Designing a Simple Loss Function for Central Banks: Does a Dual Mandate Make Sense?

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    - As documented in Svensson (2010), many central banks became "inflation targeters" to strengthen credibility and facilitate accountability, setup of ECB one prominent example

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  - Woodford optimal mandate/loss function: $L_t = (\pi_t^a - \pi^*)^2 + \lambda x_t^2$ with $\lambda = 0.048$
  - But Woodford studied a small calibrated model - what goes in an estimated empirically realistic model?

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- Results hold up when allowing for realistic measurement errors in the output gap, and when we introduce interest rate smoothing to capture the observed gradualism in policy behavior
- Given the similarity of parameters and shocks in estimated models of other advanced economies, our results should be relevant for other CBs (e.g. ECB)

Presentation outline

- Our exercise
- Model environment
- Benchmark results
- Robustness of results
- Concluding remarks

Our Exercise

Quadratic approximation of utility and Ramsey policy

- Benigno and Woodford (2006) demonstrated that households utility function could be written as:

$$\sum_{t=0}^{\infty} \mathrm{E}_0 \left[\beta^t U(X_t) \right] \simeq constant - \sum_{t=0}^{\infty} \mathrm{E}_0 \left[\beta^t X_t' W^{society} X_t \right], \qquad (1)$$

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- We adopt unconditional expectations operator for welfare evaluation, so the loss under Ramsey optimal policy is

$$Loss^{Ramsey} = \mathrm{E} \left[\left(X_t^{Ramsey} \left(W^{society} \right) \right)' W^{society} \left(X_t^{Ramsey} \left(W^{society} \right) \right) \right]$$

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- Measure welfare costs by comparing loss under mandate with Ramsey:

$$CEV = 100\left(\frac{Loss^{obj} - Loss^{Ramsey}}{\bar{C}\left(\frac{\partial U}{\partial C}\big|_{s.s.}\right)}\right), \quad (3)$$

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  - Hence, CEV is increase in SS C that make households in expectation equally well-off under simple mandate as under Ramsey policy

Model environments

Key features of model structure

- Both EHL and SW models features monopolistic competition in both goods and labour markets
- Nominal price and wage stickiness:
  - Calvo price contracts, indexation of non-optimizers $P_t^{NO} = \Pi_{t-1}^{\iota_p} \Pi^{1-\iota_p} P_{t-1}^{NO}$
  - Calvo wage contracts, indexation of non-optimizers $W_t^{NO} = \gamma \Pi_{t-1}^{\iota_w} \Pi^{1-\iota_w} W_{t-1}^{NO}$
- SW model also features real rigidities as in CEE (2005):
  - External habit persistence in consumption
  - CEE type of investment adjustment costs
  - Variable capital utilization
  - Kimball (1995) aggregator; lower slope of price and wage schedules for given Calvo parameter

Model environments
Shock structure

- Total factor productivity (ε_t^a) shocks that affect potential output.
- Two "inefficient" shocks (do not affect y_t^{pot}):
  - ε_t^p - "price markup" shock
  - ε_t^w - "wage markup" shock
  - Pay particular attention to what extent the two cost-push shocks drive our results
- SW model also includes three additional shocks; Investment-specific (ε_t^i), Risk-shock on financial assets (ε_t^b), Government-NX (ε_t^g)

Parameterization

Parameters adopted from Smets and Wouters

- We use the posterior mode parameters from SW07 (Tables 1.A-B in their paper)
- Make assumptions on adjustment functions and how we introduce the shocks so that linearized representation of our model coincides exactly with SW07

- The Erceg, Henderson and Levin (2000) model similar to SW model, but omits physical capital and habit formation in consumer preferences. Key equations:

$$\pi_t^p = \beta \mathrm{E}_t \pi_{t+1}^p + \kappa_p y_t^{gap} + \vartheta_p \omega_t^{gap}, \quad (4)$$

$$\pi_t^\omega = \beta \mathrm{E}_t \pi_{t+1}^\omega + \kappa_w y_t^{gap} - \vartheta_w \omega_t^{gap}, \quad (5)$$

$$\omega_t^{gap} \equiv \omega_{t-1}^{gap} + \pi_t^\omega - \pi_t^p - \Delta\omega_t^n. \quad (6)$$

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  - Not possible to simultaneously stabilize y_t^{gap}, π_t^p and π_t^w.
  - Example, in response to changes in ω_t^n due to ε_t^a, perfect stabilization of the output gap y_t^{gap} requires a change in the real wage ω_t, and thus a change in either prices or nominal wages (or both). But π_t^p and π_t^w cannot change if both y_t^{gap} and ω_t^{gap} are unchanged.

