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IMPERFECT RATIONALITY, MACROECONOMIC EQUILIBRIUM AND PRICE RIGIDITIES

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Imperfect rationality, macroeconomic equilibrium and price rigidities*

Giuseppe Ciccarone† Francesco Giuli‡ Enrico Marchetti§

Abstract

We introduce some elements of Prospect Theory into a general equilibrium model with monopolistic competition in the good market and real wage rigidities due to (right to manage or efficient) wage bargaining, or to efficiency wages. We show that, under these types of labor market frictions, an increase in workers' loss aversion: (i) reduces the equilibrium wage and in this way increases potential output; (ii) induces workers to work and consume less and in this way decreases potential output. If the former effect is greater (smaller) than the latter one, loss aversion increases (decreases) potential output. We also show that, under all the types of labor market frictions we consider, if loss aversion reduces equilibrium output, it also enhances the plausibility of nominal price rigidities.

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1 Introduction

In a recent contribution, Rabin (2013) proposes to introduce behavioral elements into mainstream economic models through an approach named PEEMs (portable extensions of existing models). This approach is based on the modification of an existing model by means of different psychological assumptions to be represented in terms of parameter values. The model is made portable by using the same independent variables employed in the field of research the modification tries to extend. In this paper we aim to contribute to the PEEMs approach by introducing some elements of Prospect Theory (PT, Khaneman and Tversky, 1992) into an otherwise standard general equilibrium overlapping generations economy with monopolistic competition in the good market (Blanchard and Kiyotaki, 1987). This economy is populated by loss averse agents and characterized by real wage rigidities due to (right to manage or efficient) wage bargaining, or to efficiency wages. We interpret this addition of PT behavioral elements to a standard macroeconomic model as a way to analyse the possible effects of a form of imperfect rationality at the macroeconomic level.

In spite of the early intuitions pioneered by Ackerlof (2002), the consideration of behavioral elements within macroeconomic general equilibrium models remains a frontier of economic research. The preferential application of PT to microeconomic or, in any case, to non-general equilibrium contexts hence severely limits the intellectual background of our endeavour. To the best of our knowledge, at present there exist only two contributions to the subject matter. The first one (Gaffeo, Petrella, Pfajfar and Santoro, 2012) inserts PT into a DSGE New Keynesian model in which households' utility depends on consumption deviations from a reference level below which loss aversion is displayed (Koszegi and Rabin, 2006). This creates state-dependent real rigidity and elasticity of intertemporal substitution in consumption that generate competing effects on the responses of output and inflation following a monetary shock.

Our experiment is however closer to the second contribution (Ciccarone and Marchetti, 2013), where reference dependence, declining sensitivity, loss aversion and narrow framing are introduced into Bénassy's (1999) analytically tractable version of Lucas's (1972) islands model. This makes it possible to show that potential output depends not only on market imperfections, as held since Friedman (1968), but also on behavioral elements. More in particular, the introduction of PT into this model: (i) decreases equilibrium labor supply and potential output; (ii) lowers output volatility; (iii) reduces the welfare effects of monetary policy, measured in terms of agents' expected utility; (iv) eliminates the paradoxical improvement in expected utility that may be generated by an increase in monetary policy uncertainty (Polemarchakis and Weiss, 1977). These results are brought about by the precautionary behavior of loss averse agents. They are willing to pay an insurance premium, measured by the loss they accept in potential output (consumption), against the possibility of deviations of wealth with respect to its reference amount and they aim at reducing output volatility as this implies lower wealth variability.

A third paper, although not cast in general equilibrium terms, contributes to the intuition which underlies the models we present here. By implementing Shalev's (2002) theory of symmetric Nash bargaining under PT into the Mortensen and Pissarides (1994) search and matching model, Ciccarone et al. (2013) show that the asymmetric (Nash) wage bargaining solution can be reinterpreted as a symmetric solution with loss averse agents, where the worker's bargaining power depends on the relative values of his/her and of the firm's loss aversion parameters. When considered together, these contributions show that PT plays two important roles at the macroeconomic level, as it affects both the decision process relative to the allocation of consumption and saving (i.e., the financial decisions on the level of wealth to be brought to the future), and the determination of the real wage in an imperfect labour market. Whereas the results obtained within the Lucas models rely on perfect competition in all markets, our intuition is that the two effects may go in opposite directions if the labour market is not competitive. In this case, imperfect rationality may not necessarily produce negative effects on equilibrium employment and output.

In order to test our intuition, we include PT into a simple and well-known macroeconomic framework, which we deliberately keep as simple as possible, also retaining the rational expectations hypothesis. In particular, we focus on a model in which the unique source of uncertainty is an exogenous monetary shock to aggregate demand. This assumption allows us to isolate the role of behavioral elements in the accumulation of wealth, in the spirit of Barberis et al (2001) who show that PT components in the utility function can affect the agents' consumption/saving decisions and hence the economy's demand side. Furthermore, as we aim at investigating the implications of PT for the reaction of firms to nominal/aggregate shocks when setting their prices, we rely on the assumption on money shocks, which is standard when analysing the causes of nominal rigidities (see, e.g. Ball and Romer 1990). By so doing we abstract from sources of real uncertainty in order to ascertain whether PT can have an impact on the real wage elasticity of output which, in its turn, is a crucial element to determine firms' incentive to change (or not to change) nominal prices following an aggregate demand shock. The main advantage of this simplified framework is to provide closed form solutions which allow us to precisely evaluate the effect of loss aversion and monetary volatility on general equilibrium outcomes.

More in particular, we obtain two main results. The first one is that an increase in workers' loss aversion produces two effects on equilibrium output. Under imperfectly competitive labor markets, the wage mark-up depends on agents' relative loss aversion parameters. More precisely, the more workers are loss averse, the lower is the wage mark-up and the smaller is the equilibrium wage. This wage moderation effect has a positive influence on equilibrium output. On the other hand, by making loss averse agents more cautious, it creates a saving restraint effect which decreases output. If the former effect is greater (smaller) than the latter one, then higher loss aversion produces an increase (decrease) in equilibrium employment and in potential output.

The second result we reach is that imperfect rationality - i.e., the influence of PT elements on agents' behavior - can affect nominal price rigidities, a type of stickiness which has been traditionally justified on the basis of either near rationality (Akerlof and Yellen, 1985) or small menu costs (Mankiw, 1985). Basically, price setters do not change the nominal price in response to a nominal shock in aggregate demand if this entails a "small" private cost. It is well known that, in order to obtain such a small cost, a low elasticity of the real wage to a change in aggregate real production is needed and this, in its turn, requires the presence of labor market rigidities. In all the cases of labour market frictions we consider, we obtain an unambiguous result showing that imperfect rationality (PT) inteacts with the traditional near rationality/small menu costs effect. If an increase in loss aversion reduces equilibrium output, then the reaction of the real wage to aggregate demand falls, reducing the private cost of not changing prices. In this case, an increase in loss aversion enhances the plausibility of nominal price rigidities.

The paper is structured as follows. In the next section we describe the model economy and in section **3** we characterize different types of wage rigidity. The two main effects produced by imperfect rationality on equilibrium output and employment are then discussed in section **4**. Section **5** addresses the issue of nominal price rigidity and shows the conditions under which imperfect rationality can favor this type of firms' behavior. Section **6** concludes.

2 The model economy: consumers and firms

The economy is populated by N identical consumers who can transfer the wealth produced when young to the next period by accumulating money issued by a public authority that can alter the money stock period by period. The overall money supply follows the rule:

$$M_t = X_t M_{t-1}.$$

where X_t is an aggregate exogenous monetary shock which is assumed to be unknown to the private agents and log-normally distributed, with $x_t = \ln X_t \sim N\left(0, \sigma_x^2\right)$ and with σ_x^2 interpreted as a policy parameter chosen by the authority.

To keep the model as simple as possible, we follow Ciccarone and Marchetti (2013) and assume that utility is linear in total consumption and labor, and that (ignoring for notation simplicity any indexing) the representative consumer living at time t has the biperiodal (expected) utility function:

$$E_t\left(U_t\right) = E_t\left(C_{t+1}\right) - \psi l_t + \beta E_t\left[v\left(A_{t+1}, A_{\text{ref}}\right)\right] \tag{1}$$

where C is total consumption (taking place when the agent is old) and ψ represents the disutility of working a fixed amount of hours. The function l_t is equal to one if the consumer is employed and to zero if unemployed ($l_t = 0$). If the wage is bargained in the labour market, the number of employed workers may be chosen either (i) by firms after the wage is bargained through a right to manage negotiation scheme, or (ii) through an efficient bargaining scheme (see section **3.1).** In a different version of the model (see section 3.2), the term ψl_t is instead reinterpreted as the disutility of effort in a simplified efficiency wage framework. In any case, involuntary unemployment is explicitly taken into account.

