

Appendix only: Daily nowcasting of global and Australian GDP growth¹

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Full article: [Daily nowcasting of global and Australian GDP growth](#)

Published: 26 May 2021

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This appendix explains the technical details for the GDP nowcasting contained in Anthonisz (2021). This includes details of:

A.1: Method

A.2: Robustness checks

A.3: Data

A.1: Method

There are many approaches that can be used to prepare a nowcast, each of which has its own benefits.² Relative to other nowcasting methodologies, Mixed Data Sampling (MIDAS)³ is parsimonious, robust, and accurate.⁴ The benefits of MIDAS also carry over to the factor-augmented version (FAMIDAS) which has the additional advantage of reducing the dimensionality of the data.⁵ For these reasons, FAMIDAS was the technique chosen for this exercise.

The steps below outline how daily nowcasts of global and Australian GDP growth were generated in this paper.

1. Download the data set out in A.3.
2. Sort the data into different groups. At the global level data was grouped into area of focus⁶ as this allowed information to be efficiently summarised across countries. For Australia, data was organised according to its frequency and relationship to underlying economic activity⁷ as this led to a better fit than grouping by focus.
3. Prepare the data by making it stationary and normalising it to have a mean of zero and standard deviation of one. The data was also cleaned to fill-in missing values, including at the end of the sample period.⁸

¹ This article draws on discussion from, while updating and extending the analysis in, this blog I did in late 2018.

² For example, Bayesian vector autoregressions (Cimadomo, 2020), factor-augmented vector autoregressions (Grui & Lysenko, 2017), dynamic factor models (Bok et al 2017), mixed frequency VARs (Kuzin et al 2009), MIDAS (Mixed Data Sampling) (Clements & Galvao, 2007), factor augmented MIDAS (Fererra & Marsilli, 2014), accounting-based tracking models (Higgins, 2014), and bridge equations (Ferrara & Simoni, 2018).

³ An intuitive explanation of MIDAS can be found [here](#) while a more practical explanation can be found in Ghysels, Sinko & Valkanov (2006).

⁴ For example, Clements & Galvao, 2008, Lindgren & Nilsson, 2015, Andreou, Ghysels & Kourtellis (2012).

⁵ These models have been found to be useful for nowcasting annual GDP growth on a monthly basis by Fererra & Marsilli (2014) or, in a post-COVID-19 exercise, for nowcasting annual GDP on a weekly basis by Jarret & Meunier (2020).

⁶ Specific areas of focus refer to:

- cross-country groupings of data on consumer sentiment, retail spending, employment growth, the unemployment rate and capacity utilisation
- surveys as well as series which could give a sense of demand conditions (real commodity prices, industrial production, steel production, semiconductor sales as well as import and export growth) at the global level

⁷ The frequency of the series is monthly or quarterly while relationship to underlying economic activity refers to whether the data series could be seen as a leading or coincident indicator of economic activity. This led four data groupings: Quarterly Leading; Quarterly Coincident; Monthly Leading; and Monthly Coincident.

⁸ It is common for values to be missing for some series at the end of the period while being available for others. This reflects the varying release dates for different economic data series and is known as the 'ragged edge' or 'jagged edge' problem. There are various ways in which this can be addressed. In this exercise, the latest available observation was taken if data for the period in question had as not yet been released. This is known as the 'realignment strategy' and has been used in several studies, for example Marcellino & Schumacher (2007).

4. Extract common factors from the relevant global and Australian data sets. In this exercise, principal components analysis (PCA) was used for the global data and the Kalman Filter for the Australian data.⁹
5. Use these factors as inputs into a MIDAS model, as well as a lag of the dependent variable.¹⁰
6. Estimate the model
 - Dependent variable (Global): Annual growth in world GDP (constant prices, seasonally adjusted, USD) from Oxford Economics available on a quarterly basis
 - Independent variables (Global): The Surveys factor¹¹ extracted from the series in Table 1 is the monthly variable and the Citi Global Data Change Index is the daily variable
 - Other (Global): Auto lag selection was used for the independent variables with a maximum lag set to 10 and with a polynomial degree of 1 for the PDL/Almon weighting. These settings were chosen to facilitate estimation and maximise fit.
 - Dependent variable (Australia): Annual growth in Australian GDP (constant prices, seasonally adjusted) from the ABS available on a quarterly basis
 - Independent variables (Australia): The leading and coincident factors for both the quarterly and monthly frequencies were extracted from the data series in Table 2. The Citi Australian Data Change Index and QTC's Financial Conditions Index (to be the focus of a future note) are the daily variables.
 - Other (Australia): The lags were fixed at 10 for the monthly and daily independent variables and the default setting of a polynomial degree of 3 for the PDL/Almon weighting was chosen. These settings were chosen to facilitate estimation and maximise fit.
7. Recursively estimate the FAMIDAS model so that nowcasts of annual GDP growth can be generated for each day. This involves preparing rolling daily forecasts from the first day of the current quarter onwards. In each iteration of the roll, the last 10 observations of the daily and monthly variables are used to estimate annual GDP growth. This procedure can be repeated though earlier periods such that you can create a time series of rolling daily forecasts of the quarterly variable (annual GDP growth).¹² The Australian nowcast was smoothed to be a rolling fortnightly average of the daily estimates.

