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Imperfectly Competitive Cycles with Keynesian and Walrasian Features

Leo Kaas
Paul Madden

Institut für Höhere Studien
Institute for Advanced Studies
Vienna

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Leo Kaas, Paul Madden

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Contact:

Leo Kaas
Current address:
Department of Economics
University of Vienna
Hohenstaufengasse 9
A-1010 Vienna, Austria
email: leo.kaas@univie.ac.at

Paul Madden
School of Economic Studies
Manchester University
Manchester M13 9PL, United Kingdom
email: Paul.Madden@man.ac.uk

Abstract

We consider a multi--sector overlapping generations model with imperfectly competitive firms in the output markets and wage setting trade unions in the labour markets. A coordination problem between firms creates multiple temporary equilibria which are either Walrasian or of the Keynesian unemployment type. There exist many deterministic and stochastic equilibrium cycles fluctuating between Keynesian recession and Walrasian boom periods with arbitrarily long phases in each regime. The cycles are in accordance with certain empirical regularities. Money is neutral and superneutral, but appropriate countercyclical fiscal policies stabilize the cycles in a textbook Keynesian way.

Keywords

Endogenous business cycles, imperfect competition, endogenous business cycles, imperfect competition, stabilization policy

JEL Classifications

D43, E32, E62

Comments
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Contents

1 Introduction

In this paper we consider a dynamic macroeconomic model of imperfect competition and show that it exhibits multiple equilibria and endogenous business cycles fluctuating between regimes of Keynesian unemployment and Walrasian full employment. We investigate how fiscal policy affects the equilibrium cycles and show that appropriate policies stabilize the business cycles in a standard Keynesian way.

Our multiplicity result emerges from a coordination problem between firms competing in a homogenous product market who face an input supply constraint on the labour market. Consider an elementary Cournot model of a homogeneous output market with N identical firms where production takes place under symmetric, constant marginal cost. Specifically suppose the firms produce output from a homogeneous labour service under unit constant returns (so "output=labour input"), and the constant marginal cost is then some exogenously fixed wage rate w. Suppose also that only these N firms employ this labour service, and that the supply of labour at w exceeds the Cournot–Nash aggregate output (=employment) level, so there is Keynesian unemployment on the fixed wage labour market.[1] With the same wage w suppose now that firms wish to demand much more labour, so that the labour demand from any $(N-1)$ firms exceeds the labour supply at w. In a number of models which analyse such a fixed–wage Cournot scenario (most explicitly in d'Aspremont, Dos Santos Ferreira and Gérard–Varet (1989, 1995), Kaas (1998), Schultz (1992)), it is simply assumed to be infeasible for firms to offer such labour demands. Here we assume instead, as seems at least reasonable for a fixed–wage labour market, that excess demands/supplies are rationed according to some well–

[1]For instance, suppose $N = 2$ and inverse output demand is $p = 1 - (y_1 + y_2)$ where y_i is the output and $\ell_i = y_i$ is the employment at firm $i = 1, 2$. If L is labour supply at the fixed wage w, there is unemployment at the Cournot–Nash equilibrium if $2(1 - w)/3 < L$, or $w > 1 - 3L/2$. (The paper will use CES derived demand rather than linear).

behaved rationing mechanism. With the excess labour demand indicated above, it follows that variations in any one firm's labour demand will have no effect on aggregate employment (which remains equal to aggregate labour supply at w), and hence no effect on aggregate output or its price. Price responses to individual firm output variations are now essentially Walrasian in nature, and it is easy to show that plausible rationing assumptions produce a range of wages at which there exist both a Cournot–Nash style equilibrium with Keynesian unemployment and a Walrasian style equilibrium with full employment.[2]

Now suppose all this happens in each sector of a multi–sector overlapping generations economy where a sectoral trade union sets the wage in each period prior to the firms in that sector engaging in our fixed–wage Cournot game. Union wage demands depend on whether firms coordinate on the full employment or the unemployment continuation after wages which produce two continuations; multiple temporary equilibria emerge immediately. Assuming that a commonly observed extraneous "sunspot" signal ("boom" or "recession") dictates the selection of the continuation, we show that under laissez–faire, although the model has a unique steady state equilibrium which is Walrasian, there exists also a multiplicity of (deterministic and stochastic) rational expectations equilibria with endogenous cycling between boom periods of Walrasian full employment and recession periods of Keynesian unemployment (Theorem 1). Moreover, traditional Keynesian countercyclical fiscal policies (e.g. positive government expenditure in recessions but not in booms) can generate traditional responses, i.e. unit multipliers when the budget is balanced by lump–sum taxes in each period (Theorem 2) which become greater than one with

[2]Continuing footnote 1, if firm j's labour demand is at least L and that of firm i is J_i, a plausible "symmetric" rationing specification has $\ell_i = J_i$, $\ell_j = L - J_i$ if $J_i \leq L/2$ and $\ell_i = \ell_j = L/2$ if $J_i \geq L/2$. Any $J_i \geq L$ (e.g.) is a best response for i if $1 - L - w \geq 0$, since i's profit is then $(1 - L - w)L/2$ and deviations have no effect on price $(1 - L)$ and cannot increase ℓ_i. Thus the model has 2 Nash equilibrium employment/output levels if $1 - L \geq w > 1 - 3L/2$.

unbalanced budgets at the beginning of a recession, balanced by lump–sum taxes at the end (Theorem 3).

The literature contains a number of models which generate multiple equilibria and/or endogenous business cycles from varying imperfect competition assumptions (see Silvestre (1995) for a relevant survey). Closest to our model are the overlapping generations models of d'Aspremont, Dos Santos Ferreira & Gérard-Varet (1995), Jacobsen (2000) and Rivard (1994),[3] in all of which the cycles require some gross complementarity in demand, or increasing returns to labour.[4] A novelty of our paper is that we need no such assumptions, the cycles emerging (with gross substitutes and constant returns) from the multiple equilibria of the fixed wage Cournot game which needs nothing "unusual" in fundamentals.[5] Because of the multiple temporary equilibria, the backward (and forward) dynamics of our model follows a set–valued difference equation (i.e., the right hand side is a correspondence rather than a function), where the selection from the correspondence is dictated by the deterministic or stochastic sunspot (boom or recession) series. A large set (an infinity) of deterministic cycles emerges which are all locally determinate (stable in the

[3] Also close to our model in the sense that they embody essentially the same fixed–wage Cournot idea but with wage–setting firms rather than trade unions are Gaygisiz & Madden (1997) where the labour market is spatially differentiated and multiple steady–states emerge, and the static model of Kaas & Madden (1999) where the labour market is homogeneous but involuntary unemployment results despite the absence of trade unions.

[4] Gross complement assumptions are required in Jacobsen (2000), as they are for the perfectly competitive cycles of Benhabib & Day (1982) and Grandmont (1985). Rivard (1994) assumes increasing returns, d'Aspremont et al. (1995) assume either increasing returns or gross complementarity.

[5] In the wider multiple equilibrium literature, features of other models which create multiplicities are also absent from our paper, including (again) the increasing returns of Kiyotaki (1988), Manning (1990, 1992), Rivard (1994), the differing elasticities of consumption and investment demand of Gali (1994) and the strategic complementarity in the entry of new firms of Chatterjee, Cooper & Ravikumar (1993).

backward perfect foresight dynamics), as well as nearby stochastic equilibria.[6] Our fluctuations are thus very much dependent on "animal spirits". However, a second important novelty of the paper compared with existing endogenous business cycle models is that (almost) all of our cycles have in common the business cycle asymmetries of steepness, deepness and sharpness (McQueen & Thorley (1993), Sichel (1993)), as well as exhibiting the empirically plausible co–movement of procyclical vacancies (plus procyclical real wages, inflation and countercyclical markups).

Although money is neutral and superneutral – as in other models of perfect and imperfect competition with rational expectations but without nominal rigidities – our Keynesian fiscal policy results stand in contrast to other models of the literature in which policy responses are of a more Walrasian nature. Dixon (1987), Mankiw (1988) and Benassy (1995) consider general equilibrium models of imperfect competition and find positive balanced–budget multipliers less than one. In their models, the positive effect on output follows from a stimulation of labour supply since a higher tax burden causes a lower demand for leisure, provided that leisure is a normal good.[7] Jacobsen & Schultz (1994) consider an overlapping generations model with an imperfectly competitive labour market and show that fiscal policy can only affect output when the public and the private demand elasticities differ. If these elasticities are equal, there is full crowding out since price changes completely offset the increase in aggregate demand. In our model, a higher (lump–sum) tax burden has no effect on labour supply, and prices and wages are unaffected by the fiscal policy during recessions. Therefore, our model has unit multipliers and reproduces the

[6]Azariadis & Smith (1998) consider a Diamond–type growth model with multiple temporary equilibria in which the dynamics is also described by a set–valued difference equation and in which an infinity of locally stable cycles fluctuating between two regimes emerges.

