The Inflation-Unemployment Trade-Off at Low Inflation

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Motivation

Three "conventional or controversial" views on monetary policy:

1. No long-run trade-off between inflation and unemployment:
    - Inflation-augmented Phillips curve, vertical in the long run.
    - Unique natural rate of unemployment that does not depend on monetary policy.
    - Recent monetary models with symmetric price rigidities would imply a LR relation, but properties are generally unexplored and often not standard (upward sloping).

2. Low optimal inflation.

   - In a flexible-price model, optimal rate of deflation (Friedman)

   - Recent models with price rigidity indicate that the optimal long-run inflation rate should be close to zero (and unemployment at the natural rate). (Khan, King, and Wolman, 2003, Schmitt-Grohe and Uribe, 2004).

   But:

   - No central bank is adopting a policy of price stability.

   - Inflation targeters are in search of targets (and often look at advances economies's ones).

3. The gains from appropriate stabilization policies conducted by monetary and fiscal authorities are negligible.

   - Benefits of eliminating business-cycle fluctuations are small or second order. (Lucas, 2003)

   - Monetary policy shocks have transient effects on economic activity. (View supported by recent monetary models that have tried to match the highly volatile movements in individual prices observed in U.S. data.)

   - Relevance of monetary policy may also be limited in the short run.

This Paper

This paper challenges these views by adding downward-wage inflexibility to a dynamic stochastic general equilibrium model finding that:

1. There is a long-run Phillips curve between inflation and unemployment: the curve is vertical at high inflation rates and flattens as inflation decreases.

2. Optimal inflation level should depend on the extent of macroeconomic volatility (hence differ across countries).

3. Macroeconomic volatility matters for the shape of the Phillips curve implying that stabilization policies can have first-order effects.

Moreover:

4. Exogenous downward wage inflexibility implies endogenous upward wage rigidity at low inflation. Persistence of real effects of monetary shocks at low inflation.

5. Volatility of unemployment rate increases at low inflation rates; there is a trade-off between volatility of unemployment and volatility of wage inflation.

Downward Rigidities

- Keynes (1936), Samuelson and Solow (1960), Tobin (1972), Akerlof et al. (1996), Akerlof (2007).

- Explanations: fairness and social norms (Akerlof, 2007, and Bewley, 1999) or labor market institutions (Holden, 2004).

- Strong body of evidence across a wide spectrum of countries (see for example Lebow, Saks, and Wilson, 2003, for the U.S., and the dozens of citations in Akerlof, 2007, and in Holden, 2004).

- Downward wage rigidities persist during low inflation periods: see Agell and Lundburg (2003), Fehr and Gotte (2005), and Knoppik and Beissinger (2003) for empirical studies about several European countries.

