datasets.

7. CONCLUSIONS

To recap, this paper's main contributions were to systematically assess the value of exploiting international information in producing national forecasts, specifically of New Zealand GDP growth. We looked at various data-rich approaches. Most of them have only been applied to US data, and not very often. We have found it useful to apply them in a wider range of applications and suggest that further work along these lines would be useful to improve understanding on whether these lesser-known techniques would be useful in more general practice. Finally, we showed how some of the data-rich techniques can fill a gap to some extent between structural econometric work and forecasting, by enabling assessment of the marginal predictive content of subsets of international data, and calculation of historical contributions to GDP growth forecasts. This is important for policy makers, among others, who usually want to explain the forecasts in a consistent and accessible way as a basis for policy decisions.

Our main findings were as follows. International information drawn from large international datasets can substantially improve forecasts of New Zealand GDP growth and outperform forecasts based on trade weighted aggregates of international variables. The gains are particularly large at long forecast horizons.

The forecasting performance of data-rich methods differs widely. Shrinkage methods (RR and EN) and PLS perform particularly well on our international dataset, whereas PC-based methods perform poorly. One reason may be the rather weak factor structure and, more specifically, the low commonality of the international dataset. We suggest that this result would be relevant for other examples of forecasting using international datasets, since the international dataset we use here has comprehensive coverage of the economically major

regions of the world. The factor structure of our national dataset, by contrast, is stronger, and PC or variants of PC work better as means of summarising the predictive content of this dataset. We suggest that the choice of technique in any particular application, and whether pre-selection or other weighting schemes should be used, should be guided by considerations of the strength of the factor structure, as illustrated here.

Historical decompositions based on the data-rich techniques seem to be consistent with the economic experience over the sample as documented by policymakers. A relevant caution here is that the decomposition approach taken here does not correspond to a structural decomposition with identified shocks. Related to this point, New Zealand business survey data seem to capture a substantial proportion of the signal in offshore developments for forecasting purposes, and are thus ascribed a high weight by the data-rich techniques. Only a fully identified approach (e.g. Bernanke *et al.* 2005) can resolve the causal influences on national activity in a more fundamental sense.

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Table 1: International dataset - number of series in each class

	North Amer.	Europe	Asia	Australia	World	Sum
Real	50	41	95	20	-	206
Prices	28	28	41	11	-	108
Monetary + financial	23	34	62	11	-	130
Commodity prices	-	-	-	-	38	38
Sum	101	103	198	42	38	482

Table 2: Overview of specifications

<i>trade1</i>	Trade-weighted averages	constant trade (export + imports) weights
<i>trade2</i>		2-year moving average trade (exports + imports) weights
<i>PC</i>	Principal components	$r = 1, 2, 3, 5$
<i>WPCBN</i>	Weighted PC	Rule 1c in Bai and Ng (2008), $r = 1, 2, 3, 5$
<i>WPCSW</i>		Rule SWa in Bai and Ng (2008), $r = 1, 2, 3, 5$
<i>TPH</i>	Targeted predictors	Hard thresholding, $r = 1, 2, 3, 5$
<i>TPS</i>		Soft thresholding, 30, 100, 200 variables, $v_2 = 0.25$, $r = 1, 2, 3, 5$
<i>PLS</i>	Partial least squares	$k = 1, 2, 3, 5$
<i>RR</i>	Ridge regression	$v = 0.25$, N, 5N, 10N
<i>EN</i>	Elastic net	30, 100, 200 variables, $v_2 = 0.25$

Table 3: Correlations between estimated factors and 1-quarter ahead New Zealand GDP growth

	New Zealand data				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
PC	0.53	0.04	0.15	0.02	0.06
TPH	0.54	0.05	0.14	0.16	0.22
TPS (30 variables)	0.73	0.31	0.14	0.19	0.22
TPS (100 variables)	0.54	0.03	0.52	0.01	0.06
TPS (200 variables)	0.53	0.04	0.31	0.02	0.28
PLS	0.59	0.60	0.25	0.29	0.28
	International data				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
PC	0.28	0.03	0.32	0.27	0.06
TPH	0.45	0.36	0.09	0.00	0.26
TPS (30 variables)	0.59	0.10	0.60	0.21	0.00
TPS (100 variables)	0.21	0.30	0.34	0.15	0.54
TPS (200 variables)	0.31	0.10	0.40	0.20	0.23
PLS	0.62	0.52	0.47	0.24	0.19
	New Zealand and international data				
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
PC	0.46	0.28	0.08	0.19	0.09
TPH	0.56	0.12	0.13	0.20	0.15
TPS (30 variables)	0.86	0.09	0.09	0.27	0.12
TPS (100 variables)	0.55	0.58	0.15	0.16	0.11
TPS (200 variables)	0.51	0.51	0.08	0.23	0.12
PLS	0.64	0.53	0.40	0.30	0.17

Notes: Abs. correlation between $y_{t+1,t}$ and factors estimated (in sample) from X_t or a reduced version of X_t .

Table 4: Relative RMSEs

Univar. benchm. (RMSE/h)	New Zealand				International				New Zealand + international			
	h = 1	h = 2	h = 4	h = 8	h = 1	h = 2	h = 4	h = 8	h = 1	h = 2	h = 4	h = 8
trade1	-	-	-	-	0.951	1.034	0.970	1.247	-	-	-	-
trade2	-	-	-	-	0.934	1.022	0.933	1.242	-	-	-	-
PC (r = 1)	0.951	0.865	0.985	1.113	1.033	1.090	1.060	0.948	0.984	1.247	1.657	2.500
PC (r = 2)	0.951	0.910	1.119	1.387	1.016	1.056	1.149	1.247	0.951	1.034	0.970	1.247
PC (r = 3)	0.902	0.899	1.127	1.381	1.082	1.034	1.134	1.361	0.934	1.022	0.933	1.242
PC (r = 5)	0.951	0.876	1.351	1.361	1.098	1.258	1.493	1.289	1.016	1.067	1.187	1.242
WPCBN (r = 1)	0.951	0.899	0.993	1.124	1.033	1.079	1.045	1.031	1.082	1.180	1.194	1.268
WPCBN (r = 2)	0.951	0.854	1.082	1.392	1.016	1.079	1.149	1.227	1.082	1.180	1.351	1.284
WPCBN (r = 3)	0.984	0.888	1.187	1.232	1.000	1.011	1.425	1.412	1.131	1.202	1.582	1.799
WPCBN (r = 5)	0.967	0.955	1.410	1.485	1.033	1.348	1.373	1.407	1.033	1.090	1.216	1.247
WPCSW (r = 1)	1.033	1.056	1.037	1.026	1.016	1.022	1.000	0.851	1.131	1.225	1.291	1.232
WPCSW (r = 2)	0.951	0.854	0.948	1.170	0.967	0.910	0.851	1.093	1.131	1.225	1.381	1.201
WPCSW (r = 3)	0.902	0.843	0.896	1.093	1.049	0.955	0.918	1.139	1.098	1.169	1.306	1.778
WPCSW (r = 5)	0.984	0.921	0.896	1.026	1.066	1.225	1.224	1.139	0.934	0.933	1.045	1.113
TPH (r = 1)	0.951	0.966	0.963	1.021	1.082	1.101	1.127	1.103	0.984	1.045	1.194	1.191
TPH (r = 2)	0.951	1.022	0.948	1.325	1.049	1.112	1.194	1.320	0.984	1.135	1.246	1.196
TPH (r = 3)	1.000	1.056	0.933	1.206	1.197	1.157	1.179	1.521	0.934	0.989	1.194	1.387
TPH (r = 5)	1.180	1.112	1.261	1.237	1.180	1.146	1.373	1.665	0.984	1.034	1.269	1.562
TPS (30 variables, r = 1)	1.016	1.213	1.194	1.211	1.098	1.101	1.216	1.206	1.131	1.022	1.022	1.052
TPS (30 variables, r = 2)	1.033	1.303	1.149	1.289	1.246	1.213	1.373	1.201	1.033	1.022	1.015	1.046
TPS (30 variables, r = 3)	1.033	1.225	1.224	1.273	1.311	1.202	1.261	1.263	1.049	1.045	1.015	1.062
TPS (30 variables, r = 5)	1.000	1.247	1.194	1.289	1.328	1.180	1.306	1.253	1.049	1.056	0.993	0.964
TPS (100 variables, r = 1)	0.934	0.831	1.157	1.139	1.082	0.955	0.963	1.356	1.049	1.191	1.037	1.082
TPS (100 variables, r = 2)	1.098	0.854	1.261	1.160	1.164	1.000	1.112	1.273	1.033	1.157	0.985	1.175
TPS (100 variables, r = 3)	1.066	0.843	1.276	1.206	1.197	1.079	1.060	1.340	1.016	1.101	1.231	1.247
TPS (100 variables, r = 5)	1.115	0.899	1.164	1.196	1.082	1.169	1.134	1.448	1.049	0.989	1.254	1.237
TPS (200 variables, r = 1)	0.934	0.820	1.067	1.186	1.066	1.056	1.022	1.129	0.934	0.820	0.955	1.144
TPS (200 variables, r = 2)	0.984	0.899	1.119	1.505	1.066	1.112	1.082	1.258	0.934	0.865	0.978	1.165
TPS (200 variables, r = 3)	0.951	0.944	1.209	1.649	1.000	0.933	0.925	1.418	0.951	0.820	0.970	1.196
TPS (200 variables, r = 5)	1.000	0.933	1.284	1.691	1.131	1.180	1.179	1.521	0.934	0.809	1.045	1.129
PLS (k = 1)	0.951	0.843	0.940	1.108	1.000	1.067	0.784	1.098	0.951	0.865	0.925	1.057
PLS (k = 2)	1.066	1.056	1.336	1.351	0.869	0.944	0.761	1.196	1.000	0.854	0.806	1.021
PLS (k = 3)	0.934	0.787	1.007	1.412	0.869	1.045	0.836	1.124	0.852	0.831	0.731	0.948
PLS (k = 5)	0.951	1.034	1.209	1.361	0.787	0.955	0.761	0.923	0.852	0.944	0.784	0.804
RR (v ₂ = 0.25)	1.049	0.966	1.239	1.371	0.803	1.011	0.903	1.216	0.885	0.865	0.873	0.969
RR (v ₂ = N)	0.918	0.820	0.955	1.186	0.836	0.899	0.716	1.057	0.852	0.775	0.701	1.000
RR (v ₂ = 5N)	0.934	0.876	0.933	1.046	0.902	0.910	0.806	1.010	0.902	0.854	0.813	0.995
RR (v ₂ = 10N)	0.934	0.899	0.940	1.010	0.934	0.933	0.866	1.005	0.934	0.888	0.866	0.995
EN (30 variables, v ₂ = 0.25)	1.016	0.910	1.239	1.077	0.951	1.000	0.993	1.021	0.934	0.764	0.873	0.716
EN (100 variables, v ₂ = 0.25)	1.082	1.101	1.500	1.227	0.918	0.921	0.963	1.119	0.918	0.876	1.037	0.778
EN (200 variables, v ₂ = 0.25)	1.082	1.011	1.373	1.351	0.836	0.955	0.940	1.206	0.885	0.843	0.963	0.938

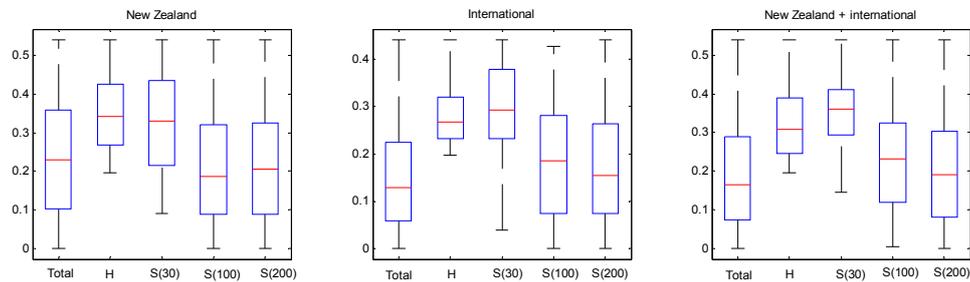
Notes: RMSE(model)/RMSE(univariate). Minima are in bold, and relative RMSEs < 1 are in gray. For more details on the forecasting setup, see the text.