[7]Similar labour supply effects are also at work in the Walrasian OLG economies of Grandmont (1986) and Aloi, Jacobsen & Lloyd-Braga (2000) who show that appropriate monetary and fiscal policy rules can stabilize endogenous fluctuations.

policy result of the seminal article of Hart (1982) in a dynamic general equilibrium model.

The paper is organized as follows. In the next section we introduce the model and show how the coordination problem of the fixed–wage Cournot game leads to multiple temporary equilibria. In Section 3 we characterize intertemporal equilibria and prove the existence and multiplicity of laissez–faire cycles. Section 4 contains our policy results and Section 5 concludes. All proofs not included in the text are contained in Appendix A.

2 The model

Consider an overlapping generations model in discrete time $t = 0, 1, 2, \ldots$, in which there are three types of goods, labour, output and fiat money. There is a continuum of sectors $s \in [0, 1]$ each of which comprises one wage–setting union and $N > 1$ price–setting firms producing the sector output from sector–specific labour. In each period and in each sector a continuum $[0, L]$ of two–period living consumers is born who supply labour in the first period of their life and who consume in both lifetime periods. The labour endowment of each consumer possesses specific attributes which allows him to be employed only in his sector, but not elsewhere. However, consumers receive profit income from various sectors (a negligible fraction coming from any one sector) and they consume output of all sectors. To finance future consumption, consumers save part of their income as fiat money. There is a government who consumes output goods, levies a lump–sum tax on young consumers, pays a nominal interest rate on money holdings (or taxes money holdings), and finances its deficit by seignorage.

Both the labour and the output market are imperfectly competitive. Each sectoral output market is characterized by the fixed–wage Cournot competition of the introduction. Firms take the sector wage as given which is set by the sector trade union at a preceding stage. Thus, in each period we consider a two–stage game between the monopolistic trade union and the N firms in each sector.

In the rest of this section, we first describe the consumers' behaviour and derive from it the objective output demand and labour supply functions. Then we formulate the game between the union and the firms whose equilibrium solution leads to the definition of a temporary equilibrium.

The consumers

Each consumer born in period t has an endowment of one unit of indivisible sector–specific labour and receives when young wage and profit income. Preferences of all young consumers are identical and are represented by the utility function

$$u(C_t, C_{t+1}) - b\ell_t \ ,$$

$$C_t = \Big(\int_0^1 c_{st}^{(\rho-1)/\rho} ds \Big)^{\rho/(\rho-1)} \ , \ C_{t+1} = \Big(\int_0^1 c_{s,t+1}^{(\rho-1)/\rho} ds \Big)^{\rho/(\rho-1)} \ ,$$

where c_{st} and $c_{s,t+1}$ denote consumption of sector s output in period t, $t+1$ respectively, $\rho > 1$ is the elasticity of substitution between sector outputs, $\ell_t \in \{0, 1\}$ is labour supply, and $b \geq 0$ is disutility of work. The function u is assumed to be twice differentiable, strictly quasi–concave, strictly monotone, homogenous of degree one, and such that indifference curves do not cut the axes.

Each young consumer supplying labour in sector $\hat{s}$ takes the sector wage $w_{\hat{s}t}$ as well as prices of output goods p_{st} as given and forecasts future prices $p_{s,t+1}$ correctly. Let R_{t+1} denote the gross nominal interest rate on money holdings from t to $t+1$ (which is a tax if $R_{t+1} < 1$). Each young consumer faces the budget constraints

$$\begin{aligned} \int_0^1 p_{st} c_{st} ds + \mu_t &\leq w_{\hat{s}t}\ell_t + \pi_t - \varphi_t \ , \\ \int_0^1 p_{s,t+1} c_{s,t+1} ds &\leq R_{t+1}\mu_t \ , \end{aligned}$$

where φ_t is a lump–sum tax, π_t is the consumer's profit income and μ_t is his money savings.

Output demand

Since all young consumers have identical homothetic preferences, the consumption demand for sector s output of all young consumers is

$$D_{st}^{Y} = \Big(\frac{p_{st}}{P_t}\Big)^{-\rho} c\Big(\frac{P_{t+1}}{P_t R_{t+1}}\Big)\frac{I_t^n}{P_t}\ ,$$

where

$$P_t = \Big(\int_0^1 p_{st}^{1-\rho} ds\Big)^{1/(1-\rho)} \quad , \ P_{t+1} = \Big(\int_0^1 p_{s,t+1}^{1-\rho} ds\Big)^{1/(1-\rho)}$$

are the aggregate price levels in period t and $t+1$, I_t^n is the aggregate net (wage and profit) income of young consumers in period t, and $c : (0,\infty) \to (0,1)$ is the propensity to consume, i.e. the fraction of income to be spent on first period consumption as a function of the real interest rate. Let M_{t-1} denote the aggregate money savings of the old generation at the beginning of period t and let $g_t = (\int_0^1 g_{st}^{(\rho-1)/\rho} ds)^{\rho/(\rho-1)}$ be the aggregator of government consumption (real government demand). Then the consumption demand of the old consumers and of the government[8] are

$$D_{st}^{O} = \Big(\frac{p_{st}}{P_t}\Big)^{-\rho}\frac{M_{t-1}R_t}{P_t} \quad \text{and} \quad D_{st}^{G} = \Big(\frac{p_{st}}{P_t}\Big)^{-\rho} g_t.$$

The aggregate demand for sector s output can be written

$$D_{st} = D_{st}^{Y} + D_{st}^{O} + D_{st}^{G} = \Big(\frac{p_{st}}{P_t}\Big)^{-\rho} Y_t$$

where

$$Y_t = c\Big(\frac{P_{t+1}}{P_t R_{t+1}}\Big)\frac{I_t^n}{P_t} + \frac{M_{t-1}R_t}{P_t} + g_t$$

[8]The sector demand of the government can be obtained either as the solution of the expenditure minimization problem subject to a given level of real government demand g_t or as the solution of the maximization of government consumption g_t subject to a given budget. Notice that the demand elasticities of the government and of consumers are the same, and so we have no elasticity effects of fiscal policy unlike Jacobsen & Schultz (1994).

is aggregate demand. If firms do not ration demand (which will be a property of equilibrium), aggregate sector output y_{st} equals demand D_{st}, and therefore the aggregate net income can be written $I_t^n = \int_0^1 p_{st} y_{st} ds - \varphi_t L = P_t(Y_t - \tau_t)$ where $\tau_t := (\varphi_t L)/P_t$ denotes the aggregate real lump–sum tax. Using the government's budget constraint $M_t = M_{t-1}R_t + P_t g_t - P_t \tau_t$, we obtain the aggregate demand identity

$$Y_t = \frac{M_t}{P_t\Big(1 - c\big(\frac{P_{t+1}}{P_t R_{t+1}}\big)\Big)} + \tau_t \ . \qquad (1)$$

Notice that Y_t is increasing in the real lump–sum tax. This is due to the fact that M_t denotes the money holdings at the end of the period, and therefore a higher real lump–sum tax τ_t at a given level of M_t increases the autonomous demand $M_{t-1}R_t/P_t + g_t$ by the same amount and is partially offset by the decrease of the demand of young consumers $c(.)I_t^n/P_t$.

Labour supply

The utility of a young individual in sector s who consumes optimally can be written

$$\frac{w_{st}\ell_t + \pi_t - \varphi_t}{P_t f\big(\frac{P_{t+1}}{P_t R_{t+1}}\big)} - b\ell_t \ ,$$

where $f(\theta) := 1/u(c(\theta), (1 - c(\theta))/\theta)$ is strictly increasing. Thus, all consumers in sector s want to supply labour if the wage exceeds the reservation wage of workers, $w_{st} > w_t^r := bP_t f(P_{t+1}/(P_t R_{t+1}))$, so in this case labour supply is $L_{st} = L$. If $w_{st} < w_t^r$ labour supply is $L_{st} = 0$, and if $w_{st} = w_t^r$, labour supply can be any $L_{st} \in [0, L]$.

The firms

In each sector s, the firms $j = 1, \ldots, N$ produce the sector output y_{st}^j from labour input ℓ_{st}^j at constant returns to scale with identical labour productivity across sectors, so

$$y^j_{st} = A\ell^j_{st}\ ,\ j = 1, \dots, N.$$

Firms take the nominal sector wage w_{st} set by the trade union as given. Firms also take the aggregate price level P_t, aggregate demand Y_t and the correctly perceived real gross interest rate $P_t R_{t+1}/P_{t+1}$ as given since deviations by firms in one sector do not affect any of these. Therefore, firms face on the labour market the labour supply constraint L_{st} and on the output market the uniformly elastic demand curve $D_{st} = (p_{st}/P_t)^{-\rho} Y_t$.

