# Modelling time series properties of Australian lending interest rates

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**Abstract:** The purpose of this paper is to examine the time series properties of Australian residential mortgage interest rates,[1] and in doing so, establish whether or not selected home loan rates (product-level monthly home loan interest rates for CBA) exhibit the expected cyclical and seasonal variations and whether seasonality, if present, is stochastic or deterministic. In particular, due to a well established presence of cyclicality in financial markets' interest rates and strong correlation between financial markets' interest rates and home loan interest rates, the paper presumes that cyclicality is also to be found in home loan interest rates. Furthermore, the paper tests the hypothesis that home loan interest rates, for selected products, exhibit the three identified ("Spring", "Autumn" and "The end of the Financial Year") season-related interest rate reductions. The paper uses a structural time series modelling approach and product-level home loan interest rates data from one of the biggest banks in Australia, Commonwealth Bank of Australia (CBA). As expected, the results overall confirm the existence of cyclicality in home loan interest rates. With respect to the seasonality of home loan interest rate, although most of the analysed variables show the presence of statistically significant seasonal factors, the majority of the statistically significant seasonal factors observed cannot be attributed to any of the three considered seasonal effects.

**Key words:** cyclicality; seasonality; structural time series modelling; home loan interest rates; home loan pricing strategies

## 1. Introduction

Home loan interest rates[2] have an exceptionally extensive scope of influence. The desire to own a home is a well-recognised aspiration of the vast majority of the population. It is commonly recognised that an average household's single largest and most important financial product is the home loan. Through their influences on a significant portion of the population, home loan interest rates considerably influence the whole economy. Consequently, research which focuses on fluctuations in home loan interest rates is of much interest. The focus of this paper, in particular, is on empirically assessing the presence of seasonal and cyclical variations in Australian home loan interest rates. To do so, the paper uses the actual data of one of the biggest Australian banks, CBA.

To a certain degree, the behaviour of Australian home loan lenders also implies the existence of cyclicality in home loan interest rates. As conversed by Karamujic (2009), Australian lenders are anecdotally known to utilise the cyclicality of financial markets' interest rates to develop innovative home loan pricing strategies. These strategies are primarily based on the notion that the slope of the yield curve[3] changes over time, and these

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[1] Residential mortgages are also known as home loans.

[2] A home loan interest rate can be defined as the payment made to a lender by a borrower for using the lender's money to fund the purchase of a house, which is expressed as an annual percentage of the funds borrowed.

[3] A yield curve is the graphical depiction of the term structure of interest rates at a point in time.

changes can be related to different stages of the interest rate cycle. Typically, in an interest rate-reducing environment (contraction phase of an interest rate cycle), the cash rate will be above most, if not all, term lending interest rates[4], and vice versa, in an interest rate-increasing environment (expansion phase of an interest rate cycle), the cash rate will be below most, if not all, term interest rates[5]. Consequently, at any point in the financial market interest rate cycle, fixed rate and variable rate home loans offering the same headline rates, will almost always have different lender profit margins. The major reason for this is that different costs of funds (COF) form the basis for the pricing of home loan products[6]. This fact in particular is used by lenders to determine a kind of pricing strategy that is best suited for any particular stage of the cycle. The premise here is that in an increasingly commoditised home loan market, interest rate shoppers are becoming an increasingly important market segment. Therefore, a lender who can offer more competitive rates has a greater chance of increasing its market share.

Although empirical evidence on cyclical variations is substantial for a number of different financial variables, such as stock returns and foreign exchange rates, it is relatively scant in addressing cyclicality of Australian interest rates. To name a few, Campbell and Lewis (1998) touched upon cyclicality of the fixed interest rate market in Australia, while Ellis and Lowe (2002) focused on changes in the cash rate. Berger-Thomson and Ellis (2004) discussed the issue of interest rate cyclicality through analysing cyclicality of the Australian housing sector. All these three studies, to varying degrees, point out the existence of interest rate cyclicality.

Based on the limited empirical evidence of the existence of interest rate cyclicality and the behaviour of Australian home lenders, the paper accepts the existence of interest rate cyclicality in Australian financial markets. Consequently and due to a well recognised correlation between financial markets' interest rates and home loan interest rates, the paper presumes that this cyclicality is also to be found in home loan interest rates.

According to Karamujic (2009), Australian lenders, and in particular, the major four banks[7], in addition of utilising the cyclicality of financial markets' interest rates to develop innovative home loan, pricing strategies are also known to recognise the influence of intra-year seasonal changes in demand for housing and consequent home lending. Among other classes, the study classifies home loan strategies into event-based pricing strategies, within which it identifies the following three seasons: “Spring”, “Autumn” and “The end of the Financial Year”. Due to competitive pressures, all three intra-year season-related pricing strategies are expected to produce seasonal home loan interest reductions for targeted products. The paper accepts this hypothesis, hence, an additional objective of the paper is to test the hypothesis that home loan interest rates, for selected products, should exhibit the three identified season-related interest rate reductions.

In summary, the purpose of modelling home loan interest rates here is to establish whether or not selected home loan interest rates (product-level monthly home loan interest rates for CBA) exhibit the expected cyclical and seasonal variations and whether seasonality, if present, is stochastic or deterministic. A structural time series modelling approach is used to model the product-level home loan interest rates. The major reason for selecting the structural time series modelling approach is that it allows testing for both stochastic and deterministic seasonality[8]. Conventional dynamic modelling with a deterministic seasonality approach totally ignores the likely possibility of

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[4] The yield curve that captures this yield composition is known as the inverse yield curve.

[5] Because most of the time yields on long-term are higher than those on short-term, the yield curve representing this yield composition is known as the normal yield curve.

[6] The interest cost that a lender pays for funding its lending operations.

[7] The following four banks are also called the major banks in Australia: Australia and New Zealand Banking Group (ANZ), Commonwealth Bank of Australia (CBA), Westpac Banking Corporation (Westpac) and National Australia Bank (NAB).

[8] Harvey and Todd (1983) identified a number of other advantages by using the structural time series modelling approach.

stochastic seasonality (manifested as changing seasonal factors over the sample period). Evidently, a problem with the conventional procedure is that deterministic seasonality is imposed as a constraint, when in fact it should be a testable hypothesis[9].

The next section of this paper outlines the methodology used. Section 3 presents detailed empirical results, while Section 4 provides an interpretation of the modelling results. Finally, in section 5, the paper concludes with an overall assessment of actual modelling results versus expected results. The conclusion also examines the limitations of the research and points out several areas for further research.

## 2. Methodology

Within a structural time series approach, the term "structural" implies that a time series is described as a set of components unobservable directly. The approach allows the selected time series, including intervention variables, to be modelled simultaneously with the unobserved components[10]. The intention is to decompose the selected time series in terms of their respective components, and to understand how these components relate to the underlying forces that shape its evolution.