Table 5: Best five models by RMSE

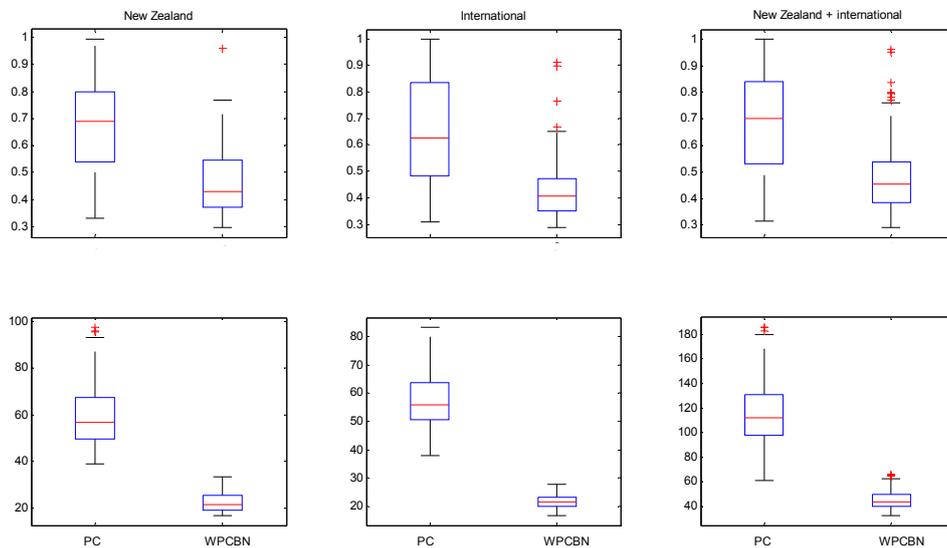
	h = 1	h = 2
1	int only, all, PLS (k = 5)	New Zealand + int, real data, PLS (k = 3)
2	int only, Australian data, WPCBN (r = 5)	New Zealand + int, Australian data, PLS (k = 3)
3	int only, Australian data, PLS (k = 1)	New Zealand + int, European data, PLS (k = 3)
4	int only, all, RR ($v_2 = 0.25$)	New Zealand + int, EN (30 variables, $v_2 = 0.25$)
5	int only, price data, PC (r = 5)	int only, European data, PLS (k = 2)
	h = 4	h = 8
1	int only, European data, RR ($v_2 = N$)	New Zealand + int, real data, PC (r = 2)
2	int only, European data, PLS (k = 2)	int only, monetary and financial data, WPCBN (r = 1)
3	int only, monetary and financial data, PC (r = 3)	New Zealand + int, Asian data, EN (30 variables, $v_2 = 0.25$)
4	int only, European data, RR ($v_2 = 5N$)	New Zealand + int, EN (30 variables, $v_2 = 0.25$)
5	int only, European data, PLS (k = 1)	int only, Asian data, PLS (k = 5)

Figure 1: Characteristics of the New Zealand, international-only, and combined datasets

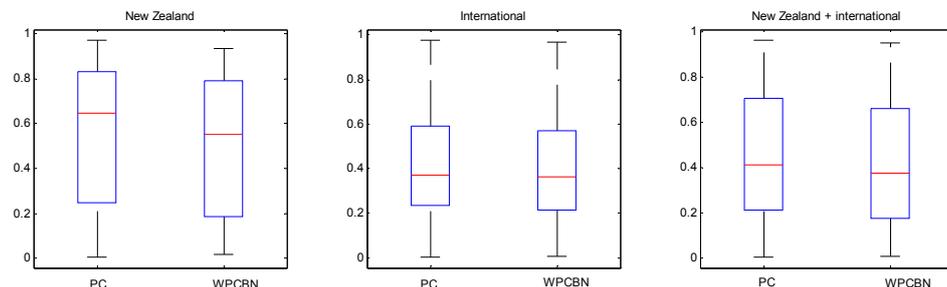
(a) Absolute correlations between predictors and target variable



(b) Absolute cross-correlation of idiosyncratic components

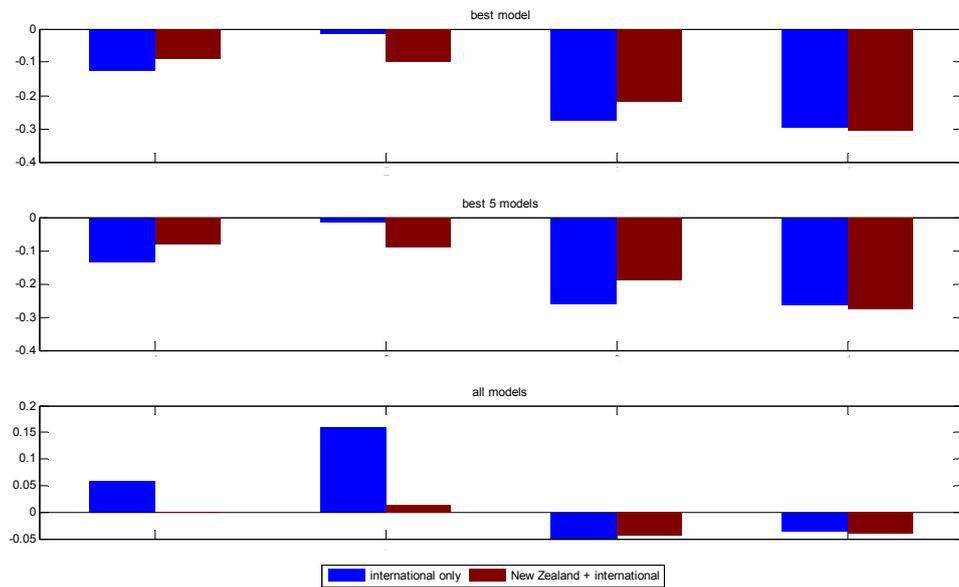


(c) Commonality



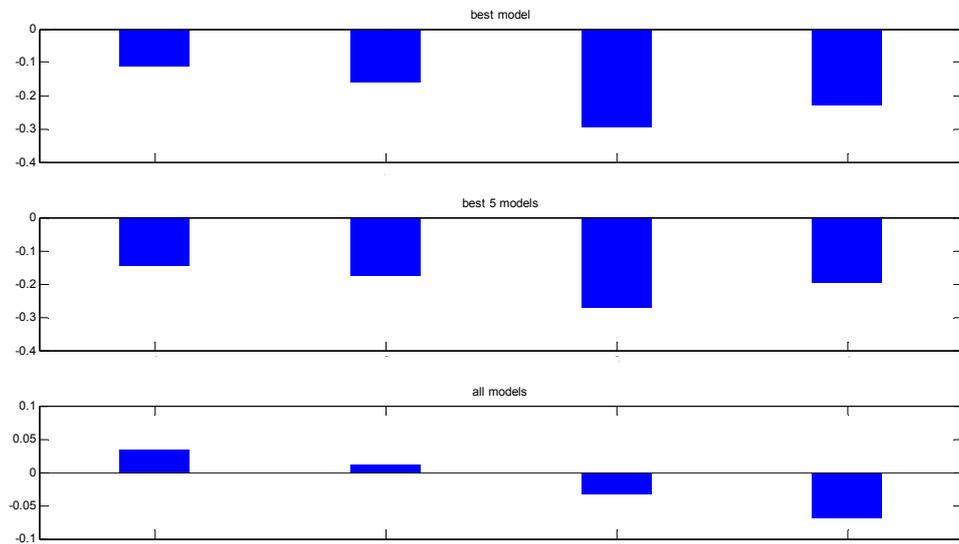
Notes: The red lines are the medians, the box indicate the lower and upper quartile values. Whiskers extend to the most extreme values of the data. Red crosses indicate outliers. Result shown in panels (b) and (c) are based on $r = 5$. H indicates variable selection with hard thresholding. S(30), S(100), S(200) indicate variable selection with soft thresholding with 30, 100 and 200 variables.

Figure 2: Forecast results – international-only, and combined New Zealand+international, versus New Zealand-only



Notes: $\text{RMSE}(\text{models using international-only, or using New Zealand+international, data}) / \text{RMSE}(\text{models using New Zealand data only}) - 1$; for more details on the forecasting setup, see the text.

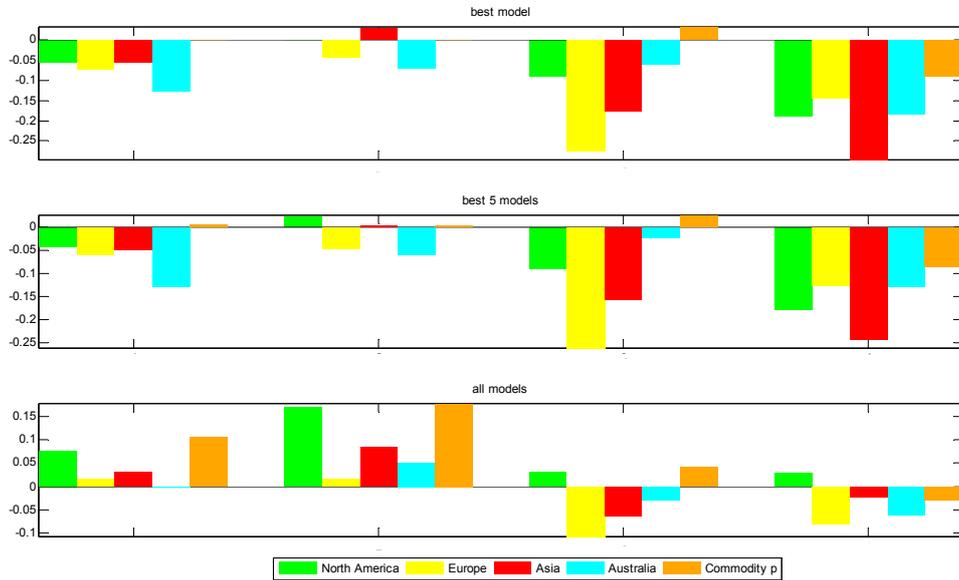
Figure 3: Forecast results - data-rich methods versus trade-weighting



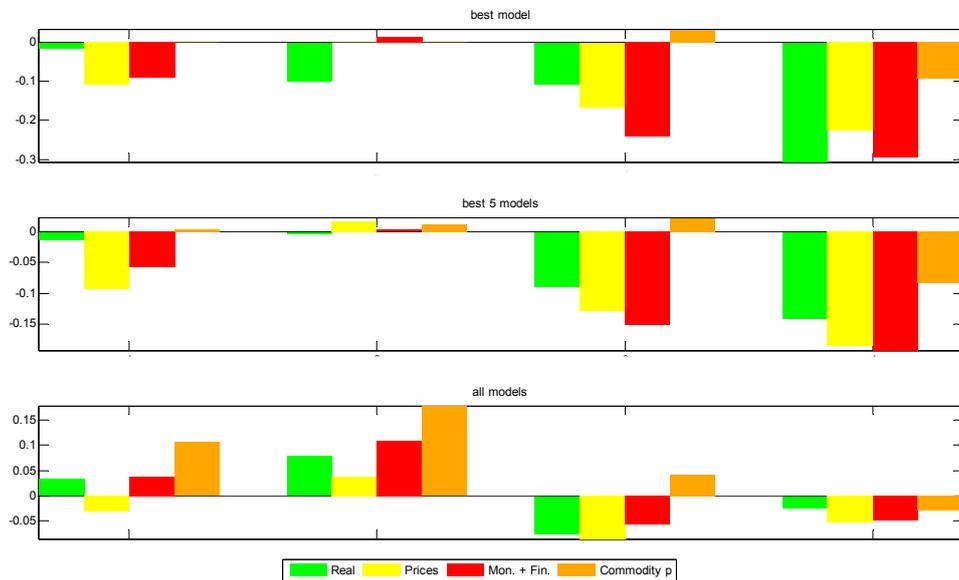
Notes: $\text{RMSE}(\text{model based on data-rich methods using international data only}) / \text{RMSE}(\text{model based on trade-weighting}) - 1$; for more details on the forecasting setup, see the text.

