Sectoral Labor Mobility and Optimal Monetary Policy*

Alessandro Cantelmo†
City University London

Giovanni Melina‡
International Monetary Fund

Abstract

In a two-sector New-Keynesian model with durable and nondurable goods, an inverse relationship between the degree of sectoral labor mobility and the optimal weight the central bank should attach to durables inflation arises. The combination of nominal wage stickiness and limited labor mobility lead to a nonzero optimal weight for durables inflation even when durables prices are fully flexible.

JEL classification: E52, E58.

Keywords: Optimal monetary policy, durable goods, labor mobility, DSGE.

---

*The views expressed in this paper are those of the authors and do not necessarily represent those of the International Monetary Fund or IMF policy.

†Department of Economics, City University London, UK. E-mail: alessandro.cantelmo.1@city.ac.uk.

‡International Monetary Fund, 700 19th Street N.W., Washington, D.C. 20431, United States; and Department of Economics, City University London, UK. E-mail: gmelina@imf.org.

1 Introduction

What inflation measure should central banks target? This question naturally arises when a New-Keynesian (NK) model is extended to include more than one sector. In fact, with only one instrument available, the central bank has to decide how much weight it has to assign to each sectoral inflation. The literature has demonstrated that the relative degree of price stickiness across sectors is crucial for the determination of this optimal weight (see, e.g., Aoki, 2001 and Benigno, 2004): more weight should be given to the sector in which prices are stickier.[1]

We show that the extent to which labor can freely move across sectors is also crucial in the determination of the optimal inflation composite and it intuitively interact with price and nominal wage stickiness. The framework in which we explore the relationship between sectoral labor mobility and the optimal inflation composite is a two-sector NK model with nondurable and durable goods. The closest contribution to ours is that of Petrella et al. (2015), who optimally find the weight attached to durables inflation in an input-output economy, but only for one given limited degree of labor mobility. Moreover, while they conduct their analysis conditional only on a sectoral technology shock, we allow for a larger set of shocks. We also assess the welfare properties of three types of simple interest rate rules in such an environment.

2 Model

We use a two-sector NK model in the spirit of Barsky et al. (2007). The basic setup is augmented with several nominal and real frictions the literature has found to be empirically relevant.

2.1 Households

There is a continuum $i \in [0,1]$ of identical and infinitely-lived households consuming both durable and nondurable goods and supplying labor, whose lifetime utility is

$$E_0 \sum_{t=0}^{\infty} e_t^B \beta^t U\left(X_{i,t}, N_{i,t}\right), \tag{1}$$

where $\beta \in [0,1]$ is the subjective discount factor, e_t^B is a preference shock, $X_{i,t} = Z_{i,t}^{1-\alpha} D_{i,t}^{\alpha}$ is a Cobb-Douglas consumption aggregator between nondurable ($Z_{i,t}$) and durable goods ($D_{i,t}$) with $\alpha \in [0,1]$ representing the share of durable consumption on total expenditure, and $N_{i,t}$ being the household's labor supply. Nondurable consumption is subject to external habit

[1] Benigno (2004) studies a two-country New-Keynesian model of a currency union which resembles a two-sector model and these conclusions can be carried over.

formation so that

$$Z_{i,t} = C_{i,t} - \zeta S_{t-1}, \tag{2}$$

$$S_t = \rho_c S_{t-1} + (1-\rho_c) C_t, \tag{3}$$

where $C_{i,t}$ is the level of the household's nondurable consumption; S_t, $\zeta \in (0,1)$ and $\rho_c \in (0,1)$ are the stock, the degree and the persistence of habit formation, respectively, while C_t represents average consumption across households. Members of each household supply labor to firms in both sectors according to:

$$N_{i,t} = \left[\left(\chi^C\right)^{-\frac{1}{\lambda}} \left(N_{i,t}^C\right)^{\frac{1+\lambda}{\lambda}} + \left(1-\chi^C\right)^{-\frac{1}{\lambda}} \left(N_{i,t}^D\right)^{\frac{1+\lambda}{\lambda}} \right]^{\frac{\lambda}{1+\lambda}}. \tag{4}$$

