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INCOMPLETE CAPITAL MARKETS, WAGE FORMATION AND STABILIZATION POLICY

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Abstract

The future purchasing power of wage income may become risky in the presence of capital market imperfections. Current nominal wages therefore have intertemporal implications which in turn affect wage determination. The influence of consumption risk on wage setting is analysed in a general equilibrium model with an imperfectly competitive labour market (monopoly union). It is shown that the adjustment process implies wage smoothing and nominal rigidities. Nominal wages are less flexible than prices and there is more persistency in wage than in price adjustment. Moreover employment shows more variability over the business cycle than real wages no matter whether the cycle is driven by supply or demand shocks. An active demand management policy is shown to affect risk and, therefore, real allocations and to be potentially Pareto improving.

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1. Introduction

The way in which the labour market works remains central for an understanding of business cycle phenomena. New Keynesian models stress different types of labour market imperfections causing a level of unemployment which is inefficiently high from a social point of view. Real Business Cycle models claim that observed fluctuations can be accounted for as the optimal response to real shocks impinging on the economy leaving no need for policy intervention. However, real business cycle models have great difficulties in accounting for the observed behaviour of wages and employment over the business cycle (see Stadler (1994) for an overview and evaluation). This seem to give credence to New Keynesian models, but do they fare better in explaining these facts?

A large part of the so-called New Keynesian literature focuses on imperfections arising from the fact that the supply side in the labour market is organized in unions possessing market power (see e.g. Moene and Wallerstein (1993)). It is not, however, clear that the formal models of union behaviour help explain central business cycle facts as the models tend to be static in nature.[1] Hence these models do not have interesting dynamic implications, although they explain why the economy may have steady state equilibria with inefficiently high unemployment. It is therefore an open question whether models with imperfections in the labour market can explain stylized facts like the employment variability puzzle (employment highly procyclical, real wages acyclical) and less wage than price variability over the cycle.[2]

The present paper takes a step towards rectifying this problem by considering wage setting in an explicit intertemporal context. In this setting capital markets come to play a central role and the focus is on a situation were capital markets do not allow workers to fully diversify

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[1] One exception is the insider-outsider model but although it explains persistency in employment, it also predicts larger real wage variability than variability in employment contrary to stylized facts.

[2] See, however, Bénassy, (1994) and Hairault and Portier (1993) for an analysis of the implications of nominal rigidities.

away the purchasing power risk of their wage income.[3] This implies that wage setting by unions is influenced by this risk and therefore intertemporal issues come to influence wage setting. Intertemporal substitution also plays a central role in RBC models, since intertemporal substitution in the supply of labour is the mechanism accounting for employment fluctuations over the business cycle. This channel of intertemporal substitution is by most taken to be weak among other things because it presumes a capital market allowing borrowing against human capital. This is ruled out in the present context. Rather capital market imperfections cause intertemporal substitution to play a role in wage setting because it makes the real consumption value of labour income risky.

The pre-setting of wages for one or several periods is a route by which to introduce dynamics in wage adjustment, in particular if wage contracts are assumed to be asynchronized (see e.g. Phelps (1978), Taylor (1979) and Blanchard (1983)). Although some progress has been made in accounting for nominal wage rigidity (non-fully indexed wages, see Gottfries (1992) and Holden (1994)) and asynchronization (see Fethke and Policano (1986)), the present analysis shows how wage inertia can arise even if there are no restraints on wage adjustment within the period. The mechanism is simply that current wages have consequences both for the present and for the future. In the presence of capital market imperfections, this is sufficient to account for different responses to temporary and permanent shocks implying wage smoothing over the business cycle.

Finding a rationale for adjustment failures and thus a propagation mechanism inducing business cycle fluctuations raises the question of whether there is a role for an active stabilization policy. It is shown that a systematic demand management policy is not only effective as a stabilizer towards supply shocks, but since it may reduce risk, it is potentially welfare improving in mitigating some of the consequences of market imperfections.

[3] Diversification of risk plays also a central role in the so-called implicit contract models, see e.g. Rosen (1985). The present model differs in focusing on the intertemporal aspects rather than on the design of ex ante optimal contingent contracts. Hence, contract contingencies in the labour market is precluded by the OLG-structure. Moreover, the basic argument given here for nominal rigidities does not rely on risk aversion.

To account properly for the interrelationship between wage setting and risk, we need a general equilibrium model. To this end an overlapping generations model without capital accumulation is used since it allows us to focus on the implications of wage smoothing without mixing it up with other propagation mechanisms. Clearly this has the cost that the model in some respects becomes very stylized, and therefore it cannot claim to provide a full characterization of how shocks are propagated over the business cycle. In the same vein specific functional forms are employed to find closed form solutions for wages and prices to see clearly how the adjustment process works. The labour market has imperfect competition[4] captured in the form of a monopoly union causing unemployment which represents an inefficiency from a social welfare point of view.[5]

The paper is organized such that section 2 first clarifies the role of capital market imperfections in intertemporal models of wage determination. Section 3 develops an overlapping generations model with imperfect competition in the labour market. Temporary equilibrium is found in section 4, and the implications of supply and demand shocks for wages, prices and employment are analysed in section 5. Section 6 considers how imperfections in information may affect the adjustment process. Finally, section 7 offers a few concluding remarks.

