Enhancing the financial sector linkages in the Bureau for Economic Research's core macroeconometric model

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C Grobler and BW Smit[1]

Abstract

The recent Great Financial Crisis (GFC) highlighted the importance of the development of financial sector linkages in macroeconomic models. The aim of this paper is to present the enhanced linkages from the financial sector to real economic activity in the Bureau for Economic Research's (BER) core traditional semi-structural quarterly macroeconometric model. While many central banks have developed DSGE-type models, many national treasuries and other institutions use models similar to the BER's core model. There is a large body of available literature on incorporating the financial sector into DSGE-type models, but this literature is rather limited for more traditional forecasting models. An additional objective was to add to this body of literature in documenting the changes to the BER's model.

Apart from incorporating the BER's finance-neutral measure of potential output (see Kemp, 2015), credit markets and assets prices are now model determined. Also, banking sector variables such as the capital adequacy and liquidity ratios as well as the EY Financial Services (as surveyed by the BER) indicators on the credit standards of retail banks influence lending rate spreads faced by households and firms. The aim was to broaden the monetary transmission mechanism in the model so that the financial sector has an explicit impact on real variables in addition to the usual interest rate and exchange rate channels. This is illustrated by comparing the results of a similar sized interest rate shock before and after the model enhancements.

JEL: E10, E17, E20, E27, E44

1. Introduction

The Bureau for Economic Research (BER) at Stellenbosch University has been using macroeconomic models for forecasting, and to a lesser extent policy analysis, since 1980. These models have continuously evolved from the initial specification to incorporate both theoretical as well as statistical developments[2] and work in this regard is an ongoing project[3].

The recent Great Financial Crisis (GFC) highlighted the importance of the development of financial sector linkages in macroeconomic models. The aim of this paper is to present the enhanced linkages from the financial sector to real economic activity in the BER's core quarterly macroeconometric model. While the BER employs a suite-of-models approach in its analysis and forecasting of the South African macroeconomy, its core model at this stage is its medium-sized semi-structural demand-orientated model with specific supply side elements. This multiple-equation econometric model is estimated with cointegration techniques for long-term behaviour (which is mostly restricted based on economic theory and model stability considerations), while allowing for dynamic error correction in the short term. The model was re-specified and re-estimated to introduce a number of new channels through which the financial sector can affect real economic activity, in particular effective lending rates, credit extended to the private sector and asset price driven net household wealth.

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[2] See Smit and Pellissier (1997), Grobler and Smit (2013).

[3] There are still minor refinements to be implemented (most importantly the specification of a fiscal block) before the full core quarterly model will be published.

The paper is organised as follows. Section 2 provides a general discussion of the developments in macroeconomic modelling post the GFC. A detailed technical description of the enhancements to the BER's macroeconometric model is presented in Section 3. The effects of these enhancements are then illustrated in the remainder of the paper. Section 4 compares the results of an identical policy interest rate shock to both the re-estimated and the previous models, while Section 5 shows preliminary results of a macroprudential-type policy shock.

2. Financial sector linkages in macroeconomic models: Post GFC developments

The recent GFC provided a major stimulus to the development of financial stimulus sector linkages in the macroeconomic models used by central banks and other institutions for policy analysis and forecasting. This followed from both the general recognition of the importance of financial sector imbalances in explaining the nature and severity of the Great Recession that followed on GFC and the need to model the new macroprudential policy measures required for financial stability purposes.

The dynamic stochastic general equilibrium (DSGE) models in vogue at the leading central banks at the time of the GFC generally did not provide for these financial sector linkages (see Tovar, 2008). This implied that the policymakers using these models could not fully comprehend and analyse the macroeconomic implications of the financial instability brought about by the crisis (see Blanchflower, 2009). This resulted in a shift in the literature on these DSGE models towards the inclusion of such financial linkages. The early initiatives in this regard (see, for example, Christensen and Dib, 2008; and Iacoviello and Neri, 2010) were based on the earlier work on the financial accelerator by Kiyotaki and Moore (1997) and Bernanke *et al* (1999). The financial sector innovations in these models focused mainly on the demand for credit, either through a collateral constraints framework or an external finance premium approach (see Steinbach, 2014). More recent developments (see, for example, Geraldi *et al*, 2010; Steinbach, 2014; and Benes *et al*, 2014) provide for an explicit role for banks in their model frameworks.

Although the academic and central bank literature focused primarily on the implications of the GFC for DSGE modelling, other macro models used by central banks and national treasuries, such as the more traditional semi-structural models, also needed reconsideration regarding the specification of financial linkages. Unfortunately, the literature on developments in this respect is very sparse. There are, however, some examples. Hervé *et al* (2010: 2) provide for "...the influence of financial and housing market developments on asset valuation and domestic expenditures via home prices and equity prices, interest rates and exchange rates" in the OECD's new global model. Also Hammersland and Træe (2011: 1) provide for "…self-reinforcing co-movements between credit, asset prices and real economic activity, often denominated a financial accelerator in the literature," in the Norges Bank Small Macro Model. They actually provide for two financial accelerator mechanisms: one where asset prices affect borrowing capacity and hence investment by firms and another between household credit, house prices and housing investment.

Across different types of macroeconomic models, it is now standard to find measures of financial tightness such as the interest rate spread between the effective deposit and effective lending rate of banks or else survey data indicators on banks' credit standards. These financial market conditions then indirectly impact real economic activity.

Finally, the other important motivation for including a more detailed representation of financial sector linkages in macroeconomic models used for forecasting and policy analysis follows from the new focus on macroprudential policies. These policies (for example variable capital adequacy and liquidity ratios as well as caps on loan to value ratios) are aimed at ensuring financial stability and are also a product of the lessons learned during the GFC (see, for example, Claessens, 2014). Modelling these policy measures requires provisioning for household and firm lending spreads and their impact on the respective credit demands, house prices, real consumption, as well as real private residential and non-residential investment (see below).

3. Technical details on the enhancements to the financial sector linkages in the BER's core model

The aim was to broaden the monetary transmission mechanism in the model so that the financial sector has an explicit impact on real variables in addition to the usual interest rate and exchange rate channels.

Apart from incorporating the BER's finance-neutral measure of potential output (see Kemp, 2015), banking sector variables such as the capital adequacy and liquidity ratios as well as the EY Financial Services (as surveyed by the BER) indicators on the credit standards of retail banks were added to the model. The banking sector assumptions influence the lending rate spreads faced by households and firms. Importantly, credit markets (separated for households and firms as well as by mortgage and other loans), asset prices (in particular house and equity prices) and household net wealth are now model determined. The enhancements impact directly on real economic activity primarily through household consumption as well as private residential and non-residential investment.

The technical details of the changes to the model are documented below. Where relevant, the estimated behavioural equations are presented[4].

3.1 Effective interest rates

As noted above, one of the features of post-crisis economic models is that they now include a range of interest rates apart from the policy rate, the prime rate and the long-term government bond yield. In many cases, the spreads between effective lending rates and the effective deposit rates are used as indicators of bank lending tightness because these spreads rose so dramatically in the wake of the financial crisis. In South Africa (SA), the spread between the total (average) effective lending rate and the effective deposit rate has been on the rise since 2011, albeit that the total effective lending rate remains closely related to the prime rate[5].

The ratios of household net wealth, debt and debt service costs to disposable income, are now published[6] as part of the South African Reserve Bank's (SARB) Quarterly Bulletin, allows the calculation of household net wealth, debt and debt costs. Importantly, given then the household debt costs as well as the debt, it provides an implicit official average effective household lending rate. In contrast to the total effective lending rate, the effective household lending rate has been noticeably higher than the prime rate post-recession – see Figure 1.