A.2: Robustness checks

Various robustness checks were performed for both the global and Australian nowcasts:

- Independent variables – Different combinations of the factors extracted were used in the FAMIDAS regression¹³
- Time period – Used different sample periods though these didn't change the model's fit
- Factor extraction – Used the Kalman Filter¹⁴ and PCA to reduce the dimensionality of the data with similar results
- Out-of-sample forecast assessment – Compared the forecast accuracy relative to an autoregressive model of GDP growth with one lag [AR(1)] as well as other specifications which focussed on the PMI indicators (global) and the Quarterly Leading and Monthly Coincident factors (Australia).¹⁵
 - The global nowcast had lower forecast errors than the benchmark AR(1) model but higher ones than the PMI focussed models. The Australian nowcast had lower forecast errors relative to all the other models examined. For both the global and Australian nowcasts, the differences in forecast accuracy were not statistically significant according to Diebold-Mariano tests. Though there were mixed results

⁹ I have used the Kalman Filter for the Australian data to address issues related to missing data and an unbalanced dataset. The Kalman Filter is described in the [technical appendix](#) to [this note](#) from my colleague Trent Saunders. PCA was also explained in section A.3 of the [technical appendix](#) to [this note](#) by Trent Saunders.

¹⁰ As per the FAMIDAS in [Fererra & Marsilli \(2014\)](#), only the first factor from the data was used for the global nowcast. For the factors derived from the quarterly and monthly Australian data, only the first factor extracted was used. That is, the first factor from the Quarterly Leading, Quarterly Coincident, Monthly Leading and Monthly Coincident data sets were used in the MIDAS model. It should be noted that these factors are not orthogonal and thus, there may be overlap between them. However, the results were not significantly different if only using one or two of these.

¹¹ Throughout this appendix I will refer to this group of monthly data series collectively as survey-based measures even though one of the variables included is the OECD Leading Indicator which is not survey-based. The usefulness of survey based measures in forecasting GDP growth is consistent with studies such as [LeBouef & Morel \(2014\)](#) and [Garnitz, Lehman & Wohlrabe \(2019\)](#).

¹² More information on this process can be found in [this](#) blog and in an example in this [EViews program](#).

¹³ See footnote 6 for the global factors. No combination offered an outcome that was superior to the preferred specification. For Australia, the factors with the best univariate explanatory power over GDP growth were the Quarterly Leading and Monthly Coincident factors. However, these offered very similar results to those for the regression in which all factors were included.

¹⁴ Where it was able to converge to a solution

¹⁵ Additional specifications for these latter ones also included an autoregressive term for annual GDP growth

in terms of improving forecast accuracy relative to benchmark models, the main benefit from using the nowcasts is the ability to have updated estimates available in real-time.

A.3: Data

At the global level, the shared trend was extracted from the monthly survey measure data set out in Table 1. The daily variable is the Citi Global Data Change Index.

Table 1: Data series used (Global)

Frequency	Data segment	Series
Monthly	Survey	J.P. Morgan Composite (Services & Manufacturing) Employment, Global
		J.P. Morgan Services New Business, Global
		J.P. Morgan Manufacturing New Orders, Global
		Sentix Investor Sentiment, Global
		Sentix Investor Sentiment – Current Situation, Global
		Sentix Investor Sentiment – Future Expectations, Global
Monthly	Activity	OECD Leading Indicator, Global
Daily		Citi Global Data Change Index, Global

Source: Bloomberg and Refinitiv

For Australia, the series from which common factors were extracted to proxy for leading and coincident measures of economic activity at both quarterly and monthly frequencies are set out in Table 2. The daily variables are QTC's Financial Conditions Index¹⁶ and the Citi Australian Data Change Index.