2. Wage Setting and Capital Market Imperfections

The standard approach to imperfectly competitive labour markets takes the utility function of workers to depend only on the real wage (and eventually the disutility of work) (see e.g. Blanchard and Fischer (1989 ch. 9)). Although unproblematic in a static model, the question is whether this procedure is also admissible in an intertemporal context. This requires that the current real wage fully characterizes the consumption possibilities of the current wage.

[4] It can readily be shown that the basic wage smoothing result does not rely on this specific way of modelling the labour market. This specific model has the advantage that it is easily tractable, well-known and consistent with unemployment. Andersen and Christensen (1996) consider a competitive labour market version of the model.

[5] The importance of risk sharing for labour market adjustment is considered by Danthine and Donaldson (1990, 1991) in an efficiency wage model. However, intertemporal considerations do not directly influence wage determination.

To address this question, consider an overlapping generations model where agents live for two periods.[6] Workers supply labour as young to finance consumption when young and old. Labour is supplied inelastically. Full current information is assumed such that risk only pertains to future consumption possibilities. Specifically assume that the expected utility of a worker can be written

$$E\left[U(c_{1t}, c_{2t+1}) | \psi_t\right] \qquad U_c' > 0 \qquad U_{cc}'' < 0$$

where c_{1t} is consumption while young in period t, c_{2t+1} is consumption while old in period t+1, and ψ_t the information set.

The intertemporal budget constraint reads

$$P_t c_{1t} + \frac{1}{1 + r_t(z_{t+1})} P_{t+1} c_{2t+1} = W_t$$

where P is the output price, W is the wage rate, and r is the rate of return on savings which possibly is contingent on period t+1 conditions (z_{t+1}).

Inserting the budget constraint in the objective function, we get

$$E\left[U\left(c_{1t}, \frac{(1 + r_t(z_{t+1}))(W_t - P_t c_{1t})}{P_{t+1}}\right) | \psi_t\right] \tag{1}$$

Suppose that the capital market is perfect in the sense that there exists an asset which offers a deterministic real rate of return i, i.e.

$$(1 + r_t(z_{t+1}))\frac{P_t}{P_{t+1}} = 1 + i_t$$

In which case the current real wage (W_t/P_t) and the real rate of return (i_t) fully characterize the implications of the wage for the consumption possibilities and therefore utility of the household, i.e.

[6] The argument is easily generalized to alow for a larger horizon and wage income in more than the first period.

$$V\left(\frac{W_t}{P_t}, i_t\right) = \underset{c_{1t}}{\mathrm{Max}}\, E\left[U\left(c_{1t}, (1 + i_t)\left(\frac{W_t}{P_t} - c_{1t}\right)\right) | \psi_t\right] \tag{2}$$

This expression summarizes the expected utility of workers in terms of an indirect utility function increasing in the period t real wage rate. Separation holds in the sense that intertemporal allocation and risks are immaterial for wage setting. The current real wage fully summarizes all relevant information.[7] A real wage target implies that the adjustment of the nominal wage has to be symmetric to the adjustment of the nominal price and this rules out that nominal shocks could affect the real wage and thereby employment. Money would be neutral leaving no role for nominal shocks as a source of business cycle fluctuations or demand management policy as a potential stabilizer.

Capital market imperfections make the assumption of full access to an asset with a deterministic real return a dubious assumption. Therefore, the current real wage does not fully characterize the future consumption value of labour income. As a consequence, a different response of nominal wags and price becomes possible, and monetary shocks may be non-neutral. It is therefore of interest to analyse how wage and price adjustment is affected by capital market imperfections and to investigate whether this can produce nominal rigidities in a fully specified intertemporal general equilibrium model.

3. Incomplete Capital Markets and Wage Formation

Building on the insight that capital market imperfections cause the consumption value of wages to depend on both current and future prices, this section develops a general equilibrium model in which to analyse the interaction between wage-setting and consumption. The model is a standard Samuelson OLG model allowing for variable employment and production.

[7] This assumption is made explicitly or implicitly in dynamic models with imperfectly competitive labour markets as in e.g. Jensen et al. (1994) and Langot (1994).

Households

Consider an economy with a given (and constant) population. Households are born as either capitalists or workers. The capitalists have access to the profit income generated by firms and do not work, while workers have to supply labour to finance consumption. Labour is supplied inelastically by young workers and young capitalist inherit firms. All households live for two periods. Households have preferences over consumption given by

$$E\left[c_{1t}c_{2t+1}^{\frac{1}{1+\theta}}|\psi_t\right]$$

where θ is the subjective time-preference rate, $c_{1t}(c_{2t+1})$ is consumption while young and old in period t and t+1, respectively, and ψ_t is the information available to the agent in period t, and it will be specified explicitly when shocks are introduced[8]. Throughout it is assumed that there is full current information, that is, the information problem only relates to the future.

The fact that labour is supplied inelastically ensures that employment would be constant if the labour market is perfectly competitive. Accordingly, employment variations arises here due to the interplay between the market power of the union and capital market imperfections.

The simplest way to model capital market imperfections precluding access to assets offering a deterministic real rate of return is to assume that non-interest bearing money is the only financial asset.[9] The intertemporal budget constraint therefore reads

$$P_t c_{1t} + P_{t+1} c_{2t+1} = I_t$$

where P_t is the output price in period t and I_t is nominal income. Saving takes place in money demanded by young equal to $M_t = I_t - P_t c_{1t}$ and old households finance consumption by their money holdings $P_{t+1}c_{2t+1} = M_t$.

