Housing Market Spillovers in South Africa: Evidence from an Estimated Small Open Economy DSGE Model

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Abstract

This paper evaluates the impact of housing market spillovers on a small open economy, namely South Africa, using a small-open economy new Keynesian dynamic stochastic general equilibrium model (SOE-NKDSGE) which explicitly incorporates a housing sector. Using quarterly data covering the period of 1971:Q1-2015:Q3, we obtain the following set of results: (a) Over the business cycle, the housing preference shock and the technology shock in the consumption sector drive most of the fluctuations of real house price; (b) The spillover effects of the housing market to the boarder economy are not negligible; (c) The central bank of South Africa has actively responded to house price movements over the past 45 years; and (d) The flexible exchange rate policy has helped South Africa maintain the macroeconomic stability to a large extent.

Keywords: Housing Market, Spillovers, Monetary Policy, Dynamic Stochastic General Equilibrium Model, South Africa

JEL Classification: E21, E32, E44, E52, R31

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1 Introduction

The housing market meltdown associated with the subprime mortgage crisis of 2007 led to the worst global financial and economic crisis since the "Great Depression" (André et al. (2017)). This has resulted in a proliferation of research on the importance of the housing market in terms of the general economy in both advanced and developing/emerging countries (see Cesa-Bianchi (2013), Hirata et al. (2013), and Cesa-Bianchi et al. (2015)). Though it is true, that research on housing market spillovers did exist even prior to the recent financial crisis, it was basically part of real estate economics, and in addition, was primarily (barring few exceptions like Davis and Heathcote (2005) and Iacoviello (2005)) limited to atheoretical regression-based analyses (see Nyakabawo et al. (2015) for a detailed review in this regard). However, the recent global crisis led to the need for deeper modelling of the housing market using microfounded structural dynamic stochastic general equilibrium (DSGE) models (Iacoviello (2010) and Iacoviello and Neri (2010)). This transition was natural as housing became part of mainstream economics, and warranted the need to understand better as to where the shocks to the housing market, and in particular house prices, originated from in their process of affecting the business cycle through the wealth effect (Iacoviello (2010)).

Against this backdrop, the objective of this paper is to evaluate the impact of housing market spillovers on a small open economy, namely South Africa, using a small-open economy new Keynesian dynamic stochastic general equilibrium model (SOE-NKDSGE). Given that housing wealth accounts for 50.05 percent of household's total assets and 38.41 percent of households net worth (Aye et al. (2014)), it is not surprising that there is ample research that looks into and documents significant housing market spillovers on both the national and regional economies of South Africa (see for example Das et al. (2011), Peretti et al. (2012), Simo-Kengne et al. (2013a), Simo-Kengne et al. (2015), Simo-Kengne et al. (2013b), Simo-Kengne et al. (2012), Simo-Kengne et al. (2014), Aye et al. (2013), Aye et al. (2014), Inglesi-Lotz and Gupta (2013), Apergis et al. (2014), and Chang et al. (2013)). However, all these studies rely on linear regressions, and variations of vector autoregressive (VAR) or vector error-correction (VEC) frameworks based on time-series or panel data. These types of models involve only a few variables and therefore tend to be misspecified (Paetz and Gupta (2016)). As a consequence, the results from these studies could be biased and probably differ from the true magnitude of the wealth effects of house price. Further, with these approaches being atheoretical and nonstructural, they suffer from the Lucas (1976) critique. The DSGE based approach treats house prices as endogenous and determines the underlying shocks that move house prices in the first place, and allows us to detect (possible) different impacts on the real economy depending on what type of shocks drive the housing market. Using a theoretical framework helps understanding the wealth channel, quantify its importance, and also provide recommendations for policy-makers, especially central bankers.

Besides the fact that housing market spillovers could be inflationary if they significantly affect aggregate demand through consumption, the recent financial crisis has rekindled the debate on whether central banks should conduct monetary policy in a more active manner to prevent the development of bubbles that can be costly in terms of future output and financial stability (André et al. (2012) and Sun and Tsang (2014)). The papers, namely that of Peretti et al. (2012), Simo-Kengne et al. (2013a), Simo-Kengne et al. (2015), Simo-Kengne et al. (2013b), Simo-Kengne et al. (2012), and Simo-Kengne et al. (2014), which investigates the behaviour of the interest rate in response to house movements in South Africa, suggest that the South African Reserve Bank (SARB) responds significantly to house price movements. However, according to Pariès and Notarpietro (2008), Finocchiaro and Queijo von Heideken (2009), and Paetz and Gupta (2016) these non-microfounded based approaches are again likely to be flawed and produce biased and dispersed estimates. Interestingly, in a recent study, Paetz and Gupta (2016) use a DSGE model to show that, the so-called significant effects of stock prices on the South African macroeconomy, as observed in the domestic literature of stock market spillover based on atheoretical models,[1] in fact becomes virtually non-existent. The findings of Paetz and Gupta (2016), in turn, provide us an additional motivation to conduct a DSGE-based study to validate or invalidate the claims of significant housing market spillovers in South Africa made by the atheoretical papers discussed above.

Some recent studies focus on small open economies and attempt to examine the role of foreign shocks in explaining housing market fluctuations; see Bao et al. (2009), Tomura (2010), Funke and Paetz (2013), and Ng and Feng (2016). Most of these studies find that foreign shocks play an

[1]For a detailed discussion of the literature on stock market spillovers in South Africa, see Aye et al. (2015) and Paetz and Gupta (2016).

important role, except Funke and Paetz (2013) who find that domestic housing preference shocks dominate foreign demand shocks in explaining dynamics of Hong Kong property price inflation. While it is expected that the domestic economy actively responds to foreign shocks in a fixed exchange rate environment, we find the contribution of foreign shocks to be minor in South Africa that implements a flexible exchange rate system since 1970.

The remainder of the paper is organized as follows: Section 2 describes the model economy. Section 3 estimates the model using Bayesian methods, interprets the impulse response functions, and conducts a historical shock decomposition to understand macroeconomic dynamics and housing market fluctuations. Section 4 quantifies the spillover effects of housing market to the broader economy and compares social welfare from the stabilization point of view between the flexible and fixed exchange rate policies. Section 5 concludes the paper.

2 Model Economy

The model we use in this paper is based on the DSGE model with housing of Iacoviello (2005) and Iacoviello and Neri (2010) and the small open economy model of Gali and Monacelli (2005). The domestic economy features entrepreneurs (denoted with a subscript e) who produce consumption goods and new houses on the supply side and two types of households (denoted with subscripts u and c) on the demand side.

Entrepreneurs: There is a continuum of measure one of entrepreneurs. They accumulate capital and hire labor to produce wholesale goods Y_t and new houses IH_t. They seek to maximize their lifetime utility:

$$V_e = E_0 \sum_{t=0}^{\infty} \beta_e^t z_t \left(\frac{1-\epsilon_e}{1-\beta_e \epsilon_e} \ln(c_{e,t} - \epsilon_e c_{e,t-1}) \right), \tag{1}$$

subject to technologies:

$$Y_t = \left(a_{c,t} \left(nc_{u,t}^{\omega} nc_{c,t}^{1-\omega} \right) \right)^{1-\mu_c} (k_{c,t-1})^{\mu_c}, \tag{2}$$

$$IH_t = \left(a_{h,t} \left(nh_{u,t}^{\omega} nh_{c,t}^{1-\omega} \right) \right)^{1-\mu_h-\mu_b-\mu_l} (k_{h,t-1})^{\mu_h} (k_{b,t})^{\mu_b} (l_{t-1})^{\mu_l}, \tag{3}$$

and a budget constraint:

$$\frac{Y_t}{X_t} + q_t IH_t + b_{e,t} = c_{e,t} + \frac{R_{t-1}b_{e,t-1}}{\pi_t} + \sum_{i=\{u,c\}} (wc_{i,t}nc_{i,t} + wh_{i,t}nh_{i,t}) + \frac{k_{c,t} - (1-\delta_{kc})k_{c,t-1}}{a_{k,t}}$$
$$+ (k_{h,t} - (1-\delta_{kh})k_{h,t-1}) + k_{b,t} + p_{l,t}(l_t - l_{t-1}) + \Phi_t, \quad (4)$$

as well as the following borrowing constraint:

$$b_{e,t} \leq m_e E_t \left(\left(\frac{(1-\delta_{kc})k_{c,t}}{a_{k,t}} + (1-\delta_{kh})k_{h,t} \right) \frac{\pi_{t+1}}{R_t} \right), \quad (5)$$

which indicates that entrepreneurs' borrowing is limited by a fraction of the present value of their capital stock.

In above equations, c and b are consumption and borrowing in real terms; q is the real house price; k_c and k_h stand for capital in the consumption and the housing sectors; R is a riskless nominal return of loans; π is the gross money inflation in the consumption sector. Entrepreneurs hire labor nc for the production of consumption goods and nh for the production of new houses at real wages of wc and wh. Entrepreneurs sell consumption goods via retailers who purchase wholesale goods and sell them at a markup X. Intermediate inputs, land, and the land price are denoted k_b, l, and p_l. The term z_t in the utility function captures the shock to intertemporal preferences and it follows an AR(1) process:

$$\ln z_t = \rho_z \ln z_{t-1} + \varepsilon_{z,t}, \quad (6)$$

where ρ_z is the autoregressive parameter; $\varepsilon_{z,t}$ is an i.i.d. innovation with mean zero and variance σ_z^2.

