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Balancing Financial Stability and Housing Affordability: The Case of Canada

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Abstract

Housing market imbalances are a key source of systemic risk and can adversely affect housing affordability. This paper utilizes a stylized model of the Canadian economy that includes policymakers with differing objectives—macroeconomic stability, financial stability, and housing affordability. Not surprisingly, when faced with multiple objectives, deploying more policy instruments can lead to better outcomes. The results show that macroprudential policy can be more effective than policies based on adjusting property-transfer taxes because property-tax policy entails excessive volatility in tax rates. They also show that if property-transfer taxes are used as a policy instrument, taxes targeted at a broader-set of homebuyers can be more effective than measures targeted at a smaller subset of homebuyers, such as nonresident homebuyers.

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I. INTRODUCTION

Housing market imbalances are prominent in Canada and are a key source of systemic risk. Rapidly-rising house prices are usually coupled with rising household indebtedness. High household debt raises the vulnerability of financial institutions to sharp corrections in house prices, and the size of exposure and interconnectedness of financial institutions make this risk systemic, not merely idiosyncratic. As such, agencies in charge of macroprudential policy/systemic risk oversight typically use macroprudential measures aimed at mitigating these risks to contain the build-up of vulnerabilities over time and enhance the resilience of the financial sector.

In addition to financial stability concerns, the rapid rise in housing prices has led to worsening housing affordability, posing a major problem to some of Canada's most dynamic metropolitan regions. Although Canada's overall affordability indices are not yet among the worst globally, the Toronto and Vancouver regions are becoming severely unaffordable.[1] This raises important social and economic concerns.

The federal government in Canada has introduced a raft of macroprudential measures over the past ten years to tackle growing housing market imbalances and associated risks to financial stability (see Arvai, Krznar, and Ustyugova, 2017). Initially, the measures were aimed at the high LTV ratio, government-backed insured mortgage market, and helping to reduce the government's exposure to the housing sector. In early 2018, the Office of the Superintendent of Financial Institutions (OSFI) tightened underwriting requirements for low-ratio mortgages to stem rising risk in the uninsured mortgage market. Low-ratio mortgages are now subject to: (i) a stress test for mortgage interest rates; (ii) Loan-to-Value (LTV) measures and limits that reflect housing market risks, to be updated as housing markets and the economic environment evolve; and (iii) restrictions on combining mortgages with other lending products (e.g. co-lending arrangements) that could circumvent LTV limits (see IMF 2018).

The governments of British Columbia (BC) and Ontario have also recently deployed property-tax measures to stem speculative activity and improve housing affordability in their major cities. A 15 percent nonresident property-transfer tax was introduced for the Toronto and Vancouver areas between 2016–17. More recently, the BCf government increased the property-transfer tax on nonresident homebuyers to 20 percent and expanded its geographic coverage.

The question remains: Which policy—macroprudential policy or property-tax policy—best satisfies the overall objectives of policymakers? This paper develops a simple Dynamic-Stochastic-General-Equilibrium (DSGE) framework to assess the effectiveness of a specific macroprudential policy—an LTV limit—against property-tax measures. The model is

[1] See, for example, 14th Annual Demographia International Housing Affordability Survey (third quarter, 2017).

estimated using Bayesian methods and Canadian data. Operational objectives are specified for the central bank, the macroprudential authority, and the property-tax authority (assumed to be provincial governments). Optimal policy experiments are conducted to assess the overall performance of each policy given the specified objectives.

The paper proceeds as follows. Section II outlines the DSGE model used in the analysis. Sections II and III describe details about the estimation of the model. Section IV outlines the details of the policy experiments. The results from the policy experiments are discussed in section V and section VI concludes with a discussion of the results and avenues for future work.

II. Model

The model follows closely from the models developed by Funke and Paetz (2018) and Funke and Others (2017). Households are divided into ω borrowers and (1- ω) savers. Borrowers differ from savers in that they discount the future at a faster rate. To prevent borrowing without limit, borrowers are assumed to face credit constraints tied to their collateral. The model contains two sectors producing housing goods and non-housing consumer goods (denoted H and C, respectively). Firms producing intermediate goods are assumed to be monopolistically competitive and the output of final goods producers of consumer goods is traded both domestically and internationally.

The model includes three policy instruments: an interest rate, a loan-to-value (LTV) ratio, and a tax rate applied the purchase of houses. For simplicity, the government is assumed to run a balanced budget in each period using lump-sum transfers to households.

Households

Households are assumed to consume, work, and accumulate housing. There are two types of households that differ in terms their degree of patience, where patient households (savers) have a higher discount factor than impatient households (borrowers). This heterogeneity gives rise to positive financial flows, as patient households save and impatient households borrow against the value of their housing stock. Housing is in fixed supply and is traded between the two household types.

Borrowers

The representative impatient borrower is infinitely lived and maximizes expected utility:

$$E_0 \sum_{t=0}^{\infty}(\beta^b)^t \left[\frac{1}{1+\sigma}(X_t^b)^{(1-\sigma)} - \frac{1}{1+\phi}(N_{C,t}^b)^{(1+\phi)} - \frac{1}{1+\phi}(N_{H,t}^b)^{(1+\phi)}\right] \qquad (1)$$

where E_0 is the conditional expectation operator evaluated at time 0, X_t^b is the welfare-relevant consumption index and $N_{j,t}^b$ represents the labor supply in sector j. The parameters σ and ϕ are the intertemporal elasticities of substitution with respect to consumption and labor, respectively, and β^b is the borrowers discount factor.

