Reserve Bank of New Zealand
Analytical Notes

A factor model of commodity price co-movements: An application to New Zealand export prices

AN2017/06

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November 2017

Reserve Bank of New Zealand Analyical Note Series
ISSN 2230 ‐ 5505

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NON-TECHNICAL SUMMARY[1]

An important focus for the Reserve Bank of New Zealand as a central bank of a small commodity exporting country is to understand movements in commodity prices and their flow through to incomes, real economic activity and inflation. Idiosyncratic movements in New Zealand export prices can have different implications for terms of trade and incomes compared to a generalised movement in all commodity prices. Therefore, a framework that can help distinguish between general and idiosyncratic movements in commodity prices can help shed some light on the implications for the New Zealand economy of movements in export commodity prices.

In this analytical note, we use principal component analysis to estimate the underlying global trend in commodity prices and then determine whether movements in New Zealand dairy and meat export prices can be explained by the global trend in commodity prices or by idiosyncratic events in each market. Using commodity price data from 1986, we find that 95 and 93 percent of the volatility of New Zealand's dairy and meat export prices can be attributed to the global trend. In addition, we find evidence that the divergence between commodity prices and our estimate of the global trend can be used to forecast individual commodity prices, in particular dairy prices. We conclude that if dairy prices are above the level implied by the global trend, then they will tend to fall until they reach the level implied by the global trend and vice versa.

1 Introduction

This analytical note uses principal component analysis to extract an estimate of the underlying global trend in commodity prices. This estimate is also referred to as the global factor. Comparing movements of key New Zealand export commodity prices, dairy and meat, to this trend enables an assessment of whether price movements are due to idiosyncratic developments in each market or due to a common global trend.

It is important for the Reserve Bank to distinguish between these price movements as they have different implications for inflation and the Reserve Bank's monetary policy stance. If New Zealand export prices are following a global trend this may have broader implications for imported inflation. If New Zealand export prices move due to an idiosyncratic factor in a specific commodity markets, this may have implications for New Zealand's terms of trade and overall economic incomes.

[1] The authors would like to thank Jed Armstrong, and delegates at the NZAE 2017 conference for their contributions to the note.

There is mixed evidence for the co-movement of commodity prices. Pindyck and Rotemberg (1990) found evidence for excess co-movement of commodity prices. Gilbert (2010) and Svensson (2008) found that global demand and supply factors can explain global co-movements in commodity prices. However, Cashin, McDermott and Scott (1999) replicated the Pindyck and Rotemberg (1990) results redefining co-movement as concordance instead of correlation[2] and found no evidence that unrelated commodity prices move together. Further, Cashin, McDermott and Scott (2002) find asymmetric behaviour in commodity price booms and slumps.

This note follows West and Wong (2014) who found evidence of an error-correcting relationship between individual commodities and the global trend in commodity prices and concluded that overall commodity prices tended to revert to a global factor over a 12 month period.

We take West and Wong's (2014) framework and findings and use them to describe the relationship between New Zealand's goods export prices and our estimate of the global trend in commodity prices. The cointegrating relationship between the global trend and commodity prices allows us to understand whether price movements in individual commodity markets are predominantly due to either a particular demand or supply event occurring in that market, or the influence of the global trend.

The rest of this note is as follows. Section 2 introduces the principal component analysis which is used to create a global factor of commodity prices. Section 3 uses this finding to analyse historical movements in dairy and meat prices in relation to the global factor and section 4 comments on the outlook for dairy and meat prices based on this analysis. Section 5 concludes.

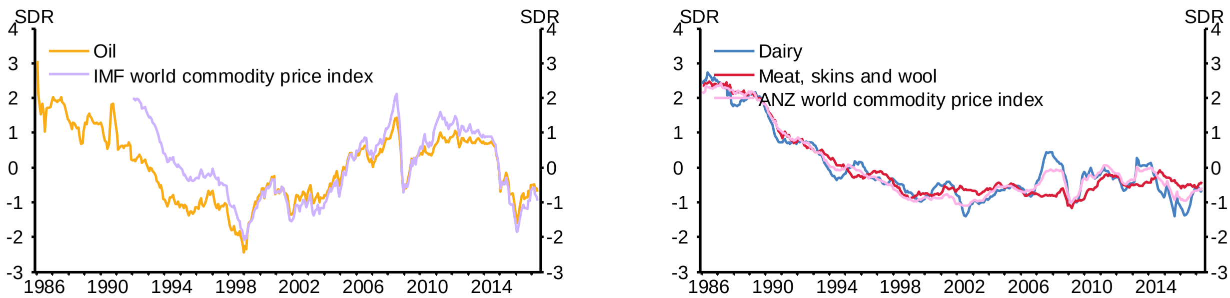
2 Applying principal component analysis to commodity prices