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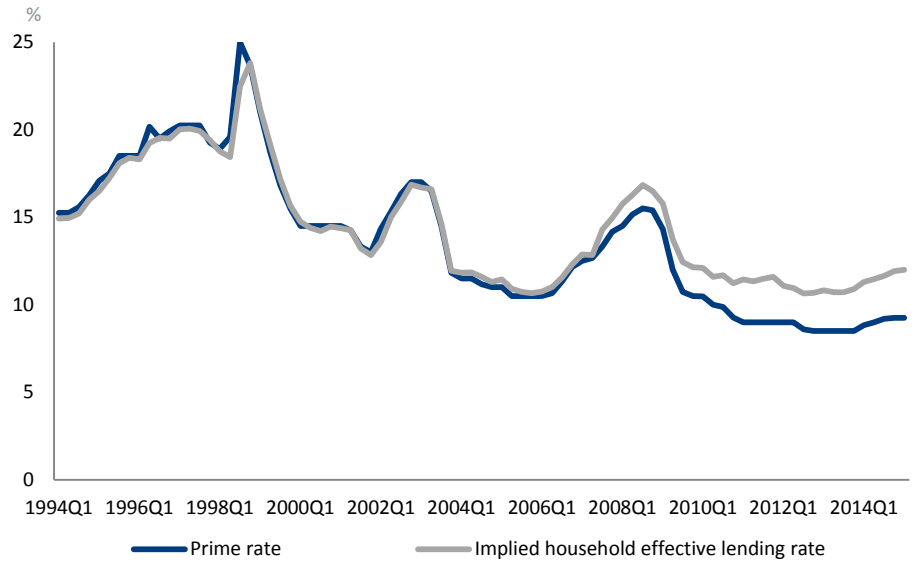
[4] The t-statistics are reported in square brackets and diagnostic tests (including tests on the residuals and the validity of restrictions, if applicable) are provided below each equation. All behavioural equations in BER econometric models are estimated using ordinary least squares (OLS) but are specified according to cointegration specification which simultaneously estimates short-run and long-run relationships. This is sometimes referred to as a type of Autoregressive Distributed Lag (ARDL) regression and is in line with the specification used in semi-structural models at central banks (see Smal *et al*, 2007 and Bank of England, 1999). One of the main advantages of using the ARDL specification is that it avoids serial correlation and endogeneity issues usually associated with cointegration specifications because it is robust to a lack of exogeneity. Furthermore, one does not have to pre-test for unit roots because the ARDL approach is applicable irrespective of whether regressors have (and the number of) unit roots. Finally, it is valid for small samples (Peseran and Shin, 1999). Confirmation of relevancy of this econometric specification in its attempt to match the unknown data generating process (and hence non-rejecting of the hypothesis of cointegration) is confirmed using the error-correction mechanism (ECM) test as developed in the paper by Banerjee *et al* (1998). Various residual tests are also performed. However, the final test remains the overall properties of the model, with individual equation specifications subordinate to the overall performance of the model when submitted to shock simulations and used in forecasting exercises.

[5] The authors are indebted to Harri Kemp, economist at the BER, for the calculation of time series data (starting in 2001) of the total effective lending and deposit rates from total banks' balance sheet and income statement data.

[6] The household net wealth to disposable income ratio was introduced in the September 2010 Quarterly Bulletin while the debt cost to disposable income ratio was first published in the March 2012 Quarterly Bulletin.

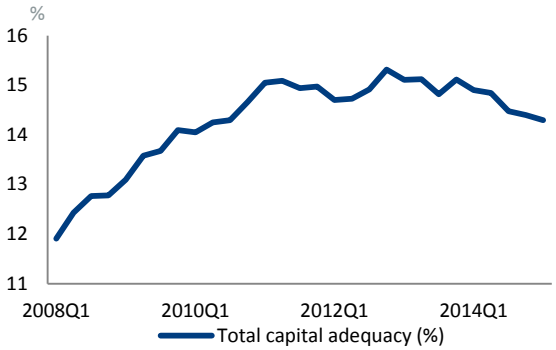
Figure 1: Prime rate versus the effective household lending rate



Source: SARB, BER calculations

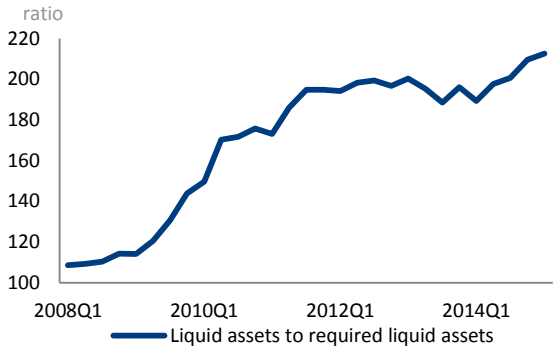
The effective household lending rate was more or less in line with the prime rate up to the first half of 2007. A positive spread (i.e. effective lending rate higher than prime) emerged since 2007Q3. Although this coincides with the enactment of the National Credit Act, 2007 also witnessed a first wave of strong growth in the unsecured lending category at higher effective rates. Moreover, this gap increased and became entrenched post-recession. In line with international experience, one can argue that the main reason for this is that banks became more risk averse after the global financial crisis. Furthermore, the implementation of Basel 2.5 and Basel III in 2012 and 2013 respectively might also have played a role in sustaining this spread, given that funding costs were effectively increased by these regulations (IMF, 2014: 16). Figure 2 and Figure 3 also show the increase in the capital adequacy (albeit that this ratio has dipped since 2014) and liquidity ratios post-recession.

Figure 2: Capital adequacy ratio



Source: SARB

Figure 3: Liquidity ratio



Source: SARB

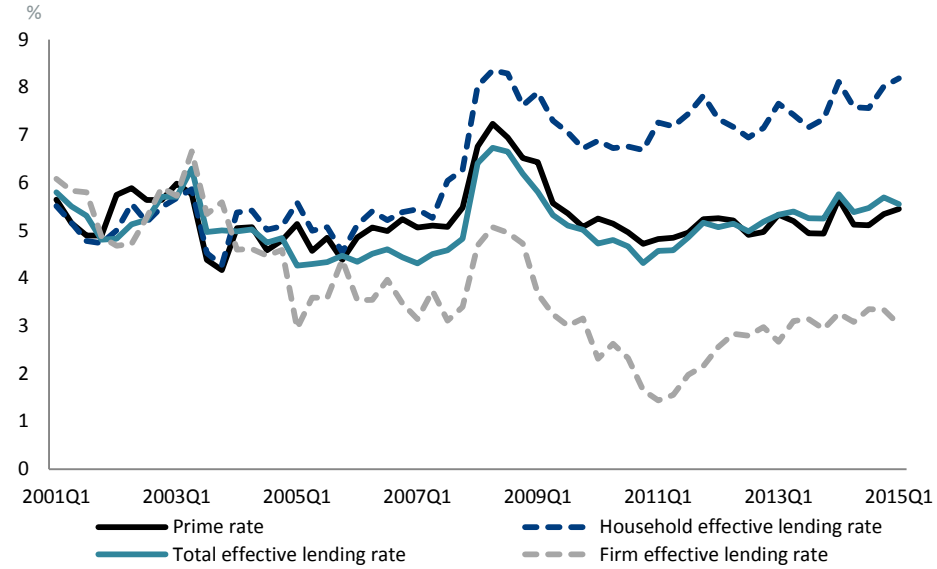
It must also be noted that a second wave of strong growth in unsecured lending took place between 2011 and early 2013. However, growth in this type of lending[7] has since slowed drastically while the household lending rate spread over the prime rate continued to increase. The effective lending rate calculated in this way (out of interest payments on total outstanding household debt) represents an average interest rate across all outstanding household debt and implies that it is not necessarily the same as the lending rate which applies to new loans to the household sector. However, because household loans are generally at the

[7] Defined here as general loans and advances to households, as well as household overdrafts and credit cards. The share of these loans and advances to households increased from 17% in 2004 to 24% in 2014. Hence, mortgage credit continues to dominate in total loans and advances to households.

variable rate in SA (also noted by Muellbauer, 2010: 3), one could argue that this disadvantage is mitigated since the average and marginal rate will then tend to move in the same direction (Havemann, 2014: 8).

