A DSGE-Based Assessment of Nonlinear Loan-to-Value Policies: Evidence from Hong Kong

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Outline

Motivation

Macroprudential Policies

"Leaning Against the Wind" or "Waiting on the Sideline"?

- The recent financial crisis raised the interest in the impact of housing price and credit cycles on the real business cycle (see IMF (2009)).
- Pro-Activists warrant the central banker to raise interest rates when there is a build-up of financial imbalances.
- Doctrine of benign neglect: The the negative side effects of pre-emptive policies could potentially exceed the benefits in terms of recessions and unemployment. Moreover, identifying non-fundamental movements in asset prices is very difficult.

$\Rightarrow$ We possibly need additional macroprudential policy tools like for example the loan-to-value (LTV) ratio (see Bank of England (2009)).

Motivation

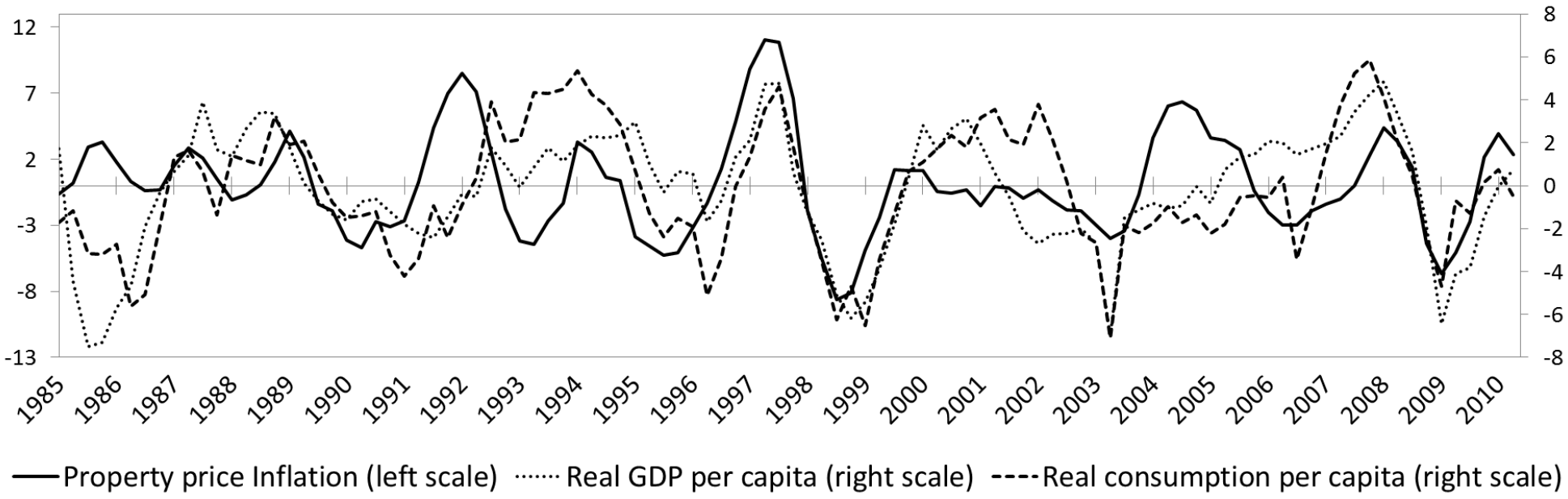
Housing Wealth Effects in Hong Kong

Housing Prices and the Business Cycle in Hong Kong

- Hong Kong has one of the world's longest-standing currency board arrangements. Hence, the central bank cannot react on asset price misalignments by increasing interest rates.
- Hong Kong observed large swings in housing prices over the last decades. Many studies find impact of property prices on the business cycle (Gan (2010), Gerlach and Peng (2005), Funke and Paetz (2011)).
- Mandatory maximum loan-to-value (LTV) ratios are a familiar stabilisation tool in Hong Kong, which has been used very often.
- The Hong Kong Monetary Authority (HKMA) has a very limited set of tools for pursuing monetary policy. In particular, Hong Kong's interbank market interest rates fluctuate within the band of the transaction costs of engaging in the US.

