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November 2008

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First version: November 2008
This version: May 2010

Abstract:
This note analyses the interaction between nominal wage stickiness and costly employment adjustment in a small closed-economy New Keynesian model with simple rule-based or optimal monetary policy. The results show (1) the costs of nominal and real rigidity to depend on the policy regime, (2) optimal policy to substantially contain the welfare loss, and (3) the absence of quantitatively important second-best interaction, suggesting that reducing rigidity along one dimension alone does not risk reducing overall welfare.

JEL classification: E24, E32, J23, J30
Keywords: wage stickiness; employment adjustment costs; second best

1. Introduction

The basic New Keynesian (NK) model emphasises the role of nominal rigidities for business cycles and monetary transmission. Real rigidities such as habit persistence on the demand and factor adjustment costs on the supply side are added to improve the empirical fit. The focus on real rigidities in the NK framework is more recent. Blanchard and Galí (2007) analyse the impact of real wage rigidity on the sacrifice ratio and inflation persistence. Ascari and Merkl (2009) investigate the effects of monetary policy shifts under real wage rigidity and given degrees of price stickiness. Lechthaler and Snower (2008) analyse the impact of labour adjustment costs on output and inflation persistence for constant price stickiness. Duval and Vogel (2007) depart from one-dimensional parameter variation and look at the interaction between nominal and real rigidities, concluding that price rigidity can be second best when real wages are sticky.

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This note extends the analysis of the nominal-real rigidity interaction by looking at nominal wage stickiness and employment adjustment costs. It shows the welfare consequences of the interaction between labour market rigidities to depend on the policy regime and the nature of exogenous shocks. The note presents results for a simple interest rate rule and optimal monetary policy. While the former may approximate the actual conduct of policy; the latter indicates the smallest possible loss for given shocks and rigidity parameters. Results are given for technology, labour supply, consumption and monetary policy shocks. The remainder of the note outlines a small model with flexible prices, but nominal and real labour market rigidities and illustrates their interaction for simple rule-based versus optimal monetary policy.

2. Model

The analysis uses a small closed-economy model with labour as the only production factor. Goods and labour markets are monopolistically competitive, so that goods prices and wages are set with a mark-up over marginal costs and the marginal disutility of labour, respectively. Goods prices are fully flexible. Nominal wages are sticky and derive from Calvo-staggered wage setting. Adjusting the level of employment is subject to quadratic employment adjustment costs.

Consider a representative household maximising welfare as the discounted stream of period utility:

$$(1) \qquad U_i = \sum_{t=0}^{\infty} \beta^t \left(e^{\varepsilon_t^c} \ln C_t - e^{\varepsilon_t^n} \frac{\kappa}{1+\varphi} N_{it}^{1+\varphi} \right)$$

where C is consumption, N_i is hours worked by labour of type i, κ is the relative weight of labour disutility, β is the discount factor, $1/\varphi$ the elasticity of labour supply, ε^c a consumption and ε^n a labour supply shock.

The household i faces the budget constraint:

$$(2) \qquad W_{it} N_{it} + P_t D_t = P_t C_t + B_{t+1} - (1+r_t) B_t$$

equating labour and dividend income, on the left side, with nominal consumption expenditure and net saving in risk-free one-period bonds B on the right. W_i is the nominal wage for labour of type i in a labour market with monopolistic competition and Calvo-staggered wage setting.

Let N be a CES aggregate of the differentiated types of labour:

$$(3) \qquad N_t = \left[\int_0^1 N_{it}^{\frac{\eta-1}{\eta}} di \right]^{\frac{\eta}{\eta-1}}$$

with η as the elasticity of substitution between the differentiated labour inputs N_i. The demand for labour of type i is:

$$(4) \qquad N_{it} = \left(\frac{W_{it}}{W_t} \right)^{-\eta} N_t \,.$$

Output of firm j derives from the one-factor production function:

(5) $$Y_{jt} = e^{\varepsilon_t^a} N_{jt},$$

where ε^a is a technology shock that is identical across all firms and N_j the labour aggregate employed by firm j.

