Money Volatility and Labour Demand Uncertainty in a Unionised Economy

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Abstract

We insert four basic assumptions in an otherwise standard real business cycle model: monopolistic unions, short term nominal wage contracts, stochastic money supply and endogenous growth. The resulting economy exhibits a number of interesting features. First, unions face an uncertain labour demand prospect and, due to increasing labour disutility, impose a risk premium over the usual monopolistic wage. Second, the risk premium reduces the natural level of employment and depresses the long term rate of growth so that uncertainty reveals to be harmful on both accounts. Third, thanks to the endogenous technology, even if nominal rigidities are short termed, monetary perturbations turn out to have permanent e¤ects on output and, in this respect, appear to be empirically equivalent to permanent supply side perturbations. Finally, the model predicts a positive relationship between the level of in‡ation and its variability and a negative relationship between the variability of in‡ation and output and the rate of growth. In this sense, we o¤er an explanation for some well known facts in empirical macroeconomics.

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1 Introduction

This paper is concerned with the analysis of the e¤ects of union wage predetermination in presence of monetary perturbations and endogenous growth technology. The aim of the research behind the study was that of providing an example of an economy capable of exhibiting long run monetary non-neutrality without relaying on ad hoc assumptions - as those adopted in a number of other works (see below) - but by using a more standard optimising model. For this reasons, our strategy has been that of enriching a standard real business cycle model with nominal wage contracting and a unionised labour market. The results we obtain, however, go much further the original intention. In particular, in addition to monetary non-neutrality in the long run, we …nd that the prospect of an uncertain labour demand - induced by monetary uncertainty - leads unions to demand a risk premium over the usual monopolistic wage and this, in turn, reduces both current employment and the long run rate of growth. Output/employment volatility and output growth are then negatively correlated as it has been documented by a number of empirical studies[1]. Furthermore, given the expected rate of money expansion, the negative e¤ect on real growth generates a positive relationship between nominal volatility and the long run in‡ation rate so that we o¤er a long run perspective to explain other relevant facts emphasised by empirical macroeconomists. These are the negative relationship between in‡ation variability and growth and the positive relationship between the level of in‡ation and its variability[2].

The search for mechanisms generating long run monetary non-neutrality traces back to the work of Nelson and Plosser (1982) In fact, within the ongoing debate over the sources of business cycles their …ndings seemed to provide a decisive support in favour of purely technological explanations due to the dif…culty to …gure out nominal rigidities entailing unit-root output perturbations from monetary shocks.

The later surge of interest on endogenous growth, however, has considerably blurred the wisdom that permanent perturbations are the result of technological shocks and that monetary shocks can only entail transitory output movements. In particular, growth theorists have brought to the attention the possibility that an endogenous accumulation process could act itself as a time propagation mech-

[1] Ramey and Ramey (1995) represents an obviuos reference.
[2] See Al-Marhubi (1998), for instance.

anism for ‡uctuations that are in principle short termed. King et al. (1988), for instance, within a Romer-type model demonstrate that even a temporary technological perturbation can have long term e¤ects thanks to the permanent shift in capital accumulation. The same mechanism is invoked in Bean (1990) to prove that a public expenditure demand shock can have permanent e¤ects on output.

Stadler (1990) formulates the …rst model focused on money perturbations and endogenous growth as a source of long term non-neutrality. The framework used, however, is highly aggregate and short of microfoundations. Furthermore, technology is rather ad hoc with the result of implying a counterfactual dynamics for output and employment. The latter aspect of the model has been greatly improved in Pelloni (1997) where a very general production function proves capable of containing both Lucas and Romer technologies as particular cases. Microfundations, however, remain not satisfactory. In particular, both papers lack explicit utility maximisation as the basis of agents behaviour in wage-setting and saving decisions. In turn, this prevents a clear confrontation with previous growth and business cycle literature and casts doubts on the robustness of conclusions once some short-cuts are removed. By contrast, in the model below, we assume that agents draw saving and wage decisions from solving an optimal program in a Romer-type economy. Similarly to Stadler and Pelloni, however, demand perturbations arise because money follows a stochastic process and a¤ects short term employment thanks to the presence of short lived nominal wage contracts.

