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Monopolistic Banks and Fixed Rate Contracts: Implications for Open Economy Inflation Targeting

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Abstract

We investigate the implications of a key feature of mortgage markets for optimal policy for open economy inflation targeters. We show that the existence of fixed mortgage contracts shifts the transmission of monetary policy away for the standard interest rate transmission channel towards direct and indirect exchange rate channels. To quantify the impact of these effects on open economy inflation targeting, we calibrate our DSGE model to the case of New Zealand and solve for optimal time-consistent policy. New Zealand is the earliest explicit inflation targeter and proves a useful test case since many of the institutional features of mortgage markets are shared with other countries and the strength of the global boom in housing has been at least as strong as other countries. We show that optimal time-consistent policy is about ten percent less effective under fixed compared to flexible mortgage contracts. In addition, we show that the ineffectiveness of policy under fixed contracts is a decreasing function of the weight placed on a measure of output stabilisation but increasing the weight placed on interest rate smoothing does not mitigate the ineffectiveness of policy under fixed contracts.

1 Introduction

When banks have monopoly power over their retail rates and choose to revise their retail (lending and deposit) rates infrequently, the efficiency of the interest rate channel of monetary policy transmission (i.e. managing domestic demand through the relative price of today's and tomorrow's consumption) can significantly drop relative to the direct and indirect exchange rate channels (i.e. redirecting domestic and foreign expenditures on domestic and foreign goods through the real exchange rate, and affecting the price of imports in the consumer's basket). The relative shift in the importance of the two channels occurs because foreign exchange arbitrages, and hence also nominal exchange rate movements, are based predominantly on wholesale rates. Wholesale rates of the same maturities are, in turn, more responsive to the official cash rate than retail rates. We find that such a modification of the transmission mechanism can have considerable implications for optimal monetary policy, and is especially amplified by two circumstances.

First, there is a strong durable goods sector, such as housing. As documented by Erceg and Levin (2006) or Barsky et al. (2007), durables sectors can change the properties of monetary transmission extensively, and are generally more sensitive to interest rates than other sectors. Sluggish responses of mortgage rates to the official cash rate make, therefore, monetary stabilisation less efficient.

Second, the export sector is relatively disconnected from the domestic economy. Such a disconnect is typically the case of countries the exports of which have high commodity and low manufacturing content. The indirect exchange rate channel redirects foreigners' expenditures to or from domestically produced export goods, and hits exporting firms. This expenditure switching effect can, however, help stabilise domestic inflation only indirectly, through balance-sheet or wealth effects.

The two conditions portray, in fact, the New Zealand economy: the housing sector has boomed recently with housing related prices leading the non-tradable CPI, and the export sector has traditionally a high farming content. Analysing the disconnect between retail and fixed mortgage rates should be important for identifying the best method of conducting monetary policy. To this end we explore the effectiveness of monetary policy under two regimes: (i) flexible mortgage contracts; and (ii) fixed mortgage contracts. We find that the these alternative regimes have important implications of the ability of the central bank to achieve their objectives, that we summarise with a linear quadratic loss function.

Section 2 details New Zealand's key institutional features and recent housing market developments. A simple VAR documents the dynamics of the housing sector our DSGE model must capture. Section 3 details our multi-sector DSGE model and calibration to the data. Section 4 and presents optimal policy under a range of alternative mortgage market structures and assesses the implications of each structural feature of the volatility of the economy. Section 5 offers concluding comments.

2 Key institutional features of the New Zealand mortgage and housing markets

2.1 The mortgage market in New Zealand

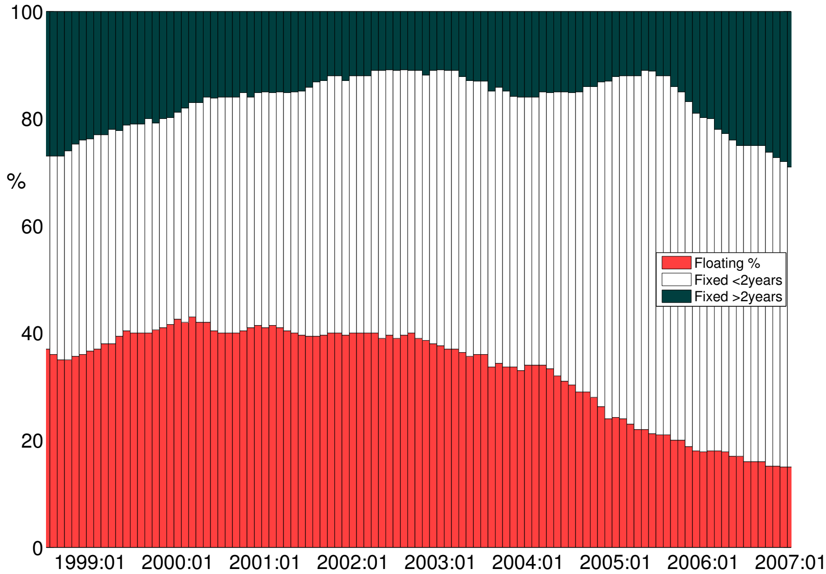
Up until the late 1980s mortgage contracts in New Zealand were set relatively conservatively. Coleman (2007), who provides a more extensive overview of the development of the New Zealand mortgage market, notes that contracts typically allowed for borrowing up to no more than 25% of annual gross earnings and banks normally lent no more than 75% of the value of the property. However, interest rate deregulation and the removal of credit allocation guidelines that began in 1984, saw banks offer progressively more flexible contracts that included higher load-to-value ratios, under the precondition that mortgagees purchase mortgage indemnity insurance.

In addition, the yield curve became steeply inverted in the late 1980s and early 1990s when New Zealand began to target inflation.[1] Combined with the earlier deregulation of interest rates, this enabled some banks to begin to offer fixed term contracts, that were later more actively promoted by large banks. Today, over 80% of new mortgage contracts are fixed rather than variable term mortgages. Furthermore, Figure 1 shows that mortgagees appear to be entering contracts that are fixed for longer periods.

These features are not unique internationally. Calza et al. (2007) find heterogeneity across mortgage market features for industrial countries and find some evidence of two clusters of mortgage-market types: (i) countries with well-developed mortgage markets that display considerable flexibility in the duration, interest-rate structure, loan-to-value ratio and equity release features of typical mortgage contracts, where mortgage debt to GDP ratios and loan-to-value ratios tend to be high and (ii) countries with less well developed mortgage markets that features where mortgage debt to GDP ratios and loan-to-value ratios tend to be low.

