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Relative Wage Concern and the Keynesian Contract Multiplier*

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Abstract

Recent quantitative dynamic general equilibrium models have cast serious doubts on the explanatory power of staggered wage/price setting in accounting for both output and inflation persistence. We enlarge a dynamic general equilibrium model with staggered wages by incorporating Keynesian relative wage concern on the part of workers. In contrast to previous models of staggered wages/prices, both output and inflation persistence is a robust finding of the model. Persistence results hold for all the sensible parameterisations.

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Everyone, on some comparison or other, feels left behind. The electricians get a rise, so the gasmen must follow; but when the gasmen get their rise, it is the electricians who feel themselves to be treated unfairly. In terms of just two industries, the behaviour sounds exaggerated; but generalize it over many, and is it not what happens? [J. Hicks [1974], pp. 71-72]

1. Introduction

Modern business cycle research is almost entirely carried out within the context of quantitative dynamic general equilibrium (DGE) macromodels. In such a framework, the role of monetary shocks in generating the output fluctuations observed in actual data is still controversial. Existing monetary DGE macromodels have incorporated various forms of nominal rigidities. The overlapping contracts models of Calvo [1983] and Taylor [1979, 1980a] have played a prominent role in that approach. The reason is that such contracting schemes bring in not only the nominal rigidity necessary for the impact effect of the monetary innovation, but they also provide a nominal propagation mechanism in a framework otherwise lacking endogenous propagation mechanisms. In Taylor's [1980a, p.2] words: "*In effect, each contract is written relative to other contracts, and it causes shocks to be passed on from one contract to another – a sort of "contract multiplier."*

Recent quantitative DGE macromodels, notably Chari, Kehoe and McGrattan [1996] (CKM henceforth) and Ascari [1997], have cast serious doubts on the explanatory power of staggered price/wage setting in accounting for output persistence. Persistence requires endogenous stickiness in the sense that price-setting agents do not want to change their prices/wages by a large amount when they reset them. On the contrary, CKM and Ascari [1997] have shown that, for sensible values of the intertemporal elasticity of substitution of consumption and/or the intertemporal elasticity of substitution of labour, the response of wages to the output gap is too high to generate output persistence. In other words, when embedded in modern DGE macromodels, staggering does not generate such contract multiplier.

Moreover, a serious weakness of staggered wage/price models is their failure to account for persistence in inflation. While these models could generate *price stickiness*, they do not generate *inflation stickiness*; inflation is a jump variable in these models. In a recent contribution, Fuhrer and Moore [1995] (FM henceforth) have stressed that the lack of inflation persistence is a major empirical failure of Taylor's staggered wage contracting scheme.

This paper reconsiders this class of models. Firstly, we focus on wage staggering, since we believe that persistent nominal rigidities are more likely to arise in the labour market rather than in the goods market. Secondly, in contrast to the simpler approach of the above previous studies, we argue that the wage setting process is better represented as the result of the combination of nominal *and* real rigidities.

In our model the real rigidity in the labour market arises from taking into explicit account relative wage concern on the part of the workers in the labour contracting process. Actually, this was meant to be the original justification for staggered wage models by their own early proponents. Taylor's model was indeed thought to incorporate a "Keynesian" component of relative wage concern on the part of the workers. Nevertheless, Taylor's specification actually does not imply any relative wage concern, since the model is analytically equivalent to one in which workers are ("neoclassically") concerned only about the level of their own real wages (see Buiter and Jewitt [1981], Blanchard [1990], Ascari [1997]).

Since the very outset of economic science economists have been talking about relative wage considerations (see Adam Smith [1976]). Furthermore, there is strong evidence of wage interdependence. We will argue that most of it come from comparability arguments arising from psychological/sociological considerations and/or institutional and customary phenomena and/or monopoly unions behaviour. We review below the empirical evidence pointing at relative wages as a fundamental factor in the wage setting process. Even if this very same point represented the main motivation for studying staggered wage models, it has actually so far been neglected. As already noted by Buiter and Jewitt [1981], this omission seems to be a serious weakness of the contracting specification assumed in Taylor's model.

The aim of the paper is therefore to answer the following question: *may it be the case that the omission of relative wage concern on the part of the workers leads to the output and inflation persistence problems mentioned above?* In other words, *could a staggered wage model with relative wage concern solve both the output and the inflation persistence puzzles?* As we will discuss in section 2, given the wide literature and the supporting empirical evidence on relative wage concern, we think these questions deserve to be addressed.

In order to do this, we keep our analytical framework as close as possible to those of the previous studies that have highlighted the weaknesses of the Taylor contracting specification, namely CKM, FM and Ascari [1997]. However, we make an additional hypothesis: we modify the utility function of the agents to take into account the fact that workers are concerned about their wage relative to the one of the others. Relative wages then become an argument of the labour supply function. By incorporating relative wage concern in this framework, we try to capture the spirit of the original work of Taylor. Our analysis then should be seen as a first step towards assessing how crucial is the omission of relative wage concern for the analytical and quantitative results of CKM and Ascari [1997].

Contrary to previous studies, the quantitative results of the paper provides support for the existence of a powerful *Keynesian contract multiplier*. Two features of the model strengthen the importance of our result. First, the wage contracting specification is the only mechanism through which the effects of nominal shocks are propagated in our model. We refrain from introducing capital accumulation, adjustment costs, input-output structure, endogenous mark-ups, or any other possible factor which enhances the nominal propagation mechanism derived here. Second, as in previous analyses of staggered wage setting, our results also highlight the potential role of high intertemporal elasticities of substitution of consumption and labour supply in favouring persistence, but *by no means* rely on them to generate a substantial degree of persistence. This latter point is evident from our calibration exercise. Despite these features of the model, we find that output and inflation persistence is a likely outcome.

Some intuition for the sharp contrast between our results and those of CKM can be obtained by comparing the log-linearisation of the two wage setting equations. The key difference is the elasticity of wages with respect to business cycle conditions. Relative wage concern on the part of workers lowers that elasticity. A sensible calibration of the parameters governing relative wage considerations could generate a powerful contract multiplier and thus substantial persistence in both inflation and output. Hence, we conclude that the answer to the above questions is yes, i.e., relative wage concern may be the missing piece in the contract multiplier.

The remainder of the paper is organized as follows. In section 2 we discuss the relative wage concern hypothesis and we present some empirical evidence supporting it. Section 3 introduces our formalisation of relative wage concern on the part of wage-setters in a staggered wage framework. Our model is presented in section 4. We study the analytical implications of relative wage concern in section 5, and we compare our findings to previous studies of staggered wage/price models. We then proceed to analyse the quantitative implications. Section 6 describes the calibration of the model and reports our simulation results. Finally, section 7 concludes.

2. The Case for Relative Wage Concern

This section argues that there is a case for relative wage concern to be seriously considered and thus for the above questions to be addressed.

2.1. The Taylor [1979,1980a] model and relative wage concern

The literature building on Taylor [1979, 1980a] has investigated whether the "contract multiplier" induced by staggered wage-setting can propagate monetary shocks so as to mimic the output persistence properties exhibited by US data. A simplified two-period wage contract version of those models can be summarised by a wage setting equation, a price level equation and a static aggregate demand equation, that is

$$x_t = \frac{1}{2}(x_{t-1} + E_{t-1}x_{t+1}) + \gamma(E_{t-1}y_t + E_{t-1}y_{t+1}) \tag{2.1}$$

$$p_t = \frac{1}{2}(x_t + x_{t-1}) \tag{2.2}$$

$$y_t = m_t - p_t \tag{2.3}$$

where lower case letters denote log-deviations from steady state and $x =$ nominal wage, $p =$ price level, $y =$ output, $m =$ money supply. The *ad hoc* wage setting equation (2.1) is exogenously specified at the outset. Each of the two wage contracts lasts two periods and overlaps with the other one. Equation (2.1) says that the wage fixed by one sector in t, for periods t and $t+1$, will depend on the wages of the other sector in those two periods; that is, on the wage negotiated last period by the other sector but still valid in t, i.e., x_{t-1}, and on the wage the other sector will fix next period, i.e., x_{t+1}.[1] In Taylor's words, "*each contract is written relative to other contracts*", or, even more explicitly, *"the behavioral equations reflect a relative wage concern on the part of the workers"* (Taylor [1983], p. 987-988).

As already noted by Buiter and Jewitt [1981] and Blanchard [1990], however this last statement is inaccurate. Substituting equation (2.2) into (2.1) yields

$$x_t = \frac{1}{2}(p_t + E_{t-1}p_{t+1}) + \frac{\gamma}{2}(E_{t-1}y_t + E_{t-1}y_{t+1}) \tag{2.4}$$

which shows that Taylor's wage setting rule have actually a different interpretation. In setting the wage, workers care only about their absolute real wage in the two periods covered by the contract. The wage depends only indirectly from others' wages through the effect these wages have

[1] The dependence of x_t from output gaps will actually be the focus of the paper and hence will be analysed later on in great details (see section 5.1).

on the price level and, in turn, on the own absolute real wage. Hence, there is no actual relative wage concern *per sé* in Taylor's model.[2]

Staggered wage models were built with the explicit intention of analysing relative wage concern. Taylor model was meant to formalise a "Keynesian" relative wage concern model. Nevertheless, instead it does not. Is there something we loose? In section 5, we will show why this omission could be crucial in generating both the output and inflation persistence problems. However, first we need to convince the skeptic reader: why should we be worried at all about relativities in wage setting?

2.2. The literature

The issue of relative comparisons has a long tradition in economics, starting from Adam Smith [1976]. However, the most influential account of relative wage concern and its implications came undoubtedly from John Maynard Keynes [1936] (p. 14):

> *Though the struggle over money-wages between individuals and groups is often believed to determine the general level of real wages, it is, in fact, concerned with a different object. Since there is imperfect mobility of labour, and wages do not tend to an exact equality of net advantage in different occupations, any individual or group of individuals, who consent to a reduction of money-wages relatively to others, will suffer a* ***relative*** *reduction in real wages, which is sufficient justification for them to resist it. [...] In other words, the struggle about money-wages primarily affects the* ***distribution*** *of the aggregate real wage between different labour groups, and not its average amount per unit of employment, [...] . The effect of combination on the part of a group of workers is to protect their* ***relative*** *real wage.*[3]

[2] This point is explictly demonstrated to hold in a DGE model in CKM and Ascari [1997], which obtains Taylor wage setting equation imposing the staggering structure on a standard utility maximising framework.

[3] The emphasis is as in the original.