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$$L_t^R = -\frac{1}{2}\left[\left(\pi_t^p\right)^2 + \lambda_w^{opt}\left(\pi_t^w\right)^2 + \lambda_y^{opt}\left(y_t^{gap}\right)^2\right], \qquad (7)$$

where $\lambda_w^{opt} \equiv \frac{\theta_\omega(1-\alpha)}{\theta_p}\frac{\vartheta_p}{\vartheta_w}$ and $\lambda_y^{opt} \equiv \left(\sigma_c + \frac{\sigma_l+\alpha}{1-\alpha}\right)\frac{\vartheta_p}{\epsilon_p}$.

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- But, assume that the CB is assigned the following simple mandate,

$$L_t^{CB} = -\frac{1}{2}\left[\left(\pi_t^p\right)^2 + \lambda_y\left(y_t^{gap}\right)^2\right], \qquad (8)$$

which does not include π_t^w.

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- This equation implies that perfectly stabilizing y_t^{gap} leads to perfect stabilization of $\vartheta_w \pi_t^p + \vartheta_p \pi_t^\omega$, where a higher weight is attached to the inflation rate for which nominal rigidities are most severe.
  - Thus, stabilizing y_t^{gap} mitigates the welfare costs of nominal rigidities in both goods and labor markets.

- We start with a standard inflation - output based function

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Benchmark results in SW Model

Results for standard inflation-output mandate

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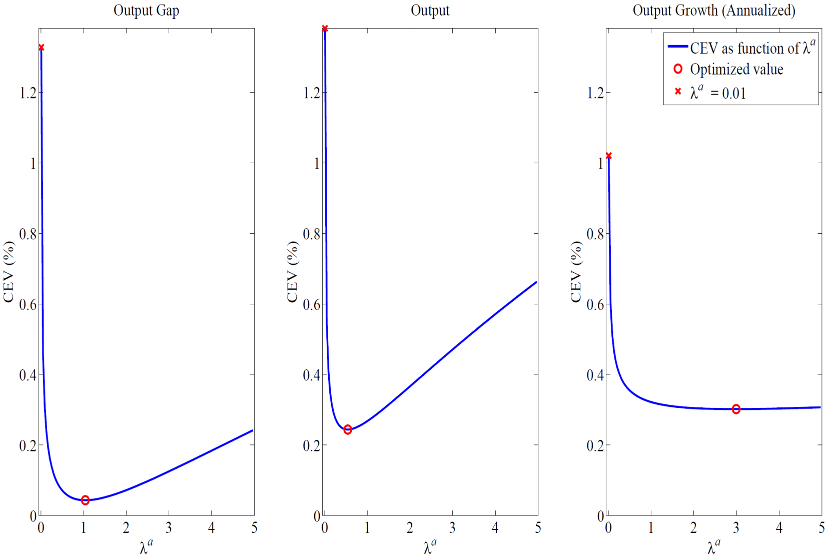
- CEV as function for λ^a for the alternate x_t measures are reported in Figure 1

