The interaction of housing cycles with the wider economy in New Zealand: An analysis of filtering methods and cycles

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Abstract

The aim of this study is to investigate the cyclical co-movement of house prices with the construction sector, the credit cycle, and economic activity in New Zealand. I seek to find both the relationships between the cycles and if the choice of filtering method matters. The filters I have chosen to evaluate are the Hodrick-Prescott and the Christiano-Fitzgerald filters. I also performed a cross-correlation analysis to find the possible leads and lags in the relationships.

I find a relationship between the cyclical components between house price and all the variables I choose. Furthermore, I find that the choice of filtering method does influence the result. The Hodrick-Prescott and the Christiano-Fitzgerald filter provide a significantly different cyclical component for house prices and private sector credit. However, the choice of filtering method has less impact on the construction sector, mortgage rate, GDP, and the unemployment rate.

Nevertheless, the most significant cyclical relationship is found between house prices and building consents, with house prices either leading or lagging. I also find evidence of a two-way relationship between house prices and mortgage rates.

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Attestation of authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person except that which appears in the citations and acknowledgements. Nor does it contain material which to a substantial extent I have submitted for the qualification for any other degree of another university or other institution of higher learning.

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Section 1 Introduction

House prices and house affordability are an increasing problem, especially in New Zealand which has one of the highest house price-to-income ratios in the world (Statista, 2022).

As the real estate market is sensitive to economic shocks, the housing cycle can present a risk to financial stability. Housing booms often precede financial crises, and the size of the boom and bust can be amplified by highly leveraged mortgage lending (Thornley, 2016). Loose monetary policy and low interest rates stimulate large investment and borrowing, thereby increasing household debt. As a result, the housing market is heavily studied in the previous literature. For New Zealand Eaqub (2016) points out that record low interest rates have been a strong driver of house prices.

Houses have two purposes, which are consumption and investment (Goodhart, Hofmann, et al., 2006). As the consumption purposes, housing is an essential good for households to either rent or own. As the investment purposes, housing is a capital asset, can be traded in the market, which is challenging to study.

Furthermore, the housing market also has a wealth effect. Housing as a capital asset represents a significant portion of household wealth. Carvalho et al. (2022) shows the rising trend for the share of housing assets as a proportion of total household assets in New Zealand, over 57% in 2022. When house prices decline, households lose wealth, with highly mortgage levered households and property investors having higher losses than others. Household consumption and the economic activity are therefore exposed to the housing market downturn. During and after housing market downturns, households tend to reduce their expenditures (Thornley, 2016).

Empirical studies confirm that the housing market is important for the business cycle. The housing market and the economy have direct and indirect interactions between each other (Żelazowski, 2017) . During an economic growth period, rising employment and income directly increase households' capacity to repay mortgages. Accordingly, increasing the demand for housing (Pain et al., 1997). On the other hand, cheaper loans, as a result of loose monetary policy, can also stimulate housing and demand through increased repayment capacity, therefore pushing up house prices (Eaqub, 2016). Higher house prices incentivise the construction of new houses, the increased demand for construction materials and labour, further drives up house prices (Zhao et al., 2019). Moreover, the construction market will further increase the economic activity with high employment and income levels. However, the housing market cycle reaches a turning point when construction has reached the maximum capacity to supply houses. On the other hand, the central bank reacts with increasing interest rates to cool down the overheated market (Finocchiaro & Von Heideken, 2013). The willingness to purchase, or invest, in a house starts decreasing and the housing market slows down. House prices start falling because of falling demand. The housing market slump subsequently transfers back to the overall economy (Żelazowski, 2017). Note, the supply of new houses is relatively inelastic in the short run. There are time delays between a change in price and the new house to be available in the market (Dipasquale, 1999). In New Zealand, the time taken to construct a new house is subject to multiple constraints which can result in considerably different total build times. In general, for New Zealand the average time from construction beginning to move in day is 6 months. When considering council consent, design process and sale of existing properties, the entire process takes an average of 10 months[1].

Put shortly, there are multiple ways that house prices interact with the economy, however, the logical sequence is not clearly defined. Is economic growth driving the housing market, or the housing market driving economic growth?

When examining the previous literature on the relationship between the housing cycle and various other macroeconomic cycles the results appear to be highly sensitive to choices in models, data, and countries. It is difficult to draw conclusions for one country when using evidence from another country. Furthermore, the existing literature on housing cycles has paid significant attention to various European countries, and the United States, but there is limited research for New Zealand. Additionally, the previous research that focuses on housing cycles in New Zealand was primarily produced using pre global financial crisis (GFC) data (Goodhart, Hofmann, et al., 2006; Hall et al., 2006).

Therefore, in this dissertation, I produce an analysis on how the New Zealand housing cycle interacts with key macroeconomic variables. In doing this research I fill two gaps in the literatures: first, I provide an analysis of the New Zealand housing cycle and how it relates to the business cycle, the credit cycle and the construction sector; and second, I provide an analysis of the New Zealand housing cycle with a dataset which includes significantly more recent observations than the earlier literature. While testing cycles, I also examine how sensitive the results are to the choice of detrending method.

Specifically, I seek to answer the following research question:

[1] Build times taken from FAQ sections of the following large new build housing construction companies: GJ Gardner, Mike Greer, Stonewood homes and Genius homes.

Does the filtering method used to extract the cycle matter for the estimated relationship between the house price cycle and the cycle in construction, the credit cycle and the business cycle?

To answer this question, I compare the Hodrick-Prescott and the Christiano-Fitzgerald filters which I use to obtain the trend-adjusted cyclical component, with data ranging from 1990 to 2021, for the house prices and other macroeconomic variables in New Zealand. I seek to find the co-movements between house prices and other selected variables and perform a cross-correlation analysis to explore the possible leads or lags in the relationships between the cycles.

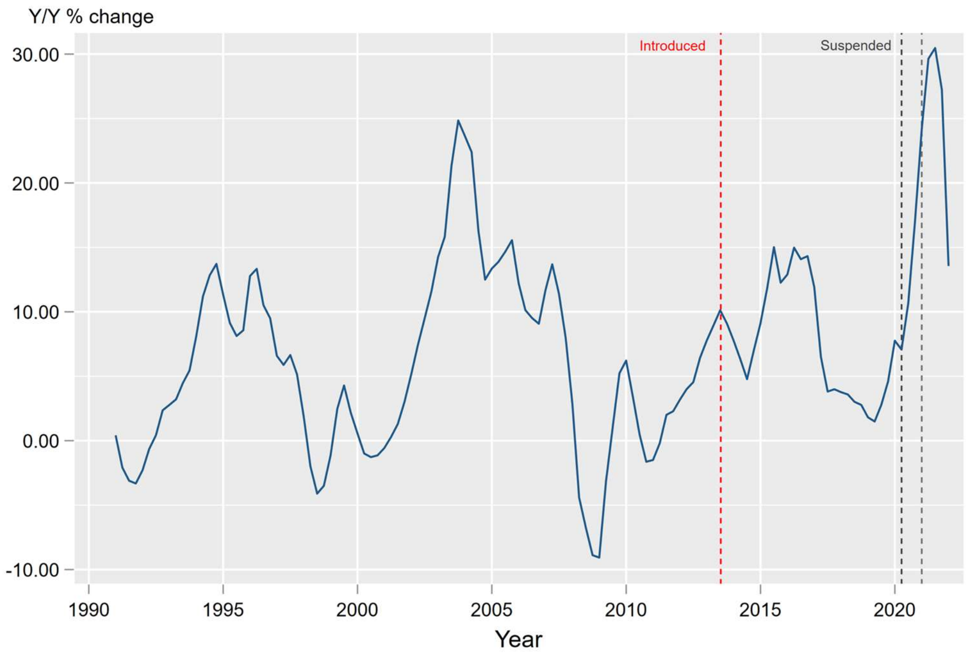
Section 2 Background

The following section gives a brief historical overview of relevant history of the housing market, and economy of New Zealand.

An important consideration when evaluating the housing cycle for New Zealand is the ongoing “Leaky homes crisis”. A significant proportion of houses built from approximately 1988 to 2004 were not fully weather tight, resulting in the decay of timber framing which, in some cases, have deemed homes structurally unsound. Even in the absence of structural integrity issues, mould and spores developing in the damp timber framing have made a large proportion of homes unhealthy to live in. It is difficult to quantify the exact costs of the leaky home crisis, however, a relatively conservative estimate by Price Waterhouse Cooper (2009) places the repair cost at 11.3 billion NZD. The result of the leaky home crisis was significant legislative changes and an ongoing stigma in the market surrounding houses built with monolithic cladding (Nuth, 2020). While recent evidence suggests that the value of remediated leaky homes is on par with unaffected dwellings, there is little doubt that the leaky homes crisis has a significant impact on the construction sector and housing market in New Zealand (Cheung & Filippova, 2019).

A further consideration when evaluating the housing cycle are the macroprudential policies implemented by the Reserve Bank of New Zealand (RBNZ). In response to rapid house price growth and a sharp increase in the use of low deposit mortgages – two features which contributed significantly to the subprime mortgage crisis in the United States - the RBNZ introduced loan-to-value restrictions (LVR) in October 2013. The purpose of the LVR was to increase the stability of the financial sector, and the economy more broadly, should there be a large correction in house prices. Initially the LVRs meant that high LVR lending, a deposit of less than 20% of the value of the house, could account for no more than 10% of a bank’s total residential lending.

Figure 1 New Zealand house price growth



Source: my own calculations based on CoreLogic house price index provided by RBNZ

Figure 1 shows the year-on-year percentage increase in New Zealand house prices with the red dotted line (far left line) marking the introduction of LVR, the black dotted line (middle line) marking the suspension of LVR and the grey dotted line (far right line) marking the reintroduction of LVR.

Housing market activity was impacted almost immediately with the growth rate of house prices halving, from 10% to 5% year-on-year, within 12 months. With house price growth beginning to accelerate again in 2015, further restrictions on property investors in Auckland were introduced in June 2015 and were extended to include all New Zealand in June 2016. Further small changes were made to the LVR, summarised in table 1 below, the most notable being the temporary 12-month suspension of the LVR beginning May 2020. The suspension of the LVR, to assist with the covid-19 pandemic, was followed by a significant increase in house prices ultimately ending in the reinstatement of LVR in March 2021 (Armstrong et al., 2019; RBNZ, 2022b).

Table 1 Loan-to-Value Ratio policy changes

Event	Date	LVR implied minimum deposit
LVR introduced	October 2013	20%
LVR tightened	June 2014	20% (owner occupier) 20-40% (Auckland property investor)
LVR tightened	June 2015	20% (owner occupier) 20-40% (all property investors)
LVR 12-month suspension	May 2020	~
LVR reinstated	March 2021	20% (owner occupier) 30% (all property investors)
LVR tightened	May 2021	20% (owner occupier) 40% (all property investors)

Notes: Only changes which impact the minimum deposit are noted here. While there are some exceptions to these limits, the majority of lending is subject to LVR rules
Source: (RBNZ, 2022)

When evaluating the cyclical relationship between macroeconomic variables it is important to do so within a framework. While no two business cycles will be completely identical, common features exist. The following section borrows from the findings of Hall & McDermott (Hall & McDermott, 2016) to give an overview of previous business cycles in New Zealand. More specifically, I outline and explain the recessionary periods that are within the time period I analyse (1990-2021).

Hall & McDermott (2016) use the Bry-Boschan model on post World War 2 data, for Real GDP and employment, to identify nine recessionary periods. Of the nine recessions identified, three fall within the period I analyse. It is worth noting that in the first two quarters of 2020 real GDP contracted in New Zealand. While not within the analysis of Hall & McDermott (2016), I identify this period as an economic downturn.[2]

I refer to the first recessionary period in my data set as 'the 1990' recession. Of the recession periods I outline, the 1990 recession is the shortest and most ambiguous. For New Zealand, the 1990 recession occurred during the first two quarters of 1990. However, when looking at the amplitude (or depth) of the contraction, the 1990 recession was almost as severe as the GFC. While there is never a single factor which triggers a recession, the 1990 recession has less definite triggers when compared to the global financial crisis (GFC) or the Asian crisis.