For this purpose, the empirical analysis uses the model as presented in Harvey (1985, 1990), whereby time series are modelled in terms of their components. The model can be written as:

$$r_t = \mu_t + \phi_t + \gamma_t + \varepsilon_t \tag{1}$$

where $r_t$ represents the actual value of the series (home loan interest rates) at time $t$, $\mu_t$ is the trend component of the series, $\phi_t$ is the corresponding cyclical component, $\gamma_t$ is the seasonal component and $\varepsilon_t$ is the irregular component (assumed to be "white noise"). The above equation is subjected to the following two restrictions: $cov\ (\mu_t, \phi_t, \gamma_t) = 0$ and $\varepsilon_t \sim$ NID $(0, \sigma^2_\varepsilon)$. These restrictions imply that the components cannot in any way be correlated and that the error term must be normally and independently distributed.

In its most general form, the trend component (representing the long-term movement in a series) can be written as a stochastic linear process.

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t \tag{2}$$

$$\beta_t = \beta_{t-1} + \xi_t \tag{3}$$

subject to $\eta_t \sim$ NID $(0, \sigma^2_\eta)$ and $\xi_t \sim$ NID $(0, \sigma^2_\xi)$, which implies that $\mu_t$ follows a random walk with a drift $\beta_t$ (following a first-order autoregressive process as represented by equation 3).

The stochastic properties of the level and slope are driven by $\eta_t$ and $\xi_t$, which are uncorrelated random errors. Each of the unobserved components is assumed to be normally distributed with mean 0 and variances $\sigma^2_\varepsilon$, $\sigma^2_\eta$, and $\sigma^2_\zeta$. If any of these variances converges to zero, the stochastic component becomes purely deterministic and the stochastic model collapses into a purely deterministic model.

The seasonal component can be represented by a trigonometric specification, as defined by Harvey and Scott (1994). This specification is commonly known to allow a smoother change in seasonal. Nevertheless, in this paper, this specification will not be used as estimates for the seasonal component which do not allow for a straightforward interpretation[11]. Consequently, stochastic dummies will be used to represent the seasonal component as:

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[9] The same conclusion was reached by Al-Sad and Moosa (2005).

[10] In this paper, unobserved components entail trend, cyclical and seasonal component.

[11] Koopman, et al (1995, p.226) discusse the difficulties of interpreting trigonometric seasonals.

$$\gamma_t = \sum_{j=1}^{s-1} \gamma_{t-j} + K_t \tag{4}$$

where $s$ is the number of possible seasonal factors in one year and $K_t$ (random term) $K_t \sim$ NID $(0, \sigma_K^2)$. For stochastic seasonality to be satisfied $\sigma_K^2 \neq 0$, whereas deterministic seasonality requires the condition $\sigma_K^2 = 0$ to be satisfied.

Finally, the cyclical component is assumed to be a stationary linear process:

$$\phi_t = a \cos \theta_t + b \sin \theta_t \tag{5}$$

where $\theta_t$ is the frequency of the cycle and $a$ and $b$ are parameters. In order to make the cycle stochastic, the parameters $a$ and $b$ are allowed to change over time, while preserving continuity is achieved by writing down a recursion for constructing $\phi$ before introducing the stochastic elements. By introducing a dampening factor and disturbances, the following are obtained:

$$\phi_t = \rho(\phi_{t-1} \cos \theta + \phi^*_{t-1} \sin \theta) + \omega_t \tag{6}$$

$$\phi^*_t = \rho(-\phi_{t-1} \sin \theta + \phi^*_{t-1} \cos \theta) + \omega^*_t \tag{7}$$

where $\phi_t^*$ appears with construction such that $\omega_t$ and $\omega_t^*$ are uncorrelated "white noise" disturbances with variances $\sigma_\omega^2$ and $\sigma_{\omega^*}^2$, respectively. The parameters $0 \leq \theta \leq \pi$ and $0 \leq \rho \leq 1$ are the frequency of the cycle and the damping factor on the amplitude, respectively. The period of the cycle, which is the time taken by the cycle to go through its complete sequence of values, is $2\pi / \theta$ (Harvey, 1990, p.38).

The above specified model is put into a state space form and estimated by the maximum likelihood procedure using the Kalman filtering technique[12]. The actual estimations are conducted by STAMP 6.0 software, which is a windows-based econometric modelling programme.

## 3. Empirical results

The structural time series model represented by equation (1) is applied to actual monthly home loan interest rate data for CBA, between June, 1994 and March, 2004. The data have been sourced from CANNEX[13,14]. For consistency, the sample for each variable is standardised to start with the first available July observation and end with the latest available June observation.

Before discussing the actual results of the modelling, a short elaboration on the meaning of the components of the final state vector might be beneficial. $\mu_t$ represents the level of the series, while $\gamma_{1t}$ is a seasonal factor relating to the last month in the annual cycle, i.e., June, with $\gamma_{2t}$ corresponding to May, $\gamma_{3t}$ corresponding to April, and so forth. $\phi_t$ and $\phi_t^*$ represent cyclical components of the series. In addition to other results, Tables 1 and Tables 2 also report on the goodness of fit and diagnostics. The estimation set covers nine dependent variables, namely, the interest rates for the following home loans[15]: basic home loan (BHL), standard variable rate home loan (SVRHL), 12-month fixed rate introductory home loan, 1-year fixed rate home loans (FRHL), 2-year FRHL, 3-year FRHL, 4-year FRHL, 5-year FRHL and line of credit (LOC) home loan. With respect to the goodness of fit,

[12] Detailed explanations of the procedure are provided in Harvey (1985, 1990) and Koopman (1997).

[13] Due to discounts applicable to the advertised rates and confidentiality surrounding those discounts, more recent reliable data was not available at the time of the analysis.

[14] CANNEX is Australia and New Zealand's specialist research service company which is used by over 450 financial institutions, government, media and finance professionals.

[15] For more details on the presented home loan products refer to Karamujic (2008).

the model is generally well defined. Overall, the diagnostic tests do not indicate any problems with the assumptions of the model. The only exceptions are the tests for serial correlation (Q) for SVRHL, 12-month fixed rate introductory home loan, 1-year FRHL, 2-year FRHL, 4-year FRHL and 5-year FRHL, which are slightly above the statistically acceptable level.

As illustrated in Table 1 and Table 2, most of the variables analysed, with the exception of the 4 and 5 years FRHLs, imply the presence of a statistically significant cyclical component. Similarly, with respect to the eleven seasonal factors, most of the variables analysed, with the exception of the 4-year FRHL and the LOC home loan, imply the presence of statistically significant seasonal (monthly) variation. Fig. 1 to Fig. 9 plot seasonal components individually for each variable. The seasonal factors presented appear to be rather regular for all variables except the 12-month fixed rate introductory home loan, implying the deterministic nature of all the seasonal factors except those corresponding to the 12-month fixed rate introductory home loan, and the stochastic nature of the seasonal factors corresponding to the 12-month fixed rate introductory home loan.