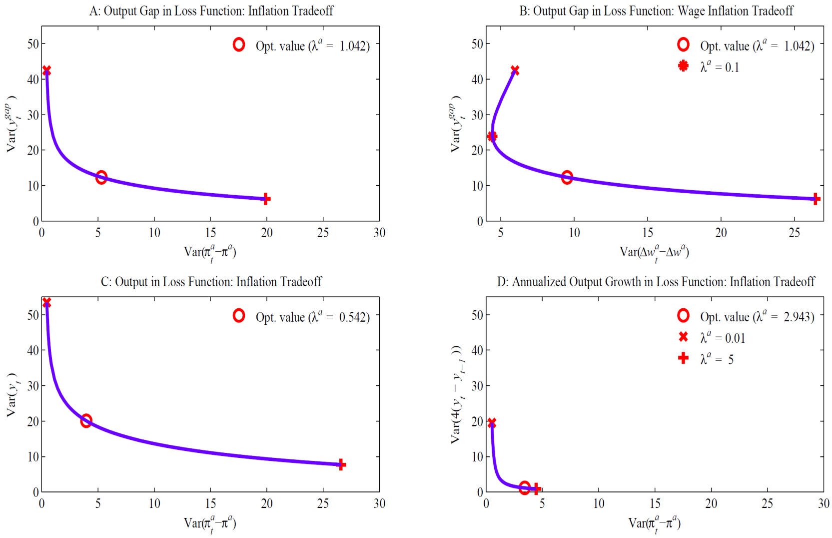
Benchmark results

CEV for simple mandates with alternative utilization measures



Benchmark results

Volatility trade-offs for alternative utilization measures



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- Are the shocks or deep parameters driving our results?

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  - This is higher than Woodford's λ^a as he assumed firm-specific labor (which c.p. lowers κ_x) and a higher substitution elasticity (θ_p)

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Benchmark results

Drivers of our results

- To understand the role of the parameters, we compute λ^a using Woodford's (2003) formula

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- Hence, we complement it by studying the influence of dynamic indexation and cost-push shocks

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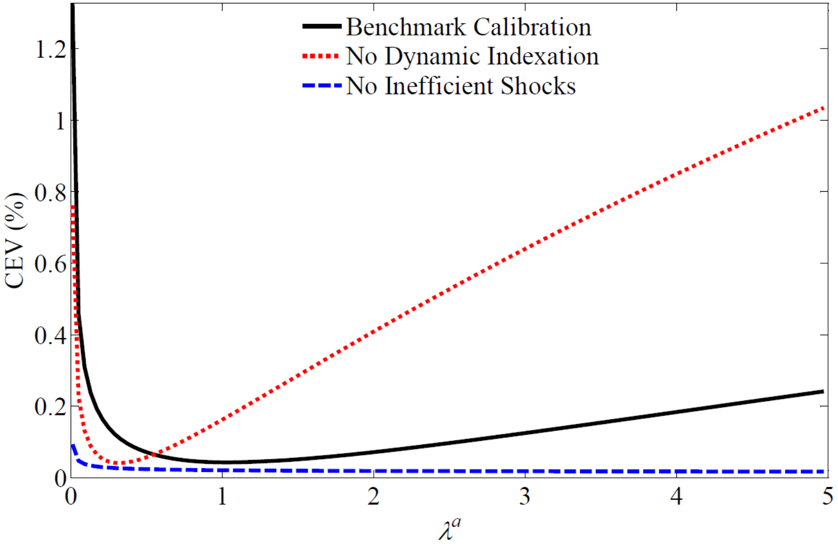
- However, when *BOTH* $\mathrm{var}(\varepsilon_t^p)$ *or* $\mathrm{var}(\varepsilon_t^w)$ are set to nil, then trade-off largely vanishes and λ^a is essentially irrelevant, but high weight still optimal