[8] It is worth pointing out that the special case $\theta = 0$ corresponds to the case where the objective and subjective discount rates are equal.

[9] The particular OLG structure here precludes borrowing against future human capital, and therefore rules out the mechanism yielding intertemporal substitution in labour supply in real business cycle models.

The optimal consumption plan implies the following aggregate demand functions

$$c_{1t} = \frac{1+\theta}{2+\theta}\frac{I_t}{P_t}$$

$$c_{2t+1} = \frac{1}{2+\theta}\frac{I_t}{P_{t+1}}$$

It is noted that aggregate nominal income is given by

$$I_t = \pi_t + w_t l_t = P_t y_t$$

where y_t is period t output.

Expected utility for an individual h can be expressed in terms of the following indirect utility function

$$V \equiv k\left(I_t^h\right)^{\frac{2+\theta}{1+\theta}} P_t^{-1} E\left(P_{t+1}^{\frac{-1}{1+\theta}}|\psi_t\right)$$

where

$$k \equiv \frac{1+\theta}{2+\theta}\left(\frac{1}{2+\theta}\right)^{\frac{1}{1+\theta}}$$

As is well-known, the Cobb-Douglas specification of the utility function implies that the savings decision is independent of the real rate of return since substitution and income effects cancel out. Although a special case, it is convenient in the present case since the focus is on the implication of consumption risk for the adjustment process rather than for the steady state level of unemployment.[10]

Public Sector

It is assumed that there in any period t is an exogenously given level of public real demand g_t financed by money issuance, i.e.

[10] The importance of risk for union wage setting is analysed in e.g. Andersen and Sørensen (1988), Naish (1988).

$$P_t g_t = \Delta M_t$$

and $M_t = M_{t-1} + \Delta M_t$. The public demand is assumed not to affect private utility (pure waste) to focus on its pure demand effects. In the present setting it is thus not possible to distinguish between monetary and fiscal policy.

Firms

Firms produce output subject to a traditional decreasing returns technology given by

$$y_t = u_t (n_t)^{\alpha} \qquad 0 < \alpha < 1$$

where u is a random variable reflecting technology shocks and n is employment. Firms are wage- and price-takers and maximizing profits[11)], the demand for labour can be written $\left(\eta \equiv (\alpha - 1)^{-1} < -\frac{2+\theta}{1+\theta}\right)$

$$n_t = \left(\frac{1}{\alpha u_t} \frac{W_t}{P_t}\right)^{\eta} \tag{3}$$

implying an output supply function given by ($\beta_0 = -\ln\alpha$, $\beta_1 = (\alpha-2)\eta$, $\beta_2 \equiv -\alpha\eta < 1$)

$$y_t = \beta_0 u_t^{\beta_1} \left(\frac{P_t}{W_t}\right)^{\beta_2} \tag{4}$$

Wage-Setting

Workers are organised in a union which has the power to set nominal wages given the labour demand function (3). The union aims at maximizing expected utility for its members given by

$$\frac{n_t}{H} V_t + \frac{H - n_t}{H} \bar{V} \tag{5}$$

where $\bar{V}$ is the exogenous and constant utility level of unemployed and

[11)] Using the utility function and the assumption that the firm is price-/wage-taker implies that the optimal activity level is the one maximizing nominal profits. Still capitalists are affected by risk but the available set of markets does not allow them to diversify away the risk.

$$V_t = k W_t^{\frac{2+\theta}{1+\theta}} P_t^{-1} E\left(P_{t+1}^{\frac{-1}{1+\theta}} \middle| \psi_t\right)$$

Finding the nominal wage maximizing (5) yields the following first order condition

$$V_t = \frac{\eta}{\eta + \frac{2+\theta}{1+\theta}} \bar{V} \equiv \phi \tag{6}$$

saying that the wage is set such that the expected utility of employed workers is a mark-up on the utility of unemployed workers. This is a standard result in the case of a utilitarian monopoly union and a constant labour demand elasticity, cf. McDonald and Solow (1981). The non-standard aspect is the fact that the utility of employed workers depends not only on the current period consumption real wage, but the "lifetime" real consumption wage. In appendix A it is shown that the same qualitative results are obtained if there is an unemployment insurance system financed by contributions levied on employed workers.

Assuming that period t+1 prices are log-normally distributed (cf. below), the nominal wage rule can be expressed as[12)]

$$\ln W_t = \omega + \gamma \ln P_t + (1 - \gamma) E\left(\ln P_{t+1} \middle| \psi_t\right) \tag{7}$$

where

$$\omega \equiv \frac{1+\theta}{2+\theta}\left(\ln\frac{\phi}{k} + \frac{1}{2}\left(\frac{1}{1+\theta}\right)^2 \mathrm{Var}\left(\ln P_{t+1} \middle| \psi_t\right)\right)$$

$$\gamma \equiv \frac{1+\theta}{2+\theta} \le 1$$

It follows that risk reinforces the imperfections caused by union power in raising the wage target ω of the union. The higher the wage target, the larger the deviation between the margi-

[12)] Using that $\ln E(x_{t+1}^{a}|I_t) = aE(\ln x_{t+1}|I_t) + a^2/2 \ \mathrm{Var}(\ln x_{t+1}|I_t)$ if x_{t+1} is log-normally distributed, cf. Aitchinson and Brown (1957).

nal product of labour and the marginal rate of substitution between work and consumption, i.e. there is an inefficiency in production (cf. e.g. Bénassy (1991)).