This CES specification of aggregate labor captures different degrees of labor mobility across sectors, governed by parameter $\lambda > 0$, i.e. the intra-temporal elasticity of substitution: $\lambda \to 0$ denotes the case of labor immobility, while as $\lambda \to \infty$ labor can freely be reallocated and all workers earn the same wage. For $\lambda < \infty$ the economy displays a limited degree of labor mobility and sectoral wages are not equal. Moreover, $\chi^C \equiv N^C/N$ represents the steady-state share of labor supply in the nondurables sector. Nominal wages are subject to quadratic costs of adjustment à la Rotemberg (1982): $\frac{\vartheta^W}{2}\left(\frac{w_{i,t}}{w_{i,t-1}}\widetilde{\Pi}_t - \widetilde{\Pi}_{ss}\right)^2 w_t N_t$, where the variable

$$\widetilde{\Pi}_t \equiv \left(\Pi_t^C\right)^{1-\tau}\left(\Pi_t^D\right)^{\tau} \tag{5}$$

is an aggregator of the gross rates of sectoral inflations, $\widetilde{\Pi}_{ss}$ is its steady-state value and $\tau \in [0,1]$ represents the weight assigned by the central bank to durables inflation. The stock of durables evolves according to law of motion

$$D_{i,t+1} = (1-\delta) D_{i,t} + e_t^I I_{i,t}^D \left[1 - S\left(\frac{I_{i,t}^D}{I_{i,t-1}^D}\right)\right], \tag{6}$$

where δ is the depreciation rate, $I_{i,t}^D$ is investment in durable goods that is subject to adjustment costs, and e_t^I represents an investment-specific shock. The adjustment costs function $S(\cdot)$ satisfies $S(1) = S'(1) = 0$ and $S''(1) > 0$. Each household consumes $X_{i,t}$, purchases nominal bonds $B_{i,t}$, receives profits Ω_t from firms and pays a lump-sum tax T_t. Finally, $Q_t \equiv \frac{P_{D,t}}{P_{C,t}}$ denotes the relative price of durables so that the period-by-period real budget constraint reads as follows:

$$C_{i,t} + Q_t I_{i,t}^D + \frac{\vartheta^W}{2}\left(\frac{w_{i,t}}{w_{i,t-1}}\widetilde{\Pi}_t - \widetilde{\Pi}_{ss}\right)^2 w_t N_t + \frac{B_{i,t}}{P_t^C} = \frac{W_{i,t}}{P_t^C} N_{i,t} + R_{t-1}\frac{B_{i,t-1}}{P_t^C} + \Omega_t - T_t. \tag{7}$$

Households choose $Z_{i,t}, B_{i,t}, D_{i,t+1}, I_{i,t}^D, w_{i,t}, N_{i,t}^C, N_{i,t}^D$ to maximize (1) subject to (2), (3), (4), (6) and (7).

2.2 Firms

A continuum $\omega \in [0,1]$ of firms in each sector $j = C, D$ operates in monopolistic competition and face quadratic costs of changing prices $\frac{\vartheta_j}{2}\left(\frac{P_{\omega,t}^j}{P_{\omega,t-1}^j} - 1\right)^2 Y_t^j$, where ϑ_j is the parameter of sectoral price stickiness. Each firm produces differentiated goods according to a linear production function,

$$Y_{\omega,t}^j = e_t^A N_{\omega,t}^j, \tag{8}$$

where e_t^A is a labor augmenting productivity shock. Firms maximize the present discounted value of profits,

$$E_t\left\{\sum_{t=0}^{\infty} \Lambda_{t,t+1}\left[\frac{P_{\omega,t}^j}{P_t^j} Y_{\omega,t}^j - \frac{W_{\omega t}}{P_t^j} N_{\omega,t}^j - \frac{\vartheta_j}{2}\left(\frac{P_{\omega,t}^j}{P_{\omega,t-1}^j} - 1\right)^2 Y_t^j\right]\right\}, \tag{9}$$

subject to production function (8) and a standard Dixit-Stiglitz demand equation $Y_{\omega,t}^j = \left(\frac{P_{\omega,t}^j}{P_t^j}\right)^{-e_t^j \epsilon_j} Y_t^j$, where ϵ_j and e_t^j are the sectoral intratemporal elasticities of substitution across goods and the sectoral price markup shocks, respectively. This leads to standard price-setting equations.