The 1990 recession affected many western countries and was the result of a variety of coinciding factors, namely: restrictive monetary policy by central banks in response to

[2] Recessions are those which are identified by Hall & McDermott whereas I define the 2020 contraction in Real GDP as a downturn.

inflation; decreasing consumer and business confidence; oil price shocks following the beginning of the Gulf War; the ongoing savings and loans crisis; decreased defence spending following the end of the Cold War (Walsh, 1993).

When looking at New Zealand specifically, there are two key factors to note. First, there was a significant fiscal contraction in response to the high levels of public debt. Second, significant monetary tightening by the RBNZ in response to the prolonged high levels of inflation. During the fiscal and monetary contraction unemployment rose while consumer and business confidence dropped. The domestic issues, when considered with the international issues noted above, had significant negative impacts on economic activity (Hall & McDermott, 2016).

In the late 1990s a significant economic downturn, beginning in Thailand, spread throughout Asia in turn depressing global economic activity. Following financial liberalisation throughout the region, countries in Asia experienced rapid capital inflows and accumulated large amounts of debt denominated in the United States dollars, as opposed to local currency. Loose financial oversight and significant risk-taking by the banking sector in Asia meant that as Asian currencies depreciated against the USD, debts became unserviceable and defaults followed (Mishkin, 1999). New Zealand's economy, an export-dependent nation, is vulnerable to global downturns and subsequently experienced the secondary recessionary period in my data set following the Asian crisis. Further depressing economic activity was the severe drought in New Zealand through 1997-1998, which is significant as the agricultural sector accounts for a large portion of New Zealand's goods exports. As defined by Hall & McDermott (2016), the Asian crisis recession lasted three quarters for New Zealand. Beginning in 1997q3 and ending in 1998q1. While lasting one quarter longer than the 1990s recession, this recession was the mildest of those outlined by Hall & McDermott (2016).

The GFC is by far the largest and longest recession within the scope of my data set. Essentially many defaults on subprime mortgages in the United States (US) caused significant decreases to the assets held by commercial banks and threatened, or caused, insolvency. This in turn severely restricted liquidity to the global financial sector resulting in global GDP contracting 1.3% in 2009.[3] While New Zealand, thus Australian, banks had relatively small exposure to the US subprime mortgage securities, the effects of the GFC were acute. As outlined by Hall & McDermott (2016), the GFC recession lasted 5 quarters for New Zealand beginning in 2008q1 and ending in 2009q1.

[3] For a detailed overview of the GFC see Hossain and Kryzanowski (2019)

The table 2 below summarises the recessions, and economic downturns, experienced by New Zealand that are within my dataset

Table 2 Business cycle history

Name	Period	Length (quarters)	Amplitude (%)
1990 recession	1991q1-1991q2	2	-3.1
Asian Crisis	1997q3-1998q1	3	-1.2
Global financial crisis	2008q1-2009q1	5	-3.2
*Covid-19	2020q1-2020q2	2	~

*Covid-19 is not given an amplitude as it is an economic downturn defined by me as opposed to results given by Hall & McDermott (2016)

Section 3 Literature review

The housing cycle is an area of economics which has received significant attention in previous literature.

The literature review is divided into two subsections. The first subsection explores previous research on housing markets more broadly. This is broken down further, based on the sectors which previous research has compared to housing. Note that the specific measurement of housing is not consistent throughout the previous literature, however, generally either house prices or housing investment is used to represent the housing sector. The second subsection explores the previous evidence of co-movement, or lack thereof, between the housing market and various sectors of the economy outlined in section 3.1.

Section 3.1 Comparison Sectors

While 'macroeconomic variables' is a broad term, previous literature provides a clear guideline on which to make appropriate variable selections. In the following I provide an overview of previous literature which provides guidance for appropriate variable choices.

Section 3.1.1 Economic Output

One of the most common choices when examining cycles is economic output. While it may seem obvious that GDP is a relevant macroeconomic variable to compare to other sectors of the economy, it is important to look at previous work and consider their findings. Hall et al (2006) study New Zealand house prices and economic activity, using a classical cycle dating method, using data from 1981 to 2004. They find that house prices have a procyclical relationship with economic activity where economic activity drives real house price cycles. Similar evidence is found for the United States by Leamer (2007), who studied the importance of residential investment and the business cycle. Using a modified Taylor rule, with data from 1940 to 2007, Leamer (2007) finds that residential investment is the best early warning sign of a contraction in GDP or recession. Additionally, Leamer finds that housing is significantly more sensitive to interest rates during periods of economic contraction than expansions. Note that Leamer (2007) explores residential investment as opposed to house prices. Evidence from China suggests that the relationship between GDP and housing is not limited to western countries. Xu (2017) suggests that there exists a complex and interdependent relationship between growth in GDP and housing prices in

China. Xu finds that GDP growth influences both building values and bank credit, this stimulates investment needs, and thus positively affects the house prices.

Section 3.1.2 Construction Sector

Much like GDP, variables which capture the construction sector are also widely explored in previous research on the housing market. Land, supply of new houses and secondary market supply of houses all have direct effects on house prices (Peng & Wheaton, 1994). Dipasquale (1999) provides a review of the literature which explores the relationship between house prices and investment demand for a variety of countries. Dipasquales (1999) draws two main conclusions from the review. First, scarcity of land raises house prices due to suppressed housing production and higher investment demand. Second, the supply of houses in the secondary market reacts to changes in house prices fast, but the supply of new houses is relatively inelastic in the short run. There are time delays between a change in price and either an increase in the supply of new houses becoming available or homeowners deciding to list their properties onto the market. The long-term effect on price is dependent on the supply response.

For evidence specific to New Zealand, Zhao et al (2019) studies the relationship between house prices and construction sectors using autoregressive integrated moving average, bivariate transfer and multivariate transfer models. Data, ranging from 2001 to 2018, on building costs and building volume is compared to house prices. This study finds strong evidence of relationships between construction activities and house price. Furthermore, they find significant correlation between building consents, building costs and house prices, an increasing number of building consents indicates that more building activity is occurring and increased demand for resources. The increasing demand for resources will influence the building cost, and indirectly influence the house prices further.

Section 3.1.3 Labour markets

Another common area of exploration in housing market research is labour markets, with the most common variable used being the unemployment rate. The unemployment rate represents households' capacity to purchase, which has always been a main determinant of housing demand. Since housing is an expensive product, it requires long-term commitment for repayment. Higher unemployment rates indicate larger constraints on households.

Accordingly, households' capacity for payment of mortgage should be an important determinant impacting house price variations (Pain et al., 1997).

Saks (2008) studies the relationship between labour markets and house prices in the United States. Using data from 1980 to 2002, Saks finds that the unemployment rate is an important indicator for the housing market. Saks (2008) also explores further aspects of the labour and housing markets, concluding that employment has a positive relationship with construction volume and house prices. Moreover, housing supply regulations have a lasting effect on metropolitan area employment. Locations with few barriers to construction experience more residential construction and smaller increases in house prices in response to an increase in housing demand. Additionally, housing supply constraints alter local employment and wage dynamics in locations where the degree of regulation is most severe.

Looking at labour market studies for New Zealand, Hall & McDermott (2016) compute classical real GDP business and growth cycles which they use to contrast classical recessions with 'technical' recessions.[4] Expansion and contraction phases of classical real GDP and employment cycles have on average, an 89% association, but the authors note that individual cycle circumstances should additionally be assessed. While it is not specific to the housing market it does provide justification for the use of labour market indicators in the study of cycles in New Zealand.

Section 3.1.4 Monetary policy

Monetary policy affects the real economy. New Zealand's central bank, the reserve bank of New Zealand (RBNZ), must maintain annual inflation of 1-3 percent over the medium term while also supporting maximum stable employment (Hall & McDermott, 2016). It follows that monetary policy is a valid area of interest when evaluating the housing market. The most common tool used by the RBNZ, and most other central banks, to meet their objective is the setting of interest rates. Pain et al (1997) studied the relationship between mortgage rates, which are influenced by central bank rates, and house prices in the United Kingdom. Using data from 1968-1990, Pain et al (1997) develop a conditional model of housing demand and compare the results to a similar, but less forward looking, model developed by HM treasury. They find that mortgage interest tax relief may have reduced real house prices. Further justification for the consideration of monetary policy comes from Finocchiaro & Von Heideken (2013) who show that central bank's actions impact house prices.

[4] Technical Recession refers to two consecutive periods of negative real GDP growth

Furthermore, they claim that central banks react to changes in house prices. Looking at New Zealand specific evidence (Eaqub, 2016) explores interest rates and the housing market in New Zealand. Eaqub (2016) shows that record low interest rates are driving large growth in housing lending and investment growth is a strong driver of house prices. Evidence from the United States also shows that monetary policy has direct effects on house prices (Tenreyro & Thwaites, 2016).

Section 3.2 Co-movement

It is important to pay attention to pre-existing evidence of housing cycles and how they move in relation to various other cycles. While results of previous studies on cycles were briefly explained above, there exists significant differences around which variable leads (lags) and the length of the lead (lag). I have selected four previous papers, that I view as most relevant to my research, to explain in depth. The results are briefly summarised in table 3.

Table 3 Literature review

Author	Method	Result
Goodhart and Hofmann (2006)	VAR and granger causality test	Monetary Policy variables (money supply, interest rates) lead house prices by four quarters
Hall et al (2006)	Bry-Boschan method	Business Cycle leads house prices by 8-10 quarters
Żelazowski (2017)	HP filter, BK filter and cross correlation	Leads and lags between business cycle and housing cycle vary between countries and methods.
Lidtveit & Albrigtsen (2018)	HP filter & cross correlation	The housing cycle has a two-way relationship with both construction cycle and monetary policy. The housing cycles lead the business cycle

*Listed results are limited to the most significant results as outlined by the authors

Goodhart and Hofmann (2006) look at house prices, money supply, credit, interest rates and GDP for 17 countries using quarterly data from 1970 to 2006.[5] Using a vector autoregressive (VAR) model with granger causality tests it is shown that monetary variables have a significant effect on future house prices, with monetary variables leading house prices by four quarters. One limitation is that the authors do not test the strength of

[5] United States, Japan, Germany, France, Italy, United Kingdom, Canada, Switzerland, Sweden, Norway, Finland, Denmark, Spain, Netherlands, Belgium, Ireland and Australia

the relationship against a variety of periods, opting to only test house prices lagged four quarters against the set of chosen explanatory variables.

Hall et al. (2006) uses quarterly data from 1975q1 to 2004q2 to look at house prices and business cycles in different regions of New Zealand. The authors employ a Bry-Boschan pattern recognition algorithm to identify the turning points in housing prices and business cycles. The business cycle is shown to lead house prices; however, the length of the lead is dependent on the choice of house price variable. When using QVNZ house pricing data the business cycle is shown to lead house prices by 8 quarters, when using REINZ house prices the lead is 10 quarters. As the REINZ house price variable is a longer time series, beginning in 1975 as opposed to 1981 for QVNZ, it is unclear if the change in lead times is due to the difference in measurements or the extended data range (Hall et al., 2006).

Żelazowski (2017) uses quarterly data from 1971q1-2015q3 to analyse the housing cycle and business cycles of Poland, Germany, France, the United Kingdom (UK) and Ireland[6]. The author employs the Hodrick-Prescott (HP) and Baxter-King (BK) filtering methods to detrend the data. The detrended series are tested using a cross-correlation analysis upon which the author compares the results given by the HP and BK filters. For Germany and the UK, the HP filter shows that the business cycles lead the housing cycle with the highest correlation by 4 quarters and 1 quarter respectively. Contrary to Germany and the UK, the HP filter shows that the housing cycle leads the business cycle with the highest correlation by one quarter in France. For Ireland and Poland, the highest correlation from the HP detrended series suggests that the business cycle and housing cycles move concurrently. The BK produces the same results of the HP for France and the UK. For Germany, the highest correlation with the BK filter suggests that the business cycle still leads the housing cycle, but the lead is reduced to 3 quarters. When using the BK filter Irelands' housing cycle is no longer concurrent with the business cycle. Instead, the highest correlation shows the business cycle leading the housing cycle by 1 quarter. Note that due to the limited data for Poland, and the trimming requirements for explained in the methodology section below, the BK filter cannot produce reliable results for Poland (Żelazowski, 2017).