This wage equation shows how intertemporal considerations affect wage setting since period t wages depend on both period t and t+1 output prices (for $\gamma < 1$). The wage-price spiral thus gets an intertemporal dimension and the lower the subjective discount rate, the lower γ and hence current prices have less importance relative to expected future prices for wage-setting. It is immediately clear that (7) implies wage smoothing in the sense that wages react less strongly to temporary than to permanent changes in prices. The intuition underlying consumption smoothing in intertemporal consumption models thus carries over to the present model of wage setting. This is interesting since it implies that the strategic complementarity between wages and prices (higher prices leading to higher wages) gets an intertemporal dimension.

4. Temporary Equilibrium

The equilibrium for given expectations is easily found as the equilibrium condition for the output market can be expressed in terms of the equilibrium condition for the money market, i.e.[13)]

$$P_t y_t - P_t c_{1t} = M_t$$

where y_t is determined by (4) and total period t consumption by young is given by

$$c_{1t} = \frac{1+\theta}{2+\theta}\frac{P_t y_t}{P_t} = \frac{1+\theta}{2+\theta} y_t$$

the equilibrium condition can thus be written[14)]

$$\frac{1}{2+\theta} y_t = \frac{M_t}{P_t}$$

implying that the period t equilibrium price becomes

[13)] Since $M_{t-1} = P_t c_{2t}$ implying that $y_t = c_{1t} + c_{2t} + g_t$.

[14)] It is easily verified that the model has a unique stationary equilibrium where $\bar{p} = M\bar{y}$ and $\bar{y}$ is the output level.

$$\ln P_t = \delta_0 + \delta_1 \ln u_t + \delta_2 \ln M_t + (1-\delta_2) E(\ln P_{t+1} | \psi_t) \qquad (8)$$

where

$$\delta_2 = (\beta_2(1-\gamma)+1)^{-1} < 1$$

$$\delta_0 = -\delta_2 \left(\ln\left(\frac{\beta_0}{2+\theta}\right) - \beta_2 \omega \right)$$

$$\delta_1 = -\delta_2 \beta_1$$

The dynamics in the equilibrium price is seen to arise from the fact that wage-setting depends on intertemporal considerations. If intertemporal considerations do not affect wages formation ($\gamma = 1$), there is no dynamics in equilibrium prices ($\delta_2 = 1$). The more current wages depend on future prices (γ lower), the less the current prices are influenced by the current money supply and the more by future prices (δ_2 lower). It follows that the model has been specified such that wage formation is the only propagation mechanism, hence the dynamics of the model is solely driven by the implications of intertemporal consumption risk for wage formation.

Given the equilibrium price (8), wages are determined from (7) and equilibrium output and employment functions from (3) and (6). All of this is for given expectations. Expectations formation will be introduced alongside the shocks and to show that the results do not rely on misperceptions, the model will be solved assuming model consistent (rational) expectations.

5. Dynamics

This section works out the dynamics of wages, prices and employment to real and nominal shocks.

Supply Shocks

To focus on the adjustment to productivity shocks, assume a constant money supply ($\ln M_t = 0$). The real shock variable is assumed to follow a first-order autoregressive process, i.e.

$$\ln u_t = \rho \ln u_{t-1} + \varepsilon_t \qquad |\rho| \leq 1 , \qquad \varepsilon_t \text{ iid } N\left(0,\sigma_\varepsilon^2\right)$$

where $\{\varepsilon_t, \varepsilon_{t-1}, \varepsilon_{t-1} ...\}$ and knowledge of the model belongs to the information set ψ_t.

To find an equilibrium with model consistent expectations, the undetermined coefficients method is used, and the equilibrium price is conjectured to be determined according to

$$\ln P_t = \pi_0 + \pi_1 \ln u_t \tag{9}$$

This formulation restricts the solution to depend solely on fundamentals thereby ruling out bubble phenomena etc. as a source of multiplicity of equilibria. Although it can readily be shown that there could be such equilibria (see e.g. Blanchard and Fischer (1989)), this type of multiplicity is not essential to the present analysis which focuses on the adjustment process to changes in market fundamentals.

Leading equation (9) one period, the expected period t+1 prices are found to be

$$E\left(\ln P_{t+1} \middle| \psi_t\right) = \pi_0 + \pi_1 \rho \ln u_t$$

Inserting in (8), we find

$$\ln P_t = \delta_0 + \delta_1 \ln u_t + (1 - \delta_2)(\pi_0 + \pi_1 \rho \ln u_t)$$

Hence, an equilibrium of the form (9) exists for

$$\pi_0 = \delta_0 + (1 - \delta_2)\pi_0 = \frac{\delta_0}{\delta_2}$$

$$\pi_1 = \delta_1 + (1 - \delta_2)\pi_1 \rho = \frac{\delta_1}{1 - (1 - \delta_2)\rho} < 0$$

This proves uniqueness of equilibrium within the class of log-linear price functions (9).