At time t the agent cares not only about his/her expected consumption level C_{t+1} *per se*, but also about his/her expected real financial wealth A_{t+1}, as compared to a reference point A_{ref}. As in Barberis et al. (2001), the parameter $\beta \geq 0$ measures the importance of gains and losses in the utility function relative to that of consumption *per se*. The agent is not only loss averse (losses are more salient than gains), and subject to reference dependence, but also susceptible to some form of narrow framing: when evaluating financial wealth, he considers it *per se*, i.e., independently of the expected utility of the consumption it can produce at time $t+1$ (Barberis and Wang, 2009).

Denoting with λ_t the consumer's demand for money to be carried over to the next period, the real financial wealth at time $t+1$ is given by his/her real money holdings, λ_t/P_{t+1} (where P is the price index) multiplied by the monetary shock X_{t+1}. Assuming monetary equilibrium we hence write the level of real wealth that can be used to purchase consumption when old as:

$$A_{t+1} = \frac{X_{t+1}\lambda_t}{P_{t+1}}$$

so as to interpret X_{t+1} as a stochastic gross rate of return on real wealth. The reference point A_{ref} is the amount of real asset (money) that would be obtained if no monetary shock occurred, i.e., $X_{t+1} = 1$, or $M_{t+1} = M_t$:

$$A_{\text{ref}} = \frac{\lambda_t}{P_{t+1}}$$

We define the prospect theory (PT) component of the consumer's utility function as:

$$v\left(X_{t+1}, \lambda_t\right) = \begin{cases} \left(\frac{X_{t+1}\lambda_t}{P_{t+1}} - \frac{\lambda_t}{P_{t+1}}\right) & \text{for } \frac{X_{t+1}\lambda_t}{P_{t+1}} - \frac{\lambda_t}{P_{t+1}} \geq 0 \\ -\eta_h\left[-\left(\frac{X_{t+1}\lambda_t}{P_{t+1}} - \frac{\lambda_t}{P_{t+1}}\right)\right] & \text{for } \frac{X_{t+1}\lambda_t}{P_{t+1}} - \frac{\lambda_t}{P_{t+1}} < 0 \end{cases} \tag{2}$$

where $\eta_h > 1$ is the household's loss aversion parameter. Substituting (2) into (1) we obtain:

$$E_t\left(U_t\right) = E_t\left(C_{t+1}\right) + \beta E_t \begin{cases} \left(\frac{X_{t+1}\lambda_t}{P_{t+1}} - \frac{\lambda_t}{P_{t+1}}\right) & \text{for } X_{t+1} \geq 1 \\ -\eta_h\left[-\left(\frac{X_{t+1}\lambda_t}{P_{t+1}} - \frac{\lambda_t}{P_{t+1}}\right)\right] & \text{for } X_{t+1} < 1 \end{cases} - l_t\psi$$

The biperiodal budget constraint of the representative consumer is:

$$C_{t+1}P_{t+1} = \lambda_t X_{t+1} = X_{t+1}D_t \tag{3}$$

where:

$$D_t = W_{i,t}l_t + R_t\left(1 - l_t\right) + \Pi_t \tag{4}$$

is the nominal income, $W_{i,t}$ is the nominal wage of production sector i (see the next section), R_t is the reservation income accruing to the unemployed. We assume that profits Π_t accrue only to the young generations.[1]

In this economy there exist $i = 1, 2...I$ differentiated goods, each of which is produced by a monopolistic firm setting its price $P_{i,t}$. Total consumption at time $t+1$ is represented by the Dixit-Stiglitz CES aggregator of the individual goods $C_{i,t+1}$:

$$C_{t+1} = I^{\frac{1}{1-\theta}} \left(\sum_i C_{i,t+1}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \tag{5}$$

where θ is the elasticity of substitution between differentiated goods.[2]

As in Blanchard and Kiyotaki (1987), the price aggregator is:

$$P_{t+1} = \left(\frac{1}{I} \sum_i P_{i,t+1}^{1-\theta} \right)^{\frac{1}{1-\theta}}$$

The consumer choice problem can be split into two phases. At time t, the agent determines the overall level of consumption in the following period, C_{t+1}, whereas at time $t+1$, knowing the actual value of the nominal stock of money carried over from the previous period, s/he decides how to split total consumption across the I differentiated goods. The problem tackled by the agent in the second stage is:

$$\begin{aligned} \max_{C_{i,t+1}} C_{t+1} &= I^{\frac{1}{1-\theta}} \left(\sum_i C_{i,t+1}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \\ \text{s.t} &: \sum_i P_{i,t+1} C_{i,t+1} = D_t X_{t+1} = \lambda_t X_{t+1} \end{aligned}$$

The solution of this problem provides the individual demand of good i (which holds at any time t):

$$C_{i,t+1} = \left(\frac{P_{i,t+1}}{P_{t+1}} \right)^{-\theta} \frac{1}{I} \frac{\lambda_t X_{t+1}}{P_{t+1}}$$

[1] For example, it can be imagined that the old generations donate their shares of firm property to their young heirs when entering the second period of their life, retaining only the money carried over from the previous period to be used to purchase consumption goods.

[2] The assumed linearity of the utility function (1) in both labor and aggregate consumption does not hence imply that utility is linear in each type of good i, while guaranteeing analitical tractability and coherence with the original framework of Blanchard and Kyiotaki ([9]). In their money in utility (MIU) scheme, utility is separable in goods and labor, while the goods component is a Cobb-Douglas function of C and real money demand. This implies an indirect utility function which is linear in the agent's income. In our model the same result is obtained by replacing the MIU assumption with the linearity in C.

Summing over households and assuming money market equilibrium (where $N\lambda_{t-1}X_t = M_t$), the total demand of good i at time t, denoted by C_{it}^T, writes:

$$C_{it}^T = \left(\frac{P_{i,t}}{P_t}\right)^{-\theta} m_t \quad \text{where:} \quad m_t = \frac{1}{I}\frac{M_t}{P_t} \tag{6}$$

Firms' behavior is described in a standard fashion. Sector i monopolist adopts a Cobb-Douglas technology represented by:

$$Y_{i,t} = L_{i,t}^{\alpha} \tag{7}$$

where labor $L_{i,t}$ is the only production input. The firm chooses the price $P_{i,t}$ so as to maximize real profits:

$$\Pi_{it}/P_t = Y_{it}\frac{P_{it}}{P_t} - \frac{W_{it}}{P_t}L_{it} \tag{8}$$

under the constraints represented by (6) and (7). The resulting individual price rule and labor demand are equal to:

$$\frac{P_{i,t}}{P_t} = \left[\frac{\theta}{\theta-1}\frac{1}{\alpha}\left(\frac{W_{it}}{P_t}\right) m_t^{\frac{1}{\alpha}-1}\right]^{\frac{\alpha}{\theta-\alpha\theta+\alpha}} \tag{9}$$

$$L_{i,t} = \left[\frac{\theta}{\theta-1}\frac{1}{\alpha}\left(\frac{W_{it}}{P_t}\right)\right]^{-\frac{\theta}{\alpha+\theta(1-\alpha)}} m_t^{\frac{1}{\alpha+\theta(1-\alpha)}} \tag{10}$$

3 The model economy: Labor market frictions

We aim to explore the consequences of agents' loss aversion in a framework where labor market imperfections can be due to collective bargaining or to efficiency wages. To this aim, in the next subsection we assume that the total workforce N is evenly distributed across the I sectoral labor markets. We first analyze the case in which the wage is determined in all sectors through a symmetric right to manage (RTM) wage bargaining scheme, and we subsequently explore the efficient bargaining case. The following subsection derives the effects of loss aversion under the efficiency wages hypothesis.