Motivation

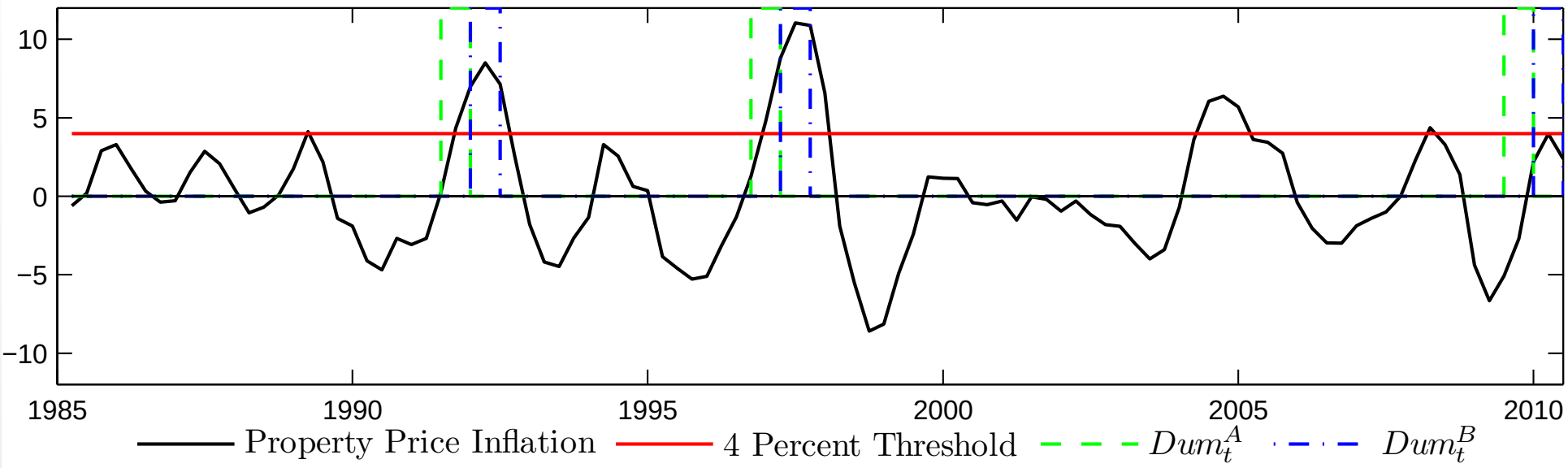
Hong Kong's Residential Property Prices at Business Cycle Frequencies



- ⇒ Ahead of the Asian financial crisis, property prices have increased by 65 percent between 1995Q4 and 1997Q3, and plummeted by 36 percent the year after. Prices fell until 2003Q3 about 65 percent.
- ⇒ From then on property prices increased strongly again (except for 2006), but fell in 2008 due to the recent financial crisis.
- ⇒ Strong co-movement between GDP, consumption and property prices, although house prices are much more volatile.

Motivation

Historical LTV Policies in Hong Kong



⇒ Several changes in the LTV ratio.

⇒ Non-linear interventions.

Motivation

Hong Kong's LTV Ratio

Changes in Hong Kong's Mandatory LTV Limits

- Prior to 1996, a 70% LTV limit was introduced to guard against overexposure to the property market.
- In light of the Asian financial crisis, the HKMA issued guidelines to adopt a 60% maximum LTV ratio for luxury properties.
- In October 2001, the HKMA restored the 70% maximum LTV ratio.
- Recent changes in 2010:
  - The maximum LTV ratio for properties with a value of at least HKD 12 million was lowered from 60% to 50%.
  - The maximum LTV ratio for residential properties with a value between HKD 8 million and HKD 12 million was reduced from 70% to 60%.
  - Regardless of market value, the maximum LTV ratio for all non-owner-occupied residential properties was reduced to 50%.

Motivation

Our Contribution

- Introduction of non-linear LTV policies in a DSGE model.
- Evaluation of these policies in a model calibrated for Hong Kong (the calibration follows the estimation of Funke and Paetz (2011)).
- We calibrate LTV policies assuming that the central bank reacts only after housing price inflation exceeds a set threshold. This policy rule allows the central bank to pursue a middle-of-the-road approach that is less aggressive than the above-mentioned "lean against the wind" approach, but more active than the "wait and clean up afterwards" approach.

The Model

A Small Open Economy with a Housing Sector

A Brief Sketch

- A symmetric two-agent, two-sector, open-economy framework with a Calvo sticky price setup in each sector.
- Final goods producers use domestic intermediate goods to produce residential and non-residential goods, which are sold internationally.
- Households are divided into borrowers and savers (as in Kiyotaki and Moore (1997)), where borrowers face a binding collateral constrained. Durables can be used as collateral in the mortgage market.
- We assume that savers trade bonds internationally, implying an international risk sharing condition.
- Monetary policy is described by a fixed exchange rate regime.
- LTV ratios are increased, when the property price inflation passes a threshold value.

The Model

Notation of Most Important Variables and Parameters

Variables

$$X_t \equiv \left(\tilde{C}_t\right)^{\left(1-\gamma\mathcal{E}_t^D\right)} \left(D_t\right)^{\gamma\mathcal{E}_t^D} :$$ Composite consumption index

$$\tilde{C}_t \equiv C_t - h_c C_{t-1} :$$ Habit adjusted consumption

$$D_t :$$ Durables (housing)

$$B_{H,t}^b :$$ Borrower's debt (mortgage backed securities)

$$B_{H,t}^s :$$ Savings of patient households

$$P_D, P_C, P_{D,C} :$$ Prices for durable and consumption goods, and relative price

Parameters

γ : Welfare relevant share of durables in the composite consumption index

ω : Share of borrowers

ζ : Share of housing in aggregate production

The Model
Households

Borrowers

$$\max E_0 \sum_{t=0}^{\infty} \beta_b^t \left[\frac{1}{1-\sigma} \left(X_t^b \right)^{1-\sigma} - \frac{1}{1+\varphi} (N_{C,t}^b)^{1+\varphi} - \frac{1}{1+\varphi} (N_{D,t}^b)^{1+\varphi} \right],$$

subject to

$$C_t^b + P_{D/C,t} I_{D,t}^b - B_{H,t}^b = -R_{t-1} \frac{B_{H,t-1}^b}{\Pi_{C,t}} + \sum_{j=C,D} \frac{W_{j,t}^b N_{j,t}^b}{P_{C,t}},$$

$$R_t B_{H,t}^b \leq (1-\chi)(1-\delta) E_t \left[P_{D/C,t+1} D_t^b \Pi_{C,t+1} \right] LTV_t,$$

$$I_{D,t}^b \equiv D_t^b - (1-\delta) D_{t-1}^b.$$

where LTV_t represents the LTV ratio.