Figure 4: Forecast results – New Zealand data only versus international data (regional and economic subsets)

(a) Subsets by region



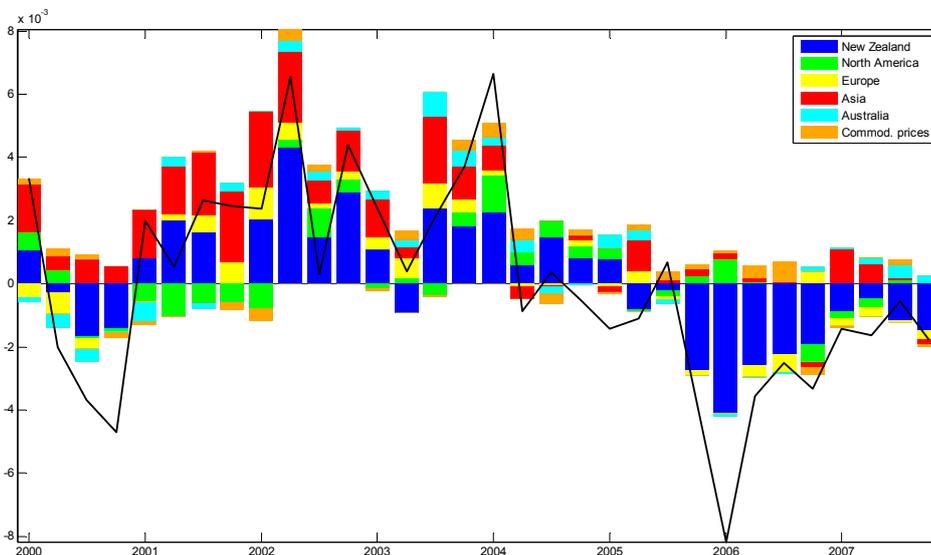
(b) Subsets by economic type



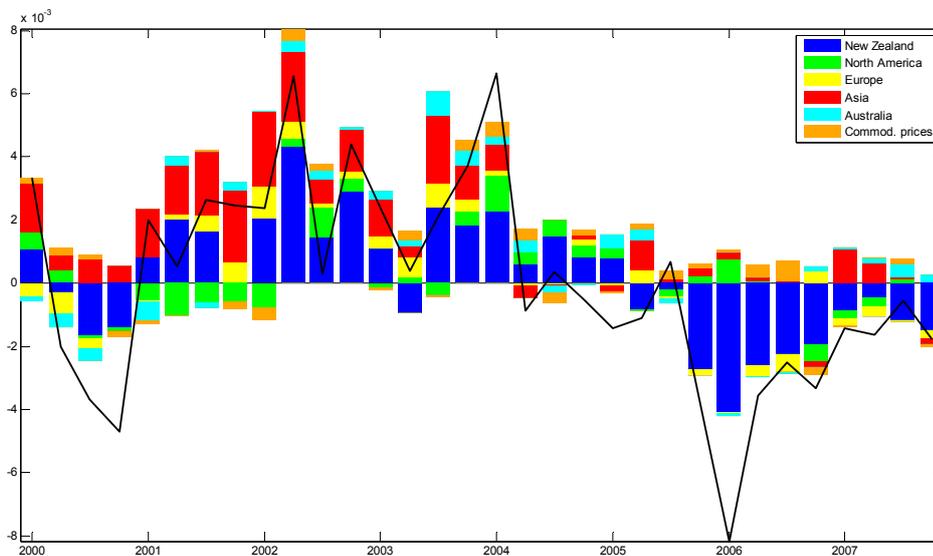
Notes: $RMSE(\text{model based on New Zealand data and subsets of international data}) / RMSE(\text{model based on New Zealand data only}) - 1$; for more details on the forecasting setup, see the text.

Figure 5: Contributions to forecasts – $RR(\nu_2 = N)$, New Zealand and international data

(a) Subsets by region



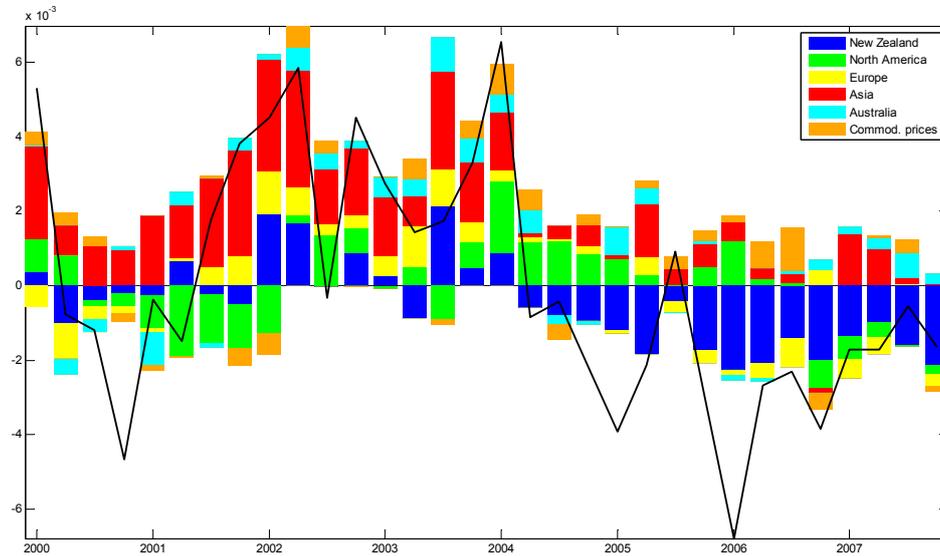
(b) Subsets by economic type



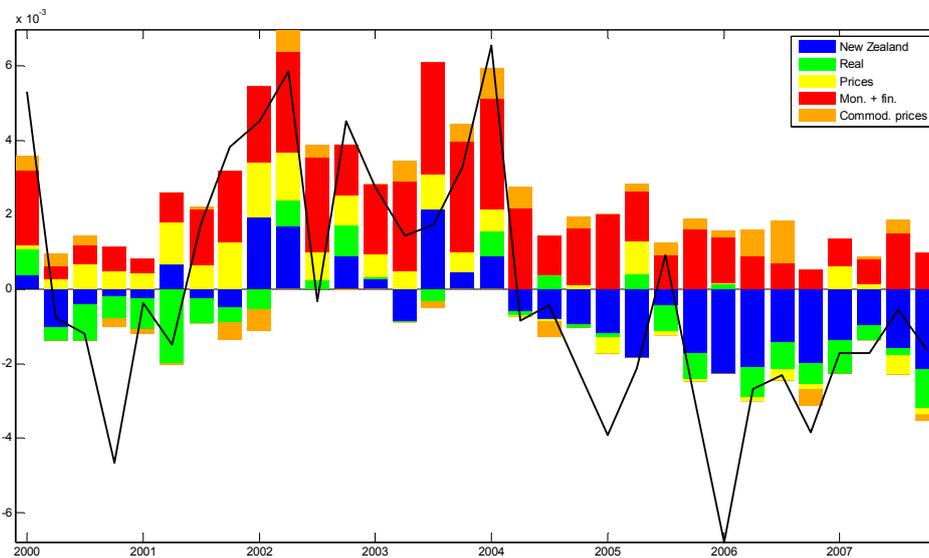
Notes: Based on a model using New Zealand and international data, $RR(\nu_2 = N)$, $h = 1$; the black line is the forecast; deviations from the mean.

Figure 6: Contributions to forecasts – $RR(v_2 = N)$, New Zealand excluding survey data, and international data

(a) Subsets by region



(b) Subsets by economic type



Notes: Based on a model using New Zealand and international data, $RR(v_2 = N)$, $h = 1$; the black line is the forecast; deviations from the mean.