3.1 Collective wage bargaining

At each time, the *i-th* firm and the coalition of that sector's workers (total coalitions being in number $N_i = \frac{N}{I}$ and all being composed by workers belonging to the young generation), must find and agreement on the level of the nominal wage.[3] Once the wage is set, sectoral employment is unilaterally set by the firm

[3] As in this phase the parties take the price index P_t as given, by setting the nominal wage they also fix the real wage.

on the basis of its labor demand function (10). The choice of the nominal wage W_{it} is provided by the solution of the Nash problem:

$$\max_{W_{it}} G_U G_\Pi$$

$$\text{s.t.:} \qquad L_{i,t} = \left[\frac{\theta}{\theta-1}\frac{1}{\alpha}\left(\frac{W_{it}}{P_t}\right)\right]^{-\frac{\theta}{\alpha+\theta(1-\alpha)}} m_t^{\frac{1}{\alpha+\theta(1-\alpha)}}$$

where G_Π and G_U are the utility gains of the firm and of the workers's coalition, respectively. As the firms' *status quo* value is equal to zero, we can write:

$$G_\Pi = \Pi_{it}/P_t$$

We assume that the coalition preferences U_s are given by the sum of the members' utilities:

$$U_s = L_{i,t}E_tU_{(l=1)} + (N_i - L_{i,t})\, E_tU_{(l=0)}$$

where $E_tU_{(l=1)}$ is the expected utility of an employed member and $E_tU_{(l=0)}$ is that of an unemployed one. The coalition's *status quo* utility is then equal to:

$$U_r = N_i E_t U_{t,(l=0)}$$

and the workers' gain G_U writes:

$$G_U = U_s - U_r = L_{i,t}\left(E_tU_{t,(l=1)} - E_tU_{t,(l=0)}\right)$$

By using (3) and (4) in the utility function (1), $E_tU_{t,(l=1)}$ and $E_tU_{t,(l=0)}$ can be written as:

$$\begin{aligned} E_tU_{t,(l=1)} &= \frac{W_{i,t}}{P_t}\Lambda - \psi + \kappa \\ E_tU_{t,(l=0)} &= \frac{R_t}{P_t}\Lambda + \kappa \end{aligned}$$

where:

$$\Lambda = E_t\left(\frac{X_{t+1}P_t}{P_{t+1}}\right) + \beta E_t\left(\frac{P_t}{P_{t+1}}\right)\left\{\begin{matrix} (X_{t+1}-1) & \text{for } X_{t+1}\geq 1 \\ -\eta_h[-(X_{t+1}-1)] & \text{for } X_{t+1}<1 \end{matrix}\right\} \quad (11)$$

$$\kappa = \frac{\Pi_j}{P_t}\Lambda \quad (12)$$

We now make the conjecture that the terms κ and Λ are both composed of constants (i.e., functions of the model parameters or of exogenous variables) to be determined once the rational expectation of the price level P_{t+1} at the macroeconomic equilibrium is computed. This conjecture will be verified in a subsequent step.

The Nash bargaining problem is then given by:

$$\max_{W_{it}} \left(L_{it}\frac{W_{it}}{P_t}\Lambda - \psi L_{it} - L_{it}\frac{R_t}{P_t}\Lambda \right) \left(\frac{P_{it}}{P} L_{it}^{\alpha} - \frac{W_{it}}{P_t} L_{it} \right) \tag{13}$$

$$\text{s.t.} \quad : \quad L_{i,t} = \left[\frac{\theta}{\theta-1}\frac{1}{\alpha}\left(\frac{W_{it}}{P_t}\right)\right]^{-\frac{\theta}{\alpha+\theta(1-\alpha)}} m_t^{\frac{1}{\alpha+\theta(1-\alpha)}}$$

In order to take into account the possible effects of the agents' loss aversion on the bargaining process, we follow Ciccarone et al. (2013) and include into problem (13) Shalev's [23] theory of Nash bargaining under loss aversion. According to this analysis, the consideration of a loss component leads to the replacement of agents' utilities $\mathcal{V}^{U,\Pi} = \left\{ \begin{smallmatrix} =\Pi & \text{for firm} \\ =U_s & \text{for workers} \end{smallmatrix} \right\}$ with:

$$\mathcal{V}^{U,\Pi} = \begin{cases} v^{U,\Pi} & \text{if: } v^{U,\Pi} \geq \mathcal{R}^{U,\Pi} \\ v^{U,\Pi} - \eta_{h,\Pi}\left(\mathcal{R}^{U,\Pi} - v^{U,\Pi}\right) & \text{if: } v^{U,\Pi} < \mathcal{R}^{U,\Pi} \end{cases} \tag{14}$$

where $\mathcal{V}^{U,\Pi}$ represents the utility of the firm/worker endowed with exogenous reference points $\mathcal{R}^{U,\Pi}$ and where $\eta_{h,\Pi}$ are the agents' loss aversion coefficients (Tversky and Kahneman, 1992). A new bargaining problem can then be formulated by employing (14). Shalev (2002) shows how to obtain a coherent bargaining solution for the transformed problem that: i) implements the transformation (14); ii) satisfies all the Nash axioms plus a "representation invariance" axiom; iii) includes the possibility of endogenous reference points.[4] Shalev's (2002, theorem 3.2) solution prescribes the following equilibrium sharing rule:

$$\left(\frac{1+\eta_\Pi}{1+\eta_h}\right)\frac{G_\Pi}{G_U} = -\frac{\partial G_\Pi}{\partial G_U} \tag{15}$$

where $G_{U,\Pi}$ are the gains defined in the original problem (13) and the term $\frac{\partial G_\Pi}{\partial G_U}$ is the derivative of the Pareto frontier of the set of feasible utility contracts. By computing this derivative, the sharing rule (15) writes:[5]

$$\frac{(W_{it}/P_t)\,\Lambda}{(W_{it}/P_t)\,\Lambda - \psi - \frac{R_t}{P_t}\Lambda} + \varepsilon_{l,w} = \frac{1-\phi}{\phi}\left(\frac{(W_{it}/P_t)\,L_{it}}{\Pi_{it}/P_t}\right)$$

where: $\varepsilon_{l,w} = \frac{dL_{it}}{d(W_{it}/P_t)}\frac{(W_{it}/P_t)}{L_{it}}$ is the labor demand elasticity and:

$$\phi = \frac{1+\eta_\Pi}{2+\eta_\Pi+\eta_h}$$

In what follows, we assume that the parameter η_Π is negligible in comparison to η_h. By allowing us to retain the firms' standard profit function, this assumption is coherent with both our focus on the effects of PT components in the

[4] In our case, we do not need to describe the endogenous reference.points, as they do not enter the analytical solution.

[5] The derivation of the slope of the Pareto frontier, in the Right to Manage model and in the subsequent case of Efficient Bargaining, makes use of the implicit function theorem (computations are available upon request).

consumers/workers preferences and our general strategy to limit the addition of behavioral elements which modify the standard framework.

By using equations (9) and (10) we obtain a simple sharing rule:

$$\frac{W_{it}}{P_t} = \Phi\left(\frac{\psi}{\Lambda} + \frac{R_t}{P_t}\right) \text{ where: } \Phi = 1 + \phi\frac{1-\zeta}{\zeta}; \qquad \zeta = \alpha\frac{\theta - 1}{\theta} \tag{16}$$

As in the standard model with right to manage (RTM) bargaining, Φ can be interpreted as a wage mark-up which now does not however depend on the relative bargaining powers of the agents, but rather on their relative loss aversion coefficient ϕ. The more workers are loss averse, the lower is ϕ and the smaller is the bargained wage.

The determination of the macroeconomic equilibrium wage rule requires to define the appropriate measure of the reservation income R_t/P_t. We here adopt the standard assumption that:

$$\frac{R_t}{P_t} = bu_t + (1 - u_t)\frac{W_t}{P_t}$$

where b is an unemployment subsidy, exogenously fixed in real terms, $u_t = (N - L_t)/L_t$ is the unemployment rate and W_t/P_t is the average real wage (at the macroeconomic level). In a symmetric equilibrium, equation (16) leads to the wage rule:

$$\frac{W_t}{P_t} = \Phi\frac{b\left(\frac{N-L_t}{N}\right) + \frac{\psi}{\Lambda}}{1 - \Phi\left(\frac{L_t}{N}\right)} \tag{17}$$

This rule displays well-known properties (e.g., Layard et al., 1991): it is always positive and monotonically increasing in L_t.[6] Under the assumption of a constant Λ, we may then couple (17) with the overall demand for labor (as determined in a symmetric equilibrium):

$$L_t = I\left(\frac{1}{\zeta}\frac{W^*}{P_t}\right)^{-\frac{1}{1-\alpha}} \tag{18}$$

This straightforwardly shows that there exists a unique labour market equilibrium at which:

$$\left(\frac{W_t}{P_t}\right)^* > \frac{W}{P}_{\text{com}} = b + \frac{\psi}{\Lambda}\left(\frac{N}{N - L_t}\right); \qquad L_t < L_{\text{com}}$$

where $\frac{W}{P}_{\text{com}}$ and L_{com} are the real wage and the employment levels under perfect competition in the goods and labor markets, i.e., when $\theta \to \infty$ and ϕ is set to 0.