[1] New Zealand's yield curve has been frequently inverted over the inflation targeting period, much more so than Australia, for example

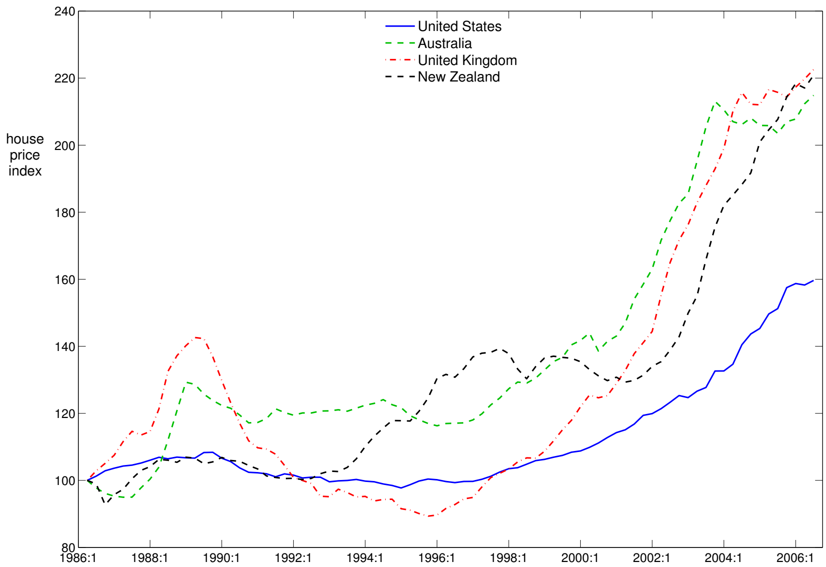
Figure 1: Maturity of new New Zealand mortgage contracts



2.2 *The housing market and monetary policy*

The strength of the global boom in housing has been at least as strong as other countries. Between January 2002 and June 2007, New Zealand's median house price essentially doubled in nominal terms (increasing 99%) with consumer price inflation of 14.5% over the same period. Figure 2 shows the increase in house prices in New Zealand against international competitors. Although the housing boom started relative late in New Zealand, the increase in house prices is of the same magnitude of both Australia and the United Kingdom with house price increases in the United States less dramatic (see Ahearne et al. (2005) for a broader discussion of monetary policy and the global house price boom).

Figure 2: International House price comparison

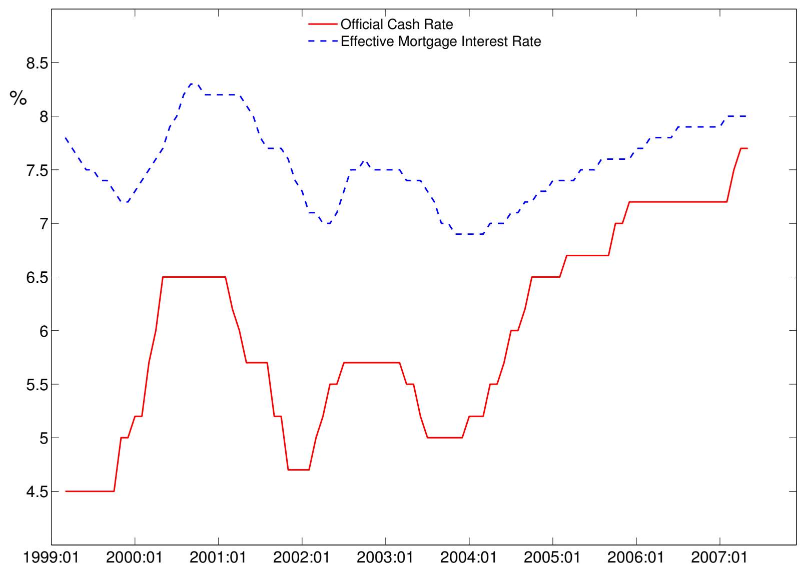


The housing boom in New Zealand has impacted both directly and indirectly on inflation. The construction cost of building new homes enters the consumer price index directly along with rents. Furthermore, the strength in the New Zealand housing market has sustained strong growth in consumption demand, see p. 56 in Reserve Bank of New Zealand (2007a). This sparked a policy response with the Overnight Cash Rate (OCR), New Zealand's monetary policy instrument, raised from 5% at the end of 2003, to 8.25% by July 26 (the time of writing). This

this sustained tightening phase can be characterized as resulting from surprisingly inflation pressure resulting from excess domestic demand, see p. 50 in Reserve Bank of New Zealand (2007a).

However, Figure 3 shows that the series of policy increases in the policy rate results in only a muted increase in the effective mortgage. Although there was some decrease in the banks' lending margins over this recent period, the increasing influence of an fixed mortgages resulted in a more limited effect on the mortgage rate.

Figure 3: Policy rate and the effective mortgage rate: 1999Q1 to 2007Q1

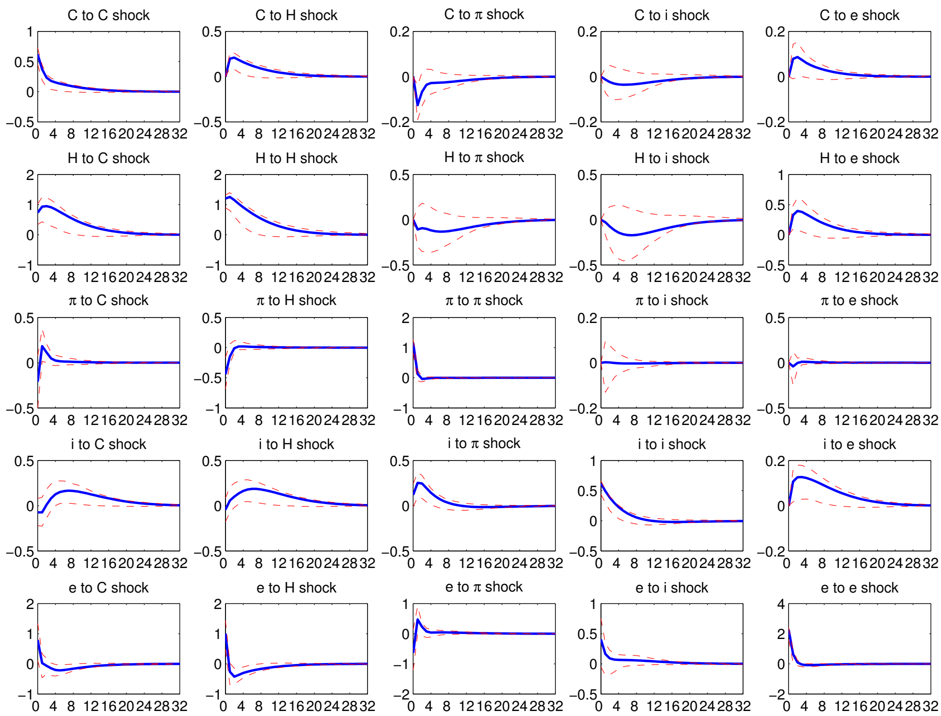


This policy response to the housing boom pushed the exchange rate appreciate to new post-float highs against the US dollar and levels against the yen not seen since the mid-1980s, helped at least in part, by "carry-trade", with the issuance of liabilities denominated in New Zealand dollars. Although New Zealand's terms of trade increases by twenty percent since the end of the 1990s, the appreciation in the New Zealand dollar put pressure on the export sector.