Table A.1: International dataset

#	Country	Variable	Treatment	Source
1	US	Gross domestic product, real	4	OECD, Main Economic Indicators
2		Private final consumption, real	4	OECD, Main Economic Indicators
3		Gross fixed capital formation, real	4	OECD, Main Economic Indicators
4		Government final consumption expenditure, real	4	OECD, Main Economic Indicators
5		Exports, volume index	4	OECD, Main Economic Indicators
6		Imports, volume index	4	OECD, Main Economic Indicators
7		Employment	4	OECD, Main Economic Indicators
8		Personal consumption, ex food and energy	4	OECD, Main Economic Indicators
9		Capacity utilization	3	OECD, Main Economic Indicators
10		Industrial production	4	OECD, Main Economic Indicators
11		Income, nominal	4	OECD, Main Economic Indicators
12		Orders of manufactured goods	4	OECD, Main Economic Indicators
13		Labour force	4	OECD, Main Economic Indicators
14		Total retail trade	4	OECD, Main Economic Indicators
15		Dwelling productions	4	OECD, Main Economic Indicators
16		Weekly hours worked	4	OECD, Main Economic Indicators
17		Machinery production	4	OECD, Main Economic Indicators
18		Intermediate goods production	4	OECD, Main Economic Indicators
19		Non-durable goods production	4	OECD, Main Economic Indicators
20		Total manufacturing production	4	OECD, Main Economic Indicators
21		Total wholesale trade	4	OECD, Main Economic Indicators
22		Ratio of inventories to shipments	2	OECD, Main Economic Indicators
23		Unemployment rate, male	4	OECD, Main Economic Indicators
24		Unemployment rate	1	OECD, Main Economic Indicators
25		Consumer confidence index	3	OECD, Main Economic Indicators
26		Purchasing managers index	3	OECD, Main Economic Indicators
27		Consumer price index	4	OECD, Main Economic Indicators
28		Consumer price index, ex food and energy	4	OECD, Main Economic Indicators
29		GDP deflator	4	OECD, Main Economic Indicators
30		Personal consumption expenditures deflator	4	Bureau of Economic Analysis
31		Durable goods deflator	4	Bureau of Economic Analysis
32		Nondurable goods deflator	4	Bureau of Economic Analysis
33		Gross private domestic investment deflator	4	Bureau of Economic Analysis
34		Fixed investment deflator	4	Bureau of Economic Analysis
35		Nonresidential investment deflator	4	Bureau of Economic Analysis
36		Residential investment deflator	4	Bureau of Economic Analysis
37		Government consumption expenditures and gross investment deflator	4	Bureau of Economic Analysis
38		Producer price index	4	OECD, Main Economic Indicators
39		Total labour costs	4	OECD, Main Economic Indicators
40		Unit labour costs	4	OECD, Main Economic Indicators
41		Export price index	4	OECD, Main Economic Indicators
42		Import price index	4	OECD, Main Economic Indicators
43		Benchmarked real output, total	4	OECD, Main Economic Indicators
44		Hourly earnings, manufacturing	4	OECD, Main Economic Indicators
45		CPI housing	4	OECD, Main Economic Indicators
46		3-month Certificates of deposit rate	1	OECD, Main Economic Indicators
47		10-year federal government securities (composite) rate	1	OECD, Main Economic Indicators
48		3-month euro-dollar deposit rate	1	OECD, Main Economic Indicators
49		10-year federal government bond yield	1	OECD, Main Economic Indicators
50		Federal funds rate	1	OECD, Main Economic Indicators
51		Prime rate	1	OECD, Main Economic Indicators
52		M3	4	OECD, Main Economic Indicators
53		M2	4	OECD, Main Economic Indicators
54		M1	4	OECD, Main Economic Indicators
55		Real effective exchange rate	4	OECD, Main Economic Indicators
56		Share price	4	IMF, International Financial Statistics
57	Canada	Gross domestic product, real	4	OECD, Main Economic Indicators
58		Private final consumption, real	4	OECD, Main Economic Indicators
59		Gross fixed capital formation, real	4	OECD, Main Economic Indicators
60		Government final consumption expenditure, real	4	OECD, Main Economic Indicators
61		Exports, volume index	4	OECD, Main Economic Indicators
62		Imports, volume index	4	OECD, Main Economic Indicators
63		Change in inventories	1	OECD, Main Economic Indicators
64		Employment	4	OECD, Main Economic Indicators
65		Labour force	4	OECD, Main Economic Indicators
66		Capacity utilisation	3	OECD, Main Economic Indicators
67		Total production	4	OECD, Main Economic Indicators
68		CLI total industry, ex construction	4	OECD, Main Economic Indicators
69		Unemployment level	4	OECD, Main Economic Indicators
70		Unemployment rate	1	OECD, Main Economic Indicators
71		Total retail trade	4	OECD, Main Economic Indicators
72		Manufacturing, finished goods stocks level	2	OECD, Main Economic Indicators
73		Manufacturing, order books level	2	OECD, Main Economic Indicators
74		Manufacturing, orders, inflow/demand tendency	1	OECD, Main Economic Indicators
75		Manufacturing, production, future tendency	1	OECD, Main Economic Indicators
76		Employees, manufacturing	4	OECD, Main Economic Indicators
77		Total employees	4	OECD, Main Economic Indicators
78		Permits issued for buildings	4	OECD, Main Economic Indicators
79		Permits issued for dwellings	4	OECD, Main Economic Indicators
80		Orders for total manufactured goods	4	OECD, Main Economic Indicators
81		Consumer price index	4	OECD, Main Economic Indicators
82		Consumer price index, ex food and energy	4	OECD, Main Economic Indicators
83		GDP deflator	4	OECD, Main Economic Indicators
84		Total labour costs	4	OECD, Main Economic Indicators
85		Producer price index	4	OECD, Main Economic Indicators
86		Consumer price index, ex housing	4	OECD, Main Economic Indicators
87		CPI services less housing	4	OECD, Main Economic Indicators
88		Hourly earnings, manufacturing	4	OECD, Main Economic Indicators
89		Wages and salaries, manufacturing	4	OECD, Main Economic Indicators
90		3-month prime corporate paper rate	1	OECD, Main Economic Indicators
91		10-year government bonds yield	1	OECD, Main Economic Indicators
92		Central bank interest rate, < 24 hours	1	OECD, Main Economic Indicators
93		Overnight money market financing rate	1	OECD, Main Economic Indicators
94		M2+, gross	4	OECD, Main Economic Indicators
95		M3, gross	4	OECD, Main Economic Indicators
96		M1+, gross	4	OECD, Main Economic Indicators
97		Narrow money M1	4	OECD, Main Economic Indicators
98		Real effective exchange rate, CPI based	4	OECD, Main Economic Indicators
99		Real effective exchange rate, ULC based	4	OECD, Main Economic Indicators
100		CAD/USD exchange rate, monthly average	4	OECD, Main Economic Indicators

101	Share price index	4	OECD, Main Economic Indicators
102	Euro area		
	Gross domestic product, real	4	AWM database, see Fagan <i>et al.</i> (2007)
103	Total demand, real	4	AWM database, see Fagan <i>et al.</i> (2007)
104	Consumption, real	4	AWM database, see Fagan <i>et al.</i> (2007)
105	Gross investment, real	4	AWM database, see Fagan <i>et al.</i> (2007)
106	Government consumption, real	4	AWM database, see Fagan <i>et al.</i> (2007)
107	Net public investment, real	4	AWM database, see Fagan <i>et al.</i> (2007)
108	Labour force	4	AWM database, see Fagan <i>et al.</i> (2007)
109	Total employment	4	AWM database, see Fagan <i>et al.</i> (2007)
110	Labour productivity, real	4	AWM database, see Fagan <i>et al.</i> (2007)
111	Exports, volume index	4	AWM database, see Fagan <i>et al.</i> (2007)
112	Imports, volume index	4	AWM database, see Fagan <i>et al.</i> (2007)
113	Household disposable income, real	4	AWM database, see Fagan <i>et al.</i> (2007)
114	Wealth	4	AWM database, see Fagan <i>et al.</i> (2007)
115	Employees, level	4	AWM database, see Fagan <i>et al.</i> (2007)
116	Retail sales	4	AWM database, see Fagan <i>et al.</i> (2007)
117	Industrial production, manufacturing	4	AWM database, see Fagan <i>et al.</i> (2007)
118	Industrial production, ex construction	4	AWM database, see Fagan <i>et al.</i> (2007)
119	Unemployment, level	4	AWM database, see Fagan <i>et al.</i> (2007)
120	Industrial confidence	1	European Commission
121	Consumer price index	4	AWM database, see Fagan <i>et al.</i> (2007)
122	Consumer price index, energy	4	AWM database, see Fagan <i>et al.</i> (2007)
123	Consumer price index, ex energy	4	AWM database, see Fagan <i>et al.</i> (2007)
124	Growth of consumption deflator	1	AWM database, see Fagan <i>et al.</i> (2007)
125	Import of goods and services deflator	4	AWM database, see Fagan <i>et al.</i> (2007)
126	Consumption deflator	4	AWM database, see Fagan <i>et al.</i> (2007)
127	Unit labour costs	4	AWM database, see Fagan <i>et al.</i> (2007)
128	Exports of goods and services deflator	4	AWM database, see Fagan <i>et al.</i> (2007)
129	Compensation to employees	4	AWM database, see Fagan <i>et al.</i> (2007)
130	Producer price index, manufacturing	4	AWM database, see Fagan <i>et al.</i> (2007)
131	Producer price index	4	AWM database, see Fagan <i>et al.</i> (2007)
132	Wage rate	2	AWM database, see Fagan <i>et al.</i> (2007)
133	GDP deflator	4	AWM database, see Fagan <i>et al.</i> (2007)
134	Short-term nominal interest rate	1	AWM database, see Fagan <i>et al.</i> (2007)
135	Long-term interest rate	1	AWM database, see Fagan <i>et al.</i> (2007)
136	10-year interest rate	1	AWM database, see Fagan <i>et al.</i> (2007)
137	5-year interest rate	1	AWM database, see Fagan <i>et al.</i> (2007)
138	2-year interest rate	1	AWM database, see Fagan <i>et al.</i> (2007)
139	2-year yield spread	1	AWM database, see Fagan <i>et al.</i> (2007)
140	5-year yield spread	1	AWM database, see Fagan <i>et al.</i> (2007)
141	10-year yield spread	1	AWM database, see Fagan <i>et al.</i> (2007)
142	Household's savings ratio	4	AWM database, see Fagan <i>et al.</i> (2007)
143	Consumer loans	4	AWM database, see Fagan <i>et al.</i> (2007)
144	Loans to NFCs	4	AWM database, see Fagan <i>et al.</i> (2007)
145	M1	4	AWM database, see Fagan <i>et al.</i> (2007)
146	M2	4	AWM database, see Fagan <i>et al.</i> (2007)
147	M2-M1	4	AWM database, see Fagan <i>et al.</i> (2007)
148	M3	4	AWM database, see Fagan <i>et al.</i> (2007)
149	M3-M2	4	AWM database, see Fagan <i>et al.</i> (2007)
150	M3-M1	4	AWM database, see Fagan <i>et al.</i> (2007)
151	Nominal effective exchange rate	4	AWM database, see Fagan <i>et al.</i> (2007)
152	Real effective exchange rate	4	AWM database, see Fagan <i>et al.</i> (2007)
153	Stock price	4	AWM database, see Fagan <i>et al.</i> (2007)
154	UK		
	Gross domestic product, real	4	OECD, Main Economic Indicators
155	Private final consumption, real	4	OECD, Main Economic Indicators
156	Gross fixed capital formation, real	4	OECD, Main Economic Indicators
157	Government final consumption expenditure, real	4	OECD, Main Economic Indicators
158	Exports, volume index	4	OECD, Main Economic Indicators
159	Imports, volume index	4	OECD, Main Economic Indicators
160	Industrial production	4	OECD, Main Economic Indicators
161	Total retail trade	4	OECD, Main Economic Indicators
162	Household disposable income	4	Office for National Statistics
163	Consumer spending	4	Office for National Statistics
164	Workforce jobs	4	Office for National Statistics
165	Productivity, whole economy	4	Office for National Statistics
166	Industrial production index, manufacturing	4	Office for National Statistics
167	Consumer confidence	1	Office for National Statistics
168	Unemployment level	4	OECD, Main Economic Indicators
169	Unemployment rate	1	OECD, Main Economic Indicators
170	Unemployment rate, survey-based	1	OECD, Main Economic Indicators
171	Passenger car registrations	4	OECD, Main Economic Indicators
172	Work started for dwellings	4	OECD, Main Economic Indicators
173	Composite leading indicator	4	OECD, Main Economic Indicators
174	Consumer confidence	1	Office for National Statistics
175	Business optimism	1	Confederation of British Industry
176	Consumer price index	4	OECD, Main Economic Indicators
177	Consumer price index, ex food and energy	4	OECD, Main Economic Indicators
178	Consumer price index, HICP all items	4	OECD, Main Economic Indicators
179	Consumer price index, services less housing	4	OECD, Main Economic Indicators
180	GDP deflator	4	OECD, Main Economic Indicators
181	Producer price index, manufacturing output	4	OECD, Main Economic Indicators
182	Total labour costs	4	OECD, Main Economic Indicators
183	Unit labour costs	4	OECD, Main Economic Indicators
184	Average earning index	4	Office for National Statistics
185	Weekly earnings, manufacturing	4	OECD, Main Economic Indicators
186	Weekly earnings, private sector	4	OECD, Main Economic Indicators
187	Export price index	4	Office for National Statistics
188	Retail price index	4	OECD, Main Economic Indicators
189	Retail price index, less mortgage interest rates	4	OECD, Main Economic Indicators
190	CPI housing	4	OECD, Main Economic Indicators
191	3-month mean, LIBID/LIBOR rate	1	OECD, Main Economic Indicators
192	3-month treasury bills discount rate	1	OECD, Main Economic Indicators
193	10-year central government securities yield	1	OECD, Main Economic Indicators
194	Sterling overnight interbank rate	1	OECD, Main Economic Indicators
195	Bank base rate, 4 UK banks	1	OECD, Main Economic Indicators
196	3-month treasury bills discount rate, sterling	1	Bank of England
197	Sterling overnight interbank rate, mean LIBID/LIBOR	1	OECD, Main Economic Indicators
198	Prime lending rate, major banks	1	Bank of England
199	M2	4	OECD, Main Economic Indicators
200	M4	4	OECD, Main Economic Indicators