**Table 1 Final state vectors**

| Component | BHL | | SVRHL | | 12 mth. fixed rate Introd. home loan | | 1-year FRHL | | 2-year FRHL | | 3-year FRHL | | 4-year FRHL | | 5-year FRHL | | LOC Home Loan | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Estimated values | t Statistics | Estimated values | t Statistics | Estimated values | t Statistics | Estimated values | t Statistics | Estimated values | t Statistics | Estimated values | t Statistics | Estimated Values | t Statistics | Estimated values | t Statistics | Estimated values | t Statistics |
| $\mu t$ | 5.64190 | 28.57 | 6.22080 | 35.32 | 5.84270 | 52.31 | 6.02250 | 65.13 | 6.27310 | 55.79 | 6.15090 | 49.13 | 6.37340 | 50.67 | 6.44750 | 52.66 | 5.94990 | 30.39 |
| $\beta$t | -0.00778 | -0.14 | -0.03197 | -0.39 | 0.07066 | 1.36 | 0.02418 | 0.43 | -0.00404 | -0.07 | -0.02563 | -0.49 | -0.02377 | 0.06 | 0.00375 | 0.05 | -0.01217 | -0.26 |
| | 0.40717 | 2.47 | 0.33938 | 2.59 | -0.22124 | -13.08 | -0.02745 | -1.46 | -0.09289 | -3.42 | -0.11486 | -2.76 | -0.19000 | -1.79 | -0.05405 | -0.81 | 0.08599 | 4.59 |
| | -0.23648 | -1.54 | -0.12772 | -0.99 | 0.04447 | 2.63 | -0.09714 | -5.19 | 0.00357 | 0.13 | -0.06327 | -1.51 | -0.16065 | -1.57 | -0.02921 | -0.45 | -0.00596 | -0.32 |
| $\gamma 1t$ | -0.03400 | -0.60 | 0.89632 | 2.58 | -0.08167 | -1.06 | 0.03069 | 0.65 | 0.05783 | 1.08 | 0.13389 | 1.50 | 0.03973 | 0.66 | 0.05809 | 1.07 | 0.02247 | 0.51 |
| $\gamma 2t$ | -0.17573 | -3.25 | 0.81005 | 2.29 | -0.03304 | -0.71 | -0.03621 | -0.84 | 0.02105 | 0.40 | 0.05565 | 0.65 | 0.06318 | 1.06 | 0.08330 | 1.57 | -0.07402 | -1.76 |
| $\gamma 3t$ | -0.11863 | -2.24 | 0.55901 | 1.56 | -0.11963 | -3.17 | -0.02579 | -0.60 | -0.00740 | -0.14 | 0.06698 | 0.78 | 0.03840 | 0.65 | 0.11496 | 2.19 | -0.02818 | -0.68 |
| $\gamma 4t$ | -0.06544 | -1.24 | 0.13215 | 0.37 | -0.17211 | -4.66 | -0.00049 | -0.01 | -0.01639 | -0.31 | -0.11411 | -1.33 | 0.07100 | 1.20 | 0.01602 | 0.31 | -0.03077 | -0.74 |
| $\gamma 5t$ | 0.06921 | 1.31 | -0.26152 | -0.74 | -0.15084 | -4.06 | -0.03845 | -0.90 | -0.09559 | -1.84 | -0.14684 | -1.71 | -0.04928 | -0.84 | 0.06442 | 1.23 | 0.04024 | 0.96 |
| $\gamma 6t$ | -0.04224 | -0.80 | -0.72415 | -2.06 | -0.12632 | -3.38 | -0.07508 | -1.75 | -0.12636 | -2.43 | -0.23514 | -2.74 | -0.06235 | -1.06 | -0.09019 | -1.72 | -0.06508 | -1.56 |
| $\gamma 7t$ | 0.03370 | 0.64 | -0.89077 | -2.53 | 0.02169 | 0.59 | -0.06496 | -1.51 | -0.12093 | -2.32 | -0.22067 | -2.58 | -0.07301 | -1.24 | -0.06497 | -1.24 | -0.00432 | -0.10 |
| $\gamma 8t$ | 0.04391 | 0.83 | -0.82647 | -2.33 | 0.07610 | 2.07 | 0.03867 | 0.90 | 0.03137 | 0.60 | 0.05587 | 0.65 | -0.05885 | -1.00 | -0.09818 | -1.87 | 0.03126 | 0.75 |
| $\gamma 9t$ | -0.01186 | -0.22 | -0.62662 | -1.75 | 0.18005 | 4.93 | 0.00696 | 0.16 | -0.02748 | -0.53 | 0.02738 | 0.32 | -0.10631 | -1.80 | -0.00567 | -0.11 | -0.02943 | -0.71 |
| $\gamma 10t$ | 0.11824 | 2.23 | -0.13114 | -0.37 | 0.10363 | 2.84 | 0.00369 | 0.09 | 0.08404 | 1.61 | 0.06777 | 0.79 | 0.00391 | 0.07 | -0.04164 | -0.79 | 0.07378 | 1.78 |
| $\gamma 11t$ | 0.12291 | 2.27 | 0.32770 | 0.92 | -0.06720 | -1.84 | 0.13119 | 3.01 | 0.13027 | 2.48 | 0.17440 | 2.02 | 0.09034 | 1.51 | -0.04618 | -0.87 | 0.02862 | 0.68 |
| $R2$ | 0.95825 | | 0.98284 | | 0.93747 | | 0.94329 | | 0.95925 | | 0.92481 | | 0.95834 | | 0.92009 | | 0.96759 | |
| $Rs2$ | 0.34333 | | 0.11180 | | 0.48700 | | 0.15955 | | 0.24218 | | -0.01595 | | 0.10570 | | 0.13194 | | 0.47521 | |
| $\sigma$ | 0.12631 | | 0.19399 | | 0.15533 | | 0.11184 | | 0.14611 | | 0.21550 | | 0.16250 | | 0.14817 | | 0.11050 | |
| $AIC$ | -3.09630 | | -2.81690 | | -2.33555 | | -3.54804 | | -3.25154 | | -2.47434 | | -3.03917 | | -3.17996 | | -3.57220 | |
| $BIC$ | -2.12172 | | -2.19603 | | -1.23589 | | -2.67539 | | -2.52808 | | -1.75088 | | -2.31571 | | -2.45269 | | -2.69956 | |
| $Q$* | 7.69800 | | 20.78000 | | 13.63000 | | 17.53000 | | 16.57000 | | 8.7310 | | 16.7200 | | 16.9200 | | 8.9780 | |
| $H$# | 0.43092 | | 0.44277 | | 0.74928 | | 0.86984 | | 0.42049 | | 0.99138 | | 0.58120 | | 1.35200 | | 1.45500 | |
| $N$ | 1.85900 | | 2.67800 | | 0.06678 | | 2.29900 | | 0.53449 | | 2.53500 | | 4.86300 | | 1.10800 | | 1.92100 | |
| | * Distributed as $X2$ (6) # Distributed as F ( 11, 11 ) | | * Distributed as $X2$ (6) # Distributed as F ( 31, 31 ) | | * Distributed as $X2$ (6) # Distributed as F ( 7, 7 ) | | * Distributed as $X2$ (6) # Distributed as F ( 15, 15 ) | | * Distributed as $X2$ (6) # Distributed as F ( 23, 23 ) | | * Distributed as $X2$ (6) # Distributed as F ( 7, 7 ) | | * Distributed as $X2$ (6) # Distributed as F ( 23, 23 ) | | * Distributed as $X2$ (6) # Distributed as F ( 19, 19 ) | | * Distributed as X2 (6) # Distributed as F (15, 15 ) | |

## 4. Findings

Having two sets of hypotheses (relating to cyclical and seasonal variations), the interpretation of the modeling results is also structured in two parts. Within each sub-section a brief interpretation of results is offered.