Given this implied effective lending rate and a calculation of the total effective lending rate on all outstanding loans from banking sector data, firms have by implication not faced a higher lending rate spread post-recession[8]. Figure 4 depicts the spreads of different lending rates – prime, the total effective lending rate as well as the disaggregation into household and firm effective lending rates – all over the effective deposit rate.

Figure 4: Spreads of different lending rates over the effective deposit rate



Source: SARB, BER calculations

The enhanced BER model aims to capture these trends by estimating the following as part of the set of endogenous variables: the effective deposit rate as well as the spread over the effective deposit rate for household and firm lending rates respectively. The main drivers of these spreads are specified as the liquidity ratio, the capital adequacy ratio and the survey indicators for the credit standards of retail banks with respect to households and firms. This implies that the effective price of credit faced by households and firms are largely determined by banking sector developments. Theoretically, one might also want to include measures of creditworthiness of households or firms. Unfortunately, such a measure for households is used to construct the lending rate spread and so implies endogeneity. Furthermore, it is difficult to define such a measure on aggregate for firms.

Finally, the effective deposit rate is closely related to the policy rate i.e. the repo rate. See below for the technical details of these selected enhancements.

3.1.1 The effective deposit rate

The calculated effective deposit rate is determined in the model as directly related to the repo rate. The Wald test does not reject this homogeneity restriction.

$$\Delta(FRDE) = \underset{[-4.67]}{-0.469} - \underset{[-5.06]}{0.272}*(FRDE(-1)-FRB4(-1)) + \underset{[17.29]}{0.817}*\Delta(FRB4) - \underset{[-5.90]}{1.059}*DUM08Q1Q2 - \underset{[-3.06]}{0.516}*\Delta(DUM14Q1) + \underset{[2.99]}{0.761}*DUM03Q3$$

[8] The effective lending rate for firms was calculated as follows: Effective firm lending rate = (Total effective lending rate – (Share of household credit in total private sector credit extended*Effective household lending rate)/Share of firm credit in total private sector credit extended)) or frpef = ((frle-(fcph/fcp)*frpe)/(fcpf/fcp)).

Where:
FRDE: Calculated effective deposit rate
FRB4: Repo rate
DUM08Q1Q2: Dummy variable for 2008 Q1 and Q2
DUM14Q1: Dummy variable for 2014 Q1
DUM03Q3: Dummy variable for 2003 Q3

Diagnostics:

Sample:	2001Q2 – 2015Q1
Adjusted R-squared:	0.85
Standard Error of regression:	0.24
ECM cointergation test:	-5.06
Breusch-Godfrey serial correlation test:	0.15
Jarque-Bera normality test on residuals:	0.93
White heteroskedasticity test:	0.89
Wald test on homogeneity restriction	0.62

The repo rate is either treated as exogenous or can be model determined by activating a policy reaction function in the form of a Taylor rule which incorporates the finance neutral measure of the output gap. For the specification of this rule please see below. It gives a weight of 0.6% to the repo rate in the previous quarter and 0.4% to an adjustment term. This term consists of the natural nominal repo rate (specified as 7%) plus a factor of the current inflation rate relative to the target inflation rate (varying from 4.5% to 6%[9]) plus a factor of capacity utilisation based on the finance neutral output gap. From theory, the factor relating to inflation is larger than one and the factor relating to capacity utilisation is smaller than one. Several permutations of these factors were tested and a selection was made based on fit.

$$FRB4T = 0.6*FRB4(-1) + 0.4*(7 + 1.3 * ((PPCI4) - TARGET) + 0.5 * (\Delta(YCUFN)))$$

Where:
FRB4T: Policy rate as per the Taylor rule
FRB4: Repo rate
PPCI4: Year-on-year % change in the Consumer Price Index (targeted inflation measure)
TARGET: Point estimate of inflation target (Taken as mid-point i.e. 4.5% of the 3-6% inflation target band up to 2010 and then the upper limit i.e. 6% thereafter)
YCUFN: Capacity utilisation as per the finance neutral output gap

3.1.2 Household lending rate spread over the effective deposit rate

As noted above, the main drivers in the behavioural equation for the household lending rate spread were the liquidity and capital adequacy ratios of the banking sector as well as credit standards of retail banks with respect to households.

$$\Delta(RSH) = -0.319 - 0.314*RSH(-1) + 1.277*LIQR(-1)/100 + 0.435*CSRH(-2)/100 + 2.824*\Delta(LIQR)/100 +$$
$$[-0.35] \quad [-2.44] \quad [4.77] \quad [2.05] \quad [3.09]$$

$$0.613*\Delta(CAPAR(-1)) + 0.580*\Delta(CSRH(-1))/100 + 0.526*\Delta(DUM14Q1) + 0.545*DUM11Q1 + 0.475*DUM11Q4 +$$
$$[2.80] \quad [2.95] \quad [3.48] \quad [2.65] \quad [2.52]$$

$$0.386*DUM14Q4$$
$$[1.86]$$

Where:
RSH: Household lending rate spread
LIQR: Liquidity ratio
CSRH: Credit standards of retail banks w.r.t. households
CAPAR: Capital adequacy ratio
DUM14Q1: Dummy variable for 2014 Q1
DUM11Q1: Dummy variable for 2011 Q1
DUM11Q4: Dummy variable for 2011 Q4
DUM14Q4: Dummy variable for 2014 Q4

Diagnostics:

Sample:	2009Q2 – 2015Q1
Adjusted R-squared:	0.77
Standard Error of regression:	0.17
ECM cointergation test:	-2.44
Breusch-Godfrey serial correlation test:	0.65
Jarque-Bera normality test on residuals:	0.41
White heteroskedasticity test:	0.33

Theoretically, one would want to include measures of household indebtedness such as the debt cost ratio to disposable income. However, since the effective lending rate is derived from these data, this is not possible. Other options, such as the National Credit Regulator (NCR) data on the number of credit applications

[9] The target inflation rate is specified as 4.5% up to 2010 and 6% thereafter. This nuance improves the fit of the rule noticeably. Furthermore, it provides flexibility with respect to this assumption in a forecast or scenario exercise.

which are rejected, were tested but were not useful. Finally, to account for the fact that the type of lending impacts the effective rate, it was tested whether non-mortgage household credit should enter the specification directly. This did, however, not improve the specification.