2.3 Fiscal and monetary policy

The government purchases nondurable goods as in Erceg and Levin (2006) and runs a balanced budget by levying lump-sum taxes. Monetary policy is conducted by an independent central bank. For the sake of robustness, we assess the welfare implications of two alternative simple interest rate rules, reparametrized to allow also for price-level and superinertial monetary responses:

$$\log\left(\frac{R_t}{\bar{R}}\right) = \rho_r \log\left(\frac{R_{t-1}}{\bar{R}}\right) + \alpha_\pi \log\left(\frac{\tilde{\Pi}_t}{\tilde{\Pi}}\right) + \alpha_y \log\left(\frac{Y_t}{\bar{Y}}\right), \tag{10}$$

$$\begin{aligned}\log\left(\frac{R_t}{\bar{R}}\right) = \rho_r \log\left(\frac{R_{t-1}}{\bar{R}}\right) + \alpha_\pi \log\left(\frac{\tilde{\Pi}_t}{\tilde{\Pi}}\right) + \alpha_y \log\left(\frac{Y_t}{Y_t^f}\right) \\ + \alpha_{\Delta y}\left[\log\left(\frac{Y_t}{Y_t^f}\right) - \log\left(\frac{Y_{t-1}}{Y_{t-1}^f}\right)\right],\end{aligned} \tag{11}$$

where $\alpha_\pi \equiv (1-\rho_r)\,\rho_\pi$, $\alpha_y \equiv (1-\rho_r)\,\rho_y$, $\alpha_{\triangle y} \equiv (1-\rho_r)\,\rho_{\Delta y}$ and ρ_r is the interest rate smoothing parameter. Equation (10) is an *implementable* rule as in Schmitt-Grohe and Uribe (2007) whereby the central bank responds to deviations of inflation and output from their respective steady states. Rule (11) is that employed by Smets and Wouters (2007) and implies that the central bank reacts to inflation, the output gap and the output gap growth. In the latter rule, the output gap is defined as the deviation of output from the level that would prevail with flexible prices and wages, Y_t^f.

2.4 Market clearing conditions and exogenous processes

In equilibrium all markets clear. As in Smets and Wouters (2007), wage markup and the price markup shocks follow ARMA (1,1) processes:

$$\log\left(\frac{\varkappa_t}{\bar{\varkappa}}\right) = \rho_\varkappa \log\left(\frac{\varkappa_{t-1}}{\bar{\varkappa}}\right) + \epsilon_t^\varkappa - \theta_i \epsilon_{t-1}^\varkappa, \tag{12}$$

with $\varkappa = \left[e^W, e^C, e^D\right]$, $i = [W, C, D]$, whereas all other shocks follow an AR (1) process:

$$\log\left(\frac{\kappa_t}{\bar{\kappa}}\right) = \rho_\kappa \log\left(\frac{\kappa_{t-1}}{\bar{\kappa}}\right) + \epsilon_t^\kappa, \tag{13}$$

where $\kappa = \left[e^B, e^I, e^A, e^G\right]$, $\rho_\varkappa$ and ρ_κ are the autoregressive parameters, θ_i are the moving average parameters, $\epsilon_t^\varkappa$ and ϵ_t^κ are i.i.d shocks with zero mean and standard deviations $\sigma_\varkappa$ and σ_κ.

2.5 Functional forms

The utility function is additively separable and logarithmic in the consumption aggregator: $U(X_t, N_t) = \log(X_t) - \nu \frac{N_t^{1+\varphi}}{1+\varphi}$, where ν is a scaling parameter for hours worked and φ is the inverse of the Frisch elasticity of labor supply. Following Christiano et al. (2005), adjustment costs in durables investment are quadratic: $S\left(\frac{I_t^D}{I_{t-1}^D}\right) = \frac{\phi}{2}\left(\frac{I_t^D}{I_{t-1}^D} - 1\right)^2$ with $\phi > 0$.