The implications of productivity shocks can now be analysed. First, we find that the nominal wage is

$$\ln W_t = \omega + \pi_0 + (\gamma \pi_1 + (1 - \gamma)\pi_1 \rho)\ln u_t$$

and hence the real wage rate can be written

$$\ln W_t - \ln P_t = \eta \omega + \pi_1 (1 - \gamma)(\rho - 1)\ln u_t$$

implying that employment is determined as ($\bar{n} \equiv \eta(\omega - \ln\alpha)$)

$$\ln n_t = \bar{n} + \eta\left[\pi_1 (1 - \gamma)(\rho - 1) - 1\right]\ln u_t$$

The smoothing of wage adjustment has interesting implications for how the real shock is transmitted into the economy. Consider first the responsiveness of the real wage to the productivity shock, i.e.

$$\frac{\partial(\ln W_t - \ln P_t)}{\partial \ln u_t} = \frac{\beta_1 (1 - \gamma)(1 - \rho)}{1 + \beta_2 (1 - \gamma)(1 - \rho)} \geq 0$$

In the case of completely permanent shocks ($\rho = 1$), it is found that the real wage is invariant to the shock. It is well-known from the standard static monopoly union model that real wages are invariant to productivity shocks under a labour demand function with constant wage elasticity, cf. McDonald and Solow (1981)). In a dynamic setting we find that this only holds if the shock is fully persistent ($\rho = 1$), otherwise productive shocks lead to real wage increases. This is also in accordance with empirical evidence from wage equations where productivity is usually found to exert a significant effect on wages (see e.g. Layard, Jackmann and Nickell (1991), and Bean (1993)). The real wage is more sensitive to the productivity shock the smaller ρ, i.e. the less persistent the shocks, the more does the real wage change.

It turns out that the real wage is more sensitive to the productivity shock the stronger the intertemporal linkage in wage setting (i.e. the higher $1 - \gamma$). The reason is that future prices come to influence current wages more and if productivity shocks are not fully persistent ($\rho < 1$), a productivity shock is expected to affect current prices more than future prices and therefore the nominal wage adjusts less and the real wage therefore becomes more sensitive to the productivity shock.

It is an implication that wages are less sensitive to the shock than prices, i.e.

$$\left|\frac{\partial \ln W_t}{\partial \ln u_t}\right| = \left|\pi_1(\gamma + (1-\gamma)\rho)\right| \leq |\pi_1| = \left|\frac{\partial \ln P_t}{\partial \ln u_t}\right| \quad \text{for} \quad \rho \leq 1$$

This accounts for the fact that wages are less variable than prices over the business cycle. Notice that wages can be freely and instantaneously adjusted as can prices and the same information goes into wage and price formation.

A simple reformulation of the employment equation yields

$$\ln n_t = (1-\rho)(\ln\gamma + \eta\omega) + \rho \ln n_{t-1} + \eta\left[\pi_1(1-\gamma)(\rho-1) - 1\right]\varepsilon_t$$

Employment evolves as a first-order autoregression process with a persistency parameter ρ as in the underlying process of the shock. This persistence implies that the employment level and thus the unemployment level slowly reverts to its long run value when the economy is exposed to shocks. The variance of the innovations to employment differs from that of the innovations to the shock. In particular it is noteworthy that the variance of employment innovations depends on the persistency of the shock variable - the more persistent productivity shocks, the more variable is employment.

Finally, it is an implication that the real wage fluctuates less than employment over the cycle, i.e.

$$\mathrm{Var}(\ln W_t - \ln P_t) < \mathrm{Var}(\ln n_t)$$

Demand Shocks

Next we turn to an analysis of demand shocks which is of relevance both for the role nominal shocks may have for business cycle fluctuations and for the effectiveness of demand

management policies. Variations in the money stock are in the present setting generated by changes in government demand. Disregard real shocks ($\ln u_t = 0$) and assume that

$$\ln M_t = \rho \ln M_{t-1} + \varepsilon_t \qquad |\rho| \leq 1, \qquad \varepsilon_t \text{ iid } N(0, \sigma_\varepsilon^2)$$

where $\{\varepsilon_t, \varepsilon_{t-1}, \varepsilon_{t-2} \ldots\}$ belongs to ψ_t.

Following the same solution procedure as in the case of supply shocks, we conjecture a solution for the equilibrium price of the form

$$\ln P_t = \pi_0 + \pi_1 \ln M_t$$

where

$$\pi_0 = \frac{\delta_0}{\delta_2}$$

$$\pi_1 = \frac{\delta_2}{1-(1-\delta_2)\rho}$$

is easily found.

The first result to note is that the nominal price is fully responsive to the nominal shock (π_1=1) implying neutrality of nominal shocks only if either i) nominal shocks are fully persistent (ρ = 1) or ii) agents are myopic (γ = 1). In all other cases there is a nominal price rigidity (π_1 < 1) causing nominal shocks to have real effects. The nominal rigidity does not rely on adjustment costs or lack of information, but arises because it is not in general optimal to raise the nominal wage proportionally to the nominal changes unless the latter is fully persistent or agents do not care about the future.

The nominal wage can be written

$$\ln W_t = (\omega + \pi_0) + (\gamma\pi_1 + (1-\gamma)\pi_1\rho)\ln M_t$$

and the real wage as

$$\ln W_t - \ln P_t = \omega + (1-\gamma)(\rho-1)\pi_1 \rho \ln M_t$$

and employment

$$\ln n_t = \bar{n} + \eta(1-\gamma)(\rho-1)\pi_1 \rho \ln M_t$$

Nominal wages and prices are not equally responsive to nominal shocks except in the case of $\rho = 0$ and $\rho = 1$, and moreover nominal wages are less responsible than nominal prices since

$$\frac{\partial \ln W_t}{\partial \ln M_t} < \frac{\partial \ln P_t}{\partial \ln M_t} \quad \text{for} \quad 0 < \rho < 1$$

The larger nominal rigidity in wages than in prices implies that the real wage is decreasing in the money stock and therefore employment is increasing. Moreover, the nominal wage shows less cyclical variability than prices, i.e.

$$Cov(\ln W, \ln y) < Cov(\ln P, \ln y)$$

It is worth stressing that the nominal rigidity does not rely on any restrictions on the type of contracts which can be made between the union and the firm. In particular both workers and capitalists are equally affected by the future consumption risk of their current nominal income. Hence it is not possible to diversify this risk between workers and capitalists in the present setting, i.e. indexation of the current wage to the future price level is not a feasible contingency precisely because the capital market is incomplete. This also brings out that the reason for nominal rigidity explored here is qualitatively different from the type arising from restrictions on the feasible contracts, cf. e.g. Gray (1976).