3.1.3 Firm lending rate spread over the effective deposit rate

The main drivers in the behavioural equation for the firm lending rate spread are similar, with liquidity and capital adequacy ratios as well as credit standards of retail banks with respect to firms featuring. However, the data indicate a more significant role for the capital adequacy ratio in the firm lending rate spread compared to the household spread. The capital adequacy ratio also proved significant when directly included as additional explanatory variables in the behavioural equations for credit extended to firms – see Sections 3.2.3 and 3.2.4.

$$\Delta(RSF) = \underset{[-5.84]}{-8.841} - \underset{[-2.70]}{0.203}*RSF(-1) + \underset{[6.20]}{0.610}*CAPAR(-2) + \underset{[5.04]}{1.541}*CSRF(-2)/100 + \underset{[3.18]}{0.975}*\Delta(CSRF(-1))/100 +$$

$$\underset{[2.64]}{1.786}*\Delta(LIQR(-1))/100 - \underset{[-4.60]}{0.622}*\Delta(DUM10Q1) + \underset{[2.15]}{0.433}*DUM14Q3 - \underset{[-1.88]}{0.394}*DUM11Q4$$

Where:	Diagnostics:	
RSF: Firm lending rate spread	Sample:	2009Q2 – 2015Q1
CAPAR: Capital adequacy ratio	Adjusted R-squared:	0.74
CSRF: Credit standards of retail banks w.r.t. firms	Standard Error of regression:	0.18
LIQR: Liquidity ratio	ECM cointergation test:	-2.70
DUM10Q1: Dummy variable for 2010 Q1	Breusch-Godfrey serial correlation test:	0.21
DUM14Q3: Dummy variable for 2014 Q3	Jarque-Bera normality test on residuals:	0.61
DUM11Q4: Dummy variable for 2011 Q4	White heteroskedasticity test:	0.54

This feature is evident in the preliminary results of a shock to the capital adequacy ratio as presented in Section 5, as the firm lending rate and firm credit reacted noticeably more than for households. This makes intuitive sense but the fine tuning of these reactions is still work in progress, so the elasticities with respect to capital adequacy showed above and also in the firm credit behavioural equations might be subject to change at a later stage.

3.2 Private sector credit extension

Private sector credit extension is disaggregated by households and firms as well as by mortgage and non-mortgage lending. The main reason for this disaggregation is that mortgage credit needs to be model determined for the estimation of house prices. However, this approach also improves the overall specification of private sector credit extension.

In general, credit extended is specified as being driven by the demand for credit (i.e. linked to economic drivers) and the real effective interest rate in the long run. However, creditworthiness (with respect to households) and banking sector variables are included if they improve the modelling of the short-term dynamic movements around the long-term trend. In the case of credit extended to firms, the capital adequacy rate entered the specifications also in the long run component. As noted above, the firm credit specifications is still work in progress, and these large and significant effects of banking sector variables, such as the capital adequacy ratio, still need to be verified.

3.2.1 Mortgage credit extended to households

Long-term (i.e. trend) movements in real mortgage credit extended to households are restricted so as not to move out of step with real house prices and real private residential investment. Weights of 80% and 20% are assigned and these coefficient restrictions are not rejected by the data. The long-term elasticity of mortgage credit to households with respect to the interest rate is around 2%. This is also pinned down by restricting the coefficient on the real effective household lending rate and is also not rejected by the data. The interest rate proved not to be significant in determining short-term variations. Rather, changes in credit standards to households and interest payment adjusted real disposable income explain dynamic movements in household mortgage credit.

$$\Delta LOG(FCMAH/PC) = 0.169 - 0.141*((LOG(FCMAH(-1)/PC(-1))-0.8*LOG(HPI(-1)/PC(-1))$$
[13.85] [-13.79]

$$-0.2*LOG(IPRB1(-1))+2*(FRPE(-1)-@PCY(PC(-1)))/100)) - 0.010*\Delta(CSRH(-1))/100 +$$
[-1.35]

$$0.871*\Delta LOG(YD1-((HHDCOST/PC)*100)) - 0.070*DUM05Q1 + 0.102*DUM08Q1 - 0.047*DUM02Q1 +$$
[5.05] [-5.94] [8.67] [-4.09]

$$0.032*DUM09Q1$$
[2.70]

Where:
FCMAH: Mortgage credit extended to households
PC: Consumption deflator
HPI: Average house price indicator
IPRB1: Real private residential investment
FRPE: Effective household lending rate
CSRH: Credit standards of retail banks w.r.t. households
YD1: Real disposable income
HHDCOST: Household interest payments
DUM05Q1: Dummy variable for 2005 Q1
DUM08Q1: Dummy variable for 2008 Q1
DUM02Q1: Dummy variable for 2002 Q1
DUM09Q1: Dummy variable for 2009 Q1

Diagnostics[10]:

Sample:	2001Q2 – 2015Q1
Adjusted R-squared:	0.85
Standard Error of regression:	0.01
ECM cointergation test:	-13.79
Breusch-Godfrey serial correlation test:	0.38
Jarque-Bera normality test on residuals:	0.75
White heteroskedasticity test:	0.07
Wald test on HPI restriction	0.78
Wald test on IPRB1 restriction	0.37
Wald test on FRPE restriction	0.97

3.2.2 Other credit extended to households

The long-term trend in other non-mortgage loans and advances to households are tied to the long-term trend in real household consumption expenditure. This restriction is not accepted by the data – with growth in these loans more than double the pace of growth in real consumption over the sample period (from end-2008). However, for forecasting purposes, this restriction is necessary because these variables should not drift too far apart over the long term. Other drivers of this type of credit are movements in the real effective household lending rate, the debt cost to disposable income of households, and total employment.

$$\Delta LOG(FCPHO/PC) = -0.889 - 0.162*(LOG(FCPHO(-1)/PC(-1))-LOG(CP1(-1))+2*(FRPE(-2)-@PCY(PC(-2)))/100)$$
[-5.69] [-6.06]

$$- 0.717*DCYDR(-1)/100 + 0.753*\Delta LOG(LET(-1)) + 0.024*DUM12Q413Q1 - 0.018*DUM11Q3$$
[-6.12] [5.32] [3.56] [-2.05]

Where:
FCPHO: Non-mortgage credit extended to households
PC: Consumption deflator
CP1: Real household consumption
FRPE: Effective household lending rate
DCYDR: Debt cost to disposable income ratio
LET: Total employment
DUM12Q413Q1: Dummy variable 2012 Q4 & 2013 Q1
DUM11Q3: Dummy variable for 2011 Q3

Diagnostics:

Sample:	2008Q4 – 2015Q1
Adjusted R-squared:	0.80
Standard Error of regression:	0.01
ECM cointergation test:	-6.06
Breusch-Godfrey serial correlation test:	0.39
Jarque-Bera normality test on residuals:	0.46
White heteroskedasticity test:	0.57
Wald test on CP1 restriction	0.00
Wald test on FRPE restriction	0.47

3.2.3 Mortgage credit extended to firms

Firm mortgages have an almost one-to-one long-term relationship with non-residential private investment (this homogeneity restriction is easily accepted by the data). The effective lending rate faced by firms is also an important factor in mortgages extended to firms. The long-run elasticity can go above -4% (but given the slow speed of adjustment the effective elasticity is notably lower), this elasticity is, however, restricted to -2% in the BER model. The short-run elasticity is -0.7%. As noted above, the data indicate a significant role for the capital adequacy ratio in credit extended to firms. Both for mortgages and other

[10] Shaded test statistics implies test is not passed i.e. probability of accepting the hypothesis tested is too small.

credit (see Section 3.2.4). Other variables significant for firm mortgages are credit standards with respect to firms and, for explaining dynamic adjustments, real GDP.

