Price Level Targeting and Financial Frictions in a Small Open Economy: Welfare Analysis.

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- The maintenance of price stability is established as the principal objective of most central banks worldwide.

- Inflation targeting, aiming at bringing inflation back to target, has been proved successful in sustaining low inflation and low inflation volatility.

- However, some central banks have recently started investigating the costs and benefits of defining the target in terms of a price level path rather than an inflation rate.

- In particular the Bank of Canada is seriously assessing the desiderability of a price-level path targeting in view of the renewal of its agreement on the monetary policy framework with the Government of Canada in 2011.

We quantify the benefits of price level targeting relying on a multi-sector small open economy model enriched with credit frictions a la Bernanke, Gertler and Gilchrist (1999).

The analysis is conducted in two steps.

–To provide a quantitative assessment of different sources of business cycle fluctuations we first fit the model to Canadian data using data from 1981:1 to 2007:2 assuming that the central bank targets inflation.

- Second, we characterize the optimal design of monetary policy under the two alternative regime, based on social welfare evaluations. For a fair treatment of the inflation targeting framework we compare the optimal price-level path targeting and inflation targeting rule.

Related Literature

PT vs IT: *Conventional view* (Fisher (1994)) in presence of nominal rigidities, a price level targeting regime would increase both inflation and output volatility in the short-run $\longrightarrow$trade off between long-term price-level variability and short-term volatility of inflation and output gap.

-Svensson (1999) deriving endogenous decision rules, and equilibrium price level and inflation, documented that under rational expectations and (at least) moderate persistence in employment, a price-level targeting path leads to lowers inflation and identical output variability.

- Clarida, Gali and Gertler (1999) and Woodford (1999) also highlights that in a forward-looking model optimal monetary policy under committment is characterized by a stationary price level.

- Vestin (2006) show that also under discretion a price-level targeting is preferred. If the central bank commits to price-level targeting, then, rational expectations become automatic stabilizers.

PT vs IT and nominal assets:

- Meh, Rios-Rull and Terajima (2008) in the presence of nominal government and foreign bonds, an unexpected one percent increase in the price level, generates consistently higher redistribution and more sizeable effects on aggregate output, under inflation targeting than price level targeting.

- Covas and Zhang (2008): in an economy with nominal debt contracts, the output-inflation volatility trade-off criterion suggests that PT is slightly better than IT.

Our Contribution to the Literature

- We compare the two monetary policy regimes relying on welfare evaluations.

- We base our analysis on a medium-scale DSGE model that takes into account several sources of business cycle fluctuations.

Main Distortions in the Model

- **nominal debt contract**

- **price and wage stickiness**

Entrepreneurs

Produce intermediate tradable and non-tradable goods using sector-specific capital and labor services.

$$Y_{i,t} \leq A_{i,t} \left(K_{i,t}\right)^{\alpha_i} \left(H_{i,t}\right)^{1-\alpha_i}, \tag{1}$$

where $i = \{N, T\}$.

As in Bernanke et al. (1999), we assume that entrepreneurs borrow to partly finance their acquisitions of capital used in the production processes.

Since entrepreneurs are ex-ante identical but face idiosyncratic shocks, lending to them involves an **agency problem** and external finance is more expensive than internal funds and the external finance premium depends on the entrepreneur's leverage ratio.

The model contemplates two different sources of external credit finance. For simplicity, we assume that entrepreneurs in the tradable and non-tradable sector have access to different credit markets. Debt is issued in **nominal** terms.

Households

Households have preferences defined over consumption, C_{ht}, and labour supply, H_{ht}.

$$E_0 \sum_{t=0}^{\infty} \beta^t U\left(C_{ht}, H_{ht}\right),$$

$$P_t C_{ht} + \frac{D_{ht}}{R_{t-1}} + \frac{e_t B^*_{ht}}{\kappa_t R^*_t} \leq W_{T,ht} H_{T,ht} + W_{N,ht} H_{N,ht} + D_{ht-1} + e_t B^*_{ht-1} + \Omega_{ht} - \Upsilon_{ht} \quad (2)$$

Households have access to domestic and international financial markets, in which they can buy or sell domestic bonds, D_{ht}, and foreign bonds denominated in foreign currency, B^*_{ht}.