As anticipated, monetary uncertainty, coupled with wage-setting behaviour and risk aversion, is also the source of a depressing e¤ect on employment. This has been originally devised by Rankin (1998) within an economy with exogenous growth (at zero rate). The insertion of an endogenous technology demonstrates that uncertainty can be harmful not only for static employment but also for the rate of growth via the employment size-e¤ect on the rate of return on capital. However, this is but the only conclusion which can be obtained from our setting since the depressing e¤ect on growth paves the way for a long run interpretation of the well known negative relationships between the volatility of output and in‡ation on one side - both arising from the volatility of money - and the average rate of growth on the other side. More precisely, we argue that it is not in‡ation or output instability to cause slow growth - as emphasised by those explanations relaying on investment decisions by risk-averse agents[3] - but instability and slow growth are both joint results of the underlying monetary instability. This view is supported by the …ndings of Ramey and Ramey (1995). In their 78 countries sample, average growth depends negatively on volatility but investments seem to be una¤ected by a more uncertain economic environment. In fact, in the model below investments represent a …xed proportion of output and the e¤ects of volatility are all generated through the working of the labour market.

Finally, the model also predict a positive reduced form relationship between the volatility and the level of in‡ation. The argument is rather simple. In the long run, lower average real growth and constant average money growth produce higher average in‡ation. High monetary uncertainty then generates both high in‡ation uncertainty and high in‡ation level, the latter through the depressing e¤ect on growth.

Here is an outline of the paper. Section 2 presents the economic setting while section 3 solves for a symmetric general equilibrium. In section 4 we discuss the e¤ects of unionisation and money uncertainty over employment, growth and volatility. In section 5 we focus on the links between monetary business cycles and long run growth. Section 6 concludes.

2 The economic Setting

Firms

On the production side, the economy is composed by a unit mass of perfectly competitive …rms producing an homogeneous good under constant returns to scale with respect to private inputs:

$$Y_t = AK_t^{\alpha}(H_tL_t)^{1-\alpha} \tag{1}$$

Y_t denotes gross output since we assume that capital fully depreciates. Output, in turn, can be used both for consumption and as an input for next period production. H_t represents aggregate disembodied knowledge, a public good which enters the production function by a¤ecting labour productivity. In line with the tradition started with Romer (1986), we assume that the aggregate level of knowledge accumulates as an external by-product of private investments

[3] See Aizenman and Marion (1993), for instance.

in physical capital. In turn, this implies proportionality between human and physical capital and increasing returns to scale with respect to both private and public inputs:

L_t is assumed to be a CES-combinations of individual labour skills with elasticity parameter θ :

$$L_t = \left[\int_0^1 L_{i;t}^{\frac{\theta - 1}{\theta}} di \right]^{\frac{\theta}{\theta - 1}} \qquad \theta > 1$$

We also assume that each skill is monopolistically supplied by a single household and, for this reason, introduce an index 'i' to refer to the i-th household and to its peculiar labour supply $L_{i;t}$. As implied by the above integral, the index 'i' is uniformly distributed along a segment of unit measure.

Efficient expenditure to secure labour services leads to the following equations for conditional skill demands and wage index:

$$L_{i;t} = L_t \left(\frac{W_{i;t}}{W_t} \right)^{-\theta} \qquad i \in [0;1] \tag{2}$$

$$W_t = \left(\int_0^1 W_{i;t}^{1-\theta} di \right)^{\frac{1}{1-\theta}}$$

Under full depreciation[4] of capital no state variable enters the maximisation of the present value of profits so that firm's optimization collapses to a sequence of purely static problems. Moreover, we assume that firms enjoy an informational advantage over households so that they bear no uncertainty in making investment decisions for next period production[5]. Textbook theory requires that in these conditions the firm should equate marginal productivity and cost for each input used in production. Applying this rule leads to the following functional distribution of income:

$$L_t W_t = (1 - \alpha) P_t Y_t \tag{3}$$

[4] This assumption is obviously disturbing. We remark, however, that full depretiation is part of the set of restrictions necessary to obtain closed form results and keep the model simple. This has also been the choice of Benassy (1995), McCallum (1989) and Bean (1990), among several others.

[5] This kind of assumption is not uncommon in macroeconomics. During the 70s, many Keynesian economists have relied on information asymmetries between firms and workers to postulate a higher responsivenes of prices - as opposed to wages - with respect to money perturbations.

$$R_t P_{t-1} K_t = \alpha P_t Y_t \tag{4}$$

Capital expenditure at the beginning of the period is represented by $P_{t-1} K_{;t}$ since capital comes from previous production and turns out to be priced at previous prices. Firms obtain funds by borrowing in financial markets at a cost measured by the (gross) nominal interest rate R_t so that, at the end of the period, they face a capital bill represented by the LHS of 4.

