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Nominal Rigidities, Supply Shocks and Economic Stability

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Abstract

This paper shows that nominal rigidities in terms of price stickiness acts as a powerful supply-shock filter that reduces the overall economic instability. Considering a range of admissable values for price stickiness, the volatility of inflation, output and interest rate induced by technology or cost-push shocks can vary up to 50%. The paper suggests a word of caution for policies designed to increase price flexibility which would expose the economy to more economic instability in presence of supply shocks.

JEL Classification: E31, E32, E37, E52.

Key Words: Price stickiness, economic stability, supply shock, technology shock, cost-push shock.

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1 Introduction

Nominal rigidities have been one of the most debated topic in modern macroeconomics since Keynes' original thought back to 1936. The basic reason is that both the analysis of economic fluctuations, and the role of monetary policy in stabilizing real activity, call for a clear stance on accepting or rejecting the presence of nominal rigidities.

The RBC literature focuses on supply-side shocks and in particular on technology shocks as the driving force of the business cycle. In this context, prices are high volatile since they are fully flexible and act as shock absorber. The economic activity instead is completely stabilized since it remains always at its natural level. In the New Keynesian (NK henceforth) tradition, nominal rigidities allow rationalizing the impact of monetary policy on real activity, which is amply documented by the empirical evidence[1]. This occurs either in terms of monetary policy shocks that cause economic fluctuations, or in terms of a stabilizing monetary policy as a response to other type of shocks. Interestingly, in both cases we are looking at nominal rigidities from the *demand side* of the economy. Indeed, due to nominal rigidities, either a monetary policy shock can alter the demand, or some other shock occurs and monetary policy can buffer it by changing the demand. While there is a large literature that looks at the relation between nominal rigidities and economic fluctuations from the demand side of the economy, to the best of our knowledge, this relation has been neglected from the supply side.

Prompted by these considerations, we focus on how nominal rigidities in terms of *price stickiness* affect the transmission of supply shocks to firms and the consequences for the transmission to the rest of the economy.

[1]Empirically, VAR analysis and an ample literature starting with the seminal work of Friedman and Schwartz (1960) document the relation between monetary policy and economic fluctuations. See, among others, Christiano Eichenbaum and Evans (1999), Sims (1992), Galì (1992), Bernanke Mihov (1998), and Uhlig (2005).

The main contribution of the analysis lies in showing that price stickiness acts as a powerful *filtering mechanism* for supply shocks. The intuition is clear: in presence of price stickiness not all the firms can change their price in any period. Thus, a supply shock that changes the firm's marginal costs affects the firm's price only if the firm can change its price. Hence, for a given persistence of the shock, the larger price stickiness, the more the shock tends to be filtered out. To show this finding we employ a standard NK model and illustrate the mechanism at work with two supply shocks of the technology and cost-push types. We show the results both analytically and also using simulation techniques.

The analysis reveals that, accounting for various admissible values of prices stickiness, economic volatility in terms of the standard deviation for inflation, output and the interest rate can change up to 50%.

This result can be also relevant to explain the Great Moderation, i.e. the remarkable decline in output and inflation volatility which has benefited industrialized economies since the '80s (Flamini, Ascari and Rossi 2012). Furthermore, this result is relevant to explain how sectoral asymmetry in price stickiness affects the economic dynamics as shown in Flamini (2012).

This finding introduces a word of caution for policies designed to increase price flexibility. These policies, indeed, would expose the economy to more inflation and output volatility and, consequently, also to more interest rate volatility required for stabilization purposes.

This remarkable result and the mechanism that determines it are not, to our knowledge, been considered by the previous literature. The fact that the NK models, both the small scale and the medium scale models, have not investigated on the filtering devise of price stickiness, and thus on its stabilizing role is only partially surprising. Indeed in the basic NK most of the shocks, as for example the cost-push shock, are not microfounded but just appended to the AS curve. In this case the direct effect of the shock in the AS curve is not affected by the degree of firms' price-stickiness. Finally, those papers that consider microfounded supply shocks, as for example most of the medium-scale models, focus on the empirical properties of the NK model and completely disregard the theoretical role played by price stickiness on the volatility of the economy.