Households:

- supply specialized labor services in a monopolistic manner to employment agencies as in Erceg, Henderson and Levin (2000).

- Households that cannot change their wages index them to the average inflation rate

Firms

Final consumption and investment goods are produced combining tradable, non-tradable and imported goods according to the following CES technology:

$$Z_t^j = \left[\left(\omega_T^j\right)^{\frac{1}{\nu_j}} \left(Y_{T,t}^j\right)^{\frac{\nu_j - 1}{\nu_j}} + \left(\omega_N^j\right)^{\frac{1}{\nu_j}} \left(Y_{N,t}^j\right)^{\frac{\nu_j - 1}{\nu_j}} + \left(\omega_F^j\right)^{\frac{1}{\nu_j}} \left(Y_{F,t}^j\right)^{\frac{\nu_j - 1}{\nu_j}} \right]^{\frac{\nu_j}{\nu_j - 1}}, \tag{3}$$

Z_t^j, with $j = \{C, I\}$, where ω_M^j, ω_N^j, and ω_F^j denote the shares of manufactured, non-tradable, and imported goods in the final good, respectively ($\omega_T^j + \omega_T^j + \omega_F^j = 1$) and $\nu_j > 0$ is the elasticity of substitution between those sectorial output.

Sectorial output is produced aggregating different brands through the Dixit-Stliglitz aggregator.

$$Y_{\varkappa,t} = \left[\int_{o}^{1} (Y_t(z^{\varkappa}))^{\frac{\theta_{\varkappa}-1}{\theta_{\varkappa}}} dz^{\varkappa} \right]^{\frac{\theta_{\varkappa}}{\theta_{\varkappa}-1}}$$

There is a continuum of producers of domestic (tradable and non-tradable) and imported brands $z^{\varkappa} \in [0, 1]$ in each sector $\varkappa = \{N, T, F\}$.

Branding firms

- buy intermediate domestic and foreign homogeneous intermediate inputs,

- slightly differentiate them and sell the products on the market in a competitive manner.

- They set the prices as in Calvo (1983).

- We follow Yung (1996) and assume that firms that cannot change their prices, index last period price to the average inflation rate.

Capital producers use investment goods to produce new capital purchased from entrepreneurs. Due to the adjustment costs, the capital producers face a dynamic problem

$$\max_{I_{i,t},} E_t \sum_{k=0}^{\infty} \beta^t \lambda_{t+k} \Pi^i_{t+k}. \tag{4}$$

where λ_{t+k} is the marginal utility of consumption in period $t+k$. The production of each capital stock yields the following time-t profit function

$$\Pi^i_t = q_{i,t} \left(I_{i,t} \varepsilon_t - S(I_{i,t}, I_{i,t-1})_t \right) - p_{I,t} I_{i,t}. \tag{5}$$

The aggregate stock of capital evolves as follows

$$K_{i,t+1} = \left(I_{i,t} \varepsilon_t - S(I_{i,t}, I_{i,t-1})_t \right) + (1-\delta) K_{i,t}, \tag{6}$$

Monetary Authority

Inflation targeting rule

$$\log\left(\frac{R_t}{R}\right) = \varrho_R \log\left(\frac{R_{t-1}}{R}\right) + \varrho_\pi \log\left(\frac{\pi_t}{\pi \in_{\pi,t}}\right) + \varrho_Z \log\left(\frac{GDP_t}{GDP}\right) + \varepsilon_{Rt}. \tag{7}$$

We define the model's GDP at constant prices as

$$GDP_t = Z_t + p_I I_t + p_T Y^*_{T,t} - SY_{F,t}$$

Estimation

A vector of structural parameters of the model, Λ, describing preferences, technology, the monetary policy rule and the shocks is estimated using Bayesian techniques

1. for given parameter values we solve the model by using standard **first-order** approximation techniques. Then, we use the **Kalman filter** to compute the likelihood $L(\Gamma_t \,|\Lambda)$ for the given sample of data Γ_t , as in Hamilton (1994).

2. we add some informative **priors**, $\varphi(\Lambda)$, into the estimation in order to downweight regions of the parameter space that are widely accepted to be uninteresting.