We consider the following game between firms after the trade union has set the sector wage. Firms simultaneously demand labour $J^j_{st} \geq 0$. If aggregate labour demand is not equal to the labour supply, one market side has to be rationed. If the labour supply exceeds demand, $L_{st} > \sum_{j=1}^N J^j_{st}$, some workers are involuntarily unemployed and the employment levels are $\ell^j_{st} = J^j_{st}$. If there is excess demand for labour, $L_{st} < \sum_{j=1}^N J^j_{st}$, all workers willing to work are employed, but firms are rationed. We assume that firms are uniformly rationed, i.e. each firm faces a uniform non–manipulable employment constraint $\bar{c}_{st} = \bar{c}(J^1_{st}, \dots, J^N_{st}; L_{st}) \geq L_{st}/N$ such that $\ell^j_{st} = \min(J^j_{st}, \bar{c}_{st})$ and $\sum_{j=1}^N \ell^j_{st} = L_{st}$.

From the labour allocated to firms, firms produce outputs $y^j_{st} = A\ell^j_{st}$, and the aggregate sector output $y_{st} = \sum_{j=1}^N y^j_{st}$ is then sold at the market clearing price

$$p_{st} = P_t \Big(\frac{y_{st}}{Y_t}\Big)^{-1/\rho}\ . \tag{2}$$

This price would also be set by firms if firms would set prices simultaneously at a subsequent stage.[9]

[9] Unlike the result of Kreps & Scheinkman (1983), this result does not depend on the way consumers' demand is rationed at asymmetric prices (efficient, proportional etc.) and ensures that the Bertrand price setting produces an essentially Cournot outcome whenever demand is uniformly elastic (see Madden (1998)).

Thus, we consider Nash equilibria of the game between firms in sector s who simultaneously demand labour $(J^j_{st})_{j=1,\dots,N}$ and make profits

$$\pi^j = P_t\Big(\frac{A\sum_{i=1}^N \ell^i_{st}}{Y_t}\Big)^{-1/\rho} A\ell^j_{st} - w_{st}\ell^j_{st} \quad \text{where} \quad \ell^j_{st} = \min(J^j_{st}, \bar{c}_{st}) \ .$$

An important feature of this fixed–wage Cournot game is that it possesses, for a certain range of wages, multiple Nash equilibria. If the wage is sufficiently high, there exists an equilibrium with involuntary unemployment which coincides with the Cournot equilibrium in which firms directly compete in employment/output ignoring the labour supply constraint. But at the same wage there may also exist a full employment equilibrium in which firms create an excess demand for labour. If the aggregate labour demand is large, the employment/output decision of a single firm has no effect on aggregate employment and output which remain at their full employment levels, even when a single firm decides not to produce. Thus, the quantity decision of each firm does not affect the resulting output price, and therefore all firms effectively behave as if they were price takers. As a result, each firm is willing to expand its demand for labour as long as the wage is less than or equal to the perfectly competitive sector wage. This wage is defined by price–taking behaviour of firms and sector output and labour market clearing and is the same across all sectors:

$$w^c_t := AP_t\Big(\frac{Y_t}{AL}\Big)^{1/\rho} \ .$$

Formally, these results are stated in the following Proposition in which we restrict attention to wages above the reservation wage.

Proposition 1: Suppose $w_{st} \geq w^r_t$. Then

(a) If $w_{st} > \dfrac{\rho N - 1}{\rho N} w^c_t$, there exists a Nash equilibrium of the fixed–wage Cournot game in sector s with involuntary unemployment in which

$$\sum_{j=1}^N J^j_{st} = \sum_{j=1}^N \ell^j_{st} = \ell_{st} = \Big(\frac{\rho N - 1}{\rho N}\frac{w^c_t}{w_{st}}\Big)^\rho L < L \quad \text{and} \quad p_{st} = \frac{\rho N}{\rho N - 1}\frac{w_{st}}{A} \ .$$

(b) If $w_{st} \leq w_t^c$, there exists a Nash equilibrium of the fixed–wage Cournot game in sector s with full employment where

$$J_{st}^j \geq \frac{L}{N-1} \ , \ j = 1, \ldots, N, \ \sum_{j=1}^{N} \ell_{st}^j = \ell_{st} = L \quad \text{and} \quad p_{st} = P_t \Big(\frac{Y_t}{AL}\Big)^{1/\rho} \ .$$

The relation between the sector wage w_{st} and sector employment in the Nash equilibria of Proposition 1 is illustrated in Figure 1. For wages in the interval $(w_t^c(\rho N-1)/(\rho N), w_t^c]$ there exist two Nash equilibria. We assume that firms coordinate on one of these equilibria in accordance with an exogenous (sunspot) state S_t. More specifically, in case of a "boom" state $S_t = \mathrm{B}$ we assume that firms believe in tight labour market conditions leading to excess demand for labour and full employment for all $w_{st} \leq w_t^c$, such that the equilibrium of type (b) in Proposition 1 emerges. In case of a "recession" state $S_t = \mathrm{R}$, firms believe in slack labour market conditions producing involuntary unemployment for all $w_{st} > w_t^c(\rho N - 1)/(\rho N)$. Obviously, for all wages $w_{st} > w_t^c$ an unemployment equilibrium follows and for all wages $w_{st} \leq w_t^c(\rho N-1)/(\rho N)$ a full employment equilibrium results, irrespective of the state R or B.[10]

The unions

We assume a utilitarian union maximizing the integral of the utilities of the workers in its sector. Since by assumption workers in each sector receive (almost all) profit income in other sectors, the union does not care about the profit income in its sector. Thus, the union sets the sector wage w_{st} in order to maximize the objective function $\ell_{st}(w_{st} - w_t^r)$.

The union observes the exogenous state S_t and anticipates the labor demand behaviour of firms in this state. Hence it maximizes $\ell_{st}(w_{st} - w_t^r)$ subject to

$$\ell_{st} = L \ , \ \text{if } w_{st} \leq w_t^c, \quad \ell_{st} = \Big(\frac{\rho N - 1}{\rho N}\frac{w_t^c}{w_{st}}\Big)^{\rho} L \ , \ \text{if } w_{st} > w_t^c \quad , \ \text{in state } S_t = \mathrm{B} \ ,$$

[10]Of course there are many more possible selection rules between the two equilibria, but this rule is the only one for which the selection is independent of the sector wage.

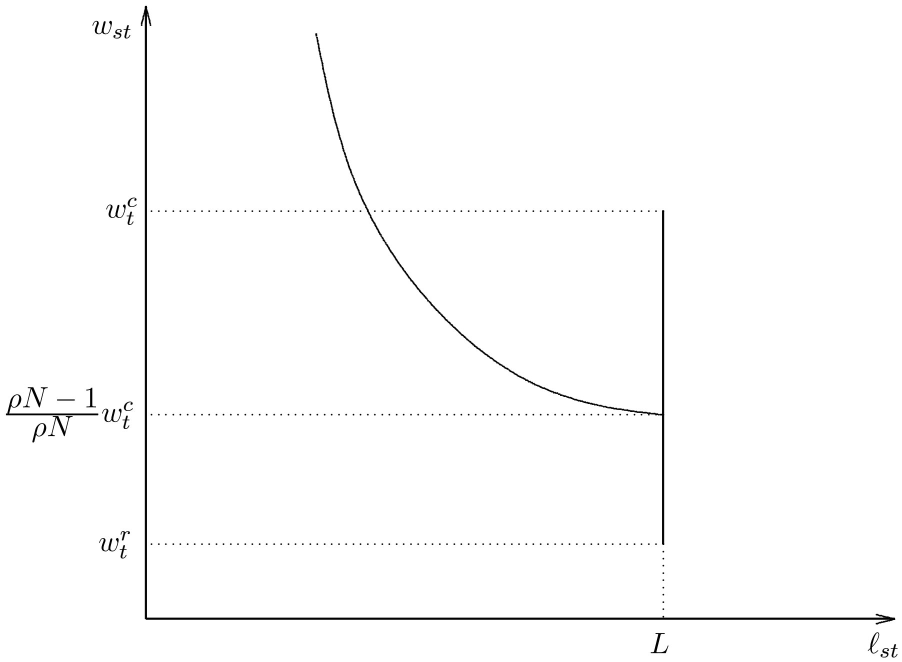

Figure 1: Relation between sector employment and the sector wage.

$$\ell_{st} = \min\Big(1, \Big(\frac{\rho N - 1}{\rho N}\frac{w_t^c}{w_{st}}\Big)^{\rho}\Big)L \quad , \text{ in state } S_t = \text{R} .$$

The solution of this problem is stated in the following Proposition.

Proposition 2:

(a) If $S_t = \text{R}$, the union's optimal sector wage is

$$w_{st} = \max\Big(\frac{\rho}{\rho - 1}w_t^r, \frac{\rho N - 1}{\rho N}w_t^c\Big) .$$

(b) If $S_t = \text{B}$, there exists a unique $z \in (1, \rho/(\rho - 1))$, such that the union's optimal sector wage is $w_{st} = w_t^c$ if and only if $w_t^c \geq z w_t^r$. If $w_t^c < z w_t^r$, the union's optimal sector wage is $w_{st} = \rho w_t^r/(\rho - 1)$.