This fragment of the *General Theory* is surely amongst the most frequently quoted and it has inspired several contributions, including Taylor [1979, 1980a]. Apart the quite radical view of Cambridge economists close to Keynes (e.g., Robinson [1937], Kalecki [1944]), many others celebrated economists held the general view that central to the explanation of wage stickiness is the fact that workers, *individually and in groups*, are concerned with their relative wage (e.g, Tobin [1972], Hicks [1974], Kahn [1976], Solow [1980]).[4] The implications of this hypothesis is what we try to assess in this paper.

There is a number of reasons why relative wages may be arguments of the labour supply function. First psychological/sociological considerations suggest that comparability is crucial for the moral and satisfaction of the worker on the job place. The pioneer work is Runciman [1966] which elaborates the relative deprivation concept.[5] Bewley [1998] points at comparability as the major concern in labour relations for the effect that fairness have on workers' morale. The same idea is behind the efficiency wage literature where relative wage considerations have been introduced with reference to fair wage determination and its impact on effort and unemployment (e.g., Frank [1984], Summers [1988], Akerlof and Yellen [1986]).[6] In standard efficiency wage models, relative wage enters both the supply and the demand of labour functions through an effort function. In this model we are in a sense more conservative because we just suppose relative wages to enter the labour supply function through the effects that relative wages have on morale and hence on utility.[7]

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[4] *"Keynes's explanation of money wage stickiness is plausible and realistic"* (Tobin [1972], p. 3).

[5] The same notion leads to the definition of poverty in relative terms (see Sen [1983]).

[6] *"The conception of fair treatment has been the subject of considerable work by social psychologist and sociologists. For the most part it is not based on absolute standards, but, rather, on comparison of one's own situation with that of other persons"* (Akerlof [1982], p. 552)

[7] Note that a full efficiency wage approach would, if anything, strengthen our point. We do not deny the importance that morale can have on workers' productivity, and thus that relative wage considerations could also enter the labour demand functions. However, by being more conservative as possible, we aim to strengthen our point.

Second, relative wage concern can arise from customary/institutional phenomena. Indeed what is fairness? Despite economists have provided different definitions, admittedly fairness is still a somewhat vague concept. Even if it is evident that workers compare, it is not clear *what* they compare (e.g., 'wage constellations', 'orbits of coercitive comparison', 'wage contours'). It is obvious that what is closer and/or more relevant is easier to check. So workers can compare wages of workers in the same workplace or plant; or in the same region (local competition in the labour market); or in the same industry (due to the competition in the product market or to the demarcation line of union organisations); or more simply wages of jobs with a similar responsability and/or skill (job content argument); or of jobs which traditionally (or for some dates in the past) have been paid the same (historical argument). Probably there is a combination of all of these comparisons and the degree of importance among them may also changes over time. The last two, however, seems particularly important. Indeed, even if *"[n]o system of wages [...] will ever be found to be fair [...]; it is necessary, for it to happen, that the system of wages should be well estabilished, so that it has the sanction of custom. It then becomes what is expected; and [...] what is expected is fair"* (Hicks [1974], p. 65). The industrial language of conciliation is full of terms as 'customary relativities', 'proper parities', 'estabilished differentials'. This is the case both in the private and especially in the public sector, because public sector pay is based on comparability given the unavailability of direct (or even indirect) measure of output and/or marginal productivity of labour. These forces may be stronger in some countries than in others reflecting istitutional arrangments and different models of society (e.g., Europe vs US).[8] Not to respect estabilished differentials is likely to cause problems in industrial relations, as demonstrated by the experiences of incomes policies, by the British experience of Fair Wage Resolutions of Parliament and of the Clegg Commission

[8] *"The general impression is one of remarkable stability over time in inter-industry pay differentials - a stability to which the forces of tradition and comparability have contributed. [...] The stability [...] is not peculiar to Britain. It also applies to Belgium, France, West Germany, Italy and The Netherlands."* (Saunders, in Blackaby [1980], p. 194)

(see Fallick and Elliot [1981]).[9]

Third, however vague is the concept of 'just/fair wage', the attempt to get it is certainly behind the early days of unionism. The push behind the origins of most trade unions was ending discrimination, getting 'equal pay for equal work', obtaining a 'fair wage'. Acting as 'collective voice', the union gives strength to the preferences and claim of the single members. Labour economists pointed out long ago the interdependence between trade union's wage claims as a stylized fact in the bargaining process. Before proposing the wage bill as unions' maximand, the founder of the modern economics of trade union states

> *Wage changes may spread by the simple method of imitation and social transference. Wage increases originating in one sector may be diffused because wage earners are determined to fare just as well as their associates. The argument that "everyone is getting an increase" is not simply a superficial point advanced in all negotiations but a vital force in the labor market that deserves more detailed attention. [...] The community of housewives, with the inevitable "you are good as the next fellow", is not to be underestimated.* [J. T. Dunlop [1966], p. 126]

Theoretical foundations of union "rivalry" and inter-union "jealousy" have been studied in Oswald [1979] and Gylfason and Lindbeck [1984]. Several episodes of unions behaviour could not be rationalised without

[9] *"These very large settlements can have a considerable disruptive effect as in the case of the recent 40 per cent award to the police force. Other groups who are being actively held down by the government interpret these large awards as evidence of some form of favouritism on the part of government and in consequence increase their efforts to obtain a large settlement in turn. It would seem plausible to argue, on the basis of the historical evidence, that the Clegg commission has a high probability of engendering exactly this situation. By recomanding awards which in some sense compensate a specific group of previous 'mistreatment' they will generate spillover effects, which although illeggittimate may eventually cause the governement to curtail or abandon the activities of the standing commission"* (Fallick and Elliot [1981], p. 124). What *"would seem plausible to argue"*, it is indeed what happened.

appealing to these concepts.[10] Similarly, the collective voice of a union could strenghten the effort to maintain estabilished differentials and/or fair relativities in *both* directions: restraining wages in favourable circumstances in exchange of preserving customary differentials in difficulties.[11]

In conclusion, the literature suggests several reasons (psychological/sociological considerations and/or institutional and customary phenomena and/or monopoly unions behaviour) why comparability in wage setting may be important.

2.3. Some Empirical Evidence

Fallick and Elliot [1981], p. 251-252, conclude the book by stating *"[t]he argument is essentially that relative wages enter the labour supply function"* and that *"[s]ubstantial evidence now exists of the considerable interdependencies that exist between the wage settlements of different bargaining groups throughout wide areas of the economy".* (On wage interdependecies see e.g., Ashenfelter et al. [1972], Flanagan [1976], Nickell and Wadhwani [1988] and also the survey by de la Croix [1994])

Risager [1992] empirically investigates the wage rivalry hypothesis in Danish data for skilled and unskilled workers. He found strong evidence in favour of interdependence between wage claims. In particular, his analysis of wage setting behaviour:

[10] E.g., *"[In 1950-53] While in the cotton industry, where recorded unemployment alone amounted to some 30 per cent, the unions not only presented to the employers a demand for a general wage increase but persisted to the point of partial success. It seems that the cotton unions were more fearful of their members' wage rates falling behind those of other industries than of the less determinate effect of a wage increase on employment."* [Turner in Dunlop [1957], p. 123]

[11] *"According to our findings the chief role of trade unions in that process was to protect the levels of earnings of those in less favourable circumstances by seeking to ensure that they received the norm despite the market and financial position of their employers. [...] The implication of the above analysis is that measures to restrain the earnings of members in favourable circumstances would be more acceptable to trade-unionists than measures that depress the relative pay of members in less favourable situations."* [Daniel in Blackaby [1980], p. 160]

(i) identifies a very strong "following" behaviour in wage setting by the unions;

(ii) finds the level of unemployment/business cycle conditions statistically non-significant.

Furthermore, in recent years a new source of empirical evidence has received considerable attention by economists: surveys on self-reported levels of satisfaction of workers, which already form the fundamental material of study for a large empirical literature in social psychology. Such data has been used as proxy for utility data.[12] Capelli and Sherer [1988] use data from a major U.S. airline; Clark and Oswald [1996a] from the British Household Panel Survey. Both studies report measures of the importance of relative wages for individual workers. Their results:

(i) identify relative wages as *the* fundamental factor (and statistically strongly significant) on regressions of job satisfaction for individual workers;

(ii) the level of the own real wage/income plays a minor role in explaining job satisfaction, if any at all. Moreover, its coefficient is found statistically non-significant.

Besides, other studies have asked employers which are the determinants of wage negotiations with workers. Campbell and Kamlani [1997] (Table II) report results from other studies based on survey data from firms which suggest that relative wage concern is very significant, especially in heavily unionized firms (Agell and Lundborg [1995]).

These findings from individual survey data provide quite strong support for utility functions that allow for relativities in wage setting. Besides, they justify the presence of the union rivalry mentioned above from the personal preferences of their potential members.

Given what said above, in what follows we will model relative wage concern by including an additional argument in the utility function of

[12] As pointed out by Clark and Oswald [1996a], footnote 4: *"It might be argued, in the extreme, that these are random numbers merely made up by survey respondents. Psychologists, who are at least as aware of this possibility as economists, have long since abandoned such a view."*

the representative household. Despite the efficiency wage literature, the available empirical evidence on unions' behaviour, sociological and psychological considerations, our introduction of relativities in the utility function may be seen as an *ad hoc* unjustifiable short-cut. This approach runs in fact against the deeply-rooted resistance to modify the structure of preferences of agents.[13] Nevertheless, similar kind of preferences have been proposed as an explanation for some puzzles in asset pricing (see Abel [1990], Gali [1994], Campbell and Cochrane [1995]), consumption (see Carrol and Weil [1994]), and growth (see Carrol *et al.* [1997]).[14] More generally, in recent years a growing literature has emerged encompassing economic and social elements, and in particular status concern (see Frank [1984, 1985] and the references therein, Baxter [1988], Kandel and Lazear [1992], Clark and Oswald [1996a,b] and Akerlof [1997]).

Moreover, by introducing relative wage considerations explicitly we aim at: (i) identifying the analytical implications of relative wage concern in wage setting; (ii) establishing whether sensible values of the key parameters governing relative wage concern can explain output and inflation persistence. In this way, we can then assess how critical is the omission of relative wage concern for the analytical and quantitative results of CKM and Ascari [1997], recalling that relative wage considerations motivated the interest in staggering models.[15]

[13] As Akerlof [1997, p. 1005] puts it: *"Traditional economics has been based on methodological individualism. Until quite recently, with some rare exceptions, it has not been appreciated that this method can be, or perhaps I should say,* ***should be****, extended in describing social decisions to include dependence of individuals' utility on the utility or the actions of others."*

[14] Depending on the particular specification they are referred to as "interdependent preferences", "external habit formation", "keeping up (or catching up) with the Joneses" or "relative income hypothesis".

[15] Further microfoundations of relative wage concern are certainly desirable and are already in our agenda for future research.

3. Relative Real Wage Concern and Staggered Wage Setting

The structure of wage setting in our model is defined by two features: (i) staggered wage setting; (ii) relative real wage concern.