The Model
Households

Borrowers' FOCs

$$\frac{W_{j,t}^b}{P_{C,t}} = \frac{\left(X_t^b\right)^{\sigma}\left(N_{j,t}^b\right)^{\varphi}\left(\tilde{C}_t^b\right)^{\gamma\mathcal{E}_t^D}}{\left(1-\gamma\mathcal{E}_t^D\right)\left(D_t^b\right)^{\gamma\mathcal{E}_t^D}}, j = C, D,$$

$$P_{D/C,t} = \beta_b(1-\delta)E_t\left[\left(\frac{1-\gamma\mathcal{E}_{t+1}^D}{1-\gamma\mathcal{E}_t^D}\right)\left(\frac{X_{t+1}^b}{X_t^b}\right)^{-\sigma}\left(\frac{D_{t+1}^b}{\tilde{C}_{t+1}^b}\right)^{\gamma\mathcal{E}_{t+1}^D}\left(\frac{\tilde{C}_t^b}{D_t^b}\right)^{\gamma\mathcal{E}_t^D}P_{D/C,t+1}\right]$$
$$+\left(\frac{\gamma\mathcal{E}_t^D}{1-\gamma\mathcal{E}_t^D}\right)\frac{\tilde{C}_t^b}{D_t^b} + (1-\chi)(1-\delta)\psi_t P_{D/C,t}E_t\left[\Pi_{D,t+1}\right]\varepsilon_t^{LTV}$$

$$R_t\psi_t = 1-\beta_b E_t\left[\left(\frac{1-\gamma\mathcal{E}_{t+1}^D}{1-\gamma\mathcal{E}_t^D}\right)\left(\frac{X_{t+1}^b}{X_t^b}\right)^{-\sigma}\left(\frac{D_{t+1}^b}{\tilde{C}_{t+1}^b}\right)^{\gamma\mathcal{E}_{t+1}^D}\left(\frac{\tilde{C}_t^b}{D_t^b}\right)^{\gamma\mathcal{E}_t^D}\frac{R_t}{\Pi_{C,t+1}}\right],$$

where ψ_t represents the marginal value of borrowing.

The Model
Households

Savers

$$\max E_0 \sum_{t=0}^{\infty} \beta_s^t \left[\frac{1}{1-\sigma} (X_t^s)^{1-\sigma} - \frac{1}{1+\varphi} (N_{C,t}^s)^{1+\varphi} - \frac{1}{1+\varphi} (N_{D,t}^s)^{1+\varphi} \right],$$

subject to

$$\begin{aligned} & C_t^s + P_{D/C,t} I_{D,t}^s - B_{H,t}^s - \mathfrak{E}_t B_{F,t}^s \\ = \quad & -R_{t-1} \frac{B_{H,t-1}^s}{\Pi_{C,t}} - \frac{R_{t-1}^* \mathfrak{E}_t B_{F,t-1}^s}{\Pi_{C,t}} + \sum_{j=C,D} \frac{W_{j,t}^s N_{j,t}^s}{P_{C,t}}. \end{aligned}$$

The Model
Households

Savers' FOCs

$$\frac{W^s_{j,t}}{P_{C,t}} = \frac{(X^s_t)^{\sigma}\left(N^s_{j,t}\right)^{\varphi}\left(\tilde{C}^s_t\right)^{\gamma\mathcal{E}^D_t}}{\left(1-\gamma\mathcal{E}^D_t\right)\left(D^s_t\right)^{\gamma\mathcal{E}^D_t}}, j = C, D,$$

$$P_{D/C,t} = \beta_s(1-\delta)E_t\left[\left(\frac{X^s_{t+1}}{X^s_t}\right)^{-\sigma}\left(\frac{1-\gamma\mathcal{E}^D_{t+1}}{1-\gamma\mathcal{E}^D_t}\right)\left(\frac{D^s_{t+1}}{\tilde{C}^s_{t+1}}\right)^{\gamma\mathcal{E}^D_{t+1}}\left(\frac{\tilde{C}^s_t}{D^s_t}\right)^{\gamma\mathcal{E}^D_t}P_{D/C,t+1}\right] + \left(\frac{\gamma\mathcal{E}^D_t}{1-\gamma\mathcal{E}^D_t}\right)\frac{\tilde{C}^s_t}{D^s_t},$$