3 Parameter values

Parameters directly related to steady-state relationships are set at values widely used in the related literature, while remaining parameters are set at the posterior mean of the Bayesian estimates of Cantelmo and Melina (2015). These imply a higher degree of price stickiness for nondurable goods, although that of durables is not negligible ($\vartheta_c = 34.27$ and $\vartheta_d = 25$). If the durables sector comprises only houses, it is reasonable to assume that prices are flexible. Thus, in our optimal policy analysis, we consider an alternative case of fully flexible house prices ($\vartheta_d = 0$). Note that in Cantelmo and Melina (2015) labor is perfectly mobile across sectors, and parameter λ has thus not been estimated. Here, we explore the implications of

$\beta = 0.99$	$\varphi = 0.65$	$\tau = 0.14$	$\rho_{e^B} = 0.65$	$\theta_C = 0.3943$	$\sigma_{e^D} = 0.0383$
$\delta = 0.01$	$\nu = 24.45$	$g_y = 0.2$	$\rho_{e^I} = 0.41$	$\theta_D = 0.6266$	$\sigma_{e^W} = 0.0424$
$\alpha = 0.2$	$\zeta = 0.79$	$\rho_\pi = 1.51$	$\rho_{e^W} = 0.95$	$\sigma_{e^A} = 0.007$	$\sigma_{e^G} = 0.0356$
$\epsilon_c = 6$	$\rho_c = 0.4$	$\rho_y = 0.02$	$\rho_{e^C} = 0.93$	$\sigma_{e^I} = 0.0747$	
$\epsilon_d = 6$	$\vartheta^W = 98$	$\rho_R = 0.71$	$\rho_{e^D} = 0.98$	$\sigma_{e^B} = 0.0192$	
$\eta = 21$	$\phi = 3.7$	$\rho_{e^A} = 0.95$	$\rho_{e^G} = 0.93$	$\sigma_{e^C} = 0.0195$	

Table 1: Parameter values

several alternative values of λ for welfare and optimal monetary policy. All other parameter values are fairly close to values found in the literature and are reported in Table 1.

4 Optimal monetary policy

4.1 Welfare measure

The optimal monetary policy analysis serves two purposes: (i) determining the optimal weights the central bank should assign to sectoral inflations subject to given degrees of labor mobility, and (ii) seeking parameter values for interest rate rules that allow them to mimic the first best allocation, i.e. that minimize the welfare loss with respect to the Ramsey policy. The social planner maximizes the present value of households' utility,

$$\Upsilon_t = E_t \left[\sum_{s=0}^{\infty} e_s^B \beta^s U\left(X_{t+s}, N_{t+s}\right) - w_r \left(R_{t+s} - R\right)^2 \right], \tag{14}$$

subject to the equilibrium conditions of the model.[2] Since it is not straightforward to account for the zero-lower-bound (ZLB, henceforth) on the nominal interest rate when using perturbation methods, we follow Schmitt-Grohe and Uribe (2007) and Levine et al. (2008) and introduce a term in (14) that penalizes large deviations of the nominal interest rate from its steady state. Hence, the imposition of this approximate ZLB constraint translates into appropriately choosing the weight w_r to achieve an arbitrarily low per-period probability of hitting the ZLB, $Pr\left(ZLB\right) \equiv Pr\left(R_t^n < 1\right)$, which we set at 0.001, and corresponds to a value of the penalty parameter $w_r = 80$. Next, we optimize the interest rate rules outlined in equations (10) and (11) by numerically searching for the combination of the policy parameters and the weight on durables inflation $\tau \in [0, 1]$ that maximize the present value of households'

[2]As established by Schmitt-Grohe and Uribe (2007), while more stylized models allow for a first-order approximation to the equilibrium conditions to be sufficient to accurately approximate welfare up to a second order, the presence of the frictions requires taking a second-order approximation both of the mean of Υ_t and of the model's equilibrium conditions around the deterministic steady state. In particular, we take the approximation around the steady state of the Ramsey equilibrium. Similarly to many other NK models in the literature (see e.g. Schmitt-Grohe and Uribe, 2007; Levine et al., 2008, among others), the steady-state value of the gross inflation rate in the Ramsey equilibrium turns out to be very close to unity, which implies an almost zero-inflation steady state.

utility. Last, we compare the welfare losses in terms of steady-state consumption-equivalent, ω, with respect to the Ramsey policy, as in Schmitt-Grohe and Uribe (2007).[3]

We use the following three interest rate rules: (i) the *implementable rule* of equation (10), (ii) the *Smets-Wouters rule* (SW rule, henceforth) of equation (11) with support for the interest rate smoothing parameter $\rho_R \in [0,1]$, (iii) the *superinertial Smets-Wouters rule* (SW superinertial rule, henceforth) with the support of ρ_R in equation (11) allowed to be $[0,5]$.[4] The central bank chooses the policy parameters in the interest rate rule and how much weight to attach to sectoral inflations subject to the degree of price stickiness and labor mobility across sectors. The latter is governed by parameter λ and we consider three cases: (i) $\lambda = 0.1$ represents the case of *quasi* labor immobility, (ii) $\lambda = 4$ the case of high labor mobility and (iii) $\lambda = 1$ an intermediate case of limited labor mobility corresponding to a Cobb-Douglas labor supply aggregator.