Table 2: Data series used (Australia)

Frequency	Data segment	Series
Daily	Activity	Citi Australian Data Change Index
		QTC Financial Conditions Index
Quarterly	Corporate activity (leading)	Westpac-ACCI Survey – Expectations
		Westpac-ACCI Survey – Output, next 3 months
		NAB Business Survey – Sales, expected
		NAB Business Survey – Sales, change in next 12 months
		NAB Business Survey – Trading performance, expected
		Westpac-ACCI Survey – New orders, next 3 months
		NAB Business Survey – Forward orders, expected
		NAB Business Survey – Confidence, expected
	Corporate profitability (leading)	Westpac-ACCI Survey – Expectations - Profits, next 12 months
		NAB Business Survey – Margins, next 3 months
		NAB Business Survey – Profitability, expected
		NAB Business Survey – Profitability, change in next 12 months
	Corporate capex (leading)	Westpac-ACCI Survey – Investment intentions, next 12 months – Buildings
		Westpac-ACCI Survey – Investment intentions, next 12 months – Plant & equipment
		Westpac-ACCI Survey – Capital expenditure, next 12 months
		NAB Business Survey – Capital expenditure, next 12 months

¹⁶ Will be the focus of a future note. The benefits of nowcasting using daily financial data has been established in [Tay \(2006\)](#) and [Andreou, Ghysels & Kourtellis \(2012\)](#)

Frequency	Data segment	Series
	Corporate access to credit (leading)	Westpac-ACCI Survey – Financing difficulty greater than three months ago
		Westpac-ACCI Survey – Factors limiting production - Finance
		NAB Business Survey – Borrowing conditions - Net
	Spare capacity (leading)	Westpac-ACCI Survey – Overtime worked, next 3 months
	Labour demand (leading)	NAB Business Survey – Employment, expected
		NAB Business Survey – Employment change, next 12 months
		Westpac-ACCI Survey – Number employed, next 3 months
		Westpac-ACCI Survey – Overtime worked, next 3 months
		ABS Job Vacancies
	Labour cost (leading)	NAB Business Survey – Labour costs, expected
	Inflation (leading)	Westpac-ACCI Survey – Average selling prices, next 3 months
		Westpac-ACCI Survey – Final product prices, next 3 months
		Westpac-ACCI Survey – Final product retail prices, next 3 months
		Westpac-ACCI Survey – Average unit costs, next 3 months
Westpac-ACCI Survey – Purchase costs, next 3 months		
Property (leading)	Westpac-MI Consumer Sentiment Survey – Wisest place for savings - Property	
Quarterly current	Corporate activity (coincident)	Westpac-ACCI Survey – Composite, actual
		Westpac-ACCI Survey – Output, last 3 months
		Westpac-ACCI Survey – General business situation
		Westpac-ACCI Survey – New orders, last 3 months
		NAB Business Survey – Sales & orders, significant constraint
		Westpac-ACCI Survey – Factors limiting production, orders
		Westpac-ACCI Survey – Factors limiting production, materials
		Westpac-ACCI Survey – Factors limiting production, capacity
		Westpac-ACCI Survey – Factors limiting production, other
		Westpac-ACCI Survey – Capacity utilisation
	Corporate profitability (coincident)	NAB Business Survey – Margins, last 3 months
	Corporate capex (coincident)	ABS Business investment
		NAB Business Survey – Premises & plant, significant constraint
	Consumer spending (coincident)	ABS Household consumption
Westpac-MI Consumer Sentiment Survey – Wisest place for savings – Spend it		
Westpac-MI Consumer Sentiment Survey – Wisest place for savings - Banks		
Westpac-MI Consumer Sentiment Survey – Wisest place for savings – Pay back debt		
Spare capacity (coincident)	Westpac-ACCI Survey – Capacity utilisation	
	Westpac-ACCI Survey – Factors limiting production, materials	
	Westpac-ACCI Survey – Factors limiting production, capacity	
	Westpac-ACCI Survey – Factors limiting production, orders	
	NAB Business Survey – Sales & orders, significant constraint	