The paper is organized as follows. Section 2 present the main features of the New-Keynesian model useful to describe the relation at issue. Section 3 explains the shock filtering device and then presents and discusses the quantitative results based on a standard calibration of the model. Concluding remarks are in section 4.

2 The basic New Keynesian model

The economy is populated by a continuum of unit mass of identical infinite-lived households each seeking to maximize

$$U_{t_0} = E_{t_0} \sum_{t=t_0}^{\infty} \beta^{t-t_0} U\left(C_t, N_t\right),$$

where β is the intertemporal discount factor and C_t and N_t are per capita consumption and employment, respectively. Period utility is modeled as

$$U\left(C, N_t\right) = \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\phi}\left(h\right)}{1+\phi},$$

where $\sigma^{-1} > 0$ is the intertemporal elasticity of substitution in consumption and $\phi > 0$ is the inverse of the elasticity of goods production. Consumption is a Dixit-Stiglitz aggregate of the continuum of differentiated goods,

$$C_t \equiv \left[\int_0^1 \left(C_t\left(i\right)\right)^{1-\frac{1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}, \tag{1}$$

where $\theta > 1$ is the sectoral elasticity of substitution between any two differentiated goods. The household is a monopolistically competitive supplier of labor and faces the following constant elasticity demand function for its services:

$$N_t\left(h\right) = \left(\frac{W_t\left(h\right)}{W_t}\right)^{-\eta_t} N_t, \tag{2}$$

where η_t is the elasticity of substitution between any two differentiated labor services and

$$W_t \equiv \left(\int_0^1 W_t(h)^{1-\eta_t} \, dh \right)^{1/(1-\eta_t)} \tag{3}$$

is the relevant aggregate wage.

The maximization of the household's problem subject to the budget constraint results in the following consumption Euler equation

$$C_t^{-\sigma} = \beta R_t E_t \left\{ \frac{C_{t+1}^{-\sigma}}{\Pi_{t+1}} \right\}, \tag{4}$$

where Π_t is gross inflation, and the optimal supply of labor is

$$\frac{W_t}{P_t} = (1 + \mu_t^w) \, C_t^{\sigma} N_t^{\phi}, \tag{5}$$

where the wage schedule reflects the household's market power and $\mu_t^w = 1/(\eta_t - 1)$ is a wage mark-up shock (cost-push shock). Wages are fully flexible, then all workers will charge the same wage and have the same level of hours. Thus, we can write

$$W_t(h) = W_t,$$
$$N_t(h) = N_t,$$

for all h and all t.

As usual we assume a perfectly competitive final-good producing sector and a monopolistically competitive intermediate-good-producing sector. Labor is the only input and firms production function in the intermediate good sector h is

$$Y_t(h) = A_t N_t(h), \tag{6}$$

where A_t is a technology shock. Cost minimization yield the following labor demand function

$$\frac{W_t}{P_t} = MC_t A_t, \tag{7}$$

where MC_t are real marginal costs.

In equilibrium, market clearing in the goods market requires

$$Y_t = C_t, \tag{8}$$

Then, combining (4), and (8) we obtain the nonlinear version of the IS relation. Turning to the producers' pricing behavior, firms in both sectors fix their prices at random intervals following the Calvo (1983) staggered price model and have the opportunity to change their prices with probability $(1-\alpha)$. Thus, a producer i that is allowed to set its price in period t, chooses its new price for the random period starting in t, $\widetilde{p}_t$, to maximize the flow of expected profits:

$$\max_{\widetilde{p}_t} E_t \sum_{T=t}^{\infty} \alpha^{T-t} \lambda_{t,T} \left\{ \widetilde{p}_t y_T(i) - \frac{y_T(i)}{A_T} \mu_T^w \frac{[y_T(j)/A_T]^{\phi}}{C_t^{-\sigma}} P_T \right\},$$

where $\lambda_{t,T}$ is the stochastic discount factor by which financial markets discount random nominal income in period T.