### 4.1 Home loan interest rates cyclicality

The estimates of equation (5), shown in Table 1, indicate that a statistically significant cyclicality is observed for almost all the included variables, except for the 4 and 5 years FRHLs, confirming the presence of cyclicality in home loan interest rates. Due to the scope of the analysis, the study is unable to provide a conclusive explanation for the absence of statistically significant cyclicality in the 4 and 5 years FRHLs. Longer period and more detailed analysis would be needed to do so, indicating an interesting topic for future research.

### 4.2 Home loan interest rates seasonality

Compared to the interpretation of the modelling results for the home loan interest rates' cyclicality, the interpretation of modelling results for home loan interest rates seasonality is a bit more complex. Here, the focus is not only on finding whether the seasonality exists or not, but also on examining the existence, or not, of the three seasonal effects in home loan interest rates: "Spring", "Autumn" and "The End of the Financial Year"[16]. Even after establishing the existence of a statistically significant seasonal factor, corresponding to one of the considered seasonal effects, an additional condition which is applicable to all three seasonal effects is for the statistically significant seasonal factor to be expressed as a product-specific seasonal rate reduction. For this reason, instead of providing a summary interpretation, brief product-level interpretations of the modelling results are offered, while at risk of being somewhat repetitive.

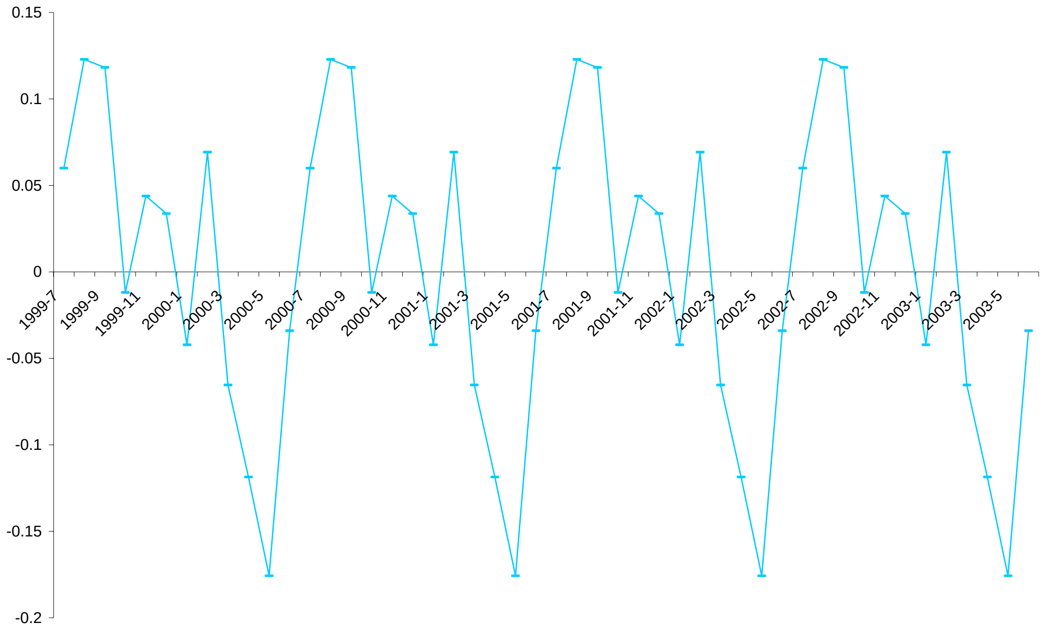


**Fig. 1 BHL: seasonal component**

[16] For more details on the considered seasonal effect refer to Karamujic (2009), 152-172.