Considering the responsiveness of real wages to the money stock and thereby the basic mechanism whereby the demand shocks have real effects, we find

$$\frac{\partial(\ln W_t - \ln P_t)}{\partial \ln M_t} = \frac{-(1-\rho)(1-\gamma)\delta_2\rho}{1-(1-\delta_2)\rho} \leq 0$$

A striking implication is that the responsiveness is non-monotone in the persistency ρ of the nominal shock. For $\rho \to 1$ and $\rho \to 0$, we find that the real wage and thus employment is

invariant to the demand shock. For intermediary values $0 < \rho < 1$ nominal shocks affect real wages and employment.

It follows directly from (13) that($|\eta| > 1$)

$$Var(\ln W_t - \ln P_t) < Var(\ln n_t)$$

Hence, given that nominal shocks are non-neutral, we are able to explain why employment shows more variability than real wages.

Since the nominal shock here arises from changes in public demand, it may be questioned whether the positive correlation between output and monetary shocks is achieved at the cost of a negative correlation between private consumption and output as public consumption crowds out private consumption. As consumption is procyclical, this would call into question the empirical importance of the source of nominal rigidity explored here and maybe even the role of demand shocks induced by changes in public demand in accounting for business cycle fluctuations. It turns out that the consumption of young households is positively correlated with the nominal innovation and thus activity, i.e.

$$Cov(c_{1t}, y_t) > 0$$

while there is a negative correlation for old households

$$Cov(c_{2t}, y_t) < 0$$

The former effect is caused by the increased income caused by the nominal shock while the later arises due to the induced price increase which lowers the real value of savings.

Clearly depending on which effect dominates, the correlation between total consumption and activity can be positive or negative. A positive correlation arises if the subjective discount rate is sufficiently high[15].

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15) We have that total consumption be written

$$c_t = y_t\left(\frac{1+\theta}{2+\theta} + \frac{1}{2+\theta}\frac{M_{t-1}}{M_t}\right)$$

hence for θ sufficiently large the covariance between total consumption and activity would be positive.

6. Active Stabilization Policy

The finding of the preceding section that shocks in a setting with non-myopic agents and an incomplete market structure can cause fluctuations raises the question of whether there is a role for an active stabilization policy. Such a possibility may arise since demand shocks are not in general neutral. As the model is set up the authorities control public demand, and given that agents dislike risk due to the incomplete market structure, there may be a welfare case for exploiting the non-neutrality of demand management policy. To analyse this problem, it is assumed that the real shock follows the process specified in section 4 and that the policy-maker follows a policy rule of the form

$$\ln M_t = \kappa_0 + \kappa_1 \ln u_{t-1} \tag{10}$$

Several points should be noted here. First the policy intervention does not rely on an informational advantage for the policy maker. Actually, the policy rule supposes that the policy maker can only react to shocks with a one period lack and therefore the policy is contingent on no more information than what is readily available to all agents in the economy. Secondly, the aim is to show that even a simple policy role can be effective and have beneficial effects. Hence we consider a policy rule of the form (10) without questioning whether this is the optimal form.

Conjecture a solution for equilibrium prices of the form

$$\ln P_t = \pi_0 + \pi_1 \ln u_t + \pi_2 \ln u_{t-1} \tag{11}$$

It is easily found that there exists a rational expectations equilibrium of the form (11) with coefficients given by

$$\pi_0 = \delta_2^{-1}(\delta_0 + \delta_2 \kappa_0)$$

$$\pi_1 = \left(1 - (1-\delta_2)\rho\right)^{-1}\left(\delta_1 + (1-\delta_2)\pi_2\right)$$

$$\pi_2 = \delta_2 \kappa_1$$

Solving for equilibrium real wages and employment, we find

$$\ln W_t - \ln P_t = \omega + (1-\gamma)(\pi_1(\rho-1)+\pi_2)\ln u_t - \pi_2 \ln u_{t-1}$$

and

$$\ln n_t = \bar{n} + \eta\left[(1-\gamma)(\pi_1(\rho-1)+\pi_2)-1\right]\ln u_t - \eta \pi_2 \ln u_{t-1}$$

Notice, that employment no longer follows a first-order autoregressive process.

It is immediately seen that policy is non-neutral as the choice of κ_1 affects the equilibrium distribution of prices and therefore employment. A simple rule for demand management policy thus plays a non trivial role as a stabilizer towards real shocks in a setting with incomplete markets.