Households consume a bundle of differentiated goods $C_t = \left[\int_0^1 C_{jt}^{\frac{\sigma-1}{\sigma}} dj \right]^{\frac{\sigma}{\sigma-1}}$, where σ is the elasticity of substitution between varieties j. For simplicity, adjustment costs are conceived as consuming such bundles of varieties too.

Demand for output j depends on aggregate demand and the relative price:

(6) $$Y_{jt} = \left(\frac{P_{jt}}{P_t} \right)^{-\sigma} Y_t$$

With fully flexible prices there is no price dispersion and aggregate production $\int_0^1 Y_{jt} dj = Y_t$ equals:

(7) $$Y_t = e^{\varepsilon_t^a} N_t.$$

Nominal wage stickiness makes wage setting a dynamic optimisation problem. Wage setters maximise (1) under the budget constraint (2), the labour demand function (4) and the production function (7).[1] The optimal nominal wage for the re-optimising households is:

(8) $$\left(W_t^*\right)^{1+\eta\varphi} = \kappa \frac{\eta}{\eta-1} \frac{E_0 \sum_{t=0}^{\infty} \left[(\omega\beta)^t e^{\varepsilon_t^n} W_t^{(1+\varphi)\eta} N_t^{1+\varphi} \right]}{E_0 \sum_{t=0}^{\infty} \left[(\omega\beta)^t \lambda_t W_t^{\eta} N_t \right]}$$

where 1-ω is the probability of wage re-adjustment, which corresponds to the share of households resetting wages in a given period, and $\lambda_t = e^{\varepsilon_t^c} / C_t$ is the marginal utility of consumption. The nominal wage level is a weighted average of reset and unadjusted contracts:

(9) $$W_t^{1-\eta} = (1-\omega)\left(W_t^*\right)^{1-\eta} + \omega W_{t-1}^{\;1-\eta}.$$

Firms operate in a monopolistically competitive goods market and face quadratic employment adjustment costs, providing them with the incentive to smooth employment adjustment over time. Maximisation of real firm profits:

(10) $$\max_{P_t^j} D_0^j = E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{P_t^j}{P_t} Y_t^j - \frac{W_t}{P_t} N_t^j - \frac{\phi}{2}\left(N_t^j - N_{t-1}^j\right)^2 \right]$$

under the production and demand functions (5) and (6) yields the profit maximising price. Assuming symmetric behaviour and symmetric constraints among firms, the aggregate price level is:

[1] Calvo wage setting is derived in detail in, e.g., Canzoneri et al. (2007).

(11) $P_t = \dfrac{\sigma W_t}{\sigma\left[e^{\varepsilon_t^a} - \phi(1+\beta)\dfrac{N_t}{e^{\varepsilon_t^a}} + \phi\dfrac{N_{t-1}}{e^{\varepsilon_{t-1}^a}} + \beta\phi E_t\left(\dfrac{N_{t+1}}{e^{\varepsilon_{t+1}^a}}\right)\right] - 1}$.

Aggregate demand in the closed economy is the sum of consumption demand and the employment adjustment costs:

(12) $Y_t = C_t + \frac{\phi}{2}(N_t - N_{t-1})^2$.

Intertemporal optimising households that can lend and borrow against future income choose the consumption path:

(13) $C_t = \frac{1}{\beta}\frac{1}{1+r_t}E_t\left(\frac{e^{\varepsilon_t^c}}{e^{\varepsilon_{t+1}^c}}\frac{P_{t+1}}{P_t}C_{t+1}\right)$.