2.3 VAR analysis of the transmission mechanism

We use the impulse responses from a VAR to document the interaction between house prices and the business cycle that our DSGE model should capture. Figure 4 below shows impulses from a VAR ordered consumption (C), real house prices (H), inflation (π), the ninety day rate (i) and the real exchange rate (e), estimated over the inflation targeting period. The impulses are based on shocks from the Cholesky decomposition with a VAR of order 1 and we Hodrick-Prescott filter real house-prices and consumption:

Figure 4: Interaction between House price and the business cycle: VAR evidence, 1990Q1 to 2006Q4



NB. An increase in the real exchange rate is an appreciation in the figure and throughout the paper. Dashed lines represent an 80% confidence interval around the VAR impulse responses.

The fourth row of the show that the policy increases gradually in response to shocks to inflation and consumption and increases in response to the real exchange rate, although this response is insignificant(check). While there is an initial decrease in the policy rate, there is a pronounced hump-shaped response to house prices between six and twelve quarters.

Importantly, consumption increases in response to a house price shock, and conversely, the real house price increases in response to output shocks, a feature we model by adding an explicit housing sector in our DSGE model.[2] In addition, the real exchange rate appreciates strongly in a shock to the real house price. This has important implications for the volatility of sectors exposed to the exchange rate and exposes a tension for the central bank in setting policy to mitigate the domestic inflation generated by the housing shocks and exposing the exporting sector to decreases in competitiveness from an appreciation in the real exchange rate.

In order to capture the implications of the data, encapsulated in the impulse responses from the VAR, a DSGE of for New Zealand should include a channel from house prices to consumption. To this end, the next section develops an open economy model with agents who derive utility from housing services, provided by property managers who rent out the housing stock that is purchased and owned by households. The open economy aspects of our model allow us to examine the impact of the existence of fixed and flexible mortgage contracts on the ability of monetary policy to stabilise the economy.

3 Key features of the model

In this section, we summarise the most important feature of our model. We use a stripeed-down version of the K.I.T.T. (Kiwi Inflation Targeting Technology), the RBNZ's newly developed core projection tool. Our analysis mainly relies on the following four basic types of monetary transmission channels:

- interest rate channels, i.e. the intertemporal substitution in (i) consumption, and (ii) residential investment;
- exchange rate channels: (i) expenditure switching between non-traded goods and imports, (ii) direct effect of the price of imported goods on the CPI basket;
- an income, or balance-sheet, channel through changes in exporters' receipts induced by nominal exchange rate movements;

[2] Iacoviello (2005) stresses this feature of the US data and introduces collateral to generate this dynamic relationship between the price of the housing asset and consumption.

- a credit channel, i.e. the effect of house prices on the loan to value ratio.

3.1 Monopoly power of banks and fixed-rate contracts

Unlike other papers with more ad-hoc fixed-rate mortgage contracts (such as Calza et al., 2007), we derive the retail rate setting as a bank's optimal decision. With certain monopoly power, the banks in our model re-negotiate mortgage contracts at exogenously determined random times, keeping their rates fixed in the meantime (analogously to Calvo, 1983). When setting new rates, they consider the expected duration of new contracts and the future costs of refinancing, i.e. the wholesale rate controlled by the monetary authority.

Obviously, key to the existence of fixed-rate contracts in our model is monopolistic competition with a certain degree of the banks' control over their own retail rates. How do we justify the existence of monopoly power? We need to introduce demand for a whole variety of differentiated bank loans. Hence, we impose the following constraint on financial intermediation: to obtain a total amount of B_t dollars, a household needs to take out a continuum of loans, b_{it}, from all existing banks, $\forall i \in [0,\ 1]$, such that

$$B_t = \left[\int_0^1 {b_{it}}^{1/\nu} \mathrm{d}i \right]^{\nu}, \tag{1}$$

with $\nu/(\nu - 1) > 1$ being the elasticity of substitution between differentiated loans (or banking services, in general). Unrealistic though this assuption might seem at an *individual* level, it can be an appropriate description of the *aggregate* behaviour of the loan market. The only simplification with potentially serious policy implications is abstracting from strategic interactions between banks: in our model, each bank has zero impact on sector-wide aggregates, and takes the market-wide developments as given.[3]

Note furthermore that the total amount available is smaller than, or equal to, the sum of all loans granted,

$$B_t \leq \int_0^1 b_{it}\, \mathrm{d}i,$$

with the equality occurring only in symmetric equilibrium, i.e. when $b_{it} = b_{kt}$, $k, \forall i \in [0,\ 1]$. We ascribe the discrepancy between the two numbers to the social

[3]Strategic interactions can play a significant role in the New Zealand loan market, which is virtually dominated by four major banks.

costs of financial intermediation. The costs affect the consolidated budget constraint, but are only second order.[4] We may therefore neglect them being interested only in first-order approximate dynamics.

Given constraint (1) and a desired level of B_t, households choose their portfolio of loans so to minimise the repayment,

$$\min \int_0^1 b_{it}(1 + j_{it})\,\mathrm{d}i \quad \text{s.t. (1).}$$

As a result, we obtain downward-sloping demand curves facing each bank,

$$b_{it} = \left(\frac{1 + j_{it}}{1 + J_t}\right)^{\nu/(1-\nu)} B_t,$$

and an aggregate gross interest rate payable on the total amount available,

$$1 + J_t = \left[\int_0^1 (1 + j_{it})^{1/(1-\nu)}\mathrm{d}i\right]^{1-\nu},$$

such that

$$\int_0^1 b_{it}(1 + j_{it})\,\mathrm{d}i = B_t(1 + J_t).$$

We can now easily show that the aggregate retail rate follows a process resembling a Phillips curve,

$$J_t - J_{t-1} = \beta\,(\mathrm{E}_t\, J_{t+1} - J_t) + \tfrac{(1-\xi_j)(1-\beta\xi_j)}{\xi_j}\,(i_t + \nu + e_t^{fi} - J_t),$$

where $1 - \xi_j$ is the probability of a bank's re-optimising the contract next period, i_t is the wholesale (or policy) rate, ν is the sector-specific markup which gives rise to a systematic lending spread, and e_t^{fi} is an i.i.d. shock to the marginal costs of financial intermediation financial intermediation.

3.2 Loan-to-value ratio, costs of borrowing, and bubbles

Households face effective borrowing costs increasing in their individual loan to value (LTV) ratios.

- the direct dependence of mortgage rates on borrowers' LTV ratios;
- additional life and/or property insurance required for higher LTV levels;
- a re-negotiation of the mortgage contract and a consequent increase in the rate after a breach of the contract occurs (such as late payments);[5] and/or

[4] Schmitt-Grohé and Uribe (2004) show that the difference between a CES index and the corresponding simple sum of individual quantities is second order.

[5] We imiplicitly assume that the probability of contract breaches is increasing in the LTV ratio.

- higher rates applied to unsecured loans (which implicitly increase a household's total LTV ratio).