The temporary equilibrium

We are now ready to formulate the temporary equilibrium of this economy in a period t which is defined as an equilibrium of prices, wages, employment and output given expectations about future prices and interest rates and a realization of the sunspot state S_t, where we impose the assumption that all sectors coordinate on the same exogenous state B or R. Proposition 2 then implies that unions in all sectors set the same wage $w_{st} = w_t$, and Proposition 1 implies that employment levels, outputs and prices in all sectors coincide: $\ell_{st} = \ell_t$, $y_{st} = y_t = Y_t = A\ell_t$, and $p_{st} = p_t = P_t$.

Suppose that state R prevails in period t. Then from Proposition 1 (a), Proposition 2 (a), and the definitions of w_t^r and w_t^c, a temporary equilibrium (P_t, w_t, Y_t) satisfies the aggregate demand identity (1) and

$$w_t = \max\Big(\frac{P_t b\rho}{\rho-1} f\Big(\frac{P_{t+1}}{P_t R_{t+1}}\Big), \frac{\rho N - 1}{\rho N} A P_t \Big(\frac{Y_t}{AL}\Big)^{1/\rho}\Big) \quad , \; P_t = \frac{\rho N}{\rho N - 1}\frac{w_t}{A} \; . \tag{3}$$

Notice that there is unemployment if the maximum is attained by the first term in the bracket. In the terminology of the literature on disequilibrium macroeconomics (see e.g. Benassy (1993)), such an equilibrium is of the Keynesian unemployment type since there is an "excess supply" on the labour and on the output market (more precisely, at the prevailing prices firms would want to sell more output and households would want to work more). If the maximum is attained by the second term in the bracket, there is a full employment equilibrium which is a boundary case between the regimes of Keynesian unemployment and repressed inflation. Output and prices are at their Walrasian temporary equilibrium levels, but the money wage is lower, and profits and the markup are positive.

If state B prevails in period t, the condition $w_t^c \geq z w_t^r$, which is according to Proposition 2 (b) required for a full employment equilibrium, turns out to be

$$A \geq zbf\Big(\frac{P_{t+1}}{P_t R_{t+1}}\Big) \; . \tag{4}$$

Hence, in this case a temporary equilibrium (P_t, w_t, Y_t) is a Walrasian equilibrium satisfying (1), (4), $Y_t = AL$, and $w_t = AP_t$. There may also exist a Keynesian unemployment equilibrium in state B satisfying again (1) and (3), in which case the condition $w_t^c < zw_t^r$ is equivalent to

$$Y_t < AL(z-1)(\rho-1) \quad . \tag{5}$$

3 Intertemporal equilibria and endogenous cycles

We assume now that the sequences of policy parameters (R_t), (g_t), (τ_t), an initial stock of money M_0, and a sequence of states (S_t) are given, and we are interested in the set of intertemporal equilibria with perfect foresight. Denoting the real balance by $m_t = M_t/P_t$, the government's budget constraint can be expressed as

$$P_{t+1}(m_{t+1} - g_{t+1} + \tau_{t+1}) = m_t R_{t+1} P_t \ . \tag{6}$$

Using this identity, the aggregate demand equation (1) is rewritten as

$$Y_t = \frac{m_t}{1 - c(m_t/(m_{t+1} - g_{t+1} + \tau_{t+1}))} + \tau_t \ . \tag{7}$$

Using the notation

$$\alpha := \frac{1}{f^{-1}(A(\rho N - 1)(\rho - 1)/(bN\rho^2))} \quad \text{and} \quad \delta := \frac{1}{f^{-1}(A/(bz))} \ (< \alpha) \quad ,$$

the conditions (3)–(5) can be expressed more conveniently as follows. If $S_t = \mathrm{R}$, it follows from (3) that there is a Keynesian unemployment equilibrium if

$$m_{t+1} - g_{t+1} + \tau_{t+1} = \alpha m_t \quad \text{and} \quad Y_t < AL \ , \tag{8}$$

and that there is full employment if

$$m_{t+1} - g_{t+1} + \tau_{t+1} \geq \alpha m_t \quad \text{and} \quad Y_t = AL \ . \tag{9}$$

If $S_t = \mathrm{B}$, (4) implies that there is a (Walrasian) full employment equilibrium if

$$m_{t+1} - g_{t+1} + \tau_{t+1} \geq \delta m_t \quad \text{and} \quad Y_t = AL \ , \tag{10}$$

and (3) and (5) imply that there is Keynesian unemployment if

$$m_{t+1} - g_{t+1} + \tau_{t+1} = \alpha m_t \quad \text{and} \quad Y_t < (z-1)(\rho-1)AL \; . \tag{11}$$

The conditions (8)–(11) together with (7) show that the set of intertemporal equilibria, for a given sequence of states S_t and fiscal parameters (g_t, τ_t), is independent (in real terms) of the initial money stock and of the sequence of nominal interest rates. Thus, money is neutral and superneutral, as is the case in competitive overlapping generations models (see Grandmont (1986)).[11] In the rest of this section we show how the model produces endogenous cycles and we suppose the "laissez–faire" case in which the government engages in no fiscal policy (LF):

(LF) For all $t \geq 0$, $g_t = \tau_t = 0$.

In this case, the bold curves in Figure 2 illustrate the equilibrium conditions (8)–(11). The line OAC indicates the condition $m_{t+1} = \delta m_t$, the line OBD indicates the condition $m_{t+1} = \alpha m_t$. The curve OABE is the Walrasian equilibrium condition

$$Y_t = \frac{m_t}{1 - c\left(\frac{m_t}{m_{t+1}}\right)} = AL \tag{12}$$

if consumption in period t and $t+1$ are gross substitutes, i.e. $c' > 0$ (for instance, if u is CES with elasticity of substitution greater than 1). Condition (8) is described by the line OB, (9) by the curve BE, (10) by the curve ABE, and (11) by some segment of OB below B. A full employment equilibrium on BE can be compatible with condition (9) (in state R) or with condition (10) (in state B).

[11] It is worth mentioning that money need neither be neutral nor superneutral in models of imperfect competition, even if there are no menu costs or other nominal rigidities, as has been stressed by Rankin (1992) and Rankin (1995). Rankin's results are due to the sensitivity of perfect foresight equilibria to the price forecast functions of consumers. These effects play no role in our model, however, since changes of the price in one sector will not affect the aggregate future price level under any reasonable assumption on the forecasting behaviour of consumers.

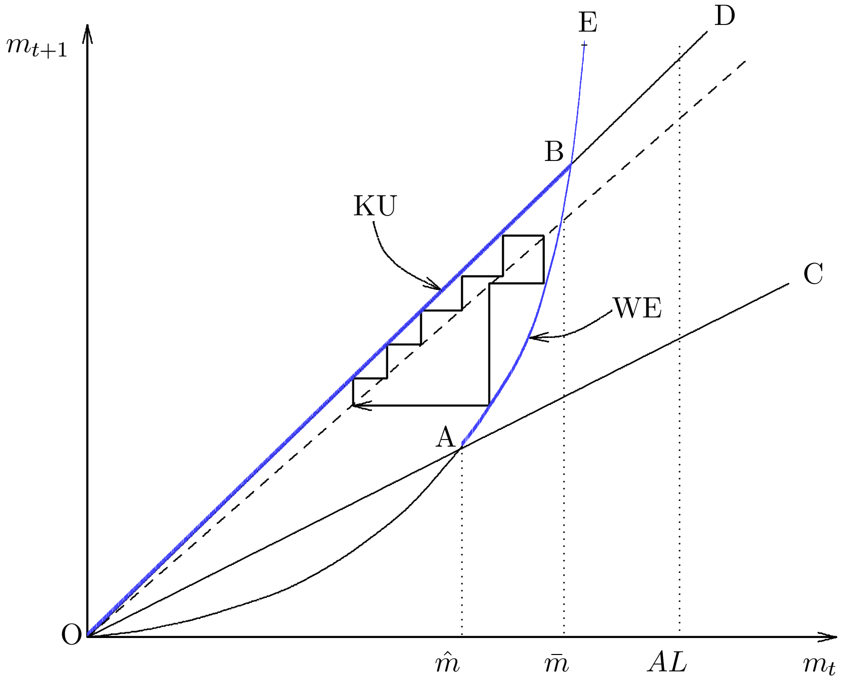

Figure 2: The equilibrium curves and a cycle of order 7.

It can be seen from Figure 2 that there are generically only steady states with full employment. When $\delta < 1$ and $\alpha \neq 1$, there exists a unique steady state $\bar{m}$ in which S_t = B for all t and which is stable in the backward perfect foresight dynamics. However, there is much scope for equilibrium cycles fluctuating between Walrasian equilibria (WE) in boom states and Keynesian unemployment equilibria (KU) in recession states. More specifically, whenever $\delta < 1$ and $\alpha > 1$, there may exist cycles between the curves OB and AB. Figure 2 illustrates a (deterministic) cycle of order 7 in which firms coordinate in five successive periods on state R and in two successive periods on state B. Below we will prove an existence theorem for general (k, l) cycles which are defined as deterministic cycles of order $k + l$ with k successive recession periods and l successive boom periods.[12] All (k, l) cycles turn

[12]There are of course many more cycles fluctuating between recessions and booms more than once until they return back to their starting point or even irregular cycles, but they will not be

out to be asymptotically stable in the local backward perfect foresight dynamics, so they are also stable in the dynamics under adaptive learning under some mild assumptions on the forecast function (see Grandmont & Laroque (1986)). There exist also non–degenerate stationary sunspot equilibria close to these cycles.