Households

The objective of the i-th household is to maximise the following intertemporal welfare function:

$$U_{i;t} = E_t \left\{ \sum_{s=0}^{\infty} \beta^s \left[\log \left[C_{i;t+s} \left(\frac{M_{i;t+s}}{P_{t+s}} \right)^{\delta} \right] - \gamma \frac{L_{i;t+s}^{\eta}}{\eta} \right] \right\}$$

$$\beta < 1 \quad \eta > 1 \quad \delta > 0 \quad i \in [0;1]$$

Notation is standard, E_t represents the rational expectation operator conditional on all information available at time t while β denotes the discount factor. Welfare depends negatively on labour supply and positively upon (the logs of) consumption and real money holdings at the end of the period. Parameter η indexes the marginal utility of labour whilst δ conveys the relative weights of consumption and money services in affecting utility. To gain some insight on this parameterisation notice that along a path of balanced growth all real variables, included labour productivity and wages, increase at the same rate while labour input remains constant. Therefore, in order to avoid an ever-increasing (or ever-decreasing) individual labour supply, income and substitution effects from higher wages need to be mutually offsetting. This can be obtained either with a log-additive form or with a somehow more general isoelastic-multiplicative form[6]. Our preference for the first is to be considered along with the choice of a Cobb-Douglas form for the production function and a unit capital depreciation rate. Indeed, these restrictions are all necessary to obtain closed forms solutions

[6] In a model without money the isolelastic-multiplicative form is given by

$$u(C;L) = \frac{1}{1-\sigma} C^{1-\sigma} v(L) \qquad v'(L) < 0$$

for $0 < \sigma < 1$ and $\sigma > 1$, whilst the log-additive form is

$$u(C;L) = \log C + v(L)$$

and, as observed by McCallum (1989), they stand at the basis of the difference between models that need calibration as, for instance, Kydland and Prescott (1982) and models that are "fully computable" as those in the tradition started with Long and Plosser (1983).

To maximise their welfare, households make three decisions at each stage. How much to consume versus how much to save of their wealth and income, how to allocate savings between money and interest paying activities and what nominal wage should they fix for next period. The first two decisions are standard in intertemporal macroeconomics, the third is less common and could be interpreted as an extension of the monopolistic wage fixing of Blanchard and Kiyotaki (1987). The main difference is that in the present context wages are fixed one period in advance and with imperfect information over next period labour demand.

The household program turns out to be constrained by (the expectation of) the employment-wage trade-off as it arises in the shape of the labour demand equation 2 and by a dynamic budget relationship:

$$P_{t-1}\left(a_{i,t-1} - \frac{M_{i,t-1}}{P_{t-1}}\right) R_t + L_{i,t}W_{i,t} + \Pi_{i,t} + T_{i,t} - P_tC_{i,t} + M_{i,t-1} = P_t a_{i,t}$$

State variable $a_{i,t}$ represents real wealth held at the end of period t and is composed of real money balances plus the value of financial activities bought at the end of t:

$$a_{i,t} = b_{i,t} + \frac{M_{i,t}}{P_t}$$

$\Pi_{i,t}$ and $T_{i,t}$ denote respectively nominal profits and nominal lump sum transfers of seignorage revenue which contribute to the household income.

First order conditions for solving the program are obtained applying standard stochastic dynamic programming. Given the formal properties of functions involved, these conditions are necessary as well as sufficient. When the operator E_t occurs, it represents a mathematical expectation conditional upon the knowledge of the economy (which is common) and the "history" vector sequence $\{P_s, Y_s, R_s, a_s, \Pi_s, T_s\}_{s \le t}$:

$$\frac{\delta}{M_{i,t}} = \beta E_t \left(\frac{1}{C_{i,t+1}} \frac{R_{t+1} - 1}{P_{t+1}}\right) \qquad (5)$$

$$\frac{1}{C_{i,t}} = \beta E_t \left[\frac{1}{C_{i,t+1}} \frac{P_t R_{t+1}}{P_{t+1}} \right] \tag{6}$$

$$W_{i,t} = \frac{\theta}{\theta - 1} \frac{E_{t-1}\left[\gamma L_{i,t}^{\eta}\right]}{E_{t-1}\left[\frac{L_{i,t}}{P_t C_{i,t}}\right]} \tag{7}$$

$$\lim_{s \to \infty} \beta^s E_t \left[\frac{1}{C_{i,t+s}} a_{i,t+s} \right] = 0 \qquad \text{Transversality Condition} \tag{8}$$

The first condition requires that, along the optimal path, marginal reallocation of financial resources between money and interest paying activities do not change expected welfare. In case the reallocation goes from activities to money, the LHS represents current marginal benefit while the RHS gives marginal expected discounted cost due to the loss in interest income.