2.1 Log-linearized relations

We now log-linearize the equilibrium conditions around the steady state where the variables $\left(Y_t, \frac{P_{t+1}}{P_t}\right)$ are equal to $(Y, 1)$ and all the shocks are equal to one. Loglinearizing the Euler equation account being taken of the market clearing condition leads to the aggregate demand

$$y_t = y_{t+1|t} - \frac{1}{\sigma}\left(\widehat{i}_t - \pi_{t+1|t}\right) \tag{9}$$

and loglinearizing the f.o.c. for the firm's problem

$$\pi_t = \kappa y_t + \beta \pi_{t+1|t} + \frac{\kappa}{(\sigma+\phi)}\left[-(1+\phi) a_t + \mu_t\right] \tag{10}$$

where

$$\kappa \equiv \frac{(1-\alpha)(1-\alpha\beta)}{\alpha}(\sigma+\phi), \tag{11}$$

Notice that $\frac{d\kappa}{d\alpha} = \frac{d\frac{(1-\alpha)(1-\alpha\beta)}{\alpha}(\sigma+\phi)}{d\alpha}$ **:** $\frac{1}{\alpha^2}\left(\alpha^2\beta - 1\right)(\sigma+\phi) < 0$ is a decreasing function of the price stickiness parameter α**.**

2.1.1 Exogenous disturbances and monetary policy

The exogenous shocks follow

$$a_{t+1} = \gamma_a a_t + \varepsilon_{t+1}^a,$$

$$\mu_{t+1} = \gamma_\mu \mu_t + \varepsilon_{t+1}^\mu,$$

where $E_t\left(\varepsilon_{t+1}^h\right) = 0,\ h = a,\ \mu.$

The model is closed with a Taylor rule describing the behavior of the central bank

$$i_t = \delta_0 i_{t-1} + (1-\delta_0)\,\delta_1 \pi_t + (1-\delta_0)\,\delta_2 y_t.$$

2.2 Calibration

We choose a standard calibration for the structural parameters of the model based on the previous literature. As in Blanchard and Galì (2007)[2], the elasticity of intertemporal substitution in consumption is $\sigma = 1$; the inverse of the elasticity of goods production is $\phi = 1$; the intertemporal discount factor is $\beta = 0.99$; the coefficients of the Taylor rule are $\delta_0 = 0.8;\ \delta_1 = 1.5;\ \delta_2 = 0.5/4$; the AR coefficients of the exogenous processes are $\gamma_a = \gamma_\mu = 0.95$ and for any shock the variance is $\sigma_\varepsilon^2 = 1$. Finally, the degree of price stickiness α is let free to vary in the range $[0.5,\ 0.9]$. None of the qualitative results are affected by the parameters' choice.

3 The transmission of supply shock in presence of price stickiness

In this section we study how price stickiness affects the transmission of the supply shock to firms and consequently to, inflation, output and to nominal interest rate.

[2] Galì (2008), among others, uses the same values.

We show that, the larger price stickiness, the lower is the volatility of the latter variables. Equation (10) clearly shows that price stickiness affects the AS in two ways: i) throught the shock semi-elasticity of inflation, which is proportional to κ for both shocks considered; ii) through the semi-elasticity of inflation with respect to output, which is exactly equal to κ. Notice that since κ is a decreasing function of the price-stickiness coefficient α, the two elasticities decrease as price stickiness gets higher. However, this is only the partial equilibrium effect of price stickiness. To establish the overall effect of price-stickiness we follow two steps: i) first, we solve the model using a simplified version of the NK model presented in Section 2.1, where the supply shock is a white noise. This allow to compute analytically the standard deviation of output, inflation and that of the nominal interest rate, as functions of the degree of price stickiness in the economy. ii) Second, to prove the robustness of the previous result we then consider the more general model presented in the previous section, where the supply shocks follow an AR(1) process. In this case the model is solved numerically, using the parameters indicated in Section 2.2.