Lidtveit & Albrigtsen (2018) uses quarterly data on house prices, residential construction, real GDP, key policy rates, average mortgage rates, and household debt levels from 1990 to 2016 to explore the housing cycle and related macroeconomic cycles of Norway. Similar to Żelazowski (2017), the data is detrended using the HP filtering method and tested for correlations. The results show that the construction cycle and housing cycle have a two-

[6] Notably Poland has a significantly limited data set, ranging from 2005q3-2015q3, while other countries data sets are 1971q1-2013q4

way relationship, with highly correlated coefficients when the housing cycle is leading or lagging. However, the highest coefficient is found when the housing cycle leads the construction cycle by approximately two quarters. The results indicate that house prices lead real GDP with the highest correlation suggesting the lead is three quarters. Similar to construction, the results show that a two-way relationship existing between the housing cycle and monetary policy. Both mortgage rates and the key policy rate are shown to be correlated when leading or lagging the housing cycle (Lidtveit & Albrigtsen, 2018).

It is worth noticing that the house price and interest rate show different results, depending on which one is the leading variable. More specifically, they tend to have a positive correlation when the house price is leading the interest rate, on the other hand, a negative correlation when the mortgage rate leads the house price. There are two possibly reasons for differing coefficients. First, increased interest rates will increase debt servicing costs thus reducing demand and house prices. This is an example of interest rates leading house prices with a negative coefficient. Second, when an economy which is “running hot” – capacity is unable to keep up with aggregate demand – or in a boom in the business cycle the central banks will raise interest rates to cool the economy. If one assumes that house prices are also increasing during the boom period, it will appear that house prices are leading interest rates with a positive coefficient (Tenreyro & Thwaites, 2016).

Section 4 Methodology

Before verifying the co-movements between house prices and various macroeconomic variables, filtering methods are applied to remove the trend components from the time series. Numerous filtering methods are used to analyse business cycles and house prices (Hall et al., 2006; Żelazowski, 2017; Lidtveit & Albrigtsen, 2018). However, an analysis using all possible filtering methods is beyond the scope of this dissertation. Therefore, I focus on the Hodrick-Prescott and the Christiano–Fitzgerald filters. The Hodrick-Prescott filter is chosen as it is popular in the literature I reviewed. In comparison, less attention has been given to the Christiano–Fitzgerald filter in the existing literature.

Section 4.1 Identifying the cyclical component using detrending methods

I first identify the trend and cyclical component in house prices and in the other macroeconomic variables. Detrending methods are used to separate a time series y_t into a trend component τ_t and a cyclical component c_t. The detrending method equation is shown below:

$$y_t = c_t + \tau_t$$

To investigate the relationship between house prices and macroeconomic variables, I have used two detrending methods, the Hodrick-Prescott (HP) filter and the Christiano–Fitzgerald (CF) filter, to get two different estimates of the house price cyclical component in this paper.

Section 4.1.1 The Hodrick-Prescott (HP) High pass filter

The high-pass filter produces a cycle that includes the noise components. The Hodrick-Prescott (HP) filter is one of the best-known detrending methods. It is widely used by macroeconomists. The HP filter was introduced by Robert J. Hodrick and Edward C. Prescott in 1981 (Hodrick & Prescott, 1981). The original HP filter constructs the trend τ_t of a time series y_t using the following minimization problem:

$$min \sum_{t=1}^{T} (y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} [(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2$$

$$t = 1, \ldots, T$$

The objective function of the minimization problem consists of the sum of two terms. The first term is trying to minimize the distance, by minimizing the squared sum of deviations, between the actual values of the time series y_t and the trend τ_t. At the same time, the second part of the objective function is trying to minimize the curvature of the trend. The trade-off between these two terms is controlled by the smoothing parameter λ , which gives different weights for these two terms of the objective function. Furthermore, Hodrick and Prescott in 1981 suggests that a value for λ of 1600 is an appropriate smoothing parameter for quarterly macroeconomic data.

Section 4.1.1.1 Critique of Hodrick-Prescott filter

Although the HP filter is widely used in macroeconomics, the HP filter results in spurious dynamics, while the trend at the beginning and end of the time series is more sensitive to the fluctuations in the actual values than for the rest of the period. The higher the lambda value, the higher the endpoint problems are. Choice of lambda is another problem associated with the HP-filter. Lambda is an exogenous parameter and is not determined in the model. With a higher value of lambda and closer to infinity, the trend is more linear with constant growth. The lower the lambda value, the higher variation in trend is allowed.

Section 4.1.2 The Christiano-Fitzgerald Band pass filter

4.1.2.1 The band pass filter

The band pass filter decomposes a series into a trend, a cycle, and a higher frequency noise (or a drift), whereas the high-pass filter produces a cycle that includes the noise components.

The Christiano-Fitzgerald (CF) filter is built on the same principles as the Baxter and King (BK) filter. The filters can provide an ideal infinity band pass filter, of detrending and smoothing the series, in the frequency domain, with an infinitely long series. However, in real life, the finiteness time series do not allow for perfect filtering.

The BK filter cannot calculate a certain number of observations at both ends of the series, due to the symmetric approximation without phase shift, resulting as lost observations at series, and the number of observations lost is depending on the trimming factor. There is a trade-off between the trimming factor and the precision. The larger trimming factor resulting a lesser number but higher precision estimates, vice versa.

However, the CF filter performs better than the BK filter for two reasons. First, CF filter uses the whole time series with all data points included in the calculation. The CF filter is designed to work well on a larger class of time series, for details see Christiano-Fitzgerald (2003). For those two reasons, I decided to include only the CF filter in my study.

4.1.2.2 The Christiano–Fitzgerald filter

The Christiano-Fitzgerald filter is also called a random walk filter, it is an asymmetric filter that converges to the optimal filter in the long run. And it works well for both stationary and non-stationary series. I have applied Augmented Dickey–Fuller unit-root test, the results are shown in Appendix 3. I find all the data used in my analysis are non-stationary series, in other words, a random walk with drift series, I will use the non-stationary version of the CF filter.

The CF filter detrending method includes two steps, the filter step is to remove the drift from the original series and therefore obtains a drift-adjusted series. The second step is to calculate the cyclical component from the drift-adjusted series.

Drift is removed by transforming the original series y_t to a new series z_t by using the following calculation:

$$z_t = y_t - \frac{(t-1)(y_T - y_1)}{T-1}$$

$$y_t, t \in \{1, \dots, T\}$$

The cyclical component c_t is calculated from the drift-adjusted series z_t , The trend component is calculated by:

$$\tau_t = y_t - c_t$$

The ideal band pass filter is given by:

$$c_t = \sum_{j=-\infty}^{\infty} b_j y_{t-j}$$

Where $b_0, b_1, \dots, b_j$ are the weights used by the ideal band-pass filter, calculated by giving minimum and maximum periods of the stochastic cycles of interest. Because my data is quarterly, I use 6 quarters and 32 quarters as the minimum and maximum periods, suggested by Burns and Mitchell (1946).

For a finite sample of data, the ideal band-pass filter is approximated by the asymmetric version of the CF filter:

$$c_t = b_0 y_t + \sum_{j=1}^{T-t-1} b_j y_{t+j} + \tilde{b}_{T-t} y_T + \sum_{j=1}^{t-2} b_j y_{t-j} + \tilde{b}_{t-1} y_1$$

Where $\tilde{b}_{T-t}$ *and* $\tilde{b}_{t-1}$ are linear functions of the ideal weights used in this calculation.

Section 4.2 Correlation analysis

Section 4.2.1 Correlation coefficients

I want to determine whether the house price cyclical component is positively or negatively correlated to the other variables' cyclical components. A positive sign of the correlation coefficient indicates that the values of the variables move in the same direction (a negative sign indicates the opposite). The absolute value of the correlation coefficient indicates the strength of the co-movement. In addition, if the correlation coefficient is close to *-1 or 1*, it is indicating that the cyclical changes of house prices and the cyclical changes of other variables is close to perfect negative correlation or perfect positive correlation respectively.

Section 4.2.2 Correlation coefficients with leads and lags

Further, I want to investigate the leading or lagging correlations of the cyclical components of house prices with other variables. I perform a cross-correlation analysis, with 4 quarters leads and lags, between the cyclical components of house prices and the selected macroeconomic variables.

I also look at the level of significance of the correlation coefficients by using a t-test, the t-statistic formula is defined as:

$$t^* = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

Where

$$r = correlation\ coefficient$$

$$n = the\ number\ of\ obervations$$

The number of observations plays a critical rule when checking for the significance of correlation coefficients. The more observations in the series, the lower the probability of the correlation is due to a coincidence. Looking at the highest correlation across the different lags and leads provides an indication of the timing of the co-movement between the cyclical variables.

Section 5 Data

As shown in the methodology section, I use two filtering methods to compare the cyclical components of housing prices with other macroeconomic variables in New Zealand. Broadly speaking I look at three separate cycles: the business cycle, the construction cycle and the credit cycle. The following section is broken down as follows: I begin by outlining my variable choices for each cycle; next, I provide summary statistics in table 4 and describe variable transformations made to aid analysis; and I conclude with a summary in table 5 showing the variables, ranges, and sources.

Section 5.1 Variables

To measure the movement in house prices, I use the House Price Index (HPI) produced by CoreLogic. The CoreLogic HPI series is a sales price appraisal ratio (SPAR) index of residential property in each period. SPAR compares the performance, difference between sales price and appraisal price, of recent sales to the entire base of properties in the area to measure how market movements have impacted all properties. The key benefit of using SPAR is that it controls for quality-mix changes in each period. For example, if a significant number of high-quality properties sell in one period and a significant number of low-quality properties sell in the following period the appraisal values can be used to control for the quality changes (Armstrong et al., 2017). Additionally, nominal house prices are chosen because housing differs from consumption. Therefore, nominal house price changes have a wealth effect. Thus, when the house price of an individual owns increases, the house owners' wealth increases, and they will not don't care about the real price. While the CoreLogic HPI is a monthly series, I source the data from RBNZ who provide it as a quarterly series in their M10 table of housing activity for New Zealand (CoreLogic New Zealand, 2022; RBNZ,).

In my study the business cycle is represented by real GDP and the unemployment rate, sourced from RBNZ table M5 and M9 respectively (RBNZ, 2022). Measures of output and employment are used widely within existing literature to measure business cycles, as in the Hall & McDermott (2011) paper on New Zealand, and as primary variables in official classifications of recessions for the United States (National Bureau of Economic Research, 2022). As with many countries, there is a strong seasonal component to GDP in New Zealand, therefore, I use the seasonally adjusted real GDP series provided by RBNZ to better reflect true patterns in economic activity. While the unemployment rate is sourced from RBNZ, it is constructed by Stats NZ using the results of the household labour force survey (HLFS). The HLFS is conducted every three months with approximately 15,000 households taking part. Stats NZ then produces estimates for a range of labour market indicators which both Stats NZ and RBNZ publish (Stats NZ, 2017).

I use two variables to represent the construction cycle: the construction sector building volumes and building consents. Building consents is a seasonally adjusted measure of the total number of consents for the construction of new dwelling units issued in each quarter. Building volumes is a seasonally adjusted measure of the real value of all building activity completed within a given quarter. I choose building consents as it captures the future supply of housing while also giving some insight to residential investment intentions. I choose building volumes as it captures the current activity in the construction sector. Building consents and building volumes are provided by the results of the Stats NZ building activity survey (Stats NZ, 2019). While I would also have liked to have a measure of building volume for residential construction, Stats NZ does not provide the building volumes measure disaggregated.

Previous literature paid attention to the interaction between monetary policy and house prices. As monetary policy decision are discrete events, which are primarily interest rate decisions, and I aim to evaluate cycles I choose to substitute credit cycle variables as a representation of monetary policy. I represent the credit cycle using mortgage rates and private sector credit. When testing the correlation between various mortgage rates I find that three-year fixed mortgage rate is close to perfectly correlated with mortgage rates of other fixed durations as well as floating rate mortgages. The results of the correlations are shown in appendix 4. Choosing different mortgage rates will have limited effect to my models. Therefore, I choose the three-year fixed mortgage rate, as provided by RBNZ table B20, as my measure for mortgage rates. The RBNZ constructs this series by taking the average of the advertised, standard, first mortgage rates offered by banks to new borrowers for residential property at the end of a given month. Therefore, any special rates or discounts offered to borrowers with conditions are excluded from the series. Private sector credit, also known as claims on other sectors, is a measure of the total debt owed by the private sector of New Zealand and is taken from the consolidated balance sheets of registered banks in New Zealand provided by the RBNZ. I choose mortgage rates as I hope to see the effects that the cost of borrowing, and to an extent monetary policy interventions, have on the housing market. I choose private sector credit as it is the broadest measure to capture the credit level in the private sector.