4.2 Results

Figure 1 shows the responses to an inflation shock (namely a shock to the price mark-up) under the Ramsey policy and sticky durable prices.[5] Higher markups in the durables sector increase inflation and decrease investment and employment in durables for any degree of labor mobility. However, when labor is prevented from moving across sectors, demand and employment fall also in nondurables. Indeed, the negative wealth effect of lower employment and wages in durables offsets the positive effect of higher wages in nondurables. Therefore, households reduce demand for both types of goods.

Conversely, when labor is very mobile, consumption in nondurables increases since labor can be reallocated to the nondurables sector, where wages increase. The optimal response of the nominal interest rate is significantly different when labor is perfectly mobile: i.e. it accommodates the increase in inflation. The intuition is that a fall in the nominal interest rate stimulates consumption in nondurables and, since more workers can flow from the durable to the nondurable sector, supply will be able to catch up with demand and avoid a recession, at least in the first five quarters after the shock. Here the bottom line is that labor mobility has important implications for the transmission mechanism of structural shocks and optimal monetary policy.

Table 2 reports the optimized parameters together with the welfare costs ω associated to each of the interest rate rules. We also assess the implications of having fully flexible prices for durables goods. Results show that the SW superinertial rule performs better than the other rules for any degree of labor mobility and regardless of stickiness for durables prices.

[3]For a particular regime associated to a given Taylor-type interest rate rule A, the welfare loss is implicitly defined as $E_0\left\{\sum_{t=0}^{\infty}\beta^t\left[U\left((1-\omega)X_t^R, N_t^R\right)\right]\right\} = E_0\left\{\sum_{t=0}^{\infty}\beta^t\left[U\left(X_t^A, N_t^A\right)\right]\right\}$, where $\omega \times 100$ represents the percent permanent loss in consumption that should occur in the Ramsey regime (R) in order agents to be as well off in regime R as they are in regime A.

[4]The support of ρ_R in the implementable rule is $[0,1]$ whereas the support of the parameters α_π, α_y and $\alpha_{\Delta y}$ is $[0,5]$ uniformly across rules.

[5]Impulse responses to all the other structural shocks are standard and available upon request.