We find the following result. In all cases considered the standard deviation of inflation, output and that of the interest rate depend negatively on the degree of price stickiness. This holds for every parameterization considered in the simulated model. Thus, we can state that the more sticky are prices, the less volatile is the economy in response to a supply shock. At the extrem case of $\alpha = 1$, i.e., when prices are rigid, then $\kappa = 0$ and the filtering devise of the shock is absent, so that both inflation and output remain always unchanged. The stabilizing role of price stickiness has been neglected by the standard NK literature since, most of the shock, as for example the cost-push shock, are not microfounded but just appended to the AS curve.[3] In this case, the shock is not filtered and no matter the value of α, it will always affect the economy in the same way.

[3] **See Blanchard and Galì (2007) for a discussion on the microufoundation of the cost push shock for example.**

3.1 Price stickiness and economic stability: analytical result

Consider now the following simplified version of the model,

$$y_t = y_{t+1|t} - \frac{1}{\sigma}\left(\widehat{i}_t - \pi_{t+1|t}\right) \tag{12}$$

$$\pi_t = \kappa y_t + \beta \pi_{t+1|t} + \frac{\kappa}{(\sigma + \phi)}\mu_t \tag{13}$$

$$i_t = \delta_1 \pi_t + \delta_2 y_t \tag{14}$$

where $\mu_t \sim WN\left(0, \sigma_\mu^2\right)$. If the supply shock hits the economy it is absorbed in one period and thus the log-deviations of expected output and inflation from their steady state values are $y_{t+1|t} = \pi_{t+1|t} = 0$ and the tree equations become

$$y_t = -\frac{1}{\sigma}\widehat{i}_t \tag{15}$$

$$\pi_t = \kappa y_t + \frac{\kappa}{(\sigma + \phi)}\mu_t \tag{16}$$

$$i_t = \delta_1 \pi_t + \delta_2 y_t \tag{17}$$

substituting the interest rate rule in the IS curve and solving for y_t

$$y_t = -\frac{\delta_1}{\sigma + \delta_2}\pi_t$$

we can substitute the latter in the AS and then solve for π_t

$$\pi_t = \frac{\kappa\left(\sigma + \delta_2\right)}{\left(\sigma + \phi\right)\left(\sigma + \delta_2 + \kappa\delta_1\right)}\mu_t$$

which the implies that y_t is

$$y_t = -\frac{\kappa\delta_1}{\left(\sigma + \phi\right)\left(\sigma + \delta_2 + \kappa\delta_1\right)}\mu_t$$

Finally the nominal interest rate becomes

$$i_t = \frac{\delta_1\kappa\sigma}{\left(\sigma + \phi\right)\left(\sigma + \delta_2 + \kappa\delta_1\right)}\mu_t$$

The volatility of inflation, output and the nominal interest rate, measured in terms of their standard deviation are, respectively

$$\sigma_\pi = \frac{\kappa(\alpha)(\sigma+\delta_2)}{(\sigma+\phi)\sigma+\delta_2+\kappa(\alpha)\delta_1}\sigma_\mu$$
$$\sigma_y = \frac{\kappa(\alpha)\delta_1}{(\sigma+\phi)(\sigma+\delta_2+\kappa(\alpha)\delta_1)}\sigma_\mu$$
$$\sigma_i = \frac{\delta_1\kappa(\alpha)\sigma}{(\sigma+\phi)(\sigma+\delta_2+\kappa(\alpha)\delta_1)}\sigma_\mu$$

where $\kappa(\alpha)$ indicates that $\kappa = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha}(\sigma+\phi)$ is a function of the degree of price-stickiness α. To study the effect of price-stickiness on the volatility of the three variables it is sufficient to compute the derivative of the three coefficients with respect to α, and study the sign of the derivative. We find that:

$$\frac{d\sigma_\pi}{d\alpha} = \frac{d\frac{\kappa(\alpha)(\sigma+\delta_2)}{(\sigma+\phi)\sigma+\delta_2+\kappa(\alpha)\delta_1}}{d\alpha}\sigma_\mu = \left(\alpha^2\beta-1\right)\left(\sigma^2+\phi\sigma+\delta_2\right)B\sigma_\mu < 0$$
$$\frac{d\sigma_y}{d\alpha} = \frac{d\frac{\kappa(\alpha)\delta_1}{(\sigma+\phi)(\sigma+\delta_2+\kappa(\alpha)\delta_1)}}{d\alpha}\sigma_\mu = \delta_1\left(\alpha^2\beta-1\right)B\sigma_\mu < 0$$
$$\frac{d\sigma_i}{d\alpha} = \frac{d\frac{\delta_1\kappa(\alpha)\sigma}{(\sigma+\phi)(\sigma+\delta_2+\kappa(\alpha)\delta_1)}}{d\alpha}\sigma_\mu = \sigma\delta_1\left(\alpha^2\beta-1\right)B\sigma_u < 0$$

where $B = \frac{(\sigma+\phi)(\sigma+\delta_2)\left(\sigma^2+\phi\sigma+\delta_2\right)}{(\sigma\delta_1+\alpha\delta_2+\phi\delta_1+\alpha\sigma^2+\alpha\sigma\phi-\alpha\sigma\delta_1-\alpha\phi\delta_1+\alpha^2\sigma\beta\delta_1+\alpha^2\beta\phi\delta_1-\alpha\sigma\beta\delta_1-\alpha\beta\phi\delta_1)^2} > 0$

The higher price stickiness, i.e., the higher α, the lower are the standard deviation of output, inflation and that of the nominal interest rate. Hence, price stickiness reduces the overall volatility of the economy.

3.2 Price stickiness and economic stability: simulations

To have a more general and complete picture of the relation between price stickiness and economic stability and to assess its quantitative relevance, we compute the unconditional standard deviations for the main macro variables over a range of price stickiness values considered admissible in the literature, specifically $\alpha \in [0.5,\ 0.9]$, for the model presented in section 2.1 and the calibration presented in 2.2. Figure 1-3 reports the results.

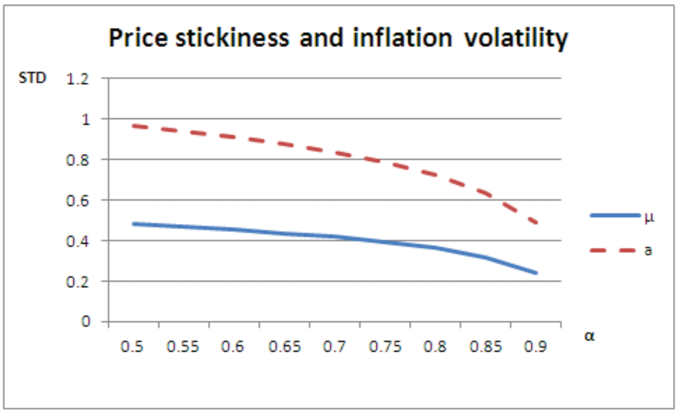

Figure 1: Price stickiness and inflation volatility in presence of cost-push, μ, and technology, a, shocks

Figure 1 shows a remarkable and non linear decrease in the inflation volatility for an increase in price stickiness captured by α. When price stickiness augments, supply shocks tend to be filtered out by firms and inflation turns out to be more insulated.