201	Real effective exchange rate, CPI based	4	OECD, Main Economic Indicators
202	Real effective exchange rate, ULC based	4	OECD, Main Economic Indicators
203	GBP/ USD exchange rate, monthly average	4	OECD, Main Economic Indicators
204	Share price index, FTSE 100	4	OECD, Main Economic Indicators
205	Australia	4	OECD, Main Economic Indicators
206	Gross domestic product, real	4	OECD, Main Economic Indicators
207	Private final consumption, real	4	OECD, Main Economic Indicators
208	Gross fixed capital formation, real	4	OECD, Main Economic Indicators
209	Government final consumption expenditure, real	4	OECD, Main Economic Indicators
210	Exports, volume index	4	OECD, Main Economic Indicators
211	Imports, volume index	4	OECD, Main Economic Indicators
212	Total employment	4	OECD, Main Economic Indicators
213	Employees, household survey	4	OECD, Main Economic Indicators
214	Labor force	4	OECD, Main Economic Indicators
215	Manufacturers and wholesale trade sales	4	Australian Bureau of Statistics
216	Gross national income	4	Australian Bureau of Statistics
217	Productivity, GDP per employed person	4	Australian Bureau of Statistics
218	Production in total manufacturing, level	4	OECD, Main Economic Indicators
219	Production in total manufacturing, index	4	OECD, Main Economic Indicators
220	Production in total service sector	4	OECD, Main Economic Indicators
221	Total retail trade	4	OECD, Main Economic Indicators
222	Unemployment level	4	OECD, Main Economic Indicators
223	Unemployment rate	2	OECD, Main Economic Indicators
224	Melbourne Westpac consumer sentiment index	3	Westpac Melbourne Institute
225	10-year central government securities yield	4	Westpac Melbourne Institute
226	Consumer price index	4	OECD, Main Economic Indicators
227	GDP deflator	4	OECD, Main Economic Indicators
228	Consumer price index, ex food and energy	4	OECD, Main Economic Indicators
229	Export price index	4	Australian Bureau of Statistics
230	Import price index	4	Australian Bureau of Statistics
231	Producer price index, food, beverage and tobacco	4	OECD, Main Economic Indicators
232	Producer price index, manufacturing	4	OECD, Main Economic Indicators
233	Total labour costs	4	OECD, Main Economic Indicators
234	Unit labour costs	4	OECD, Main Economic Indicators
235	Real output, total	4	OECD, Main Economic Indicators
236	CPI housing	4	OECD, Main Economic Indicators
237	90-day bank accepted bills yield	1	OECD, Main Economic Indicators
238	10-year government bonds yield	1	OECD, Main Economic Indicators
239	M3	4	OECD, Main Economic Indicators
240	Broad money	4	OECD, Main Economic Indicators
241	M1	4	OECD, Main Economic Indicators
242	Narrow money	4	OECD, Main Economic Indicators
243	Real effective exchange rates, CPI based	4	OECD, Main Economic Indicators
244	Real effective exchange rates, ULC based	4	OECD, Main Economic Indicators
245	AUD/USD exchange rate, monthly average	4	OECD, Main Economic Indicators
246	Share price index, S&P ASX 200	4	OECD, Main Economic Indicators
247	Share price index, S&P ASE Industrials	4	OECD, Main Economic Indicators
248	Japan	4	OECD, Main Economic Indicators
249	Gross domestic product, real	4	OECD, Main Economic Indicators
250	Private final consumption, real	4	OECD, Main Economic Indicators
251	Private residential investment, real	4	OECD, Main Economic Indicators
252	Private non-residential investment, real	4	OECD, Main Economic Indicators
253	Private inventory, real	2	OECD, Main Economic Indicators
254	Government final consumption expenditure, real	4	OECD, Main Economic Indicators
255	Public investment, real	4	OECD, Main Economic Indicators
256	Exports, volume index	4	OECD, Main Economic Indicators
257	Imports, volume index	4	OECD, Main Economic Indicators
258	Consumer confidence	3	OECD, Main Economic Indicators
259	Total employment	4	OECD, Main Economic Indicators
260	Labour force	4	OECD, Main Economic Indicators
261	Capacity utilisation	3	OECD, Main Economic Indicators
262	Total production	4	OECD, Main Economic Indicators
263	Retail trade	4	OECD, Main Economic Indicators
264	Unemployment level	4	OECD, Main Economic Indicators
265	Unemployment rate	2	OECD, Main Economic Indicators
266	Manufactured goods orders	4	OECD, Main Economic Indicators
267	Business condition survey	1	Ministry of Finance, Japan
268	Consumer price index	4	OECD, Main Economic Indicators
269	Consumer price index, ex food and energy	4	OECD, Main Economic Indicators
270	Unit labor costs	4	OECD, Main Economic Indicators
271	Producer price index, manufacturing	4	OECD, Main Economic Indicators
272	CPI housing	4	OECD, Main Economic Indicators
273	GDP deflator	4	OECD, Main Economic Indicators
274	Export unit price	4	Bank of Japan
275	Import unit price	4	Bank of Japan
276	3-month interest rate, certificates of deposit	1	OECD, Main Economic Indicators
277	10-year interest bearing government bonds yield	1	OECD, Main Economic Indicators
278	Central bank discount rate	1	OECD, Main Economic Indicators
279	Overnight call rate, uncollateralized	1	OECD, Main Economic Indicators
280	Broad money, M4	4	OECD, Main Economic Indicators
281	M2	4	OECD, Main Economic Indicators
282	M2 + Certificates of deposit	4	OECD, Main Economic Indicators
283	Broadly defined liquidity	4	OECD, Main Economic Indicators
284	M1	4	OECD, Main Economic Indicators
285	Real effective exchange rate, CPI based	4	OECD, Main Economic Indicators
286	Real effective exchange rate, ULC based	4	OECD, Main Economic Indicators
287	JPY/USD exchange rate, monthly average	4	OECD, Main Economic Indicators
288	Share price index, TSE TOPIX	4	OECD, Main Economic Indicators
289	Korea	4	OECD, Main Economic Indicators
290	Gross domestic product, real	4	OECD, Main Economic Indicators
291	Private final consumption expenditure, real	4	OECD, Main Economic Indicators
292	Gross fixed capital formation, real	4	OECD, Main Economic Indicators
293	Government final consumption expenditure, real	4	OECD, Main Economic Indicators
294	Changes in inventories	1	OECD, Main Economic Indicators
295	Exports, volume index	4	OECD, Main Economic Indicators
296	Imports, volume index	4	OECD, Main Economic Indicators
297	Total employment	4	OECD, Main Economic Indicators
298	Composite leading indicators, excluding constructions	4	OECD, Main Economic Indicators
299	Machinery orders received	4	National Statistical Office
300	Labour productivity index	4	National Statistical Office
	Industrial production	4	Bank of Korea
	Manufacturing production index	4	National Statistical Office
	Retail sales	4	Bank of Korea

301	Labour force	4	OECD, Main Economic Indicators
302	Capacity utilisation	3	OECD, Main Economic Indicators
303	Total retail trade	4	OECD, Main Economic Indicators
304	Unemployment level	4	OECD, Main Economic Indicators
305	Unemployment rate	1	OECD, Main Economic Indicators
306	Leading composite index	4	National Statistical Office
307	Consumer price index	4	OECD, Main Economic Indicators
308	Housing purchase price index	4	Bank of Korea
309	Export price index	4	Bank of Korea
310	Import price index	4	Bank of Korea
311	Consumer price index, ex food and energy	4	OECD, Main Economic Indicators
312	GDP deflator	4	IMF, International Financial Statistics
313	Producer price index	4	OECD, Main Economic Indicators
314	Unit labour costs	4	OECD, Main Economic Indicators
315	Benchmarked real output, total	4	OECD, Main Economic Indicators
316	CPI housing	4	OECD, Main Economic Indicators
317	10-year government bond yields	1	OECD, Main Economic Indicators
318	M2	4	OECD, Main Economic Indicators
319	M3	4	OECD, Main Economic Indicators
320	M1	4	OECD, Main Economic Indicators
321	Real effective exchange rate, ULC based	4	OECD, Main Economic Indicators
322	KRW/USD exchange rate, monthly average	4	OECD, Main Economic Indicators
323	Share price index, Kse KOSPI index	4	OECD, Main Economic Indicators
324	China	4	National Bureau of Statistics, China
325	Gross domestic product, real	4	National Bureau of Statistics, China
326	Exports, volume index	4	National Bureau of Statistics, China
327	Imports, volume index	4	National Bureau of Statistics, China
328	Employment	4	National Bureau of Statistics, China
329	Saving rate	2	National Bureau of Statistics, China
330	Unemployment rate	2	National Bureau of Statistics, China
331	Unemployment level	4	National Bureau of Statistics, China
332	Disposable income	4	National Bureau of Statistics, China
333	Industrial production	4	National Bureau of Statistics, China
334	Production of cement	4	OECD, Main Economic Indicators
335	Composite leading indicator	4	National Bureau of Statistics, China
336	Consumer price index (%YOY)	1	National Bureau of Statistics, China
337	Average wage	4	National Bureau of Statistics, China
338	Overnight interest rate	1	OECD, Main Economic Indicators
339	Prime lending rate	1	People's Bank of China
340	Discount rate	1	People's Bank of China
341	M2	4	OECD, Main Economic Indicators
342	M1	4	OECD, Main Economic Indicators
343	SDR reserve assets	4	OECD, Main Economic Indicators
344	M0, Currency in circulation	4	OECD, Main Economic Indicators
345	CNY/USD exchange rate	4	OECD, Main Economic Indicators
346	Hong Kong	4	Census and Statistics Department of Hong Kong
347	Gross domestic product, real	4	Census and Statistics Department of Hong Kong
348	Private consumption expenditure, real	4	Census and Statistics Department of Hong Kong
349	Gross fixed capital formation, real	4	IMF, International Financial Statistics
350	Government consumption expenditure, real	4	Census and Statistics Department of Hong Kong
351	Exports, volume index	4	IMF, International Financial Statistics
352	Imports, volume index	4	IMF, International Financial Statistics
353	Retail sales	4	Census and Statistics Department of Hong Kong
354	Labour force	4	Census and Statistics Department of Hong Kong
355	Unemployment level	4	Census and Statistics Department of Hong Kong
356	Unemployment rate	1	Census and Statistics Department of Hong Kong
357	Merchandise trade balance	2	Census and Statistics Department of Hong Kong
358	Industrial production, manufacturing	4	Census and Statistics Department of Hong Kong
359	Consumer price index	4	IMF, International Financial Statistics
360	GDP deflator	4	IMF, International Financial Statistics
361	Export unit value index	4	Census and Statistics Department of Hong Kong
362	Import unit value index	4	Census and Statistics Department of Hong Kong
363	Producer price index, manufacturing industries	4	Census and Statistics Department of Hong Kong
364	3-month interbank offered rate	1	Hong Kong Monetary Authority
365	Prime lending rate	1	Hong Kong Monetary Authority
366	M0	4	Hong Kong Monetary Authority
367	M1	4	Hong Kong Monetary Authority
368	HKD/USD exchange rate	4	IMF, International Financial Statistics
369	Effective exchange rate indices, trade-weighted	4	Census and Statistics Department of Hong Kong
370	Share price index, Hang Seng	4	Census and Statistics Department of Hong Kong
371	Malaysia	4	IMF, International Financial Statistics
372	Gross domestic product, real	4	IMF, International Financial Statistics
373	Industrial production	4	IMF, International Financial Statistics
374	Exports, volume index	4	IMF, International Financial Statistics
375	Imports, volume index	4	IMF, International Financial Statistics
376	Industrial production, manufacturing	4	Department of Statistics, Malaysia
377	Consumer price index	4	IMF, International Financial Statistics
378	Producer price index	4	IMF, International Financial Statistics
379	Manufacturing sector salaries and wages paid	4	Department of Statistics, Malaysia
380	3-month fixed deposit rate	1	IMF, International Financial Statistics
381	3-month treasury bills rate	1	IMF, International Financial Statistics
382	Overnight interbank rate	1	IMF, International Financial Statistics
383	Reserve money	4	IMF, International Financial Statistics
384	M0	4	Bank of Malaysia
385	M1	4	Bank of Malaysia
386	M2	4	Bank of Malaysia
387	M3	4	Bank of Malaysia
388	MYR/USD official exchange rate	4	IMF, International Financial Statistics
389	Share price index	4	IMF, International Financial Statistics
390	Singapore	4	Department of Statistics, Singapore
391	Gross domestic product, real	4	Department of Statistics, Singapore
392	Private consumption expenditure, real	4	Department of Statistics, Singapore
393	Gross fixed capital formation, real	4	Department of Statistics, Singapore
394	Government consumption expenditure, real	4	Department of Statistics, Singapore
395	Composite leading indicator	4	Department of Statistics, Singapore
396	Exports, volume index	4	Department of Statistics, Singapore
397	Imports, volume index	4	Department of Statistics, Singapore
398	Unemployment rate	4	Department of Statistics, Singapore
399	Retail sales index	4	Department of Statistics, Singapore
400	Industrial productions, ex rubber processing	4	Department of Statistics, Singapore
	Business expectations, manufacturing next 6 months	1	Department of Statistics, Singapore
	Composite leading indicators	4	Department of Statistics, Singapore
	Consumer price index	4	IMF, International Financial Statistics
	Producer price index	4	IMF, International Financial Statistics