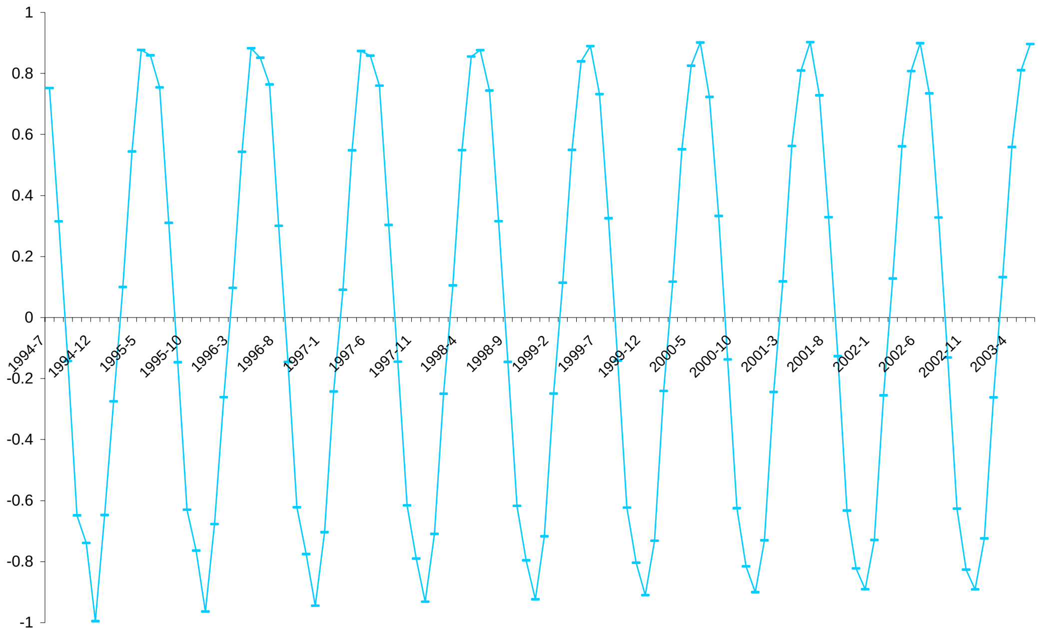


**Fig. 2 SVRL seasonal component**

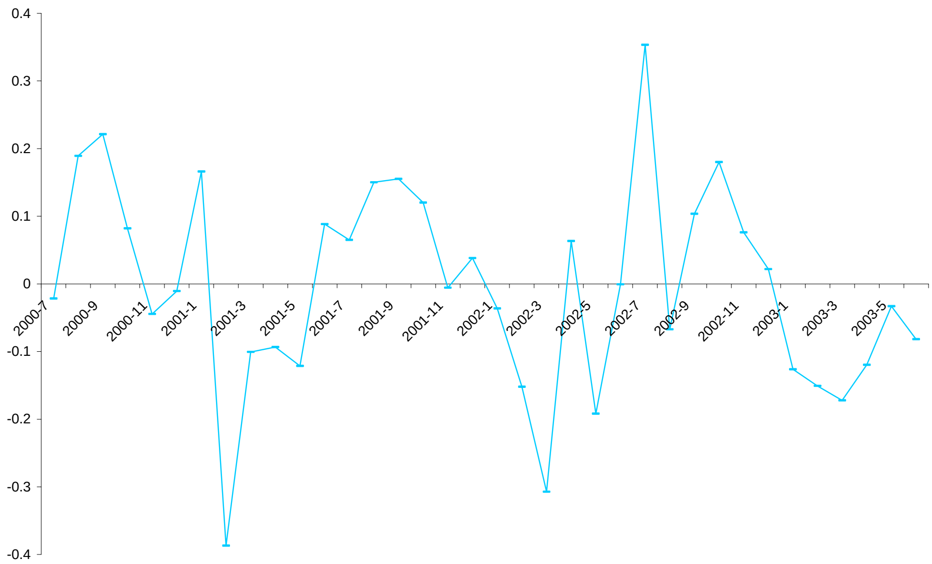


**Fig. 3 12-month fixed rate introductory HL seasonal component**

4.2.1 Basic home loan (BHL)

Of the eleven seasonal factors for BHL presented in Table 1, the factors corresponding to April ($\gamma_3$), May ($\gamma_2$), August ($\gamma_{11}$) and September ($\gamma_{10}$) show statistically significant seasonality. The seasonal factors for April ($\gamma_3$) and May ($\gamma_2$) correspond to the end of the financial year season. The end of the financial year season generally starts by the end of April or the beginning of May, and finishes at the end of the first week in July. The primary cause of this seasonal effect is that the Australian Taxation Office (ATO) accepts prepayment of the interest payable on investment properties[17]. Hence, towards the end of the financial year, investors seek financial tools that minimise

[17] For more on acceptable deduction for prepaid interest refer to the *Income tax assessment act 1997,* section 8-1.

their tax exposure, and, as such, optimise their wealth creation opportunities. The same is applicable to a lesser extent to owner-occupiers, who may come in larger numbers to the market, possibly attracted by, primarily investors' focused, marketing campaign's specials.

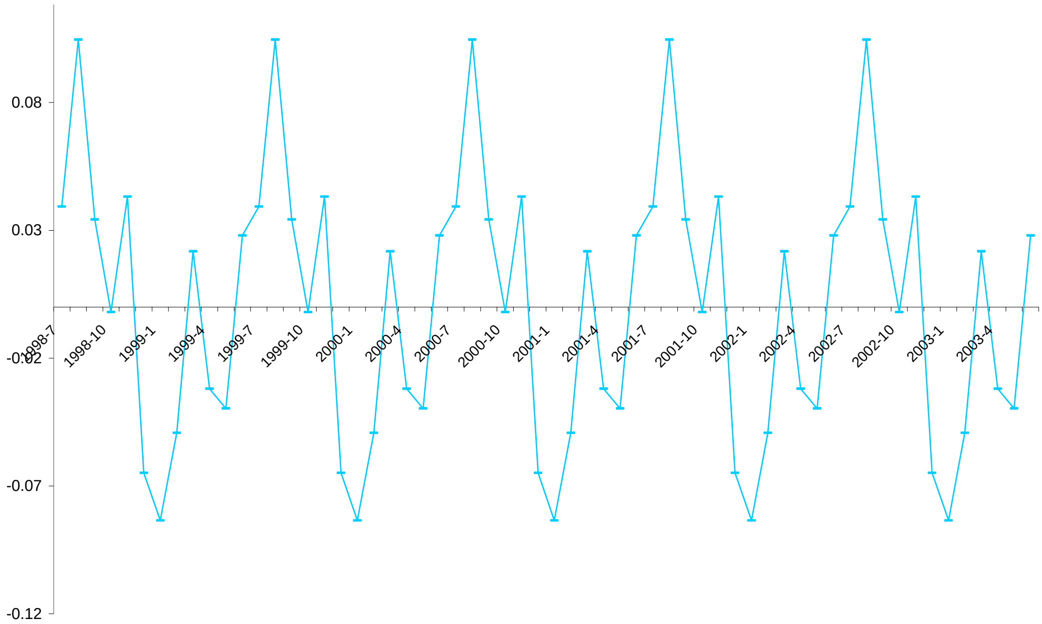


**Fig. 4 1-year FRHL seasonal component**

In summary, the statistically significant seasonal factors observed relate to the end of the financial year season and the negative values indicating seasonal rate reductions. Although, at a face value, it seems that the existence of the end of the financial year seasonal effect is confirmed by BHL, it is not a product that was expected to experience increased demand during the end of the financial year season. Even though the factors for BHL exhibited statistically significant seasonality in those two months during the observed period, BHL was not offered as an interest only product and did not allow for prepayment of interest. Furthermore, a BHL being a variable rate home loan, is not a product that should have been used for price-driven initiatives. Using a variable rate home loan and offering sizeable rate discounts would be too expensive for a bank such as NAB, as it would, at a minimum, re-price its entire BHL book[18]. The above arguments refute the possibility of linking the observed seasonality to the end of the financial year season. In addition, to the arguments raised thus far, it is important to note that because the cost of funds (COFs) for BHL are primarily determined by the cash rate, a BHL's interest rate principally moves only with the movement of the cash rate. Furthermore, given that BHL is already a heavily discounted product, it is almost never used for rate-driven initiatives.

Having refuted the above possible explanation and knowing that the BHL's interest rate principally moves only with the movement of the cash rate, it is logical to test whether the observed seasonality bears any relationship to movements in the cash rate. As already established, the COFs for a BHL are predominantly influenced by the cash rate, which is directly controlled by the RBA. Hence, this explanation can be confirmed or refuted by considering whether there has been a concentration of the RBA's cash rate reductions, coinciding with the end of the financial year season and the time horizon of the analysis. The cash rate reductions would have to

[18] The impact may be even larger as pricing of other variable rate home loans is commonly linked to the BHL interest rate.

be of a particular magnitude and time distribution to be able to cause the statistically significant seasonal factors observed.