The terms a_c and a_h in the production functions stand for technologies in the consumption and housing sectors. In the budget constraint, a_k is the investment-specific shock which captures the marginal cost, measured in terms of consumption, of producing capital used in the consumption sector. They all follow AR(1) processes:

$$\ln a_{c,t} = \rho_c \ln a_{c,t-1} + \varepsilon_{c,t}, \tag{7}$$

$$\ln a_{h,t} = \rho_h \ln a_{h,t-1} + \varepsilon_{h,t}, \tag{8}$$

$$\ln a_{k,t} = \rho_k \ln a_{k,t-1} + \varepsilon_{k,t}, \tag{9}$$

where ρ_c, ρ_h, and ρ_k are autoregressive parameters; $\varepsilon_{c,t}$, $\varepsilon_{h,t}$, and $\varepsilon_{k,t}$ are i.i.d. innovations with mean zero and variances σ_c^2, σ_h^2, and σ_k^2.

The last term in the budget constraint, Φ_t, stands for the capital adjustment cost which follows:

$$\Phi_t = \frac{\phi_{kc}}{2}\left(\frac{k_{c,t}}{k_{c,t-1}} - 1\right)^2 \frac{k_{c,t-1}}{a_{k,t}} + \frac{\phi_{kh}}{2}\left(\frac{k_{h,t}}{k_{h,t-1}} - 1\right)^2 k_{h,t-1}. \tag{10}$$

The parameters β_e and ϵ_e in the utility function capture entrepreneurs' discount factor and habits in consumption; ω in the production functions measures the income share of unconstrained households; μ_c, μ_h, μ_b, and μ_l are production function parameters; ϕ_{kc} and ϕ_{kh} are adjustment cost parameters; m_e is the loan-to-value (LTV) ratio.

Households: There is a continuum of measure one of agents in each of the unconstrained (u) and constrained (c) groups of households. Within each group $i = \{u, c\}$, a representative household maximizes:

$$V_i = E_0 \sum_{t=0}^{\infty} \beta_i^t z_t \left(\frac{1-\epsilon_i}{1-\beta_i\epsilon_i} \ln(c_{i,t} - \epsilon_i c_{i,t-1}) + j_t \ln h_{i,t} - \frac{\tau_t}{1+\eta_i}\left(nc_{i,t}^{1+\xi_i} + nh_{i,t}^{1+\xi_i}\right)^{\frac{1+\eta_i}{1+\xi_i}} \right), \tag{11}$$

subject to the following budget constraint:

$$c_{i,t} + q_t(h_{i,t} - (1-\delta)h_{i,t-1}) + \frac{R_{t-1}b_{i,t-1}}{\pi_t} = b_{i,t} + \frac{wc_{i,t}nc_{i,t}}{X_{wc,t}} + \frac{wh_{i,t}nh_{i,t}}{X_{wh,t}} + DIV_{i,t}, \tag{12}$$

where DIV stands for dividends obtained from retailers and labor unions.[2]

In above equations, h is the housing stock; j_t and τ_t capture the housing preference shock and the labor supply shock which follow:

$$\ln \tau_t = \rho_\tau \ln \tau_{t-1} + \varepsilon_{\tau,t}, \tag{13}$$

$$\ln j_t = (1-\rho_j) \ln j + \rho_j \ln j_{t-1} + \varepsilon_{j,t}, \tag{14}$$

where ρ_τ and ρ_j are autoregressive parameters; $\varepsilon_{\tau,t}$ and $\varepsilon_{j,t}$ are i.i.d. innovations with mean zero and variances σ_τ^2 and σ_j^2; j is the steady-state value of the housing preference shock; X_{wc} and X_{wh} are wage markups charged by labor unions.

In addition, constrained households face a borrowing constraint which states that their borrowing cannot exceed a fraction of the present value of their housing stock:

$$b_{c,t} \leq m_c E_t \left(\frac{(1-\delta) q_{t+1} h_{c,t} \pi_{t+1}}{R_t} \right), \tag{15}$$

where m_c is the LTV ratio associated with constrained households. This parameter affects the size of the spillover effects of the housing market to the broader economy.

Nominal Rigidities: The model allows for sticky price in the domestic consumption sector and sticky wages in both sectors. Price stickiness is introduced through assumptions of monopolistic competition at the retail level, implicit costs of adjusting nominal prices following Calvo (1983) contracts, and partial indexation to lagged inflation of those prices that cannot be re-optimized. The resulting Phillips curve for domestically produced goods is:[3]

$$\ln \pi_{H,t} - \iota_\pi \ln \pi_{H,t-1} = \beta_u (E_t \ln \pi_{H,t+1} - \iota_\pi \ln \pi_{H,t}) - \frac{(1-\theta_\pi)(1-\beta_u \theta_\pi)}{\theta_\pi} \ln \left(\frac{X_t}{X} \right) + \epsilon_{\pi,t}, \tag{16}$$

[2] Dividends take the following form:

$$DIV_{u,t} = \frac{X_t - 1}{X_t} Y_t + \frac{X_{wc,t} - 1}{X_{wc,t}} wc_{u,t} nc_{u,t} + \frac{X_{wh,t} - 1}{X_{wh,t}} wh_{u,t} nh_{u,t},$$

$$DIV_{c,t} = \frac{X_{wc,t} - 1}{X_{wc,t}} wc_{c,t} nc_{c,t} + \frac{X_{wh,t} - 1}{X_{wh,t}} wh_{c,t} nh_{c,t},$$

where we assume that retail businesses are owned by unconstrained households.

[3] A detailed derivation of the Phillips curve can be found in Smets and Wouters (2003).

where $\pi_{H,t} = p_{H,t}/p_{H,t-1}$ is the gross price inflation of domestically produced goods; X_t is the markup charged by retailers with a steady-state value of X; θ_π is the fraction of prices that cannot re-optimize in each period and ι_π is the elasticity of price indexation. The term $\epsilon_{\pi,t}$ is an i.i.d. cost push shock with zero mean and standard deviation σ_π.

Similarly, we have the following wage Phillips curves for each pair of households and sector:

$$\ln \omega c_{i,t} - \iota_{wc} \ln \pi_{t-1} = \beta_i (E_t \ln \omega c_{i,t+1} - \iota_{wc} \ln \pi_t) - \frac{(1-\theta_{wc})(1-\beta_i \theta_{wc})}{\theta_{wc}} \ln \left(\frac{X_{wc,t}}{X_{wc}} \right), \tag{17}$$

$$\ln \omega h_{i,t} - \iota_{wh} \ln \pi_{t-1} = \beta_i (E_t \ln \omega h_{i,t+1} - \iota_{wh} \ln \pi_t) - \frac{(1-\theta_{wh})(1-\beta_i \theta_{wh})}{\theta_{wh}} \ln \left(\frac{X_{wh,t}}{X_{wh}} \right), \tag{18}$$

for $i \in \{u, c\}$,with $\omega c_{i,t}$ and $\omega h_{i,t}$ nominal wage inflations, that is $\omega c_{i,t} = \pi_t wc_{i,t}/wc_{i,t-1}$ and $\omega h_{i,t} = \pi_t wh_{i,t}/wh_{i,t-1}$. The parameters θ_{wc} and θ_{wh} capture the fractions of wage contracts that cannot re-optimize in each period; ι_{wc} and ι_{wh} are the elasticities of wage indexation.

Identities: We define the effective terms of trade as:

$$S_t = \frac{P_{F,t}}{P_{H,t}}, \tag{19}$$

where $P_{H,t}$ is the price of domestically produced goods and $P_{F,t}$ is the price of imported goods expressed in domestic currency. They relate to the CPI according to:

$$P_t \equiv \left[(1-\alpha) P_{H,t}^{1-\eta} + \alpha P_{F,t}^{1-\eta} \right]^{\frac{1}{1-\eta}}, \tag{20}$$

where α corresponds to the share of domestic consumption allocated to imported goods (or an index of openness) and η measures the substitutability between domestic and foreign goods.[4] Log-linearization of the CPI formula around a symmetric steady state satisfying the purchasing power

[4]According to the definition of openness, the optimal allocation of expenditures between domestic and imported goods is given by:

$$C_{H,t} = (1-\alpha) \left(\frac{P_{H,t}}{P_t} \right)^{-\eta} C_t,$$

$$C_{F,t} = \alpha \left(\frac{P_{F,t}}{P_t} \right)^{-\eta} C_t,$$

where $C_{H,t}$ and $C_{F,t}$ are consumption of domestic goods and consumption of imported goods.

parity (PPP) condition $P_{H,t} = P_{F,t}$ yields:

$$\ln P_t = (1-\alpha)\ln P_{H,t} + \alpha \ln P_{F,t}, \\ = \ln P_{H,t} + \alpha \ln S_t. \tag{21}$$

It follows that domestic inflation and CPI inflation are linked according to:

$$\ln \pi_t = \ln \pi_{H,t} + \alpha \Delta \ln S_t, \tag{22}$$

which makes the gap between the two measures of inflation proportional to the percent change in the effective terms of trade, with the coefficient of proportionality given by the index of openness α.

We assume that the law of one price holds:

$$\ln P_{F,t} = \ln \xi_t + \ln P_t^*, \tag{23}$$

where $\ln \xi_t$ is the log nominal exchange rate and $\ln P_t^*$ is foreign price index. Combining this result with the definition of the terms of trade, we obtain:

$$\ln S_t = \ln \xi_t + \ln P_t^* - \ln P_{H,t}, \tag{24}$$

which implies:

$$\Delta \ln S_t = \Delta \ln \xi_t + \ln \pi_t^* - \ln \pi_{H,t}, \tag{25}$$

where $\pi_t^* = P_t^* / P_{t-1}^*$ is foreign gross price inflation.

The uncovered interest parity (UIP) implies:

$$\ln R_t - \ln R_t^* = E_t(\Delta \ln \xi_{t+1}) + rp_t, \tag{26}$$

where rp_t is usually interpreted as a risk premium.[5] The risk premium follows an AR(1) process:

$$rp_t = \rho_{rp} rp_{t-1} + \varepsilon_{rp,t}, \tag{27}$$

where ρ_{rp} is the autoregressive parameter and $\varepsilon_{rp,t}$ is an i.i.d. shock to the risk premium with mean zero and variance σ^2_{rp}.