3. using Bayes's rule, the **posterior distribution** can be written as the product of the likelihood function of the data given the parameters, $L(\Gamma_t \,|\Lambda)$, and the prior, $\varphi(\Lambda)$: $P(\Lambda|\Gamma_t) \propto L(\Gamma_t \,|\Lambda)\varphi(\Lambda)$

- We start by estimating the posterior distribution's mode by maximizing the log posterior function.

- We obtain a random draw of size 500.000 from the posterior distribution using the random-walk Metropolis-Hastings algorithm.

- The posterior distribution of the parameters is then used to draw statistical inference on the parameters themselves or functions of the parameters, such as second moments.

Estimations

Parameters:

T$>$ NT: Investment Adj. Cost, Risk Premium Elasticity, Stickiness

Shocks:

higher persistence: financial shocks

higher std: government spending, investment specific, preoductivity in tradable

Sources of Business Cycle Fluctuations in Canada

- **Financial Shocks** and **Investment Specific Shocks:** main sources of macro-economic fluctuations

- **Monetary Policy**: explains part of the variability in inflation and external financing cost

- **Technology Shocks**: generate part of the variability in production

- **Foreign Interest Rate**: tradable output, real exchange rate, foreign debt, risk premium in tadable

Welfare and Shocks

Welfare and Shocks: estimated rule

At	An	R	IT	X	G	Gt	Gn	Rs	Pis	Ys
2.76	**16.83**	0.00	0.03	9.51	**21.79**	5.95	**28.45**	6.69	0.02	7.97
supply			**demand**			**financial**			**foreign**	
19.59			31.33			34.4			14.68	

- demand and financial shocks have a bigger impact on welfare

Welfare Analysis

We limit our attention to simple, optimal, operational interest rate rules of the form

$$R_t = \Theta(X) \ .$$

Simplicity requires X to include easily observable macroeconomic indicators.

Welfare Measure

We rely on utility-based welfare calculations, assuming that the benevolent monetary authority maximizes the utility of households, subject to the model's equilibrium conditions. We define $V^*_{i,0}$ as the individual welfare level associated with the optimal rule

$$V^*_{i,0} \equiv E_0 \left[\sum_{j=0}^{\infty} \beta_i^j U(c^*_{i,j}, L^*_{i,j}) \right] \ ,$$

where $c^*_{i,j}$and $L^*_{i,j}$ denote the contingent planes of consumption and labor, respectively, under the optimal policy regime. Following previous literature, we start evaluating welfare conditional on the initial state being the non stochastic steady state.

Distortions and Monetary Policy

1. **Price Stickiness**: variations in inflation deliver higher cost of price dispersion.

- A strong anti inflationary stance reducing the cost of price dispersion could increase economic activity and welfare.

2. **Debt contracts in nominal terms**: generate unnecessary redistribution of wealth between borrowers and lenders as a result of unexpected changes in the price level.

- If entrepreneurs borrow from households to finance part of their capital expenditure, variations in the price level, generating distortions in the allocation of resources, affects economic activity.

- Thus, stability around a price level path could minimize the allocative distortion generated by the debt-deflation channel and improve welfare.

Optimal Inflation Targeting Rule

Table 1.a.Welfare Cost of ad-hoc rules IT

	welfare	welfare cost
ϱ_π=6.5, ϱ_y=0.5,ϱ_R=0.8138	-2.2810	$\mathbf{-0.749}$
Inflation stabilization	-2.2820	-0.811
ϱ_π=6.5, ϱ_y**=0,**ϱ_R=0.8138	-2.2814	-0.772
ϱ_π=6.5, ϱ_y =0.5, ϱ_R**=0**	-2.2819	-0.804
ϱ_π=0.0277, ϱ_y=0.4722,ϱ_R=0.8138	-2.2858	$\mathbf{-1.058}$

Welfare loss in terms of consumption as percentage of
Cconsumption level at the steady-state(multipliedby10^2)

- a strict anti inflationary stance is not optimal

- Optimal IT 40% less consumption loss w.r.t. estimated rule

Inflation Targeting Rule vs Price Level Targeting

PT vs IT

	IT	PT
ϱ_R=0.8138	ϱ_π=6.5, ϱ_y=0.5	ϱ_P=2.5, ϱ_y=1.5
welfare	-2.2810	-2.2803
$welfare\ cost$	-0.749	-0.700

Price Level Targeting performs better than an IT rule (10% lower cost)

PT increases welfare through the introduction of history dependence in monetary policy (expectation channel).