The welfare-relevant consumption index is a weighted average of the flow of non-housing consumption and the stock of housing:

$$X_t^b \equiv \left(\tilde{C}_t^b\right)^{(1-\gamma\varepsilon_t)}\left(H_t^b\right)^{\gamma\varepsilon_t}$$

where $\tilde{C}_t^b = C_t^b - hC_{t-1}^b$ and C_t^b is a composite index of non-housing consumption and the flow of housing services is H_t^b. The parameters γ and h represent habit formation in consumption and the share of housing in consumption, respectively. Borrowers also face a housing preference shock that affects the marginal rate of substitution between housing and non-housing goods, where $\varepsilon_t = \exp(\epsilon_t)$.[2]

Borrowers can trade nominal riskless bonds but cannot borrow from international markets to finance their expenditures. They face a sequence of budget constraints given by:

$$C_t^b + Q_t(1+\tau)I_t^b\varepsilon_t^\tau - B_t^b = -R_{t-1}\frac{B_{t-1}^b}{\Pi_{C,t}} + \frac{W_{C,t}^b}{P_{C,t}} + \frac{W_{H,t}^b}{P_{C,t}} + T_t^b \tag{2}$$

where $\Pi_{C,t} \equiv P_{C,t}/P_{C,t-1}$ is the period-to-period gross inflation rate based on the consumer-price index, $P_{C,t}$, Q_t is the real house price and B_t^b is the borrowers' stock of real debt (both deflated with the consumer price index). The nominal interest rate on a loan contract issued in period $t-1$ is R_{t-1}, $W_{j,t}^b$ is sector-specific wage rate, and I_t^b is borrowers' housing investment, with $I_t^b \equiv H_t^b - (1-\delta)H_{t-1}^b$, where δ is the depreciation rate on the stock of housing. The parameter τ is the steady-state tax rate on new housing investment, and the shock, $\varepsilon_t^\tau \equiv \exp(TAX_t)$, represents policy-related variations in the property-transfer tax rate, and $T_t^b$is government lump-sum transfers including those received from property-transfer taxes via $(1+\tau)\varepsilon_t^\tau$.

Borrowers do not save and are restricted by the borrowing constraint:

$$R_t B_t^b \leq (1-\chi)(1-\delta)E_t[Q_{t+1}H_t^b\Pi_{C,t+1}]\varepsilon_t^{LTV} \tag{3}$$

where χ represents the fraction of households' housing assets that cannot be used as collateral. Thus, $(1-\chi)$ is the loan-to-value ratio (LTV), and the shock, $\varepsilon_t^{LTV} \equiv \exp(LTV_t)$, represents policy-related variations in the LTV ratio. This relates the amount that will be repaid by borrowers in the following period to the expected future value of housing (adjusted for depreciation and the LTV ratio). Domestic agents cannot access international markets the LTV ratio is binding.

Borrowers maximize 1 subject to 2 and 3, which yields the first-order conditions:

[2] The shock captures changes in social and institutional norms that shift preferences toward housing

$$\frac{W_{j,t}^{b}}{P_{C,t}} = \frac{\left(X_t^b\right)^{\sigma}\left(N_{j,t}^b\right)^{\phi}\left(\tilde{C}_t^b\right)^{\varepsilon_t}}{(1-\gamma\varepsilon_t)\left(H_t^b\right)^{\phi}}, j = C, H \tag{4}$$

$$(1+\tau)Q_t\varepsilon_t^{\tau} = \frac{\gamma\varepsilon_t}{(1-\gamma\varepsilon_t)}\frac{\tilde{C}_t^b}{\widetilde{H}_t^b} + (1-\chi)(1-\delta)\psi_t E_t\left[Q_{t+1}\Pi_{C,t+1}\right] +$$

$$\beta^b(1-\delta)(1+\tau)E_t\left[\frac{(1-\gamma\varepsilon_{t+1})}{(1-\gamma\varepsilon_t)}\left(\frac{X_{t+1}^b}{X_t^b}\right)^{-\sigma}\left(\frac{H_{t+1}^b}{\tilde{C}_{t+1}^b}\right)^{\gamma\varepsilon_{t+1}}\left(\frac{\tilde{C}_t^b}{H_t^b}\right)^{\gamma\varepsilon_t} Q_{t+1}\varepsilon_{t+1}^{\tau}\right] \tag{5}$$

$$R_t\psi_t = 1 - \beta^b E_t\left[\frac{(1-\gamma\varepsilon_{t+1})}{(1-\gamma\varepsilon_t)}\left(\frac{X_{t+1}^b}{X_t^b}\right)^{-\sigma}\left(\frac{H_{t+1}^b}{\tilde{C}_{t+1}^b}\right)^{\gamma\varepsilon_{t+1}}\left(\frac{\tilde{C}_t^b}{H_t^b}\right)^{\gamma\varepsilon_t}\frac{R_t}{\Pi_{C,t+1}}\right] \tag{6}$$

where $\lambda_t\psi_t$ is the Lagrange multiplier for the borrowing constraint and ψ_t can be interpreted as the marginal value of borrowing.[3] Equation (4) represents the standard labor-leisure tradeoff, equating the marginal disutility of an additional unit of labor to the marginal utility received from additional consumption, equation (5) equates the marginal utility from non-housing consumption to the shadow value of housing services. Finally, equation (6) is the consumption Euler equation adjusted to capture the borrowing constraint. Note that, for $\psi_t = 0$, equation (6) reduces to the standard New Keynesian Euler equation so that a rise in ψ_t represents a tightening of the collateral constraint.

Savers

Patient households (savers) make intertemporal decisions in the standard way. The representative household is infinitely-lived and maximizes the expected utility:

$$E_0\sum_{i=1}^{\infty}(\beta^s)^t\left[\frac{1}{1+\sigma}(X_t^s)^{(1-\sigma)} - \frac{1}{1+\phi}(N_{C,t}^s)^{(1+\phi)} - \frac{1}{1+\phi}(N_{H,t}^s)^{(1+\phi)}\right] \tag{7}$$

Subject to the budget constraint:

$$C_t^s + Q_t(1+\tau)I_t^s\varepsilon_t^{\tau} - B_t^s - Z_t B_t^{s,F} = -R_{t-1}\frac{B_{t-1}^s}{\Pi_{C,t}} - R_{t-1}^*\frac{Z_t B_{t-1}^{s,F}}{\Pi_{C,t}} + \frac{W_{C,t}^s}{P_{C,t}} + \frac{W_{H,t}^s}{P_{C,t}} + T_t^s \tag{8}$$

where $Z_t$represents the nominal exchange rate, $B_t^{s,F}$ is foreign bond holdings, R_t^* is the foreign interest rate, and all other variables are defined in the same way as for borrowers.