In the UIP, the change in exchange rate is forward looking. This forward looking feature causes indeterminacy that the number of expectational variables is larger than the number of unstable roots of the system. To solve and estimate this indeterminate DSGE model, we adopt the method proposed by Farmer et al. (2015). The idea of this method is to treat a subset of the non-fundamental errors as newly defined fundamentals. While it is easier to implement, this method is proven to be equivalent to more conventional approaches proposed by Lubik and Schorfheide (2003) and Lubik and Schorfheide (2004). Specifically, we define an expectational sunspot shock $\varepsilon_{de,t}$ which captures the rational expectation forecast error:

$$\varepsilon_{de,t} = \Delta \ln \xi_t - E_{t-1}(\Delta \ln \xi_t), \tag{28}$$

where $\varepsilon_{de,t}$ has mean zero and variance σ^2_{de}. Then we define a new variable $dess_t \equiv E_t(\Delta \ln \xi_{t+1})$ so that it can be linked to $\Delta \ln \xi_t$ via the sunspot shock according to:

$$\Delta \ln \xi_t - dess_{t-1} = \varepsilon_{de,t}. \tag{29}$$

This newly defined variable $dess_t$ is included in the model as one of the endogenous variables.

Monetary Policy: The central bank is assumed to set the interest rate R_t according to a Taylor rule that responds to inflation and GDP growth. We also allow for the possibility for the interest

[5] The hypothesis that interest rate differentials are unbiased predictors of future exchange rate movements has been almost universally rejected in empirical studies. Actually the UIP is likely to explain only a very small proportion of variation in exchange rates. In this paper, the risk premium shock explains about 30% of the variation in the exchange rate.

rate to respond to house price growth. The behavior of the monetary authority is described by:

$$\ln\left(\frac{R_t}{\overline{R}}\right) = \gamma_R \ln\left(\frac{R_{t-1}}{\overline{R}}\right) + (1-\gamma_R)\gamma_\pi \ln\left(\frac{\pi_t}{\overline{\pi}}\right) + (1-\gamma_R)\gamma_Y \ln\left(\frac{GDP_t}{GDP_{t-1}}\right)$$
$$+ (1-\gamma_R)\gamma_Q \ln\left(\frac{q_t}{q_{t-1}}\right) + \varepsilon_{R,t}, \tag{30}$$

where $\overline{R}$ and $\overline{\pi}$ are the steady-state interest rate and the inflation target, and $\epsilon_{R,t}$ is an i.i.d. monetary policy shock with mean zero and variance σ_R^2. Real GDP is domestic output Y_t plus the real value of housing investment $\overline{q}IH_t$:

$$GDP_t = Y_t + \overline{q}IH_t, \tag{31}$$

where $\overline{q}$ denotes the steady-state real house price.

Market Clearing: The market clearing conditions are:

$$C_t + IK_{c,t}/a_{k,t} + IK_{h,t} + k_{b,t} + \Phi_t + NX_t = Y_t, \tag{32}$$

$$(h_{u,t} - (1-\delta)h_{u,t-1}) + (h_{c,t} - (1-\delta)h_{c,t-1}) = IH_t, \tag{33}$$

$$b_{u,t} + b_{c,t} + b_{e,t} = 0, \tag{34}$$

where $C_t = c_{u,t} + c_{c,t} + c_{e,t}$, $IK_{c,t} = (k_{c,t} - (1-\delta_{kc})k_{c,t-1})/a_{k,t}$, $IK_{h,t} = k_{h,t} - (1-\delta_{kh})k_{h,t-1}$, $k_{b,t}$ is the intermediate inputs in the housing sector, Φ_t is the capital adjustment cost, and NX_t stands for net exports.

Foreign Economy: We use the simple three-equation model with aggregate supply (AS), aggregate demand (IS), and monetary policy (MP) to characterize foreign economy (denoted with an asterisk):

$$\ln \pi_t^* = \delta E_t \ln \pi_{t+1}^* + (1-\delta)\ln \pi_{t-1}^* + \kappa \Delta y_t^* + \varepsilon_{AS,t}^*, \tag{35}$$

$$\Delta y_t^* = \mu E_t \ln \Delta y_{t+1}^* + (1-\mu)\Delta y_{t-1}^* - \phi\left(\ln\left(\frac{R_t^*}{\overline{R}^*}\right) - E_t \ln\left(\frac{\pi_{t+1}^*}{\overline{\pi}^*}\right)\right) + \varepsilon_{IS,t}^*, \tag{36}$$

$$\ln\left(\frac{R_t^*}{\overline{R}^*}\right) = \gamma_R^* \ln\left(\frac{R_{t-1}^*}{\overline{R}^*}\right) + (1-\gamma_R^*)\gamma_\pi^* \ln\left(\frac{\pi_t^*}{\overline{\pi}^*}\right) + (1-\gamma_R^*)\gamma_Y^* \Delta y_t^* + \varepsilon_{MP,t}^*, \tag{37}$$

where π_t^* is foreign gross inflation, Δy_t^* is foreign output growth, and R_t^* is foreign nominal gross returns of riskless loans. The terms $\varepsilon_{AS,t}^*$, $\varepsilon_{IS,t}^*$, and $\varepsilon_{MP,t}^*$ are AS, IS, and MP i.i.d. shocks with mean zero and variances σ_{AS}^2, σ_{IS}^2, and σ_{MP}^2. This way of modeling the foreign economy is different from most of the small open economy models in the literature, for example Bao et al. (2009) that features a single world interest rate shock, and Tomura (2010) and Ng and Feng (2016) that feature a shock to terms of trade. In our opinion, the three foreign shocks in our model are more meaningful and fundamental, and can be better interpreted.

3 Empirical Results

3.1 Data Description

We use quarterly data ranging from the first quarter of 1971 to the third quarter of 2015. Note that the start and end-points of the sample are not only driven by data availability at the time of writing the paper, but also to take into account the fact that South Africa moved to a flexible exchange rate regime since 1970. The dataset includes per-capita real consumption, per-capita real business investment, per-capita real housing investment, real house price, CPI inflation rate, nominal interest rate, nominal wage inflation rates in the consumption and housing sectors, nominal exchange rate between the South African Rand and the US Dollar, as well as US real GDP, inflation, and nominal interest rate.[6] Most of the South African variables have been obtained from the the South African Reserve Bank database, the exceptions being CPI, nominal interest rate and the house price index. The first two data were sourced from International Financial Statistics database of the International Monetary Fund, with ABSA - a leading private bank of the country, providing the house price index. While, data for the US economy is obtained from the FRED database of the Federal Reserve Bank of St. Louis.

[6] A usual practice in the literature is to put measurement errors on wages. We add two i.i.d. measurement error shocks, $\varepsilon_{wc,t}$ and $\varepsilon_{wh,t}$, to the nominal wage inflation rates in the consumption and housing sectors. Both shocks have zero mean and their variances are σ_{wc}^2 and σ_{wh}^2, respectively.

3.2 Calibration

Table 1 summarizes our calibrated parameters. We calibrate the discount factor of unconstrained households $\beta_u = 0.9975$ to match the average real interest rate over the sample and set the discount factors of entrepreneurs and constrained households at $(\beta_e, \beta_c) = (0.9875, 0.96)$ so that they both have enough incentive to borrow the maximum amounts they qualify. We set the LTV ratios at $(m_e, m_c) = (0.1, 0.45)$, the steady-state value of housing preference shock at $j = 0.2$, the depreciation rates at $(\delta, \delta_{kc}, \delta_{kh}) = (0.01, 0.04, 0.04)$, and the production function parameters at $(\mu_c, \mu_h, \mu_b, \mu_l) = (0.3, 0.1, 0.1, 0.1)$. The openness index parameter α is set to 30% to match the share of South African imports in GDP. We choose a widely used value 1.15 for the price and wage markups X, X_{wc}, and X_{wh}. These values, together with the estimated parameters, help pin down the steady-state loan-to-GDP ratios for constrained households and entrepreneurs.

Table 1: Calibrated Parameters

Parameter	Value	Parameter	Value	Parameter	Value
β	0.9875	μ_l	0.10	m_e	0.10
β'	0.9975	j	0.20	m_c	0.45
β''	0.96	δ	0.01	X	1.15
μ_c	0.30	δ_{kc}	0.04	X_{wc}	1.15
μ_h	0.10	δ_{kh}	0.04	X_{wh}	1.15
μ_b	0.10	α	0.30		

3.3 Estimation

The left panels of Tables 2 and 3 present the prior distributions of structural parameters and shock processes. Overall, they are broadly consistent with previous studies, e.g., Lubik and Schorfheide (2004), Iacoviello and Neri (2010), and Baele et al. (2015).