$\Longrightarrow$ PT 50% better than estimated rule

PT vs IT

	IT	PT
ϱ_R=0	ϱ_π=20, ϱ_y=1.5	ϱ_P=5, ϱ_y=3
welfare	-2.2814	-2.2803
$welfare\ cost$	-0.776	-0.702

$\Longrightarrow$ welfare gains of adopting PT are sligltly higher when the central bank doesn't respond to the lagged interest rate.

Cost of Price dispersion: IT vs PT , ϱ_R=0.8138

	ϱ_π=6.5, ϱ_y=0.5	ϱ_P=2.5, ϱ_y=1.5	ϱ_π=0.4722, ϱ_y=0.0277
$\sigma(st)$	0.01	0.01	0.01
$\mu(st)$	1.0019	1.0019	1.0034
$\sigma(sn)$	0.00	0.00	0.00
$\mu(sn)$	1.0004	1.0005	1.0010
$\sigma(sf)$	0.00	0.00	0.00
$\mu(sf)$	1.0029	**1.0026**	1.0056
$\sigma(swt)$	0.00	0.00	0.00
$\mu(swt)$	1.0017	**1.0016**	1.0035
$\sigma(swn)$	0.00	0.00	0.00
$\mu(swn)$	1.0009	1.0009	1.0020

$\Longrightarrow$ PT slightly lower cost of price dispersion.

Level effect and stabilization effect IT vs PT , ϱ_R=0.8138

	ϱ_π=6.5, ϱ_y=0.5	ϱ_P=2.5, ϱ_y=1.5	ϱ_π=0.4722, ϱ_y=0.0277
$\sigma(c)$	1.73	1.73	1.73
$\mu(c)$	0.6610	0.6612	0.6595
$\sigma(rr)$	0.60	**0.49**	0.57
$\mu(rr)$	1.0091	1.0091	1.0091
$\sigma(\pi)$	0.79	0.80	1.26
$\mu(\pi)$	1.0090	1.0089	1.0091
$\sigma(y)$	3.05	**2.83**	3.04
$\mu(y)$	1.0851	1.0853	1.0833
$\sigma(R)$	0.95	**0.86**	1.16
$\mu(R)$	1.0181	1.0181	1.0183

PT $\Longrightarrow$ lower variability of the real interest rate, output and nominal interest rate & higher consumption and output level.

In the presence of nominal debt, agents face **uncertainty** regarding the repayment of the debt.

A monetary policy that reduces variations in the real interest rate, **reduces** the distortionary redistribution of wealth induced by unexpected variations in the price level.

$\rightarrow$ **stabilization** of the real interest rate, reduces the risk embedded in the nominal contract and increases welfare.

PT performs better than IT in terms of social welfare since delivers lower variability of the **real interest rate** (nominal debt distortion) it slightly reduces the cost of **price dispersion** (price stickiness).

Uncertainty and Welfare

Uncertainty and Welfare

	HP - inf	mean	HP - sup
ϱ_π=6.5, ϱ_y=0.5	-2.2743 (0.3%)	-2.2810	-2.3003 (0.85%)
ϱ_P=2.5, ϱ_y=1.5	-**2.2741**(0.27%)	-2.2803	-**2.2978** (0.77%)
ϱ_π=0.4722, ϱ_y=0.0277	-2.2756 (0.45%)	-2.2858	-2.3159 (1.32%)
inflation stabilization	-2.2746 (0.32%)	-2.2820	-2.3027 (0.91%)

ϱ_R=0.8138

Welfare implications of getting wrong parameters' and shocks' estimates: PT performs better under uncertainty (lower variability in welfare)

Conclusions

We assess the performance of Inflation Targeting and Price Level Targeting Rules in a small open economy with credit frictions.

Optimal Rules reduce the welfare cost of business cycle fluctuations of about 40% (IT) - 50% (PT).

PT performs better than IT in terms of social welfare since delivers lower variability of the real interest rate (nominal debt distortion) it slightly reduces the cost of price dispersion (price stickiness).