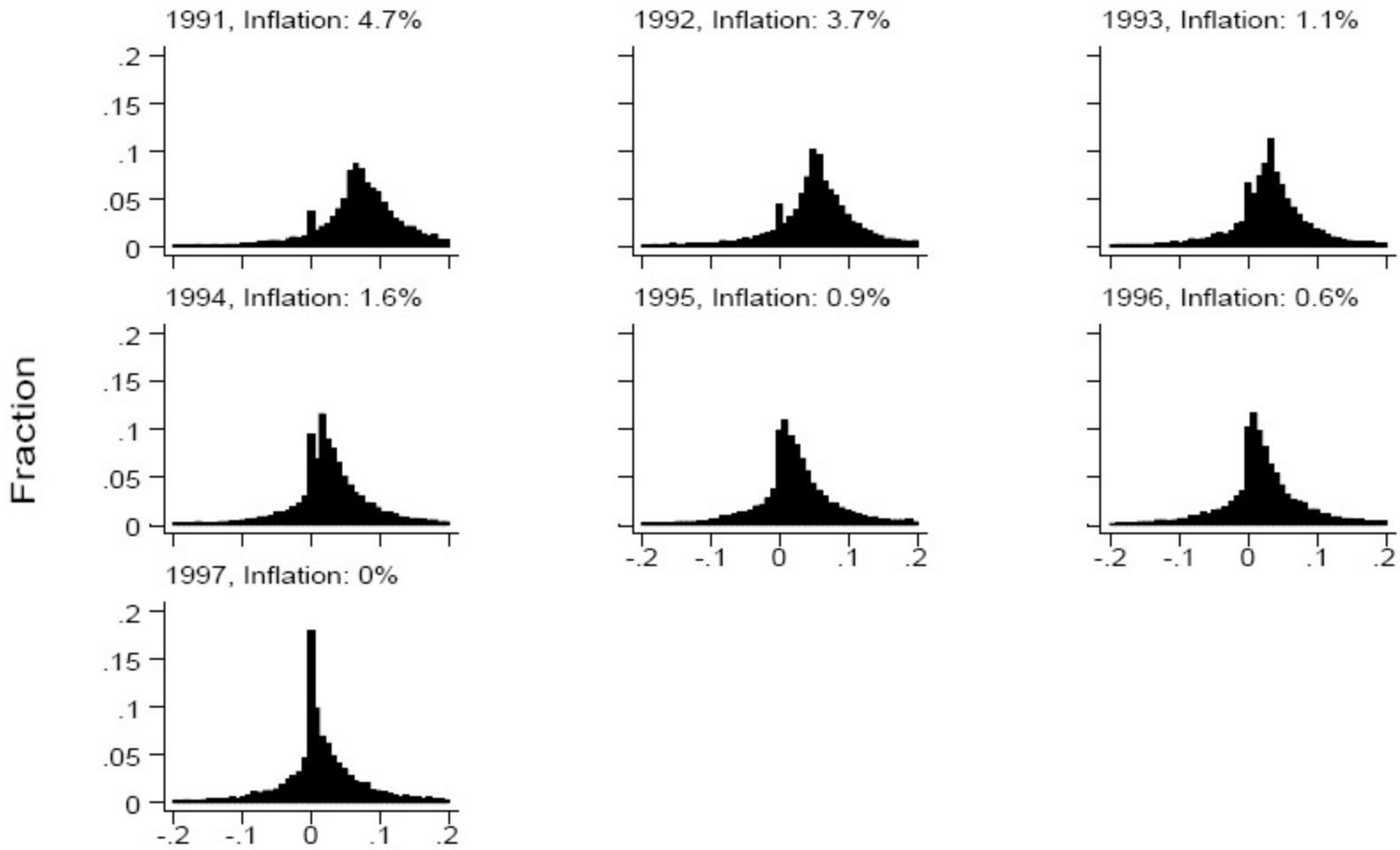
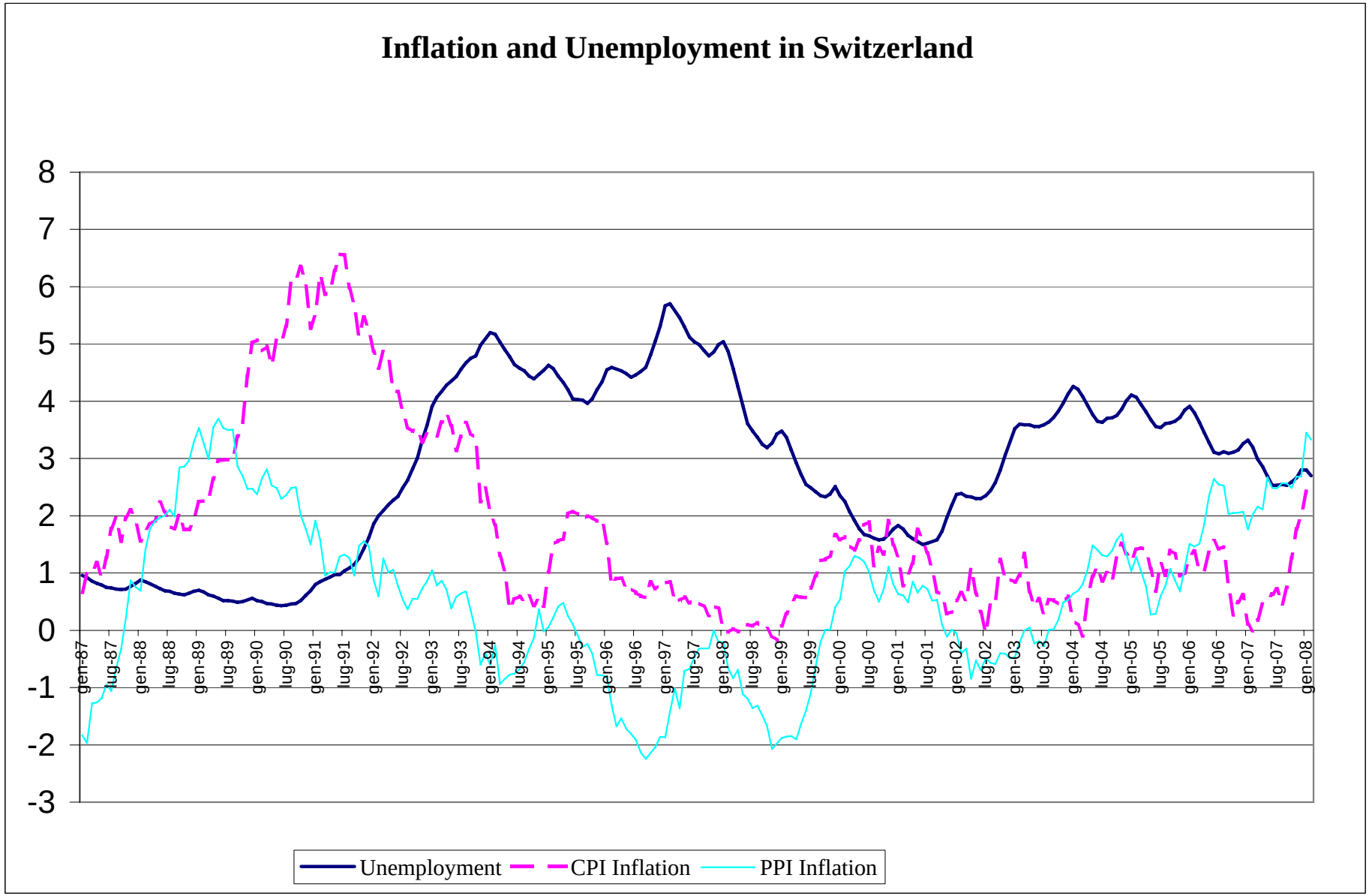


Figure 3: Distribution of Wage Changes over Time


Inflation and Unemployment in Switzerland
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Unemployment
CPI Inflation
PPI Inflation

Model

- Closed-economy model with a continuum of infinitely-lived households and firms (both in a [0,1] interval).

- Each household derives utility from consumption and disutility from supplying one of the varieties of labor in a monopolistic-competitive market

$$E_{t_0}\left[\int_{t_0}^{\infty} e^{-\rho(t-t_0)}\left(\ln C_t^j - \frac{l_t^{1+\eta}(j)}{1+\eta}\right) dt\right].$$

- Firms hire all varieties of labor to produce one of the continuum of consumption goods and operate in a monopolistic-competitive market where prices are set without any friction.

- The economy is subject to two aggregate shocks: a productivity and a nominal spending shock.

- The productivity shock is denoted by A_t, whose logarithmic a_t is distributed as a Brownian motion with drift g and variance σ_a^2

$$da_t = gdt + \sigma_a dB_{a,t}.$$

- The nominal spending shock is denoted by $\tilde{Y}_t$ whose logarithmic $\tilde{y}_t$ is also distributed as a Brownian motion, now with drift θ and variance σ_y^2

$$d\tilde{y}_t = \theta dt + \sigma_y dB_{y,t}.$$

- Optimization problem of wage setters in a monopolistic market is to maximize the following objective

$$E_{t_0}\left[\int_{t_0}^{\infty} e^{-\rho(t-t_0)}\pi(w_t(j), W_t, \tilde{Y}_t)dt\right] \tag{1}$$

by choosing $\{w_t(j)\}_{t=t_0}^{\infty}$, where

$$\pi(w_t(j), W_t, \tilde{Y}_t) \equiv \frac{1}{\mu_p}\left(\frac{w_t(j)}{W_t}\right)^{1-\theta_w} - \frac{1}{\mu_p}\frac{1}{1+\eta}\left(\frac{w_t(j)}{W_t}\right)^{-(1+\eta)\theta_w}\left(\frac{\tilde{Y}_t}{W_t}\right)^{1+\eta}.$$

Flexible Wages: Monetary Policy Neutrality

- Per-period maximization implies

$$\pi_w(w_t(j), W_t, \tilde{Y}_t) = 0.$$

- Nominal wages W_t^f, are proportional to nominal spending

$$W_t^f = (\mu_w)^{\frac{1}{1+\eta}} \tilde{Y}_t,$$

where $\mu_w \equiv \theta_w/(\theta_w - 1)$.