We assume gross substitutes (i.e. $c' > 0$, and so savings are increasing in the real interest rate) and define $c(0) = \underline{c}$ and $c(\infty) = \overline{c}$. Then the Walrasian equilibrium condition (12) can be rewritten as $m_{t+1} = \beta(m_t)$ where $\beta(m) := m/(c^{-1}(1 - m/(AL)))$ is defined for $m \in ((1 - \overline{c})AL, (1 - \underline{c})AL)$ and is increasing. Let $\bar{m}$ be the fixed point of β, let $\hat{m}$ be the unique solution of $\beta(\hat{m}) = \delta\hat{m}$ (see Figure 2) and define $\hat{m}_l := \beta^{-(l-1)}(\hat{m}) < \bar{m}$. Obviously, a sequence $m_1, \ldots, m_k, m_{k+1}, \ldots, m_{k+l}$ is a (k, l) cycle (along which the first k states are R and the remaining l states are B) if and only if m_{k+1} is a fixed point of the map $\psi(m) := \alpha^k \cdot \beta^l(m)$ in the interval $[\hat{m}_l, \bar{m}]$ (m_{k+1} must not be smaller than $\hat{m}_l$ since then the $(l-1)$th iterate of β at m_{k+1} would be smaller than $\hat{m}$). The Theorem below shows that a necessary and sufficient condition for such a fixed point is that $\psi(\hat{m}_l) \leq \hat{m}_l$. A consequence of this result is that the existence of $(k, 1)$ cycles depends only on the parameters α and δ and that the existence of a $(k, 1)$ cycle implies that there exist infinitely many cycles with arbitrary many boom periods and at most k recession periods.[13]

Theorem 1: Let $c' > 0$, assume that the government follows the policy rule (LF), assume $\delta < 1 < \alpha$ and let $(k, l) \geq (1, 1)$. Then there exists a unique (k, l) cycle if and only if $\psi(\hat{m}_l) \leq \hat{m}_l$. A $(k, 1)$ cycle exists if and only if $\alpha^k\delta \leq 1$, and whenever a $(k, 1)$ cycle exists, then there exists also a (k', l) cycle for any $1 \leq k' \leq k$ and any $l \geq 1$. If a (k, l) cycle is interior, i.e. if the inequality in (10) is strict along the cycle,

considered here.

[13]Theorem 1 can easily be extended to the case of a Cobb–Douglas utility function in which c is constant and β and ψ are not defined (the curve OABE in Figure 2 is then a vertical line). A necessary and sufficient condition for the existence of a (k, l) cycle in this case is simply $\alpha^k\delta \leq 1$.

it is asymptotically stable in the local backward perfect forward dynamics and there exist non–degenerate stationary sunspot equilibria of cardinality $k + l$ close to this cycle.

The cycles of our model can exhibit some stylized features of business cycles. First, our cycles exhibit some types of business cycle asymmetries, as illustrated in Figure 3 showing the output time series of a (5,3) cycle. The first period of a recession is characterized by a large fall in output followed (when $k > 1$) by a gradual climb back to full employment. Moreover when $l > 1$, troughs are deeper than peaks are tall (i.e. there is negative skewness relative to the mean). Hence, the cycles exhibit steepness and deepness (see Sichel (1993)). They also exhibit sharpness (see McQueen & Thorley (1993)) since (when $l > 1$) growth rate changes at troughs are larger than at peaks. Second, booms are characterized by excess demand for labour, which can be interpreted as vacancies, unlike recessions: thus procyclical vacancies emerge. Third, since real wages are higher in booms than recessions we have procyclical real wages and countercyclical markups. Fourth, (6) implies that inflation is procyclical whenever the (exogenous) sequence of nominal interest rates is procyclical or acyclical. Finally, if k and l are large, the output time series exhibits persistence.

We now examine briefly the empirical plausibility of our cycles condition. In the case of a Cobb–Douglas intertemporal utility function the conditions $\alpha\delta < 1$ and $\alpha > 1$ for which cycles exist are equivalent to

$$\frac{(N\rho - 1)(\rho - 1)}{N\rho^2} < \frac{b}{A} < \Big(\frac{(N\rho - 1)(\rho - 1)}{N\rho^2} z\Big)^{1/2} \quad . \tag{13}$$

Since the real reservation wage is $w_t^r / P_t = b(P_{t+1}/(P_t R_{t+1}))^{1-c}$ and since under (LF) the average real gross interest rate along each cycle is 1,[14] b/A is a reasonable measure

[14]This follows from (6) and from $1 = (m_1/m_2) \cdots (m_{k+l-1}/m_{k+l})(m_{k+l}/m_1)$ along each (k, l) cycle.

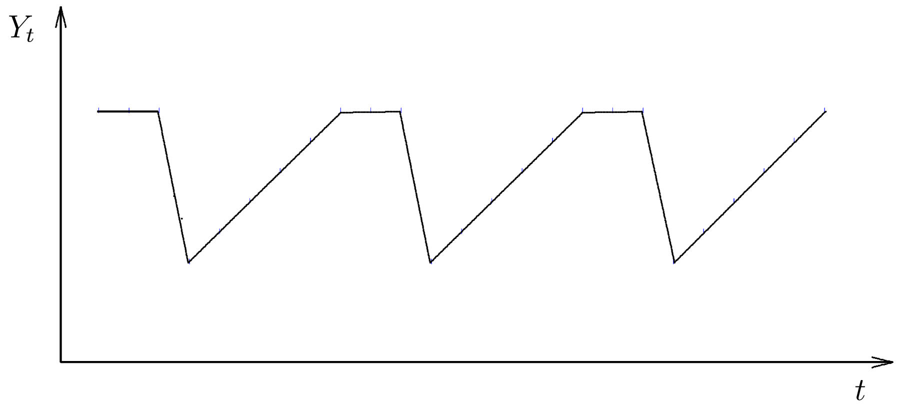

Figure 3: A steep, deep and sharp cycle ($k = 5$, $l = 3$).

of the ratio between the real reservation wage and labour productivity. A labour share between 0.6 and 0.7 and a replacement ratio between 0.5 and 0.8 suggest that a rough interval of plausible values for b/A is $[0.3, 0.56]$. Furthermore, empirical studies report average demand elasticities just below 2 and markup factors between 1.2 and 1.4 (see Rotemberg & Woodford (1995, pp. 260–61)). Table 1 summarizes the upper and lower bounds for b/A of the cycles condition (13) for some values of ρ and N compatible with these studies. They are well in accordance with empirically plausible values for b/A.

	$N = 2$	$N = 3$	$N = 4$	$N = 5$
$\rho = 1.5$	[.222,.411]	[.259,.420]	[.278,.419]	[.289,.416]
$\rho = 2.0$	[.375,.558]	[.417,.569]	[.438,.570]	[.450,.568]

Table 1: Values of b/A leading to cycles.

4 Fiscal policy

The purpose of this section is to show how appropriate fiscal policies can be effective in stabilizing cycles in a standard textbook Keynesian fashion. We concentrate our analysis on deterministic cycles only, but we would expect similar results for nearby stochastic sunspot cycles as well. We consider two different types of policies, a balanced budget policy and an unbalanced budget fiscal policy in which the government runs deficit spending at the beginning of each recession and re–balances the budget at the end of the recession. Both types of policies raise output but do not affect equilibrium prices, the first with a fiscal multiplier of one, and the latter with a fiscal multiplier in excess of one. Later we point out various limitations of these results.

Theorem 1 describes endogenous cycles in the model without fiscal policy. To investigate the efficacy of fiscal policy, we assume the economy has been in a laissez–faire regime up to period $t = 0$, and has coordinated on a (k, l) cycle for some $k, l \geq 1$. At $t = 0$ the government announces its fiscal policy and we look at the impact of the (perfectly foreseen) policy on the laissez–faire (k, l) cycle. We assume the government (like firms and trade unions) observes S_t and we look first at a balanced budget fiscal policy with $g_t = \tau_t$ for all t.

Suppose the laissez–faire (k, l) cycle has been $(m_1^*, \ldots, m_{k+l}^*)$ with outputs $(Y_1^*, \ldots, Y_{k+l}^*)$ where

$$m_{i+1}^* = \alpha m_i^* \quad \text{and} \quad Y_i^* = \frac{m_i^*}{1 - c(m_i^*/m_{i+1}^*)} < AL, \;\; i = 1, \ldots, k, \tag{14}$$

$$m_{i+1}^* \geq \delta m_i^* \quad \text{and} \quad Y_i^* = \frac{m_i^*}{1 - c(m_i^*/m_{i+1}^*)} = AL, \;\; i = k+1, \ldots, k+l, \tag{15}$$

(from now on identify $i = k + l + 1$ with $i = 1$). A natural Keynesian policy to cure the unemployment in the first k periods of the cycle is to introduce positive government spending during recessions:

(KBB) For all t, $g_t = \tau_t \geq 0$ if $S_t = \text{R}$ and $g_t = \tau_t = 0$ if $S_t = \text{B}$.