(i) *Staggered Wage Setting*

This setting is standard in the related literature. The economy consists of a continuum of industries, indexed by $i \in [0, 1]$, and a continuum of industry-specific unions, indexed by $j \in [0, 1]$.[16] The economy is divided into N sectors. Each sector is composed of $1/N$ industries and their corresponding unions. Wage contracts, denoted by X, are negotiated in nominal terms, and are fixed for N periods. That is, for a union setting the nominal wage in period t, $X_{jt+k} = X_{jt}$ for $k = 0, ...N - 1$. Furthermore, unions indexed $j \in [0, 1/N]$ set their wages in periods 0, N, $2N$, unions indexed $j \in [1/N, 2/N]$ do so in periods 1, $N+1$, $2N+1$, etc. Note that staggered wage setting breaks the complete symmetry among households in different sectors. However, unions belonging to the same sector will set the same wage.[17] Thus, in any period t there are N different contracts in effect.

(ii) *Relative Real Wage Concern*

We now turn to the analytical definition of relative wage concern. We denote the relative wage argument in the utility function of the representative household j, ${RW_t}^j$. Following FM[18], we define the *contract*

[16] A continuum of industries means that no imperfectly competitive agent is 'large' relative to the economy as a whole. The 'household-union' should be thought of as an aggregate of all the households which work in the industry, who collude in the setting of the wage.

[17] Let us call the new wage set in period t in industries $i \in [0, 1/N]$, X_t. Then, unions indexed $j \in [1/N, 2/N]$ will set their new nominal wage in period $t+1$, unions indexed $j \in [2/N, 3/N]$ will set their new nominal wage in period $t+2$, and so on. Therefore X_t, X_{t+N}, X_{t+2N}...are the wages fixed by the sector which comprises industries $i \in [0, 1/N]$, $X_{t+1}, X_{t+1+N}, X_{t+1+2N}$...the wages fixed by the sector that comprises industries $i \in [1/N, 2/N]$ and so on.

[18] In what follows we keep the notation as close as possible to that of FM. Our definition of the case presented in the main text corresponds to their *Theoretically Preferable*

price in period s, "CP_s^j", as the value of the contract signed by the union j in period s. To clarify the definitions note that in this subsection, we use the index t to indicate the period in which the real wage comparison takes place, while s refers to the period in which the contract is signed. Recall that for a union setting the nominal wage in period s, $X_{s+k} = X_s$ for $k = 0, ...N-1$. As the nominal wage X_s is fixed for N periods, such is its contract price, i.e., CP_s, (hence, we index it by s). Workers compare the value of the contract they sign in period s, CP_s, to the *index of contract prices* "V". Crucial to the modelling of the relative wage concern is the choice of the reference wage index for comparison purposes. We define V_t as the average of the contract prices of the workers in the *other* sectors in effect in period t, that is, the average of the contracts negotiated by the *other* unions. We believe this "*outward comparison*" specification to be the most relevant in the real world.[19] Thus, ${RW_t}^j$ is defined as the ratio between the value of the contract in force for union j in period t to the index of contract prices signed by the other sectors and still valid in period t.

At any period t there are N different nominal contracts in effect, hence N different CP_s and N different RW_t^j, one for each representative sectoral union. Consider the problem faced by a union setting the nominal wage in period t. Assume that the contract lasts for four periods ($N = 4$). The decision of the union then takes into account that by setting X_s, it also fixes CP_s for the next four periods. The optimal X_s is thus set by comparing the price contract the union is currently negotiating (i.e., CP_s) to the indexes of real contract prices V for the four periods in which the contract will be in force, that is t to $t+3$. The RW the workers will face in period t and in the following three periods as a result of the wage they negotiate in t are then

Case. Appendix 2 introduces two alternative specifications. We also present a brief comparison of our model with FM's one in Section 5.3.

[19] The term "outward comparison" follows a recent work by Carrol *et al.* [1997]. Its purpose is to highlight the absence of own variables in the definition of the reference stock for comparison purposes. Specifically, in our setting the "own contract price" does not enter the definition of the index of contract prices to which it is compared in the bargaining process.

$$RW_t^j = \left(\frac{CP_s}{V_t}\right) = \frac{CP_s}{(1/3)(CP_{s-3}+CP_{s-2}+CP_{s-1})};$$
$$RW_{t+1}^j = \left(\frac{CP_s}{V_{t+1}}\right) = \frac{CP_s}{(1/3)\ (CP_{s-2}+CP_{s-1}+CP_{s+1})}$$
$$RW_{t+2}^j = \left(\frac{CP_s}{V_{t+2}}\right) = \frac{CP_s}{(1/3)\ (CP_{s-1}+CP_{s+1}+CP_{s+2})};$$
$$RW_{t+3}^j = \left(\frac{CP_s}{V_{t+3}}\right) = \frac{CP_s}{(1/3)\ (CP_{s+1}+CP_{s+2}+CP_{s+3})}$$

Note that, because of the "outward comparison" specification, the V_t terms are not symmetrically updated in the four periods of duration of the contract.[20]

Last we just need to define the contract price, CP. We suppose that the workers are concerned with their average real wage over the life of the contract. Consequently CP is defined as the money wage deflated by a weighted average of the price levels in the four periods in which the contract will be in force. That is: $CP_t = X_t/\overline{P}_t$, where $\overline{P}_t = \frac{P_t+\beta P_{t+1}+\beta^2 P_{t+2}+\beta^3 P_t}{1+\beta+\beta^2+\beta^3}$. Agents therefore calculate the average $\overline{P}_t$ discounting the future price levels by the preference discount factor β. Then they compare the value of their contract, i.e., CP_t, with an average of the ones that overlap with it, that is,

$$CP_t = \frac{X_t}{\overline{P}_t}\ ; \quad RW_t = \frac{X_t/\overline{P}_t}{(1/3)\left(\frac{X_{t-3}}{\overline{P}_{t-3}} + \frac{X_{t-2}}{\overline{P}_{t-2}} + \frac{X_{t-1}}{\overline{P}_{t-1}}\right)} \quad .$$

In Appendix 2 we present two alternative formulations for RW_t.

4. The Model

The model is based on Rankin [1998]. There are three types of agents in the economy: firms, households and the government. The economy consists of a continuum of industries and every industry produces a single perishable product and comprises a continuum of firms. The goods

[20]Future variables are replaced by their expected values. We drop the expectation operator for notation convenience. Note also that the RW terms are different for each household-union in different sectors, depending on the period in which they set their wage. Recall in fact that in each period there are N different contracts in force and hence N different RW.

market in every industry is hence competitive. All households have the same preferences. Each household j consumes a composite good, defined by a CES index over consumption goods of each industry, i.e. $C_{jt} = \left[\int_0^1 C_{jit}^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}$. The elasticity of substitution among goods, θ, is assumed strictly greater than one. This specification gives rise to the standard demand function for good i by household j

$$C_{jit} = \left[\frac{P_{it}}{P_t}\right]^{-\theta} \frac{E_{jt}}{P_t} \tag{4.1}$$

where E_{jt} is household's total nominal expenditure on goods, and P_t is the aggregate price index defined as $P_t = \left[\int_0^1 P_{it}^{1-\theta} di\right]^{\frac{1}{1-\theta}}$.

4.1. Firms

All firms have the same technology, given by $Y_{it} = \alpha L_{it}^{\sigma}$, where labour is the only factor of production. Firms within each industry are price takers both in the goods and the labour market. Profits are maximised period by period given the nominal wage, X_{it} , which is set by the industrial union. The labour demand and output of firm i are respectively given by

$$L_{it} = \left[\frac{1}{\alpha\sigma}\frac{X_{it}}{P_{it}}\right]^{\frac{1}{\sigma-1}}; \qquad Y_{it} = \alpha\left[\frac{1}{\alpha\sigma}\frac{X_{it}}{P_{it}}\right]^{\frac{\sigma}{\sigma-1}} . \tag{4.2}$$

Imposing the equilibrium condition in the industry goods market, that is,

$$C_{it} = \int_0^1 C_{jit} dj = Y_{it} \qquad \forall i \,\epsilon\, [0,1], \tag{4.3}$$

yields the following relation between the labour demand and the nominal wage

$$L_{it} = K_t X_{it}^{-\varepsilon} \qquad \text{where} \qquad \varepsilon = \frac{\theta}{\sigma + (1-\sigma)\theta} \qquad \text{and} \qquad K_t = \sigma^{\varepsilon}\left[\frac{E_t}{P_t^{1-\theta}}\right]^{\frac{\varepsilon}{\theta}} . \tag{4.4}$$

The labor demand function faced by the monopolistic household-union in each industry exhibits a constant money-wage elasticity equal to ε, which depends on technology and preference parameters. K_t is parametric to the union, which takes aggregate variables as given ($E_t = \int_0^1 E_{jt}dj$ = aggregate nominal expenditure).

4.2. Households

The two fundamental features of the households' behaviour are their monopoly power in nominal wage setting and their concern with relative wages.

The industry-specific household-unions enjoy monopoly power because labour is not allowed to move across industries. In period t, the household maximises a utility function of the form (the index j is dropped to lighten notation)

$$U = \sum_{k=0}^{\infty} \beta^k E_t \left[u(C_{t+k}, m_{t+k}, L_{t+k}, RW_{t+k}) \right] \quad . \tag{4.5}$$

The arguments in the utility function C_{t+k}, m_{t+k} and L_{t+k} are, respectively, the consumption of the composite good, the end-of-period real money balances ($m_{t+k} = M_{t+k}/P_{t+k}$) and the labour supply of the households.[21] The specification of the relative wage argument RW_{t+k} is the novelty of the model and has been discussed in section 2.2. The utility function satisfies the conditions: $u_{RW}(\cdot) > 0$, $u_{RWRW}(\cdot) < 0$.

The household's budget constraint evolves according to

$$P_t C_t + M_t + \sum_{s_{t+1}} Q(s^{t+1} \mid s^t) B(s^{t+1}) \leq M_{t-1} + B_t + W_t L_t + \Pi_t + T_t \tag{4.6}$$

where $Q(s^{t+1} \mid s^t)$ is the stochastic discount factor equal to the money value of a contingent claim in state s^t to one dollar in state s^{t+1}.[22] M_t denotes money holdings at the end of period t, B_t the quantity of bonds

[21] The utility function satisfies the standard conditions $u_c(\cdot)>0$, $u_m(\cdot)>0$, $u_L(\cdot)<0$, $u_{cc}(\cdot)<0$, $u_{mm}(\cdot)<0$, $u_{LL}(\cdot)<0$, where $u_r(t)$ denotes the first partial derivative of the instantaneous utility function and $u_{rr}(\cdot)$ the second one, with respect to the argument r.