Section 5.1 Summary Statistics

Table 4 Summary Statistics of Cycle Variables

Variable	N	Mean	Std. Dev.	Min	Max
HPI	128	1344.641	802.09	466	3893
GDP	128	45408.445	11691.37	27663	67972
Unemployment Rate	112	5.421	1.276	3.2	9.3
Building Volume	127	2051355.5	575773.94	974754	3281798
Buildings Consents	108	6433.444	2027.885	3111	12719
Mortgage Rate	69	6.334	1.538	3.333	9.367
Private Sector Credit	128	233951.62	143882.85	51452.667	523530.33

Source: RBNZ, StatsNZ & CoreLogic

Of the data I collect, the only variables not provided as a quarterly series are mortgage rates and private sector credit which are instead provided as a monthly series. To transform the credit cycle variables into quarterly series I take the average of the monthly values which correspond to a given quarter. Furthermore, I test the impact that averaging the variables has on my results by taking the value in the last month of a given quarter and rerunning my models. I find that there is no significant difference in results between taking the average or last variable, shown in appendix 5.

Once I have a quarterly series for all variables, I then index all the variables using 2005q1 as the base period. The variables are indexed as it does not affect the results while also simplifying the process of graphing cyclical components for comparisons in the results section.

Of note is the difference in number of observations shown in table 4 above. This reflects the differences in lengths of data available for the given series, with 128 observations spanning 1990q1 to 2021q4. The complete lengths of each series are given in table 5 bellow.

Table 5 Complete lengths of cycle variables

Variable	First Observation	Last Observation	Source
HPI	1990q1	2021q4	RBNZ & CoreLogic
GDP	1990q1	2021q4	RBNZ
Unemployment Rate	1994q1	2021q4	RBNZ & StatsNZ
Building Volume	1990q1	2021q3	StatsNZ
Buildings Consents	1995q1	2021q4	StatsNZ
Mortgage Rate	2004q4	2021q4	RBNZ
Private Sector Credit	1990q1	2021q4	RBNZ

Section 6 Results

The following section is structured as follows. Section 6.1 shows the cyclical components and discusses the difference between the HP and CF filtering methods and cycles obtained between house price and selected macroeconomic variables which are GDP, unemployment rates, building consents, building volumes, mortgage rates, and private sector credits.

Section 6.2 shows the cross-correlation analysis results and the statistical significance, between house price and each selected variable. To compare the similarity or differences between filters and compare with the result with section 6.1.

Section 6.1 Cyclical components

Figure 2 House price index HP-and CF-Cyclical components

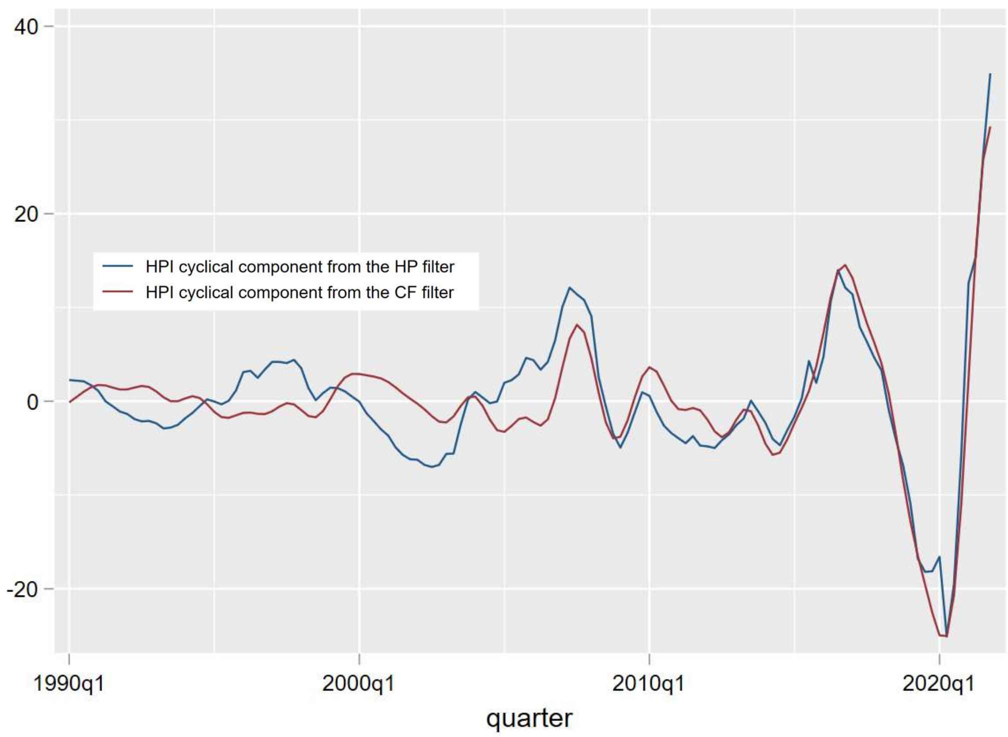


Figure 2 shows the cyclical components of house prices, from 1990 to 2021, obtained using both the HP and CF filters. While the filters produce similar results from approximately 2007 onwards, the cyclical components obtained by the HP and CF filters from 1990 until 2007 are quite different. For example from 1990 to 1995 the HP filter suggests that the HPI was growing below trend while the CF filter suggests the opposite. Again from 1995 to 1998 the two filters produce opposite cyclical results. For a graphical comparison of the cyclical components obtained by each filtering method for all other variables see appendix 6

Figure 3 Cyclical component of GDP and House Prices

(a) HP filter (b) CF filter

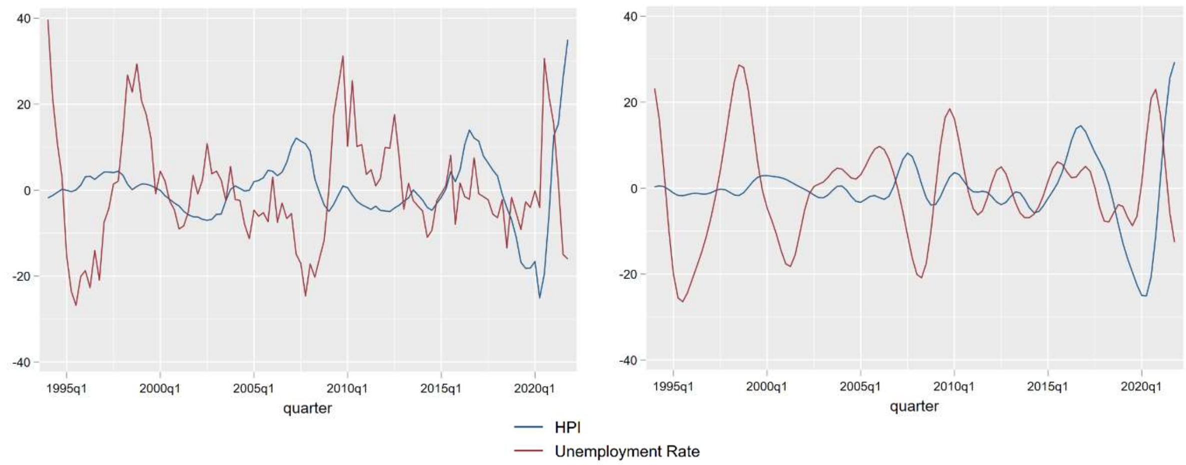
The cyclical components of real GDP and house prices, from 1990-2021, in New Zealand are obtained using the HP and CF filters and shown in figure 3.

The HP filter shows house price changes tend to track the GDP changes until 1998q2, with a tendency for house price cycles turning points to lag GDP cycle turning points. For example, GDP peaks pre-Asian crisis in 1997q2 while house prices do not peak until during the crisis in 1997q4. Beginning from 2000 the HP filter shows evidence of house prices leading GDP. For example, house prices peaked one quarter earlier than GDP pre-GFC and reached the trough one quarter earlier during the GFC. Post GFC, but before Covid-19, house prices recovered significantly faster than GDP. House prices reached a pre-covid peak in 2016q3 while GDP would not peak until 2019q3, 3 years later.

While the CF filter produces somewhat opposite cyclical components to the HP filter for house prices from 1990 to 1998, the cyclical components for GDP are relatively similar between the two methods. Therefore, the CF filter suggests that in the 1990 to 1998 period house prices have a negative relationship with GDP. From 1998 onwards the CF filter suggests that house prices have a positive relationship with GDP. The CF filter shows evidence of house prices leading, or moving concurrently, with GDP. For example, house prices peaked in 1999q4 while GDP peaked one quarter later. House prices and GDP then peak concurrently pre-GFC in 2007q3, however, house prices reach trough two quarters before GDP during the GFC.

Figure 4 Cyclical component of the unemployment rate and house prices

(a) HP filter (b) CF filter

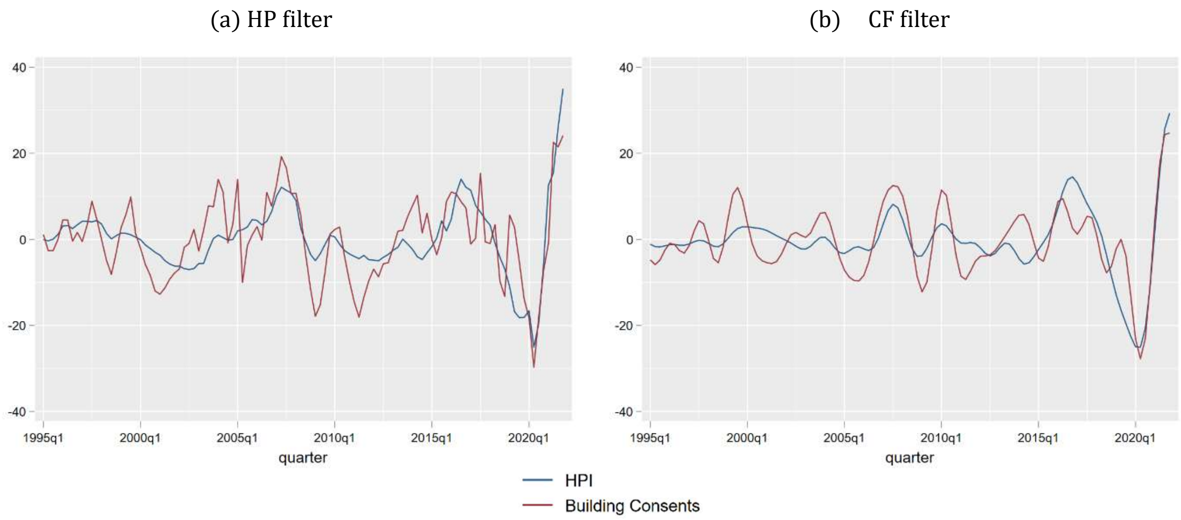


The cyclical components of the unemployment rate and house prices, from 1993-2021, are obtained using the HP and CF filters and shown in Figure 4.

The results using a HP filter, figure 4 (a), are dependent on the period, with both positive and negative relationships present at a variety of different lags and leads. For example, the unemployment rate troughs before the Asian crisis in 1995q3 and then peaks in 1998q4 after the Asian crisis. House prices peaked in 1997q4, during the Asian crisis. It is not clear visually which cycle is leading in the 1990s. During this period if one assumes that house prices are leading then the relationship is positive and vice versa. The results from 2002 to 2010 suggest that there is a negative relationship with the house price cycle leading the unemployment rate cycle. Pre-GFC the house price cycle peaks in 2007q2, two quarters before the unemployment rate troughs. During the GFC the house price cycle troughs in 2009q1, 3 quarters before the unemployment rate peaks.