We summarise all such mechanisms in an effective interest rate facing each household,

$$J_t^e = J_t + \zeta \cdot (\Lambda_t - \zeta_0)\,,$$

where ζ, $\zeta_0 > 0$ parameterise the cost of borrowing function, and

$$\Lambda_t = B_t/(\mathrm{E}_t\, P_{t+1}^h\, H_t\, \exp\, q_t)$$

is the loan-to-value ratio, P_t^h is the fundamental house price, H_t is the stock of houses, and q_t is a house price bubble: in our case, an exogenous and irrational deviation of the observed market house price from its fundamental, saddle-path stable level.

Because the LTV elasticity of borrowing costs is internalised by households, the intertemporal Euler consumption has the following form:

$$\Phi_t = \beta\ \mathrm{E}_t\, \Phi_{t+1} \cdot (1 + J_t^e + \zeta\, \Lambda_t)\,,$$

where Φ_t is the current shadow value of households' wealth. Note that the impact of the LTV ratio on the marginal price of tomorrow's consumption is double the impact on the effective rate.

3.3 Monetary Policy

To quantify the extent to which the central bank can achieve its inflation targeting objectives, we compute optimal policy under both the baseline model and economies with alternative mortgage contracts. We show the volatilities of the key macroeconomic variables that we assume enter the cental banks loss function and calculate the cost to the central bank of particular mortgage contract structure. Furthermore, we document the optimal monetary rules to show the manner in which the central bank's strategy differs under alternative contract assumptions.

We assume that the central bank has no device to commitment device available and implements time-consistent policy, setting the policy rate, i_t, so to minimise an intertemporal loss function:

$$i_t = \arg\min_{i_t}\,(1-\beta)\,\mathrm{E}_t \sum_{k=0}^{\infty} \beta^k L_{t+k}. \tag{2}$$

We follow the majority of the inflation targeting literature and assume that the one-period general loss function for the central bank is quadratic (returning thus a linear policy rule when cast in a linearised model) and penalises deviations of key macroeconomic variables from their targets or natural, i.e. flexible-price, levels. We assume that the central bank conducts flexible inflation targeting:

$$L_t = \left[(\widehat{\pi}^T)^2 + \lambda_y \cdot (\widehat{rmc}_t)^2 + \lambda_i \cdot (i_t - i_{t-1})^2 + \lambda_s \cdot (\widehat{\sigma}_t)^2 \right], \tag{3}$$

where ${\widehat{\pi}_T}^2 = \Delta \log P_t - \pi^\star$ is the deviation of CPI inflation from the target (which assumed to be the unconditional mean by construction), $\widehat{rmc}_t$ is the weighted average of real margical cost gaps across the three sticky-price sectors (tradables, non-tradables, and housing services), the third term captures losses incurred by policy rate volatility, and $\widehat{\sigma}_t = \Delta \log s_t - \mathrm{E}\, \Delta \log s_t$ is the rate of change in the nominal exchange rate centered on its unconditional mean.[6] The parameters λ_y, λ_i, λ_s express the central bank's concern with output stabilization, interest rate smoothing and exchange rate volatility. These objectives are expressed relative to a concern for CPI inflation that is normalized to one.

A measure of output in the loss function is rather standard. We use the deviation of non-tradable production from the hypothetical flexible-price level two reasons:

1. Real exports are exogenous, and hence unaffected by monetary policy. Non-tradable output is therefore a natural measure of *endogenously* driven fluctuations in domestic real economic activity.

2. The gap measures allocation inefficiencies caused by nominal frictions in three sectors: import goods, non-tradables, and housing services. If it were only for nominal frictions in one sector, the central bank could undo the inefficiency completely, reproducing a flexible-price equilibrium. Nevertheless, with more than one nominal friction, policymakers' choices are restricted by a trade-off.

Furthermore, we include a weight on the change in the interest rate to capture the empirical observation that central banks typically change policy in successive incremental changes in the policy rate in the same direction and many papers in the optimal policy literature include the change in the interest rate in the loss function, as in Svensson (2000), for example. Furthermore, Dennis (2006) shows that including the change in the interest rate in the loss function matters empirically. that a high weight should be attached to the change in interest rates to capture the dynamics on interest rates in the US data. We also allow for the possibility that our open economy central banks may be concerned with stabilising the nominal exchange rate. Obstfeld and Rogoff (1998) suggest there are costs to exchange rate

[6] In our model, the unconditional mean is uniquely determined by the inflation target, foreign inflation, and technology parameters.

volatility that generates consumption volatility and costly hedging activities on the part of firms.

However, our primary motivation is to capture the design of the Policy Targets Agreement, the contract between the RBNZ's Governor and New Zealand's Minister of Finance. Clause 2b of the contract[7] states (emphasis added by the authors of this paper):

> "For the purpose of this agreement, the policy target shall be to keep *future CPI inflation outcomes* between 1 per cent and 3 per cent *on average over the medium term*."

while Clause 4b specifies that[8]

> "In pursuing its price stability objective, the Bank shall implement monetary policy in a sustainable, consistent and transparent manner and *shall seek to avoid unnecessary instability in output, interest rates and the exchange rate*."

While optimising these macroeconomic objectives may deviate from the Ramsey policy, the legislative framework at the core of New Zealand's inflation targeting regime establishes goal independence for the central bank such that the government delegates the objectives — encapsulated in the PTA — that the RBNZ is required by law to achieve.[9] These objectives are broadly consistent with the stated objectives of other cental banks and furthermore, we conduct robustness analysis across alternative parameterisations of the loss function that include setting the various weights in the loss function, i.e. λ_y, λ_i, λ_s, to zero.

4 Policy evaluation

To evaluate the magnitude of the policy implications of alternative mortgage contracts, a metric is required. We consider the following measures:

1. The location and shape of the policy frontier, and hence the relative (in)efficiency and trade-off of monetary policy under fixed contracts.

2. Percentage deviations in the value of the loss function under the alternative mortgage contracts.

[7]See Reserve Bank of New Zealand (2007b).

[8]Note that the PTA is expressed in terms of volatilities of macroeconomic variables and not objectives in the levels such as full employment. The quadratic function approximates volatility with the variances of key macroeconomic variables.

[9]The Governor can be fired if these objectives are not met.

3. The "inflation equivalent" as proposed by Jensen (2002). We compare outcomes under flexible retail rates and fixed retail rates, and find an "inflation equivalent", $\pi^{\equiv}$, defined as a permanent increase in inflation required to make the value of the central bank's loss function identical under the two setups. To see how this inflation-equivalent measure is obtained, denote $\pi^{\equiv}$ the amount of beyond target inflation in each period, required to equate the loss under the floating-rate ($L^{\star}$) and fixed-rate contracts (L^{f}):

$$\pi^{\equiv} = \sqrt{L^{f} - L^{\star}}. \tag{4}$$

   This follows directly from the definition of our quadratic loss function and the fact that we normalise the loss by $1 - \beta$.