Table 2: Prior and Posterior Distribution of the Structural Parameters

Parameter	Prior Distribution			Posterior Distribution			
	Distribution	Mean	SD	Mean	5%	Median	95%
ϵ_e	Beta	0.500	0.075	0.5060	0.3517	0.4952	0.6674
ϵ_u	Beta	0.500	0.075	0.4425	0.3167	0.4396	0.5665
ϵ_c	Beta	0.500	0.075	0.5773	0.4235	0.5795	0.7676
η_u	Gamma	0.500	0.100	0.5040	0.3363	0.4990	0.6604
η_c	Gamma	0.500	0.100	0.5007	0.3198	0.4917	0.6913
ξ_u	Normal	1.000	0.100	0.5635	0.3874	0.5531	0.7310
ξ_c	Normal	1.000	0.100	0.9353	0.7673	0.9319	1.1090
ω	Beta	0.650	0.050	0.7349	0.6619	0.7380	0.7969
θ_π	Beta	0.667	0.050	0.7366	0.6895	0.7384	0.7771
θ_{wc}	Beta	0.667	0.050	0.8747	0.8492	0.8752	0.9037
θ_{wh}	Beta	0.667	0.050	0.7893	0.7215	0.7931	0.8552
ι_π	Beta	0.500	0.200	0.0662	0.0092	0.0583	0.1248
ι_{wc}	Beta	0.500	0.200	0.1301	0.0261	0.1180	0.2304
ι_{wh}	Beta	0.500	0.200	0.1824	0.0430	0.1770	0.3045
ϕ_{kc}	Gamma	10.000	2.500	7.1837	4.5163	7.1200	9.9559
ϕ_{kh}	Gamma	10.000	2.500	9.2792	5.3039	8.9727	12.8815
γ_R	Beta	0.750	0.100	0.6568	0.6099	0.6573	0.7085
γ_Y	Normal	0.000	0.100	0.3813	0.2860	0.3854	0.4891
γ_Q	Normal	0.000	0.100	0.5836	0.4461	0.5738	0.7097
γ_π	Normal	1.500	0.100	1.3787	1.2840	1.3800	1.4868
δ	Beta	0.400	0.100	0.0898	0.0445	0.0882	0.1339
κ	Normal	0.100	0.100	0.2231	0.1268	0.2220	0.3070
μ	Beta	0.700	0.100	0.9007	0.8570	0.9020	0.9579
ϕ	Normal	0.100	0.100	0.0282	0.0036	0.0252	0.0554
γ_R^*	Beta	0.750	0.100	0.8353	0.7721	0.8363	0.9060
γ_Y^*	Normal	0.000	0.100	0.0989	0.0007	0.0847	0.1989
γ_π^*	Normal	1.500	0.100	1.5095	1.3521	1.5107	1.6515

The posterior distributions are presented in the right panels. The labor income share of credit-unconstrained households ω is estimated to be 73.49%. This value implies that about one fourth of South African households are subject to a collateral constraint. The domestic monetary policy parameter estimates suggest that nominal interest rate is considerably persistent and it actively responds to inflation. The response of interest rate to GDP growth is also considerably significant. More interestingly, the domestic monetary policy is found to be reacting to house price growth too, while this reaction cannot be detected in the US monetary policy (see Sun and Tsang (2014)). Foreign interest rate is relatively more persistent and more responsive to inflation but less responsive to GDP growth.[7] All AR(1) shock processes are highly persistent.

[7]The US nominal interest rate has been around the zero lower bound since the last quarter of 2008, hence the simple

Table 3: Prior and Posterior Distribution of the Shock Processes

	Prior Distribution			Posterior Distribution			
Parameter	Distribution	Mean	SD	Mean	5%	Median	95%
ρ_c	Beta	0.800	0.100	0.9678	0.9445	0.9702	0.9925
ρ_h	Beta	0.800	0.100	0.9915	0.9841	0.9927	0.9990
ρ_k	Beta	0.800	0.100	0.9510	0.8927	0.9635	0.9969
ρ_j	Beta	0.800	0.100	0.9674	0.9512	0.9678	0.9865
ρ_τ	Beta	0.800	0.100	0.8387	0.7460	0.8442	0.9527
ρ_z	Beta	0.800	0.100	0.9076	0.8630	0.9122	0.9418
ρ_{rp}	Beta	0.800	0.100	0.8554	0.7697	0.8579	0.9487
σ_c	Inv. Gamma	0.100	2.000	0.0282	0.0246	0.0281	0.0315
σ_h	Inv. Gamma	0.100	2.000	0.0237	0.0215	0.0236	0.0260
σ_k	Inv. Gamma	0.100	2.000	0.0166	0.0134	0.0164	0.0194
σ_j	Inv. Gamma	0.100	2.000	0.0838	0.0617	0.0830	0.1040
σ_τ	Inv. Gamma	0.100	2.000	0.0373	0.0253	0.0371	0.0490
σ_z	Inv. Gamma	0.100	2.000	0.0325	0.0264	0.0324	0.0378
σ_r	Inv. Gamma	0.100	2.000	0.0096	0.0085	0.0095	0.0108
σ_π	Inv. Gamma	0.100	2.000	0.0339	0.0296	0.0338	0.0379
σ_{AS}	Inv. Gamma	0.100	2.000	0.0080	0.0072	0.0080	0.0086
σ_{IS}	Inv. Gamma	0.100	2.000	0.0094	0.0083	0.0094	0.0103
σ_{MP}	Inv. Gamma	0.100	2.000	0.0064	0.0058	0.0064	0.0069
σ_{rp}	Inv. Gamma	0.100	2.000	0.0251	0.0199	0.0250	0.0302
σ_{wc}	Inv. Gamma	0.100	2.000	0.0106	0.0094	0.0106	0.0116
σ_{wh}	Inv. Gamma	0.100	2.000	0.0166	0.0147	0.0164	0.0186
σ_{de}	Inv. Gamma	0.100	2.000	0.0561	0.0492	0.0561	0.0623

3.4 Business Cycle Properties

In order to evaluate the performance of our estimated DSGE model in capturing the business cycle properties of data series, we simulate the model 1,000 times and compare the standard deviations, cross correlation coefficients, and autocorrelation coefficients of key variables with those of the true data series. As Table 4 shows, our estimated model explains well the behavior of housing and non-housing variables. All of the model's business cycle statistics lie within the 95 percent probability interval computed from the data. The model replicates well the joint behavior of the components of aggregate demand, the cyclicality and volatility of house prices, and the patterns of comovement between key variables and real output.

Taylor rule estimation might not be accurate. However, the US economy is not of the primary interest of this paper.

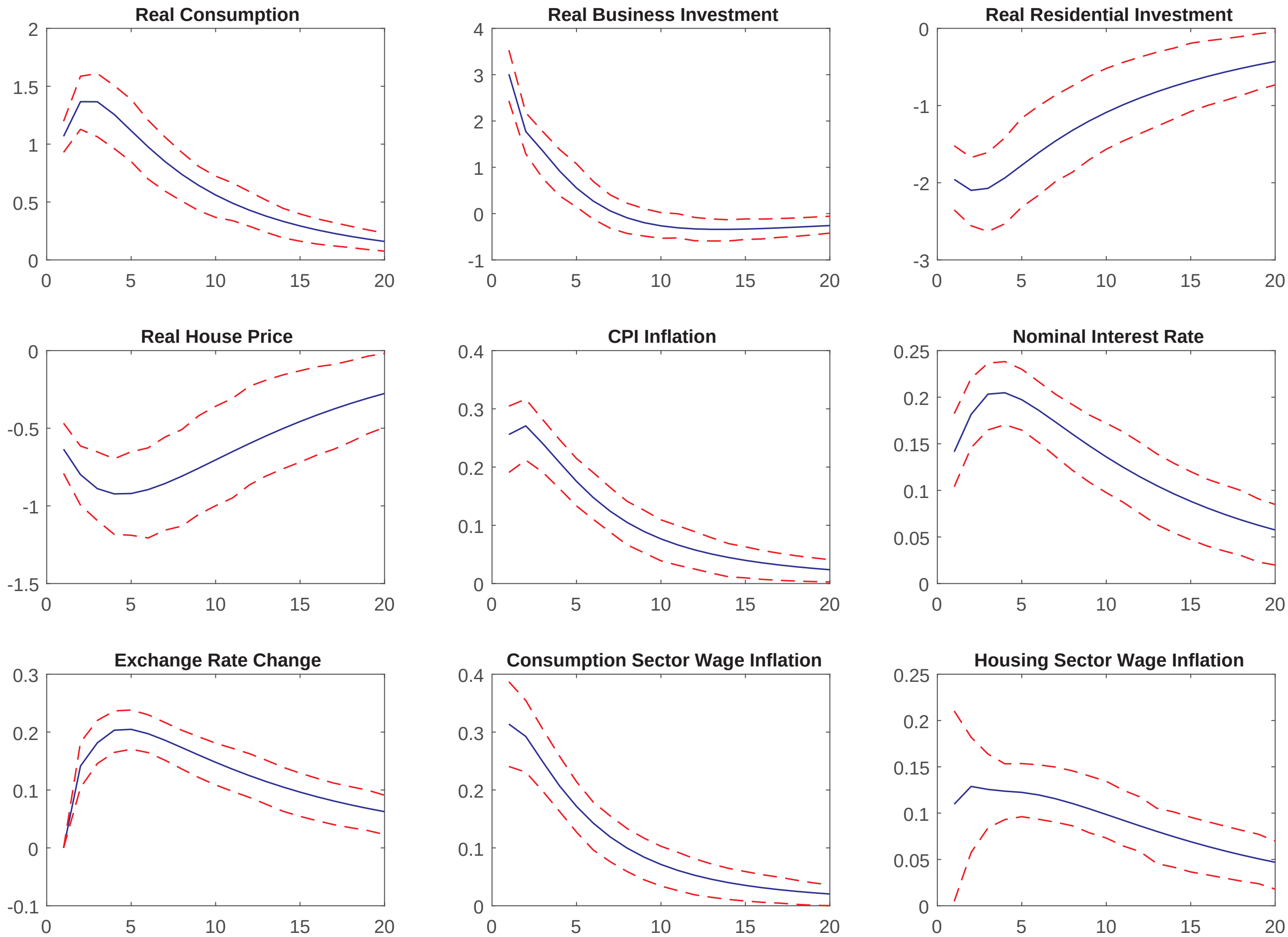
Table 4: Business Cycle Properties of the Model