As an example of the potential of the policy rule, it is seen that there exists a choice of κ_1 which eliminates uncertainty about future prices since $\pi_1 = 0$ for $\kappa_1 = \delta_1[\delta_2(1-\delta_2)]^{-1} < 0$. Since $\kappa_1 < 0$, the policy intervention is countercyclical. As the problem here is that current behaviour due to an incomplete market structure is affected by the risk relating to future prices, this indicates that an active stabilization policy to some extent can mitigate the effects of this market imperfection[16]. Specifically, in the present context it implies a lower real wage target (ω) and therefore a higher employment level and this constitutes a potential Pareto improvement since employment is ineffectively low due to the spread between the real wage and marginal product of labour caused by imperfect competition (Bénassy 1991).

The choice of κ_1 which stabilizes output is seen to be independent of the properties of the stochastic process for the real shock as it depends only on the coefficients in the price equation (8). This reflects that the operational target for demand management policy in this case is a stabilization of the price level. The analysis thus provides a foundation for price stability as an operational target for monetary policy in a setting with incomplete capital markets.

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[16] Thomas (1993) shows in a setting with incomplete markets that there is a role for a distortionary fiscal policy to counteract the inefficiencies caused by risk. Contrary to the present example policy does not work by affecting risk but by affecting the incentives underlying labour supply.

7. Imperfect Information

Given the wage smoothing caused by the different intertemporal implications of temporary and permanent shocks, it is of interest to study how the adjustment process is affected by shocks when it is not immediately clear whether these are transitory or permanent. To model this situation let us consider the case of nominal shocks (a similar analysis is readily done for the case of real shocks or confusion between real and nominal shocks).

Assume that the money stock is driven by the following process

$$\ln M_t = v_t + e_t$$

where

$$v_t = \rho v_{t-1} + u_t \qquad |\rho| < 1$$

$$u_t \sim N(0, \sigma_u^2)$$

$$e_t \sim N(0, \sigma_e^2)$$

$$E u_t e_t = 0$$

This specifies a process according to which nominal changes can be either temporary (e_t) or permanent (u_t). Even if agents have full current information on the money stock, this still leaves an information problem concerning the future money stock, how much is transitory and how much permanent?

Specifically we assume that the information set ψ includes knowledge on the current and all past levels of the money stock, i.e.

$$\{\ln M_t, \ln M_{t-1}, \ln M_{t-2} \dots\} \in \psi_t$$

As shown in the appendix, we have that

$$E(\ln M_{t+1}|\psi_t) = (\rho - h) E(\ln M_t|\psi_{t-1}) + h \ln M_t \tag{12}$$

where

$$h \equiv \rho \frac{\sigma^2}{\sigma^2 + \sigma_e^2} < \rho$$

Conjecture a solution for equilibrium prices in period t as

$$\ln P_t = \pi_0 + \pi_1 E(\ln M_{t+1}|\psi_t) + \pi_2 \ln M_t \tag{13}$$

Implying that

$$E(\ln P_{t+1}|\psi_t) = \pi_0 + (\pi_1 \rho + \pi_2) E(\ln M_{t+1}|\psi_t) \tag{14}$$

Inserting in (8), we find

$$\ln P_t = \delta_0 + (1 - \delta_2)\pi_0 + \delta_2 \ln M_t + (1 - \delta_2)(\pi_1 \rho + \pi_2) E(\ln M_{t+1}|\psi_t)$$

Hence,

$$\pi_0 = \frac{\delta_0}{\delta_2}$$

$$\pi_1 = \delta_2$$

$$\pi_2 = (1 - \delta_2)\rho$$

Using (12), we can rewrite the period t price as

$$\ln P_t = \frac{\delta_0}{\delta_2}(1 - \rho + h) + (\delta_2 + (1 - \delta_2)\rho h) \ln M_t - (\rho - h)\delta_2 \ln M_{t-1} \tag{15}$$

$$+ (1 - \delta_2)(\rho - h) \ln P_{t-1}$$

This shows how substantial inertia can build up in price adjustment from the fact that wage adjustment is smoothed and agents are unable to distinguish between transitory and permanent shocks.[17] It is noteworthy that this result arises in the absence of any restrictions on the possibility of adjusting current nominal wages and prices. Transitory shocks will thus

---

[17] This also overcomes the criticism of the Phelps-Taylor model of overlapping wage contracts, cf. Fuhrer and Moore (1995) for implying too little inflation persistence.

have lasting effects because agents are not readily able to distinguish permanent from transitory shocks.

Adding the coefficients to the nominal variables on the RHS of (15) to check the homogeneity properties of the price level, we find

$$\delta_2 + (1-\delta_2)\rho h - (\rho - h)\delta_2 + (1-\delta_2)(\rho - h) < 1 \qquad \text{for} \quad \rho < 1$$

Hence unless the permanent shocks are fully persistent ($\rho = 1$), we would not find that the price equation (15) displays homogeneity. This is interesting since empirical (macro) price equations would usually be estimated in a form including lagged values of the price and the money stock.

Using (13) and (14), it is easily verified that the nominal wage equation can be written

$$\ln W_t = (1-(\rho-h))(\omega+\pi_0) + ((1+\gamma)\pi_2 + (1-\gamma)(\pi_1+\rho))\ln M_t$$

$$- (\rho - h)\gamma\delta_2 \ln M_{t-1} + (\rho - h)\ln W_{t-1}$$

It is interesting to note that the present model has some of the same dynamic implications as models with asynchronized price and wage setting. Moreover, it shows why empirical nominal wage and price equations often show substantial inertia.