An analogous result can be obtained under the assumption that the workers' coalition and the firm undertake an efficient bargaining. This takes place when, in each sectoral labor market, they set both the real wage and employment so

[6] A positive real wage requires that the mark-up Φ is not too high: $1/\Phi > L_t/N$.

as to maximize the symmetric Nash product $G_U G_\Pi$. In this case, Shalev's ([23]) theory can be integrated in the same way into the bargaining model and the sharing rule continues so be given by (15), but the slope of the Pareto frontier is different. By adopting the standard procedure, we obtain that the wage and employment relationships under symmetric equilibrium are:

$$\frac{W_t}{P_t} = \Phi \frac{b\left(\frac{N-L_t}{N}\right)+\frac{\psi}{\Lambda}}{1-\Phi\frac{L_t}{N}}; \qquad L_t = I\left[\frac{1}{\zeta\Phi}\frac{W_t}{P_t}\right]^{-\frac{1}{1-\alpha}} \tag{19}$$

These equations share the main features of the solution generated by standard models. In particular, the equilibrium level of employment is always lower than that which would emerge in a competitive labor market (see Appendix 1).

The main conclusion to draw is that under both RTM and efficient bargaining there exists a unique equilibrium value of L_t. This allows us to verify the initial conjecture on the value of Λ. Under this conjecture, agents believe that L_t is a function of the model parameters only. By considering the macroeconomic equilibrium:

$$Y_t = L_t^\alpha = \frac{X_t M_{t-1}}{P_t}$$

they hence formulate the following "price theory":

$$P_t = \delta X_t M_{t-1} \tag{20}$$

where δ is an unknown parameter. By substituting the conjecture (20) into (11), the value of Λ is:

$$\Lambda = 1 + \beta\Gamma$$

where:

$$\Gamma = \int_1^\infty \left(1 - X_{t+1}^{-1}\right) f_X dX_{t+1} + \int_0^1 -\eta_h \left[-\left(1 - X_{t+1}^{-1}\right)\right] f_X dX_{t+1} < 0$$

and f_X is the lognormal distribution function. The sign of Γ is always negative and its value depends on the variance of the money supply σ_x^2.

This can be shown through a numerical simulation of Γ and Λ. To this aim we set $\eta_h = 2.25$ in accordance with a wide amount of experimental evidence (see, e.g., Tversky and Kahneman 1992). In the absence of strong priors and noting that β does not affect the sign of Γ, but only that of Λ, we adopt the value $\beta = 1$ (a unitary financial loss provides the same disutility as a unit of foregone consumption) and perform robustness checks of our results by changing the value of this coefficient. Finally, we let σ_x vary between 0.01 (one standard deviation) and the value for which $\Lambda = 0$ (for greater values of σ_x, Λ becomes negative, ruling out economically reasonable solutions). The results of this numerical exercise are shown in Figure 1:

Figure 1

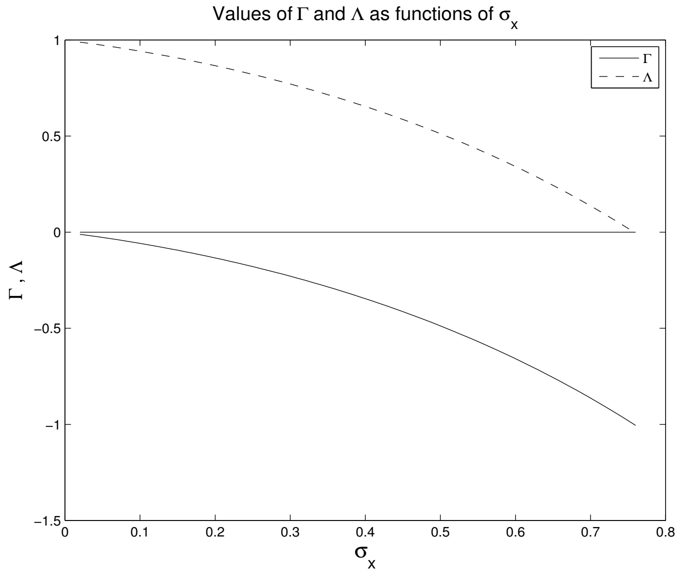

Fig.1. Parameters' range for model consistency. The figure shows the behavior of Γ and Λ for different σ_x, starting from a value close to 0. The upper limit of σ_x, 0.76, is set to the largest value for which $\Lambda \geq 0$.

The intuition for this result hinges on the agents' attitude towards the possibility of losses of their real wealth. When formulating their forecasts on the economy's evolution, agents know that monetary shocks can induce gains or losses with respect to their reference wealth. As their rational expectations will be (on average) fulfilled, they consider this effect when formulating a lower average demand of consumption as a form of precautionary behavior. The difference between Λ and 1 (the value obtained when $\beta = 0$) may thus be interpreted as an equilibrium insurance premium to be paid against the possibility of experiencing deviations of wealth with respect to its reference amount.

The solution we found for Λ fully satisfies the initial conjecture. Actually, as highlighted in the discussion of equations (17)-(18) and (19), there exists a unique equilibrium value of aggregate output, Y^*, under both the RTM and the efficient bargaining schemes. Being $\Lambda = 1 + \beta\Gamma$, this equilibrium level only depends on the model parameters and this ensures that the conjecture (20) is satisfied with $\delta = 1/Y^*$. The solution of the rational expectation also allows us to understand that loss aversion produces two distinct effects on the macroeconomic equilibrium represented by equations (17)-(18) (RTM), or by equations (19) (efficient bargaining). An increase in the loss aversion parameter η_h, on the one side, induces a reduction in Φ and, on the other side, by reducing Γ, pushes ψ/Λ up.[7]

[7] The value for κ can be obtained in a similar way.

3.2 Efficiency wages

We now wish to explore the macroeconomic consequences of loss aversion in an economy where labor market imperfections are due to efficiency wages. In order to make our point as simple as possible, we adopt a simplified version of the Shapiro and Stiglitz's ([24]) model based on the idea of efficiency wages as a discipline device.[8]

In this set-up, whereas the worker's income $D_j = W_i l_t + R_t (1 - l_t) + \Pi_t$ and the interpretation of l_t as the employment status remain unchanged, we substitute the term ψl_t in the utility function (1) with ψe_t, where e is the level of effort provided by the worker, which is here assumed to be either $e_t = 1$, when the worker commits him/herself to the required level of effort, or $e_t = 0$, when the worker shirks. The production function of firm i is then equal to $Y_{it} = (e_t L_{it})^{\alpha}$. In order to further simplify the model, we also assume that the firm, when choosing the optimal incentive scheme for the real wage, is not loss averse. Under this assumption, the determination of the real wage only requires to determine the workers' utility levels in the shirking and in the no-shirking case, and to assure that the incentive compatibility and the participation constraints are satisfied.

The utility level of an employed worker providing the amount of effort $e_t = 1$ is equal to:[9]

$$U_{\text{eff}} = \Lambda \frac{W_{i,t}}{P_t} - \psi$$

If the employed worker decides to shirk, s/he enters a lottery: s/he can be detected, and fired, with probability q, or s/he can avoid detection with probability $(1-q)$. In line with PT, we assume that s/he evaluates this prospect in the following way:

$$U_{\text{shir}} = (1 - q) \left(U_{\text{e=0}} - U_{\text{ref}} \right) + q \left[\eta_h \left(U(R) - U_{\text{ref}} \right) \right]$$

where $U_{\text{e=0}} = \Lambda \frac{W_{i,t}}{P_t}$ is the utility level when undetected shirking, $U(R)$ is the utility of an unemployed worker and U_{ref} is a reference level of utility. We assume (and show below) that:

$$U_{\text{e=0}} - U_{\text{ref}} \geq 0 \quad \text{and} \quad U(R) - U_{\text{ref}} < 0 \tag{21}$$

[8] We do not of course rule out the possibility that other explanations/interpretations of efficiency wages can be coherent with the presence of loss aversion, as already hinted at by Akerlof (2002). For example, the fair wage interpretation put forward by Akerlof and Yellen (1990), which has provided several models bearing important macroeconomic implications (e.g., Skott, 2005 and Ball and Moffitt, 2002), may prove to be consistent with the presence of loss averse agents. These models are however dynamic and they tipically use different types of labor and a relative wage set-up, which makes our point more difficult to propose and to grasp.

[9] As we have eliminated the term $\kappa = (\Pi_t/P_t)\Lambda$ from indirect utility, by choosing the appropiate level of $U_{e=0}$, U_{ref} and $U(R)$ the final result remains unchanged.