Variable	Data	Model: Median	Model: 95% Probability Interval
A: Standard Deviations (percent)			
Real Consumption	10.0865	11.9989	[6.3521, 18.4658]
Real Business Investment	24.5764	25.2140	[18.5257, 33.0807]
Real Residential Investment	28.6238	29.1089	[20.2917, 39.9189]
Real House Price	34.5829	34.4807	[25.1373, 43.9235]
Real GDP	14.1577	15.1824	[9.3790, 21.7456]
CPI Inflation	1.3234	1.5397	[1.2819, 1.8563]
Nominal Interest Rate	1.1597	1.1099	[0.7448, 1.5655]
B: Correlation Coefficients with Real GDP			
Real Consumption	0.9750	0.9684	[0.8516, 0.9892]
Real Business Investment	0.9506	0.9571	[0.8986, 0.9791]
Real Residential Investment	0.8505	0.7608	[0.3957, 0.9047]
Real House Price	0.9274	0.8937	[0.6982, 0.9601]
C: Autocorrelation Coefficients			
Real Consumption	0.9905	0.9913	[0.9689, 0.9962]
Real Business Investment	0.9592	0.9504	[0.9073, 0.9718]
Real Residential Investment	0.9863	0.9806	[0.9600, 0.9899]
Real House Price	0.9961	0.9963	[0.9934, 0.9975]
Real GDP	0.9912	0.9906	[0.9760, 0.9952]

3.5 Impulse Response Analysis

We plot the impulses of nine domestic observables – real consumption, real business investment, real residential investment, real house price, CPI inflation, nominal interest rate, exchange rate change, and wage inflations in the consumption and the housing sectors – to the intertemporal preference, housing preference, housing technology, and monetary policy shocks as wells as foreign monetary policy shock.

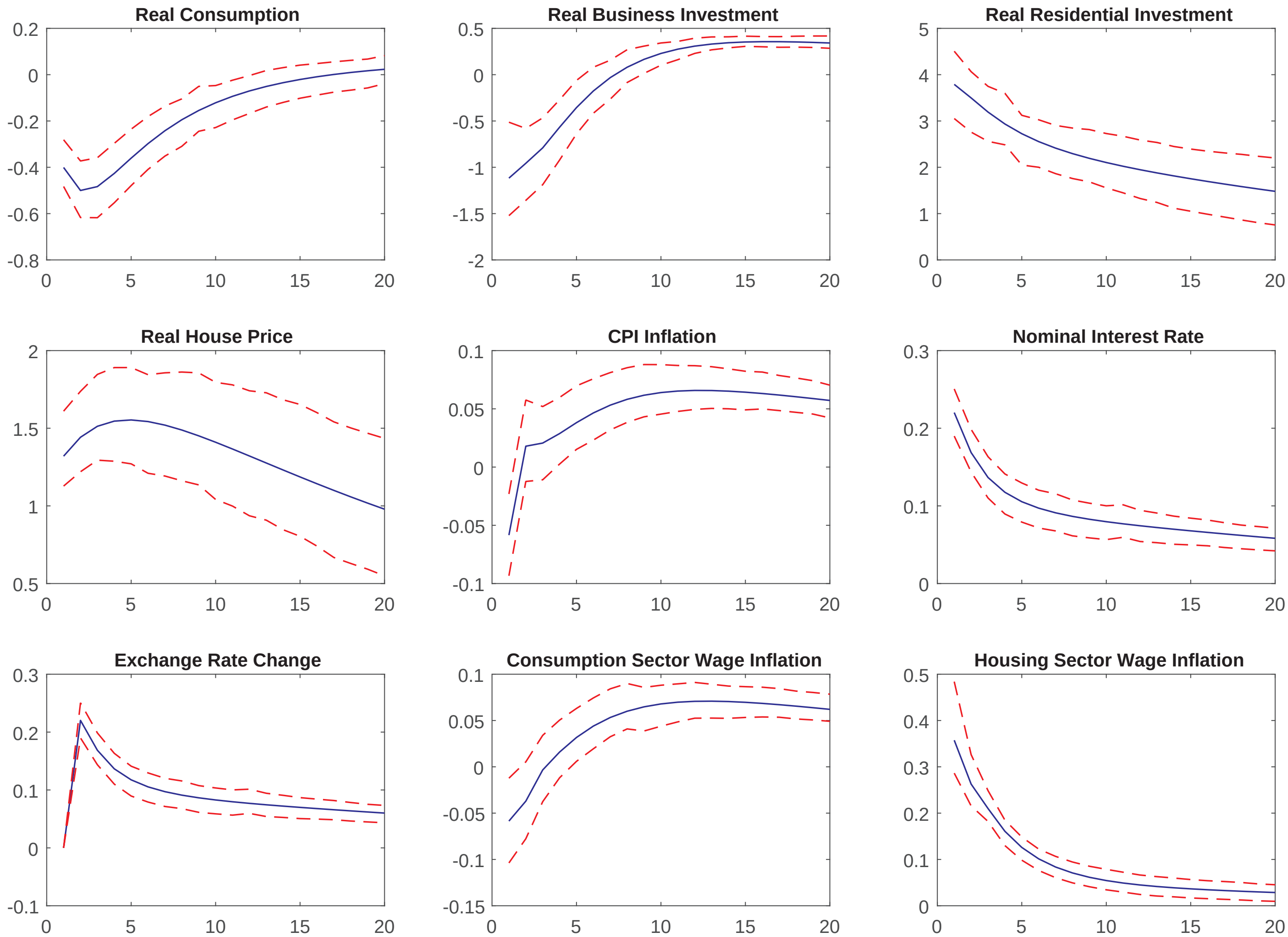
Figure 1 shows that the intertemporal preference shock plays an important role in domestic economy. When economic agents become less patient, they increase current consumption. Entrepreneurs invest more in the consumption sector but less in the housing sector. Real house price drops but CPI inflation rises. The central bank responds to the rise in CPI inflation by raising nominal interest rate. According to the UIP, domestic currency is expected to depreciate and the exchange rate increases since the next period.



Note: The y-axis measures the percent deviation from the steady state.

Figure 1: Impulse Responses to a One Standard-Error Intertemporal Preference Shock

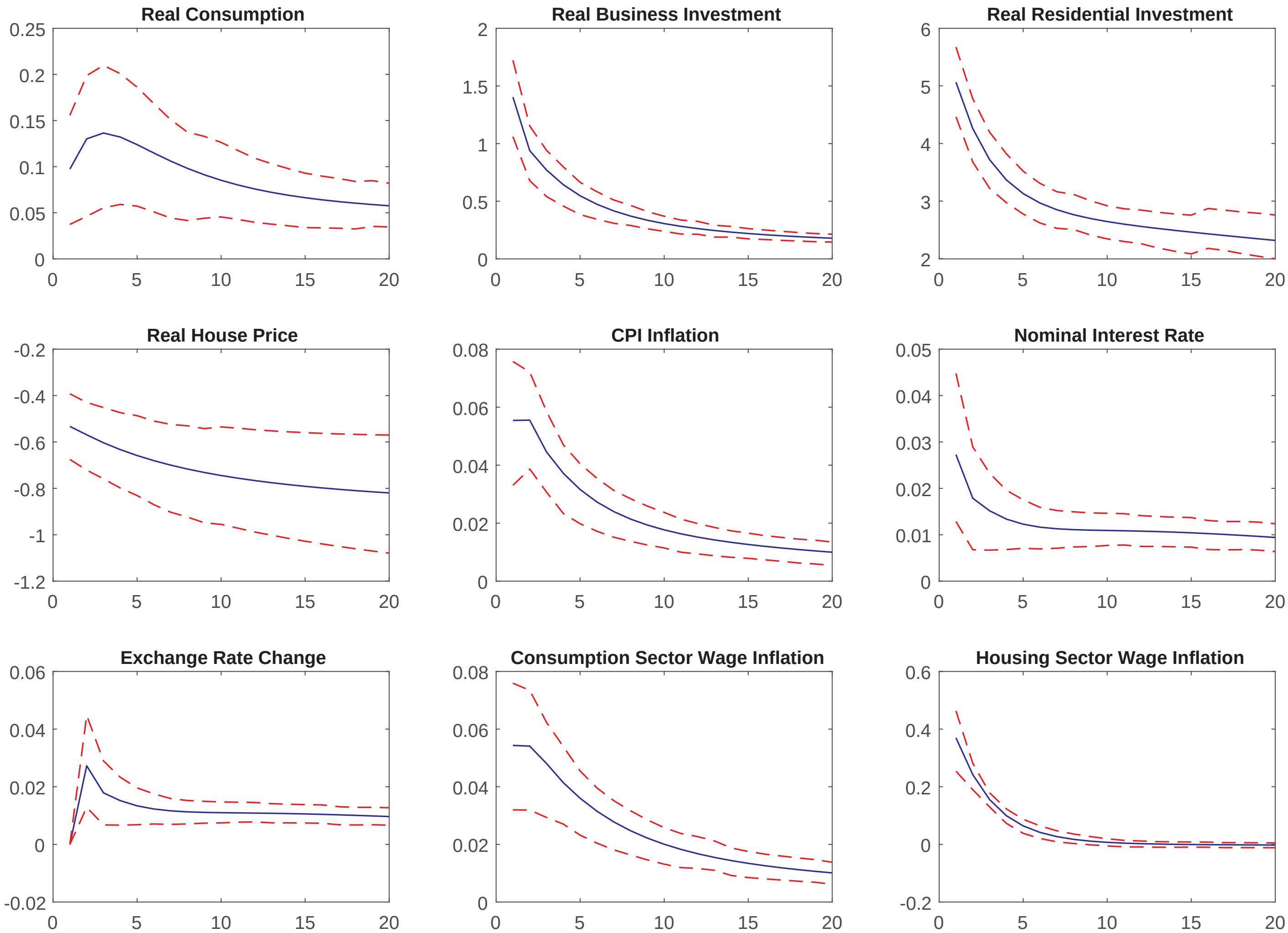
Figure 2 depicts the impulse responses to the housing preference shock which has a significant impact on housing investment and real house price. When households have a stronger preference over housing relative to consumption, they choose to consume less and hence real consumption decreases. Therefore investment in the consumption sector also goes down. The impact on CPI inflation is limited. The central bank slightly raises nominal interest rate as a response to house price growth. Domestic currency starts to depreciate since one period later. While the housing preference shock heavily influences the wage inflation in the housing sector, it does not affect consumption sector wage inflation much.