In particular, given the laissez–faire (k, l) cycle, suppose for $i = 1, \ldots, k$

$$g_t = g_i \quad \text{if} \quad S_t = \ldots = S_{t-i+1} = \text{R and } S_{t-i} = \text{B}.$$

Thus g_i is the expenditure in the ith period of a recession. With this policy, a new (k,l) cycle $(m_1,\ldots,m_{k+l})$ with outputs $(Y_1,\ldots,Y_{k+l})$ has to satisfy

$$m_{i+1}=\alpha m_i \quad\text{and}\quad Y_i=\frac{m_i}{1-c(m_i/m_{i+1}))}+g_i\le AL,\; i=1,\ldots,k, \tag{16}$$

$$m_{i+1}\ge \delta m_i \quad\text{and}\quad Y_i=\frac{m_i}{1-c(m_i/m_{i+1}))}=AL,\; i=k+1,\ldots,k+l. \tag{17}$$

Suppose that $g_i\in[0,AL-Y_i^*]$, $i=1,\ldots,k$. Then it is immediate from (14), (15), (16) and (17), that there exists indeed a new cycle $(m_1,\ldots,m_{k+l})$, $(Y_1,\ldots,Y_{k+l})$ with the following features:

(i) For all $i=1,\ldots,k+l$, $m_i=m_i^*$. Since the nominal money stock evolves under the balanced budget policy as under laissez–faire, prices also evolve as under laissez–faire. Hence, nominal prices and so wages are unaffected by the fiscal policy. The economy responds to the policy in a "fixprice" fashion.

(ii) For $i=k+1,\ldots,k+l$, $Y_i=Y_i^*=AL$. Unsurprisingly the policy has no real effects during booms.

(iii) For $i=1,\ldots,k$, $Y_i=Y_i^*+g_i$. During recessions the economy responds to the government expenditure with g_i producing a one–for–one increase in output. We have the classic textbook unit balanced budget multiplier operating. And if $g_i=AL-Y_i^*$, $i=1,\ldots,k$, output is stabilized at the full employment level throughout the cycle.

Theorem 2: Suppose the laissez–faire economy has coordinated on a (k,l) cycle up to period 0, with real balances $(m_1^*,\ldots,m_{k+l}^*)$ and outputs $(Y_1^*,\ldots,Y_{k+l}^*)$ given by (14) and (15). Suppose the government announces in period 0 a Keynesian balanced–budget fiscal policy (KBB) in which expenditures are $g_i\in[0,AL-Y_i^*]$ in the ith period of a recession and zero throughout a boom. Then the policy produces a perfect foresight (k,l) cycle in which recession output levels increase with a balanced–budget multiplier of one and in which nominal prices and wages are as under laissez–faire. If $g_i = AL - Y_i^*$, $i = 1, \ldots, k$, output is stabilized at the full employment level throughout the cycle.

In the textbook fixprice story, the balanced–budget multiplier of one gives way to a multiplier in excess of unity with unbalanced budgets where the government expenditure is not matched by current taxation. A similar outcome can emerge here. Start again from a laissez–faire (k, l) cycle given by (14) and (15) and consider the following policy (suppose $k \geq 2$):

(KUB) $g_t = g > 0$ if $S_t = \text{R}$ and $S_{t-1} = \text{B}$, and $g_t = 0$ otherwise.
$\tau_t = \tau = \alpha^{k-1} g > 0$ if $S_t = \text{R}$ and $S_{t-k} = \text{B}$, and $\tau_t = 0$ otherwise.

Here the government spends g in the first period of a recession and imposes the tax τ in the last recession period. The money supply thus expands at the beginning of the recession and contracts at the end. The restriction $\tau = \alpha^{k-1} g$ means that the contraction exactly matches the expansion since α is the real gross interest rate during recessions (see also the proof of Theorem 3). If g is small then the economy's response is again "fixprice", but now with multipliers (on g) in excess of unity for all periods of the recession.[15]

Theorem 3: Suppose the same laissez–faire starting point as Theorem 2. Now the government announces in period 0 a Keynesian unbalanced budget fiscal policy (KUB). If g is sufficiently small, then the policy produces a perfect foresight (k, l) cycle in which the output in each period of a recession increases by a multiplier (of g) in excess of unity, and in which nominal prices and wages evolve as under laissez–faire.

[15] If the budget is re–balanced only in the first boom period instead of the last recession period, multipliers are still positive, but possibly less than unity.

Theorems 2 and 3 show how Keynesian fiscal policies may produce fixprice responses with textbook multipliers in our model. We should point out that the unit multipliers of Theorem 2 result from the fact that labour supply is perfectly elastic at the reservation wage and inelastic at all other wages, which leads to a horizontal AS curve in the Keynesian regime. With a more general upward sloping labour supply schedule, fiscal policies may induce price changes. We would expect, however, that multipliers are close to the multipliers of Theorems 2 and 3 if the labour supply curve is close to ours.

Of course, policies outside the range of Theorems 2 and 3 may produce different prices from laissez–faire and so different multipliers. In the following we briefly report our results for some policy variations like a non–cyclical policy, excessive government spending, permanently unbalanced budgets or income taxation in the case of a Cobb–Douglas intertemporal utility function. Detailed derivations are contained in Appendix B.

When government spending is the same in all periods (booms as well as recessions - e.g. the government cannot observe S_t), the balanced–budget multiplier is still positive but falls below unity. Government spending during booms produces inflation in all boom periods $k+1, \ldots, k+l$ which raises the reservation wage and thereby the union wage in period k. This leads again to higher inflation in period k and by the same argument to higher inflation and higher wages in all recession periods. The higher wages lead to lower employment and output levels than those obtained with a (KBB) policy in which government spending is raised only during recessions.

Similarly, excessive government spending or permanently unbalanced budgets lead to inflation in recession periods and thus to higher wage demands and higher unemployment in all previous recession periods. On the other hand, it can be shown that even a contractionary policy without government spending but with taxation at the end of a recession raises recession output levels with the same tax multipliers as a (KUB) policy with positive government spending. Thus, it is the deflationary effect of the contraction at the end of the recession which raises output and not the government spending at the beginning.

Finally, if the government levies a proportional tax on (wage and profit) income instead of a lump–sum tax, the reservation wage and thereby the union wage are directly adversely affected by taxation. A higher income tax rate has thus three effects on the recession output levels: a positive aggregate demand effect since a higher tax rate raises aggregate demand (similar to equation (1) in case of a lump–sum tax), a positive inflation effect if the increase of the tax rate is not matched by an increase of government spending (as in case of a lump–sum tax, a budget surplus decreases inflation which leads to lower wages in the previous period), but now also a negative labour supply (reservation wage) effect. Both in case of a (KBB) and in case of a (KUB) policy the negative labour supply effect offsets the two positive effects, and so Theorems 2 and 3 do not extend to the case of an income tax. Instead all multipliers become negative.[16]

5 Conclusions

This paper contains several features which are new relative to the existing literature. First, the firms' coordination problem in our model provides a novel explanation for multiple equilibria under imperfect competition. Second, these multiple equilibria give rise to many endogenous cycles which exhibit several stylized business cycle features. And third, our policy analysis reproduces Keynesian textbook multipliers in a dynamic general equilibrium model without nominal rigidities.

Our multiplicity results use the assumption that sectoral labour markets are sepa-

[16] See also Molana & Moutos (1991) who show that the positive multipliers of Dixon (1987) and Mankiw (1988) become zero or negative if there is income taxation.

rated in the sense that workers can only work for firms in one sector, but nowhere else, and that these workers are represented by one sectoral trade union. It is worth pointing out, however, that the same multiplicity would emerge in an economy with one homogenous labour market and with a single trade union, in which workers can freely move between sectors but face a positive, arbitrarily small cost if they do not work in their home sector.[17] All wages in the intermediate range of Figure 1 produce again two equilibria: an unemployment equilibrium in which firms in all sectors coordinate on the Cournotian labour demand of Proposition 1(a); but there is also a full employment equilibrium in which all firms signal the excess labour demands of Proposition 1(b) since a lower labour demand of any one firm would not alter employment, output and price levels of all sectors when it is costly for the workers to move to another sector.

The firms' coordination problem can lead to a Walrasian temporary equilibrium even though there is imperfect competition on both the labour and the output markets. When firms believe in a boom state, they create excess vacancies and behave as if they were price–takers whenever the wage is below the competitive wage. Trade unions anticipate this behaviour and set the competitive wage since it is the maximal wage consistent with full employment. In contrast, when firms believe in a recession state, the outcome is Keynesian unemployment, as would be expected in any model with imperfect competition on the output and the labour market. Fiscal policy in both regimes has opposite effects: in the Walrasian regime prices change and output stays constant, and vice versa in the Keynesian regime.