[22] Following CKM, let s^t denote the state of the world in period t. Denote with $\Pr(s^{t+1} \mid s^t)$ the probability that in the next period the state of the world will be s^{t+1},

in period t, T_t the nominal lump-sum transfer received by the household from the government, Π_t the profits distributed by firms, and $L_t W_t$ the labour income.

Households maximise their expected lifetime utility subject to the sequence of budget constraints (4.6), the sequence of labour demand curves (4.4), and the additional constraint that the nominal wage will be fixed for N periods. They choose the level of consumption, the quantities of money and bonds to be transferred to the next period and the level of the nominal wage that must be fixed for N periods. However, they fix the wage before the realisation of period t shock, while the other decisions are taken after the shock has been realised. The first-order conditions for this problem can be expressed as follows

$$\frac{u_m(t)}{u_C(t)} = \frac{R_t - 1}{R_t} \tag{4.7}$$

$$u_C(t) = \beta R_t E_t \left(\frac{u_C(t+1) P_t}{P_{t+1}} \right) \tag{4.8}$$

$$\sum_{s^{t+1}} Q(s^{t+1} \mid s^t) = \frac{\beta E_t(\lambda_{t+1})}{\lambda_t} = \beta E_t \left(\frac{u_C(t+1) P_t}{u_C(t) P_{t+1}} \right) = \frac{1}{R_t} \tag{4.9}$$

$$X_t = \left(\frac{\varepsilon}{\varepsilon - 1} \right) \left\{ \frac{E_{t-1} \left[\sum_{r=o}^{N-1} \beta^r \left(-u_L(t+r) K_{t+r} \right) \right]}{E_{t-1} \left[\sum_{r=o}^{N-1} \beta^r \left(\frac{u_C(t+r) K_{t+r}}{P_{t+r}} \right) \right]} + \frac{E_{t-1} \left[\frac{1}{\varepsilon} u_{RW}(t+r) \frac{\partial RW(t+r)}{\partial X_t} \right]}{E_{t-1} \left[\sum_{r=o}^{N-1} \beta^r \left(\frac{u_C(t+r) K_{t+r}}{P_{t+r}} \right) \right]} \right\} \tag{4.10}$$

where λ_t is the multiplier attached to the budget constraint in period t. The first three equations are standard: (4.7) represents the optimal

conditional to the state s^t in period t. To lighten notation and avoid indexing each variable with respect to the state of the world, we use the expectation operator and the dating of the variables. Then, $\Theta_t = \Theta(s^t)$ and $E_t(\Theta_k) = \sum_{s^k} \Pr(s^k \mid s^t) \Theta(s^k)$, where Θ_t is whatever variable or function of variables, s^k is the state in period $k > t$ and the sum is calculated over all the possible future states s^k.

choice between consumption and money, (4.8) is the Euler equation for consumption and (4.9) gives the gross nominal interest rate R_t.[23]

Equation (4.10) gives the optimal nominal wage set by the monopolistic household-union for the following N periods, on the basis of period $t-1$ information set. The optimal wage is given by a fixed mark-up, i.e., $\varepsilon/(\varepsilon-1)$, over the quantity in the curly brackets. This latter expression is composed of two terms. The first term represents the ratio between expected weighted averages of the marginal disutility of labour and the marginal utility of consumption over N periods. In other words, the first component is a weighted average of the optimal flexible wages of the N periods. The second term is an expected weighted average of the relative wage concern components over the N periods. In both terms the weights are defined by β, K_{t+i}, P_{t+i} and ε.[24]

4.3. Government

The role of the government is limited to provide lump-sum transfers through which money is introduced in the economy. These transfers satisfy

$$T_t = M_t - M_{t-1} \tag{4.11}$$

and the growth of the nominal money supply is described by

$$M_t = \mu_t M_{t-1} \tag{4.12}$$

where μ_t follows a stochastic process (to be specified below).

[23]Note that $\sum_{s^{t+1}} Q(s^{t+1} \mid s^t)$ is the current value of a nominal bond that gives one unit of money for sure in the next period. On the other hand, $Q(s^{t+1} \mid s^t) = \beta \Pr(s^{t+1} \mid s^t) \left(\frac{u_C(s^{t+1}) P_t}{u_C(t) P(s^{t+1})} \right)$is the current price of a claim of one unit of money contingent on the realisation of state s^{t+1} in the next period.

[24]Given (4.10), note that it is *ex-post* optimal for the unions to satisfy an unexpected increase in labour demand. Unions are obviously *ex-post* willing to satisfy extra demand for labour until the real wage is equal to the competitive one. In what follows we suppose that never to be the case. The fact that employment is always on the labour demand curve is hence consistent with optimisation in this case, in contrast to the old style Gray-Fischer-Taylor models in which the wage was set in accordance with a target level that cleared the labour market in expectation.

The resource constraint for this economy is obtained by aggregating (4.6) over all households and imposing equilibrium conditions on the bonds and money markets

$$\int_0^1 P_t C_{jt} dj \leq \int_0^1 (W_{jt} L_{jt} + \Pi_{jt}) dj \tag{4.13}$$

while the equilibrium condition on goods markets (4.3) implies

$$\int_0^1 P_t C_{it} di = \int_0^1 P_{it} Y_{it} di = P_t Y_t \tag{4.14}$$

where $Y_t = \frac{\int_0^1 P_{it} Y_{it} di}{P_t} = C_t$ is real aggregate output, defined as in national income accounting.

An equilibrium for this economy is described by a vector of allocations $\{C_{jt},\ M_{jt},\ B_{jt},\ X_{t-k},\ L_{jt},\ Y_{it},\ P_{it},\ P_t,\ Y_t,\ R_t,\ Q(s^{t+1} \mid s^t)\}$ for $k = 0, ..., N-1$ such that: (i) taking other sectors' variables and aggregate variables as given, consumer allocations solve the consumer's problem $\forall j$, that is, (4.7), (4.8), (4.9) and (4.10) hold $\forall j$; (ii) taking the nominal wage as given, firms' output and labour demand maximise profits according to (4.2) and (4.4); (iii) the transfers and the money supply process satisfy (4.11) and (4.12); (iv) the resource constraint (4.13) and the goods market equilibria ((4.3) and (4.14)) are satisfied.

To solve for the model dynamics, we first calculate the steady state of the model and then apply the Blanchard-Khan's [1980] methodology to the log-linearised model around the steady state.

5. Analytical Implications of Relative Wage Concern

In this section we provide the intuition how relative wage concern can help to solve both the output (5.1 and 5.2) and the inflation (5.3) persistence puzzles.

5.1. The "γ-puzzle"

With respect to the output persitence problem, the fundamental property of the Taylor's wage setting equation is the dependence of wages on business cycle conditions. Since output levels feed back directly into equation (2.1), it immediately follows that output fluctuations will have a small impact on prices *if and only if* the elasticity of wages with respect to output, the Taylor's γ, is low. Early authors estimate this parameter from macrodata using basically (2.1). For the US, Taylor [1980b] estimates γ to be between 0.05 and 0.1, while Sachs [1980] estimates it to be between 0.01 and 0.07. In his numerical investigation of persistence properties of Taylor's [1980a] model, West [1988] uses two possible values for γ: 0.01 and 0.1. More recently, Phaneuf [1990] takes estimated values for γ for Canada, Germany, Italy, UK and US. He finds γ to lie between 0 and 0.32 and hence Ambler and Phaneuf [1992] calibrate $\gamma = 0.15$. Jeanne [1997] suggests that γ should lie between 0.05 and 0.2.

Recent research incorporating staggered wages/prices into a DGE framework, notably CKM and Ascari [1997], has opened the "black box" of the *ad hoc* parameters in the wage setting equation. Log-linearising the optimal wage setting rule around a deterministic steady-state with constant money supply ($\overline{\mu} = 1$) and constant returns to scale to labour ($\sigma = 1$), the parameter γ is found to be determined by the elasticities of the marginal utilities of consumption with respect to consumption, i.e., η_C, and of labour with respect to labour, i.e., η_L, both evaluated at steady state. By calibrating the expression for γ, CKM argue that only values of γ greater than one are compatible with sound microfoundations in models of staggering. On the same line, a log-linearisation of our model with an additively separable utility function in all its arguments and without relative wage concern yields[25]

$$\gamma = \left\{ \frac{\eta_L - \eta_C}{\theta \eta_L + 1} \right\} \quad . \tag{5.1}$$

Given the existing evidence from microdata on the intertemporal elasticities of substitution of consumption ($-1/\eta_C$) and of labour supply ($1/\eta_L$), a sensible calibration of (5.1) gives a value of γ far too high to gener-

[25] The present model without the relative wage concern term coincides exactly with Ascari's [1997] model. See Ascari [1997] for an exhaustive analysis of the output persistence properties of such a model.

ate output persistence.[26] As a conclusion, the calibration of γ based on well-established evidence from microdata is at odds with all the empirical estimates from macrodata. This is what we called the "γ-puzzle".

5.2. Effects of Relative Wage Concern

Can our model solve the "γ-puzzle"? We argue that this is the case. The intuition is as follows. A negative η_{RW} determines a "following" behaviour in wage setting.[27] Suppose a negative shock to the rate of growth of money. Agents want to keep their real wage in line with the existing ones. Under staggering, it generates a slower adjustment in nominal variables, that is, a degree of *endogenous stickiness*, which leads to persistence of the real effects of money shocks. In short, relative real wage concern lowers the sensitivity of nominal variables to the business cycle conditions.

The intuition can be formalised as follows. Let the utility function be separable in all its argument and the RW_t term be linear in X_t. Then, log-linearising the resulting wage setting rule around the steady-state with $\overline{\mu} = 1$, the elasticity of wages with respect to output is

$$\gamma_{RW} = \left\{ \frac{\left\{ \frac{\frac{\varepsilon}{\theta}\eta_L - \eta_C}{\varepsilon\eta_L + 1} \right\} - \left\{ \left[\frac{\frac{\varepsilon}{\theta} + \eta_C}{\varepsilon\eta_L + 1} \right] \left[\frac{U_{RW}(.)}{-\varepsilon\, U_L(.)\, K_t\, X_t^{-\varepsilon}} \right] \right\}}{1 - \left\{ \left[\frac{\eta_{RW} + \varepsilon}{\varepsilon\eta_L + 1} \right] \left[\frac{U_{RW}(\cdot)}{-\varepsilon\, U_L(.)\, K_t\, X_t^{-\varepsilon}} \right] \right\}} \right\} . \tag{5.2}$$

It is then evident that γ_{RW} is decreasing in the absolute value of η_{RW} ($\eta_{RW} < 0$).