Equation 6 regulates intertemporal allocation of resources by imposing equality between the marginal benefit and the expected discounted marginal cost from consuming an extra unit of resources.

Condition 7 gives the current nominal wage as fixed by household-unions during the previous period. We could gain some insight of this formula by dropping the expectation operators and dividing numerator and denominator by $L_{i,t}$. In this (certainty) case the nominal wage would result from the application of the monopolistic mark-up $\theta/(\theta - 1)$ to what could be labelled as the competitive nominal wage, i.e. the ratio between the marginal disutility of labour and the marginal utility of one unit of money. In this respect the model crucially departs from the perfect competition setting of Benassy (1995) and Stadler (1990) where wages are predetermined by Gray-type contracts at the expected market clearing levels. There, to ensure that equilibrium lies on the labour demand schedule and to avoid labour rationing for firms, contracts also force households to supply labour in excess to the optimal (ex post) level when positive shocks occur. Therefore, the role of wage contracting - as it is interpreted by Gray (1978) and others - is not to provide a mechanism for wage determination, which appears to be rather ad hoc, but to avoid any problem of regime switching to disequilibrium in the form of firms rationed on the labour market. By contrast, in the present setting, the insertion of monopoly in the labour market makes redundant any side-assumption on the location of the equilibrium. The reason lies in the mark-up wedge between wage and expected marginal disutility of labour so that households are always willing (ex post) to supply labour in excess of their expectations[7]. Rationing could only arise in case of a demand perturbation exceptionally large, i.e. such that the marginal disutility of labour outweighs the marginal utility of income. However, on theoretical grounds, this occurrence can be swept aside by assuming adequate bounds for the stochastic process that generates shocks.

Monopolistic wage setting therefore provides a theory of wage formation and, at the same time, does not require the insertion of contractual provisions too compelling for workers. Moreover - as it will shortly become clear - it enables an explicit analysis of the effects of uncertainty.

We conclude the discussion on the solution of the model by considering the implications of the transversality condition. For this purpose, notice that non-negativity of real balances and non-exploding debt imply[8]:

$$\lim_{s \to \infty} \beta^s E_t \left[\frac{1}{C_{i;t+s}} \frac{M_{i;t+s}}{P_t} \right] \geq 0 \tag{9}$$

$$\lim_{s \to \infty} \beta^s E_t \left[\frac{1}{C_{i;t+s}} b_{i;t+s} \right] \geq 0 \tag{10}$$

These are consistent with the transversality condition 8 only if they hold strictly. Below, we will see that equations 9 and 10 - taken with the equal sign - play a major role within the solution of the model.

Money Supply

Description of the economic setting ends with a money supply equation. In

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[7] Pelloni (1997) shares the Gray contracts approach of Benassy (1995) and Stadler (1990) but moves from perfect competition thanks to the introduction of unions. The modification, however, entails no substantial difference since unions objectives are restricted to maintaining an exogenously given employment level.

[8] Excluding explosive dynamics for debt has become popular in macroeconomics with the name of no-Ponzi-Game condition. It usually amounts to impose a non-negative constraint for the discounted asymptotic portfolio value. Therefore, within the present setting, it would originally appear as

$$\lim_{s \to \infty} E_t \left\{ \left[\left(\frac{P_t R_{t+1}}{P_{t+1}} \right) \left(\frac{P_{t+1} R_{t+2}}{P_{t+2}} \right) ::::::: \left(\frac{P_{t-1+s} R_{t+s}}{P_{t+s}} \right) \right]^{-1} b_{i;t+s} \right\} \geq 0$$

where $\left(\frac{P_t R_{t+1}}{P_{t+1}} \right)$ represents the real interest rate at time t. The latter, however, is equivalent to equation 10 in the main text since it can be proved that, in equilibrium, the expected discounting factor is equal to $C_{i;t} E_t \left[\beta^{-s} \frac{1}{C_{i;t+s}} \right]$

principle two alternative rules could be adopted:

$$\frac{M_t}{M_{t-1}} = \mu_1 \xi_t \qquad \mu_1 > 1 \tag{11}$$

$$\frac{M_{t-1}}{M_t} = \mu_2 \xi_t \qquad \mu_2 < 1 \tag{12}$$

ξ_t represents an i.i.d. stochastic variable with unit expected value. In the first and more traditional equation we hold constant the expected money growth rate while, in the second, the expected inverse growth rate or the money contraction rate. Choice between the two alternatives requires considerations that are postponed until the discussion of equilibrium in market for money.