We use principal component analysis to construct a measure of the global trend. A common method for summarising movements in commodity prices is to use a commodity price index; however consideration must be given to the weightings behind the index. The IMF index applies a 53 percent weighting on spot crude oil so the IMF index will closely follow the trend in oil prices (figure 1, left). The ANZ world price index is weighted towards New Zealand export goods so more closely reflects trends in dairy and meat prices (figure 1, right). Using principal component to extract a common factor allows for an agnostic

[2] Concordance is the proportion of time that prices of commodity are in the same boom or slump period.

view on weighting. Cashin, McDermott and Scott (1999) find that commodity prices exhibit a large amount of individual variation in their cyclical behaviour and Cashin and McDermott (2002) find that commodity prices exhibit small trends and large volatility. These papers suggest a single index may not capture all of the variation in a collection of commodity prices. Principal component analysis allows us to test the significance of lower order components.

Figure 1: Summary measures of commodity prices



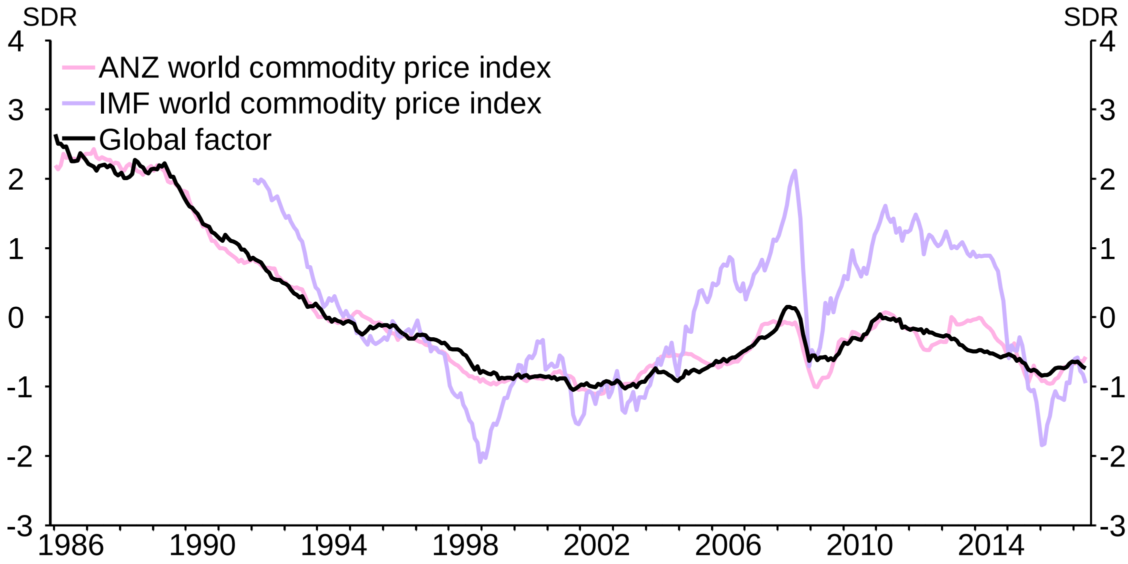
Source: IMF, ANZ

To construct our estimate of the global trend, principal component analysis is applied to a panel of global commodity prices including 53 energy, metal and agricultural prices from the World Bank and ANZ commodity price datasets.[3] Within the panel of commodity prices, only one price for each commodity has been used. ANZ prices are added to the panel for New Zealand exports (dairy; meat skin and wool; horticulture; forestry; and seafood) in place of the World Bank prices, as these prices are used in the Bank's internal forecasting process. The prices are converted from NZ or US dollar terms into real special drawing rights (SDR) terms. The SDR is defined as a basket of currencies and is used to separate out the effects of movements in a particularly currency. The prices are then deflated using the IMF world consumer price index and logged and standardised for comparability. The data set is constructed from January 1986 to June 2017.

The first principal component estimated from our panel explains 83 percent of the variation in the panel of commodity prices and appears to be in line with the ANZ and IMF indices (figure 2). The second principal component explains only 6 percent of the variation in the data. Hence, to simplify interpretation, the first principal component is used to represent the global factor.

[3] Sourced from World Bank and ANZ. See the Appendix D for full description of World Bank data and sources.