The first order conditions that result from maximizing equation (7) with respect to the budget constraint (8) exactly mirror those of borrowers when $\psi_t = 0$, since savers do not face a borrowing constraint. Savers, however, have an additional first-order condition, reflecting the intertemporal saving decision rather than for borrowing:

$$1 = \beta^s E_t\left[\frac{(1-\gamma\varepsilon_{t+1})}{(1-\gamma\varepsilon_t)}\left(\frac{X_{t+1}^s}{X_t^s}\right)^{-\sigma}\left(\frac{H_{t+1}^s}{\tilde{C}_{t+1}^s}\right)^{\gamma\varepsilon_{t+1}}\left(\frac{\tilde{C}_t^s}{H_t^s}\right)^{\gamma\varepsilon_t}\frac{Z_{t+1}}{Z_t}\frac{R_t}{\Pi_{C,t+1}}\right] \tag{9}$$

[3] Note, the optimality condition can be interpreted as equating the marginal rate of substitution between housing and non-housing consumption to the user cost of housing.

Tradable Goods Sector

The non-housing consumption index is given by a weighted average of domestic and foreign consumption, with subscripts D and F, respectively.[4]

$$C_t \equiv \left[(1-\alpha)^{\frac{1}{\eta}} C_{D,t}{}^{\frac{\eta-1}{\eta}} + \alpha^{\frac{1}{\eta}} C_{F,t}{}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$$

where

$$C_{D,t} \equiv \left[\int_0^1 C_{D,t}(k)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}},\ \ C_{F,t} \equiv \left[\int_0^1 C_{F,t}(k)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{\zeta}{\zeta-1}}, C_{i,t} \equiv \left[\int_0^1 C_{i,t}(k)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}}$$

and where η represents the intra-temporal substitution elasticity between domestic and foreign goods, ζ is the intra-temporal substitution elasticity between goods produced in the rest of the world, and ϵ is the intra-temporal substitution elasticity between differentiated goods within one country, and α is the degree of openness of the domestic economy.[5] Consequently, the price consumer's price index is given by:

$$P_t \equiv \left[(1-\alpha)P_{C,D,t}{}^{1-\eta} + \alpha P_{C,F,t}{}^{1-\eta}\right]^{\frac{\eta}{\eta-1}} \qquad (10)$$

Assuming the law of one price holds, aggregation over all tradable products and countries yields the terms of trade (see Funke and Others, 2017, for more details):

$$S_t = \frac{Z_t P^*_{C,F,t}}{P_{C,D,t}} = \frac{P_{C,F,t}}{P_{C,D,t}} = \frac{P^*_{C,F,t}}{P^*_{C,D,t}} \qquad (11)$$

Finally, the consumer price index based real exchange rate $\mathcal{R}_t$can be written as:

$$\mathcal{R}_t = \frac{S_t P^*_t}{P_t} \qquad (12)$$

International Risk Sharing

Savers are able to share country-specific risks internationally via trading bonds in complete security markets, implying the risk-sharing condition:

$$\mathcal{R}_t = \left(\frac{X^s_t}{X^{s,*}_t}\right)^{-\sigma} \left(\frac{\tilde{C}^{s\,\varepsilon_t}_t}{\tilde{C}^{s,*\,\varepsilon^*_t}_t}\right)^{\gamma} \left(\frac{H^{s\,\varepsilon_t}_t}{H^{s,*\,\varepsilon^*_t}_t}\right)^{\gamma} \qquad (13)$$

[4] The superscripts for borrowers and savers have been dropped because all arguments hold for borrowers, savers, and aggregates.

[5] For simplicity, ϵ is assumed to be the same in each sector.

where $\tilde{C}_t^{s,*}$ is the composite index of foreign savers' non-durable consumption after accounting for habit persistence, $H_t^{s,*}$ is the index of housing consumption, $X_t^{s,*}$ is the index of foreign savers' consumption and ε_t^* is the foreign counterpart to domestic preference shocks.

Firms

Retailers are assumed to produce final goods in sector j by combining domestic intermediate goods using a constant elasticity of substitution production function. Furthermore, the wholesale sector produces intermediate goods using a Cobb–Douglas production function, $Y_{j,t}(k) = A_{j,t}N_{j,t}(k)$, where $A_{j,t}$ is a sector specific productivity measure.

The price adjustments of the monopolistically competitive firms are assumed to follow a variant of Calvo pricing. Specifically, a randomly-selected fraction of the firms in each sector $(1-\theta_j)$ adjust prices, while the remaining fraction of firms θ_j does not adjust. In addition, a fraction $(1-\iota_j)$ of the firms behaves in a forward-looking way, while the remaining fraction ι_j uses the recent history of the aggregate price index to set prices. Thus, ι_j is a measure of the degree of backward-looking price-setting. These assumptions yield the conventional mark-up rule, whereby firms set the price as a mark-up over current and future real marginal costs (mc_k). First- order log-linear approximation around the steady states yields fairly standard New Keynesian Phillips curves for inflation in the consumption and housing sectors:

$$(1+\beta^s\iota_C)\hat{\pi}_{C,t} = \beta^s E_t\hat{\pi}_{C,t+1} + \iota_C\hat{\pi}_{C,t-1} + \kappa_C\widehat{mc}_{C,t-1} + \epsilon_t^{\mu_C} \tag{14}$$

$$(1+\beta^s\iota_H)\hat{\pi}_{H,t} = \beta^s E_t\hat{\pi}_{H,t+1} + \iota_H\hat{\pi}_{H,t-1} + \kappa_H\widehat{mc}_{H,t-1} + \epsilon_t^{\mu_H} \tag{15}$$

where $\kappa_j = \frac{(1-\theta_j)(1-\beta^s\theta_j)}{\theta_j}$ is the slope of the New Keynesian Phillips curve and $\epsilon_t^{\mu_j}$ is a sector-specific cost-push shock.