4. The relative contribution of interest rate versus exchange rate channels. To this end, we examine the relative standard errors of the policy instrument (the 90-day rate) with respect to consumption and the nominal exchange rate, their cross-correlations as well as the cross-correlations of tradable and non-tradable CPIs.

Table 1 displays the key results for our policy experiment. We fix the weight on interest rate smoothing ($\lambda_i = 0.25$ but allow the weight on output stabilisation to range 0 to 1. We calculate losses when the central bank is faced with fixed mortgage contracts of an average of two years duration and compare this case to an environment where all mortgage contracts are fully flexible, floating contracts. In each case the central bank implements the optimal time-consistent policy.

The table displays results for the case where there is no weight on output stabilisation ($\lambda_y = 0$) in the first row of the table. The second and third columns of the table show the loss from evaluating the central bank's intertemporal loss function (see equation 2). The loss for the case of fixed contracts is higher than for the case of floating contracts. At least according to our metric, targeting inflation, is more difficult when mortgage contracts are fixed. In percentage terms, the fourth column of the table suggests that the central bank's loss is 23% higher when contracts are fixed. The fifth column reports $\tilde{\pi}$, the inflation-equivalent measure. The cental bank would be willing to incur 1.22 percentage points more inflation in each quarter to shift to an environment where mortgage contracts are floating rather than fixed. The final columns of the table show that the change in interest rates are more volatile under fixed mortgage contracts — monetary policy must work harder to achieve inflation targeting objectives.

Increasing the weight on output stabilisation somewhat mitigates the importance of the existence of fixed mortgage contracts. When the weight on output stabilisation is 0.5, half the weight on inflation stabilisation, the percentage difference in loss is 7.80. However, the inflation equivalent measure remains non trivial

Table 1: Policy under fixed vs floating mortgage rates

					Fixed			Floating		
λ_y	Float	Fixed	% diff.	$\pi^{\equiv}$	π_t	Δi_t	$\widehat{rmc}_t$	π_t	Δi_t	$\widehat{rmc}_t$
0.0	6.44	7.92	22.99	1.22	2.50	1.85	4.15	2.27	1.63	4.16
0.1	8.30	9.68	16.73	1.18	2.49	1.97	3.97	2.29	1.75	3.97
0.2	9.96	11.27	13.14	1.14	2.49	2.10	3.81	2.31	1.88	3.81
0.3	11.48	12.72	10.79	1.11	2.50	2.23	3.67	2.34	2.02	3.67
0.4	12.86	14.05	9.10	1.08	2.51	2.36	3.55	2.36	2.15	3.55
0.5	14.17	15.27	7.80	1.05	2.52	2.49	3.44	2.39	2.28	3.44
0.6	15.38	16.41	6.75	1.02	2.53	2.61	3.34	2.42	2.40	3.35
0.7	16.51	17.48	5.87	0.98	2.54	2.72	3.25	2.44	2.53	3.26
0.8	17.58	18.48	5.12	0.95	2.56	2.84	3.17	2.46	2.64	3.19
0.9	18.60	19.43	4.46	0.91	2.57	2.94	3.09	2.48	2.75	3.12
1.0	19.56	20.32	3.87	0.87	2.58	3.05	3.02	2.50	2.86	3.05
2.0	27.35	27.32	−0.11	···	2.68	3.88	2.53	2.65	3.71	2.61

— the central bank would be prepared to incur 1.05 percentage points of inflation, in each period, to move to operate in an environment where mortgage contracts are flexible. When output stabilisation takes the same weight as inflation stabilisation, the percentage difference in loss is 3.87 % although the inflation-equivalent measure remains high.

To illustrate the dependence of whether fixed contracts matter on the parameterisation of the loss function, figure 5 traces the standard deviations of the variables that enter the loss function as the weight on output stabilisation is varied from 0 to 2, keeping the weight on interest rate smoothing at 0.5. Figure 6 traces out the corollary of the exercise, allowing the weight on interest rate smoothing to vary between 0 to 2, but keeping the weight on output stabilisation at 0.5. In each figure, the left hand panel depicts the standard deviations of inflation and $\widehat{y}_t$ the weighted average of the real marginal costs across all sectors (labeled "rmc", real marginal cost, in the figure), while the right-hand panel shows the standard deviation of inflation and the change in the nominal interest rate. In each panel, "0", "1" and "2" denote the appropriate loss function weights for each figure under the case of floating rates (the fixed case cane be easily interpreted from the figure).

Figure 5 shows that floating contracts relax the constraint on monetary policy and allow for better monetary policy outcomes because the policy frontier is always closed to the origin (representing lower volatility) that the fixed rate frontier. In addition, the figure reinforces the finding that the difference between the two regimes is a function of the weight on stabilisation of the weighted average of the real marginal cost. When the weight on stabilising real marginal cost is twice

Figure 5: Optimal Policy Frontier: Varying Output Stabilisation

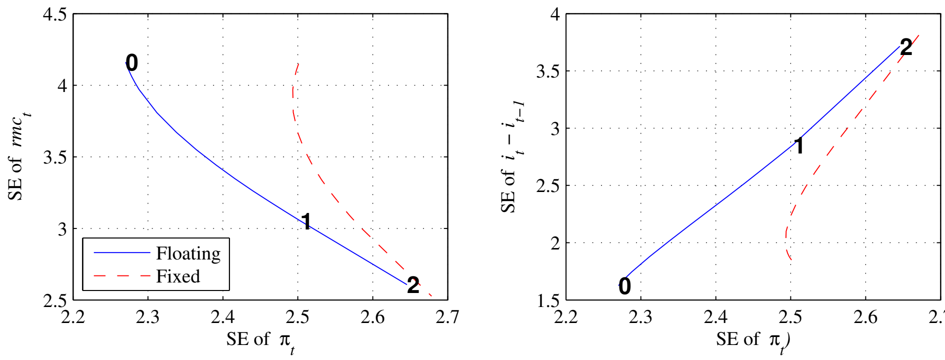
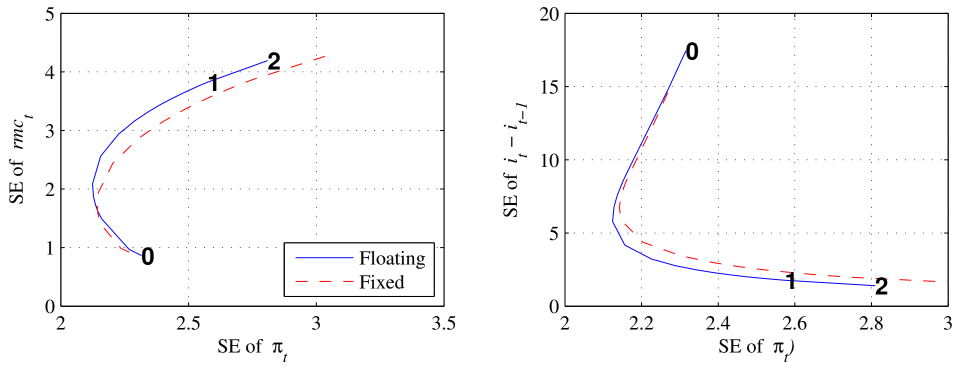


Figure 6: Optimal Policy Frontier: Varying Interest Rate Smoothing



that of inflation stabilisation ($\lambda_y = 2$), the differences in outcomes is diminished relative to lower values of $\lambda_y = 2$. Figure 6 maps the volatility of the key macroeconomic variables when λ_i is varied from 0 to 2. When there is no weight on interest rate smoothing the central bank is unconcerned about manipulated the interest rate aggressively and the standard deviation of the change in the interest rate is almost 20. Clearly, some weight on interest rate smoothing is required to return results more consistent with the data. For parameterisations with some weight on interest rate smoothing, fixed mortgage contracts are more costly. However, the distance between the two regimes appears to be an increasing function of interest rate smoothing.