Figure 2: World commodity price indices and the global factor



Source: IMF, ANZ, RBNZ estimates

To strengthen the conclusion that the first principal component is a robust measure of underlying commodity prices, West and Wong (2014) found that prices consistently display a tendency to revert to the estimated factor. They tested this using an in-sample regression and found over one year 80% of the gap between an individual commodity price and the factor was expected to be closed. West and Wong (2014) then test whether a divergence between an individual commodity price and the global factor can forecast future commodity price movements. Using root mean squared prediction error (RMSPE) as a measure of performance, West and Wong (2014) found these forecasts performed well at the 12-month horizon compared to forecasts generated from a random walk,[4] an industrial production model and an exchange rate.[5] In particular, West and Wong (2014) found that the global factor model forecasts of energy performed well, forecasts of metals did not perform well, and the agricultural forecasts performance fell somewhere in between. Taking West and Wong's (2014) result as given suggests our global factor is a good characterisation of the underlying common trend in global commodity prices.

3 Forecasting commodity prices

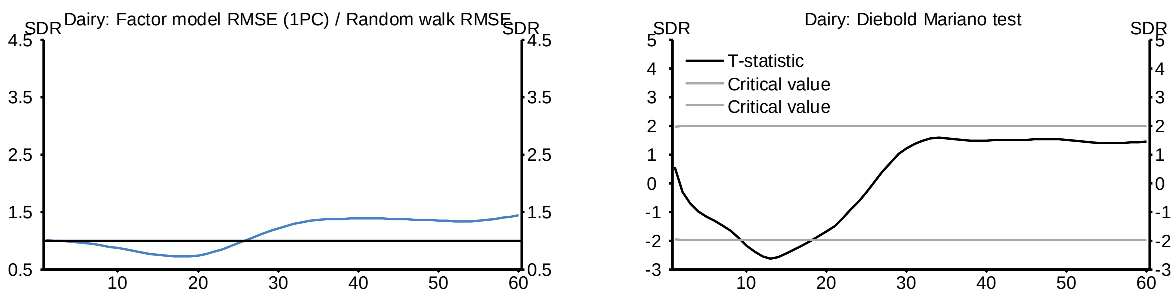
To examine West and Wong's (2014) error-correcting relationship we assess how well our factor model forecasts dairy and meat. Similar to West and Wong (2014) we find the model performs adequately for agricultural prices. We focus on dairy and meat prices as

[4] A random walk forecast is a flat line (no change) forecast. It is often the best performing forecast for series that are very difficult to predict such as commodity prices.
[5] The methodology is outlined in detail in Appendix B.

they are New Zealand's two largest merchandise exports, accounting for 37 percent (25 and 12 percent respectively) of total merchandise exports in the year to June 2017. We find that our factor model forecasts dairy better than a random walk model at the 12 to 15 month horizon. However, the forecasts for meat prices are not significantly different from those of a random walk in the short to medium term (using the Diebold Mariano (1995) test). These estimates reinforce our ability to generalise the West and Wong (2014) approach to New Zealand's export commodities, in particular to dairy prices.

Figure 3 shows the ratio of the factor model root mean squared error (RMSE) to the random walk RMSE for dairy. At first glance, it appears the dairy forecast performs better than the random walk forecast, as the ratio of RMSE falls below one at the eight to 25 months ahead horizon. To test the null hypothesis of equal RMSE against the alternative that the two RMSE are significantly different the Diebold Mariano test is used. The second row of figure 3 plots the Diebold-Mariano (1995) test statistic relative to the critical value and shows the dairy RMSE ratio is only statistically different at the 10 to 19 months ahead horizon (or about 1 year ahead). This enables us to conclude the dairy factor model forecasts outperform the random walk forecasts at the 10 to 19 month ahead horizon.

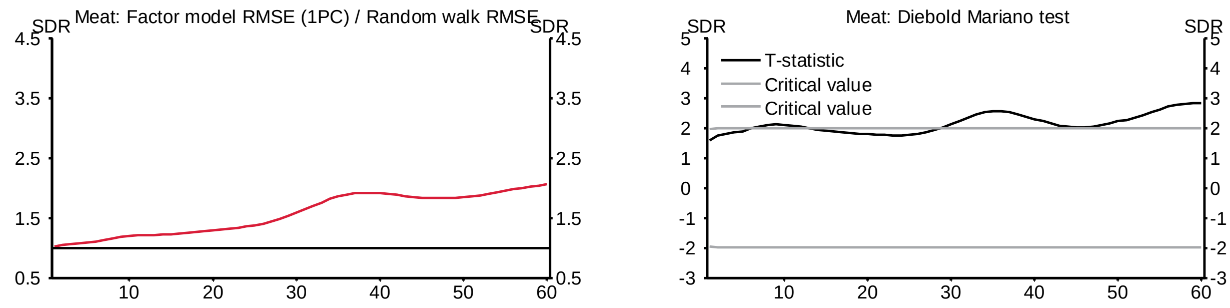
Figure 3: Dairy factor model forecast performance



Source: RBNZ estimates. Note: the horizontal axis displays the forecast horizon in months

Likewise, figure 4 shows the ratio of the factor model RMSE to the random walk RMSE for meat. The RMSE ratio is above one, but it is only statistically significantly different at the 10 months ahead horizon, and then after 24 months ahead. This enables us to conclude that at the medium term (between 10 to 24 months) the factor model performs as well as a random walk.