- Aggregate labor L^f and equilibrium unemployment rate u^f are constant

$$L^f = \mu_p^{-1} \mu_w^{-\frac{1}{1+\eta}}, \qquad u^f = 1 - L^f.$$

Downward wage rigidity

- Agents choose a nominal-wage path to maximize (1) under the constraint

$$dw_t(j) \geq 0.$$

- The Bellman equation for the wage-setter problem is thus:

$$\rho V(w_t(j), W_t, \tilde{Y}_t)dt = \max_{dw_t(j)} \pi(w_t(j), W_t, \tilde{Y}_t)dt + E_t\{dV(w_t(j), W_t, \tilde{Y}_t)\}.$$

Optimal solution:

- Optimal solution defines a shadow wage $W(\tilde{Y}_t)$ that represents the current *desired* wage taking into account future downward-rigidity constraints, but not the current one.

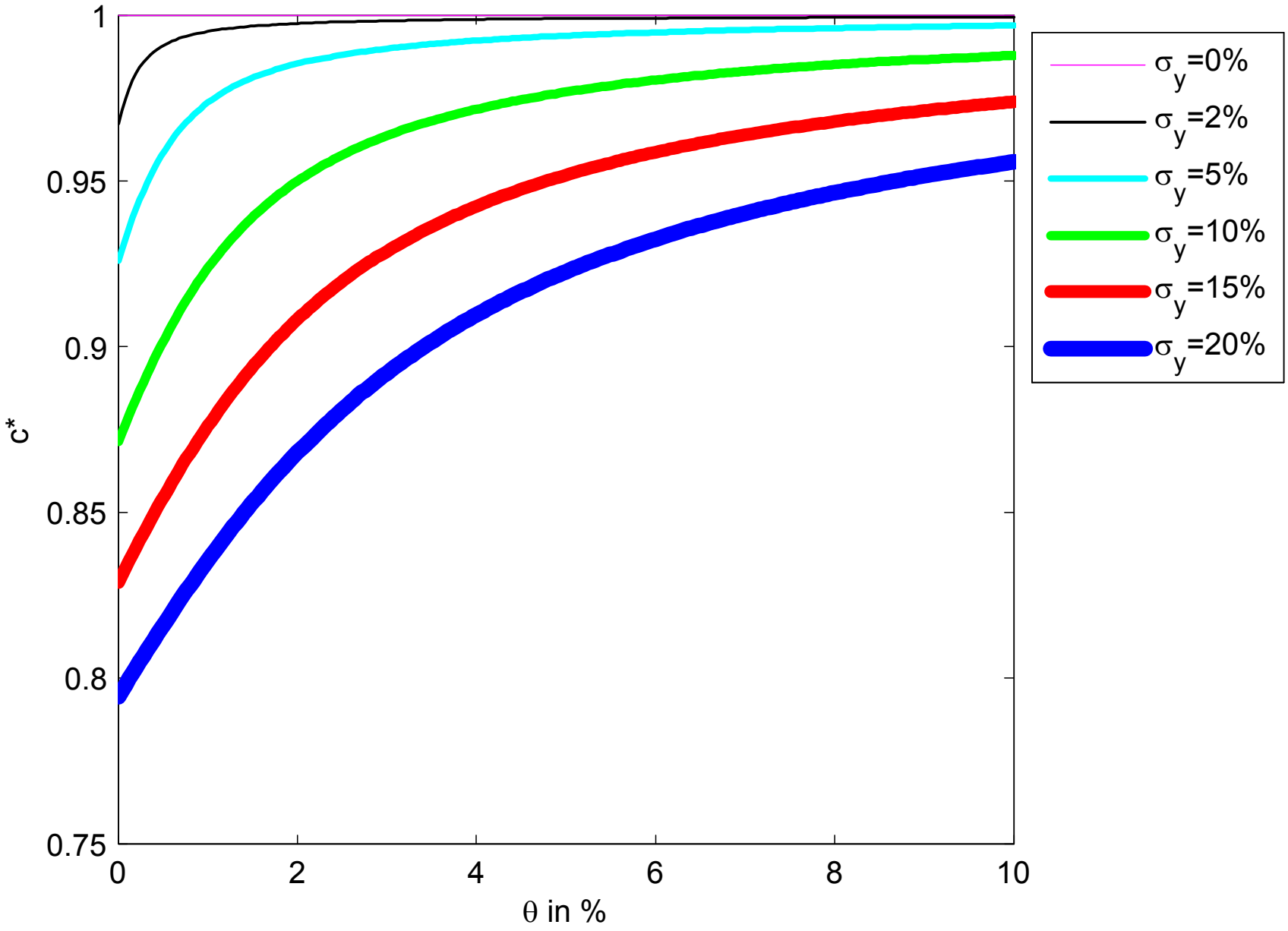
- The agent will set $W_t = W(\tilde{Y}_t)$ whenever $dW_t \geq 0$, so that *actual* wages are the maximum of previous period wages and current *desired* wages. It follows that *actual* wages cannot fall below $W(\tilde{Y}_t)$, i.e. $W_t \geq W(\tilde{Y}_t)$.

- In particular, it is shown that

$$\begin{aligned} W(\tilde{Y}_t) &= c(\theta, \sigma_y^2, \eta, \rho) \cdot \mu_w^{\frac{1}{1+\eta}} \tilde{Y}_t \\ &= c(\theta, \sigma_y^2, \eta, \rho) \cdot W_t^f \end{aligned}$$

  where $0 \leq c(\cdot) \leq 1$.

- $c(\cdot)$ decreases when θ decreases, σ_y^2 increases (also when ρ decreases, η decreases).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- Employment is given by

$$L_t = \frac{1}{\mu_p} \frac{\tilde{Y}_t}{W_t}.$$

- Since $W_t \geq c(\cdot) \left(\mu_w\right)^{\frac{1}{1+\eta}} \tilde{Y}_t$, it follows that $0 \leq L_t \leq L^f / c(\cdot)$.

- Moreover $l_t = \ln L_t$ is going to follow a Brownian motion but with a reflecting barrier at $\ln(L^f / c(\cdot))$.

- The probability distribution function for such process can be computed at each point in time. Standard results assure that this probability converges in the long run when the drift of the Brownian motion of nominal-spending growth is positive, $\theta > 0$.

- In this case, it can be shown that the long-run cumulative distribution of L_t, denoted with $P(\cdot)$, is given by

$$P(L_\infty \leq x) = \left(\frac{x}{L^f / c(\cdot)} \right)^{\frac{2\theta}{\sigma_y^2}}$$

for $0 \leq x \leq L^f / c(\cdot)$ where L_∞ denotes the long-run equilibrium level of employment.