Note: The y-axis measures the percent deviation from the steady state.

Figure 2: Impulse Responses to a One Standard-Error Housing Preference Shock

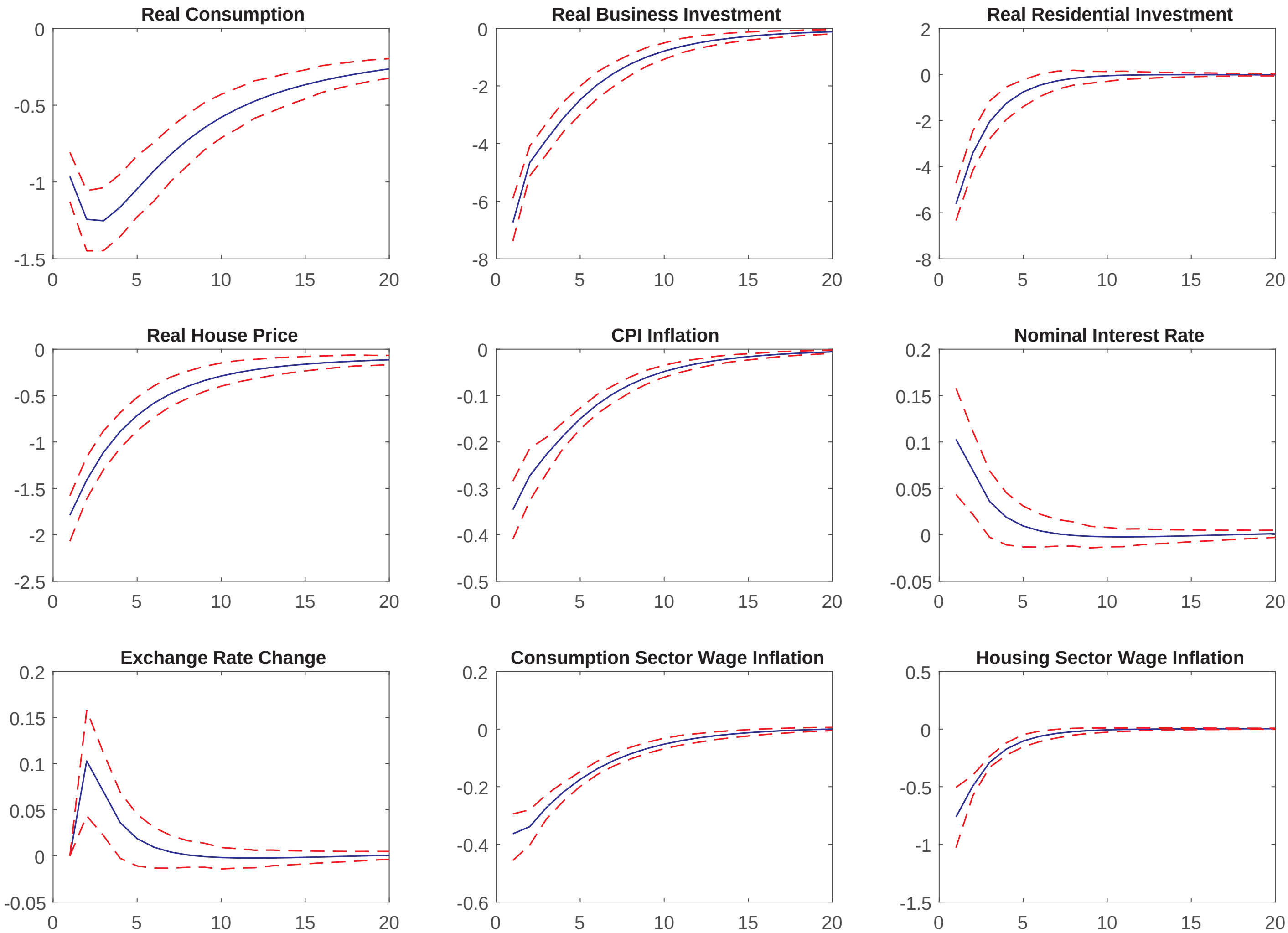
As shown in Figure 3, the housing technology shock stimulates entrepreneurs' investment in the housing market and brings real house price down for a long time though the drop in house price is only mild. The impact of the housing technology shock on consumption and CPI inflation is limited. The central bank is supposed to adjust nominal interest rate in two directions as a response to the increase in all components of domestic aggregate demand and the decrease in real house price. The net effect is positive but almost negligible. Domestic currency slightly depreciates since one period later. While the housing technology shock does not affect wage inflation in the consumption sector, its impact on housing sector wage inflation is significant. The spillover result based on the impulse response analysis is in line with the atheoretical literature on South Africa discussed in the introduction.



Note: The y-axis measures the percent deviation from the steady state.

Figure 3: Impulse Responses to a One Standard-Error Housing Technology Shock

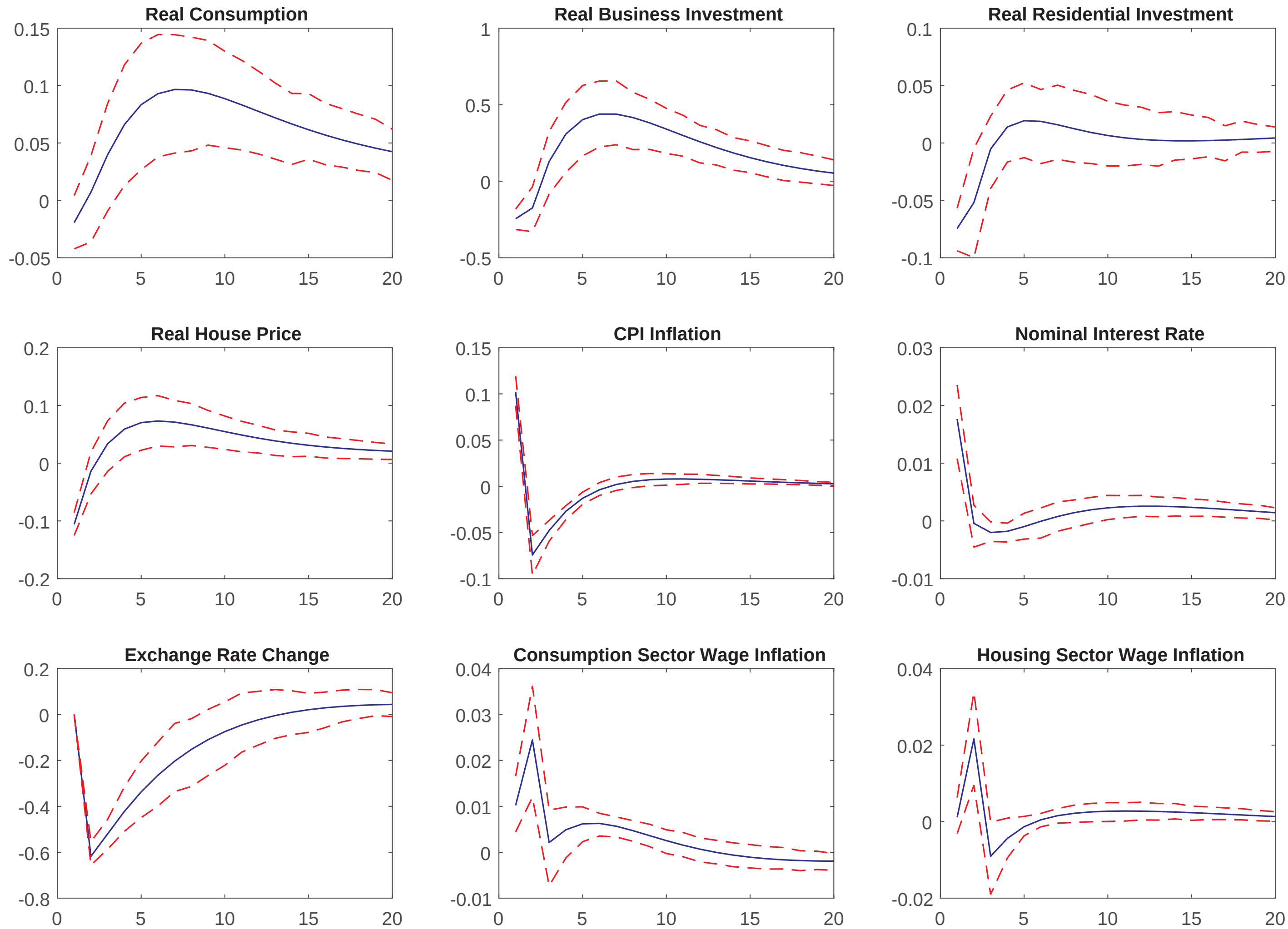
Figure 4 indicates that the monetary policy shock affects the real economy to a large extent. Following a contractionary monetary policy shock, both business investment and housing investment drop by more than 5%, real consumption drops by almost 1%. The impact on business and housing investment diminishes within a year and the impact on consumption lasts longer. CPI inflation decreases, so does wage inflation in both sectors. Due to the higher gross return, domestic currency is expected to depreciate since the next period. The negative impact on house prices following a monetary policy shock is in line with the VAR literature (see for example Gupta et al. (2010), Ndahiriwe and Gupta (2010), Simo-Kengne et al. (2013b), and Simo-Kengne et al. (2014)).