401	Export unit value	4	IMF, International Financial Statistics
402	Import unit value	4	IMF, International Financial Statistics
403	Domestic supply price index	4	Department of Statistics, Singapore
404	Unit labour costs	4	Department of Statistics, Singapore
405	3-month interbank rate	1	IMF, International Financial Statistics
406	3-month deposit rate	1	IMF, International Financial Statistics
407	3-month treasury bill rate	1	Monetary Authority of Singapore
408	Prime lending rate	1	Monetary Authority of Singapore
409	M0	4	Monetary Authority of Singapore
410	M1	4	Monetary Authority of Singapore
411	M2	4	Monetary Authority of Singapore
412	M3	4	Monetary Authority of Singapore
413	SGD/USD exchange rate	4	Monetary Authority of Singapore
414	Share price index	4	IMF, International Financial Statistics
415	Taiwan	4	Directorate General of Budget, Accounting and Statistics
416	Gross domestic product, real	4	Directorate General of Budget, Accounting and Statistics
417	Private consumption, real	4	Directorate General of Budget, Accounting and Statistics
418	Gross domestic fixed capital formation, real	4	Directorate General of Budget, Accounting and Statistics
419	Gross national production	4	Directorate General of Budget, Accounting and Statistics
420	Government consumption, real	4	Directorate General of Budget, Accounting and Statistics
421	Exports, volume index	4	Directorate General of Budget, Accounting and Statistics
422	Imports, volume index	4	Directorate General of Budget, Accounting and Statistics
423	Industrial production index	4	Ministry of Economic Affairs
424	Industrial production index, manufacturing	4	Ministry of Economic Affairs
425	Export orders received	4	Directorate General of Budget, Accounting and Statistics
426	Unemployment rate	1	Directorate General of Budget, Accounting and Statistics
427	Labour force	4	Directorate General of Budget, Accounting and Statistics
428	Employment	4	Directorate General of Budget, Accounting and Statistics
429	Unemployment level	4	Directorate General of Budget, Accounting and Statistics
430	Labour productivity index	4	Directorate General of Budget, Accounting and Statistics
431	Composite leading indicators	4	Directorate General of Budget, Accounting and Statistics
432	Consumer price index	4	Directorate General of Budget, Accounting and Statistics
433	Consumer price index, ex food and energy	4	Directorate General of Budget, Accounting and Statistics
434	Average monthly earnings, manufacturing	4	Directorate General of Budget, Accounting and Statistics
435	Unit labour costs	4	Directorate General of Budget, Accounting and Statistics
436	Export price index	4	Directorate General of Budget, Accounting and Statistics
437	Import price index	4	Directorate General of Budget, Accounting and Statistics
438	GDP deflator	4	Directorate General of Budget, Accounting and Statistics
439	Discount rate	1	Central Bank of China
440	90-day money market rate	1	Central Bank of China
441	Prime lending rate, 5 major banks	1	Central Bank of China
442	M0	4	Central Bank of China
443	M1	4	Central Bank of China
444	M2	4	Central Bank of China
445	TWD/USD exchange rate	4	Central Bank of China
445	Commodity	4	London Metal Exchange
446	Aluminum	4	London Metal Exchange
447	Cooper	4	London Metal Exchange
448	Lead	4	London Metal Exchange
449	Nickel	4	London Metal Exchange
450	Tin	4	London Metal Exchange
451	Zinc	4	London Metal Exchange
452	Cotton	4	US Department of Agriculture
453	Nylon yarn	4	Taiwan Economic Journal
454	Polyester	2	Taiwan Economic Journal
455	Wool	4	Australian Wool Council
456	Fuel oil	4	Dow Jones energy services
457	Gas oil	4	ICIS Pricing
458	Gasoline	4	Dow Jones energy services
459	Jet kerosene-cargos	4	ICIS Pricing
460	Crude oil	4	ICIS Pricing
461	Palm oil	4	Public Ledger
462	Sunflower oil	4	Public Ledger
463	Soya oil	4	Public Ledger
464	Peanut oil	4	Public Ledger
465	Linseed oil	4	Public Ledger
466	Raw sugar	4	Public Ledger
467	Rubber	4	Malaysian Rubber Exchange
468	Coffee	4	International Coffee Organization
469	Cocoa	4	International Cocoa Organization
470	Soybeans	4	US Department of Agriculture
471	Rapeseed	4	Public Ledger
472	Wheat (hard Kansas, Cts./Bu)	4	US Department of Agriculture
473	Wheat 2 (soft)	4	US Department of Agriculture
474	Rice	4	Public Ledger
475	Platinum	4	Metal Bulletin
476	Silver	4	London Metal Exchange
477	Palladium	4	Metal Bulletin
478	Corn	4	US Department of Agriculture
479	Gold	4	London Metal Exchange
480	Pork bellies	4	US Department of Agriculture
481	Eggs	4	US Department of Agriculture
482	Oats	4	US Department of Agriculture
483	Live hogs	4	Standard & Poor's

Notes: Series are treated as follows. 1: no transformation, 2: first difference, 3: log, 4: log difference.

Table A.2: Forecast results for subsets of international data

(a) International subset = North American data only

	International				New Zealand + international			
	h = 1	h = 2	h = 4	h = 8	h = 1	h = 2	h = 4	h = 8
Univar. benchm. (RMSE/h)	0.0061	0.0063	0.0067	0.0069	0.0061	0.0063	0.0067	0.0069
trade1	1.115	1.416	1.955	2.655	-	-	-	-
trade2	1.115	1.416	1.955	2.660	-	-	-	-
PC (r = 1)	1.033	1.045	0.836	0.825	0.984	0.933	1.030	1.170
PC (r = 2)	1.049	1.056	0.948	1.077	1.016	0.978	1.142	1.160
PC (r = 3)	1.082	1.090	0.978	1.119	1.016	1.000	1.149	1.180
PC (r = 5)	1.148	1.382	1.418	1.948	1.033	0.876	1.119	0.928
WPCBN (r = 1)	1.049	1.079	0.828	0.871	0.984	0.989	1.030	0.959
WPCBN (r = 2)	1.082	1.101	0.940	1.139	1.000	0.944	1.045	0.938
WPCBN (r = 3)	1.000	1.067	0.925	1.392	0.869	1.000	0.933	0.820
WPCBN (r = 5)	1.049	1.236	1.127	1.464	0.852	0.955	1.425	1.165
WPCSW (r = 1)	1.016	1.067	0.925	0.871	1.066	1.202	1.187	1.134
WPCSW (r = 2)	1.000	1.000	0.993	1.170	0.967	1.022	1.037	0.948
WPCSW (r = 3)	1.000	1.045	0.978	1.093	1.049	1.000	1.157	1.314
WPCSW (r = 5)	0.984	1.056	0.851	1.134	1.016	1.011	1.194	1.031
TPH (r = 1)	1.066	1.236	1.209	1.206	0.918	0.910	1.134	1.175
TPH (r = 2)	1.131	1.337	1.336	1.521	0.885	0.899	1.134	1.155
TPH (r = 3)	1.164	1.404	1.313	1.515	0.902	0.978	1.119	1.191
TPH (r = 5)	1.344	1.449	1.396	1.701	0.918	1.101	1.164	1.340
TPS (30 variables, r = 1)	1.016	1.056	0.963	1.072	1.131	1.157	1.134	1.005
TPS (30 variables, r = 2)	1.131	1.056	1.388	1.402	1.066	1.135	1.224	1.242
TPS (30 variables, r = 3)	1.098	1.135	1.396	1.454	0.984	1.079	1.164	1.258
TPS (30 variables, r = 5)	1.131	1.236	1.500	1.675	1.016	1.011	1.104	1.206
PLS (k = 1)	1.098	1.180	0.873	1.160	0.967	0.876	0.978	1.129
PLS (k = 2)	1.328	1.416	1.194	1.608	1.115	1.011	1.052	1.186
PLS (k = 3)	1.475	1.697	1.545	1.876	0.967	0.787	0.813	1.160
PLS (k = 5)	1.410	1.607	1.560	1.670	0.984	1.090	1.052	1.098
RR (v ₂ = 0.25)	1.836	1.910	2.142	2.670	1.033	1.000	1.104	1.165
RR (v ₂ = N)	1.098	1.225	1.127	1.330	0.918	0.820	0.851	1.082
RR (v ₂ = 5N)	1.033	1.056	0.948	1.067	0.934	0.888	0.896	1.015
RR (v ₂ = 10N)	1.016	1.022	0.955	1.031	0.951	0.910	0.925	1.000
EN (30 variables, v ₂ = 0.25)	1.311	1.584	1.970	1.794	0.984	0.933	1.224	1.005