Long-Run Phillips Curve

- Long-run mean of unemployment rate is given by

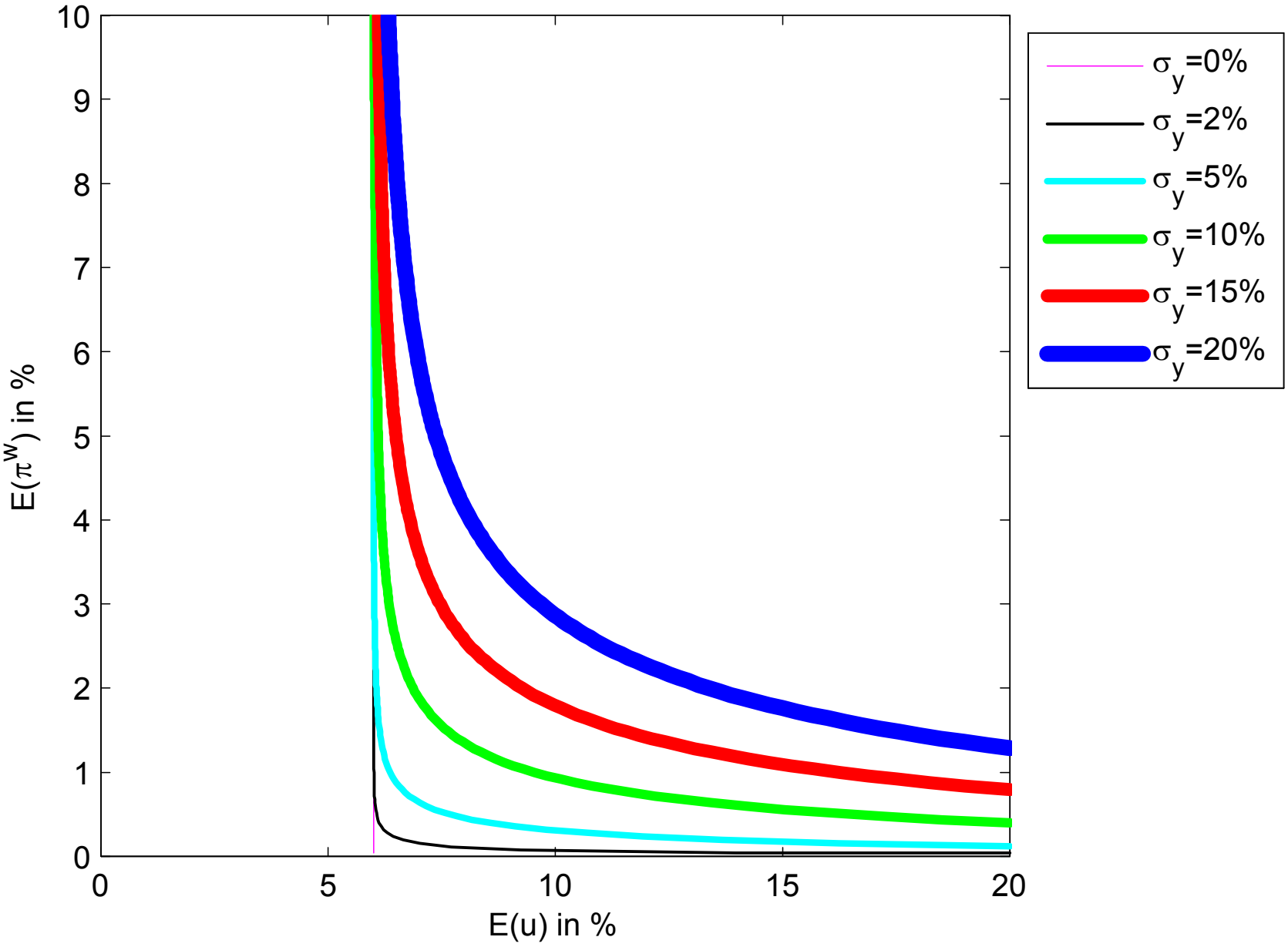
$$E[u_\infty] = 1 - \frac{1}{1 + \frac{\sigma_y^2}{2\theta} c(\theta, \sigma_y^2, \eta, \rho)} \frac{(1 - u^f)}{}.$$

- Long-run mean of inflation rate

$$E[\pi_\infty^w] = \theta.$$

- It follows that the long-run Phillips curve is

$$E[u_\infty] = 1 - \frac{1}{1 + \frac{\sigma_y^2}{2E[\pi_\infty^w]} c(E[\pi_\infty^w], \sigma_y^2, \eta, \rho)} \frac{(1 - u^f)}{}.$$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- No unique natural rate of unemployment.

- Significant trade-off between unemployment and wage inflation in a low inflation environment as in a Phillips curve.

- Shape of the trade-off depends on the degree of volatility present in the economy.

Varying Degree of Downward Rigidity

- Main criticism is that downward wage inflexibility should disappear as the inflation rate declines toward zero.

- Replace the assumption $dw_t^j \geq 0$ with

$$dw_t^j \geq -\kappa(\theta) w_t^j dt.$$

  Nominal wages are now allowed to fall, but the percentage decline cannot exceed $\kappa(\theta)$, where $\kappa(\theta)$ is a non-increasing function of the mean of nominal-spending growth, θ.