The cyclical component of the unemployment rate obtained from the CF filter, shown in figure 4 (b), provides relatively similar results to the HP filter. Therefore, just like the HP filter, the CF filter provides ambiguous evidence of cyclical relationships during the 1990s. Similar to the HP results, the CF filter suggests that the house price cycle is leading the unemployment rate cycle in the period before and during the GFC. Where the CF and HP results differ is in the length of the lead. The HP filter has house prices leading unemployment by 2-3 quarters around the GFC period whereas the CF filter has house prices leading unemployment by 3-4 quarters.

Figure 5 Cyclical component of building consents and house prices



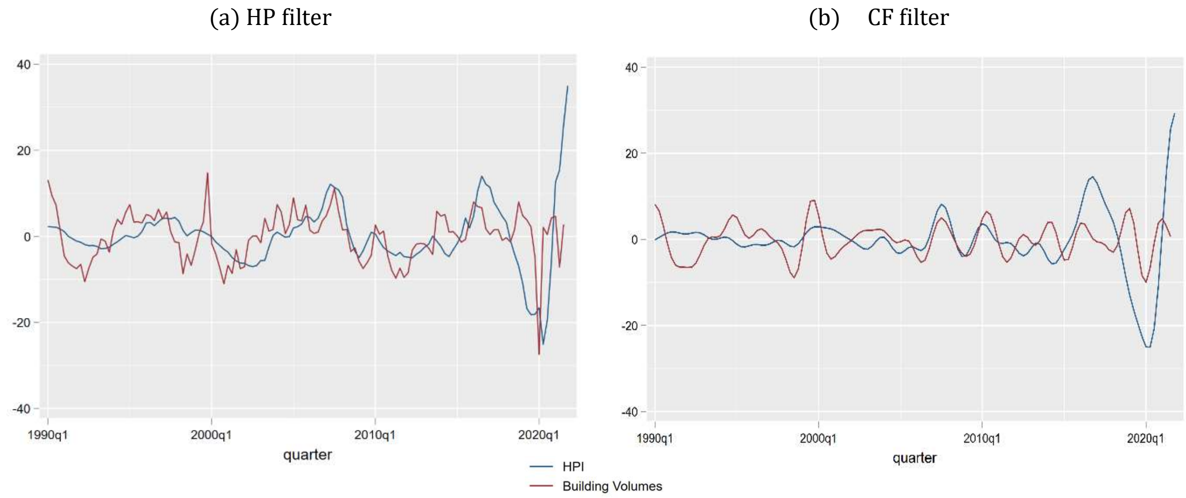
The cyclical components of building consents and house prices, from 1995-2021, are obtained using the HP and CF filters and shown in Figure 5.

The results from both methods consistently show that overall, there is a close positive relationship between these two variables. However, the filtering methods provide slightly different evidence on lead and lags.

From 1995 to 2003 both methods suggest that building consents are leading house prices. Again, both filter methods show house price and building consents peak simultaneously before the GFC. The methods differ slightly in the timing of the peak, with the HP filter determining 2007q2 as the pre-GFC peak while the CF filter has the pre-GFC peak in 2007q3. Despite the one quarter difference in pre-GFC peak, both the HP and CF filters find that building consents and house prices trough in 2009q1.

When looking at the Covid-19 period both filters again provide evidence of a positive relationship with simultaneous peaks and troughs for building consents and house prices.

Figure 6 Cyclical component of building volume and house prices

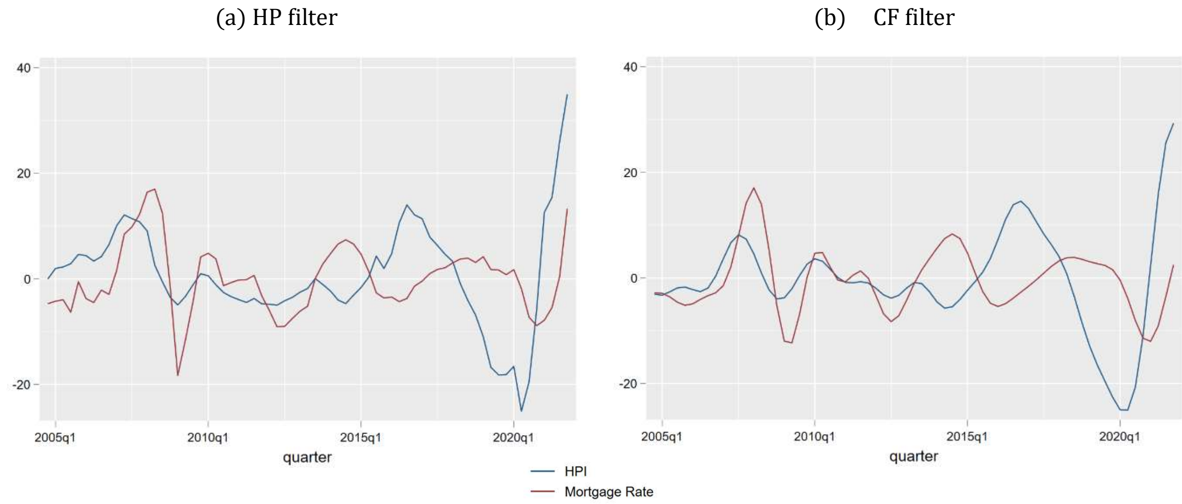


The cyclical components of building volumes obtained from the HP and CF filters, shown in Figure 6 (a) and Figure 6 (b) respectively, provide almost identical results for peaks and troughs in the building volume cycle.

Excluding the period in and around the GFC, the HP detrended series shows that building volumes and house prices have a positive cyclical relationship with building volumes leading house prices. However, the lead periods vary significantly. For example, building volumes peak pre-Asian crisis in 1995q1 whereas house prices do not peak until during the crisis in 1997q4, a 11-quarter lead. Then looking at 2016, building volumes peak in 2016q1 and house prices peak in 2016q3 a two-quarter lead.

In contrast, the CF filter provides less clarity. In general, the CF filter shows that the building volume cycle and house price cycle have a positive relationship, however due to significantly shorter lags in cycles, they appear to move concurrently and provide no obvious indication of one cycle consistently leading the other. This result is primarily due to the significantly different cyclical component of house prices in the pre-Asian crisis period obtained from the CF filter.

Figure 7 Cyclical components of mortgage rates and house prices



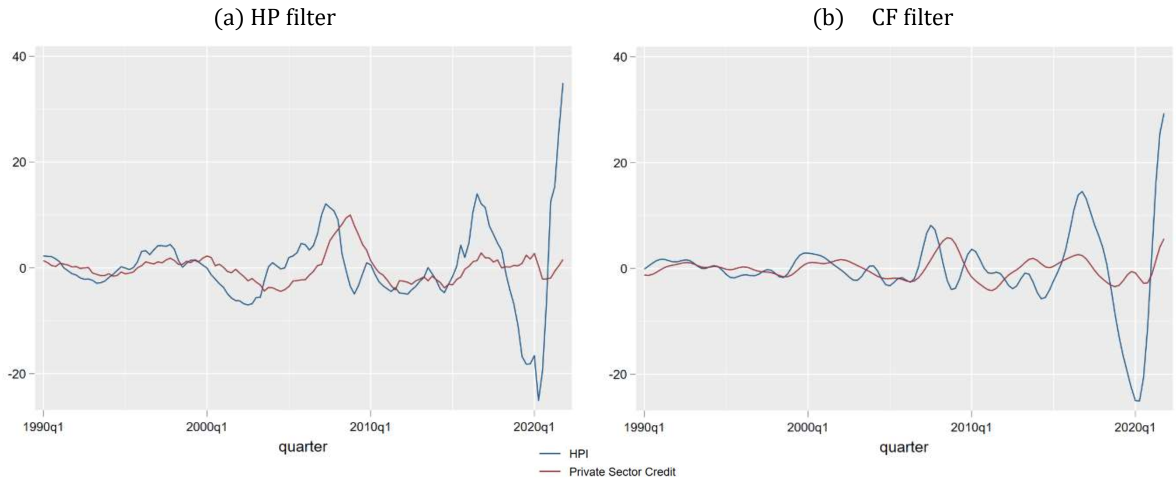
**Mortgage rate is represented by the average 3 year fixed term mortgage rate*

The cyclical components of mortgage rates and house prices, from 2005 to 2021, are obtained using the HP and CF filters and shown in Figure 7.

Neither the HP nor CF detrended series show an obvious relationship between house prices and mortgage rates. Looking at the mortgage rates, in general the CF and HP detrended series produce similar peaks and troughs, with the median variance between the filters being one quarter. Furthermore, both series show an intuitive two-way relationship. When house price leads mortgage rates there is a positive relationship. When mortgage rates lead house prices there is a negative relationship.

Both filters show a positive relationship with house prices peaking before interest rates pre-GFC. In the post-GFC period, from approximately 2013, both filters show that mortgage rates begin to lead house prices and subsequently the relationship becomes negative. The presence of a two-relationship fits with the theory of (Tenreyro & Thwaites, 2016) discussed in the literature review above.

Figure 8 Cyclical component of private sector credit and house prices



The cyclical components of private sector credit and house prices, from 1990-2021, are obtained using the HP and CF filters and shown in Figure 8.

Both the HP filter, Figure 8 (a), and CF filter, Figure 8 (b), show that there is a limited cycle component to private sector credit. However, there is a large cyclical increase in private sector credit from approximately 2005 that is led by the house price cycle. The HP filter suggests the lead is four quarters while the CF filter suggests the lead is six quarters. Despite there being a relatively limited cycle component in private sector credit both filters suggest that the house price cycle leads private sector credit cycle.

Section 6.2 The cross-correlation analysis

Table 6 Cross-correlation coefficients

Variables	GDP		Unemployment rate		Building consent		Building volume		Mortgage rate		Private sector credit	
	HP	CF	HP	CF	HP	CF	HP	CF	HP	CF	HP	CF
HPI, var t-4	-0.17	-0.51	0.10	0.37	0.06	-0.10	0.13	-0.17	-0.32	-0.41	-0.15	0.19
HPI, var t-3	-0.10	-0.25	0.10	0.36	0.20	0.13	0.29	0.00	-0.34	-0.46	-0.12	0.19
HPI, var t-2	0.18	0.07	0.06	0.27	0.44	0.40	0.41	0.15	-0.27	-0.39	-0.05	0.24
HPI, var t-1	0.27	0.33	-0.08	0.10	0.61	0.64	0.38	0.23	-0.09	-0.21	0.05	0.33
HPI, var t	0.35	0.45	-0.22	-0.09	0.71	0.76	0.34	0.22	0.21	0.04	0.19	0.43
HPI, var t+1	0.29	0.44	-0.29	-0.21	0.61	0.64	0.29	0.17	0.33	0.23	0.28	0.38
HPI, var t+2	0.26	0.36	-0.29	-0.28	0.44	0.43	0.23	0.10	0.38	0.34	0.34	0.29
HPI, var t+3	0.24	0.26	-0.26	-0.30	0.25	0.19	0.16	0.02	0.37	0.36	0.39	0.16
HPI, var t+4	0.21	0.17	-0.18	-0.28	0.04	-0.02	0.06	-0.05	0.27	0.32	0.41	0.04

*The table 6 shows the correlation coefficients between the house price cyclical movement with each of the variables. The level of significance is indicated with highlights in the table. The blue highlights show when the correlation is positive and statistically significant, at the 5% (light blue) and 1% (dark blue) level of confidence. The orange highlights show when the correlation is negative and statistically significant, at the 5% (light orange) and 1% (dark orange) level of confidence.

Section 6.2.1 GDP

Table 6 shows the correlation coefficients of the house price and the GDP, for the HP filter and the CF filter. Both positive and negative coefficients are obtained in both filters at the same lag periods. The negative coefficients are in t-3 and t-4, however, only the CF filter results are significant indicating that the negative coefficient from the HP filter have no correlation.

The largest significant correlation coefficient (in absolute terms) is obtained by the CF filter when house prices are lagged 4 quarters (i.e., t-4) with a value of -0.51. This correlation coefficient suggests that GDP at time t is highly negatively correlated with house prices at time t-4, so that if house prices go above trend, one can expect GDP to go below trend a year later. However, the CF filter also provides evidence of a two-way relationship.