To uncover the impact on the relative strength of the channels through which monetary policy operates under the two regimes, table 2 presents cross-correlations for the case where the central bank is twice as concerned about stabilising inflation than either output ($\lambda_y = 0.5$) or smoothing interest rates ($\lambda_i = 0.5$). The first row of each matrix in the table shows the correlation of aggregate consumer price inflation with the key macroeconomic variables. Comparing the floating case to the fixed case shows that the correlation between non-tradables inflation and aggregate consumer price inflation is much weaker under floating contracts. This stems from the stronger negative cross-correlation between tradables and non-tradables inflation under floating contracts. This negative cross-correlation is about 50 percent stronger in the case of floating contracts. It appears that the central bank can set policy to offset shocks to each sector. The penultimate column of the matrix shows the cross-correlation between gap between actual housing services output and its flexible-price level, $\widehat{y}_t^n = \log Y_t^N - \log Y_t^{N\star}$, and key macroeconomic variables. The correlation between this variable and consumer price inflation is much higher under the fixed contract case because the central bank must be willing to drive large changes in interest rates to offset the fixed contracting behaviour.

5 Conclusions

New Zealand has not stood isolated from the global increase in house prices and deregulation of mortgage markets. This paper examines one key feature of mortgage markets, the existence of both fixed and floating mortgages, and shows that this matters for the ability of a small open economy inflation targeter to achieve their objectives. In particular, we build calibrate an open economy DSGE model with an explicit housing sector to capture the key features of the New Zealand data.

[12] APC denotes annual percentage changes, i.e. year-on-year growth rates.

[12] RMC denotes the cycle in real marginal costs.

[12] QPC denotes quarterly percentage changes, i.e. quarter-on-quarter growth rates, not annualised.

Table 2: Cross-correlations under fixed vs floating mortgage rates

	Floating									
CPI, APC[10]	1									
Change in interest rates	0.16	1								
Gap in RMC[11]	0.02	0.58	1							
Log consumption	-0.25	0.22	0.04	1						
Non-tradable CPI, QPC[12]	0.13	0.37	-0.23	-0.09	1					
Tradable CPI, QPC	0.56	0.46	0.44	-0.01	-0.39	1				
Exchange rate, QPC	0.01	-0.40	-0.60	-0.10	0.05	-0.15	1			
RMC in non-tradables	-0.57	0.05	-0.14	0.45	0.28	-0.58	0.07	1		
RMC in housing services	0.32	0.12	-0.20	0.22	0.56	-0.19	-0.09	0.02	1	
RMC in tradables	0.19	0.47	0.93	-0.15	-0.35	0.61	-0.53	-0.49	-0.27	1
	Fixed									
CPI, APC	1									
Change in interest rates	0.15	1								
Gap in RMC	0.09	0.59	1							
Log consumption	-0.13	0.26	0.06	1						
Non-tradable CPI, QPC	0.28	0.43	-0.15	-0.05	1					
Tradable CPI, QPC	0.54	0.46	0.47	0.05	-0.26	1				
Exchange rate, QPC	0.01	-0.36	-0.57	-0.09	0.05	-0.14	1			
RMC in non-tradables	-0.34	0.21	-0.06	0.47	0.28	-0.41	0.06	1		
RMC in housing services	0.48	0.13	-0.11	0.24	0.58	-0.07	-0.08	0.00	1	
RMC in tradables	0.15	0.45	0.93	-0.13	-0.29	0.57	-0.53	-0.40	-0.21	1

We find that operating monetary policy in an environment where mortgage contracts are fixed, and average two years in duration, hampers the central bank's ability to stabilise the economy. Using a standard quadratic loss function to approximate the inflation targeting objectives of the central bank, the central bank is approximately 7-15 percent worse off under the fixed rate regime and would be willing to around one percentage points in quarterly inflation each period in order to operate under a world of floating rates. Under fixed rates, the central bank's ability to buffer shocks is limited.

Interestingly, the magnitude of the impact on monetary policy is a function of the weight placed on a measure of output stabilisation — stabilising average real marginal cost across all sectors in the DSGE model. However, this is not true of the weight on interest smoothing. Interest rate smoothing increases the wedge between the two regimes and makes flexible mortgages contracts more appealing from the central banks perspective.

Future work could extend the range of fixed contracts to mimic other international markets and our modelling approach to examine other features of the mortgage markets. Our framework appears flexible enough to address alternative loan-to-value contracts and mortgage debt to income ratios.

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A The model

The model used in the paper is a stripped-down version of the K.I.T.T. (Kiwi Inflation Targeting Technology), the RBNZ's newly developed core projection model.

- There are three distinct production sectors driven by their own stochastic trends in productivity/technology: an import (or tradable) sector, a non-traded sector including housing, and an export sector. The setup allows us to explain permanent movements in relative prices (such as a permanent diiferential between the inflation rates of tradables and non-tradables).

- Relatively simple production functions are tailored to fit the stylised facts of the three production sectors in New Zealand. The import sector does not use any domestics input factors. The non-tradable sector (including housing) use only labour and their own intermediates. The export sector is left exogenous for the purposes of this paper. The last assumption relfects the fact that New Zealand's exports (mainly dairy and other farming products) are, to a large extent, supply-constrained in the short run, see e.g. McCaw (2007).

- Consumers demand three types of goods and services: import goods, non-tradable goods, and housing services. Furthermore, they supply inelastically one unit of labour to the non-tradable sector. However, output in the non-tradable sector may vary in response to demand shocks because of roundabout production structure, in which the sector's own output is used as intermediate input factor.

- Consumers are impatient relative to the rest of the world, and borrow against their housing wealth. The effective costs of borrowing are sensitive to the loan-to-value ratio, but not restricted by a particular value of the ratio.

- The terms of trade are determined exogenously.

The model possesses a number of independent *stochastic* trends,[13] and these trends can contain their own drift terms. The drift terms imply, in general, different growth rates for the model's real and nominal variables. We, however, concetrate these *deterministic trends*, i.e. the drift terms, out of behavioural equations into measurement equations. This step yields, of course, an equivalent representation of the model, but the drift parameters can be now handled and/or estimated much more easily. Although the model's various real and nominal variables are not co-integrated and can drift away from each other permanently, the structure of the model guarantees that all nominal expenditure shares are stationary, i.e. have a fixed steady state. We achieve the last feature by using unit long-run elasticities of substitution in consumption and production. The long-run unit elasticities are, however, reduced to more realistic numbers in the short run by various types of frictions defined so to have effect only over the business cycle, such as habit formation or adjustment costs.