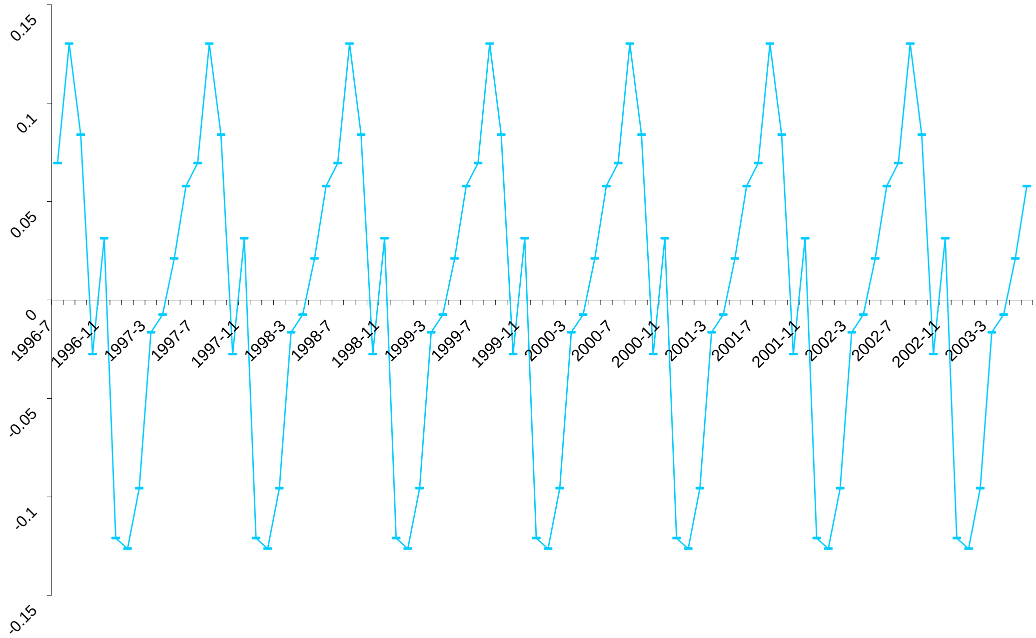


**Fig. 5 2-year FRHL seasonal component**

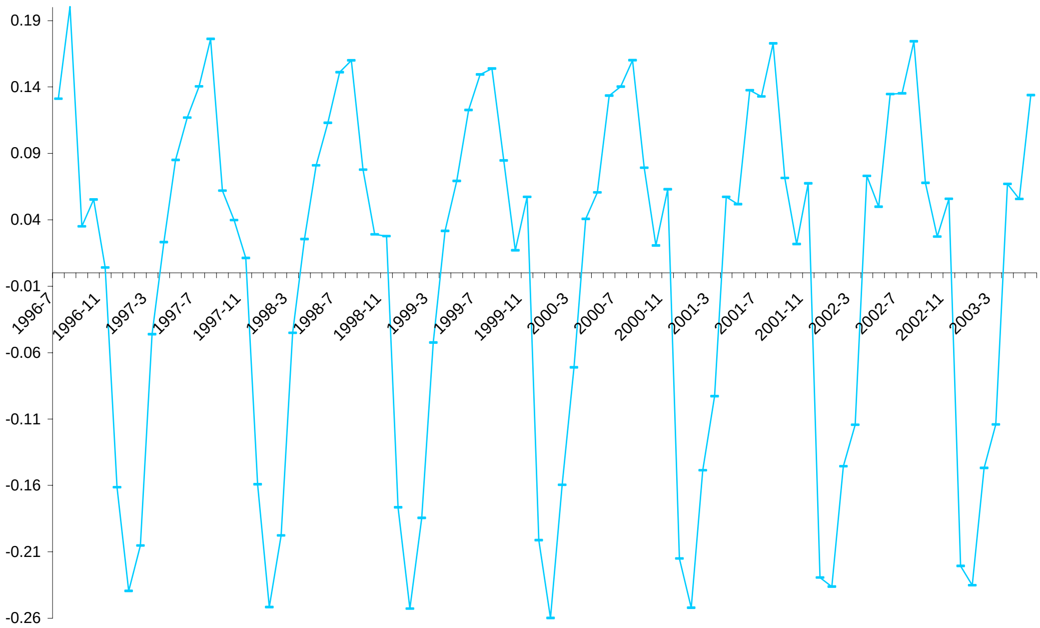


**Fig. 6 3-year FRHL seasonal component**

The result of tests on whether the RBA has reduced the cash rate in April and May, during the observed period, is encouraging. The cash rate changes observed support this interpretation, revealing that in four of the five years observed, the RBA has actually reduced the cash rate during one or both of those two months or the two months surrounding the period, i.e. March and June. To conclude, it seems that the observed seasonality is related to the particular stage of the interest rate cycle and is not linked to the end of the financial year season.