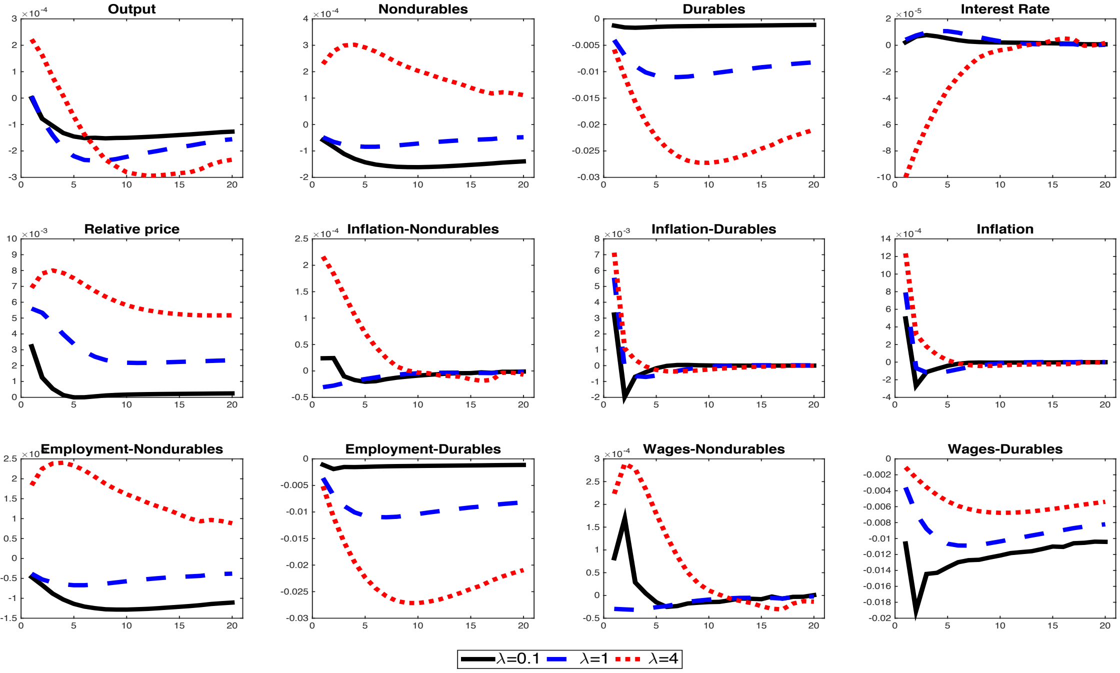

Figure 1: Responses to a durables price markup shock: Ramsey policy

Key to this result is that ρ_R is not bounded at 1 such that the central bank is allowed to implement a higher degree of inertia than that implied by a price level rule ($\rho_R = 1$).[6] To get a quantitative sense of the issue, consider the case of sticky durables prices and limited labor mobility ($\lambda = 1$). Switching from the implementable to the SW rule does not yield significant welfare improvements. Indeed, households give up 0.0819% and 0.0799% of their Ramsey consumption streams, respectively, when such policies are adopted. Conversely, switching to the SW superinertial rule implies that agents give up only 0.0219% of their Ramsey consumption stream. In other words, a superinertial rule implies a consumption-equivalent welfare loss amounting to about $1/4$ of the loss suffered in the other cases. In addition, when ρ_R is not bounded between zero and one, more mobile labor always leads to lower welfare losses.

Uniformly, the higher weight in the inflation composite is assigned to nondurables ($\tau < 0.5$), as this is the sector with the higher price stickiness. However, conditional on the interest rate rule employed and the degree of durables price stickiness, an inverse relationship between labor mobility and the optimal weight placed on durables inflation arises. As labor becomes more mobile (i.e. λ increases) the central bank finds it optimal to place even less weight on durables inflation (i.e. optimal τ decreases). Indeed, when labor is very mobile ($\lambda = 4$), in all cases no weight is assigned at all. The intuition is that, with more mobile labor, adjustments to shocks easily occur through quantities (via the reallocation of labor itself) rather than prices, and the the central bank finds it optimal to focus more on the sector with the higher

[6] See Giannoni and Woodford (2003) for a detailed discussion on superinertial rules.

	Sticky durables prices						Flexible durables prices					
λ	ρ_R	α_π	α_y	$\alpha_{\Delta y}$	τ	$\omega\%$	ρ_R	α_π	α_y	$\alpha_{\Delta y}$	τ	$\omega\%$
						Optimized implementable rule						
0.1	1	0.0397	0.0000	\	0.3906	0.0697	1	0.0279	0.0000	\	0.0929	0.0687
1	1	0.0975	0.0000	\	0.0898	0.0819	1	0.0939	0.0000	\	0.0010	0.0878
4	1	0.2683	0.0000	\	0.0000	0.1512	1	0.2866	0.0000	\	0.0000	0.1782
						Optimized SW rule						
0.1	1	0.0477	0.0000	0.0180	0.3049	0.0671	1	0.0381	0.0000	0.0204	0.0450	0.0643
1	1	0.0952	0.0000	0.0216	0.0149	0.0799	1	0.1002	0.0000	0.0167	0.0000	0.0868
4	1	0.2683	0.0000	0.0000	0.0000	0.1512	1	0.2862	0.0000	0.0000	0.0000	0.1783
						Optimized SW superinertial rule						
0.1	1.2273	0.0265	0.0021	0.0144	0.3200	0.0421	1.1527	0.0071	0.0013	0.0000	0.0170	0.0418
1	3.1444	0.6962	0.0126	0.4416	0.0455	0.0219	2.9228	0.6062	0.0157	0.2381	0.0000	0.0223
4	5	2.7920	0.0000	0.0000	0.0000	0.0051	5	2.8054	0.0000	0.0000	0.0000	0.0221

Table 2: Optimized simple monetary policy rules

price stickiness.