Equilibrium

Government is assumed to purchase a time-varying fraction f_t of output of each good in each sector, financed by lump-sum taxation (see Gali, 2003). Consequently, aggregate goods market clearing for each good k in each sector j requires:

$$(1-f_t)Y_{C,t}(k) = C_{D,t}(k) + \int_0^1 C_{D,t}^i(k) \tag{16}$$

$$(1-f_t)Y_{H,t}(k) = I_t(k) \tag{17}$$

where $C_{D,t}^i$ represents non-durable consumption from country i. Defining a government expenditure shock g_t as $\log(1-f_t) = \exp(-g_t)$, these equations can be approximated around a symmetric steady state by:

$$\hat{y}_{C,t} = (1-\alpha)\hat{c}_t + \alpha\widehat{c^*}_t + \alpha(\zeta + \eta(1-\alpha))\hat{s}_t + g_t \tag{18}$$

$$\hat{y}_{H,t} = \hat{\imath}_t + g_t \tag{19}$$

Aggregate consumption of non-durable goods and the housing stock is given by:

$$C_t = \omega C_t^b + (1-\omega)C_t^s,\ H_t = \omega H_t^b + (1-\omega)H_t^s$$

and aggregate labor supply and real debt are:

$$N_t = \omega N_t^b + (1-\omega)N_t^s,\ B_t = \omega B_t^b + (1-\omega)B_t^s$$

Finally, aggregate real output (denominated with the in the aggregate producer price index, $P_{D,t}$) must satisfy $P_{D,t}Y_t = P_{C,D,t}Y_{C,t} + P_{H,t}Y_{H,t}$, where the price index of aggregate output is a weighted average of prices of domestic consumption and housing.

Monetary Policy

Monetary policy is assumed to follow a standard Taylor-type rule. The log-linearized rule expressed in deviations from a symmetric steady state is:

$$\hat{r}_t = \rho_r \hat{r}_{t-1} + (1-\rho_r)\left(\phi_\pi \hat{\pi}_{C,t} + \phi_y \Delta\hat{y}_t\right) + \nu_t^r \tag{20}$$

where the central bank adjusts the policy interest rate when CPI inflation deviates from target and output growth deviates from trend. The parameters ϕ_π and ϕ_y represent the responsiveness of the interest rate to inflation and output growth, respectively, ρ_r represents the inertia of policy adjustments, and ν_t^r is a monetary policy shock.

Exogenous Processes

To estimate the model, it is log-linearized using a first-order Taylor approximation and all variables are expressed as log-deviations from steady state levels. The exogenous forces driving the dynamics of the model are:

$$a_{C,t} = \rho_{a_C} a_{C,t-1} + \nu_t^{a_C} \tag{21}$$

$$a_{H,t} = \rho_{a_H} a_{H,t-1} + \nu_t^{a_H} \tag{22}$$

$$\widehat{c_t^*} = \rho_{c^*} \widehat{c_{t-1}^*} + \nu_t^{c^*} \tag{23}$$

$$\epsilon_t^{\mu_C} = \rho_{\mu_C} \epsilon_{t-1}^{\mu_C} + \nu_t^{\mu_C} \tag{24}$$

$$\epsilon_t^{\mu_H} = \rho_{\mu_H} \epsilon_{t-1}^{\mu_H} + \nu_t^{\mu_H} \tag{25}$$

$$\epsilon_t = \rho\, \epsilon_{t-1} + \nu_t \tag{26}$$

$$g_t = \rho_g\, g_{t-1} + \nu_t^g \tag{27}$$

$$\nu_t^r = \nu_t^r \tag{28}$$

where all $\nu_t^i \sim N(0, \sigma_i^2)$. With the exception of the monetary policy shock ν_t^r, all shocks are assumed to follow AR(1) processes. Equations (21) and (22) represent shocks to technology in the non-durable consumption and housing sectors, respectively. Equation (23) is a foreign demand shock, and equations (24) and (25) are cost-push shocks in the non-durable consumption and housing sectors, respectively. Finally, equation (26) is a housing preference shock and equation (27) is a government spending shock. For the purposes of estimation, LTV and tax policy are assumed to be inactive over the sample period (i.e., ϵ_t^τ and ϵ_t^{LTV} are set to zero).

III. Data and Estimation

Data

The model parameters are estimated using quarterly data ranging from 1993 to 2017. The measurement variables used in estimation are real GDP per capita, real consumption per capita, real residential investment per capita, employment per capita, headline CPI inflation, house price inflation, and the overnight policy interest rate. Each variable is expressed in log deviations from steady states, where steady states are computed using the Hodrick-Prescott filter for the real variables and as sample averages for the nominal variables.

Estimation

The model is estimated using Bayesian methods (see An and Schofheide, 2007). The parameters determining the steady-state of the model are calibrated to produce reasonable values to steady-state values and ratios. Some of the other parameters are difficult to estimate given our set of observable variables. The calibrated parameters and their values are displayed in table 1. The steady state ratios for the discount factors, depreciation of the housing stock, and the LTV are set broadly in line with previous studies. The property tax rate parameter τ is an estimate of average settlement costs of buying real estate in Canada (around 5 percent) and the degree of openness is calibrated to roughly match the share of imports in aggregate Canadian production. The statistics relating to the prior and posterior distributions of the estimated parameters are displayed in table 2.[6]

Table 1. Calibrated Parameters

β^s	Discount factor (savers)	0.99
β^b	Discount factor (borrowers)	0.98
δ	Depreciation rate of housing stock	0.01
$(1-\chi)$	Loan-to-value ratio steady state	0.60
τ	Property tax steady state	0.05
α	Degree of openness	0.30
γ	Share of housing in utility	0.30

[6] The Metropolis-Hastings algorithm is used to draw 500,000 sets of parameters from the posterior distribution. The first half of the draws is discarded to ensure convergence.