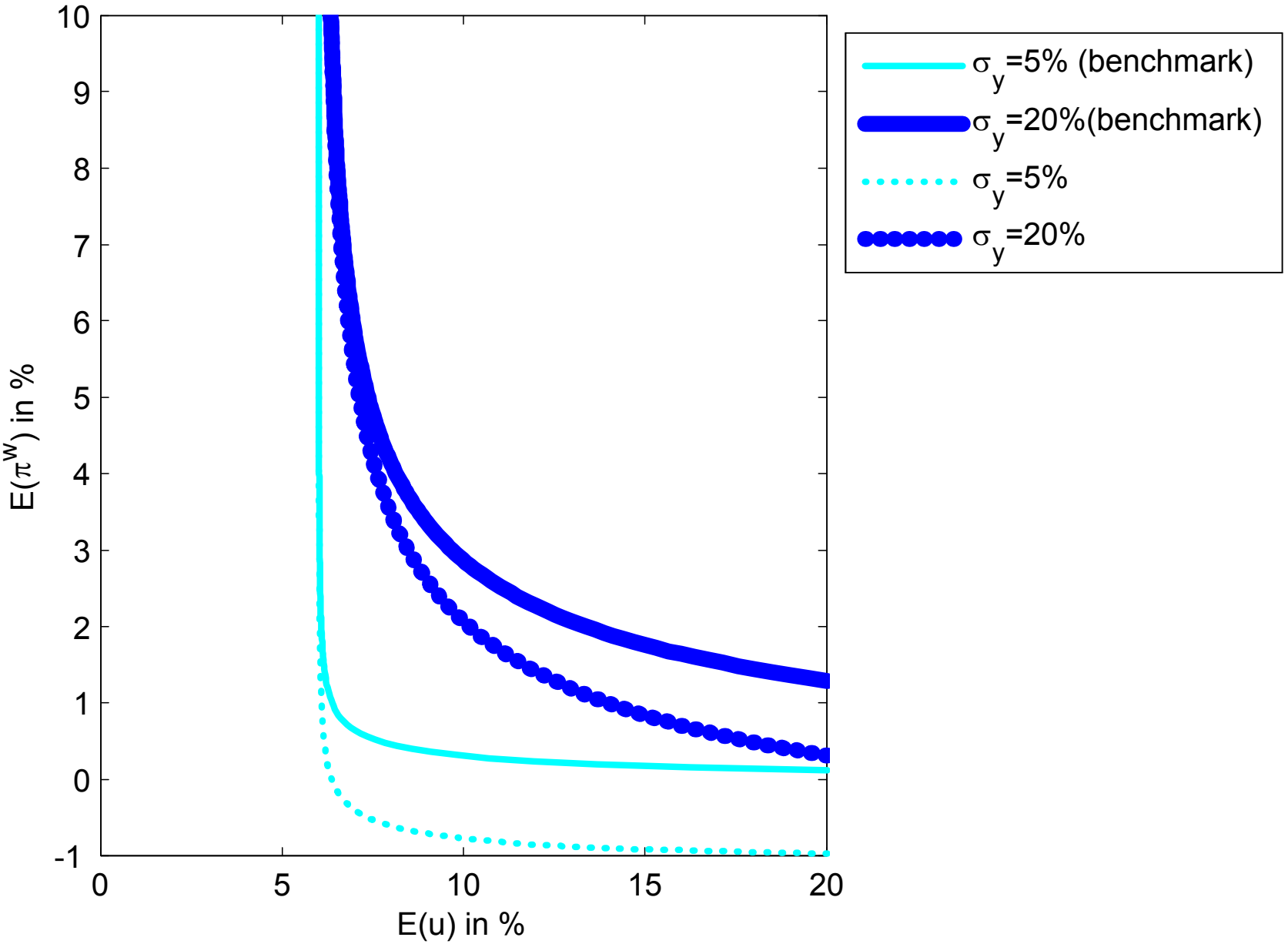
- It is easy to see that the solution of the model is similar to the previous case except that θ should now be replaced by $\lambda(\theta)$ with $\lambda(\theta) \equiv \theta + \kappa(\theta)$. In particular, the long-run Phillips curve becomes

$$E[u_\infty] = 1 - \frac{1}{1 + \frac{\sigma_y^2}{2\lambda(E[\pi_\infty^w])}} \frac{(1 - u^f)}{c(\lambda(E[\pi_\infty^w]), \sigma_y^2, \eta, \rho)},$$

- For illustrative purposes set

$$\kappa(\theta) = \kappa_1 - \kappa_2 \theta$$

where $\kappa_1 = 1\%$ at annual rates and $\kappa_2 = 0.1$.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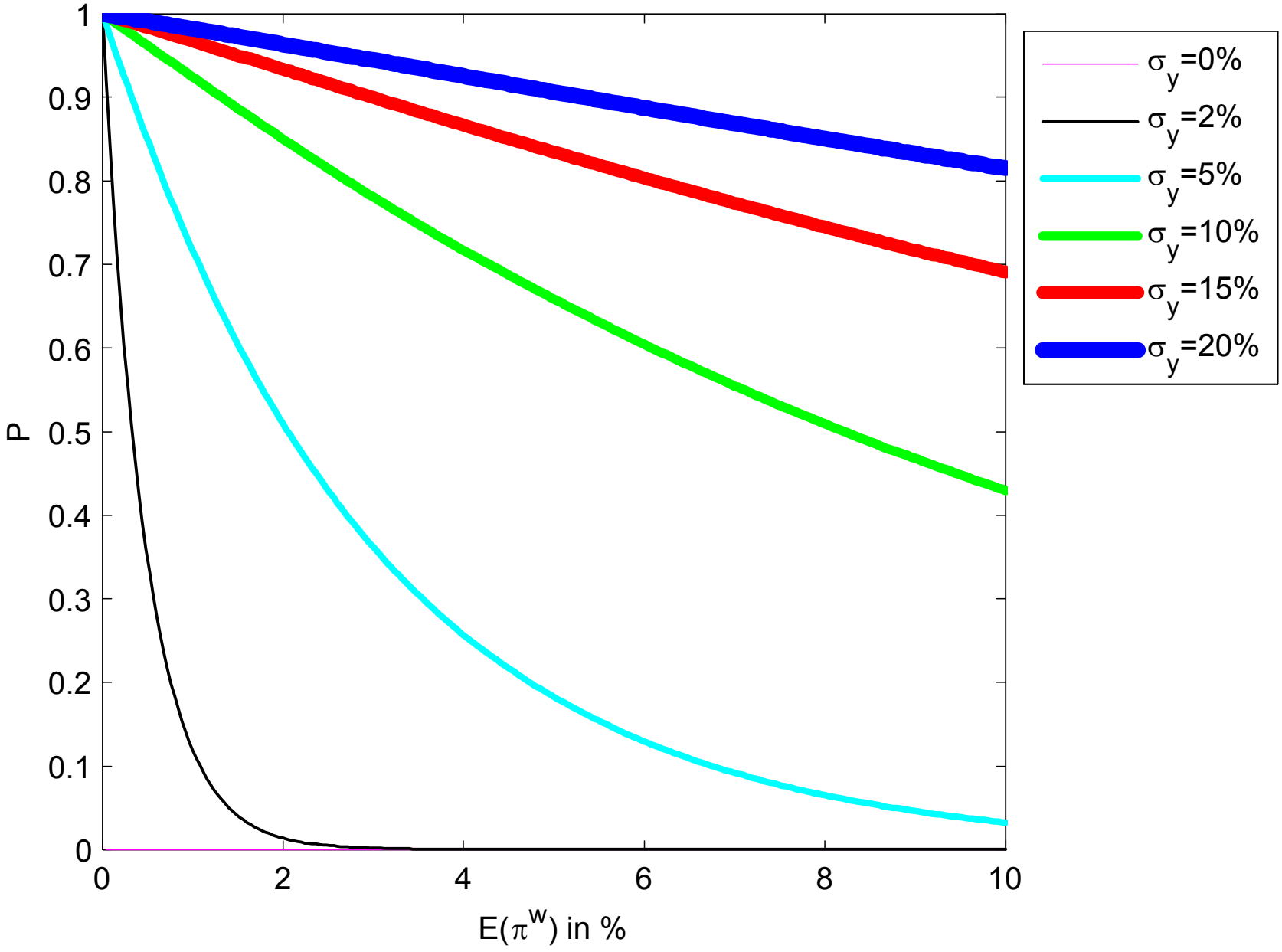
σ_y=5% (benchmark)
σ_y=20%(benchmark)
σ_y=5%
σ_y=20%