$$1 = \beta_s E_t\left[\left(\frac{1-\gamma\mathcal{E}^D_{t+1}}{1-\gamma\mathcal{E}^D_t}\right)\left(\frac{X^s_{t+1}}{X^s_t}\right)^{-\sigma}\left(\frac{D^s_{t+1}}{\tilde{C}^s_{t+1}}\right)^{\gamma\mathcal{E}^D_{t+1}}\left(\frac{\tilde{C}^s_t}{D^s_t}\right)^{\gamma\mathcal{E}^D_t}\frac{R_t}{\Pi_{C,t+1}}\right],$$

$$1 = \beta_s E_t\left[\left(\frac{1-\gamma\mathcal{E}^D_{t+1}}{1-\gamma\mathcal{E}^D_t}\right)\left(\frac{X^s_{t+1}}{X^s_t}\right)^{-\sigma}\left(\frac{D^s_{t+1}}{\tilde{C}^s_{t+1}}\right)^{\gamma\mathcal{E}^D_{t+1}}\left(\frac{\tilde{C}^s_t}{D^s_t}\right)^{\gamma\mathcal{E}^D_t}\frac{\mathfrak{E}_{t+1}}{\mathfrak{E}_t}\frac{R^*_t}{\Pi_{C,t+1}}\right].$$

The Model
Households

Intratemporal Allocation

Consumption and Housing are composite indices:

$$C_t \equiv \left[(1-\alpha_C)^{\frac{1}{\eta_C}} C_{H,t}(j)^{\frac{\eta_C - 1}{\eta_C}} + \alpha_C^{\frac{1}{\eta_C}} C_{F,t}(j)^{\frac{\eta_C - 1}{\eta_C}} \right]^{\frac{\eta_C}{\eta_C - 1}},$$

$$D_t \equiv \left[(1-\alpha_D)^{\frac{1}{\eta_D}} D_{H,t}(j)^{\frac{\eta_D - 1}{\eta_D}} + \alpha_D^{\frac{1}{\eta_D}} D_{F,t}(j)^{\frac{\eta_D - 1}{\eta_D}} \right]^{\frac{\eta_D}{\eta_D - 1}}.$$

$\Rightarrow$ α_C and α_D are sector-specific degrees of openness.

$\Rightarrow$ η_C and η_D are sector-specific elasticities of substitution.

The Model
The International Dimension

Sector-Specific Terms-of-Trade

Sector-specific relative prices are given by

$$
\begin{aligned}
S_{C,t} &= \frac{P_{C,F,t}}{P_{C,H,t}} = \left(\int_0^1 S_{C,i,t}^{1-\zeta_C} di\right)^{\frac{1}{1-\zeta_C}}, \\
S_{D,t} &= \frac{P_{D,F,t}}{P_{D,H,t}} = \left(\int_0^1 S_{D,i,t}^{1-\zeta_D} di\right)^{\frac{1}{1-\zeta_D}} \\
&\Rightarrow \begin{cases} \widehat{\pi}_{C,t} = \widehat{\pi}_{C,H,t} + \alpha_C \triangle \widehat{s}_{C,t}, \\ \widehat{\pi}_{D,t} = \widehat{\pi}_{D,H,t} + \alpha_D \triangle \widehat{s}_{D,t}. \end{cases}
\end{aligned}
$$

Assuming that the LOOP holds on a brand level implies

$$
P_{j,F,t} = \mathfrak{E}_t P^*_{j,F,t}, P_{j,H,t} = \mathfrak{E}_t P^*_{j,H,t}, P_{j,t} = \mathfrak{E}_t P^*_{j,t}.
$$

The Model

The International Dimension

Sector-Specific Terms-of-Trade

A log-linearization of $P_{j,F,t}$ around a symmetric steady state gives

$$\widehat{p}_{j,F,t} = \int_0^1 \left(\widehat{e}_{i,t} + \widehat{p}^{i}_{j,i,t}\right) di = \widehat{e}_t + \widehat{p}^{*}_{j,t}$$

$$\Rightarrow \qquad \widehat{e}_t = \widehat{s}_{C,t} - \widehat{p}^{*}_{C,t} + \widehat{p}_{C,H,t} = \widehat{s}_{D,t} - \widehat{p}^{*}_{D,t} + \widehat{p}_{D,H,t}.$$

Moreover, the sectoral terms-of-trade are linked by

$$(1-\alpha_C)\,\widehat{s}_{C,t} - (1-\alpha_D)\,\widehat{s}_{D,t} = \widehat{p}_{D/C,t} - \widehat{p}^{*}_{D/C,t}.$$

The Model

The International Dimension

International Risk Sharing

Domestic and foreign savers can trade bonds internationally. Assuming complete markets, the exclusion of arbitrage yields:

$$\left(\frac{X_t^s}{X_t^{s,*}}\right)^{-\sigma}\left(\frac{\tilde{C}_t^{s\mathcal{E}_t^{D,s}}}{\tilde{C}_t^{s,*\mathcal{E}_t^{D,*}}}\right)^{\gamma}\left(\frac{D_t^{s\mathcal{E}_t^{D,s}}}{D_t^{s,*\mathcal{E}_t^{D,*}}}\right)^{\gamma}=\mathcal{R}_t,$$

where $\mathcal{R}_t$ is the consumer price based real effective exchange rate, and $\mathcal{E}_t^{D,*}$ represents the foreign counterpart to domestic preference shocks.