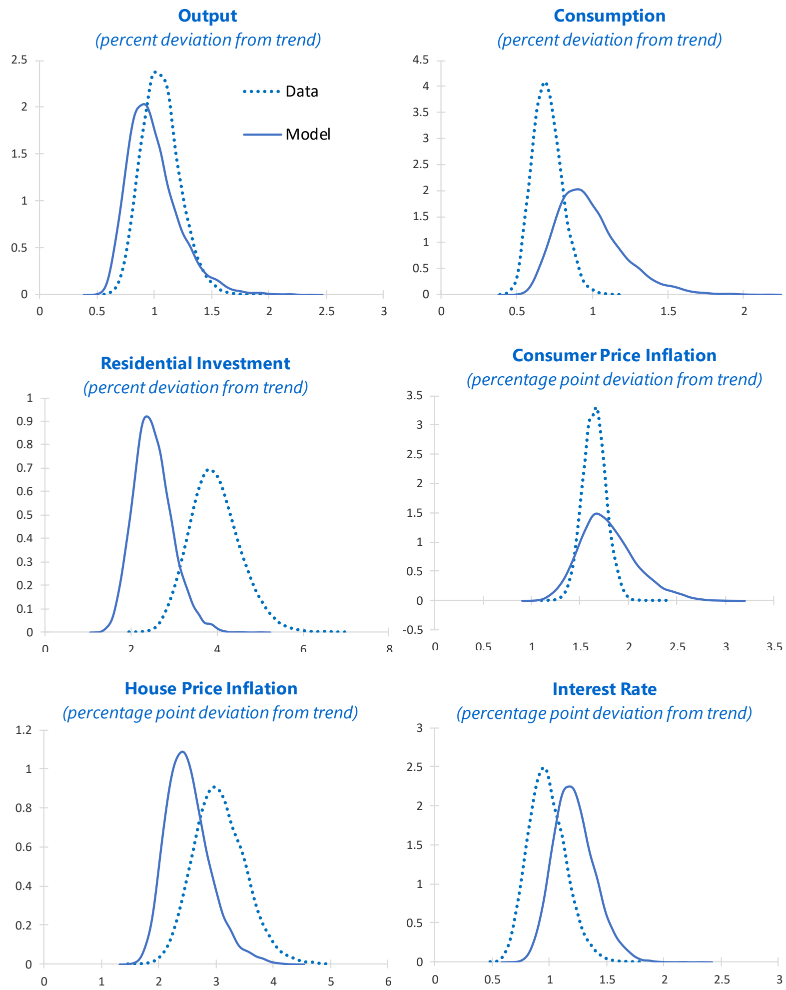
Table 2. Estimated Parameters

Parameter	Description	Prior Distribution	Posterior Mean	Posterior [10%, 90%]
σ	Elasticity of substitution (consumption/labor)	$\beta(1, 0.05)$	1.05	[0.97, 1.12]
ψ	Elasticity of substitution (labor)	$\Gamma(2, 0.1)$	1.97	[1.81, 2.13]
h	Habit persistence	$\beta(0.5, 0.05)$	0.69	[0.67, 0.71]
ω	Share of borrowers	$\beta(0.3, 0.05)$	0.61	[0.59, 0.63]
ζ	Elasticity of substitution (foreign)	$\Gamma(1,0.05)$	1.13	[1.06, 1.21]
η	Elasticity of substitution (domestic/foreign)	$\Gamma(1,0.05)$	1.09	[1.01, 1.17]
ϵ	Elasticity of substitution (domestic goods)	$\Gamma(4,0.1)$	4.05	[3.89, 4.21]
ρ_r	Monetary policy rule: Interest smoothing	$\beta(0.8,0.05)$	0.76	[0.72, 0.79]
ϕ_π	Monetary policy rule: Inflation reaction	$\Gamma(2, 0.1)$	2.10	[1.83, 2.36]
ϕ_y	Monetary policy rule: Output reaction	$\Gamma(0.2, 0.05)$	0.21	[0.13, 0.29]
θ_C	Calvo parameter (consumption)	$\beta(0.5,0.1)$	0.71	[0.67, 0.74]
θ_H	Calvo parameter (housing)	$\beta(0.5,0.1)$	0.50	[0.47, 0.54]
ι_C	Inflation inertia (consumption)	$\beta(0.8, 0.05)$	0.80	[0.72, 0.89]
ι_H	Inflation inertia (housing)	$\beta(0.8, 0.05)$	0.79	[0.71, 0.88]
ρ_{a_C}	Persistence (technology in consumption sector shock)	$\beta(0.5,0.1)$	0.56	[0.50, 0.62]
ρ_{a_H}	Persistence (technology in housing sector shock)	$\beta(0.5,0.1)$	0.52	[0.47, 0.56]
ρ_{c^*}	Persistence (foreign consumption shock)	$\beta(0.5,0.1)$	0.60	[0.50, 0.70]
ρ_{μ_C}	Persistence (consumption cost-push shock)	$\beta(0.5,0.1)$	0.82	[0.77, 0.86]
ρ_{μ_H}	Persistence (housing cost-push shock)	$\beta(0.5,0.1)$	0.56	[0.47, 0.66]
ρ	Persistence (housing preference shock)	$\beta(0.5,0.1)$	0.93	[0.92, 0.94]
ρ_G	Persistence (government spending shock)	$\beta(0.5,0.1)$	0.64	[0.58, 0.70]
σ_{a_C}	Std dev: Productivity in consumption sector shock	$\Gamma^{-1}(1, 2)$	1.09	[0.67, 1.51]
σ_{a_H}	Std dev: Productivity in housing sector shock	$\Gamma^{-1}(1, 2)$	0.79	[0.18, 1.38]
σ_r	Std dev: Monetary policy shock	$\Gamma^{-1}(1, 2)$	0.18	[0.11, 0.24]
σ_{c^*}	Std dev: Foreign consumption shock	$\Gamma^{-1}(1, 2)$	1.95	[1.21, 2.67]
σ_{μ_C}	Std dev: Consumption cost-push shock	$\Gamma^{-1}(1, 2)$	0.50	[0.30, 0.69]
σ_{μ_H}	Std dev: Housing cost-push shock	$\Gamma^{-1}(1, 2)$	1.36	[0.18, 2.44]
σ	Std dev: Housing preference shock	$\Gamma^{-1}(1, 2)$	2.19	[1.30, 3.11]
σ_g	Std dev: Government spending shock	$\Gamma^{-1}(1, 2)$	0.55	[0.34, 0.76]

Model Fit

The estimated model does a good job at explaining the volatility seen in historical data. The policy experiments that follow rely on policymakers setting policy instruments that minimize the variance of several key variables. As such, the model should be able to adequately capture the volatility seen in data observed over history. Simulated data from the estimated model have comparable standard deviations to those seen in historical data, suggesting that the model fits the data reasonably well (figure 3).[7]

Figure 1. Model Fit: Estimated Standard Deviations



Source: Staff estimates.