[17]A similar argument would apply if there were several separated labour markets, each comprising one trade union and many different sectors.

Appendix A: Proofs

Proof of Proposition 1:

(a) Notice first that the unique Cournot equilibrium (i.e. the Nash equilibrium of the game in ℓ_{st}^j without a labour supply constraint), is symmetric and is given by $\ell_{st}^j = \ell_{st}/N$ which is less than L/N provided that $w_{st} > (\rho N - 1)/(\rho N) w_t^c$. Now consider the game in J_{st}^j. Clearly, any $J_{st}^j \leq L - (N-1)\ell_{st}/N$ leads to $\ell_{st}^j = J_{st}^j$ and therefore gives no higher profit than $J_{st}^j = \ell_{st}/N$. If a firm tries to create an aggregate excess demand for labour with $J_{st}^j > L - (N-1)\ell_{st}/N$, uniform rationing implies $\ell_{st}^i = \ell_{st}/N$, $i \neq j$, and $\ell_{st}^j = L - (N-1)\ell_{st}/N$, irrespective of J_{st}^j. Therefore, $J_{st}^j = \ell_{st}/N$ is a best response to $J_{st}^i = \ell_{st}/N$, $i \neq j$. The equilibrium sector price is obtained immediately from (2), $y_{st} = A\ell_{st}$ and the definition of w_t^c.

(b) Notice that any $J_{st}^j \geq 0$ leads to full employment in sector s, since $\sum_{i \neq j} J_{st}^i \geq L$. Thus, the sector output price remains at $p_{st} = P_t(Y_t/AL)^{1/\rho} = w_t^c/A$, and each (constant returns) firm would optimally produce as much as possible if $w_{st} \leq w_t^c$. Uniform rationing implies that $\ell_{st}^j = L/N$ for all $J_{st}^j \geq L/N$ and $J_{st}^i \geq L/N$, $i \neq j$. In particular, any $J_{st}^j \geq L/(N-1)$ is a best response to $J_{st}^i \geq L/(N-1)$, $i \neq j$. $\square$

Proof of Proposition 2:

(a) follows easily from the fact that the unconstrained maximum of $w_{st}^{-\rho}(w_{st} - w_t^r)$ is $w_{st} = \rho w_t^r/(\rho - 1)$.

(b) If the union sets the wage $w_{st} = w_t^c$, its payoff is $W_1 = (w_t^c - w_t^r)L$. If $w_t^c > \rho w_t^r/(\rho - 1)$, then the union's payoff

$$\Big(\frac{\rho N - 1}{\rho N}\frac{w_t^c}{w_{st}}\Big)^{\rho} L(w_{st} - w_t^r)$$

is decreasing in w_{st} for $w_{st} > w_t^c$ and less than W_1 at $w_{st} = w_t^c$; so w_t^c is the union optimum then. If $w_t^c < \rho w_t^r/(\rho - 1)$, the best the union can get from $w_{st} > w_t^c$ is at

$w_{st} = \rho w_t^r/(\rho-1)$ giving the payoff

$$W_2 = \Big(\frac{(\rho N-1)(\rho-1)w_t^c}{\rho^2 N w_t^r}\Big)^\rho L \frac{1}{\rho-1} w_t^r \ .$$

Therefore, $W_1 \geq W_2$ if and only if

$$\Phi(\bar{z}) := \bar{z} - 1 - \Big(\frac{\rho N - 1}{\rho N}(1-1/\rho)\bar{z}\Big)^\rho \frac{1}{\rho-1} \geq 0 \ , \qquad (18)$$

where $\bar{z} := w_t^c/w_t^r$. Notice that this inequality is not fulfilled at $\bar{z} = 1$, but that it is strictly fulfilled at $\bar{z} = \rho/(\rho-1)$. Since Φ is strictly increasing on $[1, \rho/(\rho-1)]$, there exists a unique $z \in (1, \rho/(\rho-1))$ which fulfills (18) with equality, and any $\bar{z} \in (z, \rho/(\rho-1))$ satisfies (18). Therefore, $w_t^c \geq z w_t^r$ if and only if the union's optimal wage is w_t^c. $\square$

Proof of Theorem 1:

As has been noted above, a (k,l) cycle exists if and only if there is a fixed point of the map $\psi = \alpha^k \cdot \beta^l$ in the interval $[\hat{m}_l, \bar{m}]$. Notice that

$$\begin{aligned} \beta'(m) &= \frac{1}{c^{-1}(1-m/(AL))} + \frac{m/(AL)}{c^{-1}(1-m/(AL))^2 c'(c^{-1}(1-m/(AL)))} \\ &> \frac{1}{c^{-1}(1-m/(AL))} \ . \end{aligned}$$

Hence, at any fixed point m^F of ψ we have

$$\begin{aligned} \psi'(m^F) &= \alpha^k \cdot \beta'(m^F) \cdot \beta'(\beta(m^F)) \cdot \cdots \cdot \beta'(\beta^{l-1}(m^F)) \\ &> \alpha^k \cdot \frac{1}{c^{-1}(1-m^F/(AL))} \cdot \cdots \cdot \frac{1}{c^{-1}(1-\beta^{l-1}(m^F)/(AL))} \\ &= \alpha^k \cdot \frac{\beta(m^F)}{m^F} \cdot \frac{\beta^2(m^F)}{\beta(m^F)} \cdot \cdots \cdot \frac{\beta^l(m^F)}{\beta^{l-1}(m^F)} = \frac{\alpha^k \cdot \beta^l(m^F)}{m^F} = 1 \ . \end{aligned}$$

Since $\psi(\bar{m}) = \alpha^k \cdot \bar{m} > \bar{m}$, the condition $\psi(\hat{m}_l) \leq \hat{m}_l$ is necessary and sufficient for the existence of a fixed point m_{k+1} of ψ in $[\hat{m}_l, \bar{m}]$, and whenever a fixed point exists, it is unique. Since ψ describes also the local forward perfect foresight dynamics when the (k,l) cycle is interior, $\psi'(m_{k+1}) > 1$ implies stability of any interior (k,l) cycle in the local backward perfect foresight dynamics. If $l = 1$, $\hat{m} = \hat{m}_l$ and the condition $\psi(\hat{m}) \leq \hat{m}$ is equivalent to $\alpha^k \delta \leq 1$. Hence, a $(k, 1)$ cycle exists iff $\alpha^k \delta \leq 1$. Suppose $\alpha^k \delta \leq 1$ and consider any $k' \leq k$ and $l \geq 1$. Since

$$\alpha^{k'} \beta(\hat{m}) = \alpha^{k'} \delta \hat{m} \leq \alpha^k \delta \hat{m} \leq \hat{m} \leq \hat{m}_l$$

we have $\psi(\hat{m}_l) = \alpha^{k'} \beta^l(\hat{m}_l) = \alpha^{k'} \beta(\hat{m}) \leq \hat{m}_l$ and thus the existence of a (k', l) cycle.

Finally, we have to show the existence of a non–degenerate stationary sunspot equilibrium with k unemployment states $S_1, \ldots, S_k$ and l full employment states $S_{k+1}, \ldots, S_{k+l}$ and positive transition probabilities π_i^j, $i, j = 1, \ldots, k+l$. The utility maximization problem of the consumer under uncertainty has similar solutions as under certainty. The only difference is that the functions c and f are replaced by

$$c\Big(\frac{P_{t+1}^1}{P_t R_{t+1}}, \ldots, \frac{P_{t+1}^{k+l}}{P_t R_{t+1}}, \Pi_i\Big) \quad \text{and} \quad f\Big(\frac{P_{t+1}^1}{P_t R_{t+1}}, \ldots, \frac{P_{t+1}^{k+l}}{P_t R_{t+1}}, \Pi_i\Big) \ ,$$

where P_t is the price level in period t, $P_{t+1}^1, \ldots, P_{t+1}^{k+l}$ are the expected price levels for the next period, and $\Pi_i = (\pi_i^1, \ldots, \pi_i^{k+l})$ is the vector of transition probabilities assuming $S_t = S_i$. These functions are continuously differentiable in all arguments (since u is twice differentiable) and coincide with $c(P_{t+1}^j / P_t R_{t+1})$ and $f(P_{t+1}^j / P_t R_{t+1})$ if $\pi_i^j = 1$. The equilibrium conditions (8) and (10) change accordingly. Since a (k, l) cycle is a degenerate sunspot equilibrium with transition probabilities $\pi_{k+l}^1 = \pi_i^{i+1} = 1$, $i = 1, \ldots, k+l-1$, and $\pi_i^j = 0$ else, the implicit function theorem yields a solution $(m_1, \ldots, m_{k+l})$ of the equations in (8) and (10) when the transition matrix is close to the degenerate transition matrix (the inequalities in (8) and (10) are then also fulfilled since they hold strictly at the interior (k, l) cycle) and when the Jacobian of the equilibrium equations at the cycle is invertible. But this condition turns out to be equivalent to the condition $dm_{t+k+l}/dm_t|_{m_t = m_1} = \psi'(m_{k+1}) \neq 1$ which has been shown above. $\square$