Figure 4: Meat factor model forecast performance



Source: RBNZ estimates. Note: the horizontal axis displays the forecast horizon in months

4 Understanding dairy and meat price movements

The West and Wong (2014) results and our forecasting results enable us to use the factor model to determine whether movements in dairy and meat prices are explained by common global developments or idiosyncratic events in each market. We find that common global developments in commodity prices explain 95 and 93 percent of the volatility in dairy and meat prices since the start of our data set. It is therefore useful to compare the global factor to each commodity price in order to understand periods where the commodity price differed significantly. In order to do this we create a fitted global factor price for each commodity[6] and plot it against that commodity's price, showing periods where the difference between the two prices is greater than one standard deviation.[7]

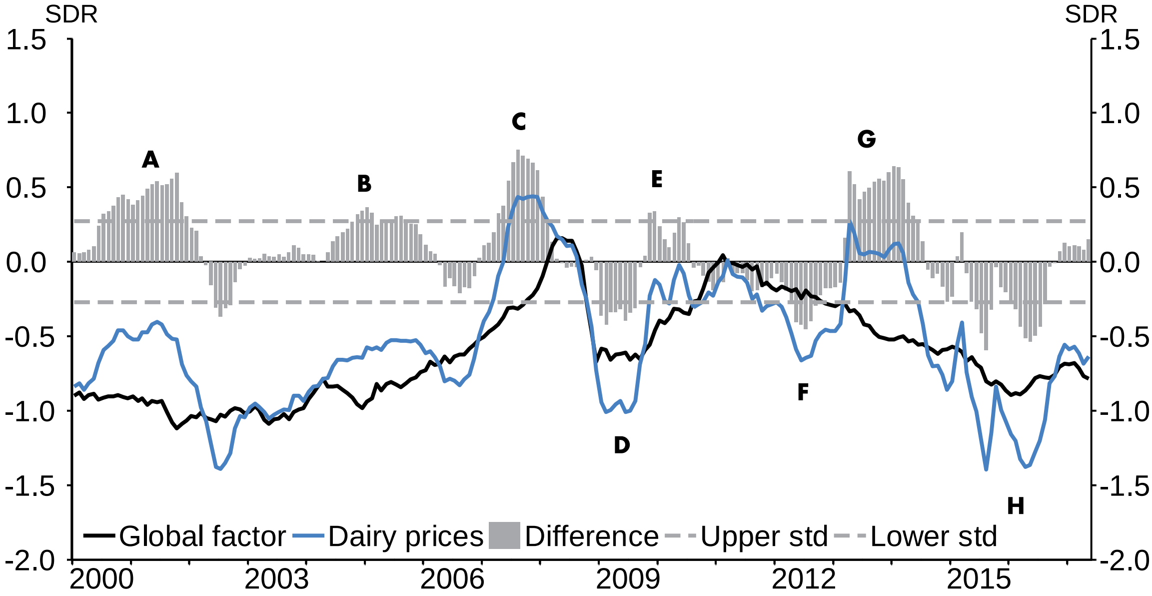
Dairy prices

Figure 5 charts dairy prices compared to our fitted global factor focusing on the period from 2000. It shows that the general trend in dairy prices follows movements in the global factor but there are also periods where the influence of idiosyncratic events in the global dairy market outweighs the global factor. On figure 5 these are shown as the periods when dairy prices differ significantly from the global factor (by more than one standard deviation). The results of our forecasting exercise indicate that going forward we could expect dairy prices to remain at current levels in the short to medium term unless significant events in the dairy industry occur for example developments in farm support policies in the EU and US.

[6] The fitted global factor $F1_{i,t}$ is constructed following $F1_{i,t} = \partial_{1,i} * PC1_t$ where $\partial_{1,i}$ represents the loading of commodity *i* on the first principal component $PC1_t$.

[7] The principal component is estimated with the full sample of data, but for ease of interpretation the chart ranges begin at 2000.

Figure 5: Comparing the global factor (fitted) to dairy prices



Source: RBNZ estimates, ANZ.