The first term in curly brackets in the numerator corresponds to the γ arising from staggered wages, i.e., (5.1). In our model, it is complemented by additional terms incorporating the marginal utility of the

[26] A low intertemporal elasticity of substitution of labour supply means that a substantial increase in wages is required for workers to supply more labour. This makes the marginal cost to rise fast after a money shock, pushing up the nominal variables and thus dampening persistence.

[27] See Clark and Oswald [1996b]. η_{RW} represents the elasticity of the marginal utility of the relative wage term in the utility function with respect to the relative wage term.

relative wage term, $U_{RW}(\cdot)$, and its own elasticity η_{RW}. The inconsistency of the microfounded wage setting equations and the empirical estimates can then be solved. For this, the presence of $(-\eta_{RW})$ increasing the denominator of the expression is critical, as it lowers the sensitivity of wages to the business cycle conditions, allows for endogenous stickiness and hence makes output persistence a more likely. The quantitative implications of this finding are the focus of the remaining sections of the paper.[28]

5.3. A Comparison with the FM Specification

This section completes the description of the analytics of the model by deriving the full log-linearisation of the money-wage setting rule and addressing the inflation persistence problem. In a recent contribution, FM stress as a major empirical failure the fact that Taylor wage setting equation can not generate inflation persistence. Thus, they propose a different *ad hoc* contracting scheme able to replicate the properties of the inflation time series. Our log-linearised model is close to the FM contract equation and thus potentially capable of generating inflation persistence. A brief comparison between the two specifications clarifies further the driving forces behind the model. Moreover, the log-linearised wage setting equation that we obtain here will play a fundamental role for the calibration of the relative wage parameters in section 6.

We parameterise the instantaneous utility function as

$$u\left(C, \frac{M}{P}, L, RW\right) = \frac{1}{\nu} \ln \left[bC^{\nu} + (1-b)\left(\frac{M}{P}\right)^{\nu} \right] - dL^{e} + \frac{\phi}{1-\tau}\ (RW)^{1-\tau} \quad . \tag{5.3}$$

Note that η_{RW} is simply equal to $(-\tau)$ in our formulation.

A log-linearisation of (4.10) around the steady state with $\overline{\mu} = 1$ and $\beta = 1$ then yields

$$\Omega\ x_t = \frac{1}{4}\Omega\ \sum_{i=0}^{3} E_t p_{t+i} + \frac{1}{4}\ \Lambda \sum_{i=0}^{3} E_t(v_{t+i} - cp_t) + \frac{1}{4}\Gamma \sum_{i=0}^{3} E_t y_{t+i} \tag{5.4}$$

[28] It is also worth noting that the effect of the intertemporal elasticity of substitution in labour supply, i.e. η_L, is ambiguous.

where lower case letters denote log-deviations from steady state values and

$$\Omega \equiv \frac{\sigma(\varepsilon-1)[1+\varepsilon(e-1)]-\phi e\varepsilon}{\sigma(\varepsilon-1)}; \qquad \Lambda \equiv \frac{\phi(\tau-1)}{\sigma(\varepsilon-1)}; \qquad \Gamma \equiv \frac{\sigma(\varepsilon-1)[\theta+\varepsilon(e-1)]-\phi e\varepsilon}{\theta\sigma(\varepsilon-1)} \quad .$$

Ω represents the weight on the own real wage, Λ weights the relative wage concern and Γ captures the sensitivity of the nominal wage with respect to the business cycle conditions.[29] The fundamental novelty of the paper is the presence of the relative wage concern weighted by Λ in the wage setting rule. Traditional staggered wage models, like Taylor [1980a], CKM and Ascari [1997], instead impose $\Lambda = 0$.

Our log-linearised wage setting rule could be thought as a micro-founded version of that of FM. They present and estimate an *ad hoc* "*...contracting model, in which agents are concerned with relative real wages, that is data consistent*" (FM, abstract). In FM, agents set nominal wages such that CP equals the average real contract price index expected to prevail over the life of the contract, adjusted for excess demand conditions, that is

$$cp_t = \sum_{i=0}^{3} f_i E_t(v_{t+i} + \gamma y_{t+i}) \quad . \tag{5.5}$$

Since, given the definition of the contract price in our model, $cp_t = x_t - \frac{1}{4}\sum_{i=0}^{3} E_t p_{t+i}$, we can rewrite equation (5.4) as

$$cp_t = \frac{1}{4}\frac{\Lambda}{\Lambda+\Omega}\sum_{i=0}^{3} E_t v_{t+i} + \frac{1}{4}\frac{\Gamma}{\Lambda+\Omega}\sum_{i=0}^{3} E_t y_{t+i} \tag{5.6}$$

which looks very much alike FM's formulation (5.5).

However, note that there are two important differences between our microfounded wage setting equation and the one of FM.[30] First,

[29] Given the restrictions on parameters, Ω, Λ and Γ are non-negative.

[30] A third minor difference highlights the additional insights obtained from microfoundations. FM impose the weights f_i to be decreasing linearly and estimate the slope parameter. Instead, without imposing $\beta = 1$, in our model the equivalent to the f_i terms are decreasing and have a very intuitive interpretation: they depend naturally on the discount factor β, i.e., $f_i = \beta^i / \sum_{i=0}^{3} \beta^i$.

FM define the v_{t+i} terms as the average of the existing real contract prices *including* its own real contract price. As explained in section 3, we believe that our outward comparison better replicates actual relative wage concern. Second, the coefficient on the sum of v_{t+i} is not necessarily equal to unity in our model, being equal to $\Lambda/(\Lambda+\Omega)$. For equation (5.6) to match FM's formulation we need to impose $\Omega = 0$ which implies: (i) setting the own real wage concern equal to zero; (ii) imposing a one-to-one following behaviour in wage setting, since a 10% change in v_{t+i} leads then to a 10% change in CP_t.

6. Quantitative Implications of Relative Wage Concern

6.1. Model Calibration

We set one period equal to one quarter and assume that contracts last for one year ($N = 4$). The rate of growth of money is assumed to follow the stochastic process

$$\ln\ \mu_t = \rho\ \ln\ \mu_{t-1} +\ (1-\rho)\ \ln\ \overline{\mu}\ +\ \xi_t \tag{6.1}$$

where ξ is a normally distributed i.i.d. mean zero shock with standard deviation $\widetilde{\sigma}$. Following CKM, we calibrate $\overline{\mu} = 1.06^{\frac{1}{4}}$ and $\rho = 0.57$.[31]

Since households can exchange contingent claims, they perfectly insure themselves against fluctuations in income by pooling resources. They will therefore attain the same marginal utility of consumption in every period. Given (5.3), they will enjoy the same level of consumption and real money balances in each period. Moreover, given (5.3), (4.7) implies the following money demand equation

$$\ln\left(\frac{M_t}{P_t}\right) = -\frac{1}{1-\upsilon}\ln\left(\frac{b}{1-b}\right) + \ln C_t - \frac{1}{1-\upsilon}\ln\left(\frac{R_t-1}{R_t}\right) \tag{6.2}$$

[31] Since we are just interested in the persistence properties of the model, we actually focus only on impulse response functions to money shocks. Hence, the standard deviation of the rate of growth of money process does not play any role. In addition, in what follows, we calibrate the model as closely as possible to CKM to allow for a comparison with their results.

which is identical to equation (43) in CKM. Following CKM, we use Mankiw and Summers' [1986] money demand regressions, and set $\nu = -17.52$ and $b = 0.73$.

The parameter e determines the intertemporal elasticity of labour supply ($1/\eta_L = 1/(e-1)$). Macurdy [1981] suggests $e = 4.3$, while Pencavel's [1986] estimations place e between 3.2 and infinity. We calibrate $e = 6$ (which implies a small intertemporal elasticity of substitution of labour supply of 0.2).

For the discount factor we choose the standard value from business cycle literature, i.e. $\beta = 0.96^{\frac{1}{4}}$. We interpret our production function as a short-run production function where the level of capital is fixed. Hence, the labour share of output, i.e. σ, is set equal to 0.67. Following Hairault and Portier [1993], we calibrate $\theta = 6$.[32] Finally we calibrate d such that the number of average aggregate hours of work in steady state is equal to 1/3 and α, which is just a scaling factor, such that aggregate output is equal to one.

6.2. Calibration of the Relative Wage Concern Parameters

Crucial for the analysis are the values of the parameters of the relative wage concern argument in the utility function, i.e. ϕ and τ. To our knowledge, there are no microestimates in the labour literature for these parameters. We thus proceed as follows.

Traditional staggered wage models (as Taylor [1980a], CKM or Ascari [1997]) impose $\Lambda = 0$. The empirical evidence reviewed in section 2.3 instead suggests that wage setting behaviour is better characterized by strong following behaviour and almost pure relative wage considerations, with the level of own real wage playing a minor role, if any at all. We therefore impose $\Omega = 0$ and employ the estimates in FM to calibrate ϕ and τ. Specifically, from equation (5.6), we use the constraint $\Omega = 0$ to

[32] There is no parameter corresponding to our θ in CKM. Since they use a CES function as technology for producing final goods from intermediate goods, it follows that their CES parameter is a technology parameter which gives the elasticity of substitution in input demand.

pin down ϕ; then use FM's estimate of γ =0.00109 to determine τ. We obtain a value for ϕ of 0.76.[33] However the value of τ implied by the estimate of FM is sky-high, equal to 844!! With $\tau = 844$ the model generates a ridiculous degree of persistence, as Figure 1 shows. The level of output remains below its steady state value for more than 60 periods. FM estimates of γ are however only marginally significant[34] and substantially lower than the results form the empirical literature discussed in section 5.1. Moreover, coming from macrodata, those values actually pick up all the persistence in the output process. There is however another strong evidence we can use to pin down τ, not directly link with the persistence properties of the output process. Blanchflower and Oswald [1994] using microdata from household statistics provide estimates of the effects of unemployment on wages in more than 10 countries, which are consistently around "-0.1". Several other studies provide additional evidence in favour of the so called 'wage curve' corroborating this finding (see e.g., Bratsberg and Turunen [1996], Baltagi and Blien [1998] and reference therein).

We therefore consider as a benchmark case a value of γ equal to 0.1. Thus, the implied value of τ is 10.2. Table I below summarizes the calibration of the model parameters.

Table I: Parameter Values	
Preferences	$\beta = 0.96^{\frac{1}{4}}$; $\theta = 6$; $e = 6$; $\nu = -17.52$; $b = 0.73$; $d = 3.4$
Technology	$\sigma = 0.67$
Money Growth Process	$\overline{\mu} = 1.06^{\frac{1}{4}}$; $\rho = 0.57$
Relative Wage Concern	$\phi = 0.76$; $\tau = 10.2$

Appendix 1 presents some sensitivity analysis with respect to the calibration of the relative wage concern parameters, i.e., ϕ and τ

[33] The steady state of the model imposes an upper bound on the value of ϕ equal to $\overline{\phi} = 0.84$, to avoid negativity of nominal wages.