The note considers two alternative settings for monetary policy. First, a simple Taylor-type rule:

(14) $r_t = \alpha_r r_{t-1} + (1-\alpha_r)\left(\frac{1-\beta}{\beta} + \alpha_y \hat{y}_t + \alpha_\pi \pi_t\right) + \varepsilon_t^r$,

where $\hat{y} \equiv \ln Y - \ln Y^f$ is the output gap as the log difference between actual output and output in absence of nominal and real stickiness, $\pi_t \equiv \ln P_t - \ln P_{t-1}$ is inflation and ε^r is a monetary policy shock. Second, optimal monetary policy with full information and credible commitment. The first setting, adopted e.g. in Canzoneri et al. (2007), accounts for the fact that monetary policy is rarely optimal; the second one shows the loss frontier as the best possible outcome for given structural parameters and shocks.[2]

The relevant measure of economy-wide welfare under staggered wage setting is:

(15) $U_i = \sum_{t=0}^{\infty}\beta^t\left(e^{\varepsilon_t^c}\ln C_t - e^{\varepsilon_t^n}\frac{\kappa}{1+\varphi}DW_t N_t^{1+\varphi}\right)$

where C is per capita consumption and $DWN^{1+\varphi}$ the average disutility of work. DW measures the dispersion of wages:

(16) $DW_t = (1-\omega)\left(\frac{W_t^*}{W_t}\right)^{-\eta(1+\varphi)} + \omega\left(\frac{W_{t-1}}{W_t}\right)^{-\eta(1+\varphi)} DW_{t-1}$.

Wage dispersion makes firms hire different amounts of work from individual households. If wages are flexible (ω=0), firms hire the same amount of labour from each households (3) and individual and economy-wide welfare coincide (see Canzoneri et al., 2007).

To study the interaction of nominal wage stickiness and costly employment adjustment, the model is simulated over a grid of rigidity combinations. The Calvo parameter ω varies between 0.1 and 0.9, on quarterly basis, and adjustments costs ϕ between 0 and 10, comprising the estimates of Hall (2004) or

[2] Ramsey optimal policy is computed using the routine of Levin et al. (2005).

Ratto et al. (2010) for the U.S. economy. The parameter values β=0.99, σ=10, η=5, κ=1, φ=2.5, α_r=0.9, α_y=0.1 and α_π=1.5 reflect parameter estimates in Ratto et al. (2010), Sahuc and Smets (2008) and Smets and Wouters (2005, 2007). To facilitate comparison, the technology, labour supply and consumption shocks $\varepsilon_t= \rho\varepsilon_{t-1}+\nu_t$ have persistence ρ=0.90 and an innovation ν of 0.10 standard errors; the monetary shock has ρ=0, because the autoregressive component in the policy rule already implies persistence, and a smaller innovation of 0.01 standard errors. The values are within the estimated order of magnitude in Sahuc and Smets (2008) and Smets and Wouters (2005, 2007).

3. Results

This section describes the interaction between nominal wage stickiness and real employment adjustment costs and their impact on economic welfare as defined by equation (15). Figures 1 and 2 display the welfare loss as percentage of steady-state consumption. A first view shows the magnitude of losses to depend on the type of shock; notably, technology shocks imply larger losses than labour supply or consumption shocks of the same size and persistence.

[Figure 1]

Figure 1 shows results for the Taylor rule (13) and indicates a substantial impact of nominal wage rigidity on the welfare loss. The reason is that with a monetary rule focusing on price level stability, higher nominal wage rigidity also increases the stickiness of real wages, which constrains the optimal adjustment of real variables. In the frictionless economy, a positive technology shock (A) reduces production costs and prices; households consume more but work less, so that the shock does not fully translate into higher real wages, output and consumption. The combination of nominal wage stickiness with a strong inflation target in the policy rule prevents the gradual rise in the price level deriving from declining labour supply and a less than proportionate increase in real wages; activity and consumption are higher and leisure lower than in the flexible economy. The welfare loss from real adjustment costs is largest for the technology shock which implies the biggest employment adjustment. A positive shock to the disutility of labour (B) raises nominal wage claims and lowers activity and consumption in the frictionless economy; production costs and prices increase and moderate the rise in real wages. Nominal wage stickiness combined anti-inflation policy eliminates the dampening of real wage growth. Real wages increase and activity and consumption fall more strongly than under flexible adjustment. A positive shock to consumption utility (C) dampens nominal wage claims; activity and consumption increase especially in a low inflation environment. In case of zero adjustment frictions, lower wage claims translate into less real wages moderation and activity growth. Finally, the interest rate shock (4) dampens demand and output. Nominal wage flexibility translates this into falling nominal wages and production costs; monetary policy turns expansionary to prevent the fall in the price level and offsets the decline in activity and consumption. Nominal wage stickiness prevents a swift adjustment of nominal wages and productions costs; short of monetary easing the initial shock causes larger contraction. Taken together, the combination of nominal wage rigidity and monetary policy with strong focus on price level stability increases the impact of shocks on real variables.