Below, we relate the recent episodes of divergence and convergence between dairy prices and the global factor through history to some idiosyncratic developments in the dairy sector.[8]

A. 2000-2002: volatile dairy prices.
   - The EU and US dairy production markets were not fully exposed to global market forces due to supportive government farm policies. The portion of the market trading at truly free global market forces was small and more easily influenced by idiosyncratic events.

B. 2003: higher dairy prices.
   - US relaxed dairy farm support increased US production.
   - Reduced production from Australia and the EU.

C. 2007: higher dairy prices.
   - Adverse weather conditions in Australia, Argentina and Uruguay reduced production.
   - Increased dairy demand from emerging economies.

D. 2009: lower dairy prices
   - Relaxation of farm support and (restrictive) dairy production quotas in EU. These relaxations changed production incentives and resulted in an increasing number of more efficient farms.

[8] The analysis draws from data and analysis from CLAL, Eurostat, Haver Analytics, USDA, RBNZ estimates, Briggs et al (2011) and Wheeler (2014).

- Global financial crisis (reduced demand for consumption goods).

E. 2010: higher diary prices.
- Strong recovery in dairy prices due to increased demand from China and economic recovery in developed countries.
- EU buying interventions extended into early 2010.

F. 2012: lower dairy prices
- Increased production in US, EU and Australia and South American countries as they responded to previously higher dairy prices.

G. 2013: higher dairy prices
- Increase in demand from China due to increased wealth and changing consumption preferences.
- Drought in New Zealand, declines in EU production, adverse weather in Asia and an outbreak of foot and mouth disease in China decreases production.

H. 2014 – 2015: lower dairy prices
- Further removal of industry support in the EU increases EU production.
- Strong supply response from key exporters to previous high prices.
- Weak import demand from China and Russia.

Meat, skin and wool prices

The historical composition of the meat price index is difficult to reconcile with divergences between the global factor and prices. This is partly because the ANZ index is made up of lamb and beef as well as skins and wool prices. However, prices generally follow broader commodity trends as shown in figure 6.

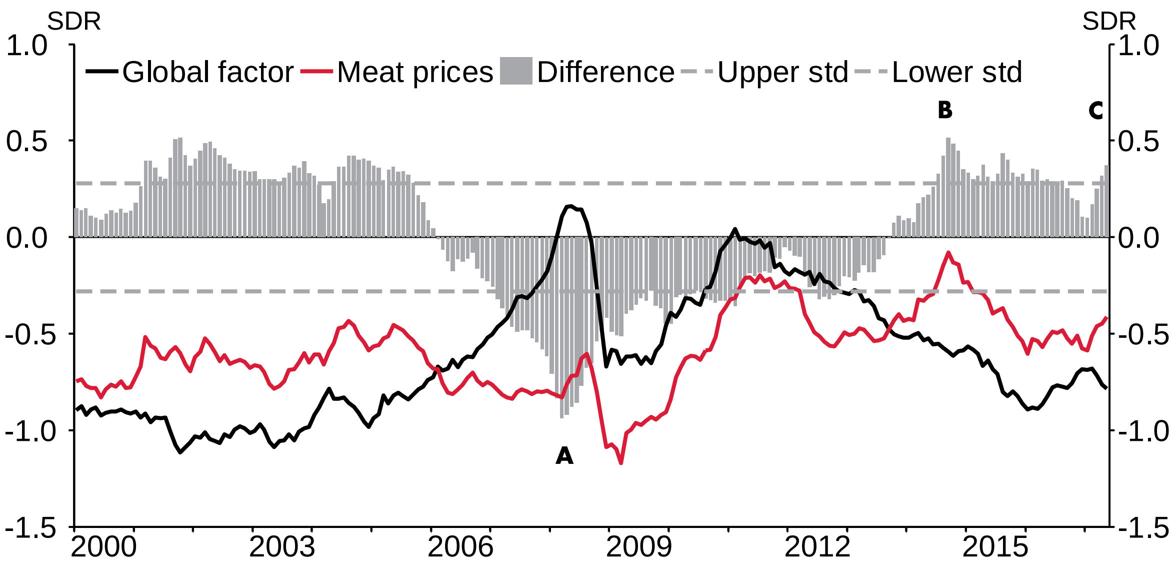
There is a particularly large deviation between the global factor and meat prices from 2007 to 2010 (labelled A). Briggs et al. (2011) noted there were several factors influencing the differing types of meat supply and demand during this period. In particular, due to the global financial crisis at this time, the demand for lower grade beef increased as higher grade beef became a luxury product. Combined with lower imported beef supplies to the United States, prices for lower grade beef rose in early 2008, but by late 2008, overall demand (and prices) for both lower grade beef and higher grade beef had declined. There was also a fall in manufacturing resulting in lower demand for leather, and which caused the price of skins to drop through this period.