3 General Equilibrium

Output market equilibrium

In this section we solve the model for a symmetric general equilibrium so that all variables referred to the i-th household represent aggregate variables after dropping the "i" index. Since the economy is closed and government does not issue bonds[9], aggregate holdings of real financial activities coincide with next period invested physical capital:

$$b_t = K_{t+1} \tag{13}$$

so that equilibrium in output market requires

$$Y_t = C_t + b_t \tag{14}$$

After substituting equation 4 in 6, manipulating and imposing general equilibrium in the form of equations 13 and 14, we obtain a dynamic relationship involving only the ratio b_t/C_t:

$$\left(\frac{b}{C}\right)_t = \beta\alpha E_t \left[1 + \left(\frac{b}{C}\right)_{t+1}\right]$$

Since agents are free to choose in every period a different allocation of their resources between consumption and saving the ratio b_t/C_t is a non-predetermined

[9] Government budget constraint is $T_t = M_t - M_{t-1}$. In theory, government could issue bonds to achieve $T_t > M_t - M_{t-1}$. However, since Ricardian equivalence holds, this would bear no effect on equilibrium.

variable. It follows that current decisions will have a pure forward-looking nature according to the above equation.

A well known result in mathematical economics is that stochastic difference equations with non-predetermined variables have an infinity of forward-looking solutions: one of them is the so-called fundamental solution while all the others contain a bubble component. To solve the multiplicity problem in favour of the fundamental solution we follow Blanchard (1985). First we notice that, since $\beta\alpha < 1$; all "bubble" paths are explosive so that they can be ruled out by imposing a convergence condition. Second, we recall that equation 10 - taken with the equal sign - provides indeed the required non-explosive condition. The unique fundamental solution is then easily obtained by running forward the equation and applying condition 10:

$$\frac{b_t}{C_t} = \frac{\beta\alpha}{1 - \beta\alpha}$$

Proportions of income allocated to consumption and saving are constant through time and this can be true only if they represent constant fraction of output:

$$C_t = [1 - \beta\alpha] Y_t \tag{15}$$

$$b_t = \beta\alpha Y_t \tag{16}$$

Money market equilibrium

Solving for the money market equilibrium requires the definition of a money demand equation. For this purpose we substitute equation 6 in 5:

$$\frac{\delta}{M_t} = \frac{1}{C_t P_t} - \beta E_t \left[\frac{1}{C_{t+1} P_{t+1}} \right] \tag{17}$$

If money provided a service lasting only one period, agents would equate the marginal rate of substitution between money and current consumption to their relative price P_t. This corresponds to the equation above after dropping the second term on the RHS. However, unlike consumption, money maintains its exchange value next period and the marginal benefit of being such a reserve of value is represented by the term $\beta E_t \left[\frac{1}{C_{t+1} P_{t+1}} \right]$. Therefore, the equation could be interpreted as the equality between the marginal utility of money, as a good in itself and as a store of value, and its marginal cost in terms of foregone consumption.

Imposing equilibrium in money market amounts to thinking that M_t in equation 17 follows one of the two processes described above. Under this interpretation 17 becomes a stochastic difference equation. After some straightforward steps the equation can be expressed in terms of the ratio between real balances and consumption:

$$\left(\frac{m}{C}\right)_t = \delta + \frac{\beta}{\mu_1} E_t \left[\left(\frac{m}{C}\right)_{t+1} \frac{1}{\xi_{t+1}} \right] \tag{18}$$

$$\left(\frac{m}{C}\right)_t = \delta + \beta \mu_2 E_t \left[\left(\frac{m}{C}\right)_{t+1} \xi_{t+1} \right] \tag{19}$$

Equations 18 and 19 assume respectively processes 11 and 12. Notice that the current perturbation ξ_t does not enter the relationships and that the variable $(m/C)_t$ is completely forward-looking as it contains prices. This implies independence between ξ_t and $(m/C)_t$ and, in turn, between ξ_{t+1} and $(m/C)_{t+1}$. It follows that the expected value can be thought of as a product of two expected values:

$$\left(\frac{m}{C}\right)_t = \delta + \frac{\beta}{\mu_1} E_t \left[\left(\frac{m}{C}\right)_{t+1} \right] E_t \left[\frac{1}{\xi_{t+1}} \right] \tag{20}$$

$$\left(\frac{m}{C}\right)_t = \delta + \beta \mu_2 E_t \left[\left(\frac{m}{C}\right)_{t+1} \right] \tag{21}$$

Again, each equation corresponds to a different money process. As a preliminary observation notice that the variance of shocks affects equilibrium only when the more traditional money process 11 is assumed. By contrast, variance dependence disappears when the expected inverse money growth is held constant. In what follows we present two arguments in favour of this case.