The firm must choose the real wage so as to satisfy the incentive compatibility constraint:

$$U_{\text{eff}} - U_{\text{ref}} \geq U_{\text{shir}} \rightarrow \frac{W_{i,t}}{P_t} \geq \frac{\psi}{q\Lambda} + \frac{\eta_h}{\Lambda} U(R) + \frac{(1-\eta_h)}{\Lambda} U_{\text{ref}} \tag{22}$$

We now set:

$$\begin{aligned} U_{\text{ref}} &= \Lambda \frac{W_t}{P_t} - \psi; \\ U(R) &= (1-u_t)\left(\Lambda \frac{W_t}{P_t} - \psi\right) + u_t(\Lambda b) \\ U(R) &= (1-u_t)(U_{\text{ref}}) + u_t(\Lambda b) \end{aligned}$$

where $\frac{W_t}{P_t}$ is the average equilibrium real wage. We hence assume that the reference level of utility is given by what would accrue to a non shirking worker in a macroeconomic symmetric equilibrium (notice that, at this stage of the decision process, the average wage W_t and the individual one W_{jt} must be kept distinct, although they will coincide in the overall symmetric equilibrium). On the other hand, the reservation utility of a generic unemployed worker, $U(R)$, is given by: (i) the utility of a job for a non shirking worker weighted by the probability of finding a job (the employment rate $1-u_t$) plus (ii) the utility level Λb obtained if remaining unemployed (with probability equal to the unemployment rate u_t) and receiving the fixed subsidy b. Substituting these values into equation (22) we derive the wage rule under efficiency wages:

$$\frac{W_t}{P_t} = \left[1 + \frac{1-q}{q\eta_h}\left(\frac{N}{N-L_t}\right)\right]\frac{\psi}{\Lambda} + b \tag{23}$$

Equation (23) allows us to check that inequalities (21) hold true:

$$U_{\text{e=0}} - U_{\text{ref}} = \psi > 0 \qquad U(R) - U_{\text{ref}} < 0 \rightarrow b < \frac{W_t}{P_t} - \frac{\psi}{\Lambda}$$

The competitive limit for (23), computed by assuming perfect monitoring (i.e., $q = 1$) is:

$$\frac{W}{P}_{\text{com}} = \frac{\psi}{\Lambda} + b < \frac{W_t}{P_t}$$

This result is similar to that obtained in the case of wage bargaining. As the efficient wage rule (23) implies a real wage which is always greater than the competitive one, and since firms choose employment according to the aggregate labor demand (18), a positive level of involuntary equilibrium unemployment arises. Agents can adopt the same procedure discussed in the wage bargaining case to determine the value of Λ under rational expectations, which is again equal to $\Lambda = 1 + \beta\Gamma$. Furthermore, the position of the wage rule (23) in the $(\frac{W_t}{P_t}, L_t)$ space continues to depend on the loss aversion coefficient η_h. This term produces also in this case two distinct impacts on employment and output: a direct one, related to wage determination and operating *via* the term $(1-q)/q\eta_h$, and an indirect one, operating *via* the term Λ.[10]

[10] The analysis carried out in this section can be replicated under the assumption of a utility

4 Macroeconomic effects of imperfect rationality

In all the cases considered in the previous section, the overall effect of a change in loss aversion (η_h) on equilibrium output and employment is ambiguous, depending on the relative size of two counteracting effects. Using eq. (17) we can compute the reaction of the real wage to an increase in η_h under RTM bargaining :

$$\left.\frac{d\left(W_t/P_t\right)}{d\eta_h}\right|_{\mathrm{RTM}} = \frac{\frac{1}{\Phi}\frac{W_t}{P_t}\varepsilon_\Phi - \frac{\psi}{\Lambda}\varepsilon_\Lambda}{\left(\frac{1}{\Phi} - \frac{L_t}{N}\right)\eta_h} \tag{24}$$

where $\varepsilon_\Phi = \frac{d\Phi}{d\eta_h}\frac{\eta_h}{\Phi} < 0$ and $\varepsilon_\Lambda = \frac{d\Lambda}{d\eta_h}\frac{\eta_h}{\Lambda} < 0$ are the elasticities of Φ and of Λ with respect to η_h.[11] These two elasticities shows how a change in loss aversion deploys its effects through two different channels. The first one, which can be dubbed *wage moderation effect* and is represented by ε_Φ, operates via a reduction of the bargained wage in the labor market. The second one, named savings restraint effect and encapsulated in ε_Λ, is related to the increase of the insurance premium related to the allocation of wealth, as a form of precautionary behavior. The position of the wage rule depends on the relative magnitude of these two effects. It follows that, as the price rule (18) does not depend on these two parameters, the influence of loss aversion on equilibrium employment can be summarized as follows:[12]

$$\left.\frac{\partial L_t}{\partial \eta_h}\right|_{\mathrm{RTM}} \gtrless 0 \quad \text{iff:} \quad \left|\frac{\varepsilon_\Phi}{\varepsilon_\Lambda}\right| \gtrless \Phi\frac{\psi/\Lambda}{W_t/P_t} \tag{25}$$

This shows that a reduction in the real wage leads to an increase in employment and output if and only if the wage moderation effect prevails on the savings restraint effect. The opposite occurs when the saving restraint effect dominates.

The same holds under efficient wage bargaining. In this case, the reaction of employment to an increase in loss aversion is given by:[13]

$$\left.\frac{dL_t}{d\eta_h}\right|_{\mathrm{EB}} = \left(IL_t\frac{\Phi}{\eta_h}\right)\frac{\frac{\psi}{\Lambda}\varepsilon_\Lambda - \frac{L_t}{N}\frac{W_t}{P_t}\varepsilon_\Phi}{\left(1-\alpha\right)\frac{W_t}{P_t} + \Phi\frac{L_t}{N}\left(\alpha\frac{W_t}{P_t} - b\right)} \tag{26}$$

---

function concave in consumption and in the loss aversion component, i.e., when $E_t\left(U_t\right) = E_t\left(C_{t+1}^{\chi}/\chi\right) + \beta E_t\begin{cases}\frac{1}{\chi}\left(R_{t+1}-R_{\mathrm{ref}}\right)^{\chi} & \text{for } X_{t+1}\geq 1\\ -\eta_h\left[-\frac{1}{\chi}\left(R_{t+1}-R_{\mathrm{ref}}\right)^{\chi}\right] & \text{for } X_{t+1}<1\end{cases} - \psi l_t$. In this case, the wage rule retains the general properties of (23) and, in particular, is monotonically increasing in the real wage. The conjecture on the equilibrium nominal price can hence be kept unchanged and the value of Λ can be computed, *via* an appropriate conjecture on the price level, as seen before. The function Γ is negative and decreasing in η_h.

This property does not however hold for the wage bargaining framework, in which case the wage rules (17) and (23) are no longer monotonic in the real wage. This is a well-known limitation of this class of models.

[11] Note that the denominator $\frac{1}{\Phi} - \frac{L_t}{N}$ must be positive (see eqation (17) - the BRW).

[12] The inequality directly stems from equation (24).

[13] In order to obtain $\left.\frac{dL_t}{d\eta_h}\right|_{\mathrm{EB}}$, differentiate both equations (19) with respect to W/P and L and solve the resulting system of equations.

Being the denominator always positive, we can write:

$$\left.\frac{dL_t}{d\eta_h}\right|_{\text{EB}} > 0 \quad \text{iff} \quad \left|\frac{\varepsilon_\Phi}{\varepsilon_\Lambda}\right| > \frac{\psi/\Lambda}{W_t/P_t}\frac{N}{L_t}$$

As in the RTM case, when η_h goes up employment increases if and only if the saving restraint effect is smaller than the wage moderation effect.

It is easy to show that the same qualitative conclusion is reached when the economy is characterized by the presence of efficiency wages. In this case the reaction of the wage rule (23) to a change in η_h is:

$$\left.\frac{d\left(W_t/P_t\right)}{d\eta_h}\right|_{\text{E-W}} = -\frac{1}{\eta_h}\left[(1+\varepsilon_\Lambda)\left(\frac{W_t}{P_t}-b\right)-\frac{\psi}{\Lambda}\right]$$

and hence:[14]

$$\left.\frac{\partial L_t}{\partial \eta_h}\right|_{\text{E-W}} \gtrless 0 \quad \text{iff:} \quad |\varepsilon_\Lambda| \lessgtr \frac{1}{1+\eta_h \frac{q}{1-q}u_t} \tag{27}$$

An increase in L_t following a rise in loss aversion requires the saving restraint effect to be small enough.