If the degree of persistency in price and wage adjustment is measured by the coefficient to the lagged variable, we find more persistency in wage than in price adjustment as

$$\frac{\partial \ln P_t}{\partial \ln P_{t-1}} = (1-\delta_2)(\rho - h) < \rho - h = \frac{\partial \ln W_t}{\partial \ln W_{t-1}}$$

Again, despite no restrictions on price and wage adjustment, we find an asymmetry with more rigidity in wage than in price adjustment.

8. Concluding Remarks

Intertemporal considerations come to influence wage determination if capital markets are not complete. This introduces interesting dynamics into wage adjustment which has important

implications for the adjustment to both supply and demand shocks. This shows why wage adjustment may be sluggish and therefore propagate the influence of shocks.

The specific way of modelling capital market imperfections by assuming a single non-interest bearing asset (money) can clearly not claim generality. The point is, however, that as long as there is not access to assets providing full contingency on shocks influencing the future consumption value of current wages, the basic mechanism of the paper stands. Similarly, the specific overlapping structure is not critical to the results which depend on the fact the future expected prices influence current wages. The OLG-structure only serves the purpose of being a tractable way of building this mechanism into a general equilibrium model with an incomplete market structure.

Appendix

A. Unemployment Benefits

Assume that unemployed receive an unemployment compensation B which is a fraction of wages, i.e. $B_t = fW_t$, $f < 1$. Unemployment benefits are financed by a fixed contribution T paid by all employed. The budget constraint for the unemployment insurance system is

$$T_t n_t = B_t(H - n_t) \qquad \text{(A-1)}$$

Aggregate demand is clearly unaffected by the unemployment insurance system as demand only depends on total income. Hence, the only effect of unemployment insurance would come from the wage setting. We have (d is disutility from work)

$$V_t = k(W_t - T_t)^{\frac{2+\theta}{1+\theta}} P_t^{-1} E\left(P_{t+1}^{\frac{1}{1+\theta}} \middle| \psi_t\right) - d$$

$$\bar{V}_t = k(B_t)^{\frac{2+\theta}{1+\theta}} P_t^{-1} E\left(P_{t+1}^{\frac{1}{1+\theta}} \middle| \psi_t\right)$$

Hence, the first order condition to be union's maximization problem can be written

$$\eta\left(V_t - \bar{V}\right) + W_t\left(\frac{\partial V_t}{\partial W_t} - \frac{\partial \bar{V}_t}{\partial W_t}\right) = 0 \qquad \text{(A-2)}$$

The optimal wage can be recovered from expression (A-2) as an implicit function of P_t and E_tP_{t+1}, (all other variables suppressed), i.e.

$$W_t = G\left(P_t, E_tP_{t+1}\right), \quad \lambda W_t = G\left(\lambda P_t, \lambda EP_{t+1}\right) \quad \forall \quad \lambda > 0$$

It follows that the model in this case has the same qualitative implications as the model analysed above.

B. Determination of $E(\ln M_{t+1} | \psi_t)$

We have that

$$E\left(\ln M_{t+1} | \psi_t\right) = E\left(\ln v_{t+1} | \psi_t\right)$$

where

$$E\left(\ln v_{t+1} | \psi_t\right) = E\left(\ln v_{t+1} | \psi_{t-1}, \ln M_t\right)$$

$$= E\left(\ln v_{t+1} | \psi_{t-1}\right) + E\left(\ln v_{t+1} - E\left(\ln v_{t+1} | \psi_{t-1}\right) | \ln M_t - E\left(\ln M_t | \psi_{t-1}\right)\right)$$

Since

$$E\left(\ln v_{t+1} | \psi_{t-1}\right) = \rho E\left(\ln v_t | \psi_{t-1}\right)$$

and

$$\ln v_{t+1} - E\left(\ln v_{t+1} | \psi_{t-1}\right) = \rho\left[\ln v_t - E\left(\ln v_t | \psi_{t-1}\right)\right] + \mu_t$$

$$\ln M_t - E\left(\ln M_t | \psi_{t-1}\right) = \ln v_t - E\left(\ln v_t | \psi_{t-1}\right) + e_t$$

We find that

$$E\left(v_t - E\left(v_t | \psi_{t-1}\right) | \ln M_t - E\left(\ln M_t | \psi_{t-1}\right)\right) = h\left(\ln M_t - E\left(\ln M_t | \psi_{t-1}\right)\right)$$

where the h-coefficient defined as the variance of $\ln v_t$-$E(\ln v_t | \psi_{t-1})$ is given by

$$h = \frac{\rho\sigma^2}{\sigma^2 + \sigma_e^2}$$

where σ^2 is the variance of $\ln v_t$-$E(\ln v_t | \psi_{t-1})$.

It follows that

$$E\left(\ln M_{t+1} | \psi_t\right) = (\rho - h)E\left(\ln M_t | \psi_{t-1}\right) + h \ln M_t$$

subtracting $\ln v_t = \rho \ln v_{t-1} + u_t$ from both sides yields

$$E\left(\ln v_{t+1}|\psi_t\right) - \ln v_{t+1} = (\rho - h)\left(E\left(\ln v_t|\psi_{t-1}\right) - \ln v_t\right) + h\ln v_t - u_t$$

From this expression the variance of $\ln M_{t+1}$ - $E(\ln v_{t+1}|\psi_t)$ is found to be

$$\sigma^2 = (\rho - \eta)^2\sigma^2 + h^2\sigma^2 + \sigma_u^2$$

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