[34] The t-ratio for their Theoretically Preferable Specification (corresponding to our benchmark case) is 1.54.

6.3. Simulation Results

Figure 2 shows the impulse response functions for output and inflation, following a 1% negative money shock. Output jumps on impact 1.02% below its steady state value. Its adjustment path then mimics the hump-shaped response of output found by Blanchard and Quah [1989], Cochrane [1994] and Cogley and Nason [1995] and persistence both in output and inflation is substantial. Specifically, the effects on output last for 3 years.[35] Our analysis hence suggests that staggered wage setting together with a relative real wage concern can be a powerful mechanism through which monetary shocks are propagated. Workers look for a 'fair' wage relative to the others one and therefore conform to the norm. By determining a following behaviour in wage setting, relative wage concern provides the type of wage stickiness suggested by Keynes. Previous studies may have therefore failed to obtain output persistence after money shocks in a microfounded model with staggering because of their oversimplified modelling of the wage setting decisions.

With respect to the inflation persistence problem, inflation seems sticky apart the initial jump, which is however somewhat artificial. We interpret our stylised production function as a short-run production function where capital is fixed and thus calibrate $\sigma = 0.67$. However this implies $(1-\sigma)/\sigma \simeq 0.5$. Hence, a 10% increase in output automatically leads on impact to a 5% increase in prices.[36] However, factor hoarding and inventory stocks may limit the impact of increased output on prices, leading to nearly constant returns to scale in the short-run, that is, $\sigma \simeq 1$. For illustrative purposes, Figure 3 shows the impulse responses of output and inflation for $\sigma = 1$.[37] Inflation becomes much more sluggish: it

[35] To measure the degree of persistence we take the quarter in which the log-deviation of output from steady state falls and remains thereafter below 0.05% in absolute value.

[36] The log-linearised formula for the price level is $p_t = \left(\frac{1-\sigma}{\sigma}\right) y_t + \sum_{i=0}^{3} q^i x_{t-i}$ where $q^i = \left(\frac{\mu^{i(\varepsilon-1)}}{\sum_{i=0}^{3} \mu^{i(\varepsilon-1)}}\right)$.

[37] In this case, some values of the parameters change: $\tau = 10.67$ (to keep $\gamma = 0.1$), $\phi = 4.2$ (to keep $\Omega = 0$) and $d = 10.74$ (to keep steady-state working hours equal to 1/3). Note that also the upper value on ϕ changes, i.e., $\overline{\phi}$ is now equal to 4.85; the

reaches a negative peak after 5 quarters and then gradually returns to its steady state level. As a result, the shape of the impulse response function for output also changes: after 6 quarters from the shock, the economy would enter a boom which peaks after 8 quarters. This shows how this model, being its log-linearised version similar to FM, can generate strong inflation persistence.

This paper aims to highlight the effects of the omission of relative wage considerations in wage setting on the findings of the recent literature that questions the existence of a contract multiplier. It is then very much important to stress the robustness of our results. The two crucial elements of our approach are the specification of the relative wage argument, RW, and the calibration of the parameters governing the relative wage concern. We present some sensitivity analysis in the appendices. Specifically, Appendix 1 considers alternative values for the key parameters ϕ and τ. Unsurprinsingly the degree of persistence decrease with ϕ and τ. The lower ϕ and τ, the lower the effect of relative wage concern (analytically, the lower Λ in (5.4)). The lower τ, the lower the curvature of the utility function with respect the RW term, the less agents 'follow' in the wage setting process; the lower ϕ, the less the weight of the RW term in the utility function. If $\phi = 0$, there is no relative wage concern at all and we are back to Taylor model, which we know can not generate neither ouput nor inflation peristence. However, a wide range of values of ϕ and τ induces a substantial degree of persistence. Appendix 2 addresses the robustness of our results to the specification of the relative wage argument RW by presenting two alternative cases of the relative real wages the wage-setters are concerned with. In the first case, in each period workers compare the real wage they get, with the real wage workers in the other sectors are paid in that period. In the second case, the comparison is instead based on the real wage workers attain in the period they negotiate the contract. While in the first case the degree of persitsence is somewhat smaller than in our benchmark case, in the second one it is greater. Above all, the appendices show that the persistence results in output and inflation are very robust to the alternatives

value of ϕ above is thus still consistent.

considered in both appendices. Thus, given our results and the empirical evidence in favour of the existence of a relative wage concern, we conclude that this may be the missing piece in the money shocks persistence puzzle.

7. Conclusions

We have reconsidered the presence of a contract multiplier as a potential nominal propagation mechanism in staggered wage economies. Recent research has questioned the existence of such a multiplier because their microfounded staggered wage models have failed to generate persistence of the effects of money shocks on output and inflation persistence. We built a DGE model with staggered wage setting and Keynesian relative real wage concern on the part of the workers. We found that this combination of nominal and real rigidities generates a substantial amount of endogenous stickiness, even with a very inelastic intertemporal elasticity of labour supply. As a result, output and inflation persistence are likely in our framework. Relative wage concern can hence help understanding the apparent inconsistency between the empirical estimates from macro-data and the calibration of the elasticity of wages to output condition (what we called the "γ-puzzle"). While there may not be a simple contract multiplier, it seems there may be a *Keynesian contract multiplier* given by the combination of staggered wages and relative wage concern.

Relative wage concern on the part of the workers is the key feature of the model. The notion of relative wage concern is not new for economists and goes back a long way, at least to J.M. Keynes, and has substantial support from empirical work. Moreover, it was the original motivation behind the interest in staggered wage models. Introducing a relative wage concern in the analysis places our work within the growing economic literature that drops the assumption of methodological individualism to explain some puzzles that standard economic framework has trouble with. The explicit account of relative wage concern allows us to provide clear analytical insights of its effects and rely on a key parameter to assess the importance of its omission for the quantitative results of Chari *et al.* [1996]. Our analysis can be seen as a first step towards a deeper understanding of the effect of relative wage concern on the monetary propagation mechanism. Further microfoundations of relative wage concern and exploration of this hypothesis are desirable, given the robustness of our results.

Appendix 1. Alternative Calibration of the Relative Wage

Concern Parameters

We provide here some sensitivity analysis of the two key parameters ϕ and τ. Our aim is to show that the results do not critically depend on the specific calibration of these parameters, but are mainly due to the introduction of relative wage considerations in wage setting. This appendix also contributes to highlight the mechanisms at work in the model to generate persistence.

A. Sensitivity of Persistence with respect to τ.

Figures $4, 5$ and 6 show the impulse response functions for values of τ of 31.63, 19.38 and 5.59, corresponding to values of γ of 0.03, 0.05 and 0.2 respectively. Unsurprisingly, the degree of output persistence consistently decreases with τ. With $\tau = 31.36$, the effects of money shocks on output die away after 21 quarters, if $\tau = 19.38$ after 4 years and if $\tau = 5.59$ after 9 quarters.

In CKM's model: "*the persistence properties of output are highly nonlinear in γ, so that increasing γ to a small amount above 0.05 reduces persistence sharply. [...] even with values of γ as low as 0.25 output movements are not very persistent.*" (CKM [1996], p. 15). Values of γ higher than 0.25 also decrease persistence in our model. Nevertheless, the perspective changes: even with values of γ as **high** as 0.25, our staggered wage model is still able to generate output persistence. As discussed in section 5.1, empirical estimates put 0.25 among the highest possible values for γ. CKM argue that only values of γ greater than one are compatible with sound microfundations in staggered wage models. On the contrary, our model suggests that traditional staggered wage models omit fundamental features of the wage setting. Once relative wage concern considerations are embedded into the analysis, we show in section 5.2 that they may solve the data inconsistency of microfounded staggered wage models with respect to the calibration of γ. We further investigate the relationship between γ and the key parameter τ. Figure

7 shows the trade-off between the values of γ and τ. This relationship is highly non-linear and it implies that fairly small departures from our conservative parameter choices can increase persistence sharply.

Inflation persistence is, on the other hand, very little sensitive to changes in τ. The effects of money shocks on inflation die away in all cases after 10/12 quarters, as it is in the base case.

B. Sensitivity of Persistence with respect to ϕ

In the previous section, we set $\Omega = 0$ in our wage setting rule and calibrated ϕ to be 0.76. Empirical evidence reviewed in section 2.3 points to this case as the most relevant one. However, our money-wage setting equation (5.4) incorporates two elements: (i) the absolute real wage concern (weighted by Ω); (ii) the relative wage concern (weighted by Λ). In this section we analyse the implications of both relative wage and level of own real wage considerations for wage setting decisions.

Recall that equation (5.4) can be written as (5.6). We consider two alternative cases. In the first case $\Lambda = 3\Omega$. The parameter on the indexes of real wages in the other sectors ($\sum_{i=0}^{3} E_t v_{t+i}$) in equation (5.6) above is equal 3/4. Thus, there is no more one-to-one following behaviour: a 10% increase in the sum of the future indexes of real contract prices leads to a 7.5% in the current contract price, CP. The implied value for ϕ in this case is 0.62.[38] Output and inflation persistence decrease to 9 quarters (see Figure 8). In the second case we set $\Lambda = \Omega$. There is then equal weighting of absolute and relative real wage considerations in wage setting. It follows that a 10% increase in the sum of the future indexes of real contract prices leads only to a 5% in the contract price, CP. The implied value for ϕ in this case is extremely low and equal to 0.2.[39] Persistence in both inflation (2 years) and output (7 quarters)

[38] d is the weight of the labour supply term and ϕ that of the relative wage concern in the utility function. d is calibrated to produce an average level of hours worked in the economy equal to 1/3, as standard in this literature. For the benchmark case $\phi = 0.76$, $d = 3.4$. Note however that as ϕ decreases, then d has to increase to maintain the average aggregate labour hours at 1/3. Specifically, d in this case becomes 10.77. This tends to make more costly any marginal increase in the supply of labour.

[39] The implied value of d is 32.7!!

decreases further (see Figure 9).

Both output and inflation persistence therefore decrease with ϕ. The intuition is simple. If $\Omega = 0$ wage setting is mainly influenced by relative wage considerations and persistence is then likely. On the other hand, as Ω increases, we go back to Taylor's model, which we already know cannot generate neither output nor inflation persistence.

Appendix 2. Alternative Specifications of the Relative Wage

We consider here two additional definitions of the value of a contract and hence of RW. We also drop the distinction between the indexes s and t introduced in the main text for explanatory purposes. For we highlight the differences on the RW_t^j faced by the union j arising in these two cases, we also drop the superscript j.