$$\Delta LOG(FCMAF/PC) = 0.145 - 0.065*(LOG(FCMAF(-1)/PC(-1))-LOG(IPO1(-1))+2*FRPEF(-1)/100)$$
[2.30] [-5.70]

$$-0.031*CAPAR(-1) - 0.037*CSRF(-1)/100 + 0.869*\Delta LOG(Y1) - 0.741*\Delta(FRPEF)/100 - 0.051*\Delta(CAPAR)$$
[-15.90] [-3.51] [3.01] [-3.54] [-10.59]

$$- 0.224*DUM04Q1 + 0.048*DUM05Q1 + 0.048*DUM07Q3Q4 - 0.222*DUM08Q1 + 0.034*DUM11Q2Q3$$
[-19.28] [3.78] [5.60] [-18.38] [4.22]

Where:
FCMA: Mortgage credit extended to firms
PC: Consumption deflator
IPO1: Real private non-residential investment
FRPEF: Effective firm lending rate
CAPAR: Capital adequacy ratio
CSRF: Credit standards of retail banks w.r.t. firms
Y1: Real GDP
DUM04Q1: Dummy variable for 2004 Q1
DUM05Q1: Dummy variable for 2005 Q1
DUM07Q3Q4: Dummy variable for 2007 Q3 and Q4
DUM08Q1: Dummy variable for 2008 Q1
DUM11Q2Q3: Dummy variable for 2011 Q2 and Q3

Diagnostics:

Sample:	2003Q2 – 2015Q1
Adjusted R-squared:	0.96
Standard Error of regression:	0.01
ECM cointergation test:	-5.70
Breusch-Godfrey serial correlation test:	0.02
Jarque-Bera normality test on residuals:	0.99
White heteroskedasticity test:	0.70
Wald test on IPO1 restriction	0.79
Wald test on FRPEF restriction	0.22

3.2.4 Other credit extended to firms

The long-term trend in other non-mortgage loans and advances to firms are tied to the long-term trend in real GDP, but with an elasticity of 2%. While we would prefer a one-to-one relationship, as explained for the other credit extended to households, this does not seem possible from a statistical perspective. Other drivers of this type of credit are movements in the real effective firm lending rate (however, the lending rate is restricted into the specification) and the capital adequacy ratio of banks.

$$\Delta LOG(FCPFO/PC) = -5.834 - 0.469*(LOG(FCPFO(-1)/PC(-1))-2*LOG(Y1(-1))+FRPEF(-1)/100)$$
[-5.42] [-5.48]

$$- 0.044*CAPAR(-1) - 0.025*\Delta(CAPAR) - 0.052*DUM12Q2 + 0.061*DUM08Q1$$
[-5.24] [-1.81] [-2.20] [2.19]

Where:
FCPFO: Non-mortgage credit extended to firms
PC: Consumption deflator
Y1: Real GDP
FRPEF: Effective firm lending rate
CAPAR: Capital adequacy ratio
DUM12Q2: Dummy variable for 2012 Q2
DUM08Q1: Dummy variable for 2008 Q1

Diagnostics:

Sample:	2005Q3 – 2015Q1
Adjusted R-squared:	0.56
Standard Error of regression:	0.02
ECM cointergation test:	-5.48
Breusch-Godfrey serial correlation test:	0.18
Jarque-Bera normality test on residuals:	0.73
White heteroskedasticity test:	0.86
Wald test on Y1 restriction	0.20
Wald test on FRPEF restriction	0.10

3.3 Asset prices and net wealth

Two central asset prices are represented in the re-specified model. The first is house prices as measured by an average of all available house price indices. This is done to ensure that movements in the house price index used are more likely to be representative of price movements in the actual housing market. In the model, real disposable income (restricted to a one-to-one relationship but this is in line with the data) and the nominal effective household lending rate are the long-term drivers of real house prices. The lending rate elasticity is high and has been restricted to -1.5% (the data would indicate an elasticity of above 3%). The short-run elasticity (estimated) is -0.7%. Other short-term dynamic drivers include real gross domestic expenditure, real total mortgage credit extended and the credit standards of banks.

Equity prices are the second asset price included in the model. The JSE All Share Index, as published by the SARB, is modelled. This index is restricted to have a one-to-one relationship with nominal GDP over the long term – as indicated by the data. Short-term drivers are specified as nominal global economic growth, commodity prices relevant to SA's producers, and total private sector credit extension. A dummy variable controls for quantitative easing policies globally.

As mentioned above, net wealth of households, as calculated from SARB ratios, are model determined in the re-specified BER model. Both long-term (i.e. trend) and short-term (i.e. dynamic adjustments) movements in household net wealth are estimated based on house and equity price indicators (to represent the major assets held by households) and the effective household lending rate (to control for movements in household liabilities). While this specification yields satisfactory results, the inclusion of, for example, a measure of the stock of housing can be considered at a later stage provided quarterly estimates are available which match the official annual data.

3.4 Real economy linkages

The demand components most affected by the re-specified structure are real household consumption expenditure and real private fixed investment.

Household spending is modelled separately for durable, semi-durable and non-durable goods, as well as services. Three new explanatory variables could be tested in each of the four behavioural equations for consumption expenditure: real net household wealth, the effective household lending rate (as opposed to the prime rate), and household credit extended. The re-estimated equations now include real net household wealth together with real disposable income in the one-to-one long-term cointegration relationship between household "income" and household expenditure. Secondly, the effective household lending rate was found to be a more significant long-term driver (negative) of real household spending than the prime rate. In the case of spending on durable goods and semi-durable goods, the elasticity of the lending rate is higher and short-term movements in the effective household lending rate also directly affect volumes. Thirdly, credit extended to households is often significant in explaining some of the short-term dynamic movements in the household spending categories. The relative prices of these goods or services usually also feature both in the long-term and short-term components of these behavioural equations.

Private fixed investment is split between residential and non-residential investment in the BER model. The international literature post-crisis has highlighted that missing financial sector linkages to residential investment was a key shortcoming of pre-crisis models. The re-specified behavioural equation for real private residential investment now includes the effective household lending rate so that changes in banking sector variables impact this type of investment via the lending rate spread. Also, the link to asset prices – in particular to house prices – is significant in explaining both long-term and short-term variations in real private residential investment. Finally, mortgage credit extended to households play an additional role as a driver of short-term movements.

The financial sector linkages in real private non-residential investment have also been enhanced. Not only is the capacity utilisation measure included now based on calculations which embed the financial sector, but the effective lending rate of firms also directly features as long-term driver. Previously, firm lending rates where proxied by, for example, short-horizon government bond yields. The move to the effective lending rate now activates the impact of changes in banking sector variables on this type of investment via the lending rate spread. Credit extended to firms are also now included directly as long-term driver of real non-residential investment – after controlling for a one-to-one relationship with real GDP growth as well as the effective lending rate (negative).