Frequency	Data segment	Series
		NAB Business Survey – Availability of labour, significant constraint
		Westpac-ACCI Survey – Factors limiting production, other
		Westpac-ACCI Survey – Factors limiting production, labour
		Westpac-ACCI Survey – Hiring difficulty last 3 months
		Westpac-ACCI Survey – Overtime worked last 3 months
	Labour demand (coincident)	Westpac-ACCI Survey – Labour market composite
		Westpac-ACCI Survey – Number employed last 3 months
		Westpac-ACCI Survey – Overtime worked last 3 months
		Westpac-ACCI Survey – Factors limiting production, labour
		Westpac-ACCI Survey – Hiring difficulty last 3 months
		NAB Business Survey – Availability of labour, significant constraint
	Labour costs (coincident)	Westpac-ACCI Survey – Enterprise wage deal
	Inflation (coincident)	Westpac-ACCI Survey – Average selling prices, last 3 months
		Westpac-ACCI Survey – Final product retail price, last 3 months
		NAB Business Survey – Price of final products
		Westpac-ACCI Survey – Average unit costs, last 3 months
Monthly	Business Activity (leading)	AiG Services PMI – New Orders
		AiG Manufacturing PMI – New Orders
	Corporate capex (leading)	ABS Non-residential building approvals
	Consumer spending (leading)	Westpac-MI Consumer Sentiment
		Westpac-MI Consumer Sentiment -Expectations
		Westpac-MI Consumer Sentiment – Economic conditions in 1 yr
		Westpac-MI Consumer Sentiment – Economic conditions in 5 yr
		Westpac-MI Consumer Sentiment – Family finances in 1 yr
		ABS Personal finance – Revolving commitments
	Labour demand (leading)	Westpac-MI Consumer Sentiment – Unemployment expectations
		ANZ Job ads
		Australian Government Department of Jobs & Small Business – Employment leading indicator
	Inflation (leading)	Westpac-MI Consumer inflationary expectations – Weighted mean (range)
	Property (leading)	Housing finance for owner-occupiers - construction
		Housing finance for owner-occupiers – purchase of new property
		Residential building approvals - Total
		Residential building approvals – Alterations & additions
		AiG/HIA Construction PMI – New Orders
	Other (leading)	Westpac-MI – Leading Index
Monthly	Corporate activity (coincident)	AiG Manufacturing PMI – Production
		NAB Business Survey – Trading
		NAB Business Survey – Business Conditions
		NAB Business Survey – Capacity utilisation
		AiG Manufacturing PMI – Capacity utilisation
		AiG Services PMI – Capacity utilisation

Frequency	Data segment	Series
	Corporate profitability (coincident)	NAB Business Survey – Profitability
	Corporate capex (coincident)	NAB Business Survey – Capital expenditure
	Consumer spending (coincident)	ABS Retail sales
		Motor vehicle sales
		Westpac-MI Consumer Sentiment – Family finances, now
		Westpac-MI Consumer Sentiment – Current conditions
		Westpac-MI Consumer Sentiment – Time to buy a major household item
	Spare capacity (coincident)	NAB Business Survey – Capacity utilisation
		AiG Manufacturing PMI – Capacity utilisation
		AiG Services PMI – Capacity utilisation
		AiG/HIA Construction PMI – Capacity utilisation
		Newstart Allowance payments
		ABS Underutilisation rate
		ABS Unemployment rate
		ABS Underemployment rate
	Labour demand (coincident)	ABS Employed persons
		ABS Hours worked
		ABS Underutilisation rate
		ABS Unemployment rate
		ABS Underemployment rate
		ABS Participation rate
		Newstart Allowance payments
		NAB Business Survey – Employment
		AiG Manufacturing PMI – Employment
		AiG Services PMI – Employment
		AiG/HIA Construction PMI – Employment
	Labour cost (coincident)	AiG Manufacturing PMI – Average wages
		AiG Services PMI – Average wages
		AiG/HIA Construction PMI – Average wages
	Inflation (coincident)	MI Inflation Gauge, Excluding volatile items
		MI Inflation Gauge, Trimmed mean
		NAB Business Survey – Prices of final products
		NAB Business Survey – Retail prices
		NAB Business Survey – Purchase Costs
	Property (coincident)	Core-Logic 5-capital city dwelling price index
		Core-Logic 5-capital city rental yield
		HIA Private new home sales (mainland states)
		AiG/HIA Construction PMI – Activity
		AiG/HIA Construction PMI – Capacity utilisation

Source: Bloomberg and Refinitiv