Summing up: in all the wage setting frameworks we have considered, an increase in output or employment following a rise in loss aversion requires the saving restraint effect to be small enough. The economic explanation of this result is straightforward. When formulating their rational expectations, agents take into account the possibility that monetary shocks affect the real value of the monetary resources they bring to the next period, and they know that this induces gains or losses with respect to their reference wealth. The lower average amount of labour that more loss averse agents optimally decide to supply is a form of precautionary behavior. The lower consumption that this entails represents the equilibrium insurance premium they pay against the possibility of deviations of wealth with respect to its reference amount. This cautious behavior has a negative impact on equilibrium output. At the same time, more loss averse workers are willing to accept a lower equilibrium wage, independently of whether this is set according to RTM, efficient bargaining, or efficiency wages. This alternative form of cautious behavior has a positive impact on equilibrium output.

It should be noticed that under perfect competition in the goods and labor markets ($\theta \to \infty$, $\phi = 0$ and $q = 1$) the wage restrain effect disappears but the saving restraint effect remains, leading to a negative influence of loss aversion on

[14] As in our efficiency wage framework employment is set by equation (18) alone, it is sufficient to deteremine the conditions under which an increase in η_h produces an increase in the real wage W/P. From the wage rule (23) we have:

$$\left.\frac{d\left(W/P\right)}{d\eta_h}\right|_{\text{E-W}} = -\frac{1}{\eta_h}\frac{\psi}{\Lambda}\left\{\frac{1-q}{q\eta_h u_t}+\left[1+\frac{1-q}{q\eta_h u_t}\right]\varepsilon_\Lambda\right\} > 0$$

which implies: $-\frac{1-q}{\eta_h q u_t + 1 - q} > \varepsilon_\Lambda$. Being $\frac{1-q}{q\eta_U u_t + 1 - q} > 0$ and $\varepsilon_\Lambda < 0$, the absolute value of ε_Λ must hence be bigger than the (positive) value $\frac{1-q}{q\eta_U u_t + 1 - q}$.

the equilibrium real variables. This effect is interesting *per se*. It can be thought of as a specific form of money non-neutrality generated by imperfect rationality: if we hold η_h constant and consider an increase in monetary variability σ_x^2, the result is a reduction in Λ which in its turn induces a fall in real output.

Comparative statics with respect to η_h is not the only way to explore the effects of imperfect rationality in this context. In order to deepen this analysis, we can also assume an increase in the parameter $\beta \geq 0$, which measures the importance agents assign to gains/losses relative to that of consumption *per se*,[15] and which produces only a savings effect. It is easy to check that the increase in β, by decreasing Λ, unambiguously reduces equilibrium employment (and hence output) under the three wage determination schemes we are considering. In all these cases, the effect of β is channeled trough an increase in the real wage:

$$\begin{aligned}
\left.\frac{d\left(W_t/P_t\right)}{d\beta}\right|_{\text{RTM-EB}} &= -\frac{\psi\Gamma}{\Lambda^2}\left(\frac{1}{\Phi}-\frac{L_t}{N}\right)^{-1} > 0 \rightarrow \left.\frac{\partial L_t}{\partial\beta}\right|_{\text{RTM-EB}} < 0 \\
\left.\frac{d\left(W_t/P_t\right)}{d\beta}\right|_{\text{E-W}} &= -\frac{\psi\Gamma}{\Lambda^2}\left[1+\frac{1-q}{q\eta_h}\left(\frac{N}{N-L_t}\right)\right] > 0 \rightarrow \left.\frac{\partial L_t}{\partial\beta}\right|_{\text{E-W}} < 0
\end{aligned}$$

It hence becomes clear that the macroeconomic consequences of loss aversion depend on the chosen specification of the competitive process in the goods and labor market. It is worth noting that, contrary to traditional findings, under imperfect rationality the presence of relevant frictions in these markets can *increase*, rather than decrease, the level of potential output.

5 Imperfect rationality and nominal rigidities

The phenomenon of nominal price rigidity has been traditionally explained on the basis of near rationality (Akerlof and Yellen, 1985), or small menu costs (Mankiw, 1985). Basically, the choice of not changing the nominal price, P_{it}, in response to a nominal shock in aggregate demand (M_t/P_t) may correspond to a (near) rational behavior if it entails a small cost for the price setter. It is well known that a small elasticity of the real wage to a change in aggregate real production, $\varepsilon_{w,Y} = \frac{d(W_t/P_t)}{dY_t}\frac{Y_t}{(W_t/P_t)}$, is required in order to obtain a small private cost from not adjusting nominal prices. This, in its turn, asks for labor market real rigidities preventing the wage from quickly and sharply reacting.

In this section we address the question of whether the presence of PT influences on agents' behavior - i.e., imperfect rationality - can affect price stickiness. We tackle the issue by adopting a standard procedure (Akerlof and Yellen, 1985; Ball and Romer, 1990) and define the individual price setter's private cost of not adjusting his/her nominal price P_{it} as:

$$Cost_\Delta = \frac{1}{2}\frac{\partial^2\Pi_{it}}{\partial p_{it}^2}\left(\frac{dp_{it}\left(Y_t\right)}{dY_t}\right)^2\Delta_T^2$$

[15] An increase in β can also be interpreted as an increased relevance of narrow framing.

where $p_{it} = P_{it}/P_t$ is the agent's control variable and Y_t is real output (real aggregate demand). $Cost_\Delta$ is calculated as the individual real revenues lost due to the failure in adjusting p_{it} after the realization of a nominal shock, represented by the total change Δ_T in aggregate demand. By making use of equations (8) and (9), we obtain the standard formula:

$$\mathcal{L}_\Delta = \frac{1}{2}\left(1-\frac{1}{\theta}\right)\frac{\left[1+\alpha\left(\varepsilon_{w,Y}-1\right)\right]^2}{\alpha\left(1-\alpha+\alpha/\theta\right)}\Delta^2$$

where L_Δ is the private cost, expressed as a percentage of individual real revenues lost due to a failure in adjusting p_{it}, and Δ is the percentage change of the single monopolist's share of aggregate demand (i.e., $\Delta = \Delta_T/Y$).

In order to understand the role played by loss aversion and narrow framing in fostering or hindering the (near rational) choice of not adjusting P_{it}, the derivative of the wage rule elasticity $\varepsilon_{w,Y}$ with respect to the loss aversion parameter η_h must be calculated. We do this in the three cases of real wage rigidity we have considered in this paper.

From equation (17) and taking into account the aggregate supply, $Y_t = I\left(\frac{\theta}{\theta-1}\frac{1}{\alpha}\frac{W_t}{P_t}\right)^{-\frac{\alpha}{1-\alpha}}$, the real wage elasticity under RTM bargaining writes:[16]

$$\varepsilon_{w,Y} = \frac{\left(\frac{\theta-1}{\theta}\alpha\right)I^{\frac{1-\alpha}{\alpha}}L_t^{\alpha-1}-b}{\alpha\left[\frac{N}{L_t}\left(b+\frac{\psi}{\Lambda}\right)-b\right]} \tag{28}$$

It follows that its derivative with respect to η_h is:

$$\begin{aligned}
\frac{d\varepsilon_{w,Y}}{d\eta_h} &= \frac{\omega_1\varepsilon_{L,\eta}+\omega_2\varepsilon_\Lambda}{\omega_3} \quad \text{where:}\\
\omega_1 &= \alpha\left[\frac{N}{L_t}\left(\frac{\psi}{\Lambda}+b\right)-b\right]\frac{W_t}{P_t}+\left[\frac{W_t}{P_t}-\frac{N}{L_t}\left(b+\frac{\psi}{\Lambda}\right)\right]b\\
\omega_2 &= \frac{N}{L_t}\frac{\psi}{\Lambda}\left(\frac{W_t}{P_t}-b\right)>0\\
\omega_3 &= \alpha\eta_h\left[\frac{N}{L_t}\left(b+\frac{\psi}{\Lambda}\right)-b\right]^2>0
\end{aligned}$$

where $\varepsilon_{L,\eta} = \frac{dL_t}{d\eta_h}\frac{\eta_h}{L}$ is the elasticity of employment with respect to a change in η_h. From the price rule (18), we write this term as:

$$\varepsilon_{L,\eta} = \left(\frac{1}{1-\alpha}\right)\frac{\frac{\psi}{\Lambda}\varepsilon_\Lambda-\frac{W_t/P_t}{\Phi}\varepsilon_\Phi}{\frac{W_t}{P_t}\left(\frac{1}{\Phi}-\frac{L_t}{N}\right)} \tag{29}$$

It can be show that, for reasonable unemployment rates and parameter values, the sign of the term ω_1 is positive[17] (see Appendix 2). This implies that,

[16] Notice that it is $\varepsilon_{w,Y}>0$ as it is $\left(\frac{\theta-1}{\theta}\alpha\right)I^{\frac{1-\alpha}{\alpha}}L_t^{\alpha-1}=\frac{W_t}{P_t}$.