Under fully flexible durables prices and sufficiently limited labor mobility, τ is still nonzero. This result is driven by nominal wage stickiness. In fact, wage stickiness affects firms' marginal costs and their price setting behavior. The pass-through of sticky wages to the durables sector marginal cost induces the central bank to place some weight on inflation in this sector despite price flexibility. Figure 2 shows the relationship between the optimal τ and durables price stickiness, ϑ^d, under sticky and flexible wages.[7] Three important remarks emerge from this figure. First, regardless of nominal wage stickiness, τ is an increasing function of ϑ^d. Second, for any degree of durables price stickiness, τ is always higher under wage stickiness. Third, when durables prices are flexible $\left(\vartheta^d = 0\right)$, τ is small but still nonzero if wages are sticky; it becomes zero when also wages are flexible.

5 Conclusion

Imperfect sectoral labor mobility significantly alters the transmission mechanism of shocks to the economy and the optimal monetary policy response. Regardless of the intensity of price stickiness in the durables sector, an inverse relationship between the degree of labor mobility and the optimal weight to be attached by the central bank to durables inflation arises. This result survives three interest rate rule specifications, among which a superinertial rule exhibits the lowest welfare loss relative to the Ramsey policy. Finally, the combination of nominal wage stickiness and sufficiently limited labor mobility lead to a nonzero optimal

[7]Labor mobility is limited with $\lambda = 1$. The interest rate rule is the optimized implementable rule.

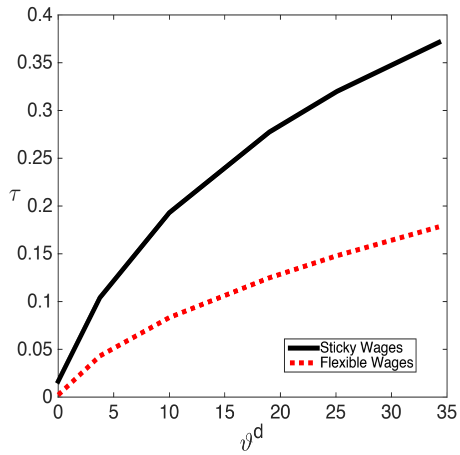

Figure 2: Durables price stickiness and optimal weight on durables inflation: flexible vs. sticky wages

weight for durables inflation even when durables prices are fully flexible.

References

Aoki, K. (2001). Optimal monetary policy responses to relative-price changes. *Journal of Monetary Economics*, 48(1):55–80.

Barsky, R. B., House, C. L., and Kimball, M. S. (2007). Sticky-price models and durable goods. *American Economic Review*, 97(3):984–998.

Benigno, P. (2004). Optimal monetary policy in a currency area. *Journal of International Economics*, 63(2):293–320.

Cantelmo, A. and Melina, G. (2015). Monetary Policy and the Relative Price of Durable Goods. CESifo Working Paper Series 5328, CESifo Group Munich.

Christiano, L. J., Eichenbaum, M., and Evans, C. L. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of Political Economy*, 113(1):1–45.

Erceg, C. and Levin, A. (2006). Optimal monetary policy with durable consumption goods. *Journal of Monetary Economics*, 53(7):1341–1359.

Giannoni, M. P. and Woodford, M. (2003). Optimal Interest-Rate Rules: I. General Theory. NBER Working Papers 9419, National Bureau of Economic Research, Inc.

Levine, P., McAdam, P., and Pearlman, J. (2008). Quantifying and sustaining welfare gains from monetary commitment. *Journal of Monetary Economics*, 55(7):1253–1276.

Petrella, I., Rossi, R., and Santoro, E. (2015). Monetary policy with sectoral trade-offs. mimeo.

Rotemberg, J. J. (1982). Monopolistic price adjustment and aggregate output. *Review of Economic Studies*, 49(4):517–31.

Schmitt-Grohe, S. and Uribe, M. (2007). Optimal simple and implementable monetary and fiscal rules. *Journal of Monetary Economics*, 54(6):1702–1725.

Smets, F. and Wouters, R. (2007). Shocks and frictions in US business cycles: A Bayesian DSGE approach. *American Economic Review*, 97(3):586–606.