PT implies lower variability in the welfare cost under uncertainty.

EXTRA SLIDES

Shocks and Optimal Policy

PT vs IT NOMINAL (blocks of shocks)

ALL	SUPPLY	DEMAND	FINANCIAL	FOREIGN
IT	-2.2719	$\mathbf{-2.2747}$	-2.2732	$\mathbf{-2.2703}$
	-0.147	-0.332	-0.233	-0.042
PT	$\mathbf{-2.2712}$	-2.2748	$\mathbf{-2.2729}$	-2.2704
	-0.101	-0.339	-0.214	-0.048

Welfare loss in terms of consumption as percentage of Cconsumption level

Optimal PT better than optimal IT under supply (31%) and financial shocks (8.15%) and slightly worse under demand (2%) and foreign (12.5%) shocks.

Stabilization effect IT

	$\sigma(c)$	$\sigma(rr)$	$\sigma(\pi)$	$\sigma(R)$	$\sigma(y)$	$\sigma(vf)$	$\mu(c)$
			supply				
IT	0.89	0.43	0.19	0.43	1.65	0.52	0.6630
PT	**0.86**	**0.15**	0.28	0.08	1.40	0.48	**0.6631**
			demand				
IT	**1.04**	**0.31**	0.74	0.75	1.21	0.71	**0.6621**
PT	1.05	0.38	0.74	0.79	1.10	0.71	0.6620
			foreign				
IT	0.46	**0.12**	0.09	**0.16**	1.27	0.49	0.6632
PT	0.46	0.14	**0.06**	0.17	1.25	0.49	0.6632
			financial				
IT	0.96	0.5	0.18	0.17	1.87	0.74	0.6626
PT	0.96	**0.24**	0.13	0.26	1.81	0.73	**0.6627**

$\Longrightarrow$ the rule that performs better delivers lower variability of the real interest rate, lower variability of consumption and higher consumption level

Inflation and Optimal Policy

What is the probability of inflation being more than 1% above or below target (2% annual) under the alternative rules?

Inflation: 200 periods, average over 500 simulations for each rule

	above	1% above	below	1% below
IT	31.84%	1.49%	**68.16%**	4.98%
PT	**69.15%**	13.93%	30.85%	1.99%
$estimated$	73.13%	31.84%	26.87%	10.45%

under PT inflation is more likely to be more than 1% above target!

Entrepreneurs in the non tradable sector borrow from domestic intermediaries Thus, the demand for capital in the non-tradable sector should satisfy the following optimality condition:

$$E_t f_{N,t+1} = E_t \left[\Psi_N(\cdot) R_t / \pi_{t+1} \right], \tag{8}$$

where $E_t \left(R_t / \pi_{t+1} \right)$ is an expected real interest rate, and the external finance premium is

$$\Psi_N(\cdot) = \Psi_N \left(\frac{X_{N,t+1}}{q_{N,t} K_{N,t+1}} \right), \tag{9}$$

with $\Psi'_N(\cdot) < 0$ and $\Psi_N(1) = 1$.

While entrepreneurs that produce tradable goods rise funds on the international credit market. Thus, the demand for capital in the tradable sector should satisfy the following optimality condition:

$$E_t f_{T,t+1} = E_t \left[\frac{R*_t}{\pi^*_{t+1}} \frac{s_{t+1}}{s_t} \Psi_T(\cdot) \right], \tag{10}$$

where the external finance premium is given by

$$\Psi_T(\cdot) \equiv \Psi_T \left(\frac{X_{T,t+1}}{q_{T,t} K_{T,t+1}} \right), \tag{11}$$

with $\Psi'_T(\cdot) < 0$ and $\Psi_T(1) = 1$.

The foreign bond return rate, $\kappa_t R_t^*$, depends on the foreign interest rate R_t^* and a country-specific risk premium κ_t, that is increasing in the foreign-debt-to-GDP ratio

$$\kappa_t = \exp\left(-\varkappa \frac{e_t \tilde{B}_t^*/P_t^*}{P_t Y_t}\right), \tag{12}$$

The uncovered interest rate parity (UIP) condition derived from first order conditions is such that

$$\frac{R_t}{\kappa_t R_t^*} = \frac{e_{t+1}}{e_t}. \tag{13}$$