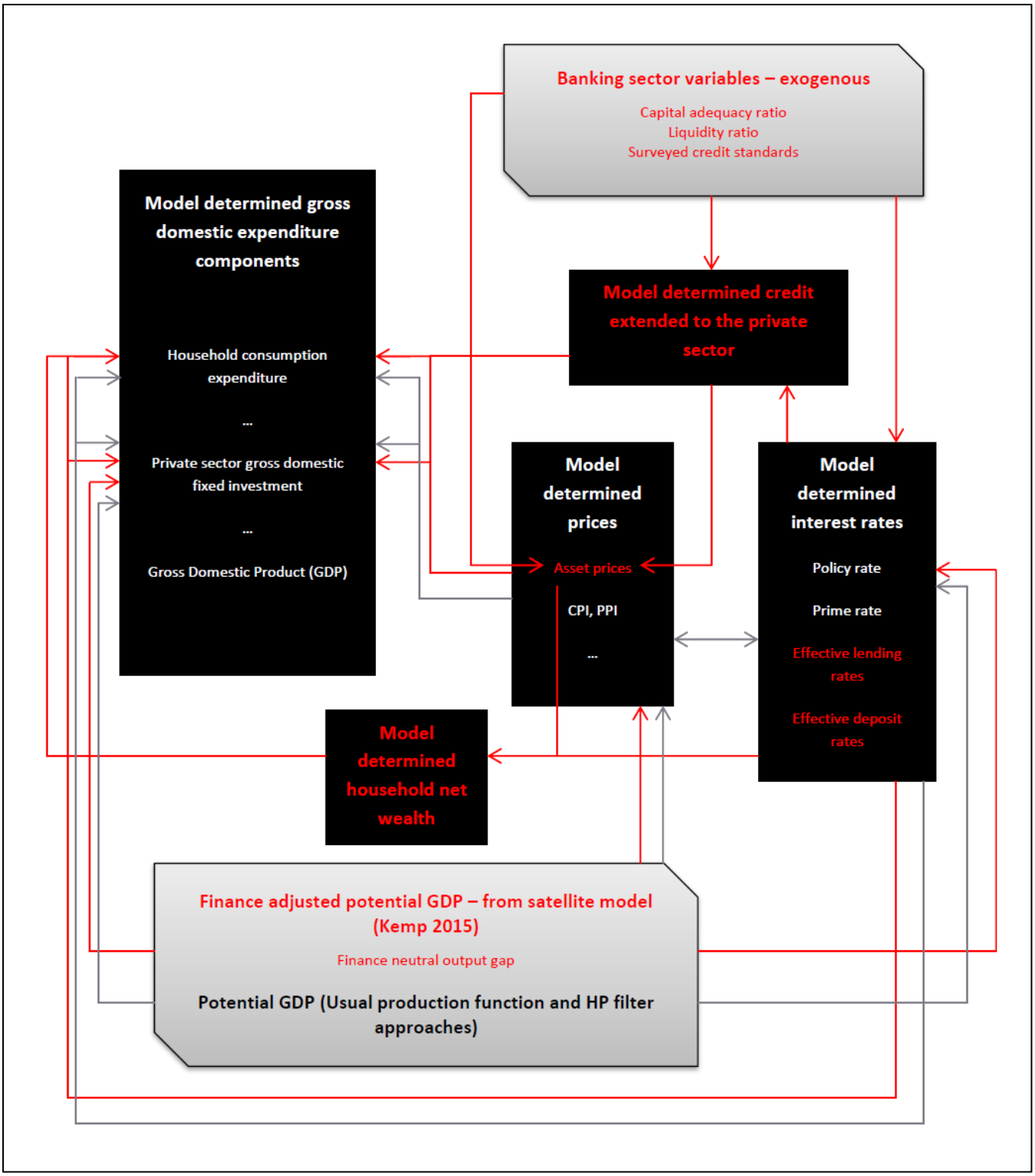
4. A comparison with the previous version of the BER's quarterly model

Figure 5 illustrates how the financial sector influence has been enhanced in the re-estimated macroeconometric model. The variables and linkages shown in red represent the enhancements. These have increased the channels of monetary policy transmission[11] in the model. In the previous model, monetary policy transmission mainly took place along two channels: the direct effect of the prime rate (based on the

[11] See Smal and De Jager (2001) for a description of the monetary transmission mechanism in South Africa.

repo rate) on the household expenditure and private investment components of demand (impacting capacity utilisation and ultimately inflation); and the exchange rate channel (triggered by the interest rate) which affects net exports (given the relative prices of imports and exports) and finally demand. Apart from introducing a more nuanced direct interest rate impact given a more comprehensive set of interest rates, the credit channel of monetary policy transmission is represented in the re-estimated model. Also, the new model has an active asset price channel, affecting demand mainly through net wealth. Finally, the re-estimated model allows for impacts from the broader set of macroprudential-type policy instruments such as capital adequacy and liquidity ratios – these impacting aggregate demand via the credit market, effective lending rate spreads and asset prices.

Figure 5: Graphical illustration of the enhanced financial sector linkages in the BER core model



There is, however, also a case to be made from a theoretical perspective for an expectations channel, where inflation expectations impact wages, but this channel is not represented in the model's current version. The adding of forward-looking components such as inflation expectations is one of the major areas highlighted for future work.

4.1 Interest rate shock simulations

To illustrate the enhanced transmission of monetary policy in the re-estimated model, the results of an identical shock to the repo rate is compared between the current and previous macroeconometric models. The temporary repo rate shock consists of a 100 basis point increase in the repo rate for the 4 quarters 2010Q1 to 2010Q4. For this purpose, the repo rate equation in the model was exogenized.

Given the linkages highlighted in Section 3 and Figure 5 above, one would expect a larger and perhaps more persistent dampening effect on real economic activity in the re-estimated model. The results are presented up to 2015Q1 (i.e. 20 quarters after the shock) and are in line with expectations – see Figure 6. In the re-estimated model, the repo rate shock works through the model via its effect on other interest rates, the credit market, asset prices and the exchange rate. Inflation and real economic activity are affected. The most important shortcomings of the transmission of the interest rate shock in the previous version of the BER model are the lack of any credit and wealth feedbacks to real private consumption and investment (given that credit and asset markets are not specified).