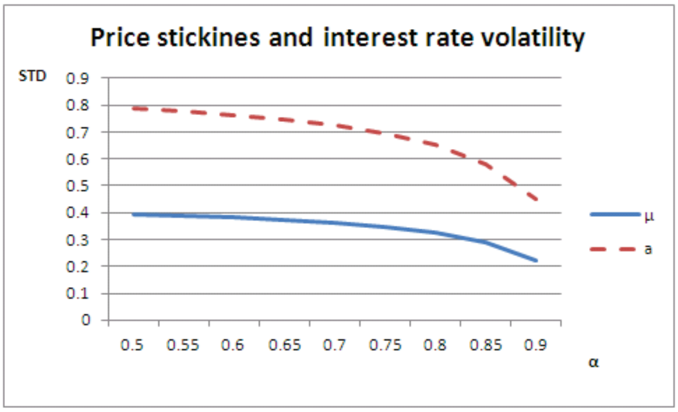

Figure 2: Price stickiness and interest rate volatility in presence of cost-push, μ, and technology, a, shocks

Accounting for monetary policy, Figure 2 then shows that a decrease in inflation volatility is mirrored in a decrease in the interest rate volatility

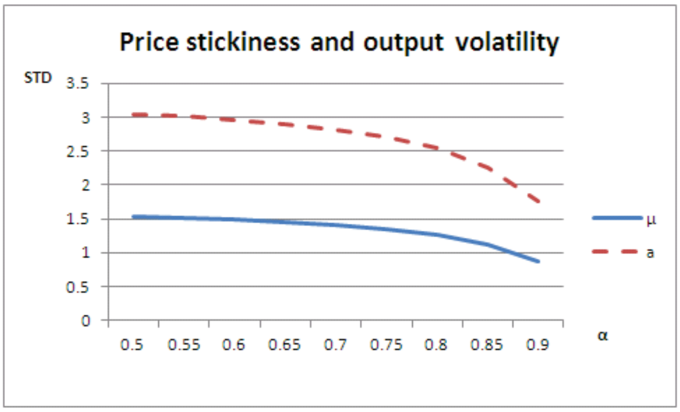

Figure 3: Price stickiness and output volatility in presence of cost-push, μ, and technology, a, shocks.

and, finally, Figure 3, reveals that also real activity is shielded by supply shocks the larger price stickiness.

To have a measure of the impact of price stickiness on economic stability, we report in Table 1 the standard deviations of y, π, and i for three representative values of α in the admissible range.

Table 1: Price stickiness and economic volatility

	$\boldsymbol{\mu}$	$\boldsymbol{a}$	$\boldsymbol{\mu}$	$\boldsymbol{a}$	$\boldsymbol{\mu}$	$\boldsymbol{a}$
$\boldsymbol{\alpha}$	σ_π	σ_π	σ_i	σ_i	σ_y	σ_y
0.5	0.4833	0.9665	0.3927	0.7855	1.5230	3.0459
0.7	0.4185	0.8369	0.3631	0.7263	1.4103	2.8207
0.9	0.2435	0.4870	0.2246	0.4493	0.8748	1.7495

Table 1 shows that increasing α from 0.5 to 0.9 results in a remarkable fall in the volatility of inflation, the interest rate, and output of 49.6%, 42.8% and 42.5% respectively.

4 Concluding remarks

This paper shows the existence of a positive and quantitatively relevant relation between price stickiness and economic stability in presence of supply shocks. This relation is based on a shock filtering device that operates via a reduction of firms' profits and limits the full transmission of the shock to the rest of the economy. Thus, when price stickiness increases economic stability increases too, and considering a range of admissible values for price stickiness, inflation, output and the interest rate can reduce their volatility up to 50%.

An interesting policy implication is that structural measures designed to increase price flexibility should take into account the cost of larger economic instability.

While this work focuses on price stickiness, we conjecture that another shock filtering device arises if one considers nominal rigidities in terms of *wage stickiness.* In this case, the shock will be buffered out by a compression of real wages incurred by households. We leave to further investigation the comparison between this second filtering device and the one analyzed in the current work, and the extent to which the relation between nominal rigidities and economic stability would be strengthen by the presence of this second filter.

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