The Model
Equilibrium

Aggregated Output and the GDP Deflator

Obviously, aggregated real output (denominated with the aggregated producer price index $P_{H,t}$) must fulfil:

$$P_{H,t} Y_t = P_{C,H,t} Y_{C,t} + P_{D,H,t} Y_{D,t}.$$

Moreover, the price index for aggregated output is a weighted average of domestic prices for non-residential consumption and housing:

$$P_{H,t} \equiv P_{C,H,t}^{1-\xi \mathcal{E}_t^D \mathcal{E}_t^{D,*}} P_{D,H,t}^{\xi \mathcal{E}_t^D \mathcal{E}_t^{D,*}},$$

where ξ represents the share of the housing sector in aggregate production, which we allow to be affected by domestic and foreign preference shocks.

The Model
Monetary Policy

Currency Board

Since 1983 the Hong Kong dollar (HKD) is freely convertible against the US dollar (USD) at 7.80 USD/HKD.
Hence, the exchange rate is fixed, and $\widehat{e}_t = 0$:

$$\Rightarrow \qquad \Delta\widehat{s}_{C,t} = \widehat{\pi}_{C,F,t} - \widehat{\pi}_{C,H,t}$$
$$\Leftrightarrow \qquad \Delta\widehat{s}_{D,t} = \widehat{\pi}_{D,F,t} - \widehat{\pi}_{D,H,t}$$

The Model
Shock Structure

Seven Domestic Shocks

- two sector-specific productivity shocks,
- two sector-specific mark-up/cost-push shocks,
- two household-specific housing preference shocks,
- and a government spending shock.

Five Foreign Shocks

- two sector-specific demand shocks,
- two sector-specific price-shocks,
- and a housing preference shock.

All shocks are modelled as AR(1) processes with an i.i.d. innovation.

Simulation of Non-Linear LTV Policies

LTV Policy

A Threshold Approach

- LTV limits are only raised when property prices increase strongly.
- Moreover, they are not changed on a quarterly basis.
- No authority would follow a Taylor-type rule and increase LTV limits, if property price inflation is too low.

$\Rightarrow$ So we use a non-linear reaction function:

$$\widehat{ltv}_t = -\phi'_{ltv} \sum_{i=0}^{T} \left(\pi_{D,H,t-i} - \overline{\pi}_{D,H}\right)^+ ,$$

where ϕ'_{ltv} and T represent the strength and the persistence of the reaction, and $\overline{\pi}_{D,H}$ represents the threshold inflation rate, respectively.

Simulation of Non-Linear LTV Policies

Efficient Simulation of DSGE Models with Inequality Constraints

The Algorithm

- Holden and Paetz (2012) describe a very simple method to deal with inequality constraints in DSGE models.
- The algorithm can be used for IRFs and complete simulations and is much faster than, for example, the extended path methods proposed by Adjemian and Juillard (2011) (steady state IRFs and simulations need a few seconds).
- The idea is based on the introduction of *shadow price* shocks that hit the bounded variable whenever it violates the constraint:

$$\sum_{s=0}^{T-1} \epsilon_{s,t-s}^{SP},$$

where $\epsilon_{s,t}^{SP} \overset{i.i.d.}{\sim} \mathcal{N}(0,1)$, if $t = 0$ and zero otherwise.

$\Rightarrow$ Shocks hit the equation in consecutive periods (if $s = t$).

Simulation of Non-Linear LTV Policies

Efficient Simulation of DSGE Models with Inequality Constraints

The Algorithm

1. Add a load of T shadow price shocks to the equation, determining the bounded variable, where T represents the number of periods you believe the constraint to hold.
2. Generate IRFs of the model with shadow price shocks. Save the IRFs with respect to the shadow price shocks consecutively as column vectors in a matrix M.
3. Solve the following optimisation problem:

$$\alpha^* = \arg\min \left[\alpha' \left(v + m + M^* \alpha\right)\right]$$
$$\text{s.t. } \alpha \geq 0 \text{ and } v + M^* \alpha \geq 0,$$

   where M^* is the $T \times T$ upper square Matrix of M, and v and m represent the IRFs and the steady state of the constrained variable.
4. The IRFs of the constrained variable are now given by $v + m + M\alpha^*$. And the results for all other variables are derived in the same fashion by multiplying the corresponding shadow price IRF matrix by α^*

Simulation of Non-Linear LTV Policies

Efficient Simulation of DSGE Models with Inequality Constraints

Intuition

α determines the linear combination of shadow price shocks, needed to keep the variable bounded:

$$\alpha^* = \arg\min \left[\alpha' \left(v + m + M^* \alpha\right)\right]$$
$$\text{s.t. } \alpha \geq 0 \text{ and } v + M^* \alpha \geq 0,$$

- $\Rightarrow$ If the IRF in a particular period is greater than zero, the optimal α entry would be zero and the shadow price shock has no impact.
- $\Rightarrow$ If the constraint in a particular period is violated, the optimal α entry is exactly of the size, that implies $v + M^* \alpha = 0$, and the constraint binds.
- $\Rightarrow$ Since the shocks hit in the future, but are known today, the method is consistent with a rational expectations solution of the model.