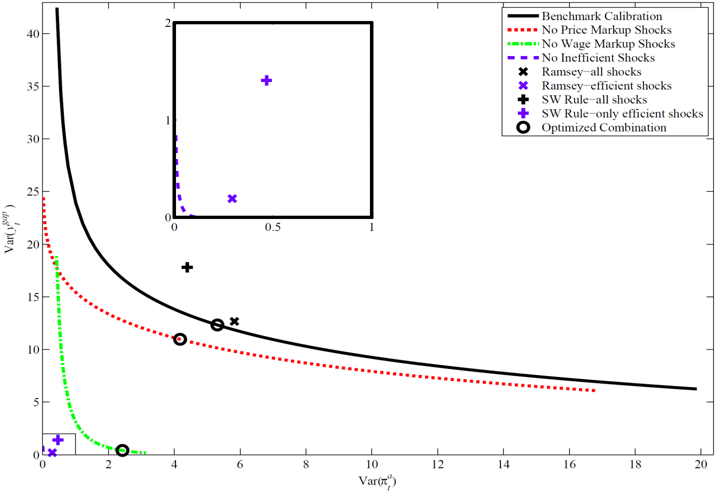
Benchmark results

Sensitivity of results w.r.t. parameters and shocks



Benchmark results

Variance frontiers for alternative calibrations



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- While we do not neccessarily disagree with JPT, their "no trade-off" result is a special case in the sense that it applies only if *BOTH* price and wage markup shocks are irrelevant
  - And since we do not know if this is the case, robustness argument calls for large λ^a in actual policy communication

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- Estimate ρ and std(ε_t) in different ways, then recalculate λ^a in a loss eq. (10), but now assuming CB responds to $y^{gap,obs}$ rather than to y_t^{gap}

Robustness of results

Measurement errors - results

- Importantly, we find that our results hold up when we assume output gap is measured with sigificant errors

Results When y_t^{gap} Is Measured with Errors

Measurement of Output Gap	λ^a	CEV (%)
No measurement errors	1.042	0.044
Orphanides and Williams	0.969	0.084
Rudebusch	1.024	0.209
HP-filtered Real Time Data	0.918	0.157

- Weight on y_t^{gap} large in all cases even with significant measurment errors
- Need much more persistent errors to lower weight significantly

Robustness of results

Interest rate volatility

- Importantly, we find that our results hold up when we put restrictions on std(r_t^a):

Results for loss function with interest rate term

Loss Function	$\lambda^a - y_t^{gap}$	λ_r	CEV (%)	std(r_t^a)
Woodford	0.048	–	0.471	8.92
Optimized	1.042	–	0.044	9.00
Optimized*: $r_t^a - r^a$	1.161	0.0770*	0.076	2.24
Optimized*: Δr_t^a	1.110	1.0000*	0.084	2.04

- Obviously, commitment assumption important here
- Results also hold up when we assume output gap measured with errors in real time

Robustness of results

Labour market mandate a good idea (in principle)

- Also study the merits of an alternative mandate with nominal wage inflation and a labor market gap $(l_t - l_t^{pot})$:

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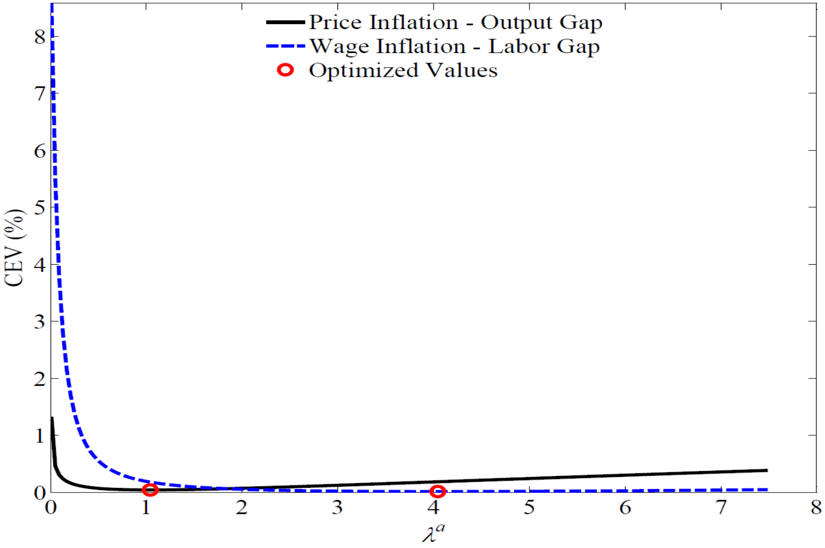
- Find that labor market variables may warrant further attention; not surprising given that the model features labor market frictions (nominal wage frictions)

Robustness of results

On the importance of labor market variables



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- We study the robustness of our results in a number of directions, including price- and wage-level targeting, speed-limit policies etc.
  - Find that our basic result of a strong response to economic activity holds up in all cases
- Our results warrant further work to check robustness in models with financial frictions, expectations formation, imperfect information, and plausible transmission lags of monetary policy