(b) International subset = European data only

	International				New Zealand + international			
	h = 1	h = 2	h = 4	h = 8	h = 1	h = 2	h = 4	h = 8
Univar. benchm. (RMSE/h)	0.0061	0.0063	0.0067	0.0069	0.0061	0.0063	0.0067	0.0069
trade1	1.049	1.079	1.127	1.113	-	-	-	-
trade2	1.049	1.067	1.127	1.119	-	-	-	-
PC (r = 1)	1.000	1.045	1.060	1.021	0.951	0.865	1.007	1.129
PC (r = 2)	1.000	0.955	0.836	1.124	0.951	0.843	1.067	1.134
PC (r = 3)	1.016	0.944	0.873	1.139	0.951	0.888	1.075	1.299
PC (r = 5)	1.000	0.876	1.045	1.309	0.984	0.955	1.239	1.572
WPCBN (r = 1)	1.000	1.011	1.015	0.887	0.951	0.978	0.948	0.866
WPCBN (r = 2)	1.000	0.910	0.724	0.938	0.934	1.056	0.970	1.144
WPCBN (r = 3)	0.934	0.865	0.769	1.119	0.951	1.079	1.239	1.624
WPCBN (r = 5)	1.066	0.944	1.075	1.077	1.115	1.000	1.403	1.804
WPCSW (r = 1)	1.033	1.067	1.037	1.021	1.066	1.135	1.082	1.082
WPCSW (r = 2)	0.934	0.910	0.955	1.155	0.984	0.865	1.007	0.923
WPCSW (r = 3)	1.000	1.034	1.030	1.186	0.984	0.899	1.030	1.222
WPCSW (r = 5)	0.967	0.955	1.022	1.170	0.934	0.820	1.007	1.232
TPH (r = 1)	0.967	1.000	0.948	0.995	0.885	0.944	1.112	1.211
TPH (r = 2)	0.951	0.989	1.030	1.196	0.852	0.921	1.224	1.134
TPH (r = 3)	0.951	1.000	1.187	1.072	0.836	0.933	1.194	1.232
TPH (r = 5)	0.951	1.011	1.291	1.180	0.967	1.000	1.119	1.232
TPS (30 variables, r = 1)	1.000	1.045	1.007	1.175	1.246	1.146	1.201	1.144
TPS (30 variables, r = 2)	1.000	1.169	1.060	1.299	1.213	1.135	1.209	1.119
TPS (30 variables, r = 3)	1.033	1.090	1.201	1.284	1.230	1.146	1.261	1.134
TPS (30 variables, r = 5)	1.016	1.079	1.224	1.381	1.246	1.191	1.284	1.113
PLS (k = 1)	0.918	0.854	0.701	1.031	0.934	0.831	0.910	1.072
PLS (k = 2)	0.869	0.775	0.672	1.175	1.000	0.910	1.030	1.253
PLS (k = 3)	1.033	0.899	0.799	1.088	0.918	0.753	0.716	1.242
PLS (k = 5)	1.279	1.079	0.828	0.969	0.967	1.034	0.925	1.216
RR (v ₂ = 0.25)	1.770	1.461	1.164	1.304	1.000	0.910	0.925	1.278
RR (v ₂ = N)	0.902	0.809	0.649	1.041	0.902	0.787	0.784	1.119
RR (v ₂ = 5N)	0.902	0.843	0.694	0.995	0.918	0.854	0.851	1.021
RR (v ₂ = 10N)	0.918	0.876	0.776	0.985	0.934	0.876	0.896	1.000
EN (30 variables, v ₂ = 0.25)	1.016	1.022	0.903	0.948	1.016	0.831	1.045	1.031

(c) International subset = Asian data only

Univar. benchm. (RMSE/h)	International				New Zealand + international			
	h = 1	h = 2	h = 4	h = 8	h = 1	h = 2	h = 4	h = 8
trade1	1.115	1.213	0.978	1.294	-	-	-	-
trade2	1.115	1.213	0.978	1.294	-	-	-	-
PC (r = 1)	0.984	0.944	0.851	1.000	0.967	0.933	1.075	1.165
PC (r = 2)	1.115	1.258	0.910	1.216	0.984	0.876	1.052	1.376
PC (r = 3)	1.033	1.101	0.828	1.129	0.951	0.876	0.918	1.309
PC (r = 5)	1.098	0.899	0.873	1.423	0.984	0.809	0.828	1.742
WPCBN (r = 1)	0.984	0.955	0.881	0.969	0.984	1.011	1.119	1.196
WPCBN (r = 2)	1.115	1.202	0.896	1.186	0.984	0.933	1.157	1.490
WPCBN (r = 3)	1.000	1.169	1.067	1.268	0.967	0.899	1.127	1.289
WPCBN (r = 5)	0.951	1.056	1.000	1.345	0.934	0.888	1.216	1.443
WPCSW (r = 1)	1.016	0.944	0.739	0.923	1.000	1.067	1.045	1.067
WPCSW (r = 2)	1.066	1.157	0.806	1.005	0.934	0.820	0.910	1.211
WPCSW (r = 3)	1.066	1.180	0.873	1.124	0.967	0.843	1.082	1.284
WPCSW (r = 5)	1.049	1.146	0.993	1.356	1.000	0.944	1.179	1.531
TPH (r = 1)	1.180	1.191	1.187	1.959	0.934	0.843	1.030	1.129
TPH (r = 2)	1.213	1.213	1.396	1.985	0.934	0.854	1.045	1.237
TPH (r = 3)	1.213	1.213	1.418	1.979	0.967	0.989	1.179	1.227
TPH (r = 5)	1.279	1.315	1.634	2.041	0.984	0.989	1.194	1.572
TPS (30 variables, r = 1)	0.951	1.022	1.254	0.923	1.066	1.124	1.381	1.144
TPS (30 variables, r = 2)	1.115	1.202	1.455	1.412	1.098	1.247	1.433	1.247
TPS (30 variables, r = 3)	1.377	1.292	1.440	1.387	1.098	1.258	1.463	1.258
TPS (30 variables, r = 5)	1.377	1.270	1.478	1.392	1.180	1.236	1.410	1.191
PLS (k = 1)	1.082	1.213	1.060	1.082	0.951	0.843	0.940	1.052
PLS (k = 2)	0.852	0.966	0.799	1.093	0.984	0.854	0.948	1.242
PLS (k = 3)	0.885	0.933	0.761	0.881	0.852	0.865	0.896	1.046
PLS (k = 5)	0.984	1.270	0.940	0.722	0.967	1.112	0.918	0.907
RR ($v_2 = 0.25$)	1.115	1.225	1.254	0.969	0.967	0.933	1.015	1.062
RR ($v_2 = N$)	0.902	1.011	0.799	0.923	0.885	0.809	0.828	1.046
RR ($v_2 = 5N$)	0.918	0.933	0.813	0.943	0.918	0.865	0.851	1.000
RR ($v_2 = 10N$)	0.934	0.944	0.851	0.974	0.934	0.888	0.881	0.995
EN (30 variables, $v_2 = 0.25$)	0.918	1.067	1.060	1.186	0.951	0.933	1.045	0.711

(d) International subset = Australian data only

Univar. benchm. (RMSE/h)	International				New Zealand + international			
	h = 1	h = 2	h = 4	h = 8	h = 1	h = 2	h = 4	h = 8
trade1	0.984	1.011	0.955	0.928	-	-	-	-
trade2	0.984	1.011	0.955	0.928	-	-	-	-
PC (r = 1)	0.934	1.000	1.007	1.005	1.000	1.000	1.201	1.325
PC (r = 2)	0.902	1.011	1.060	1.031	1.000	1.034	1.321	1.655
PC (r = 3)	0.902	0.955	1.067	1.046	0.984	1.056	1.381	1.552
PC (r = 5)	0.820	0.989	1.134	1.113	0.918	1.056	1.552	1.531
WPCBN (r = 1)	0.918	1.034	1.007	0.979	0.934	0.865	1.000	1.139
WPCBN (r = 2)	0.902	0.978	1.067	1.077	0.934	0.876	1.067	1.361
WPCBN (r = 3)	0.885	0.888	1.075	1.093	0.934	0.865	1.104	1.067
WPCBN (r = 5)	0.787	1.034	0.985	1.170	1.000	0.933	1.164	1.474
WPCSW (r = 1)	0.852	0.854	1.030	1.026	1.246	1.315	1.276	1.082
WPCSW (r = 2)	0.918	0.933	1.060	1.021	1.098	1.079	1.022	1.376
WPCSW (r = 3)	1.033	1.022	1.045	1.077	1.098	1.112	1.269	1.608
WPCSW (r = 5)	0.984	1.011	1.075	1.010	1.016	0.978	1.067	1.335
TPH (r = 1)	0.951	0.989	0.993	1.088	0.951	0.955	0.963	1.000
TPH (r = 2)	1.000	1.045	0.948	0.964	0.951	0.989	1.007	1.304
TPH (r = 3)	0.984	1.056	0.940	1.505	0.934	1.011	1.052	1.335
TPH (r = 5)	1.016	1.146	1.336	1.758	1.016	1.124	1.313	1.376
TPS (30 variables, r = 1)	1.016	1.067	1.052	0.985	1.016	1.056	1.284	1.258
TPS (30 variables, r = 2)	1.016	1.045	1.037	0.990	1.148	1.135	1.284	1.392
TPS (30 variables, r = 3)	1.049	1.056	1.060	1.041	1.295	1.180	1.231	1.448
TPS (30 variables, r = 5)	0.984	1.090	0.955	0.985	1.295	1.315	1.216	1.418
PLS (k = 1)	0.787	0.831	1.104	1.072	0.934	0.831	0.940	1.103
PLS (k = 2)	0.869	0.899	0.925	1.005	1.016	1.000	1.306	1.345
PLS (k = 3)	0.918	0.888	0.903	0.959	0.902	0.730	0.970	1.402
PLS (k = 5)	1.066	1.124	0.918	0.990	0.902	0.944	1.119	1.284
RR ($v_2 = 0.25$)	1.803	1.831	1.776	1.005	1.016	0.933	1.157	1.366
RR ($v_2 = N$)	0.803	0.775	0.843	0.825	0.869	0.775	0.933	1.180
RR ($v_2 = 5N$)	0.836	0.854	0.955	0.912	0.918	0.865	0.925	1.036
RR ($v_2 = 10N$)	0.869	0.888	0.985	0.948	0.934	0.888	0.940	1.005
EN (30 variables, $v_2 = 0.25$)	1.246	1.281	1.261	1.026	1.000	0.820	1.246	1.134

(e) International subset = real data only

	International				New Zealand + international			
	h = 1	h = 2	h = 4	h = 8	h = 1	h = 2	h = 4	h = 8
Univar. benchm. (RMSE/h)	0.0061	0.0063	0.0067	0.0069	0.0061	0.0063	0.0067	0.0069
trade1	1.049	1.090	0.948	0.933	-	-	-	-
trade2	1.049	1.079	0.940	0.923	-	-	-	-
PC (r = 1)	1.066	1.056	0.970	0.990	0.951	0.888	1.037	1.149
PC (r = 2)	1.066	1.146	0.985	0.912	0.967	0.921	1.194	1.387
PC (r = 3)	1.049	1.045	0.866	1.412	0.984	0.966	1.231	1.443
PC (r = 5)	1.148	1.146	1.187	1.608	1.000	1.000	1.254	1.464
WPCBN (r = 1)	1.049	1.034	0.970	1.026	0.934	0.899	1.030	1.170
WPCBN (r = 2)	1.066	1.112	0.970	0.938	0.951	0.933	1.142	1.077
WPCBN (r = 3)	1.082	1.034	0.963	1.309	0.967	0.910	1.119	1.160
WPCBN (r = 5)	1.131	1.124	1.030	1.325	0.934	0.933	1.358	1.320
WPCSW (r = 1)	1.049	1.101	1.045	0.979	1.033	1.056	1.134	1.103
WPCSW (r = 2)	1.066	1.124	1.030	1.005	0.967	0.933	1.172	1.289
WPCSW (r = 3)	1.033	1.112	1.075	1.418	0.984	0.966	1.284	1.603
WPCSW (r = 5)	1.016	1.180	0.933	1.186	0.951	0.910	1.104	1.402
TPH (r = 1)	1.066	1.079	1.097	1.124	0.984	0.933	1.149	1.253
TPH (r = 2)	1.066	1.045	1.299	1.423	0.984	0.910	1.164	1.402
TPH (r = 3)	1.180	1.112	1.254	1.314	1.016	0.978	1.134	1.423
TPH (r = 5)	1.180	1.157	1.254	1.351	1.098	1.101	1.246	1.381
TPS (30 variables, r = 1)	1.016	1.022	0.948	1.345	1.213	1.180	1.037	1.103
TPS (30 variables, r = 2)	1.033	1.079	1.112	1.273	1.197	1.348	1.075	1.031
TPS (30 variables, r = 3)	1.098	1.079	1.149	1.459	1.180	1.337	1.000	1.021
TPS (30 variables, r = 5)	1.262	1.404	1.291	1.536	1.148	1.371	0.963	1.062
PLS (k = 1)	1.066	1.045	0.851	1.242	0.967	0.843	0.963	1.124
PLS (k = 2)	0.967	0.966	0.940	1.330	1.049	0.933	0.978	1.222
PLS (k = 3)	0.885	0.933	0.881	1.299	0.902	0.708	0.821	1.046
PLS (k = 5)	0.967	1.034	0.851	1.139	0.918	0.955	0.903	1.031
RR ($v_2 = 0.25$)	0.934	1.067	1.000	1.381	0.951	0.865	0.993	1.103
RR ($v_2 = N$)	0.934	1.067	0.993	1.381	0.902	0.798	0.799	1.046
RR ($v_2 = 5N$)	0.918	1.045	0.978	1.361	0.934	0.888	0.866	0.995
RR ($v_2 = 10N$)	0.918	1.034	0.963	1.340	0.951	0.910	0.910	0.990
EN (30 variables, $v_2 = 0.25$)	1.082	0.978	0.896	1.278	0.984	0.865	0.918	0.701