Other results: Long-run probability of wage rigidity

Coincides with the probability that L_t remains within the barrier: i.e. $P(0 \leq L_t \leq L^f/c(\cdot) - \epsilon)$ for a small $\epsilon > 0$.

- Focusing on the long run, we obtain that

$$P(0 \leq L_\infty \leq L^f/c(\cdot) - \epsilon) = \left(1 - \frac{\epsilon c(\cdot)}{L^f}\right)^{\frac{2\theta}{\sigma_y^2}} \approx 1 - \frac{2E[\pi_\infty^w]}{\sigma_y^2}\frac{c(\cdot)}{L^f}\epsilon$$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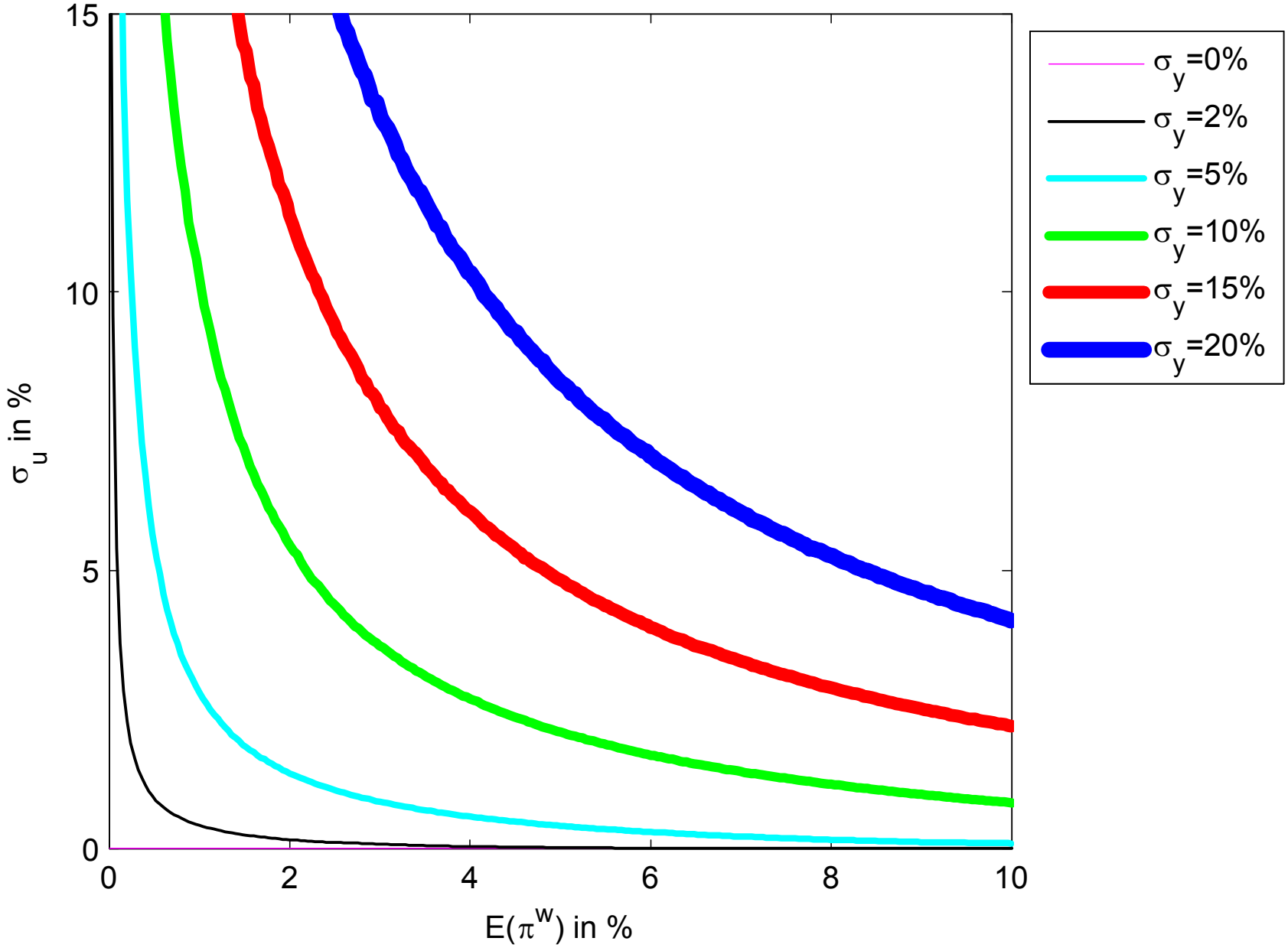
Other results: Implications for volatility

- The fact that wages are endogenous rigid at low inflation rates implies that the volatility of inflation is low at low inflation rates and increases as inflation increases.

- Moreover, the volatility of unemployment is high at low inflation rates and decreases as inflation increases.