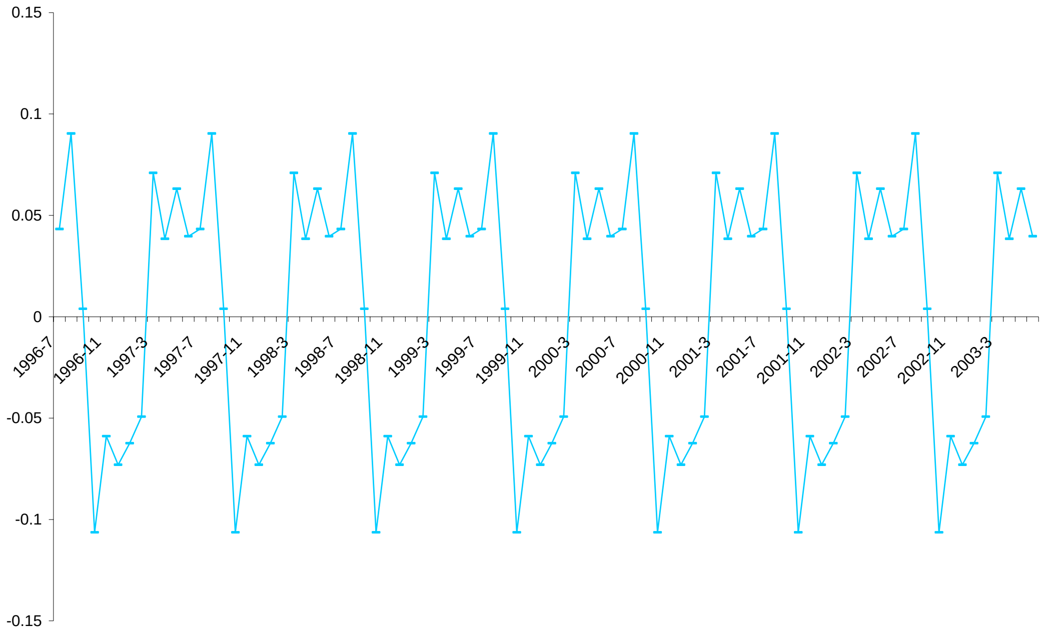


**Fig. 7 4-year FRHL seasonal component**

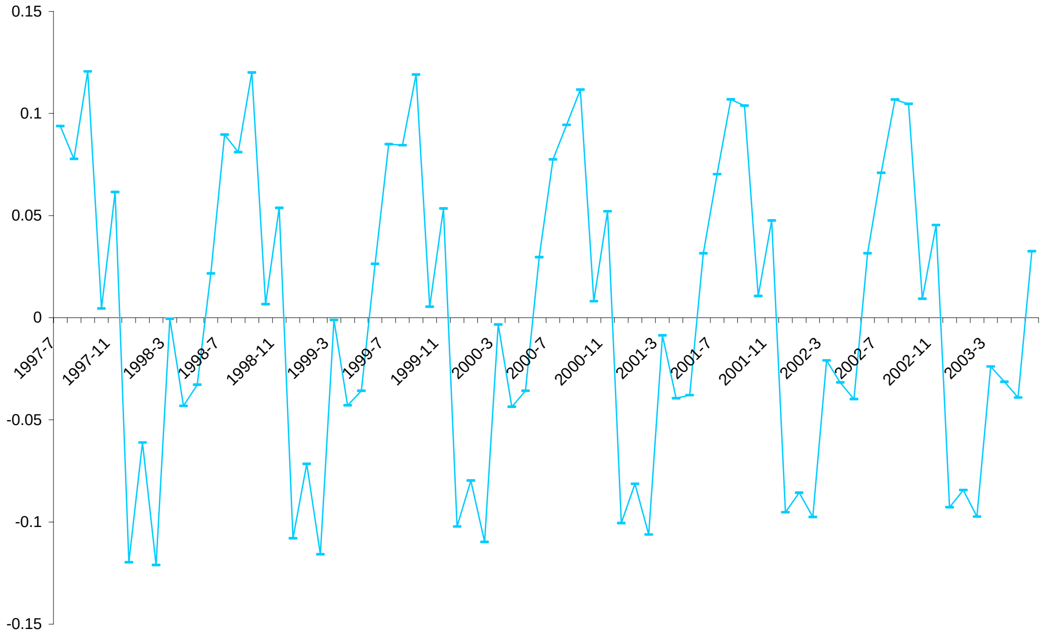


**Fig. 8 5-year FRHL seasonal component**

At face value, an explanation for the statistically significant interest rate increase in August ($\gamma_{11}$) and September ($\gamma_{10}$) may be a post-end of the financial year season correction. This explanation is not particularly plausible as variable rate products are not typically used during the end of the financial year season. Another possible explanation is to check whether the cause of the observed seasonalities has any relation to the movement of the cash rate during the observed period. Throughout the entire four year period used for modeling the CBA's

BHL interest rates (July, 1999 to June, 2003), during August, the RBA has actually maintained or increased the cash rate. Consequently, as for other BHL observed statistically significant seasonal factors, the interpretation for the observed statistically significant interest rate increase in August ($\gamma_{11}$) and September ($\gamma_{10}$) seems to be related to the particular stage of the interest rate cycle, but does not have anything to do with the end of the financial year season.

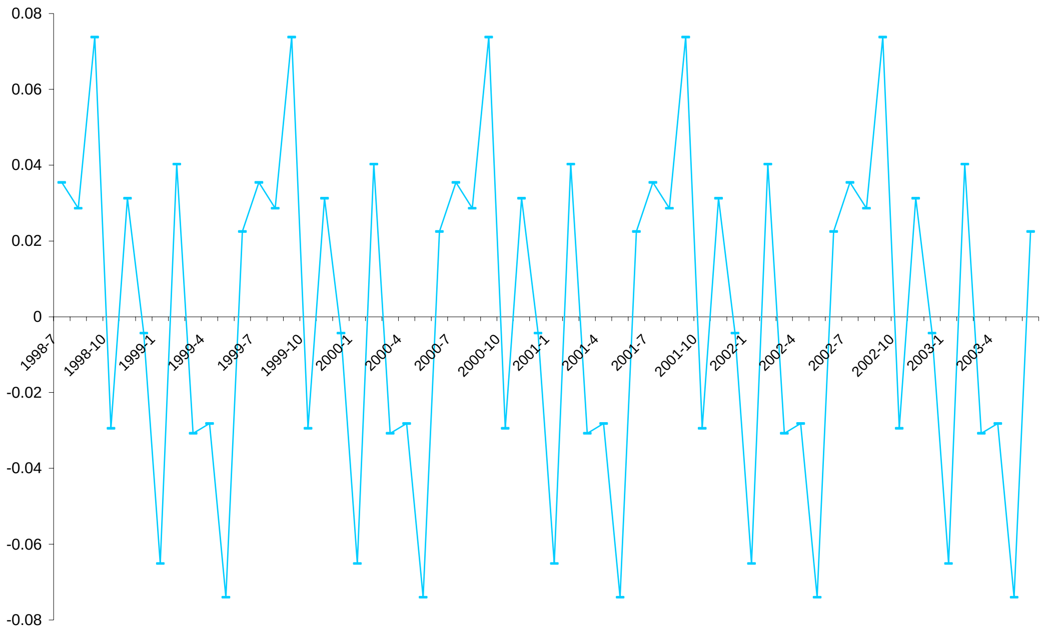


**Fig. 9 LOC home loan seasonal component**

4.2.2 Standard variable rate home loan (SVRHL)

Of the eleven SVRHL seasonal factors presented in Table 1, five seasonal factors were found to be statistically significant, namely, the factors corresponding to May ($\gamma_2$), June ($\gamma_1$), November ($\gamma_8$), December ($\gamma_7$) and January ($\gamma_6$). The seasonal factors for May ($\gamma_2$) and June ($\gamma_1$) show statistically significant interest rate increases, while the factors for January ($\gamma_6$), December ($\gamma_7$) and November ($\gamma_8$) show statistically significant interest rate decreases.

While interpreting the modeling results for the variable rate home loans, a clear pattern emerges. Specifically, it seems that the statistically significant seasonalities for the variable rate home loans cannot be attributed to any of the considered seasonal effects. The principal reason for this is that all of the three seasonal effects are primarily induced by seasonal rate decreases, and, as such, are not applicable to the variable rate home loan products whose interest rates change very rarely in isolation without a change in the cash rate. Consequently, by using the same logic as for other variable rate home loans, i.e., by considering whether the cause of the observed seasonalities is related to movements of the cash rate during the observed period, we should reach the same conclusion. Of the nine years observed for the SVRHL (July, 1994 to June, 2003), during January, December and November, for approximately 80 per cent of the observations the RBA has actually maintained or reduced the cash rate. Similarly, for approximately 80 per cent of the observations, during May and June, the RBA has actually maintained or increased the cash rate. Therefore, we can reach the same conclusion as for the BHL, i.e. that the observed seasonalities are not related to the bank’s intervention and can be attributed to the particular stage of the interest rate cycle.