Note: The y-axis measures the percent deviation from the steady state.

Figure 4: Impulse Responses to a One Standard-Error Monetary Policy Shock

Figure 5 shows the impact of the foreign monetary policy shock on the domestic economy. Overall, the impact is limited. When foreign goods become more expensive, domestic consumers reduce their consumption. While all components of aggregate demand shrink, CPI inflation increases due to the higher price of imported goods. The central bank slightly raises nominal interest rate as a response to CPI inflation. However, since foreign interest rate increases dramatically after a monetary policy shock, domestic currency starts to appreciate since one period later.

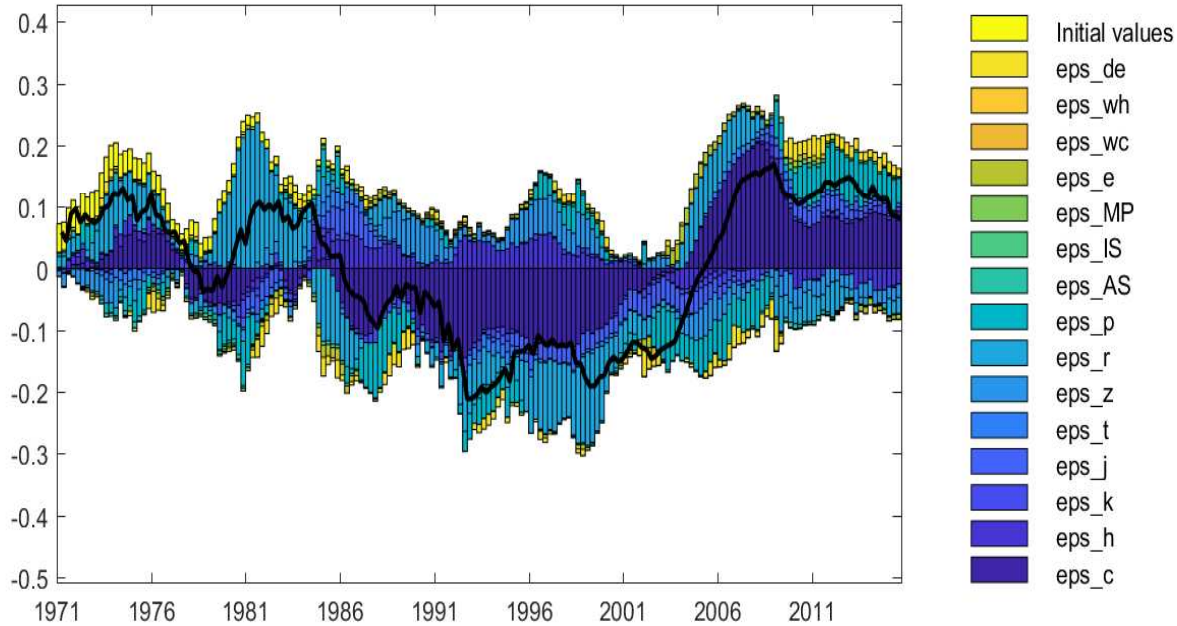


Note: The y-axis measures the percent deviation from the steady state.

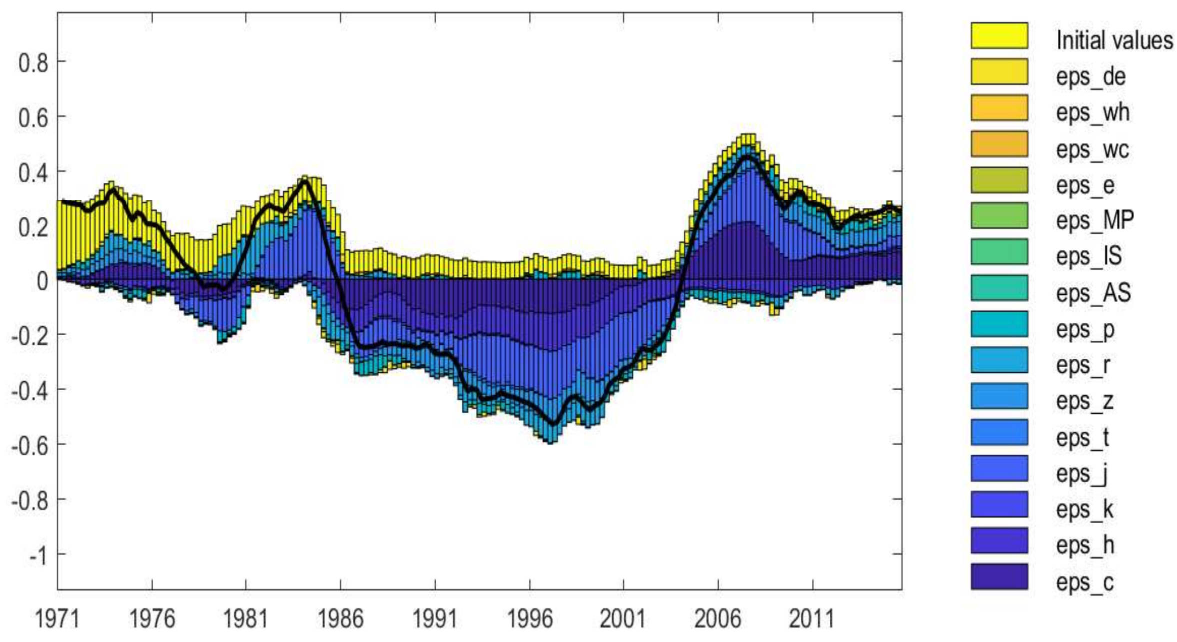
Figure 5: Impulse Responses to a One Standard-Error Foreign Monetary Policy Shock

3.6 What Shocks Drive the Macroeconomy and the Housing Market?

To understand the relative importance of structural shocks in explaining the dynamics of the macroeconomy and the housing market fluctuations, we conduct a historical shock decomposition for real GDP and real house price in Figure 6. Since consumption accounts for the majority of aggregate demand, the technology shock in the consumption sector (ε_c) becomes the leading driving force of the dynamics of real GDP. The monetary policy shock (ε_r) also contributes significantly around 1980 and in the second half of the 1990s. Most of the fluctuations of house price are driven by the housing preference shock (ε_j) and the technology shock in the consumption sector (ε_c). The monetary policy shock (ε_r) and the technology shock in the housing sector (ε_h) also contribute to house price fluctuations, but to a lesser extent.



(a) Real GDP



(b) Real House Price

Note: The solid lines plot model variables, expressed in percentage deviation from their steady-state values. The bars show the contributions of the estimated structural shocks.

Figure 6: Historical Decomposition of Key Variables

The historical shock decomposition suggests that foreign shocks, including aggregate supply, aggregate demand, and monetary policy shocks, are not important in explaining the dynamics of real output or real house price in South Africa, which goes against the findings of Bao et al. (2009), Tomura (2010), and Ng and Feng (2016). Most of the small open economies considered in these abovementioned articles have a fixed exchange rate, for example Hong Kong, Singapore, Denmark, and Ireland. In a fixed exchange rate environment, foreign monetary policy shocks tend to cause changes in domestic interest rate. In Hong Kong that implements a linked exchange rate system, it is even more straightforward to expect the domestic economy to actively respond to foreign shocks. While Ng and Feng (2016) also consider economies with a floating exchange rate regime, foreign shocks have a considerably smaller contribution in those economies. We believe that the minor contribution of foreign shocks is partly due to the flexible exchange rate regime adopted by South Africa since 1970. In the next section, we conduct a counterfactual analysis to examine what would have happened if South Africa had adopted a fixed exchange rate policy over the sample period. We find that the overall volatility of the South African economy would have been much higher under a fixed exchange rate policy regime. In fact, the foreign shocks would have contributed much more to the business cycle fluctuations as well in that case.

4 Economic Implications

4.1 Spillover Effects of the Housing Market

To quantify the spillover effects of the housing market to the broader economy, we run a bivariate regression of the percentage change in consumption on the lag percentage change in housing wealth (both data series are generated from the estimated model):

$$\Delta \ln C_t = \beta_0 + \beta_1 \Delta \ln HW_{t-1} + \varepsilon_t, \tag{38}$$

where $HW_t = q_t(h_{u,t} + h_{c,t})$. The coefficient β_1 measures the elasticity of consumption to housing wealth. It provides a raw estimate of the direct and indirect effects of housing wealth on consumption, while the true relationship is in fact determined by the structural model presented in Section 2. The spillover effects are reinforced by the degree of financial frictions, which depends on the LTV ratio (m_c). We report the regression result for the baseline model in the first column of Table 5 and then we simulate a counterfactual model in the absence of collateral effects (by setting m_c to zero) and report the same regression result in the second column.

Table 5: Spillover Effects of the Housing Market

	(1) Baseline	(2) No Collateral Effects
Constant	0.0004	0.0003
	(0.0009)	(0.0009)
$\Delta \ln HW_{t-1}$	0.1911	0.1657
	(0.0321)	(0.0315)

Note: Standard errors are in parentheses.

The results in Table 5 suggest that the structural shocks in the model generate a positive correlation between consumption and previous period housing wealth even without collateral effects. A one percent increase in previous period housing wealth leads to about a 0.17% increase in consumption. In the presence of collateral effects, however, the positive correlation becomes even stronger. The comparison between columns (1) and (2) indicates that collateral effects strengthen the elasticity of consumption to housing wealth by 2.54 percentage points.