[Figure 2]

Figure 2 displays the welfare losses under optimal monetary policy, i.e. the smallest possible loss for given shocks and rigidities. Losses for each shock are substantially below those in Figure 1. In addition, the loss frontier has almost identical shape for all three shocks and the impact of nominal wage rigidity is practically zero.[3] The reason is that optimal policy places less restrictions on price level adjustment than the above Taylor rule. Flexible prices allows real wages to adjust freely to limit the impact of shocks on consumption and activity. Optimal policy cannot prevent the welfare loss from real adjustment costs, however, which remain the only costly dynamic rigidity.

Figures 1 and 2 do not display any quantitatively relevant interaction between nominal wage rigidity and employment adjustment costs in the sense of a second-best solution discussed in Duval and Vogel (2007) for the given shocks and rigidity parameter ranges.[4] The lack of second-best interaction suggests that policy reforms undertaken independently in one of the areas do not risk having detrimental impact on economic welfare.

4. Conclusion

The results of this note suggest three conclusions on the interaction of nominal and real labour market rigidity: (1) Costs of nominal and real inertia depend on the policy regime: nominal wage inertia can be costly under non-optimal policy, but under optimal monetary policy only real rigidities matter. (2) Compared to a simple Taylor rule, optimal policy can substantially limit the welfare loss from exogenous shocks. (3) There is no quantitatively relevant second-best interaction between nominal and real stickiness for the selected shocks and parameter spaces; absence of second-best interaction implies that structural reforms in one dimension will not incur welfare losses if adjustment frictions in the other dimension remain unchanged.

Acknowledgements

The views in the paper are solely those of the author and not those of the European Commission. I thank an anonymous referee for very helpful comments on an earlier draft.

[3] Figure 2 does not include an interest rate shock as the latter is difficult to conceive in the context of optimal monetary policy.

[4] Second-best solution here means that, from the welfare perspective, higher might be preferable lower nominal (real) rigidity for given real (nominal) adjustment frictions.