Both filters provide positive correlation coefficients from t-2 to t+4, with results being significant at the 1% level from t-1 to t+3. The largest significant positive correlation coefficient for the HP filter, and the largest significant positive coefficient for the CF filter, is at time t with values of 0.35 and 0.45 respectively, indicating a high positive contemporaneous correlation between GDP and house prices. Furthermore, all coefficients for both filters are positive and statistically significant when house prices lead the GDP. This result indicates that when the house prices lead GDP, or when they move concurrently, they have a positive correlation.

Section 6.2.2 Unemployment rate

When looking at the correlation coefficients of the house price with the unemployment rate, both significant positive and negative correlation coefficients can be observed in both filters.

Both the HP and the CF filters obtain a positive correlation between lagged house prices and the unemployment rate (from t-4 to t-2), however, only the CF filter results are statistically significant. The CF filter results show that, when the house price leads the unemployment rate, they are negatively correlated, with the most substantial results in t+2.

The negative coefficients for the HP filter series are from t-1 to t+3. Period t is significant at the 5% level with t+1 to t+3 coefficients being significant at the 1% level. The similar negative results are found in CF filter series with the coefficients from t to t+4 being negative. Period t+1 is significant at the 5% level, and t+2 to t+4 is significant at the 1% level.

For the HP filter the house price leads the unemployment rate with the largest negative correlation coefficient (in absolute terms) in period t+1 and t+2 with value of -0.29. For the CF filter the house price leads the unemployment rate with the highest correlation coefficient in period t+3 with value of -0.3. The results indicates that, when house prices lead the unemployment rate by two to three quarters, they are negatively correlated. As house prices rise the unemployment rate falls.

The same negative relationship is found in both filtering methods. When house prices lead the unemployment rate, they have a negative relationship; as house price increase the unemployment rate declines. However, the CF filter also shows significant positive correlations when unemployment rates leading house prices.

Section 6.2.2 Building consents

The correlation between house prices and building consents is the highest cyclical movement correlation in my results. All the coefficients for the HP filter are positive while coefficients within the range from t-3 to t+3 for the CF filter are positive. However, the two negative coefficients from the Cf filter do not reach the 5% significant level.

Both results suggest that the house prices and building consents have a positive relationship in New Zealand from 1995q1 to 2021q4. The three most significant coefficients for both methods are found from period **t-1** to **t+1** with the most substantial period being **t,** with a value over 0.7.

The correlation coefficient indicates that the house price and building consent are highly positively correlated, additionally, it is reasonable to say that they move simultaneously. However, this relationship is ambiguous because the coefficients are also highly significant for other period lags. In other words, the house price and the building consents influence each other strongly and with a minimal lag.

Section 6.2.4 Building volume

Looking at the correlation coefficients of the house prices and the building volume, for the HP filter and the CF filter, the HP filter has significantly higher coefficients than the CF filter. The coefficient signs are similar to the building consents results, with all the HP coefficients being positive, and two of the nine coefficients from CF filter being negative. The CF filter provides limited statistically significant results, with no results significant at the 1% level and only two results significant at the 5% level.

Both results suggest that the house prices are positively correlated with the building volume. As house prices increase, the building volume tends to rise as well. The largest coefficient for the HP filter is in **t-2**, with value 0.41, and significant at 1% level. The CF filter shows different results, the most significant result is in **t-1**, with the coefficient 0.23, at 5% level.

The HP filter results indicate that building volumes and house prices have a positive relationship when either cycle leads, however, the most substantial coefficient is found when building volumes lead by two quarters. The CF filter suggests that the building volume leads are shorter, and the relationship is weaker.

Section 6.2.5 Mortgage rate

The correlation coefficients for the house price and the mortgage rate, for the HP filter are comparable with the CF filter. Both positive and negative coefficients are obtained in both filters at the same periods of lags.

Both filtering methods show the coefficients, for lags from **t-4** to **t-2**, that are negative and significant.

The HP filter results that lag from **t-4** to **t-2** are at least significant at a 5% level, and the CF filter results with the same lags are all significant at a 1% level. The most substantial negative coefficient is in ***t-3*** with the value of -0.34 and -0.46 for the HP filter and the CF filter respectively.

Results suggest that when the mortgage rate leads the house price, they have a negative relationship. As the mortgage rate rises, house prices tend to drop.

However, both filters provide evidence of a two-way relationship. The coefficients from **t** to **t+4** are positive for both filters; Moreover, the coefficients for the HP filter are significant at 1% level from **t+1** to **t+3** and 5% for **t+4**, the coefficients for the CF filter are significant at 1% level from **t+2** to **t+4**.

The largest positive correlation coefficient for the CF filter is in t+3 with a value of 0.36. The results suggest that when the house price leads the mortgage rate, they have a positive relationship with house prices leading by 2 to 3 quarters. In other words, when house prices increase mortgage rates also increase.

The HP filter provides two large coefficient values in t+2 and t+3 with a value of 0.38 and 0.37 respectively.

The correlation coefficients for both filtering methods indicate that the house price and mortgage rate have a two-way interaction relationship from 2004q1 to 2021q4. When the house price leads the mortgage rate by three quarters, they have a positive relationship. When the mortgage rate leads the house price by three quarters, they have a negative relationship.

Section 6.2.6 Private sector credit

When looking at the private sector credit and the house price, different correlation coefficient results are found in the HP and CF filters.

For the HP filter, positive results are observed from **t-1** to **t+4** and negative results are observed from **t-4** to **t-2**. However, none of the negative results is statistically significant. Within the positive results, **t** is significant at 5% level, and from **t+1** to **t+4** coefficients are significant at 1% level. The most significant coefficient is in **t+4** with a value of 0.41. The results indicate that, when house prices lead, the house price and the private sector credit are positively correlated, as house price increases private sector credit increase.

Furthermore, the house price seems have the highest correlation with the private sector credit when the housing leads the private sector credit by four quarters.

The correlation coefficients for the CF filter are all positive with t-3 and t-4 significant at the 5% level, and t-2 to t+2 significant at the 1% level. The most significant result in t with a value of 0.43, which indicates that the house price, and the private sector credit are positively correlated and influence each other.

Both filters' coefficients suggest that the house price and private sector credit are positively correlated. However, the HP filter suggests that the house price cycles lead the private credit cycle, but the CF filter suggests that either cycle can lead.

Section 7 Discussion

In this section, I will discuss my results in relation to the previous literature, and New Zealand economic history, and compare the differences between filtering methods.

While the cyclical components of most variables are relatively insensitive to the choice of filtering method, I find that the HP and the CF filter provide significantly different cyclical components for house prices from 1990 to 2000. Additionally, the cyclical components obtained by the HP and CF filters for private sector credit, excluding the period around the GFC, are significantly different throughout my time series. Furthermore, I find that all three cycles included in this study, the business cycle, the construction cycle and the credit cycle, are correlated with the house price cycle. However, the correlation is dependent on the variable examined.

When looking at the credit cycle my results provide evidence that house prices lead the total level of credit in the private sector. An intuitive result as higher house prices will necessitate higher mortgages, increase the collateral available to secure borrowing, and increase credit. The CF filter also provides weak evidence of private sector credit leading house prices.

When looking at the mortgage rates, the cyclical components and the correlation analysis of both filtering methods shows similar results. The results suggest a two-way relationship. When house prices are leading, the relationship is positive; increasing house prices are followed by increasing mortgage rates. When mortgage rates are leading the relationship is negative; increasing mortgage rates will lead to decreasing house prices. My finding is consistent with the previous literature that suggests interest rates and house prices interact (Eaqub, 2016; Goodhart, Hofmann, et al., 2006; Pain et al., 1997). Furthermore, my findings add to the evidence of a two-way relationship between interest rates and house prices (Finocchiaro & Von Heideken, 2013; Lidtveit & Albrigtsen, 2018). However, it should be noted that previous literature found two-way relationships using key policy rates set by central banks while I looked at mortgage rates. When combined with the suggestions of previous literature, I find support for Tenreyro & Thwaites (2016) argument that the sign of the correlation is dependent on the phase of the business cycle. Specifically, my results show a negative correlation between mortgages rates and house prices in the post GFC period. This makes sense when placed in the context of the world during this period. Pre-GFC economies were booming, and central banks were raising rates accordingly. During the GFC central banks, including the RBNZ, dropped rates to historic lows. While house prices did suffer slightly during the GFC, the long and slow recovery of economies post-GFC resulted in central banks keeping rates suppressed. In general rates were kept near the zero lower bound and have only seen significant increases recently as central banks attempt to stop inflation building, evident in the graphs where the relationship become positive from the beginning of 2021.[7] Therefore, my results also provide evidence for Eaqub (2016) argument that the historically low interest rates set by the RBNZ in the post GFC period contributed to the large increase in house prices.

When looking at the business cycle the choice of filtering method impacts the results. In general, I find evidence that house prices lead GDP and are positively correlated for both filtering methods. However, the CF filter also suggest that when GDP is leading house prices they are negatively correlated. The CF result is counterintuitive as GDP is at its core a measure of a nation's income and it is reasonable to expect that falling incomes would be associated with falling house prices. However, the CF filter result suggests that falling GDP will lead to increased house prices. Furthermore, the HP filter method provides no support for the existence of a negative correlation between GDP and house prices. All previous literature I reviewed find no evidence of a negative correlation and supports a positive correlation between house prices and GDP (Hall et al., 2006; Lidtveit & Albrigtsen, 2018; Żelazowski, 2017)

The unemployment rate, my second measure of the business cycle, shows similar results to GDP. When house prices are leading both filtering methods suggest that there is a negative correlation: as house prices increase the unemployment rate drops. My results, when house prices are leading, are consistent with the finding of Pain et al. (1997) and Saks (2008). However, the CF filter again provides a counterintuitive result when the unemployment rate is leading. When the unemployment rate is leading house prices they are negatively correlated: the increasing unemployment rate increases house prices.

When looking at the construction sector cycles, I find evidence that the house prices have a positive relationship with the construction sector.

I find strong evidence that house prices and building consents are positively correlated, when either house prices lead or lag using both filtering methods. Results suggest that when the house price rises, the number of building consent will also rise. At the same time, when the number of building consents increases, it will also push up the house price. The results provide evidence for Zhao et al. (2019) argument that an increasing number of building consents indicates that more building activity is occurring which increases demand for resources and subsequently influences the building cost, indirectly influencing house prices.

[7] As my data does not include 2022 observations, I do not capture the recent decreases in the HPI.

While the HP and CF provide consistent results for building consents, they produce different results for volumes. When using the HP filter building volumes are positively correlated with house prices with different leads and lags. While providing similarly signed coefficients, the CF filter results are substantially less significant. As mentioned in the methodology section, the number of observations play a critical role in the significance test. The more observations in the series, the lower probability that the correlation is due to coincidence. As building consents have less observations the correlation coefficient between building consents and house prices is greater than the coefficient between volumes and house prices. Simply put, my results do not suggest that building consents are more correlated with house prices than the building volumes are with house prices.

Overall, there does appear to be a difference between the results obtained by different filtering methods. While in some cases the filtering methods produce similar cyclical components for building consents, building volumes, mortgage rates, GDP, and unemployment rates, the difference in cyclical components of house prices influences the correlation analysis results. Therefore, when evaluating cycles in house prices for New Zealand the choice of filtering method matters.

Section 8 Conclusion

In my study I estimate the cyclical relationship between house prices and various macroeconomic variables in New Zealand. Using the Hodrick-Prescott and the Christiano-Fitzgerald filtering methods on a data set compiled from RBNZ and StatsNZ, I obtain the cyclical components for house prices, the business cycle, the construction sector, and the credit cycle.

In support of all previous literature I reviewed, I find evidence that cycles in house prices are positively correlated with the business cycle (Hall et al., 2006; Lidtveit & Albrigtsen, 2018; Żelazowski, 2017). However, my study also shows that the choice of filtering method matters. While both filters show a positive correlation with the business cycle when house prices are leading, the CF filter suggests that there exists a two-way relationship when business cycle variables are leading. With GDP leading, GDP is shown to be negatively correlated with house prices. This implies that increasing GDP leads to a decrease in house prices. The CF filter results also suggest that when the unemployment rate is leading house prices there is a positive correlation: rising unemployment increases house prices. While the CF filter produces unintuitive results, when business cycle variables are leading, it is beyond the scope of my methodology to explain the reasoning behind the results.