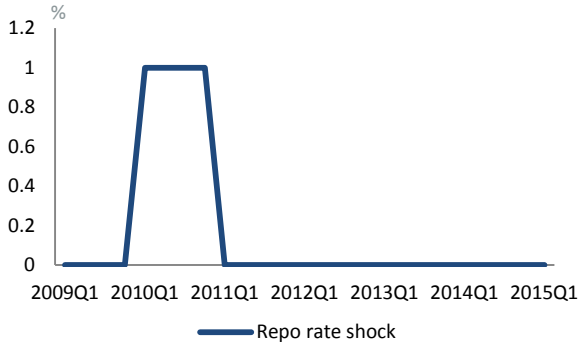
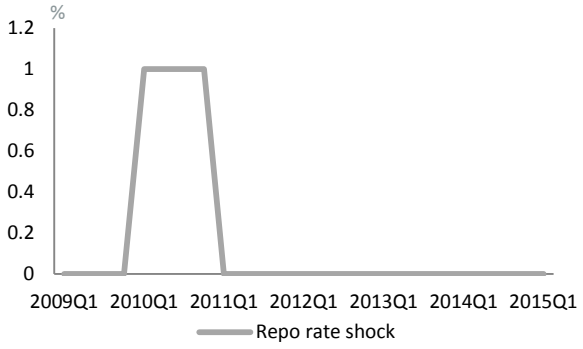
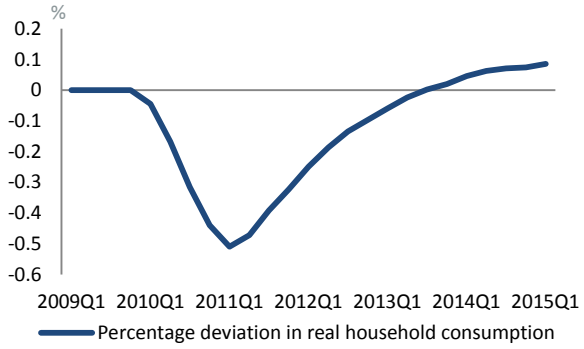
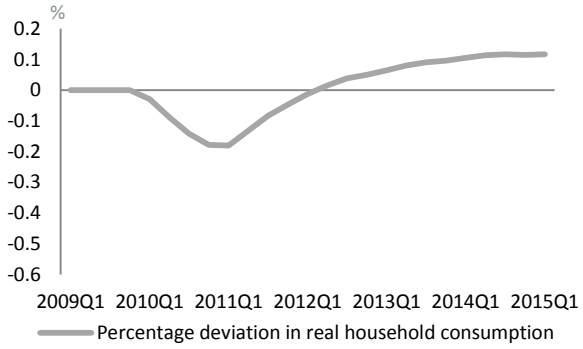
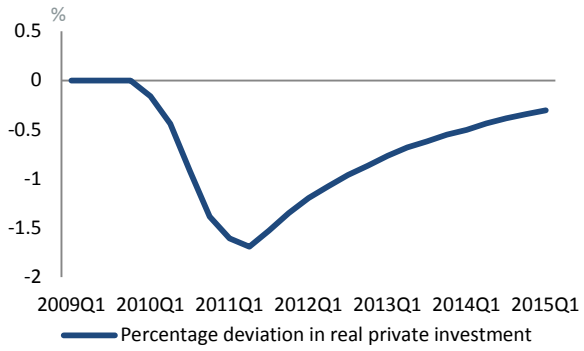
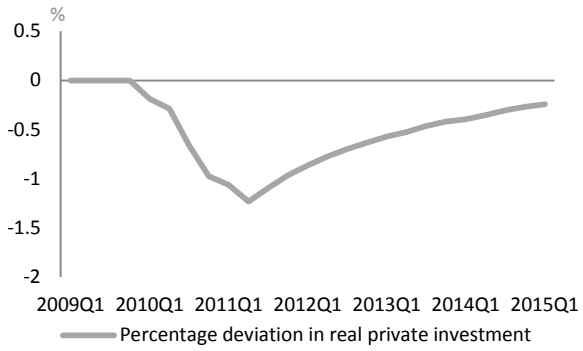
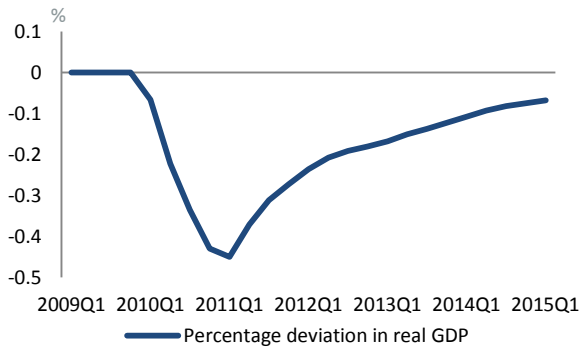
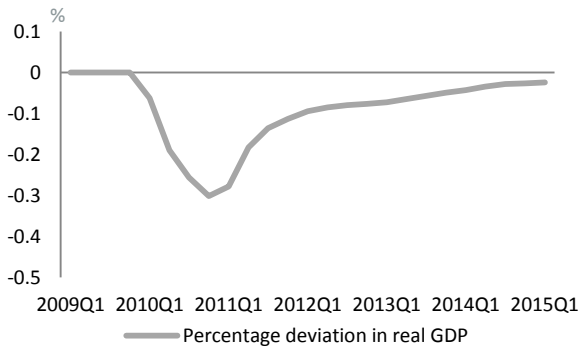
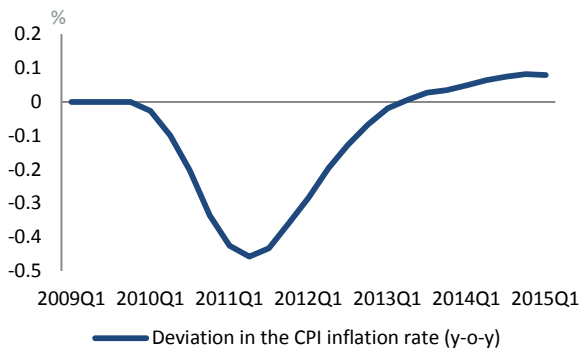
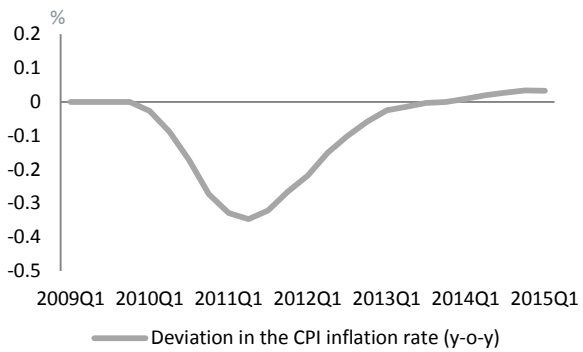
The larger and more persistent negative effect on real household consumption expenditure is the most notable change in the results of a temporary interest rate shock between the two models. In the previous model, real consumption reached a maximum percentage deviation from baseline of -0.18% in 2011Q1 and small positive deviations emerged from 2012Q2 as lower inflation boosts real spending (i.e. spending in volume terms, household spending in current prices remains lower compared to baseline throughout the sample of the shock). The re-estimated model produces a much stronger negative effect on consumption, with the negative percentage deviation reaching -0.51% in 2011Q1 and positive deviations only emerging from the second half of 2013.

The reaction of real private residential investment, disaggregated between residential and non-residential investment in both versions of the model, is also stronger (negative) in the re-estimated version. While the non-residential investment response is stronger, a key difference in the investment response between the models is that of residential investment. In the previous version, where there is no role for either house prices or the mortgage market, the maximum negative percentage deviation in residential investment was only -1.03% and already in 2010Q4. Moreover, the negative effect petered out quite fast, with this deviation down to -0.58% by 2012Q3. On the other hand, the re-estimated model indicates a maximum negative deviation of -1.48% in 2011Q3, and remains large -1.30% up to 2012Q3. Both models see deviations shrinking to around -0.4% to -0.3% by the end of the sample. In all, the maximum negative deviation on real private investment is at -1.69% and -1.23% in 2011Q2 for the re-estimated and previous models respectively.

The magnitude and timing of the negative effect on overall gross domestic product (GDP) differs between the two models. The re-estimated model reaches a maximum negative impact with a percentage deviation of -0.45% in 2011Q1, while the corresponding deviation is -0.30% reached in 2010Q4 in the previous model. Furthermore, given the more persistent negative effect on real consumption, the GDP also takes longer to recover from the interest rate shock in the re-estimated model. Finally, the effect on inflation as measured by the Consumer Price Index (CPI) is also somewhat more pronounced in the re-estimated model. CPI inflation is down 0.46 percentage points in 2011Q2 versus a maximum decline of 0.35 percentage points (also in 2011Q2) in the previous version[12].

[12] These GDP and CPI effects are more or less in line with the international evidence for similar policy rate shocks.