After being below the global factor through the financial crisis, meat prices had a swift recovery in the years following the financial crisis. This is in line with the global factor, although rising global price of grains also increased the cost of production in the US and

Europe. In 2011, lamb prices increased, driving the increase in the meat price index. Meat prices were significantly higher than the factor from 2014 – 2015 (labelled B). This can be explained by higher beef prices due to drought. In 2013 beef prices surged higher than the global factor following the US droughts in 2012 and 2014 and the Australian drought from 2012 to 2014.

The current strength in meat prices is also greater than the level given by the global factor (labelled C). This is due to price strength in lamb and beef prices through 2017. Lamb supply has been tight from New Zealand as favourable feed conditions have delayed slaughter, and Chinese demand has been strong due to Chinese approval of chilled lamb imports from NZ. Further, Brazil's beef exports suffered following corruption scandals which led to Brazilian beef import bans from several economies.[9]

Figure 6: Comparing the global factor (fitted) to meat, skin and wool prices



Source: RBNZ estimates, ANZ.

5 Conclusion

This paper introduced West and Wong's (2014) principal component analysis to characterise the global trend of global commodity prices. The error-correcting relationship between commodity prices and the global factor found by West and Wong (2014) is shown to be relevant for New Zealand's largest goods export markets dairy and meat, skin and wool. Using this model we can infer when past commodity price movements were driven by the global trend or by idiosyncratic events. This decomposition can help the Reserve Bank form a view on imported inflation and New Zealand's terms of trade, making it a useful tool informing the Reserve Bank's inflation outlook and monetary policy.

[9] Penny (2017)

Further, the error-correcting relationship between commodity prices and the global factor given by the West and Wong (2014) result can contribute to our view on future commodity price movements.

Future work could extend this analysis by performing West and Wong's (2014) forecasting exercise using an alternative summary measure of the trend in global commodity prices such as a commodity price index or measure of world activity. This would enable a comparison of whether a principal component or another measure of the global trend in commodity prices is better for estimating the error correcting relationship between individual commodity prices and the global trend in commodity prices.

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APPENDIX

A Loadings on first and second components

Loadings are given for the first and second principal component estimated from January 1986 to June 2017. These loadings are applied to the global factor in order to create the fitted global factor for each commodity.

Table 1: Principal component loadings

Rank	Commodity	Loading (PC1)	Loading (PC2)
1	Soft Red Winter Wheat	1.067	-0.358
2	Maize	1.0633	-0.1894
3	Horticultural	1.0633	-0.5386
4	Dairy	1.063	-0.0159
5	Soybean meal	1.0626	-0.0749
6	Soybean oil	1.0621	-0.096
7	Sorghum	1.061	-0.249
8	Meat/Skins/Wool	1.0607	-0.5753
9	5 Percent Broken White Rice	1.0594	-0.2609
10	Hard Red Winter Wheat	1.0588	-0.3818
11	A1 Special Rice	1.0525	0.1715
12	Coal	1.0494	0.7139
13	Tea	1.045	-0.8458
14	Woodpulp	1.0423	-0.9171
15	Forestry	1.0401	-1.1696
16	Barley	1.0383	-0.1682
17	Groundnuts	1.0301	-0.741
18	Groundnut oil	1.0299	-0.3428
19	Unmanufactured Tobacco	1.0271	-1.1112
20	DAP	1.0268	0.9248
21	Bananas	1.0261	-0.2908
22	Aluminium	1.026	-0.8941
23	Cocoa	1.0251	-0.269
24	Chicken	1.0248	-1.1109
25	Palm oil	1.0246	-0.3014
26	A Index Cotton	1.0205	-1.1251
27	Sugar	1.0182	-0.3212
28	Logs	1.0112	-1.1346
29	TSP	1.01	0.9457
30	Coffee	1.0094	-0.6023
31	Zinc	1.0068	-0.0881

32	Tin	1.0061	1.3053
33	Seafood	1.0054	-0.8148
34	Sawnwood	1.0025	-1.3367
35	Oranges	0.9996	-0.3707
36	Rubber	0.9955	1.0058
37	Copra	0.9904	-0.0404
38	Gold	0.9864	1.3233
39	Coconut oil	0.9847	-0.1041
40	Plywood	0.9766	-1.5429
41	Platinum	0.9743	1.2202
42	Copper	0.9698	1.4633
43	Fishmeal	0.9635	1.1765
44	Urea	0.9633	1.1632
45	Lead	0.9368	1.7177
46	Shrimp	0.9225	-2.0176
47	Silver	0.92	1.8006
48	Nickel	0.9119	0.676
49	Iron Ore	0.9078	1.8499
50	Phosphate Rock	0.8936	1.4611
51	Potassium Chloride	0.8922	1.3803
52	Oil	0.7783	2.2389
53	Gas	0.6777	-0.6803