Consistent with previous literature, I find that the cycles in house prices are positively correlated with cycles in construction sector variables (Lidtveit & Albrigtsen, 2018; Zhao et al., 2019). Contrary to the business cycles results, I find that the HP and CF filters provide similar results when evaluating the cyclical components of construction sector variables.

In support of the findings of Lidtveit & Albrigtsen (2018). I find evidence of a two-way relationship between the cyclical components of house prices and mortgage rates. Furthermore, the two-way relationship is observed using both filtering methods. When house prices are leading, there is a positive correlation between mortgage rates and house prices. When mortgage rates are leading there is a negative correlation between mortgage rates and house prices. While the results for mortgage rates are less influenced by choice of filtering method private sector credit, my other measure of the credit cycle, is influenced by choice of filtering method. When evaluating the private sector credit cycle the HP filter provides clear evidence of house prices leading private sector credit whereas the CF filter provides evidence for house prices both leading and lagging private sector credit.

The periods around 2020 and 2021 were unique in that the services sector of the economy was largely shut, and the manufacturing industry faced significant supply chain issues in the wake of the Covid-19 pandemic. The combination of these effects will have had an adverse effect on economic activity during this period, so care should be taken when interpreting the results. Specifically, the movements of the cyclical components.

Overall, my results suggest that when analysing cyclical components, the results can be influenced by choice of filtering method. Therefore, I suggest that future research on macroeconomic cycles, especially for New Zealand, should consider the use of multiple filtering methods to ensure that results are robust to different methodological approaches.

I make the following recommendations for further research:

1. Future research could test the results if 2020 and 2021 not included in the sample.
2. Future research could test how longer periods of lags or different smoothing parameters impact the results I have provided.
3. Future research could test transformed variables, such as logged GDP and credits, and house prices that have been corrected for inflation.

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Appendices

Appendix 1 House price index with HP- and CF- Trend

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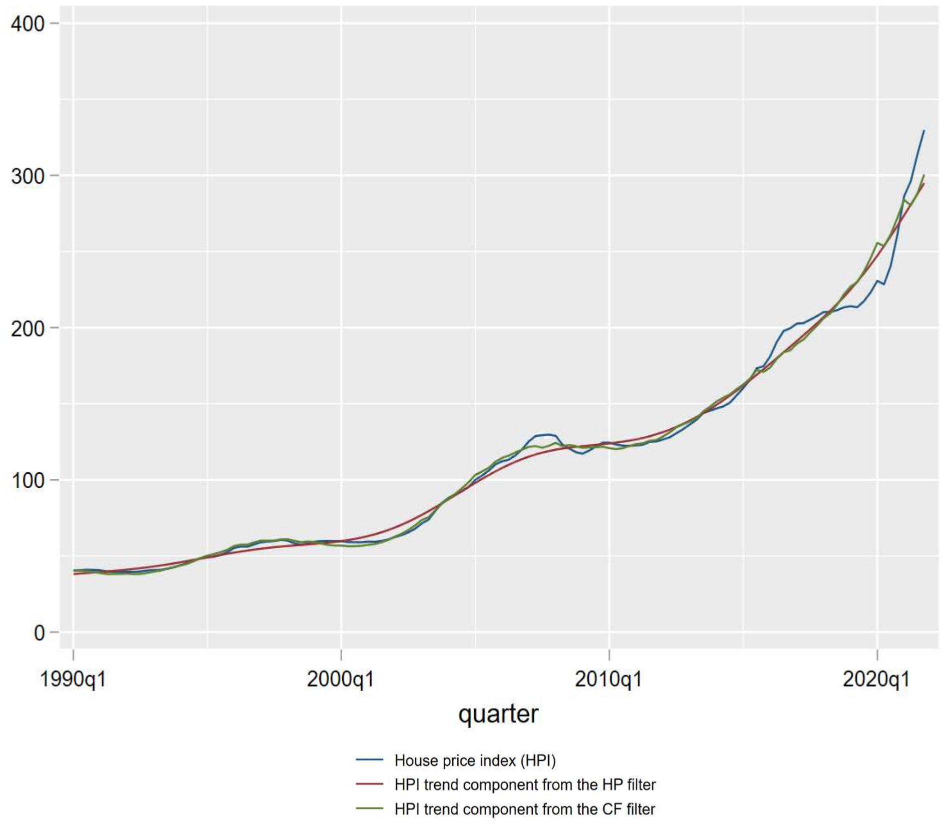

Appendix 2 Real GDP and Seasonally Adjusted Real GDP

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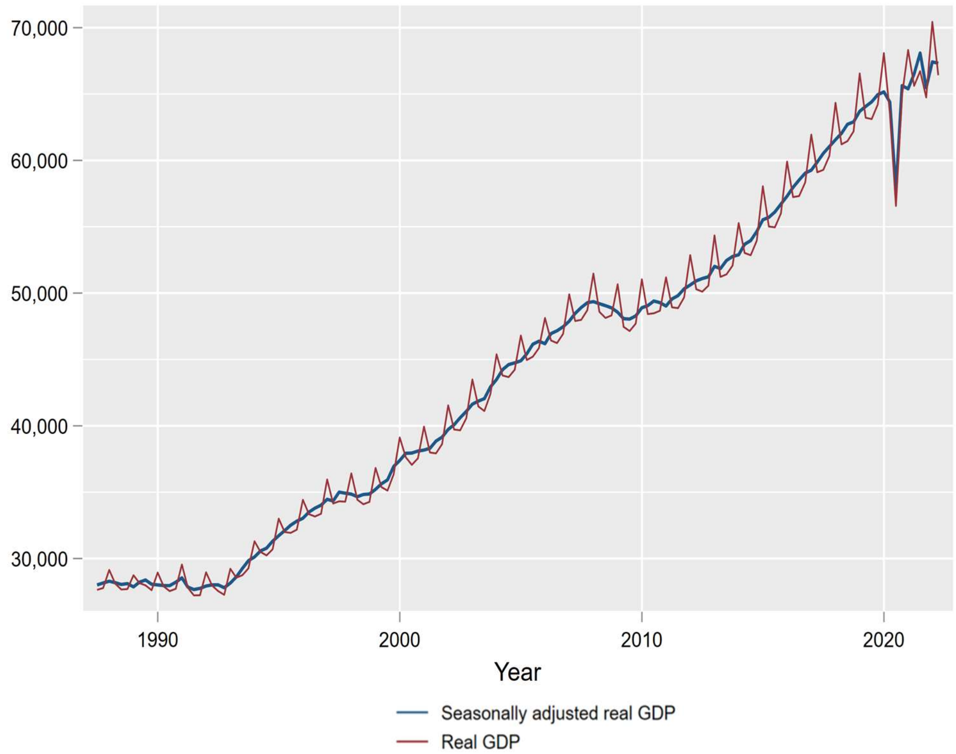

Real GDP and Seasonally Adjusted Real GDP, a strong seasonal component in New Zealand real GDP series.

Appendix 3 Augmented Dickey–Fuller unit-root test

From the Augmented Dickey–Fuller unit-root test results, which test statistics are greater than the critical values for all variables. We failed to reject the null hypothesis that data are non-stationary. Suggesting that all the variables are non-stationary.

	Test Statistic	Dickey-Fuller critical value		
		1%	5%	10%
HPI	1.76	-4.031	-3.447	-3.147
GDP	-2.912	-4.031	-3.447	-3.147
Unemployment rate	-2.127	-4.037	-3.449	-3.149
Building Volume	-2.057	-4.032	-3.447	-3.147
Buildings Consents	0.654	-4.038	-3.449	-3.149
Mortgage Rate	-4.101	-4.113	-3.483	-3.17
Private Sector Credit	-1.41	-4.031	-3.447	-3.147

Appendix 4 Mortgage rates and correlations

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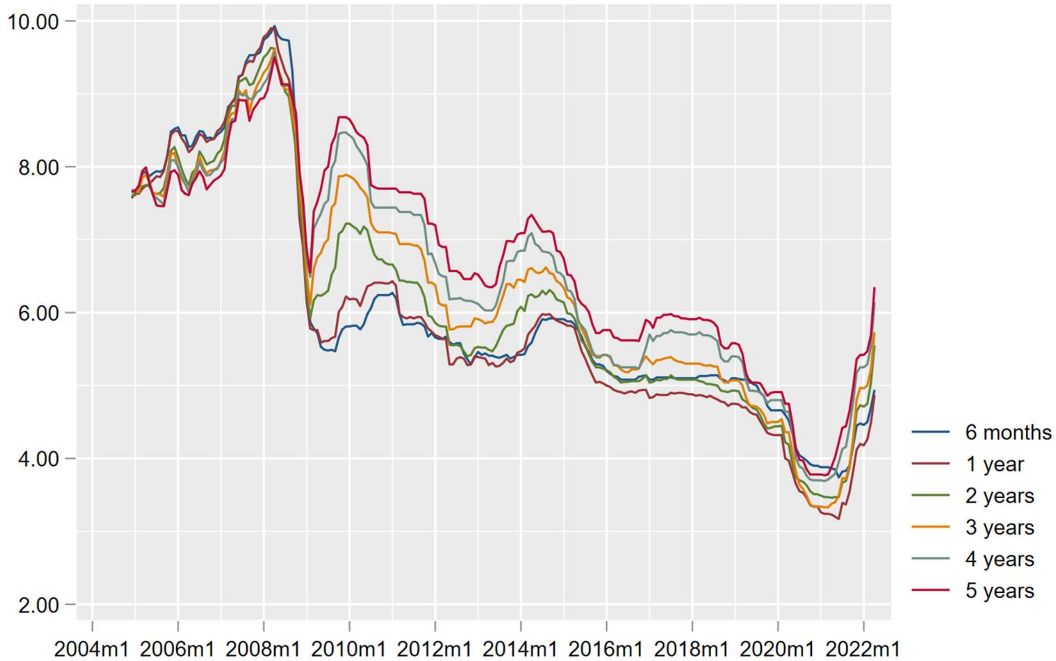


A correlation analysis between 3-year mortgage rates and 6-month, 1-, 2-, 4-, and 5-year mortgage rates. The results show they are almost perfectly correlated, with the correlation coefficients ranging from 0.92 to 0.99.

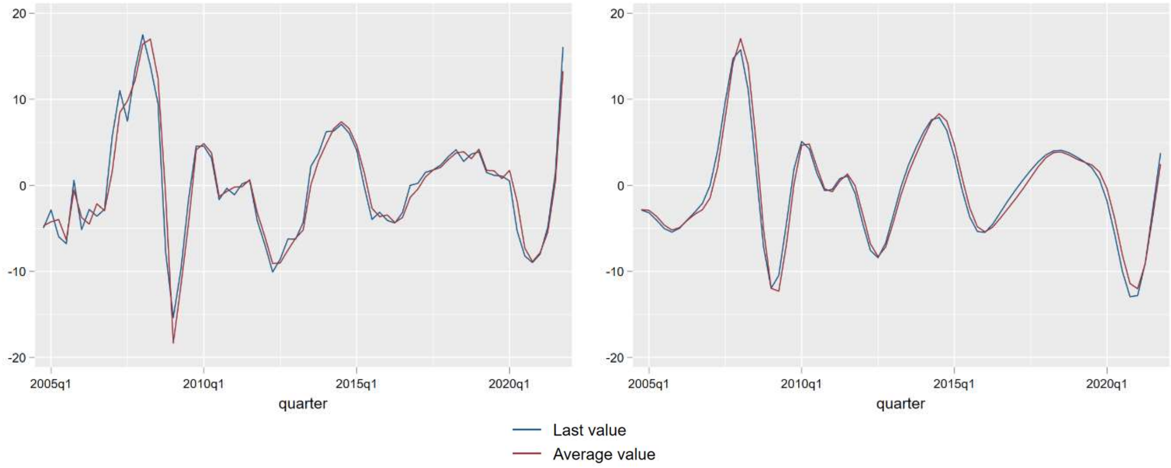
	3 years
6 months	0.9157
1 year	0.9535
2 years	0.9882
4 years	0.9926
5 years	0.9801

Appendix 5 Last value and average value cyclical components

The figures below are the HP and CF cyclical components comparisons of the last value and the average value, of the mortgage rate and the private sector credit. No significant difference is found.