Figure 6: Comparing the results of a policy interest rate shock

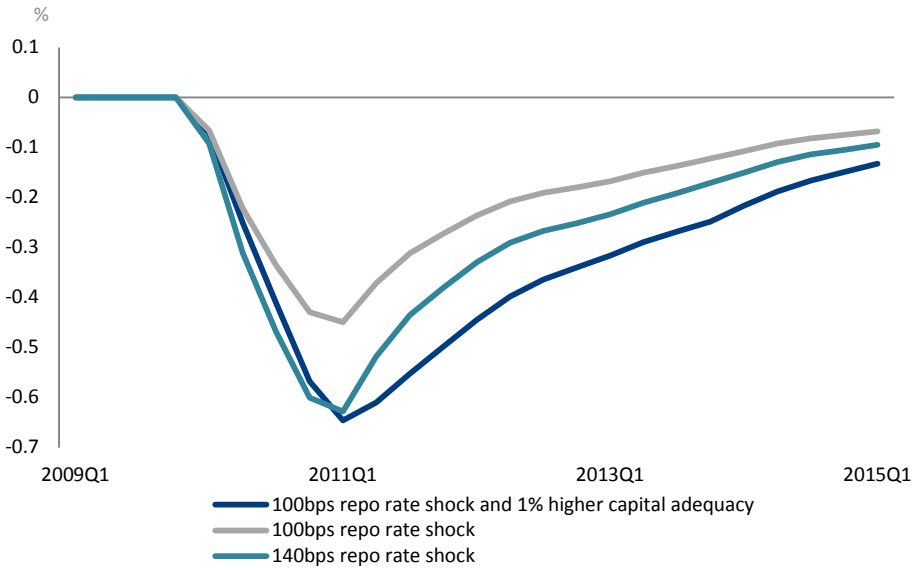
Enhanced BER model:	Previous BER model:
	
	
	
	
	

5. An application of the enhanced model

While the current set of developments of the BER's core macroeconometric model is still work in progress, this section presents the preliminary results of a shock to a new macroprudential policy lever – the capital adequacy ratio of banks – active in the re-estimated model. This ratio effects the lending rate spreads of households and firms as well as the credit market (in particular credit extended to firms) in the model.

A shock of a one percentage point increase in the capital adequacy ratio of banks between 2010Q1 and 2010Q4 was layered over the policy interest rate shock described above. The overall initial additional negative impact on GDP seems reasonable, and is in fact similar to the findings of Havemann (2014) in that it corresponds with an interest rate shock of 40 basis points. If the shock was repackaged as a 140 basis points increase in the repo rate, then the initial decline in real GDP is in line with the repo and capital adequacy combination shock. Figure 7 illustrates this by comparing the percentage deviation in real GDP between the combination shock, the original repo rate shock, and a repo rate shock of 140 basis points.

Figure 7: Percentage deviations in real GDP



The fact that the combination shock yields a more persistent negative impact on the economy makes intuitive sense, but still needs to be verified in the light of the international literature. Barrell and Gottschalk (2009) do find strong effects on GDP from changes in capital adequacy requirements in emerging markets. However, the reactions of the firm lending rate spread and firm credit extension might have to be fine-tuned. More detailed preliminary results are provided in the Appendix.

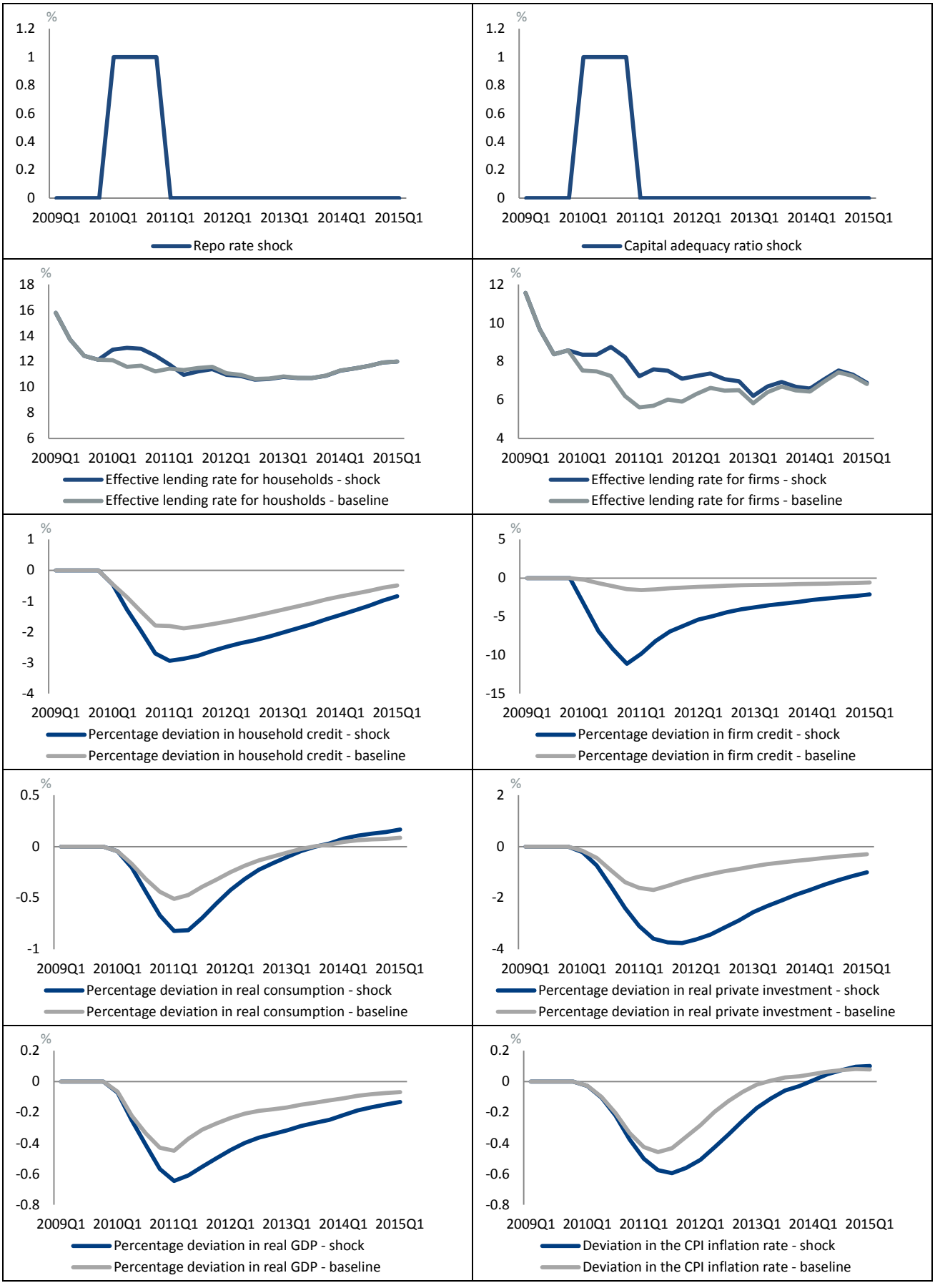
6. Conclusion

This paper presented the enhanced linkages from the financial sector to real economic activity in the BER's core traditional semi-structural quarterly macroeconometric model. Apart from incorporating the BER's finance-neutral measure of potential output, banking sector variables such as the capital adequacy and liquidity ratios as well as the indicators on the credit standards of retail banks were added to the model. The banking sector assumptions influence the lending rate spreads faced by households and firms. Importantly, credit markets (separated for households and firms as well as by mortgage and other loans), assets prices (in particular house and equity prices) and household net wealth are now model determined. The enhancements impact directly on real economic activity primarily through household consumption as well as private residential and non-residential investment. This has increased the channels of monetary policy transmission in the model and has also introduced macroprudential-type policy levers.

There is a large body of literature on incorporating the financial sector into DSGE-type models, but this literature is rather limited for more traditional forecasting models. The hope is that this paper will add to this literature in documenting the changes to the BER's core model.

Appendix

Figure: Results of a shock to the capital adequacy ratio in addition to the policy rate increase



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