The first argument is given in Rankin (1994) where the issue of the spread effect on equilibrium is clearly addressed within a simple pure exchange setting. There, the traditional process is dismissed in favour of the alternative by arguing that the variance effect is not related to agents preferences but arises only as a pure mathematical result. The second argument hinges on the formal properties of above equations. In particular, to avoid multiple convergent paths it is necessary that current values of money depend upon next period values through a multiplier less than one. While this turns out to be always guaranteed in equation 21 we need instead additional restrictions on the variance of ξ_t if the alternative 20 is to be taken.

In order to rule out explosive paths we use again Blanchard's approach. In this case the convergence condition is provided by equation 9 taken with the equal sign:

$$P_tC_t = \frac{1-\beta\ ^{1}}{\delta}M_t \qquad ^{1}\ \eta\ ^{1}{}_{2} \tag{22}$$

At every stage, prices adjust to make consumption expenditure proportional to nominal balances. This result is not robust to any other parameterisation but logarithms. Proportionality, however, along with linearity of equations 3, 4 and 15 is what ensures a closed form solution for the employment level.

Employment

The first step to solve for employment is to aggregate and rearrange equation 7:

$$\frac{E_{t-1}\left[\frac{1}{C_t}\frac{W_t}{P_t}L_t\right]}{E_{t-1}[\gamma L_t^{\eta}]} = \frac{\theta}{\theta-1} \tag{23}$$

Numerator and denominator give respectively (in terms of expectations) the marginal utility of real wage and the marginal disutility of labour, both multiplied by L_t. As a matter of fact, however, since consumption expenditure P_tC_t and nominal labour income W_tL_t are both proportional to the value of aggregate production P_tY_t (just check equations 3 and 15), the variable at the numerator is a constant and the expectation operator can be dropped. It follows that the only expected value remaining in the equation can be expressed explicitly:

$$E_{t-1}[L_t^{\eta}] = \frac{1}{\gamma}\frac{\theta-1}{\theta}\frac{1-\alpha}{1-\alpha\beta} \tag{24}$$

Equation 24 gives the expected disutility of labour in terms of exogenous parameters. It could be demonstrated that this coincides with actual labour disutility in the corresponding economy without uncertainty. Thus, given that $\eta > 1$, Jensen's inequality proves that expected employment is below the certainty level and, implicitly, that nominal wages contain a risk premium component. Since marginal labour disutility increases with labour, unions exhibit aversion with respect to the uncertainty over next period labour demand. Accordingly, they fix nominal wages above the certainty level with the purpose of reducing expected marginal disutility.

To obtain an expression for actual employment, we multiply by L_t both terms in equation 23 and notice that W_t is known at time t-1:

$$W_t L_t E_{t-1}\left[\frac{L_t}{P_t C_t}\right] = \frac{\theta}{\theta-1}\gamma L_t E_{t-1}[L_t^{\eta}]$$

Then we substitute equation 24 in the above formula and note again that both wage income $W_t L_t$ and consumption expenditure $P_t C_t$ are proportional to nominal money. After some manipulations the following simple relationship emerges:

$$\frac{L_t}{M_t} = E_{t-1}\left[\frac{L_t}{M_t}\right]$$

The ratio between employment and money coincides with its expected value. Since the latter is a predetermined variable at time t, employment depends linearly on money supply:

$$L_t = \rho M_t \qquad \rho \equiv E_{t-1}\left[\frac{L_t}{M_t}\right]$$

To express ρ in terms of parameters and lagged variables, elevate to the power η both terms of the last equation and substitute in 24. The result at the end of this procedure is represented by the following reduced form for the employment level:

$$L_t = L_c \frac{1/\xi_t}{\left(E_{t-1}[1/\xi_t]^{\eta}\right)^{\frac{1}{\eta}}} \qquad L_c \equiv \left(\frac{1}{\gamma}\frac{\theta-1}{\theta}\frac{1-\alpha}{1-\alpha\beta}\right)^{\frac{1}{\eta}} \tag{25}$$

where L_c represents the certainty level of employment..

As one would expect, current money shocks affect employment and real activity. When money supply is above its expected value - $\xi_t < 1$ - prices increase and, given predetermination of nominal wages, real wages decrease. Firms respond to the demand perturbation by raising prices and production while unions are willing to supply the extra labour demanded since this increases their welfare.