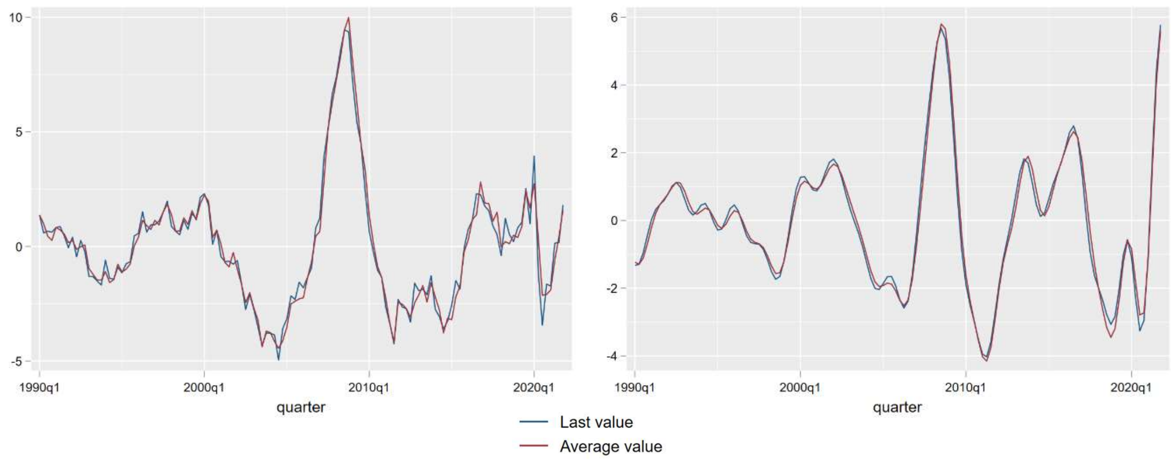
Appendix 5 a Mortgage rate cyclical components

(a) HP filter (b) CF filter



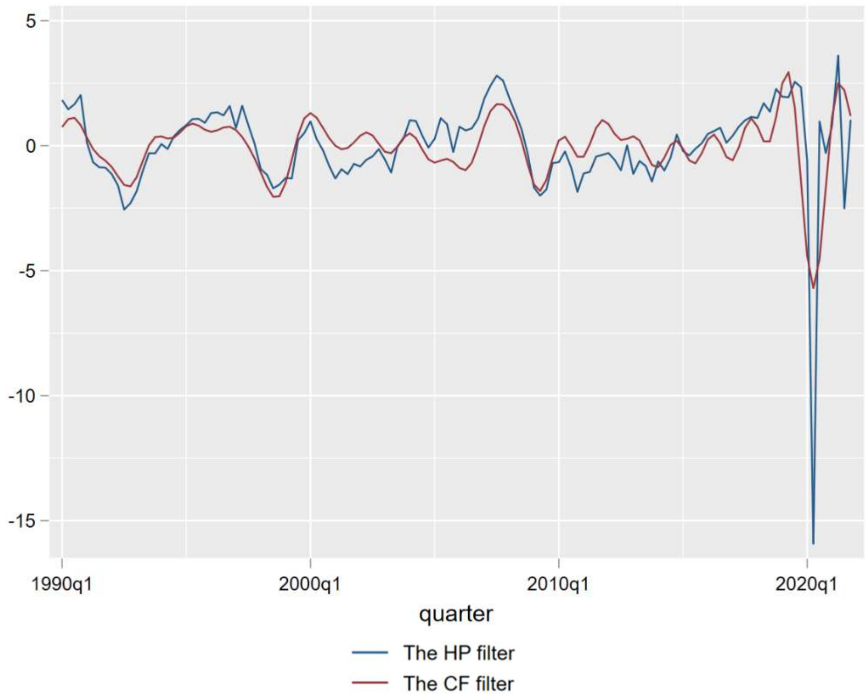
Appendix 5 b Private sector credit cyclical components

(a) HP filter (b) CF filter

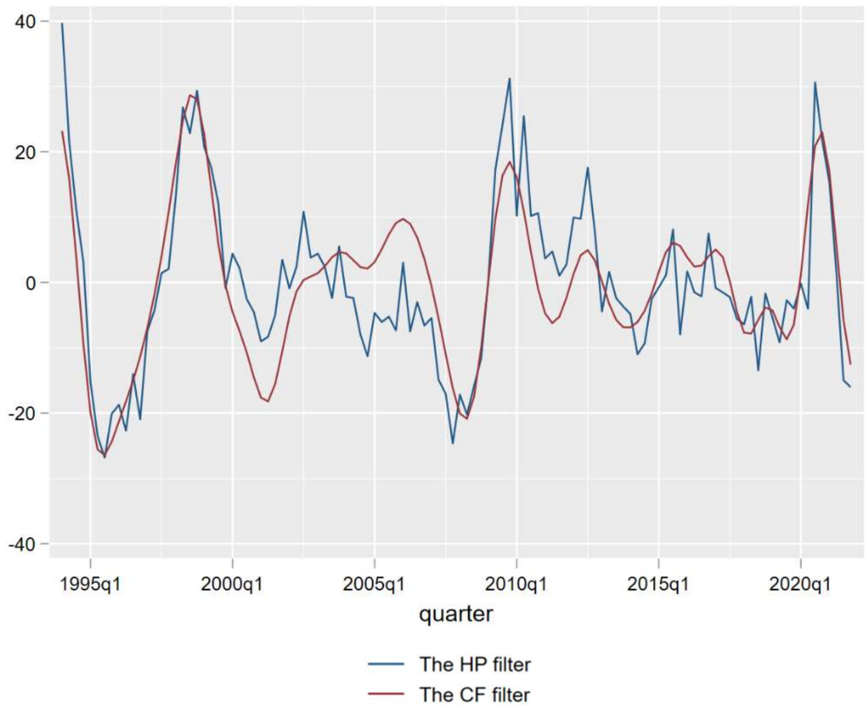


Appendix 6 HP- and CF-filters cyclical components

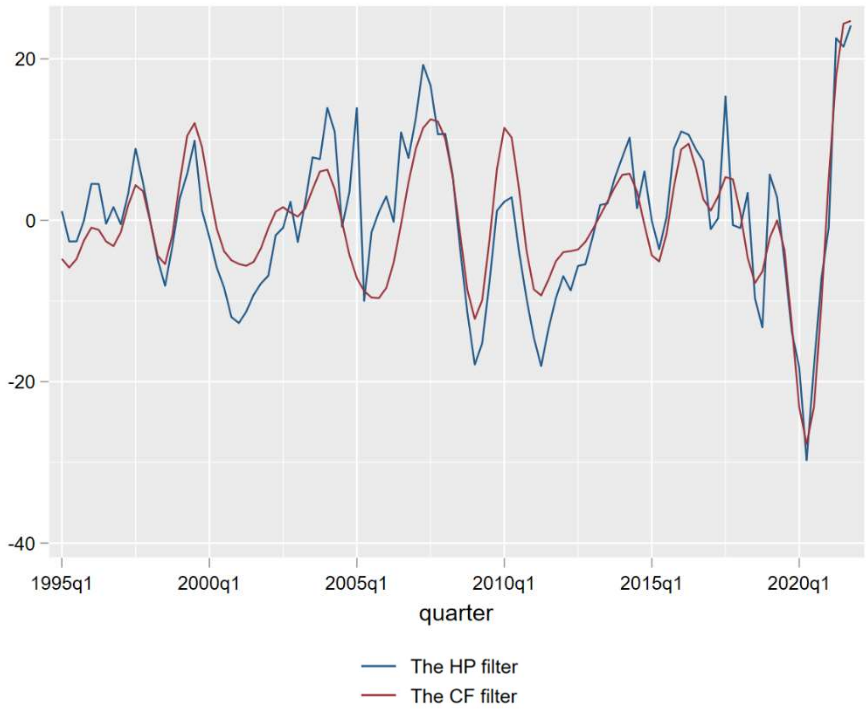
Appendix 6 a GDP



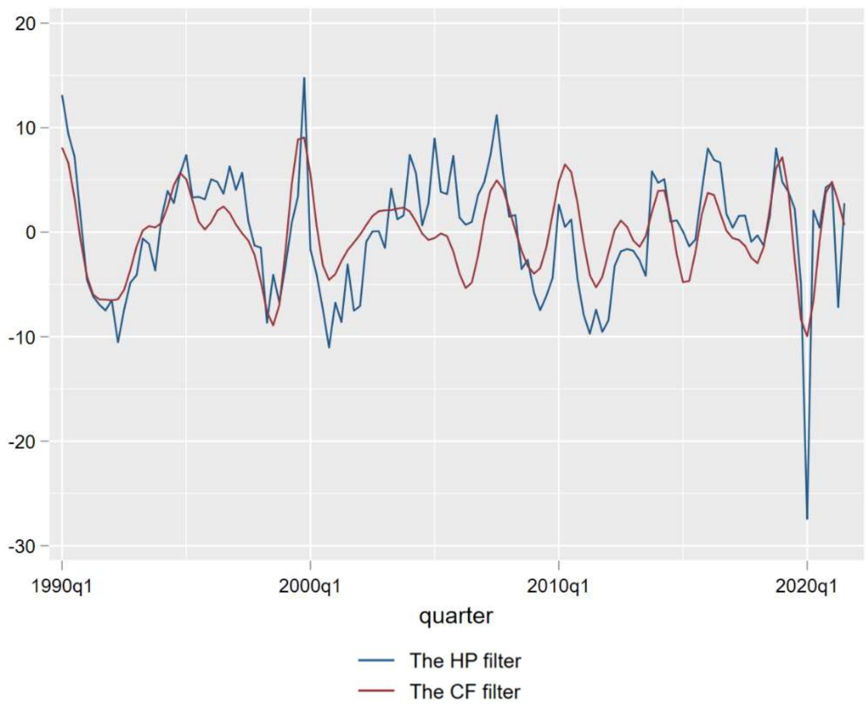
Appendix 6 b Unemployment rates



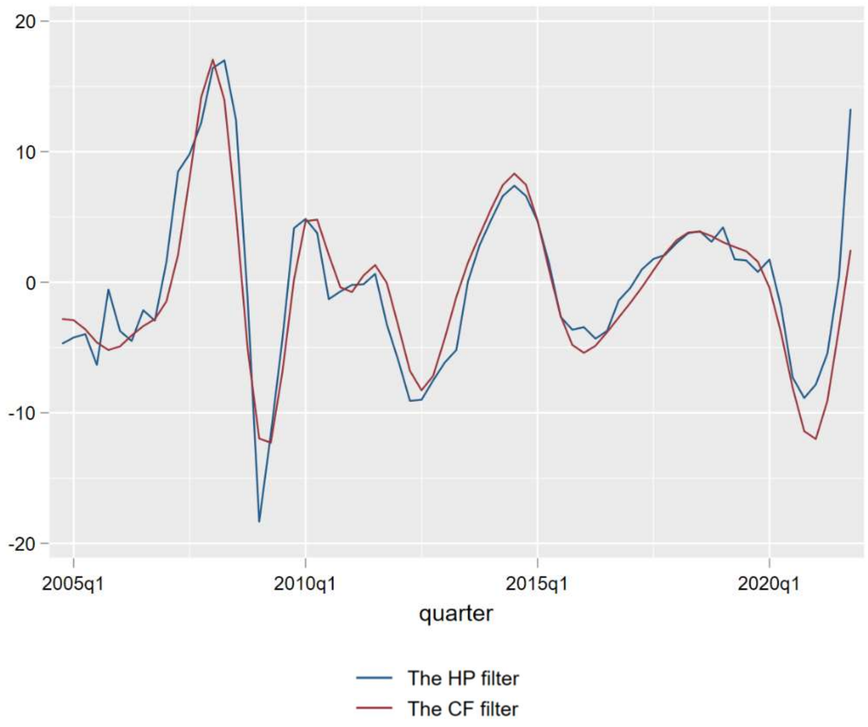
Appendix 6 c Building consents



Appendix 6 d Building volume



Appendix 6 e Mortgage rates



Appendix 6 f Private sector credit