4.2 Understanding the Housing Preference Shock

As demonstrated in the last section, the housing preference shock accounts for a large fraction of housing market fluctuations. However, what does the housing preference shock measure? On the one hand, the housing preference shock might represent genuine shifts in tastes for housing. On the other hand, the shock could be a measure of the inability of the DSGE model to fit the data well. In order to address this concern, we conduct a standard multivariate time-series analysis. We choose a set of factors, denoted $\mathbf{x}$, that potentially change consumer tastes and investigate the following specification:

$$\varepsilon_{j,t} = \theta \varepsilon_{j,t-1} + \mathbf{x}'_{t-1}\beta + \nu_{j,t}, \tag{39}$$

where θ is the autoregressive parameter of the housing preference shock, β is the vector of coefficients of potential explanatory variables, and $\nu_{j,t}$ is a mean zero i.i.d. error term.

The selected explanatory variables include population (in millions), real disposable income (in trillions of South African rand), real interest rate, and inflation rate.[8] The estimation results are presented in Table 6. Besides the lag of housing preference shock, only interest rate is significant in the regressions with one single regressor beyond the lag dependent variable. In our preferred specification presented in column (5), all regressors are significant and some of them have the expected sign. The preference shock depends positively on population and negatively on interest rate. It also depends negatively on inflation, which goes against the idea of inflation illusion. The overall explanatory power of the regressors is relatively high; the adjusted R^2 is about 52 percent. However, this is mostly driven by the persistence of the housing preference shock. The joint contribution of population, income, interest rate, and inflation is limited. The results imply deviations from the i.i.d. assumption on the structural shocks, which further imply the mis-specification of, for example, the cross-equation restrictions embedded in the DSGE model.

Table 6: Predictability of the Housing Preference Shock

	(1)	(2)	(3)	(4)	(5)
Lag of preference shock	0.6762***	0.6743***	0.7061***	0.6890***	0.7344***
	(0.0557)	(0.0558)	(0.0541)	(0.0569)	(0.0550)
Lag of population	0.0002				0.0067***
	(0.0005)				(0.0021)
Lag of income		0.0054			-0.1300***
		(0.0103)			(0.0457)
Lag of interest rate			-1.1699***		-2.7821***
			(0.3149)		(0.5399)
Lag of inflation				0.3521	-1.3551**
				(0.3728)	(0.5527)
N	178	178	178	178	178
adj. R^2	0.453	0.453	0.492	0.455	0.524

Note: Standard errors are in parentheses. Constants are not reported. * (p<0.10), ** (p<0.05), *** (p<0.01).

[8]The main determinants of household preferences are demographics. While Iacoviello and Neri (2010) use the share of population between ages 25 and 39, we use the total population instead because there is no such a measure of population by age groups in South Africa.

4.3 Welfare Analysis under Fixed Exchange Rate Policy

As we mentioned in the data section, South Africa moved to a flexible exchange rate regime since 1970. Given the estimated structural shocks, we conduct a counterfactual analysis to examine what would have happened if South Africa had adopted a fixed exchange rate policy over the entire sample period.[9] We assume that the risk premium shock does not play a role in the UIP so that South Africa simply follows the US monetary policy. As Figure 7 shows, consumption, business investment, and housing investment would have been higher during the two crises around 1982 and 2008 when the US central bank significantly lowered nominal interest rate to fight against the economic downturn. Real house price would have not been affected much. An apparent difference is that the South African economy would have been much more volatile if the country had given up using its own monetary policy but simply adopted a fixed exchange rate policy. Next, we move a step further to see how social welfare would have been affected by the fixed exchange rate policy.

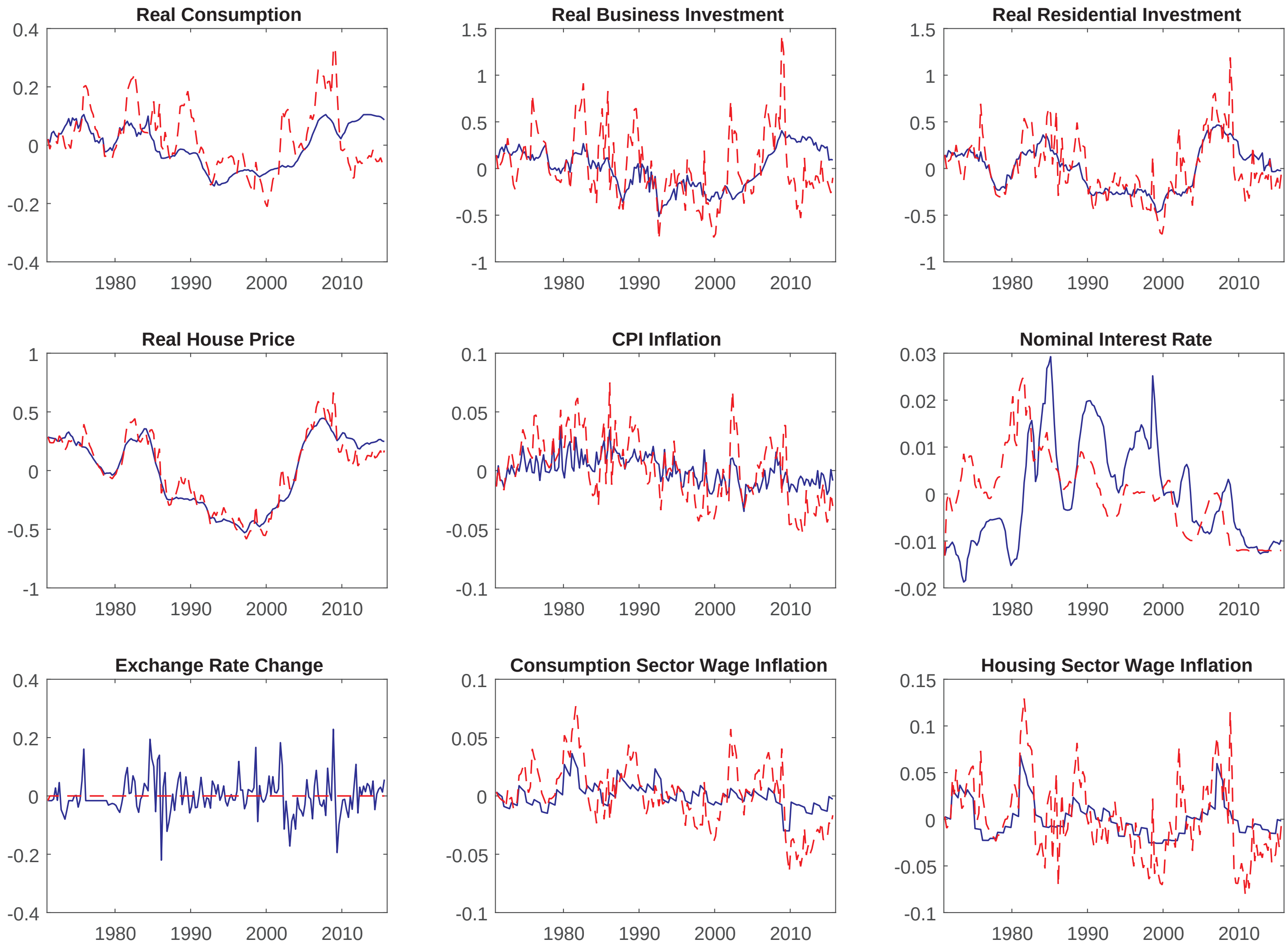
We use an ordinary loss criterion (a weighted variability of money inflation and output growth) as in Giannoni and Woodford (2003) to measure social welfare from the stabilization point of view:

$$\mathfrak{L} = var(\ln \pi_t - \iota_\pi \ln \pi_{t-1}) + \lambda_y var(\ln GDP_t - \ln GDP_{t-1}), \tag{40}$$

where λ_y is suggested to be 0.048.

According to this criterion, the loss in the baseline model case is $1.54 * 10^{-4}$ and this value under a fixed exchange rate policy increases to $11.41 * 10^{-4}$. Such a comparison suggests that the overall economic stability of South Africa would have been worsen more than seven times if a fixed exchange rate policy had been adopted.

[9]For detailed expositions of stock and housing market spillovers in estimated DSGE models for the small open economy of Hong Kong operating under a fixed exchange rate regime, please refer to Funke and Paetz (2013) and Funke et al. (2011) respectively.



Note: The solid lines are observed data series and the dashed lines are counterfactual series under fixed exchange rate.

Figure 7: Counterfactual Analysis under Fixed Exchange Rate

5 Conclusion

The impact of house price on the real economy of South Africa has been quite extensively analyzed. Related to this, there are also studies that have looked into the role of monetary policy on the housing markets and, in turn, have also asked whether house price movements are accounted for by the SARB when formulating its monetary policy stance. However, this literature is based primarily on atheoretical small-scale models which are likely to suffer from misspecification due to omitted variable bias, making their results unreliable, over and above the fact, that these models are not immune to the Lucas (1976) critique. Given this, our paper estimates a small-open economy new Keynesian dynamic stochastic general equilibrium model (SOE-NKDSGE) with an explicit housing sector, in attempt to validate or invalidate the claims made by the existing econometric regression-based methods. Using quarterly data covering the period of 1971:Q1-2015:Q3, we draw the following inferences: (a) Over the business cycle, the housing preference shock and the technology shock in the consumption sector drive most of the fluctuations of real house price; (b) The spillover effects of the housing market to the boarder economy are not negligible; (c) The central bank of South Africa has actively responded to house price movements over the past 45 years; and (d) The flexible exchange rate policy has helped South Africa maintain the macroeconomic stability to a large extent. While findings (a) and (b) are not novel, (c) and (d) are of interest and suggest that the pro-active monetary policy and the flexible exchange rate policy help stabilize the housing market and the aggregate economy in South Africa.

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