(f) International subset = price data only

	International				New Zealand + international			
	h = 1	h = 2	h = 4	h = 8	h = 1	h = 2	h = 4	h = 8
Univar. benchm. (RMSE/h)	0.0061	0.0063	0.0067	0.0069	0.0061	0.0063	0.0067	0.0069
trade1	0.885	0.933	0.918	0.985	-	-	-	-
trade2	0.885	0.921	0.925	0.979	-	-	-	-
PC (r = 1)	0.902	0.888	0.821	0.866	0.951	0.888	1.015	1.134
PC (r = 2)	0.951	0.966	0.828	0.809	0.984	0.933	1.127	1.098
PC (r = 3)	0.869	0.955	0.940	1.155	0.967	0.978	1.127	1.268
PC (r = 5)	0.803	1.101	1.373	1.459	0.934	0.921	1.090	1.500
WPCBN (r = 1)	0.918	0.910	0.858	0.897	0.951	0.921	0.896	1.129
WPCBN (r = 2)	0.918	1.079	1.082	0.784	0.967	0.910	1.015	1.211
WPCBN (r = 3)	0.967	1.056	1.276	1.696	0.918	0.966	1.157	1.412
WPCBN (r = 5)	1.098	1.056	1.231	1.892	1.016	1.045	1.463	1.562
WPCSW (r = 1)	0.984	0.989	0.963	0.933	1.049	1.191	1.149	1.093
WPCSW (r = 2)	0.951	0.978	0.888	0.825	0.934	0.876	0.955	0.985
WPCSW (r = 3)	0.934	1.011	1.022	0.964	1.000	0.888	0.925	1.170
WPCSW (r = 5)	0.934	1.067	1.090	0.979	0.951	0.876	0.836	1.103
TPH (r = 1)	0.869	1.022	0.940	1.000	0.984	0.854	0.970	1.072
TPH (r = 2)	0.885	1.079	1.082	1.144	0.984	0.854	0.970	1.196
TPH (r = 3)	0.902	1.202	0.933	1.474	1.000	0.888	0.985	1.072
TPH (r = 5)	0.984	1.337	1.187	1.680	1.049	0.888	1.321	1.273
TPS (30 variables, r = 1)	0.967	1.067	0.978	0.959	1.131	1.157	1.269	1.227
TPS (30 variables, r = 2)	0.967	1.090	1.291	1.340	1.164	1.090	1.269	1.242
TPS (30 variables, r = 3)	1.016	1.202	1.433	1.536	1.230	1.090	1.299	1.278
TPS (30 variables, r = 5)	0.984	1.326	1.500	1.588	1.230	1.157	1.321	1.206
PLS (k = 1)	0.852	0.910	0.799	0.923	0.934	0.843	0.940	1.062
PLS (k = 2)	0.852	1.022	0.888	1.495	0.984	0.899	1.067	1.387
PLS (k = 3)	0.885	0.989	0.828	1.356	0.934	0.843	0.851	1.206
PLS (k = 5)	0.951	1.090	0.851	0.990	0.967	1.056	0.955	1.124
RR ($v_2 = 0.25$)	1.098	1.247	1.007	1.330	0.984	0.933	1.007	1.268
RR ($v_2 = N$)	0.803	0.921	0.746	1.129	0.869	0.787	0.866	1.149
RR ($v_2 = 5N$)	0.852	0.888	0.813	0.990	0.902	0.843	0.873	1.031
RR ($v_2 = 10N$)	0.902	0.910	0.858	0.979	0.918	0.876	0.903	1.010
EN (30 variables, $v_2 = 0.25$)	0.967	1.056	1.022	1.345	0.951	0.876	1.022	1.175

(g) International subset = monetary and financial data only

Univar. benchm. (RMSE/h)	International				New Zealand + international			
	h = 1	h = 2	h = 4	h = 8	h = 1	h = 2	h = 4	h = 8
trade1	1.000	1.011	1.052	1.196	-	-	-	-
trade2	1.000	1.011	1.045	1.191	-	-	-	-
PC (r = 1)	1.082	1.112	0.933	0.742	1.000	1.000	1.119	1.211
PC (r = 2)	1.016	0.978	0.739	0.979	0.967	0.899	1.127	1.474
PC (r = 3)	1.066	1.000	0.679	1.015	0.984	0.921	1.149	1.603
PC (r = 5)	1.148	1.079	0.873	1.222	1.082	0.978	1.388	1.742
WPCBN (r = 1)	1.033	1.022	0.873	0.711	1.000	1.034	1.157	1.186
WPCBN (r = 2)	1.049	1.112	1.194	0.871	0.918	0.910	1.134	1.031
WPCBN (r = 3)	1.049	1.169	1.082	1.273	0.967	0.910	1.164	1.381
WPCBN (r = 5)	1.115	1.135	1.246	1.222	1.033	1.090	1.052	1.562
WPCSW (r = 1)	1.066	1.101	1.000	0.923	1.000	1.067	1.045	1.077
WPCSW (r = 2)	1.082	1.169	1.037	1.242	0.951	0.831	0.903	1.299
WPCSW (r = 3)	1.197	1.315	1.276	1.335	0.951	0.921	0.970	1.227
WPCSW (r = 5)	1.180	1.270	1.209	1.057	0.984	0.888	1.082	1.325
TPH (r = 1)	1.115	1.191	1.194	1.247	0.951	0.865	1.104	1.227
TPH (r = 2)	1.197	1.258	1.127	1.345	0.984	0.809	1.149	1.289
TPH (r = 3)	1.180	1.258	1.030	1.366	0.984	0.843	1.067	1.139
TPH (r = 5)	1.098	1.494	1.224	1.351	0.820	0.831	1.015	1.273
TPS (30 variables, r = 1)	1.000	1.022	0.910	1.165	0.934	1.213	1.030	1.088
TPS (30 variables, r = 2)	0.902	1.079	0.918	1.247	1.033	1.146	1.045	1.093
TPS (30 variables, r = 3)	0.820	1.169	1.194	1.330	1.016	1.270	1.164	0.943
TPS (30 variables, r = 5)	1.033	1.315	1.194	1.325	1.016	1.191	1.097	0.897
PLS (k = 1)	1.180	1.315	1.351	1.186	0.951	0.854	0.940	1.077
PLS (k = 2)	1.066	1.157	1.127	1.253	1.049	0.933	1.015	1.253
PLS (k = 3)	1.049	1.247	1.216	1.103	0.885	0.843	0.791	1.134
PLS (k = 5)	1.148	1.303	1.187	1.304	0.934	1.056	0.940	1.057
RR (v ₂ = 0.25)	1.689	1.494	1.470	1.876	0.967	0.910	0.963	1.149
RR (v ₂ = N)	0.984	1.056	1.067	1.088	0.902	0.798	0.821	1.082
RR (v ₂ = 5N)	0.984	1.000	0.970	1.010	0.934	0.865	0.881	1.021
RR (v ₂ = 10N)	0.967	0.966	0.933	1.010	0.934	0.888	0.896	1.005
EN (30 variables, v ₂ = 0.25)	1.033	1.247	1.358	1.206	1.049	0.888	0.993	1.113

(h) International subset = world commodity prices only

Univar. benchm. (RMSE/h)	International				New Zealand + international			
	h = 1	h = 2	h = 4	h = 8	h = 1	h = 2	h = 4	h = 8
PC (r = 1)	0.984	1.034	1.037	1.031	0.951	0.865	0.993	1.119
PC (r = 2)	1.082	1.067	1.075	1.041	0.984	0.910	1.097	1.284
PC (r = 3)	1.082	1.079	1.060	1.026	1.000	0.910	1.276	1.325
PC (r = 5)	1.049	1.090	1.104	1.144	1.016	0.989	1.366	1.686
WPCBN (r = 1)	0.984	1.022	0.985	0.943	0.951	0.910	1.007	1.134
WPCBN (r = 2)	1.033	1.067	1.015	0.948	0.934	0.831	1.194	1.144
WPCBN (r = 3)	1.066	1.079	1.015	0.974	1.016	0.854	1.142	1.134
WPCBN (r = 5)	1.000	1.146	1.097	1.010	1.033	0.921	1.224	1.232
WPCSW (r = 1)	1.033	1.090	1.075	0.995	1.066	1.180	1.134	1.077
WPCSW (r = 2)	1.016	1.056	1.015	0.954	0.967	0.876	1.030	1.134
WPCSW (r = 3)	1.033	1.079	1.067	0.954	0.934	0.888	1.022	1.325
WPCSW (r = 5)	1.049	1.101	1.075	1.067	1.016	0.899	1.112	1.294
TPH (r = 1)	1.049	1.180	1.231	1.242	0.951	0.978	0.970	1.015
TPH (r = 2)	0.951	1.225	1.246	1.057	0.967	0.955	0.955	1.320
TPH (r = 3)	1.180	1.213	1.090	1.000	0.984	1.034	0.978	1.273
TPH (r = 5)	1.164	1.079	1.149	1.175	1.131	1.000	1.470	1.402
TPS (30 variables, r = 1)	0.984	1.079	1.037	0.918	1.213	1.292	1.231	1.093
TPS (30 variables, r = 2)	0.984	1.067	1.015	0.995	1.164	1.281	1.254	1.196
TPS (30 variables, r = 3)	1.000	1.045	1.097	0.933	1.115	1.169	1.306	1.284
TPS (30 variables, r = 5)	0.967	1.101	1.142	1.031	1.148	1.236	1.239	1.314
PLS (k = 1)	1.049	1.236	1.119	1.196	0.951	0.854	0.940	1.098
PLS (k = 2)	1.295	1.618	1.328	1.479	1.049	1.045	1.299	1.356
PLS (k = 3)	1.492	1.596	1.478	1.536	0.902	0.787	0.970	1.351
PLS (k = 5)	1.770	1.966	1.784	1.701	0.934	1.034	1.194	1.273
RR (v ₂ = 0.25)	2.951	3.382	3.396	3.227	1.016	0.989	1.194	1.335
RR (v ₂ = N)	1.148	1.247	1.104	1.093	0.902	0.820	0.948	1.165
RR (v ₂ = 5N)	1.016	1.067	1.000	0.995	0.934	0.876	0.925	1.036
RR (v ₂ = 10N)	1.016	1.034	0.993	0.990	0.934	0.899	0.933	1.005
EN (30 variables, v ₂ = 0.25)	1.934	2.112	1.746	2.325	1.049	0.933	1.299	1.057

Notes: RMSE(model)/RMSE(univariate). Minima are in bold, and relative RMSEs < 1 are in gray. For the trade-weighted aggregates, we consider the following information: real: GDPs of all 12 countries; prices: CPIs of 12 countries; monetary and financial: interest rates of 5 countries; North America: GDPs and CPIs of the US and Canada and US interest rates; Europe: GDPs, CPIs and interest rates of the euro area and the UK; Asia: GDPs and CPIs of all Asian countries and interest rates of Japan; Australia: Australian GDP, CPI and interest rates. For more details on the forecasting setup, see the text.

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