Simulation of Non-Linear LTV Policies

Efficient Simulation of DSGE Models with Inequality Constraints

Simulation

1. Sample from the shock distribution to generate the period t exogenous shock.
2. Simulate the model for T periods to attain the path by which it would return to trend were there no bounds, and no shocks after period t. If the bounds are never hit along this path, then we have a valid simulation of period t.
3. Otherwise, add shadow shocks in the same way as before, except that the simulated return paths of the economy's variables take the role of the IRFs above.
4. The found solution to the quadratic programming problem gives a valid, new value for variables at t, and we to repeat steps $1. - 3.$ for $t + 1$.

Note: It is not ensured that the "news" contained in shadow shocks is guaranteed to come true, since other shocks may arrive in the meantime, pushing us away from the bounds.

Simulation of Non-Linear LTV Policies

Efficient Simulation of DSGE Models with Inequality Constraints

Introducing an Auxiliary Variable

$$ltv_t^{aux} = \overline{\pi}_{D,H} - \pi_{D,H,t} \geq 0.$$

The LTV policy is now redefined in terms of this auxiliary variable:

$$\widehat{ltv}_t = -\phi'_{ltv} \sum_{i=0}^{T} \left(ltv_{t-i}^{aux} + \widehat{x}_{t-i} - \overline{\pi}_{D,H} \right).$$

When $\overline{\pi}_{D,H} - \pi_{D,H,t} > 0$, the target variable is below the threshold, $ltv_t^{aux} = \overline{\pi}_{D,H} - \pi_{D,H,t}$, and the central bank does not intervene on the housing market ($\widehat{ltv}_t = 0$). However, if $\overline{\pi}_{D,H} - \pi_{D,H,t} \leq 0$, the auxiliary variable becomes zero and $\widehat{ltv}_t = -\phi'_{ltv} \sum_{i=0}^{T} (\pi_{D,H,t-i} - \overline{\pi}_{D,H})$.

Calibration and Results

Calibration on a Quarterly Basis

Standard Parameters

- Depreciation rate of durables: 1 percent.
- Discount factors of borrowers and savers: 0.96 and 0.99.
- Mark-ups in both sectors: 10 percent.

Model-Specific Parameters

- The share of housing in aggregate production is fixed at 10 percent.
- The share of borrowers varies between 10 and 35 percent.
- The welfare relevant share of durables in the composite consumption index varies between 44 and 49 percent.

All remaining parameters follow the 4 estimation scenarios of Funke and Paetz (2011), who found strong housing wealth effects for Hong Kong.