[17] A minimal condition for $\omega_1>0$ is $\frac{\psi/\Lambda}{b}\geq 1$, when the unemployment rate is below 41%.

being $\varepsilon_\Lambda < 0$, the sign of $\frac{d\varepsilon_{w,Y}}{d\eta_h}$ crucially depends on the sign of $\varepsilon_{L,\eta}$. From equation (29), it is easy to check that this sign is ruled by the ratio between the elasticities of the two parameters Φ and Λ with respect to η_h, i.e., by the term $\left|\frac{\varepsilon_\Phi}{\varepsilon_\Lambda}\right|$ contained in inequality (25).

We can hence state that when an increase in loss aversion η_h reduces the equilibrium output $\left(\left|\frac{\varepsilon_\Lambda}{\varepsilon_\Phi}\right| > \frac{W_t/P_t}{\Phi\psi/\Lambda}\right)$, then the reaction of the real wage to aggregate demand ($\varepsilon_{w,Y}$) falls, thus reducing the private cost of not changing nominal prices ($\mathcal{L}_\Delta$). It follows that when $\frac{\partial L_t}{\partial \eta_h}_{\text{RTM}} < 0$, an increase in loss aversion also increases the plausibility of nominal price rigidity. When the effect of η_h on employment is positive $\left(\frac{\partial L_t}{\partial \eta_h}_{\text{RTM}} > 0\right)$, the sign of $\frac{d\varepsilon_{w,Y}}{d\eta_h}$ is instead uncertain, even though it is certainly negative if $\left|\frac{\varepsilon_{L,\eta}}{\varepsilon_\Lambda}\right| < \frac{\omega_2}{\omega_1}$.

Under *efficient bargaining*, the elasticity of the wage with respect to a change in aggregate demand is:

$$\frac{d\varepsilon_{w,Y}}{d\eta_h} = \varepsilon_\Phi \frac{\varepsilon_{w,Y}}{\eta_h} + \frac{\omega_1 \varepsilon_{L,\eta} + \omega_2 \varepsilon_\Lambda}{\omega_3}$$

where employment, the real wage and the ω coefficients are the same as those of the RTM scheme. As the first of equations (19) guarantees that $\varepsilon_{w,Y} > 0$, we can confirm the conclusion reached under RTM. As it is reasonable that $\omega_1 > 0$, the sign of $\frac{d\varepsilon_{w,Y}}{d\eta_h}$ crucially depends on the ratio $\left|\frac{\varepsilon_\Lambda}{\varepsilon_\Phi}\right|$: if $\left|\frac{\varepsilon_\Lambda}{\varepsilon_\Phi}\right| > \frac{W_t/P_t}{\Phi\psi/V}\frac{L_t}{N}$, an increase in loss aversion, by decreasing output, also favours nominal rigidity.

As for the *efficiency wage* scheme, we compute the elasticity $\varepsilon_{w,Y}$ from the wage rule: (23):

$$\varepsilon_{w,Y} = \frac{1}{\alpha}\left(1 - \frac{L_t}{N}\right)^{-1}\left(1 - \frac{b}{W_t/P_t}\right)$$

and then compute the reaction of this elasticity to a change in η_h:

$$\frac{d\varepsilon_{w,Y}}{d\eta_h} = \frac{\varepsilon_{L,\eta}}{\alpha\eta_h}\left(\frac{N - L_t}{N}\right)^{-2}\left[\frac{L_t}{N} - \left(1 - \alpha\frac{N - L_t}{N}\right)\frac{b}{W_t/P_t}\right]$$

If the unemployment subsidy is sufficiently small in comparison to the real wage, or if $\frac{L}{N}$ is reasonably high (unemployment is not too high), then the term in the square brackets is positive[18] and the sing of $\frac{d\varepsilon_{w,Y}}{d\eta_h}$ is ruled by that of $\varepsilon_{L,\eta}$. This result is qualitatively analogous to that of wage bargaining: if the saving restraint effect $|\varepsilon_\Lambda|$ is strong enough, employment falls ($\varepsilon_{L,\eta} < 0$) in response to an increase in η_h and this eases the condition to obtain nominal price rigidities.[19]

[18] A sufficient condition for this coefficent to be positive is: $L_t\frac{W_t}{P_t} - bN > 0$. As the equilibrium real wage is always greater than the subsidy, this condition is easily verified in times of low unemployment.

[19] It is worth noting that with efficiency wages the sign of the effect of η_h on the private cost $\mathcal{L}_\Delta$ (*via* $\varepsilon_{L,\eta}$) is reversed if the unemployment level is sufficiently high.

The general conclusion that we can draw from the three equations involving $\frac{d\varepsilon_{w,Y}}{d\eta_h}$ under the different wage setting schemes is that the elasticity $\varepsilon_{w,Y}$ falls when the saving restraint effect (represented by ε_Λ) is strong enough, either in comparison to the wage restraint effect ε_Φ or by itself (in the case of efficiency wages). The intuition behind this result can be summarised as follows. For simplicity, focus on the RTM scheme and rule out the saving restraint effect by assuming $\beta = 0$, so that $\Lambda = 1$ and is independent from η_h. In this case we have $\frac{d\varepsilon_{w,Y}}{d\eta_h} = \frac{\omega_1 \varepsilon_{L,\eta}}{\omega_3}$ and the elasticity of employment to η_h is unambiguously positive:

$$\varepsilon_{L,\eta} = \left(\frac{1}{1-\alpha}\right) \frac{-\frac{W_t/P_t}{\Phi}\varepsilon_\Phi}{\frac{W_t}{P_t}\left(\frac{1}{\Phi} - \frac{L_t}{N}\right)} > 0$$

Thus it must be $\frac{d\varepsilon_{w,Y}}{d\eta_h} > 0$, as long as $\omega_1 > 0$. In these circumstances, the increase in η_h has an impact only on the wage bargaining process: workers/consumers are more cautious in their wage claims. This also means that the labor market equilibrium is relatively closer to that emerging under perfect competition. Recall that as long as the labor market is approaching perfect competition, an increase in aggregate demand tends to generate a substantial reaction of the real wage.

Now, consider the opposite case in which the wage bargaining process is not affected at all by the workers' loss aversion, so that it is $\phi = 1/2$, and $\beta > 0$. In this case the saving restraint effect is active, i.e., Λ is affected by the level of η_h and an increase in the loss aversion parameter will only translate onto ε_Λ, giving rise to:

$$\varepsilon_{L,\eta} = \frac{\left(\frac{1}{1-\alpha}\right)\frac{\psi}{\Lambda}\varepsilon_\Lambda}{\frac{W_t}{P_t}\left(\frac{1}{\Phi} - \frac{L_t}{N}\right)} < 0$$

This implies that the elasticity $\varepsilon_{w,Y}$ must decrease in response to $d\eta_h$: $\frac{d\varepsilon_{w,Y}}{d\eta_h} = \frac{\omega_1 \varepsilon_{L,\eta} + \omega_2 \varepsilon_\Lambda}{\omega_3} < 0$. The reason behind this negative response is related to the utility that workers attach to the real wage. Recall that the utility gain of the workers is $L_{it}\left[\left(\frac{W_{it}}{P_t} - \frac{R_t}{P_t}\right)\Lambda - \psi\right]$. If η_h increases and Λ decreases, workers obtain less utility from the real bargained wage due to the saving restraint effect. If an aggregate demand shock occurs, both employment and the bargained wage will change. Yet, with an higher η_h lowering the utility gain from the real wage (and from being employed), there will be less incentives to change the wage in the face of a change in output and employment (also because η_h does not affect the bargaining process *per se*, via the wage restraint effect). In other words, the reactivity of the real wage to an increase in demand is lower when η_h is higher. Clearly, when both the saving restraint and the wage moderation effects are present, they must be combined in order to determine the final effect of a change in Y or L on the real wage. If the saving restraint is the prevailing one, then the reactivity of the real wage to Y will be reduced.

Notice that the same intuition holds for the efficient bargaining scheme and for the efficiency wage mechanism. In this latter case, we simply need to acknowledge that the wage moderation effect ε_Φ is replaced by the role that η_h plays in enhancing the effectiveness of the monitoring technology via the term $\frac{1-q}{q\eta_h}$ in the wage rule (23).