Source: RBNZ estimates

B West and Wong's forecast methodology

Principal component analysis is used to compute a factor loading $\partial_{1,i}$ that relates the principal component $PC1_t$ to the i^{th} commodity price series. We specify the fitted value for each commodity i in equation (1) by fitting the first principal component to each commodity price using the factor loading.

$$\mathbf{F1_{i,t} = \partial_{1,i} * PC1_t} \quad (1)$$

The fitted global factor $F1_{i,t}$ is then used in a recursive forecast evaluation using equation (2).

$$\mathbf{p_{i,t+h} - p_{i,t} = \alpha + \beta(F1i_{,t} - p_{i,t})} \quad (2)$$

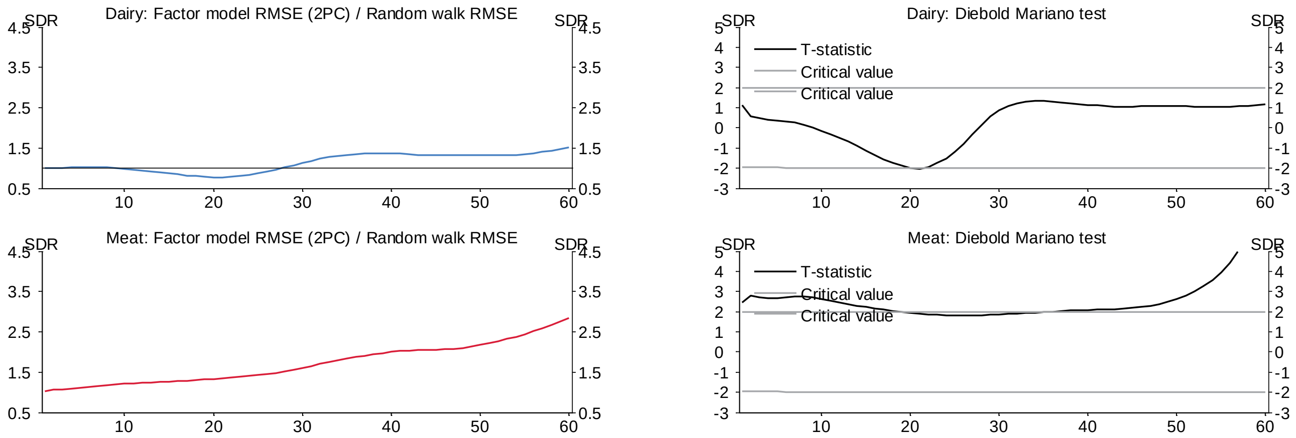
We make local linear projections with equation (2) for horizons (h) from 1 to 60 months (five years). For each horizon the RMSE of the forecast model is compared to the RMSE of a random walk forecast model. If the ratio is less than one then the forecast model out performs the random walk model (but not necessarily statistically significantly). The statistical significance of the ratio difference is tested using the Diebold Mariano (1995) test.

The forecasting exercise does not take into account how the factor itself may move in the forecast horizon.

C Estimating forecast models using two factor model

Figure 7 shows the factor model forecasts for dairy and meat using two principal components, and gives similar results.

Figure 7: Forecast performance of the two-component global factor (fitted) compared to the 'no change' model



Source: RBNZ estimates.

D World Bank commodity price series

Description

Coal (Australia), thermal, f.o.b. piers, Newcastle/Port Kembla, 6,700 kcal/kg, 90 days forward delivery.
Crude oil, average price of Brent, Dubai and West Texas Intermediate, equally weighed.
Natural Gas Index (Laspeyres), weights based on 5-year consumption volumes for Europe, US and Japan (LNG), updated every 5 years.
Natural Gas (U.S.), spot price at Henry Hub, Louisiana.
Cocoa (ICCO), International Cocoa Organization daily price, average of the first three positions on the terminal markets of New York and London, nearest three future trading months.
Coffee (ICO), International Coffee Organization indicator price, Robustas, average New York and Le Havre/Marseilles markets, ex-dock.
Tea, average three auctions, arithmetic average of quotations at Kolkata, Colombo and Mombasa/Nairobi.
Coconut oil (Philippines/Indonesia), bulk, c.i.f. Rotterdam.
Copra (Philippines/Indonesia), bulk, c.i.f. N.W. Europe.
Groundnuts (US), Runners 40/50, shelled basis, c.i.f. Rotterdam.
Groundnut oil (any origin), c.i.f. Rotterdam.
Fishmeal (any origin), 64-65%, c&f Bremen, estimates based on wholesale price.
Palm oil (Malaysia), 5% bulk, c.i.f. N. W. Europe.