4.2.3 12-month fixed rate introductory home loan

As shown in Table 1, of the eleven seasonal factors for the 12-month fixed rate introductory home loan, seven were found to be statistically significant. These are the factors corresponding to November ($\gamma_8$), October ($\gamma_9$), September ($\gamma_{10}$), April ($\gamma_3$), March ($\gamma_4$), February ($\gamma_5$) and January ($\gamma_6$). The factors for April ($\gamma_3$), March ($\gamma_4$), February ($\gamma_5$) and January ($\gamma_6$) show statistically significant interest rate decreases, while the factors for November ($\gamma_8$) October ($\gamma_9$) and September ($\gamma_{10}$) show statistically significant interest rate increases.

The presence of statistically significant factors for March ($\gamma_4$), February ($\gamma_5$) and even January ($\gamma_6$) imply the presence of the Autumn seasonal effect[19]. According to Karamujic (2009), "Autumn" is anecdotally well-recognised low demand season for house purchases and corresponding home lending. During this low demand season, the Australian home lending market is known to experience seasonal reductions in home loan interest rates. Increased competition is again the underlying cause for seasonal home loan interest rates reduction. However, instead of competing to capture a portion of increased demand for home lending, lenders are competing for a reduced number of additional sales opportunities.

Furthermore, the presence of the Autumn seasonal effect can even be taken as an explanation for the April ($\gamma_3$) result as sometimes the Autumn season is extended to April, depending on the results of the Autumn season-related pricing initiatives and the lender's business goals. Nevertheless, the absence of statistically significant seasonal rate reductions during the Spring season is surprising. Anecdotally, the Spring season is known as the strongest home loan high-demand season. Furthermore, because CBA doesn't have a 6-month fixed rate introductory home loan, the expectation was for the 12-month fixed rate introductory home loan to be utilised instead during the Spring season. The absence of statistically significant seasonal factors for the end of the financial year season is expected, as introductory home loans are rarely used during the end of the financial year season. A possible explanation for the absence of statistically significant seasonal factors during the Spring season is that the product is relatively new on the market, i.e. only four years' monthly data was available at the time of the analysis. For this reason, it would be interesting to replicate the analysis after more reliable data become available.

4.2.4 1-year fixed rate home loan (FRHL)

Of the eleven seasonal factors for the 1-year FRHL, shown in Table 1, only that corresponding to August ($\gamma_6$) was found to be statistically significant. With the introduction of introductory home loans, the importance of the 1-year FRHL has significantly diminished. In particular, after the introduction of the 12-month fixed rate introductory home loan, borrowers could opt for a more functional and more competitively priced 12-month fixed rate introductory home loan instead of a 1-year FRHL. Therefore, it is not surprising to find the absence of statistically significant seasonal factors during the Spring or Autumn seasons. An explanation for the statistically significant interest rate increase in August ($\gamma_6$) may be due to a post-end of the financial year season correction, as this product is known to be used for the end of the financial year season. However, this is not shown in the results as the seasonal factors, corresponding to April ($\gamma_3$), May ($\gamma_2$) and June ($\gamma_1$) that were found not to be statistically significant.

4.2.5 2-year FRHL

Of the eleven seasonal factors presented in Table 1, January ($\gamma_6$), December ($\gamma_7$) and August ($\gamma_{11}$) were found

[19] Late January is typically taken as a starting point for the Autumn season. For more, see Karamujic (2009), Chapter 7.

to be statistically significant. Statistically significant interest rate reductions for December ($\gamma_7$) and January ($\gamma_6$) may be explained as a result of the end of the Spring and the beginning of the Autumn seasonal effects. Anecdotally, the CBA is known to go to the market toward the end of the Spring season and often extends the same pricing initiative into the beginning of the Autumn season. In line with several other observations of the presence of a statistically significant August ($\gamma_{11}$) seasonal factor, an interpretation here may also be the presence of an end of the financial year season correction. This may be a plausible explanation as this product is known to be used for the end of the financial year season. The estimated results support the claim, showing statistically significant rate increases during the month. Nevertheless, a difficulty with this explanation is that we have not observed statistically significant interest rate reductions during the end of the financial year season. Yet again, we can not reach a conclusive explanation for which more detailed analysis would be needed.

4.2.6 3-year FRHL

In line with the modeling results obtained for the 2-year FRHL, of the eleven seasonal factors presented in Table 1, the same three factors were found to be statistically significant. Due to product similarity, the same explanation offered for the 2-yeas FRHL is also applicable to the 3-year FRHL.

4.2.7 4-year FRHL

Of the eleven seasonal factors for the 4-year FRHL, shown in Table 1, none was found with statistically significant. To be able to provide a more conclusive explanation for the observed modelling results, a more detailed analysis of associated changes in the yield curve and pricing strategies that used the 4-year FRHL during the observed period would be needed.

4.2.8 5-year FRHL

With respect to the eleven 5-years FRHL seasonal factors presented in Table 1, only one factor was found with statistically significant, namely, the factor corresponding to April ($\gamma_3$). The statistically significant rate increase for April cannot be related to any of the examined seasonal effects. To be able to provide a more conclusive explanation for the observed modeling results, a more detailed analysis of associated changes in the yield curve and pricing strategies that used the 5-year FRHL, during the observed period, would be required.

4.2.9 LOC home loan

In contrast to other variable rate home loans, with respect to the eleven LOC seasonal factors presented in Table 1, none was found to be statistically significant. An explanation for this may be that the data available for the LOC home loan, compared to the other variable rate products, covered a different time period. In particular, the data available for the LOC home loan covered the period between July, 1998 and June, 2003.

## 5. Conclusion

The modelling results, with respect to the expected cyclicality of home loan interest rates, largely confirm the existence of cyclicality in home loan interest rates for CBA. The magnitude of possible cycle-related changes on home loan interest rates ranges from around 0.08 per cent to almost 0.41 per cent. The findings, though are significant, are not conclusive as two variables indicate the absence of a statistically significant cyclical factor. To that end, a possible explanation for those factors is offered, and several possibilities for future research that may lead to a more conclusive explanation are indicated.

With respect to home loan interest rate seasonality, most of the variables analysed (with the exception of CBA's 4 FRHL and LOC home loan) show the presence of statistically significant seasonal factors. The magnitude of these seasonal changes range from around 0.08 per cent to almost 0.90 per cent. Furthermore, the seasonal factors presented appear to be regular for all variables, except for the 12-month fixed rate introductory home loan, implying the deterministic nature of all other seasonal factors observed, and, the stochastic nature of the 12-month fixed rate introductory home loan seasonal factors. Although most of the variables analysed show the presence of statistically significant seasonal factors, the majority of the observations cannot be attributed to any of the three considered seasonal effects. Nonetheless, even for the observed statistically significant seasonal factors that cannot be attributed to any of the three seasonal effects, a possible explanation has been offered.

The study has identified several interesting possibilities for future research, such as extending the scope of the analysis by testing the data for other major Australian banks. Finally, due to a recent significant turbulence on financial markets world wide, it will be exceptionally interesting, when data become available, to include the time series for the current financial crisis into the analysis.

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