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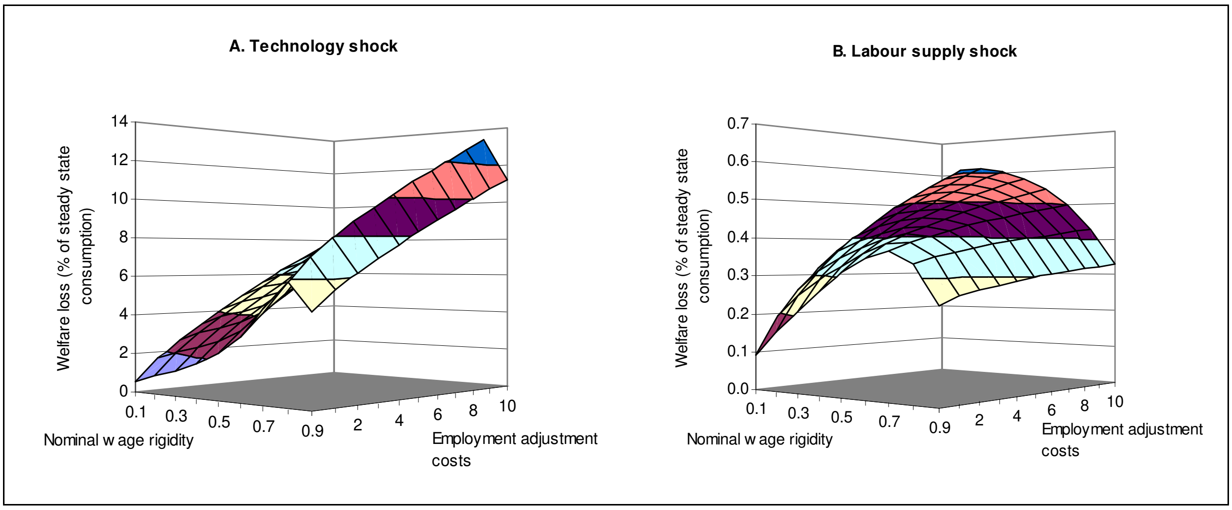
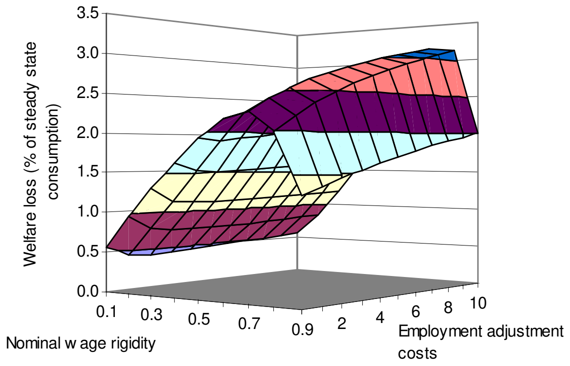
Figure 1: Welfare loss under Taylor rule



C. Consumption shock



D. Monetary policy shock

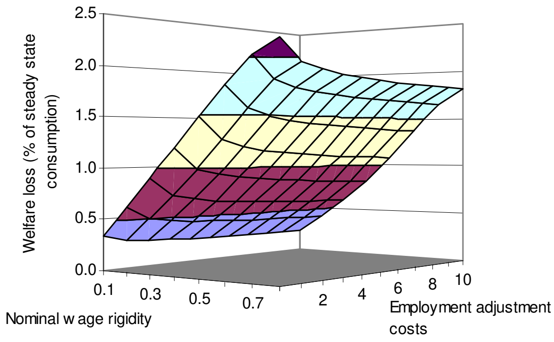
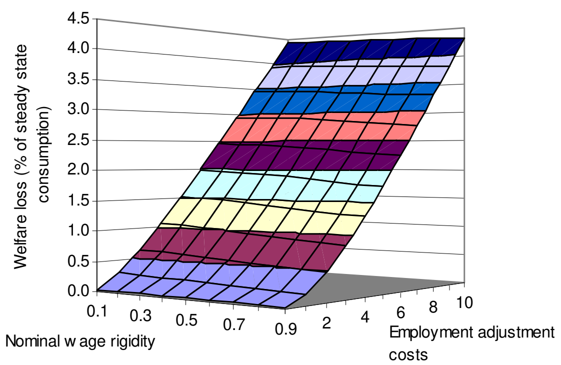
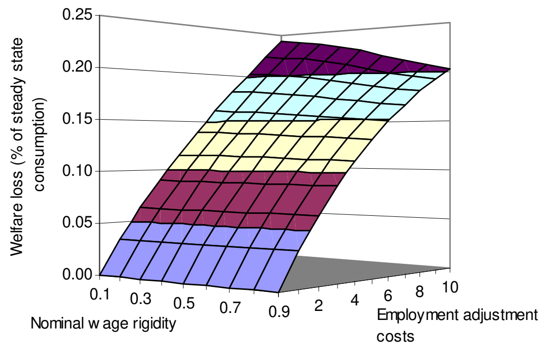


Figure 2: Welfare loss under optimal policy

A. Technology shock



B. Labour supply shock



C. Consumption shock