- There is a trade-off between inflation and unemployment volatilities.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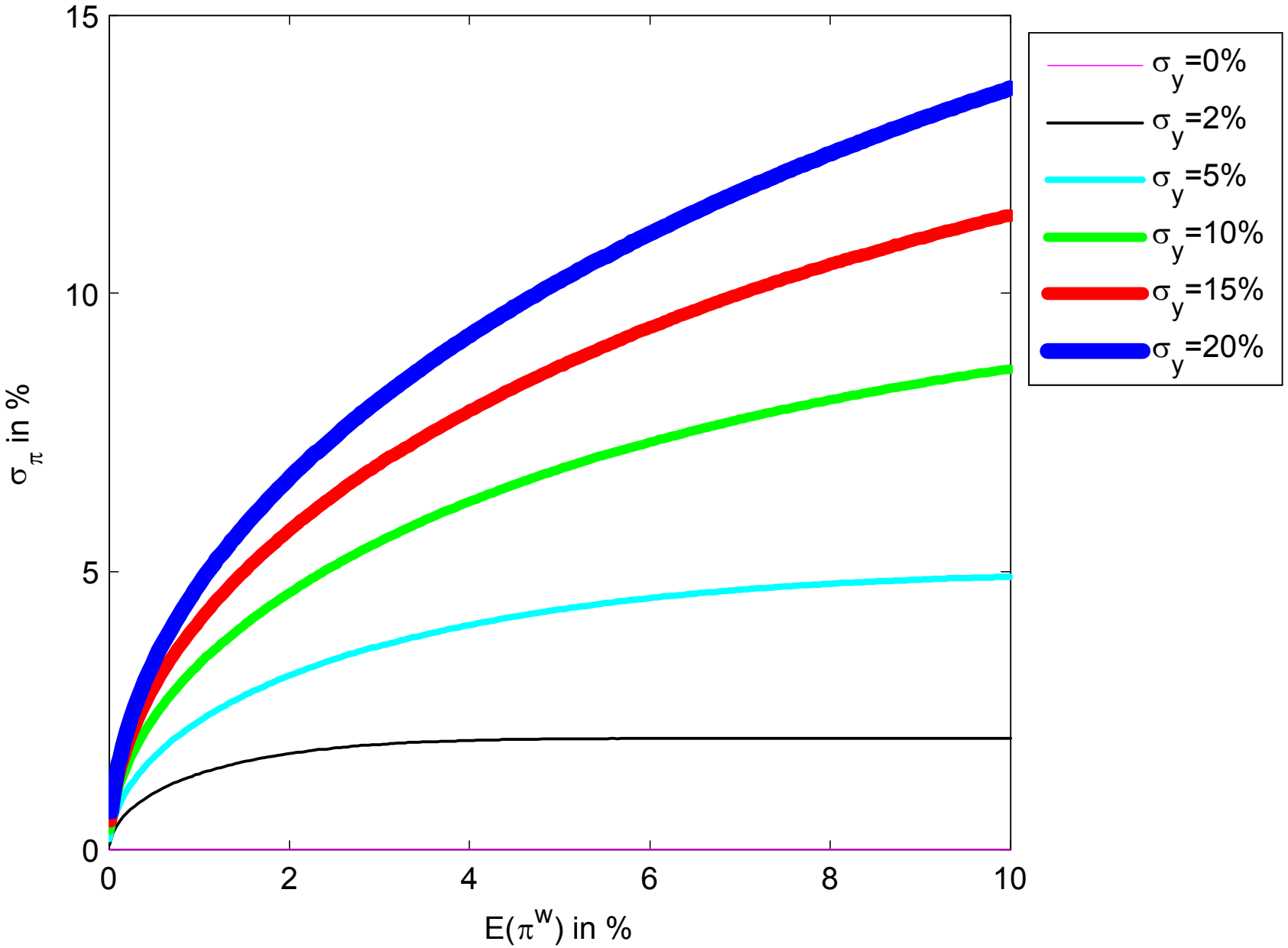
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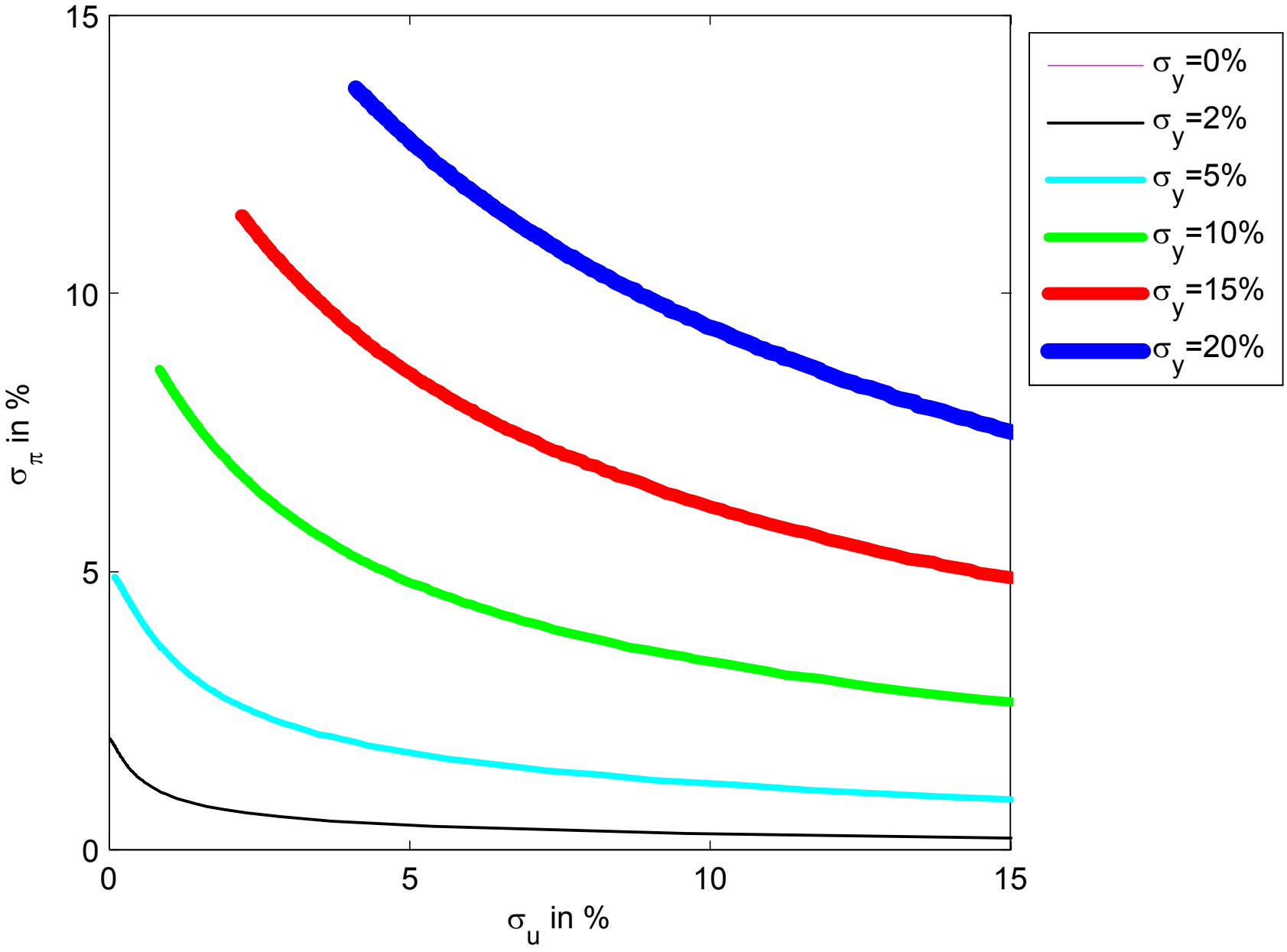
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Conclusions

Downward wage rigidities in a dynamic general equilibrium model imply that:

- There is a long-run trade-off between inflation and unemployment at low inflation.
- Macroeconomic volatility shifts the Phillips curve outwards.
- Stabilization policies have first-order effects.