4 Volatility, Growth and Inflation

In this section we explore three related issues, the link between monetary uncertainty and growth, the link between growth and the volatility of inflation and output and the link between the level of inflation and its variability. Although a large number of studies have addressed the second and the third issues, both on empirical and theoretical grounds, almost no attention has been devoted to the first. Yet, in the present context, we find that this imbalance of attention could turn out to be misleading in that the first represents a relationship deeply rooted in the working of the economy whilst the second and the third can be regarded as mere empirical counterparts of the first.

For the purpose of analysing the real dynamics of the economy we first observe that the growth path is completely described by the following equations:

$$Y_t = AK_tL_t^{1-\alpha}$$

$$K_{t+1} = \alpha\beta Y_t$$

$$L_t = L_n\frac{1}{\xi_t} \qquad L_n \equiv L_c\frac{1}{\left(E_{t-1}\left[1/\xi_t\right]^{\eta}\right)^{\frac{1}{\eta}}}$$

The first gives the aggregate production function obtained from 1 after imposing $H_t = K_t$. The second replicates equation 16 as it describes accumulation of capital and, after a slight modification, the third replicates the employment equation 25. L_n represents the "natural rate" of employment, that is the level of employment that prevails when agents correctly forecast the supply of money.

Taking logarithms, the rate of growth implied by above dynamics turns out to be given by:

$$g_t = \log Y_t - \log Y_{t-1} = c - (1-\alpha)\log \xi_t \qquad (26)$$

where $c \equiv \log A + (1-\alpha)\log L_n + \log(\alpha\beta)$

The rate of growth is then composed by a deterministic part c and a residual stochastic part due to changes in the level of employment. Implications of variable employment will be explored in the next section; here we concentrate on the study of the deterministic component. We first observe that the latter is given by the sum of three elements. Two of them - A and L_n - represent the size-growth effect typical of endogenous growth economies with a Romer-type externality. The third element - $(\alpha\beta)$ - represents instead the effect of private accumulation on the aggregate rate of growth.

Monopolistic wage setting reduces the deterministic component of growth through the restricted labour supply imposed by unions[10], as can be easily

[10] See Daveri and Tabellini (1997) for another example of an economy where unions affect the rate of growth trhough a reduction in the scale of production.

noticed by looking at equation 25. In this respect the effect of unionisation on growth is comparable to that of monetary uncertainty in that both affect negatively the level of natural employment. The impact of uncertainty emerges clearly in above formula for L_n. For a given L_c, natural employment decreases as money supply becomes more volatile. In fact, higher volatility leads risk-averse wage setters to raise their risk premium over the certainty-equivalent level of wages and this depresses employment[11].

We now turn to the relationship between growth and the volatility of inflation and output and between the level of inflation and its volatility. Two well known stylised fact in the field of empirical macroeconomics are that high nominal and real volatility appear to be associated with low growth and that high inflation appears to be associated with high inflation volatility. Explanations of these facts are abundant. The negative correlation between volatility and growth, for instance, is generally attributed to the detrimental effect of uncertainty on investments. The number of particular mechanisms which release this result is rather large as it ranges from the behaviour of risk-averse agents who refrain from long term contracts and inhibit relation specific investment (Al-Marhubi, 1998) to investment irreversibility which generates a preference to delay the installation of capital (Aizenman and Marion, 1993). Yet, as documented by Ramey and Ramey (1995), however, investments in the real world do not turn out to be negatively affected by volatility.

In the present context we propose a unified long term perspective which proves capable to rationalise these facts without relaying on arguments involving investments which, as implied by equation 16, represent at all times a constant fraction of output. To make the argument in a simple and clear way we assume that the money perturbation ξ is log-normally distributed with unit expected value and σ_ξ^2 variance parameter . Combining equations 22, 15 and 26 we may express the inflation rate as follows:

$$\pi_t = Constant + \frac{1-\alpha}{\gamma} \log\left[E_{t-1}(1/\xi_t)^\gamma\right] - \alpha \log(\xi_t)$$

so that the variance of π_t can be easily computed:

[11] Uncertainty reduces natural employment and the rate of growth. Therefore, in principle one could question the conduct of monetary policy as it is posed in the model. One possible answer is that the economy contains internal (structural) sources of noise that prevent full control on money supply.

$$Var(\pi_t) = \alpha^2 \log\left[\sigma_\nu^2 + 1\right]$$

On the other hand, we may compute the variance of the rate of growth from equation 26:

$$Var(g_t) = (1 - \alpha)^2 \log\left[\sigma_\nu^2 + 1\right]$$

We may clearly observe that an increase in money volatility increases both inflation and real growth volatility whereas above we noticed that an increase in money volatility depresses growth. In terms of reduced form this amounts to predict that growth and nominal/real volatility are negatively correlated through their structural link with money volatility.