6 Conclusions

By introducing Prospect Theory into a general equilibrium overlapping generations economy with monopolistic competition in the good market and real wage rigidities in the labor market we have shown that potential output may increase or decrease with the strength of agents' loss aversion. This is due to the existence of two counteracting effects produced by loss aversion. On the one hand, the more workers are loss averse, the lower is the wage mark-up, the smaller is the equilibrium wage and the higher is equilibrium output. On the other hand, the more agents are loss averse, the more they become cautious in supplying labor (and consuming when old) and the lower is equilibrium output. If the wage moderation effect is greater (smaller) than the saving restraint effect, potential output increases (decreases) with loss aversion. Under perfect competition in the good and labor markets the former effect disappears but the latter one remains, leading to a negative influence of loss aversion on the equilibrium real variables. This shows that, in sharp contrast with traditional findings, the introduction of imperfect rationality may allow market frictions to increase, rather than decrease, the level of potential output.

The second important result we have reached is that, in all the cases of labour market frictions we have considered, when an increase in loss aversion reduces equilibrium output, then the reaction of the real wage to aggregate demand falls, thus reducing the private cost of not changing prices and enhancing the plausibility of nominal price rigidity. This conclusion bears an important policy implication. If a strong and persistent economic crisis makes agents more loss averse and if the saving restraint effect happens to be high as compared to wages moderation effect, unemployment will keep on spiralling upward. At the same time, the increase in loss aversion, by reducing the private cost of not changing prices, will favour nominal price rigidities. If the central bank's main target is to control inflation, the increased nominal price stickiness will prevent prices to fall as they "should", thus preventing the central bank from fully adopting the necessary expansionary stance. Imperfect rationality would in this way make monetary policy less expansionary when this would be most needed.

In the light of the encouraging results obtained with the static macroeconomic models we have proposed in this paper, we envisage the next step of our research project in the construction of a portable extension of DSGE models. This should be done by incorporating PT into a standard New Keynesian model with search frictions in the labor market. We are of course aware of the difficulties involved in this endeavour (see, e.g., Grüne and Semmler, 2008), but we nevertheless believe it is an attempt which is worth to try.

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APPENDIX

1. Efficient bargaining under loss aversion Starting from equations:

$$\frac{W}{P}=\Phi\frac{\frac{\psi}{\Lambda}+b\left(\frac{N-L}{N}\right)}{1-\Phi\frac{L}{N}}; \qquad L=I\left[\frac{1}{\zeta\Phi}\frac{W}{P}\right]^{\frac{1}{\alpha-1}} \tag{30}$$

it is easy to show that a unique (and meaningful) solution exists. Equation $\frac{W}{P}=\Phi\left[b\left(\frac{N-L}{N}\right)+\frac{\psi}{\Lambda}\right]/\left(1-\Phi\frac{L}{N}\right)$ is monotonically increasing in L, it has a positive vertical intercept ($W/P=\Phi b+\frac{\psi}{\Lambda}$) for $L=0$ and $W/P\to\infty$ when $L\to\frac{N}{\Phi}<N$. Equation $L=I\left[\frac{1}{\zeta\Phi}\frac{W}{P}\right]^{-\frac{1}{1-\alpha}}$ is monotonically decreasing in the real wage and has the two axes as asymptotes. There must hence exist a positive couple $\left(\frac{W}{P}_{EB};L_{EB}\right)$ satisfying both equations with $L_{EB}<N$. The competitive real wage $(W/P)_{\mathrm{C}}$ obtains from the first of equations (30) with $\Phi=1$: $\frac{W}{P}_{\mathrm{c}}=b\left(\frac{N-L}{N}\right)+\frac{\psi}{\Lambda}\left(\frac{N}{N-L}\right)$, and by making use of this value, the price rule $L=I\left(\frac{1}{\zeta}\frac{W}{P}\right)^{-\frac{1}{1-\alpha}}$ allows us to write the equation which determines the employment level attached to a competitive labor market, L_{c}:

$$\left(\frac{\theta-1}{\theta}\right)\frac{\alpha}{I}L^{\alpha-1}\left(1-\frac{L}{N}\right)-b\left(\frac{N-L}{N}\right)-\frac{\psi}{\Lambda}=0 \tag{31}$$

By repeating this procedure for equations (30), with $\Phi>1$, we obtain:

$$\left(\frac{\theta-1}{\theta}\right)\frac{\alpha}{I}L^{\alpha-1}\left(1-\Phi\frac{L}{N}\right)-b\left(\frac{N-L}{N}\right)-\frac{\psi}{\Lambda}=0 \tag{32}$$

The right hand sides of (31)-(32) can be seen as two functions of employment L:

$$\begin{aligned} y_1 &= \frac{\zeta}{I}L^{\alpha-1}\left[1-\frac{L}{N}\right]-b\left(\frac{N-L}{N}\right)-\frac{\psi}{\Lambda} \\ y_2 &= \frac{\zeta}{I}L^{\alpha-1}\left(1-\Phi\frac{L_t}{N}\right)-b\left(\frac{N-L_t}{N}\right)-\frac{\psi}{\Lambda} \end{aligned}$$

In order to check whether the two function y_1 and y_2 have a positive intersection, equate them and obtain: $y_1-y_2\to 1-\frac{L}{N}=1-\Phi\frac{L}{N}$, which is impossible. Hence the two functions y_1 and y_2 do not have an intersection in the admissible range of values of L. The limit values of these y functions are:

$$\begin{aligned} \lim_{L\to0} y_1 &= \lim_{L\to0} y_2=+\infty \\ \lim_{L\to N} y_1 &= -\frac{\psi}{\Lambda}; \qquad \lim_{L\to N} y_2=\frac{\zeta}{I}N^{\alpha-1}\left(1-\Phi\right)-\frac{\psi}{\Lambda}<\lim_{L\to N} y_1 \end{aligned}$$

Furthermore, by direct inspection, both y_1 and y_2 are monotonically decreasing in L ($dy_{1,2}/dL < 0$). This is sufficient to show that the function y_2 always lies above the function y_1 in their common graph. The values of L satisfying equations (31) and (32) must thus respect the inequality: $L_{EB} < L_{\text{c}}$.

2.Properties of $d\varepsilon_{Y,w}/d\eta_h$ under RTM bargaining Starting from:

$$\omega_1 = \left[\frac{N}{L}\left(\frac{\psi}{\Lambda}+b\right)-b\right]\alpha\frac{W}{P}+\left[\frac{W}{P}-\frac{N}{L}\left(b+\frac{\psi}{\Lambda}\right)\right]b$$

consider the lowest possible level of the real wage $\underline{w}$, which corresponds to the competitive limit for $\Phi \to 1$:

$$\underline{w} = \frac{N\left(b+\frac{\psi}{V}\right)-bL}{N-L} \tag{33}$$

The bargained wage turns out to be equal to $\underline{w}$ multiplied by a factor greater than 1: $\frac{W}{P} = \Phi\frac{N-L}{N-\Phi L}\underline{w}$. Now consider the term $\frac{W}{P} - \frac{N}{L}\left(b+\frac{\psi}{\Lambda}\right)$ in ω_1; as it is: $\frac{W}{P} \geq \underline{w}$, the following inequality holds:

$$\frac{W}{P}-\frac{N}{L}\left(b+\frac{\psi}{\Lambda}\right) \geq \underline{w}-\frac{N}{L}\left(b+\frac{\psi}{\Lambda}\right)$$

It must be ascertained that the expression $\underline{w} - \frac{N}{L_t}\left(b+\frac{\psi}{\Lambda}\right)$ is always positive. This term is equal to:

$$\underbrace{\frac{N\left(b+\frac{\psi}{\Lambda}\right)-bL}{N-L}}_{=\underline{w}}-\frac{N}{L}\left(b+\frac{\psi}{\Lambda}\right) = \left[\left(\frac{1}{N}-\frac{1}{L}\right)b+\left(\frac{1}{N-L}-\frac{1}{L}\right)\frac{\psi}{\Lambda}\right]N$$

From equation (33):

$$\left[\left(\frac{1}{N}-\frac{1}{L}\right)b+\left(\frac{1}{N-L}-\frac{1}{L}\right)\frac{\psi}{\Lambda}\right]N > 0 \quad \text{when} \quad \frac{\psi/\Lambda}{b} > \frac{u^2}{1-2u}$$

By explicit computation, it is easy to verify that $\frac{u^2}{1-2u}$ is positive and smaller than 1 for $u \in [0;\ 0.41]$. It follows that, being the unemployment subsidy reasonably small, the inequality $\frac{\psi/\Lambda}{b} > \frac{u^2}{1-2u}$ is satisfied for reasonable values of the unemployment rate and the condition $\frac{\psi/\Lambda}{b} \geq 1$ holds.

This implies that, for reasonable values of the model parameters and of the unemployment rate, the minimal condition for having $\omega_1 > 0$:

$$\frac{W}{P}-\frac{N}{L}\left(b+\frac{\psi}{\Lambda}\right) > 0$$

is satisfied.