[13] Stochastic trends are contained in import technology, non-tradable technology, real exports, the terms of trade, and domestic and foreign general price levels.

A.1 Varieties of goods

As described later in this appendix, households have tastes for varieties of differentiated import goods, non-tradables, and housing services. Consequently, there are unit-mass continua of producers (importers, non-tradable firms, and property managers) indexed on the interval $[0,\,1]$ who offer each a differentiated product and face a downward-sloping demand curve. We use the Dixit and Stiglitz (1977) framework based on continuous CES indices to describe this type of behaviour. However, because the design of these indices as well as all related results (i.e. first-order optimality conditions) are well-established in macroeconomics literature, we do not derive them formally in this paper.

Instead, we use the following notation. A CES index and its expenditure-minimising price index are denoted by upper-case letters, whereas the individual quanitities and prices by coresponding lower-case letters, such as

$$C^{\tau}_t = \left[\int_0^1 (c^{\tau}_{it})^{1/\mu}\, \mathrm{d}i \right]^{\mu}, \quad P^{\tau}_t = \left[\int_0^1 (p^{\tau}_{it})^{1/(1-\mu)}\, \mathrm{d}i \right]^{1-\mu},$$

in the import (or tradable) sector, where $\mu/(\mu-1)$ is the elasticity of subsitution between individual goods, and μ is the implied flexible-price markup. Furthermore, we omit the superscript i and just refer to c^{τ}_t and p^{τ}_t when deriving the optimal behaviour of a particular producer.

A.2 Production sectors

In this subsection we desribe technology avaiable for the production of three types of goods present in our model economy: import goods, non-tradables, and exports. The first two sectors are subject to nominal frictions, namely an infrequent opportunity of optimising the price. The optimal price setting is summarised later in this appendix, and is based on real marginal cost functions. To this end, we derive each sector's marginal cost schedule.

- *Importers* purchase goods abroad and distribute them locally. Each importer's one-period profit is given by

  $$p^{\tau}_t y^{\tau}_t - P^m_t m_t,$$

  with $P^m_t = P^{mf}_t / S_t$. The importer chooses p^{τ}_t, y^{τ}_t, and m_t to maximise the profits over an infinite horizon (discounted at households's present shadow value of wealth) subject to a production function,

  $$y^{\tau} = A^{\tau}_t m_t,$$

a monopolistically competitive demand curve,

$$y_t^\tau = (p_t^\tau / P_t^\tau)^{\mu/(1-\mu)} \, Y_t^\tau, \quad \mu > 1,$$

and a infrequent opportunity of optimisng the price. The importer's real marginal cost schedule is determined by the foreign price of import goods and independent of the importer's own level of output,

$$Q_t^\tau = P_t^m / A_t^\tau.$$

- *Producers of non-tradable consumer goods and housing investment* use roundabout production structure with labour and the sector's own intermediate production as inputs. Each firm's one-period profit is given by

  $$p_t^n \, y_t^n - W_t \ell_t - P_t^n z_t^n.$$

  The firm chooses p_t^n, y_t^n, ℓ_t, and z_t to maximise the profits over an infinite horizon (discounted at household's present shadow value of wealth) subject to a production function,

  $$y_t^n = (A_t^n \ell_t)^{\gamma_n} (z_t^n)^{1-\gamma_n}, \quad \gamma_n \in (0,\, 1),$$

  a monopolistically competitive demand curve,

  $$y_t^n = (p_t^n / P_t^n)^{\mu/(1-\mu)} \, Y_t^n, \quad \mu > 1,$$

  and a infrequent opportunity of optimising the price. The firm's marginal cost schedule is proportional to the two input factor's prices, and independent of the firm's own level of output,

  $$Q_t^n = \propto (W_t)^{\gamma_n} (P_t^n)^{1-\gamma_n}.$$

- *Real exports* follow a log random walk,

  $$\log X_t = \log X_{t-1} + \epsilon_t^x.$$

  where ϵ_t^x is an i.i.d. export shock. The profits received from exporters by households are then simply $P_t^x X_t$, where $P_t^x = P_t^{xf} / S_t$, and the process for P_t^{xf} is specified later in this appendix.

A.3 Households and property managers

Households derive their utility from consuming three types of goods: import goods, non-tradables, and housing services. Furthremore, households purchase houses, borrow from banks using the houses as collaterals, and engage property managers. Finally, households are each endowed with an exogenous, potentially time-varying, amount of labour, and supply this labour inelastically to non-tradable firms. Because they behave competitively and symmetrically in all markets, we can describe theit aggregate behaviour as a single representative household.

Each household's expected lifetime utility is given by

$$\mathrm{E}_0 \sum_0^{\infty} (\exp \epsilon_t^{tp}\, \beta)^t \Big[\omega_\tau \cdot u(C_t^\tau) + \omega_s \cdot u(C_t^s) + (1 - \omega_\tau - \omega_s) \cdot u(C_t^n)\Big],$$
$$\beta,\, \omega_\tau,\, \omega_s,\, (1 - \omega_\tau - \omega_s) \in (0,\, 1),$$

where ϵ^{tp} is an i.i.d. time-preference shock, and the utility index from consuming a particular type of goods, $u(\cdots)$, is

$$u(C_t^\tau) = \log \left(C_t^\tau - \chi \textstyle\int C_{t-1}^\tau\right), \quad \chi \in (0,\, 1),$$

(analogously for other types of goods) where $\int C_{t-1}^\tau$ denotes last period's aggregate, rather than individual, consumption. This is our short-cut for external habit formation. Note that the habit parameter, χ, is the same for all three types of goods.

The household's decisions are subject to a dynamic budget constraint. The change in the household's debt, $t = 0, 1, \ldots, \infty$,

$$B_t - B_{t-1} = \cdots$$

equals

- effective interest costs paid, with the effective costs depending on the household's own loan-to-value ratio,

  $$\cdots j_{t-1}^e B_{t-1} \cdots$$

  where $j_t^e = j_t + \zeta \cdot [B_t/(\mathrm{E}_{t-1}\, P_{t+1}^n H_t) - \zeta_0]$,

- plus the purchases of import goods, non-tradables, housing services, and housing investment, and costs of housing utilisation,

  $$\cdots + P_t^\tau C_t^\tau + P_t^n C_t^n + P_t^s C_t^s + P_t^n \big[H_t - H_{t-1} \cdot (1 - \delta_h)\big] + \tfrac{\upsilon_0}{1+\upsilon} P_t^n {U_t}^{1+\upsilon} \cdots$$

- plus costs of changing the level of housing services (scaled by the aggregate level of nominal housing services),

$$\cdots + P_t^n \int C_t^s \cdot \eta_s \cdot \left(\log C_t^s - \log C_{t-1}^s\right)^2 \cdots$$

- plus housing capital/investment adjustment costs (scaled by the aggregate nominal value of housing capital),

$$\cdots + P_t^n \int H_{t-1} \cdot \eta_h \cdot (\Delta \log H_t - \phi_h \cdot \Delta \log H_{t-1})^2 \cdots$$

- less labour income, income obtained from property managers for the household's vacancies they take care of, and net profits from firms,

$$\cdots - W_t L_t - Q_t^s U_t H_{t-1} - \Pi_t.$$

Furthermore, households have tastes for a whole variety of differentiated housing services, refusing to dwell in their own houses only. Consequently, they rent other places from property managers. This is the way we introduce a rental market and rental expenses, which are a component of the New Zealand CPI basket, instead of just imputed rents.