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[7] The standard deviations in historical data are estimated using a vector-autoregressive model (VAR) that uses the same sample period and data as the DSGE model. The VAR includes 4 lags and is simulated 1000 times using bootstrapping methods. In the chart, the uncertainty around the model and data estimates reflects both parameter and shock uncertainty.

IV. POLICY OBJECTIVES

This section specifies the objectives of the central bank, the macroprudential authority, and the tax authority.

Central Bank Policy

The central bank is given the objective of stabilizing inflation and output and aims to minimize the loss function:

$$L^{cb} = \frac{1}{(\Omega_{\pi}^{cb}+\Omega_{y}^{cb}+\Omega_{\Delta r}^{cb})}\left\lfloor \Omega_{\pi}^{cb}\sigma_{\pi_c}^{2} + \Omega_{y}^{cb}\sigma_{y}^{2} + \Omega_{\Delta r}^{cb}\sigma_{\Delta r}^{2}\right\rfloor \tag{29}$$

and where σ^2 represents the asymptotic variance of consumer-price inflation (π_c), output (y), and changes in the policy interest rate (r). The weights Ω^{cb}characterize the policymaker's preferences over these variables, with $\Omega_{\pi}^{cb}, \Omega_{y}^{cb}, \Omega_{\Delta r}^{cb} \geq 0$. As discussed in Angelini et al (2014), a positive $\Omega_{\Delta r}^{cb}$ is warranted to avoid excessive volatility in the policy interest rate.

Macroprudential Policy

Modelling the objectives of macroprudential policy is difficult because systemic risk can come in a variety of forms and most models do not have a specific proxy for it. Following Angelini et al (2014), this paper assumes that the macroprudential authority reacts to the "abnormal" behavior of credit, where abnormal behavior is determined with respect to the level of economic activity. Thus, the key argument in the macroprudential authority's loss function is the debt-to-GDP ratio (z). Like the central bank, the macroprudential authority is also concerned with the variability of its policy instrument, the LTV ratio.

$$L^{mp} = \frac{1}{(\Omega_{z}^{mp}+\Omega_{\Delta LTV}^{mp})}\left\lfloor \Omega_{z}^{mp}\sigma_{z}^{2} + \Omega_{\Delta LTV}^{mp}\sigma_{\Delta LTV}^{2}\right\rfloor \tag{30}$$

where $\Omega_{z}^{mp}, \Omega_{\Delta LTV}^{mp} \geq 0$. Note that the symmetric nature of the loss function implies that the macroprudential authority dislikes both excessively high leverage and excessively low leverage. Here, it is assumed that low leverage can result in a credit crunch with adverse feedback effects on economic activity and ultimately financial stability.

Tax Policy

The property-tax authority is concerned with housing affordability. As with the objectives of the macroprudential authority, there are a variety of indicators of housing affordability that can be considered in practice. There are several relevant aspects in dealing with affordability. The first is making housing cheaper for vulnerable populations which, in the long term, depends more on supply responses to rising demand. The second is one of dealing with price/affordability stability from a short-term, demand-side perspective. This is a worthy objective since large fluctuations can have adverse welfare consequences. The measure of housing affordability included in the tax authority's loss function is the house-price-toincome ratio (u). Like the other policymakers, the tax authority is concerned about the variability of its policy instrument, the property-transfer tax rate, TAX.

$$L^{tp} = \frac{1}{\left(\Omega_u^{tp} + \Omega_{\Delta TAX}^{tp}\right)} \left[\Omega_u^{tp} \sigma_u^2 + \Omega_{\Delta TAX}^{tp} \sigma_{\Delta TAX}^2\right] \quad (31)$$

with $\Omega_u^{tp}, \Omega_{\Delta TAX}^{tp} \geq 0$. Note that the tax rate can be applied to either all home purchases or only to those houses purchased by savers that are not subject to the collateral constraint.

The savers in the economy encompass nonresident homebuyers. Assuming nonresident homebuyers are not collateral constrained, they will not be subject to LTV limits imposed by the macroprudential authority. Nonresidents of Canada are less likely to have access to mortgage loans in Canada and are more likely to purchase houses with cash. As such, from a modelling perspective, nonresident homebuyers are encompassed by the savers in the economy that are not subject to collateral constraints.

Overall objectives

The overall loss function for the economy is a simple weighted average of the loss functions of the three policy-setting authorities:

$$L = \Psi^{cb} L^{cb} + (1 - \Psi^{cb})(\Psi^{mp} L^{mp} + (1 - \Psi^{mp}) L^{tp}) \quad (32)$$

where the weights associated with the individual loss functions, Ψ^{cb}, Ψ^{mp}, are between 0 and 1. Thus, the total loss of the economy depends on the weights associated with the objectives of monetary policy, macroprudential policy, and property-transfer tax policy.

Optimal Policy

The authorities are assumed to select policy rules that minimize the total loss of the economy in an optimal way. Optimal policy rules determine the paths of the policy interest rate, the LTV ratio, and the property tax rate that minimize the intertemporal version of the total loss function (4) (see Woodford, 2003). In this case, the three policy instruments will be functions of all variables in the model (and Lagrange multipliers). In the analysis that follows, the weights in the individual loss functions of each policymaker are fixed at values that are standard in the monetary policy and macroprudential policy literature, and the standard deviation of monetary policy shocks is set to zero.[8] All other parameters are set to their estimated values. The baseline weights in the loss functions (30, 31, and 32) are:

$$\Omega_\pi^{cb} = 1,\ \Omega_y^{cb} = 0.5,\ \Omega_{\Delta r}^{cb} = 0.1;\ \Omega_z^{mp} = 1,\ \Omega_{\Delta LTV}^{mp} = 0.1;\ \Omega_u^{tp} = 1,\ \Omega_{\Delta TAX}^{tp} = 0.1$$

[8] See, for example, Angelini and others (2014). Optimized simple policy rules have also been examined and the results are qualitatively very similar to those found in the context of optimal rules. These results are available from the author on request.

Six different optimal policies are examined, depending on which of the four policy instruments (interest rate, LTV, property-transfer tax rate, and property-transfer tax rate on savers only) are operating. When a policy instrument is not in operation (*LTV* or *TAX*), the policymaker responsible for that instrument is assumed to be "passive" in the sense that it relies on the other authorities to adjust their instruments to minimize the total loss in the economy, including the objectives of all other policymakers. A summary of the optimal policy scenarios examined are displayed in table 3.