Calibration and Results

Calibration on a Quarterly Basis

The LTV Policy

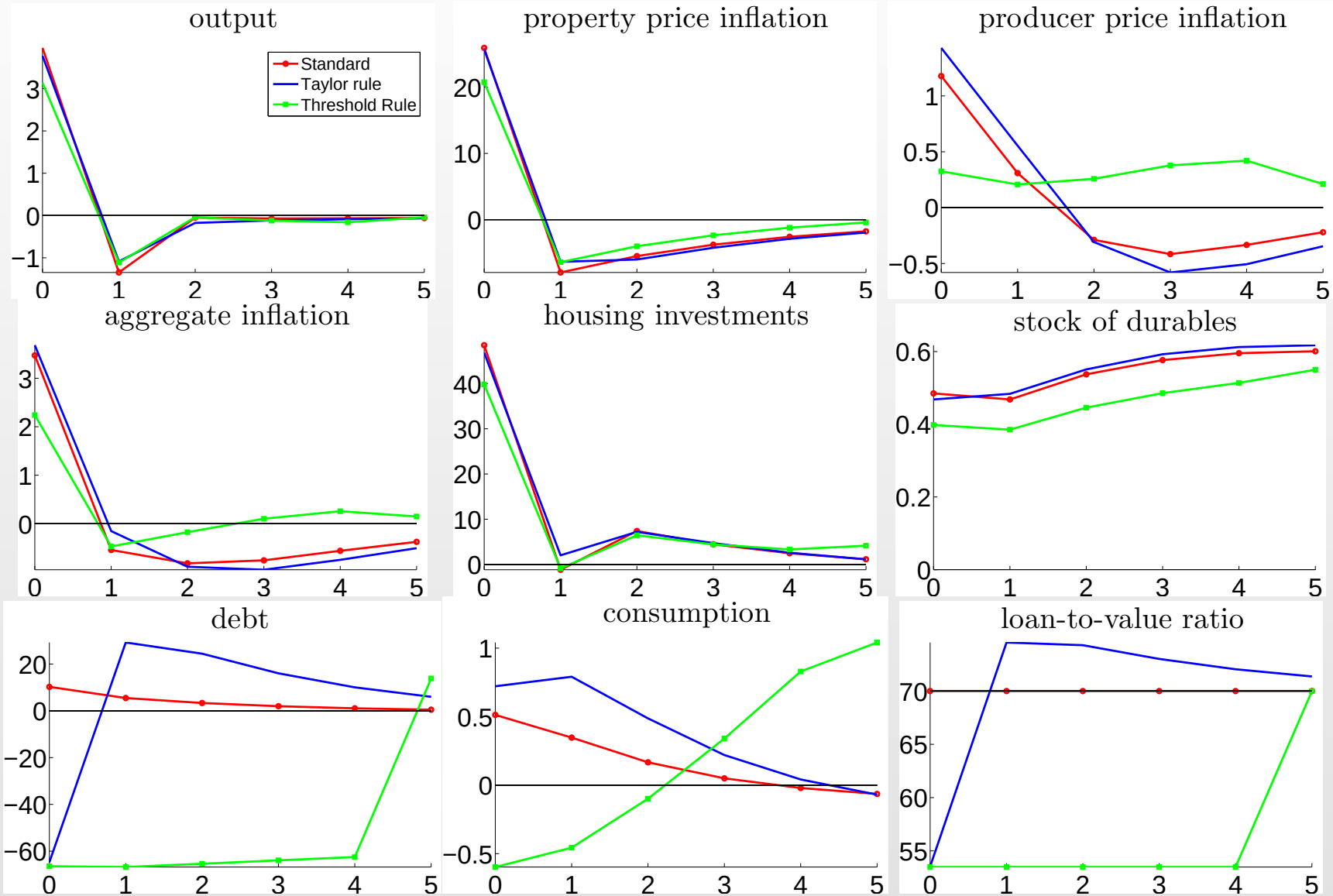
- The threshold value is set to 4% (roughly 17% on an annual basis), and the lag length is set to $T = 4$ quarters.
- The strength of the reaction is set to 20 in the baseline simulation, implying a fall from 70% to 54%, if the annual property price inflation is around 25%, which is in line with the data.
- We compare our results with linear Taylor-type rules:

$$\widehat{ltv}_t = -\phi_{ltv}\widehat{x}_t.$$

These are calibrated, so that the LTV interventions of linear and the non-linear rules at impact are the same.