Soybean meal (any origin), Argentine 45/46% extraction, c.i.f. Rotterdam.
Soybean oil (Any origin), crude, f.o.b. ex-mill Netherlands.
Soybeans (US), c.i.f. Rotterdam.
Barley (US) feed, No. 2, spot, 20 days To-Arrive, delivered Minneapolis.
Maize (US), no. 2, yellow, f.o.b. US Gulf ports.
Rice (Thailand), 5% broken, white rice (WR), milled, indicative price based on weekly surveys of export transactions, government standard, f.o.b. Bangkok.
Rice (Thailand), 100% broken, A.1 Super from 2006 onwards, government standard, f.o.b. Bangkok.
Sorghum (US), no. 2 milo yellow, f.o.b. Gulf ports.
Wheat (US), no. 1, hard red winter, ordinary protein, export price delivered at the US Gulf port for prompt or 30 days shipment.
Wheat (US), no. 2, soft red winter, export price delivered at the US Gulf port for prompt or 30 days shipment.
Bananas (Central & South America), major brands, free on truck (f.o.t.) Southern Europe, including duties.
Meat, chicken (US), broiler/fryer, whole birds, 2-1/2 to 3 pounds, USDA grade "A", ice-packed, Georgia Dock preliminary weighted average, wholesale.
Oranges (Mediterranean exporters) navel, EEC indicative import price, c.i.f. Paris.
Shrimp , (Mexico), west coast, frozen, white, No. 1, shell-on, headless, 26 to 30 count per pound, wholesale price at New York.
Sugar (world), International Sugar Agreement (ISA) daily price, raw, f.o.b. and stowed at greater Caribbean ports.
Logs (Southeast Asia), meranti, Sarawak, Malaysia, sale price charged by importers, Tokyo.
Plywood (Africa and Southeast Asia), Lauan, 3-ply, extra, 91 cm x 182 cm x 4 mm, wholesale price, spot Tokyo.
Sawnwood (Southeast Asia), Malaysian dark red seraya/meranti, select and better quality, average 7 to 8 inches; length average 12 to 14 inches; thickness 1 to 2 inches; kiln dry, c. & f. UK ports, with
Woodpulp (Sweden), softwood, sulphate, bleached, air-dry weight, c.i.f. North Sea ports.
Cotton (Cotton Outlook "CotlookA index"), middling 1-3/32 inch, traded in Far East, C/F.
Rubber (Asia), RSS3 grade, Singapore Commodity Exchange Ltd (SICOM) nearby contract.
DAP (diammonium phosphate), standard size, bulk, spot, f.o.b. US Gulf.
Phosphate rock (Morocco), 70% BPL, contract, f.a.s. Casablanca.
Potassium chloride (muriate of potash), standard grade, spot, f.o.b. Vancouver.
TSP (triple superphosphate), bulk, spot, granular, fob Tunisia.
Urea, (Black Sea), bulk, spot, f.o.b. Black Sea (primarily Yuzhnyy).
Aluminum (LME) London Metal Exchange, unalloyed primary ingots, standard high grade, physical settlement.
Copper (LME), standard grade A, cathodes and wire bar shapes, physical settlement.
Iron ore (any origin) fines, spot price, c.f.r. China, 62% Fe.
Lead (LME), refined, standard high grade, physical settlement.
Nickel (LME), cathodes, standard high grade, physical settlement.
Tin (LME), refined, standard high grade, physical settlement.
Zinc (LME), refined, standard special high grade, physical settlement.
Gold (UK), 99.5% fine, London afternoon fixing, average of daily rates.
Platinum (UK), 99.9% refined, London afternoon fixing.
Silver (UK), 99.9% refined, London afternoon fixing.

Sources

Bloomberg, Cotton Outlook, Fertilizer Week, INFOFISH, INTERFEL Fel Actualités hebdo, International Cocoa Organization, International Coffee Organization, International Rubber Study Group, International Tea Committee, International Tropical Timber Organization, Internatonal Sugar Organization, ISTA Mielke GmbH Oil World, Japan Lumber Journal, MLA Meat & Livestock Weekly, Platts International Coal Report, Singapore Commodity Exchange, Sopisco News, Sri Lanka Tea Board, US Department of Agriculture, US NOAA Fisheries Service, World Gas Intelligence.