Case A: *Current Value Relative Real Wage Concern*

In this case agents compare the real wage they earn in period t with the average of the real wages earned by the other workers *in period* t. Then all the nominal wages are deflated by the same price index P_t. It follows that the price level cancels out in the definition of RW_t and we are left only with nominal wages. Hence, in every period the wage-setters behave as comparing their "money wage" with the average "money wages" in the *other* sectors,

$$CP_t = X_t \; ; \quad RW_t = \frac{X_t}{(1/3)(X_{t-3} + X_{t-2} + X_{t-1})} \quad .$$

Case B*: Simplified Relative Real Wage Concern*

In this case workers care about the relative real wage unions manage to attain at the negotiation table. CP is therefore defined as the money wage deflated only by the aggregate price level in the period the wage was negotiated, that is[40]

[40] Suppose a union negotiates in period t and succeeds to get a real wage X_t/P_t in period t. Then, in the next period, i.e. $t+1$, another union will negotiate a new wage. This union does not want to leave the negotiation table with a real wage for that period lower than the one negotiated last period by the previous union. In other words, the real wage the unions obtain in the negotiation is seen by the members as a sign of their bargaining power. This approach to the wage bargaining process implies a degree of myopic behaviour from the union since the wage contract lasts four periods. Even if theoretically unsatisfactory, this behavioural hypothesis: (i) could be interpreted as a simplified case of the one considered in the main text (ii) indeed it corresponds to the simplified case considered by FM; (iii) it is probably not far from actual unions' behaviour.

$$CP_t = \frac{X_t}{P_t} \ ; \quad RW_t = \frac{X_t/P_t}{(1/3)\left(\frac{X_{t-3}}{P_{t-3}} + \frac{X_{t-2}}{P_{t-2}} + \frac{X_{t-1}}{P_{t-1}}\right)} \quad .$$

To sum up, in Case A workers compare their real wage period by period, in Case B they compare the real wage they manage to attain at the time they negotiated. In the case presented in the main text, our benchmark case, they instead compare their real wage over the whole life of the contract.

Figures 10 and 11 present the impulse responses to a 1% money shock for these two additional cases. Case A (the Current Value Real Wage Concern) exhibits the lowest degree of output persistence equal to 11 quarters. Persistence increases to 18 quarters in Case B (the Simplified Relative Real Wage Concern)[41], above that of our benchmark case. There is an intuitive reason for those differences. Case A implies the lowest order of dynamics in the model, since the price level is absent from CP. The degree of agents backward-lookingness is the same as their forward-lookingness, but both these degrees are limited with respect to the two other cases. That is, substituting the definitions of CP and the equation for the price level in equation (5.4), the highest lagged nominal wage term is x_{t-3}, while the highest lead nominal wage term is x_{t+3}. The dynamics instead goes from x_{t-6} to x_{t+3} in Case B in this appendix and from x_{t-6} to x_{t+6} in the theoretically preferable case presented in the main text.[42] In fact, in the Simplified Relative Real Wage Concern case, the price level enters the specification of CP and hence, since V_t includes CP_{t-3}, X_{t-6} enters equation (5.4). However, since future prices do not enter the specification of CP_t, V_{t+3} brings in only p_{t+3} and hence x_{t+3}. In the theoretically preferable case, instead, agents are less myopic and CP includes future prices through $\overline{p}$. Then, it follows that v_{t+3} depends on $\overline{p}_{t+3}$ and hence x_{t+6}. To sum up, in Case A agents basically care about their relative *nominal* wages over the length of the contract and

[41] After ten quarters, output actually falls below the steady state value.

[42] The same holds if we express (5.4) in terms of inflation, because we get: $\Psi(\pi_{t-3}, ..., \pi_{t+3}, \widetilde{y}_t) = 0$ in case A; $\Psi(\pi_{t-6}, ..., \pi_{t+3}, \widetilde{y}_t) = 0$ in case B and $\Psi(\pi_{t-6}, ..., \pi_{t+6}, \widetilde{y}_t) = 0$ in our benchmark case in the main text.

hence the order of the dynamics is limited with respect to the other two cases, since the price level does not enter CP. In Case B agents are only concerned about the real wage attained in the negotiation period and hence they myopically look backward more than they look forward. Finally, in our benchmark case in the main text, agents compare relative real wages over the whole length of the contract and hence look backward the same degree they look forward. This implies a higher degree of inertia in Case B with respect to our benchmark one and hence an higher degree of persistence, as shown in the figures.[43]

Given these results, we conclude that both ouput and inflation persistence are robust to alternative specifications of the relative wage concern term.

[43] Higher dynamics do not necessarily imply higher persistence. It mainly depends on the relative weights on backward *vs* forward looking variables. Hence, it seems that the relative weight of backward and forward looking variables is not the same in the three models. This suggests that the different specifications do not simply spread the same relative weights over higher order dynamics.

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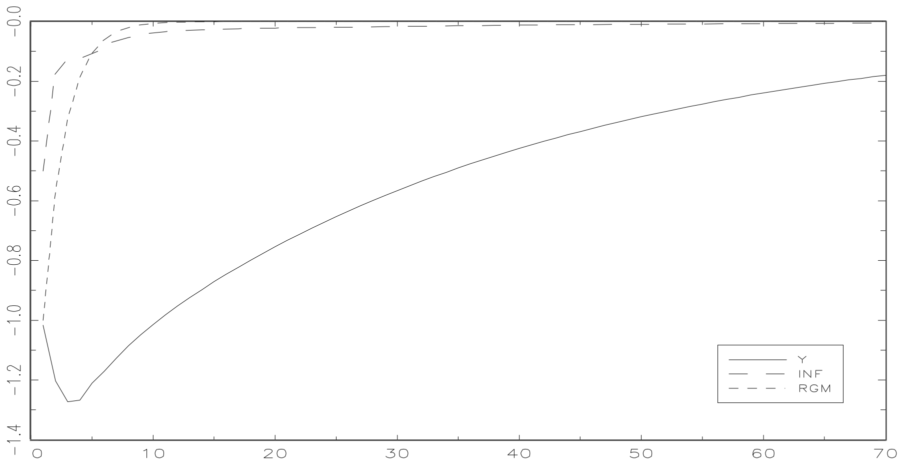

Figure 1: *Benchmark Case, 1% Money Shock: Output and Inflation.*
$\tau = 843.9689$, $\phi = 0.7588$

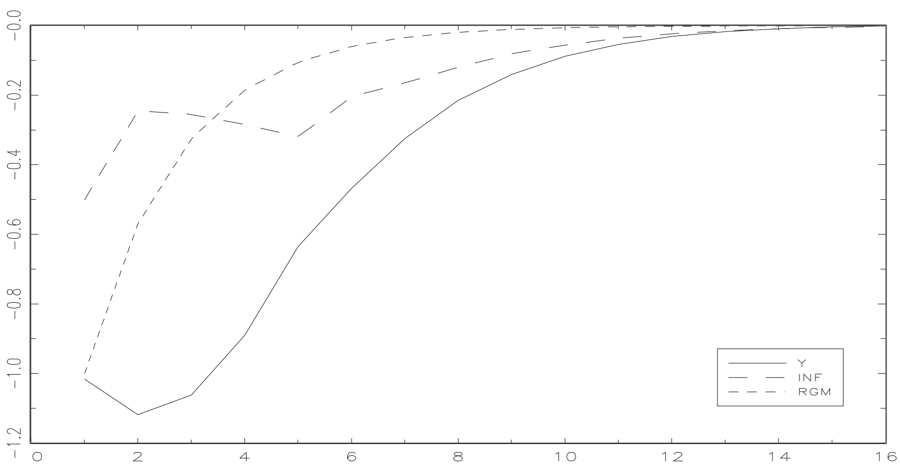

Figure 2: *Benchmark Case, 1% Money Shock: Output and Inflation.*
$\tau = 10.1884$, $\phi = 0.7588$

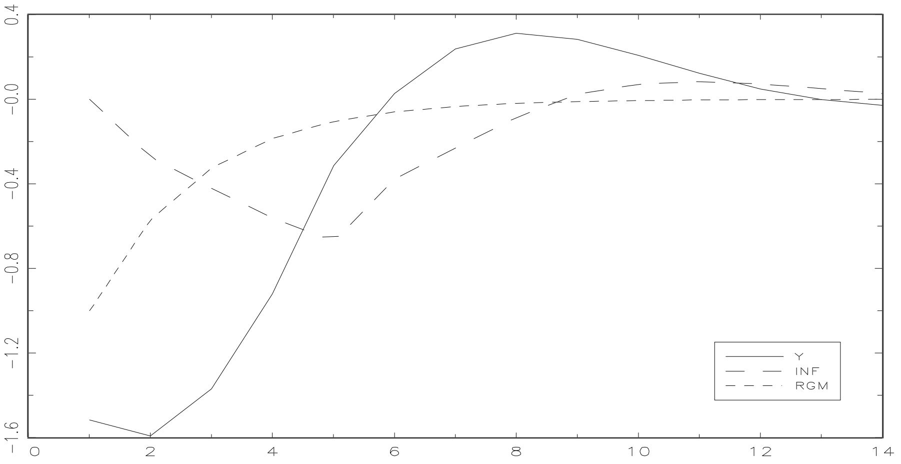

Figure 3: *Benchmark Case, 1% Money Shock: Output and Inflation.*
$\sigma = 1$, $\tau = 10.7$, $\phi = 4.2$, $d = 10.7$

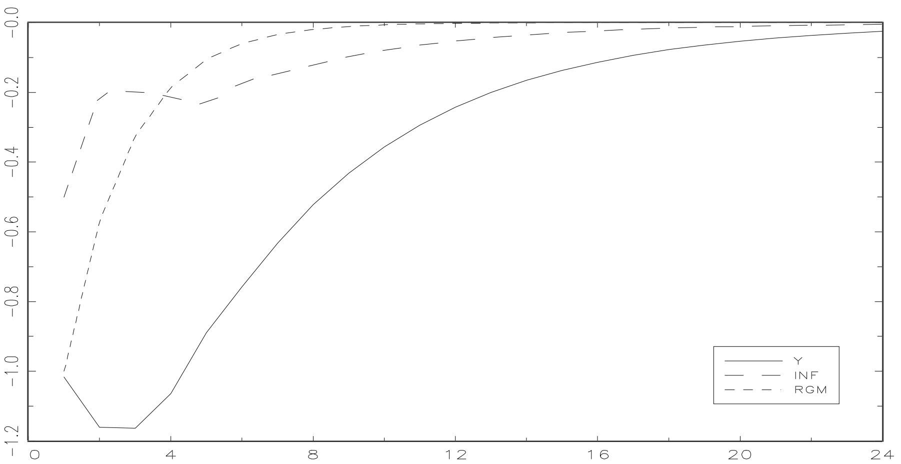

Figure 4: *Benchmark Case, 1% Money Shock: Output and Inflation.*
$\tau = 31.6279$, $\phi = 0.7588$