Accordingly, the role of property managers (who are, in fact, another type of firm owned by households) is to take care of vacancies available from households (i.e. from households acting as landlords), and rent them out in a monopolistically competitive market to households (i.e. to households acting as consumers of housing services). A property manager's one-period profit is given by

$$(p_t^s - Q_t^s)\, c_t^s.$$

The property manager chooses p_t^s and c_t^s to maximise the profits over an infinite horizon (discounted by the households' present shadow value of wealth) subject to a monopolistically competitive demand curve,

$$c_t^s = (p_t^s / P_t^s)^{\mu/(1-\mu)} C_t^s,$$

and an infrequent opportunity of optimising the rent. The price Q_t^s, at which property managers rent the vacancies from households, is also the marginal cost for setting the rental price, p_t^s.

A.4 Price setting

Following Calvo (1983) and Christiano et al. (2005), we randomly choose a fixed proportion of producers in each period and let them re-optimise their prices. The non-optimisers use a simple indexation rule,

$$\log p_{t-1} = \log p_{t-1} + \widetilde{\pi}_t,$$

where the indexing factor is the weighted average of past sector-wide inflation outcomes with exponentially decaying weights,

$$\widetilde{\pi}_t = \tfrac{1-\psi}{\psi} \sum_{k=1}^{\infty} \psi^k \, \pi_{t-k}, \quad \pi_t = \log P_t - \log P_{t-1}.$$

For $\psi = 0$, we get the usual full backward indexation, $\widehat{\pi}_t$, whereas for $\psi \to 1$, sectoral inflation tends to be indexed to its unconditional mean.

As a result, the law of motion for sector-wide inflation (the Phillips curve) is

$$\pi_t - \widetilde{\pi}_t = \beta(\mathrm{E}_t \, \pi_{t+1} - \widetilde{\pi}_{t+1}) + \tfrac{(1-\xi)(1-\beta\,\xi)}{\xi} \left[\log(Q_t/P_t) - \log(1/\mu)\right] + \varepsilon_t^p,$$

where $1-\xi$ is the proportion of firms re-optimising in any given period, the rest of the second term on the r.h.s. is the gap in the sector-specific real marginal cost, and ε_t^p is a sector-wide i.i.d. cost-push shock. We may think of ψ as governing the intrinsic persistence of inflation, whereas ξ controls its inertia, i.e. the responsiveness of inflation to its real driver, the real marginal cost cycle. Note that the indexing factors are sector-specific, as are the newly introduced parameters and shocks: $\widetilde{\pi}_t^\tau$, $\widetilde{\pi}_t^n$, $\widetilde{\pi}_t^s$, ψ_τ, ψ_n, ψ_s, ξ_τ, ξ_n, ξ_s, $\varepsilon_t^{p\tau}$, ε_t^{pn}, and ε_t^{ps}.

A.5 Financial intermediation

Banks intermediate loans to households, refinancing themselves from the international financial market or the central bank at wholesale rates. Each bank's next-period expected profit is

$$b_t(1+j_t) - (b_t - b_t^*)(1+i_t) - \mathrm{E}_t \, \tfrac{S_t}{S_{t+1}} b_t^*(1+i_t^f),$$

where j_t is the bank's prime rate, b_t is total volume of loans granted by the bank, and b_t^* is the volume of loans financed through borrowings in foreign currency. The bank chooses j_t and b_t to maximise the profit subject to a monopolistically competitive demand curve,

$$b_t = \left(\frac{1+j_t}{1+J_t}\right)^{\nu/(1-\nu)} B_t.$$

Furthermore, the bank applies an ad-hoc surcharge over the prime rate depending on the household's loan-to-value ratio, so that the actual (or effective) lending rate is

$$j_t^e = j_t + \zeta(\Lambda_t - \zeta_0),$$

with the LTV ratio is defined as $\Lambda_t = b_t/(\mathrm{E}_{t-1}\, P_{t+1}^n H_t)$.

A.6 Monetary policy

The central bank is an inflation targeter seeking to achieve a low stable inflation around a fixed target, $\pi^\star$. However, in pursuing this overriding objective the central bank also considers fluctuations in output, interest rates, and the nominal exchange rate. We describe the central bank's behaviour as an optimisation problem w.r.t to the policy rate, i_t

$$i_t = \arg\min_{i_t}\, (1-\beta)\, \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t L_t,$$

with the following one-period loss function:

$$L_t = \left[(\widehat{\pi}_T)^2 + \lambda_y \cdot (\widehat{rmc}_t)^2 + \lambda_i \cdot (i_t - i_{t-1})^2 + \lambda_s \cdot (\widehat{\sigma}_t)^2 \right].$$

where $\widehat{\pi}_T{}^2 = \Delta \log P_t - \pi^\star$ is the deviation of CPI inflation from the target (which assumed to be the unconditional mean by construction), $\widehat{rmc}_t$ is the weighted average of the deviations in real marginal costs from their flexible-price levels in the three sticky-price sectors,

$$\widehat{rmc}_t = \omega_\tau \log(Q_t^\tau/P_t^\tau) + \omega_s \log(Q_t^s/P_t^s) + (1-\omega_\tau-\omega_s)\log(Q_t^n/P_t^n) - \log(1/\mu),$$

actual non-tradable output and its flexible-price level, the third term captures losses incurred by policy rate volatility, and $\widehat{\sigma}_t = \Delta \log s_t - \mathrm{E}\,\Delta \log s_t$ is the is the rate of change in the nominal exchange rate centered on its unconditional mean.

A.7 Exogenous processes

We close the model by specifying the processes for exogenous and external variables:

- world price inflation and world interest rates, $[\pi_t^{mf}, i_t^f]$, follow a stationary VAR;

- the terms of trade follow a log random walk,

$$\log T_t = \log T_{t-1} + \varepsilon_t^{tot},$$

  where $T_t = P_t^x / P_t^m$;

- the two productivity, or technology, processes are log random walks,

$$\log A_t^\tau = \log A_{t-1}^\tau + \varepsilon_t^\tau,$$
$$\log A_t^n = \log A_{t-1}^n + \varepsilon_t^n.$$

B Parameterisation of the model