Finally, we may also verify that the level of inflation and its variability are positively related. For this purpose we first report the expected value of inflation:

$$E_{t-1}\pi_t = constant + \frac{1 + \eta(1 - \alpha)}{2} \log\left[\sigma_\nu^2 + 1\right]$$

and notice that high money volatility induces high average inflation. The intuition behind this result is rather simple. The version of the quantitative theory of money represented by equation 22.suggests that in the long run, for a given rate of money growth, inflation turns out to be negatively correlated to real growth. Since we have proved that money volatility reduces the rate of growth, this amounts to state that money volatility increases the level of inflation. In fact, the link between expected inflation and the volatility of money becomes stronger as the risk parameter η increases. That is, the increase in risk aversion leads unions to ask an higher risk premium on wages thereby exacerbating the effect of uncertainty on growth and inflation. The link between the level of inflation and its volatility emerges therefore in reduced form since we have previously observed that the economy also displays the rather intuitive property that the volatility of inflation depends positively on that of money.

Summing up, the overall prediction of the model is that countries with a highly volatile conduct of monetary policy exhibit on average high inflation, high nominal and real volatility and low growth. By contrast, countries with stable monetary policy present on average low inflation, low nominal and real volatility and high growth.

5 Monetary Business Cycles and Growth

In a previous discussion we noticed that money affects short term employment and activity thanks to a short term nominal friction in the labour market. Equation 26, however, stretches this non-neutrality result to the long term by stating that perturbations enter the output dynamics with a unit root. Indeed, running forward the equation we obtain the following impulse response function:

$$\log Y_t = \log Y_0 + ct - (1 - \alpha) \sum_{\tau=0}^{t-1} \log \xi_{\tau+1}$$

As in Stadler (1990) and Benassy (1995), once the perturbation has shifted income away from its path, it never returns to it. Rather, it jumps to a new path in that it continues growing at the same deterministic rate but starting from a new position.

The explanation lies in the underlying endogenous growth process. As a positive shock hits the economy[12], employment increases above its natural level and lifts income above its long run level. To achieve precision, assume that the ratio between actual income and its long run level be "x". The higher level of output causes an increase in consumption and saving, i.e. next period capital. Moreover, since capital accumulates as a fixed proportion of income, the increase will result in a capital level x times above its long run path. In turn, given its effect on the productivity of labour, capital enters linearly next period production function. Therefore, conditional upon the absence of any further shocks, next period production will also be an x-multiple of its theoretical level on the former path.

Reproducing again the casual chain, we can prove that, if no further shock hits the economy, all future levels of income are x-multiple of their levels on the former path. In summary, constant returns to capital and proportional accumulation cause the economy to settle on a superior path with unchanged rate of growth. By contrast, with decreasing returns and away from the steady state, next period income would increase below x-times the level on the no-shock path and, as the time goes on, the economy would return to it. In this sense

[12] Notice that, given the assumed money process, shocks are expansive when $\xi < 1$.

endogenous technology acts as a unit root mechanism of propagation and even a short lived nominal friction can cause nominal perturbations to have permanent e¤ects.

6 Conclusions

We have presented a stochastic model of endogenous growth containing two main features, monopolistic competition in labour and good markets and a short term nominal rigidity in the form of wage contracts. Uncertainty arises from random money supply.

A …rst result attains to the depressing e¤ect of monopoly and monetary uncertainty on employment and growth. In particular, we show how uncertainty over future labour demand leads household-unions to add a risk premium to the wage so that average employment lies below the certainty level. Growth turns out to be a¤ected since, with the Romer-type technology, the level of employment a¤ects productivity of capital and, ultimately, its accumulation.

Second, we show that slow growth and high nominal/real volatility are not linked by a structural relationship but represent joint e¤ects of high monetary volatility. This is rather at odds with the common wisdom that volatility structurally reduces growth through the negative e¤ect on investments but one should also bear in mind that the latter is not supported by empirical analysis.

Third, we show how endogenous growth provides a propagation mechanism for output movements caused by pure short term employment changes. These, in turn, originate from monetary perturbations and thanks to short-lived wage contracts. This source of hysteresis is particularly relevant in the light of the empirical investigation of Nelson and Plosser (1982) as it implies that the link between business cycle and long run performance does not necessarily entail the dominance of permanent technological shocks. On conceptual grounds, the fact that we resort to the same microfountations commonly used in real business cycle models increases the robustness of these conclusions and proves the redundancy of all special assumptions used in other papers concerned with the same issue.

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