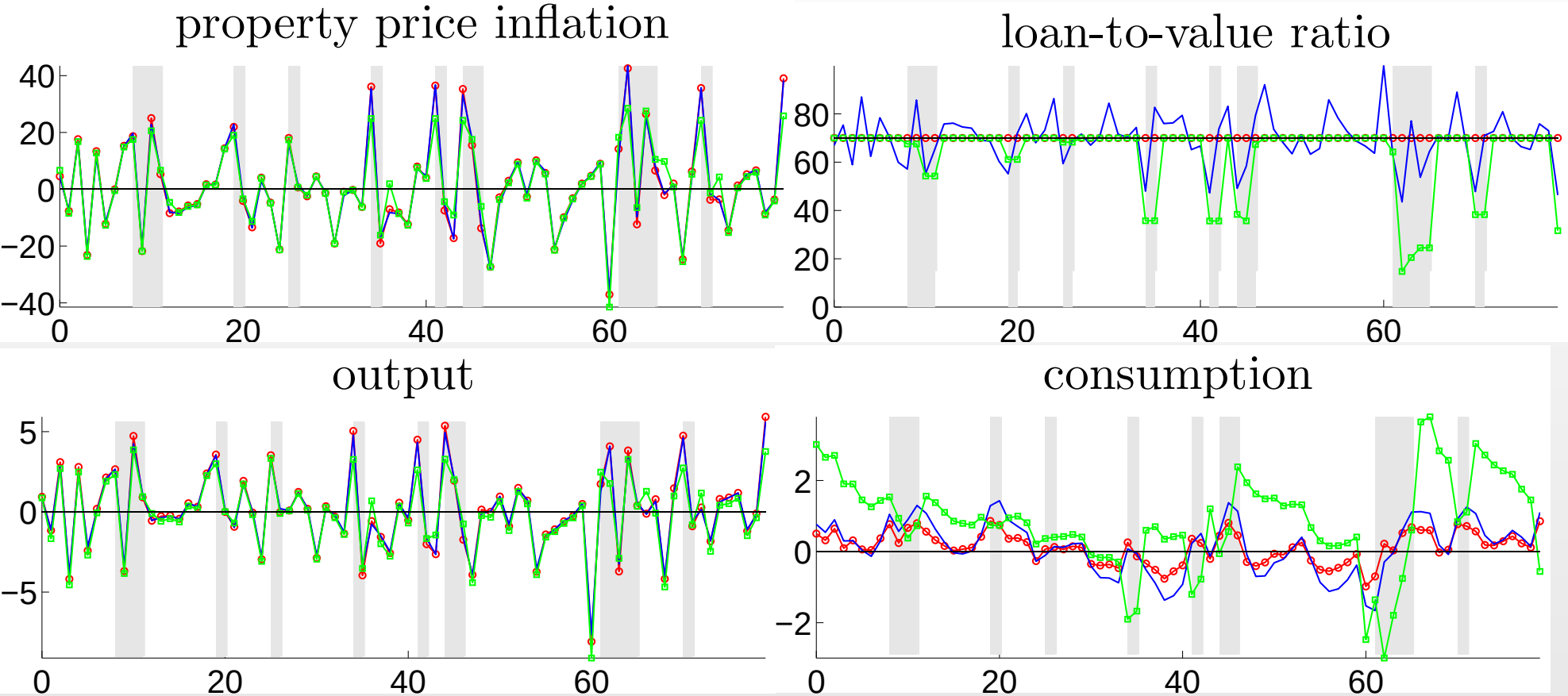
Calibration and Results

IRFs, Positive Saver's Housing Preference Shock ($\rho_{d,s} = 0.69, \sigma_{d,s} = 3.2$)



Calibration and Results

Simulations of the Model



Red line: Standard, **Blue line:** Taylor rule, **Green line:** Threshold rule

Calibration and Results

Simulations of the Model

Red line: Standard, **Blue line:** Taylor rule, **Green line:** Threshold rule

Calibration and Results

Standard Deviations of Different Policy Scenarios and Calibrations

Funke/Paetz(2011), Baseline Estimation ($\omega = 0.09$)

variable	property infl.			producer infl.			aggregate infl.			output			ϕ_{ltv}	ϕ'_{ltv}
threshold	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)		
3	4.04	4.03	3.92	0.09	0.09	0.08	0.36	0.36	0.34	1.22	1.22	1.21	4.35	10.40
4	4.04	4.03	3.95	0.09	0.09	0.08	0.36	0.36	0.34	1.22	1.22	1.21	2.80	10.40
5	4.04	4.04	3.98	0.09	0.09	0.08	0.36	0.36	0.35	1.22	1.22	1.21	1.23	10.40

Funke/Paetz(2011), Fixed Low Share of Borrowers ($\omega = 0.2$)

variable	property infl.			producer infl.			aggregate infl.			output			ϕ_{ltv}	ϕ'_{ltv}
threshold	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)		
3	4.21	4.16	3.84	0.12	0.13	0.13	0.40	0.40	0.36	1.30	1.32	1.29	4.45	16.00
4	4.21	4.18	3.93	0.12	0.12	0.12	0.40	0.40	0.36	1.30	1.31	1.29	2.80	16.00
5	4.21	4.19	4.00	0.12	0.12	0.12	0.40	0.40	0.37	1.30	1.31	1.29	1.20	16.00

Note: (1) refers to the standard scenario without LTV policy, (2) refers to the time-varying Taylor rule, and (3) refers to the threshold rule.

Calibration and Results

Standard Deviations of Different Policy Scenarios and Calibrations

Funke/Paetz(2011), Fixed High Share of Borrowers ($\omega = 0.35$)

variable	property infl.			producer infl.			aggregate infl.			output			ϕ_{ltv}	ϕ'_{ltv}
threshold	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)		
3	2.39	2.37	2.27	0.19	0.19	0.17	0.40	0.38	0.37	0.37	0.38	0.38	4.45	16.00
4	2.39	2.38	2.33	0.19	0.18	0.18	0.40	0.39	0.39	0.37	0.38	0.38	2.80	16.00
5	2.39	2.38	2.36	0.19	0.18	0.18	0.40	0.40	0.40	0.37	0.37	0.38	1.20	16.00

Funke/Paetz(2011), ω and γ Uniformly Distributed ($\omega = 0.24$)

variable	property infl.			producer infl.			aggregate infl.			output			ϕ_{ltv}	ϕ'_{ltv}
threshold	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)		
3	4.34	4.26	4.02	0.24	0.35	0.47	0.62	0.70	0.70	2.77	2.51	2.53	4.35	20.00
4	4.34	4.28	3.95	0.24	0.31	0.29	0.62	0.67	0.57	2.77	2.60	2.51	2.80	20.00
5	4.34	4.31	4.02	0.24	0.27	0.25	0.62	0.64	0.56	2.77	2.68	2.56	1.35	20.00

Note: (1) refers to the standard scenario without LTV policy, (2) refers to the time-varying Taylor rule, and (3) refers to the threshold rule.

Conclusions

Evaluation of LTV Policies

Key Findings

- LTV policies are no silver bullet against house market bubbles, but can dampen excessive increases in property prices.
- The more realistic non-linear approach to model LTV policies performs much better than the Taylor type rules.

Conclusions
Outlook

Future Work

- The method of Holden and Paetz (2012) is so efficient, that one can easily run average IRFs and higher accuracy simulations (based on MC simulations).

$\Rightarrow$ More accurate treatment of non-linearities of the model (comparable to higher order approximations of the bounded constraint).

$\Rightarrow$ This introduces uncertainty: If the agents know, that the CB could decrease the LTV ratio, the dynamics will already differ, even if property price inflation does not pass the threshold (as long as there is a positive probability, that it could).

Conclusions

Thanks for your attention!

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