- Optimal inflation is likely to depend on the level of macroeconomic volatility.

- There is a trade-off between the volatility of unemployment and that of inflation rate.

Policy implications

- First, not every country should target the same inflation rate: differences in, among other things, the degree of macroeconomic volatility should matter for the choice of the inflation rate.

- Second, policymakers can influence the inflation unemployment trade-off: stabilization policies aimed at reducing macroeconomic volatility would improve the trade-off, thus reducing the unemployment costs of lowering long-run inflation.

- The results suggest that the "great moderation" experienced by the U.S. over the past two decades may have significantly steepened the Phillips curve in the U.S., making it even more unlikely that empirical analyses would uncover such a curve, thus potentially strengthening the case for the conventional view of a vertical long-run curve in this country.

- A recent literature has shown that ignorance of the model economy can lead to very costly choices (Primiceri, 2006; Sargent, 2007). Our results would point at the risk of an opposite misperception (ignoring the presence of a trade-off) in low inflation periods, a risk that can result in significantly higher unemployment.

Future work

- Adding standard symmetric goods-price rigidities would introduce an argument for inflation as "sand" as in modern monetary models, as it would introduce price dispersion.

- Allowing for heterogeneity of sectoral shocks would strengthen the argument for inflation as "grease", as it would increase the need for relative price adjustments.

- Including a game-theoretic interaction between price setters and monetary authorities would unleash the comparison of discretionary versus commitment equilibria.

- Allowing for open economy features would offer a model more useful for emerging markets.

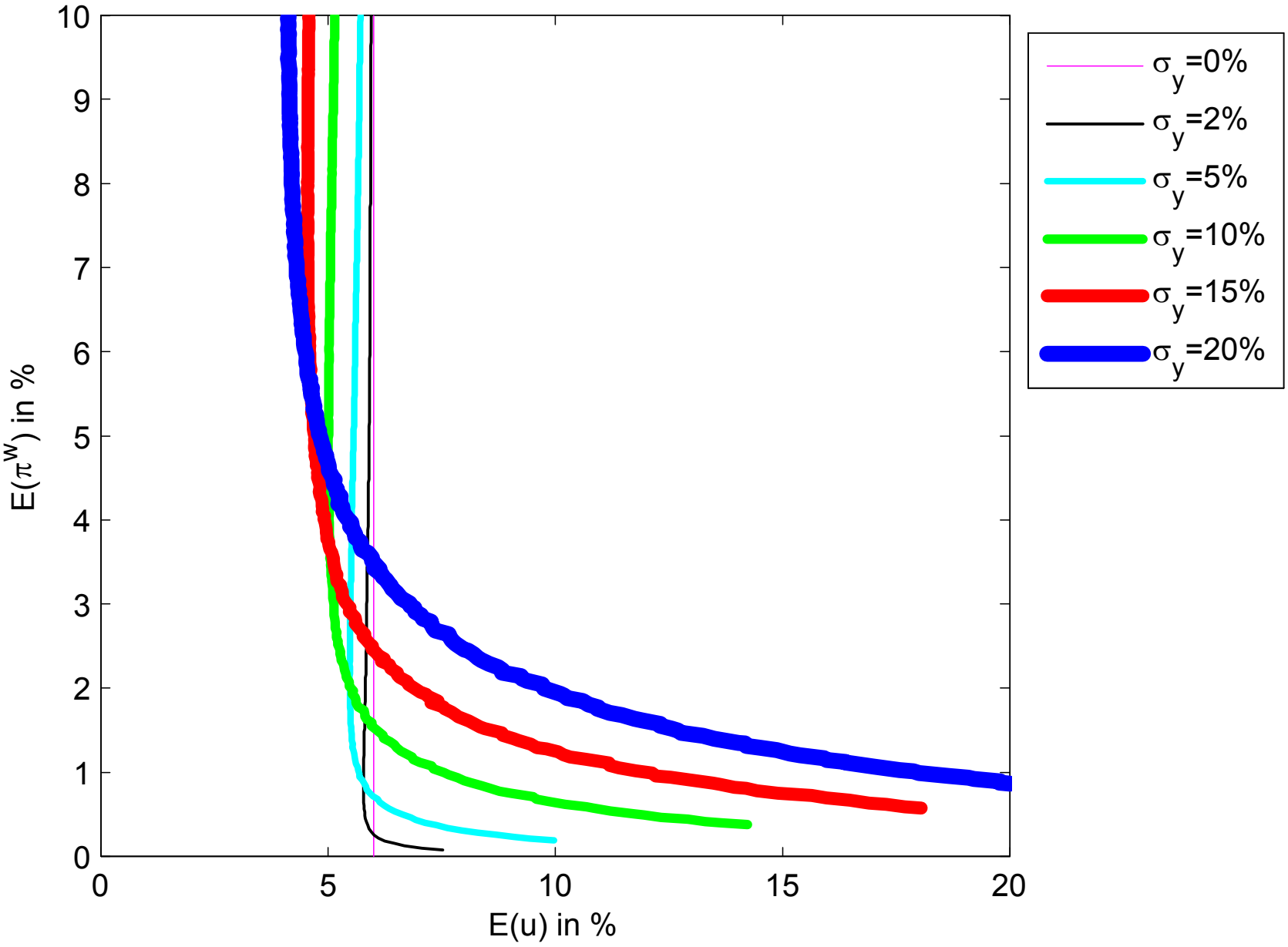
- Estimating such an extended model would allow to gauge optimal inflation levels in many countries.

Short-Run Phillips Curve

- The short-run Phillips curve ALSO implies a significant trade-off, dependent on volatility.

- The SR PC would tend to shift to the right over time, as the extent to which wages are likely to be binding would tend to increase over time (until long-run convergence is achieved).

- The relative positions of the SR PC for countries with different degrees of volatility would depend on the level of inflation (higher volatility: PC more to the right for low inflation, and to the left for moderate-high inflation).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