Table 3. Policy Options

	Active Policy Instrument(s)
Monetary Policy	r
LTV Policy	r, LTV
Tax Policy	r, TAX
Tax Policy (savers)	r, TAX (savers)
ALL Policies	r, LTV, TAX
ALL Policies (savers tax)	r, LTV, TAX (savers)

For robustness, three different scenarios are also examined, depending on how much weight each policymaker's objective has in the overall loss function of the economy. In the baseline specification, the central bank's loss function has a 50 percent share in overall loss, with the remainder of total loss allocated evenly across the objectives of the macroprudential and tax authorities. Two other specifications are examined, one in which overall loss has more weight on managing household debt levels than affordability and the other in which overall loss has more weight on managing affordability than on household debt (see table 4).

Table 4. Focus of Objectives

Baseline	$\Psi^{cb} = 0.5,$	$\Psi^{mp} = 0.5$
Debt Focus	$\Psi^{cb} = 0.5,$	$\Psi^{mp} = 0.9$
Affordability Focus	$\Psi^{cb} = 0.5,$	$\Psi^{mp} = 0.1$

V. Results

Some policies satisfy objectives better than others. The optimal policy frontiers for each model are displayed in figure 4.[9] The results suggest:

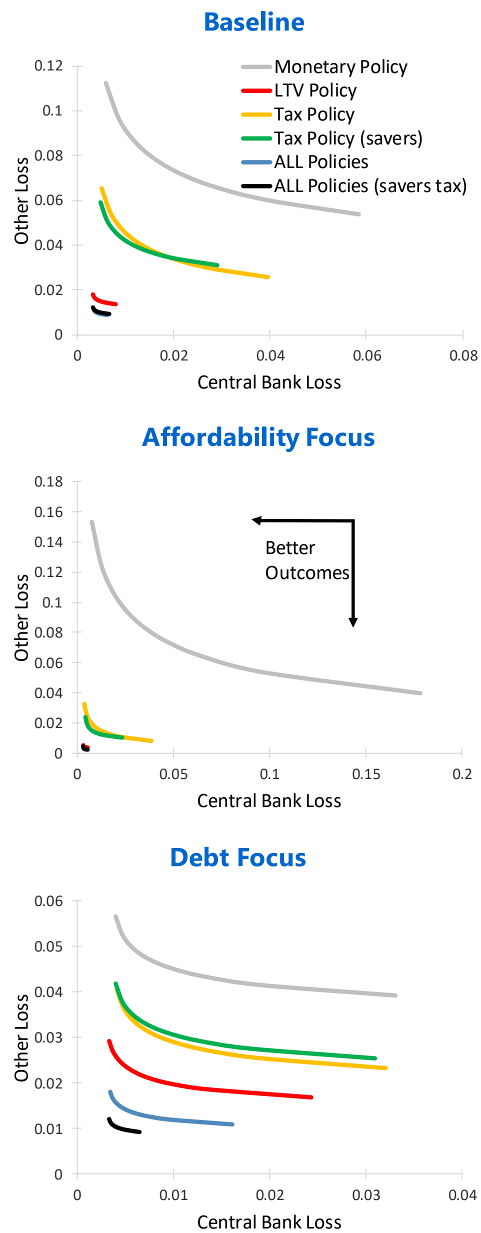
- *Having more policy instruments leads to better outcomes.* Regardless of the overall focus of objectives, monetary policy alone leads to higher losses than when monetary policy is augmented with LTV and/or tax policy. Having all policies in operation leads to even greater gains.

- *Macroprudential policy is better than tax policy.* LTV policy reduces overall loss by more than tax policy, regardless of whether the tax is applied to all homebuyers or only to savers that are not subject to collateral constraints.

- *The 'best' policies depend on the focus of objectives.* In the baseline specification, applying all policy instruments leads to slightly better outcomes than when tax policy is not operating. When the focus of objectives is on households' debt and all policies are operating, a tax on savers is better than a tax on all homebuyers. However, when the focus of objectives is on affordability and all policies are operating, a tax on all homebuyers is very similar to imposing a tax on savers alone. Overall, the 'best' policy from a loss-minimization perspective depends on the focus of policymakers' objectives. It is also worthwhile to evaluate the viability of each policy with respect to the volatility of the policy instrument(s) over the normal course of the business cycle.

Figure 2. Optimal Policy Frontiers

(Ψ^{cb} ranging between 0 and 1)



Source: Staff Estimates

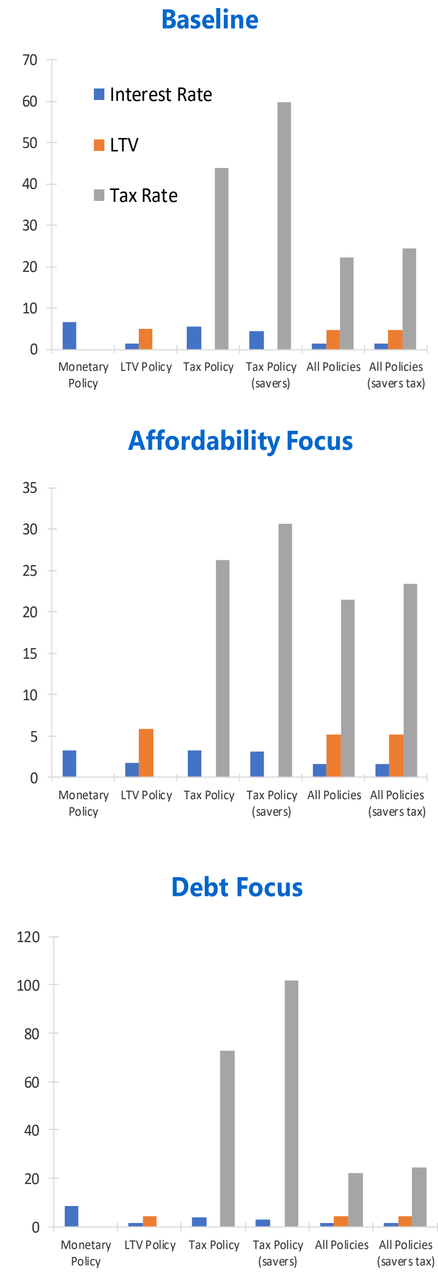
[9] Other loss is simply the weighted average of the macroprudential and tax authorities' loss functions.