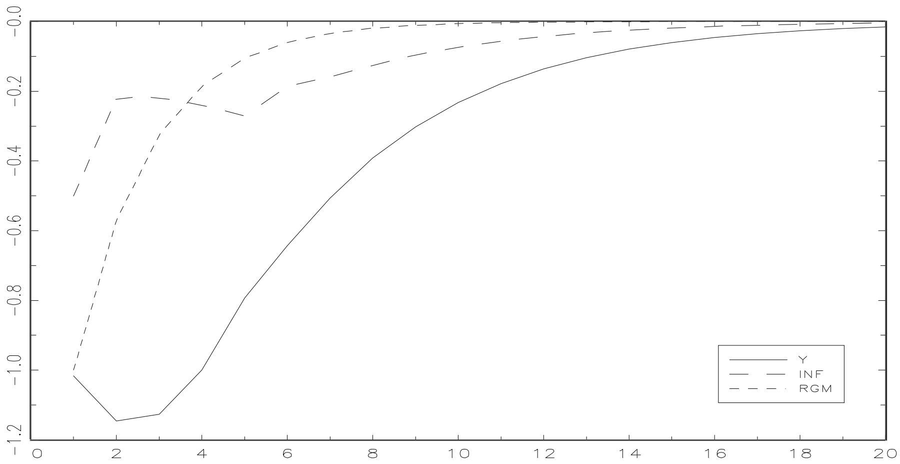

Figure 5: *Benchmark Case, 1% Money Shock: Output and Inflation.*
$\tau = 19.3767$, $\phi = 0.7588$

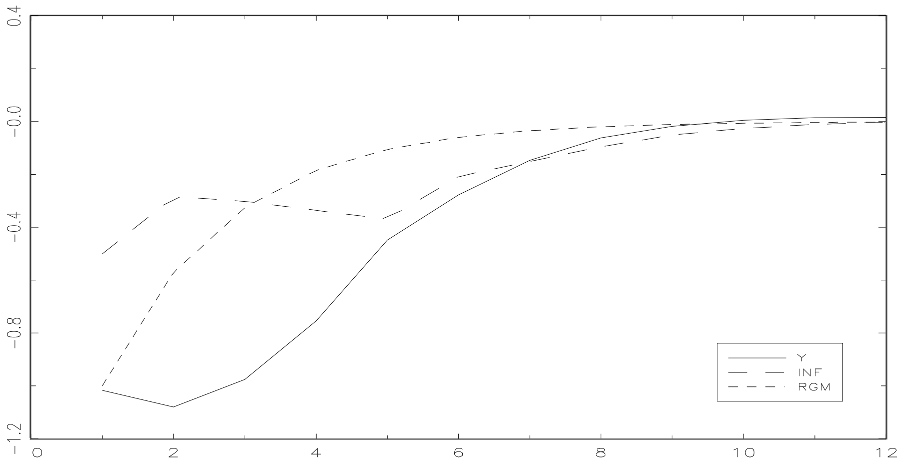

Figure 6: *Benchmark Case, 1% Money Shock: Output and Inflation.*
$\tau = 5.5942$, $\phi = 0.7588$

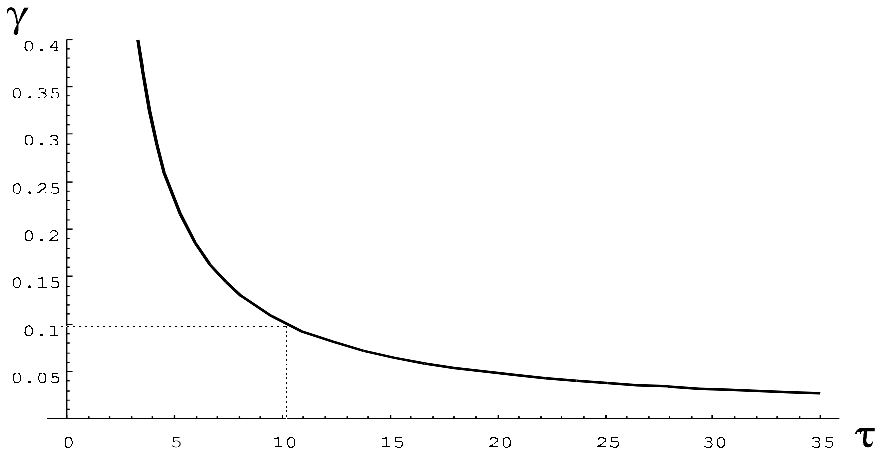

Figure 7: *Benchmark Case: γ and τ Trade-off*

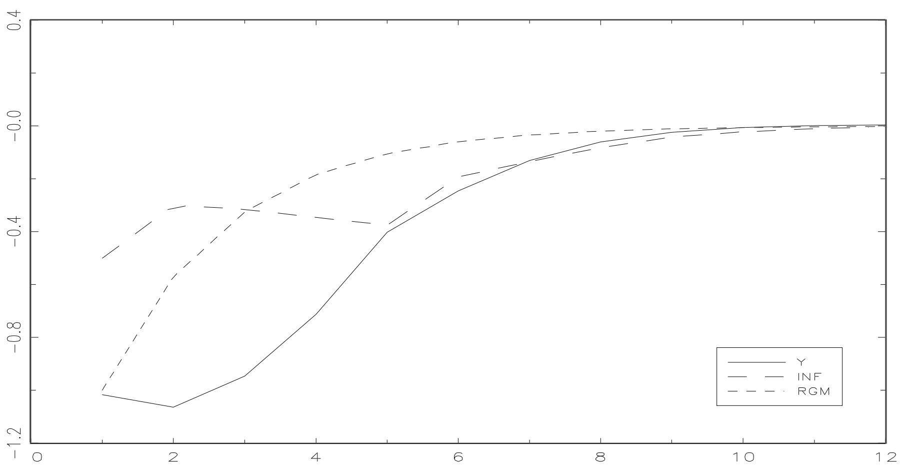

Figure 8: *Benchmark Case, 1% Money Shock: Output and Inflation.*
$\tau = 10.1884$, $\phi = 0.6192$

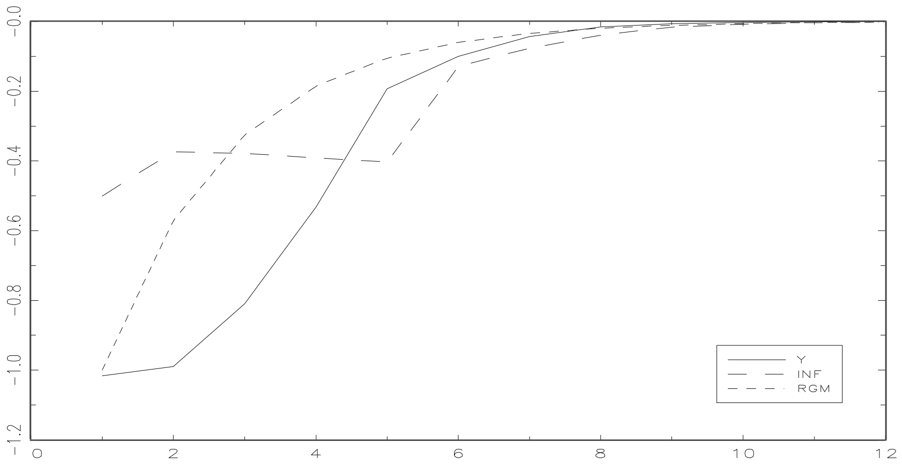

Figure 9: *Benchmark Case, 1% Money Shock: Output and Inflation.*
$\tau = 10.1884$, $\phi = 0.2032$

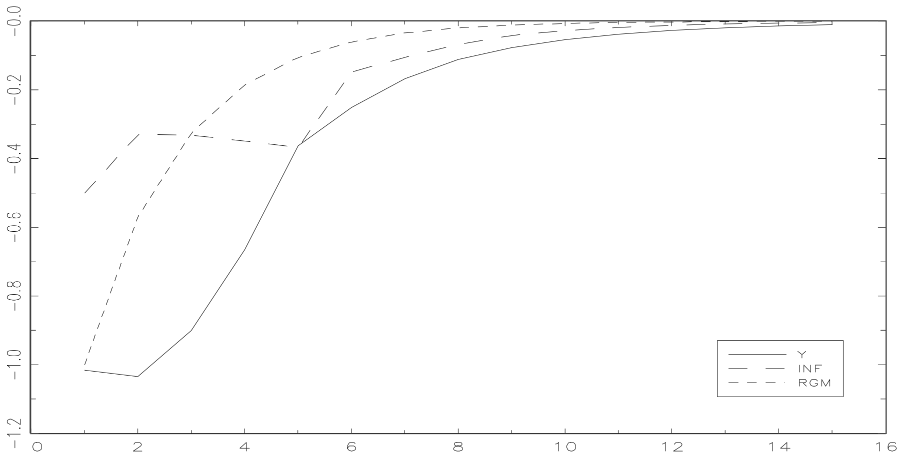

Figure 10: *Current Value Relative Wage Concern, 1% Money Shock: Output and Inflation.*
$\tau = 10.1884$, $\phi = 0.7588$

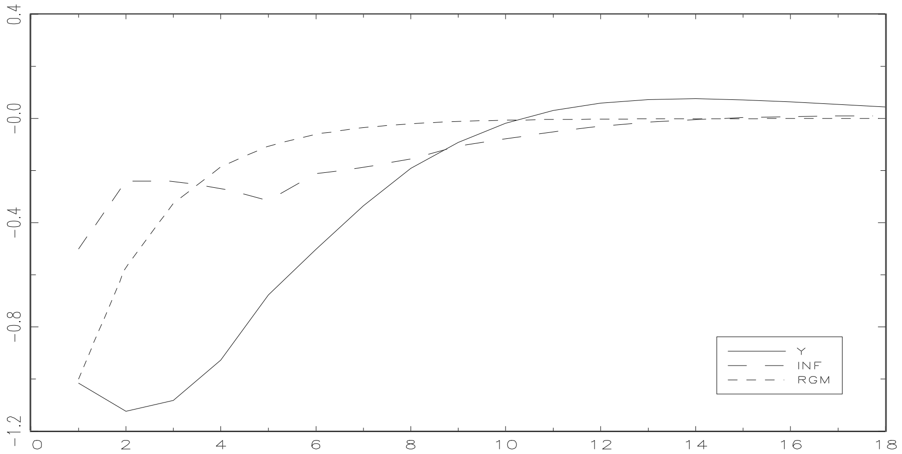

Figure 11: *Simplified Relative Real Wage Concern, 1% Money Shock: Output and Inflation.*
$\tau = 10.1884$, $\phi = 0.7588$