The results show that the volatility of tax rates required to satisfy objectives is very high relative to when monetary policy and/or LTV policy are operating alone (figure 5). In the baseline specification, for example, the asymptotic standard deviation of the property tax rate is about 45 percent, suggesting that a 99 percent confidence interval around the typical dynamics of the economy would require the tax rate to swing by around 150 percentage points around its steady state level. This is clearly excessive, requiring negative tax rates in downturns and rates above 100 percent in expansions. Tax rate volatility is even higher when the taxes are targeted at savers alone, irrespective of the focus of policymakers' objectives.

Figure 6 displays the volatility of property-tax rates as the share of savers in the economy increases. The results show that property-tax policy targeted at savers alone leads to greater volatility in taxes than a tax that targets all homebuyers. Irrespective of whether a property-transfer tax is applied on its own or in conjunction with LTV policy, the volatility of the tax rate is higher when it is applied only to savers. Indeed, the volatility of the property tax rate is particularly high when taxes are targeted at savers and the share of savers in the economy is low. Tax rate volatility tends to decline when the share of savers increases, but, irrespective of the share of savers, targeting a narrower set of homebuyers leads to greater volatility in the tax rate than when the tax targets all homebuyers.

Figure 3. Instrument Volatility

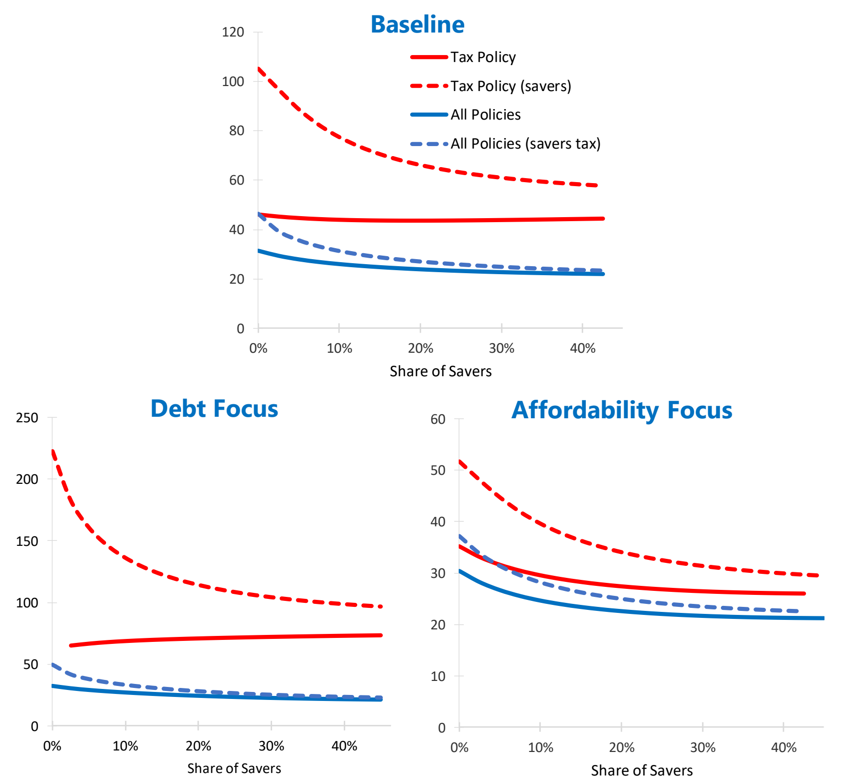
(standard deviation, percent)



Source: Staff estimates

Figure 4. Tax Volatility and the Share of Savers

(standard deviation, percent)



Source: Staff Estimates

VI. Summary and Conclusion

This paper examines the effectiveness of LTV limits versus property-transfer taxes in achieving policymakers' overall objectives, including macroeconomic and financial stability, and housing affordability. The results show that multiple policy instruments can lead to better outcomes when policymakers face of multiple policy objectives. Faced with a choice between an LTV limit or using a property-transfer tax, policymakers should choose an LTV limit because it can be more effective in achieving desired objectives. In this framework, deploying multiple policy instruments can lead to excessive volatility in property-tax rates and this problem is exacerbated when the taxes are targeted at a narrower base of homebuyers.

Targeting property-transfer taxes at a broader-set of homebuyers is more effective than measures aimed solely at savers (or nonresident home buyers). The results suggest that targeting property tax rates at savers alone—instead of all homebuyers—would require greater swings in tax rates to achieve desired objectives. To the extent that nonresident homebuyers are not collateral constrained, this suggests that property-transfer taxes targeted at them would require greater swings in tax rates than if the taxes were targeted at all homebuyers. Recent data show that that nonresident homeowners represent only a small fraction of the existing housing stock in Vancouver and Toronto, potentially limiting the effectiveness of the BC and Ontario property transfer taxes on nonresidents. As such, the evidence presented here suggests that to the extent that speculators are found to be driving excessive house price inflation and raising housing affordability concerns, tax measures targeting the speculative demand of residents and non-residents alike would likely be more effective than targeting demand from nonresidents alone.

The model used in this paper is stylized and very simple. Like most macroeconomic models, the model used here does not explicitly include the key distortion that macroprudential policy should address—systemic risk. This partly reflects the elusive nature of this risk and difficulties in modeling it in a rigorous way. Likewise, the impact of housing affordability on the welfare of consumers has not been studied in models of the type used here. As such, a purely welfare-based analysis of the policies discussed is beyond reach for now, but it remains a fruitful avenue for future research. In this sense, this analysis is limited to using ad-hoc objective functions for policymakers instead of using more micro-founded, welfare-based analysis. The policy experiments in this paper also assume that policymakers cooperate to achieve the overall objectives for the economy. In future work, this assumption could be relaxed to assess optimal policy when policymaker's do not cooperate and only focus on their own objectives. Future work could also explicitly model the behavior of nonresident homebuyers instead of using the assumption that they behave in the same why as domestic savers.

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