Proof of Theorem 3:

The conditions of a (k,l) cycle $(m_1,\ldots,m_{k+l})$, $(Y_1,\ldots,Y_{k+l})$ under a (KUB) policy are:

$$m_{i+1}=\alpha m_i \quad \text{and} \quad Y_i=\frac{m_i}{1-c(m_i/m_{i+1})}<AL,\ i=1,\ldots,k-2, \tag{19}$$

$$m_k=\alpha m_{k-1}-\tau \quad \text{and} \quad Y_{k-1}=\frac{m_{k-1}}{1-c(m_{k-1}/(m_k+\tau))}<AL, \tag{20}$$

$$m_{k+1}=\alpha m_k \quad \text{and} \quad Y_k=\frac{m_k}{1-c(m_k/m_{k+1})}+\tau<AL, \tag{21}$$

$$m_{i+1}\geq \delta m_i \quad \text{and} \quad Y_i=\frac{m_i}{1-c(m_i/m_{i+1})}=AL,\ i=k+1,\ldots,k+l-1, \tag{22}$$

$$m_1\geq \delta m_{k+l}+g \quad \text{and} \quad Y_{k+l}=\frac{m_{k+l}}{1-c(m_{k+l}/(m_1-g))}=AL. \tag{23}$$

From (19), (20) and (21) we obtain $m_{k+1}=\alpha^k m_1-\alpha\tau$ and using (22) and (23) we find

$$m_1-g=\beta^l(m_{k+1})=\beta^l(\alpha^k m_1-\alpha\tau)=\beta^l(\alpha^k(m_1-g))\ .$$

Thus, $m_1=m_1^*+g$, since m_1^* is the unique fixed point of $\beta^l(\alpha^k.)$. From (19) follows $m_i=m_i^*+\alpha^{i-1}g$ for $i=1,\ldots,k-1$, (20) implies $m_k=\alpha^{k-1}(m_1^*+g)-\tau=\alpha^{k-1}m_1^*=m_k^*$, (21) implies $m_{k+1}=\alpha m_k^*=m_{k+1}^*$ and (22) yields $m_{k+i}=\beta^{i-1}(m_{k+1}^*)=m_{k+i}^*$ for all $i=2,\ldots,l$. From this and (19), (20) and (21) we obtain the recession output levels:

$$\begin{aligned} Y_i &= Y_i^*+\frac{\alpha^{i-1}}{1-c(1/\alpha)}\cdot g \quad ,\ i=1,\ldots,k-1\ ,\\ Y_k &= Y_k^*+\alpha^{k-1}g\ . \end{aligned}$$

If g is sufficiently small, we have $Y_i\leq AL$ for all $i=1,\ldots,k$. Moreover, all multipliers of g are greater than one. Furthermore, the inequalities in (22) are fulfilled since $m_{i+1}=m_{i+1}^*\geq \delta m_i^*=\delta m_i$ for $i=k+1,\ldots,k+l-1$ and the inequality in (23) is fulfilled since $m_1=m_1^*+g\geq \delta m_{l+k}^*+g=\delta m_{l+k}+g$. Hence, $(m_1,\ldots,m_{k+l})$ is indeed a (k,l) cycle if g is sufficiently small.

Finally, we have to show that prices are the same as under laissez–faire. Consider some period t in which $S_t=$ B and $S_{t+1}=$ R, and so $M_t=M_t^*$ (since the budget is balanced during a boom, the money stock at the end of the boom coincides with the laissez–faire money stock). Using $m_{t+1} = m^*_{t+1} + g$ (since $t + 1$ is the first recession period), $M^*_{t+1} = R_{t+1}M^*_t$ and $M_{t+1} = R_{t+1}M_t + P_{t+1}g$, we obtain easily $P_{t+1} = P^*_{t+1}$. For $2 \leq i \leq k - 1$ we know $M_{t+i} = R_{t+2} \cdots R_{t+i}M_{t+1}$ and $m_{t+i} = \alpha^{i-1}m_{t+1}$ from which we obtain

$$R_{t+2} \cdots R_{t+i}P_{t+1} = \alpha^{i-1}P_{t+i} \ , \tag{24}$$

for $i = 2, \ldots, k-1$. From $M_{t+k} = R_{t+2} \cdots R_{t+k}M_{t+1} - P_{t+k}\tau$ and $m_{t+k} = \alpha^{k-1}m_{t+1} - \tau$ we also obtain (24) for $i = k$. Since (24) also holds for (P^*_{t+1}, P^*_{t+i}) and since $P_{t+1} = P^*_{t+1}$, we have $P_{t+i} = P^*_{t+i}$ for all $i = 2, \ldots, k$. Equation (24) also implies that the budget is in fact re–balanced in period $t + k$, and since there is no fiscal policy between $t + k + 1$ and $t + k + l$ we have $M_{t+i} = M^*_{t+i}$ and $P_{t+i} = P^*_{t+i}$ for all $i = k + 1, \ldots, k + l$. $\square$

Appendix B: Policy variations

We assume throughout this appendix a Cobb–Douglas utility function, so that the propensity to consume is a constant $c \in (0, 1)$ and the function f is $f(\theta) = \theta^{1-c}$.

Non–cyclical policy

Consider a balanced–budget policy in which government spending is the same in all periods (booms as well as recessions – e.g. the government cannot observe S_t), so $g_i = \tau_i = g$, $i = 1, \ldots, k + l$. With such a policy it turns out that a higher level of government activity g raises output during recessions, but with a multiplier below unity. In fact, if $\alpha^k\delta \leq 1$, it can be shown that for any $g \in [0, AL)$, there exists a (k, l) cycle in which recession output levels are

$$Y_i = \alpha^{-(k+1-i)}(AL - g) + g < AL \ , \ i = 1, \ldots, k \ .$$

Thus the multiplier is $1 - \alpha^{-(k+1-i)} < 1$ and there is partial crowding out during recessions and full crowding out during booms.

Excessive spending

Starting from a (KBB) policy, suppose the government spends "excessively" during a recession period (but unlike the first case does not expend during booms). Specifically consider a laissez–faire (k, l) cycle where $k > 1$ and a (KBB) policy where $g_k = AL - Y_k^*$ and $g_i = 0$ otherwise. From Theorem 2, the only policy impact is to raise Y_k from Y_k^* to AL. Now suppose that the expenditure in k becomes slightly excessive: $g_k = AL - Y_k^* + \varepsilon$ with some small $\varepsilon > 0$. The equilibrium conditions (8), (9) and (10) produce a new (k, l) cycle as follows. From (9) for a period k

$$Y_k = \frac{m_k}{1-c} + AL - Y_k^* + \varepsilon = AL \quad \text{implies} \quad m_k = m_k^* - \varepsilon(1-c) \ .$$

Applying (8) for periods $i = 1, \ldots, k-1$ gives

$$m_i = m_i^* - \frac{1}{\alpha^{k-i}}\varepsilon(1-c) \ , \ Y_i = \frac{m_i}{1-c} = Y_i^* - \frac{\varepsilon}{\alpha^{k-i}} \ , \ i = 1, \ldots, k-1.$$

With $m_i = m_i^*$ and $Y_i = Y_i^*$, $i = k+1, \ldots, k+l$, we have a new (k, l) cycle satisfying (8) for $i = 1, \ldots, k-1$, (9) for $i = k$ and (10) for $i = k+1, \ldots, k+l$ if ε is small enough. On this cycle recession prices (and so wages) are everywhere higher, and recession outputs are lower (the same in the last period k) than under the first (KBB) policy.

Permanently unbalanced budgets

Consider a policy of permanently unbalanced budgets in which the government never re–balances its budget by taxation. Suppose positive government spending during recessions $g_1, \ldots, g_k \geq 0$ and $g_i = 0$ otherwise, and no taxation $\tau_i = 0$ for all i. Then, if $g_1, \ldots, g_k$ are small enough, the equilibrium conditions (8) and (10) can be solved for a (k, l) cycle in which for $i = 1, \ldots, k-1$:

$$m_i = m_i^* - \alpha^{-(k-i)} g_k - \ldots - \alpha^{-1} g_{i+1} \ ,$$

and $m_i = m_i^*$ for $i = k, \ldots, k+l$. Recession outputs are $Y_k = Y_k^*$ and for $i = 1, \ldots, k-1$,

$$Y_i = Y_i^* - \frac{1}{1-c}\left(\alpha^{-(k-i)} g_k - \ldots - \alpha^{-1} g_{i+1}\right) ,$$

and so decreasing in $g_{i+1}, \ldots, g_k$. Similar to the excessive spending policy above, this policy produces inflation in periods $i = 2, \ldots, k$, and therefore raises wages and lowers output in periods $i = 1, \ldots, k-1$.

On the other hand, a modified (KUB) policy in which $g = 0$ but $\tau > 0$ leads to the same equilibrium conditions (19)–(23) as a (KUB) policy with positive government spending. Thus, tax multipliers on recession output levels are the same as for a (KUB) policy with positive government spending.[18]

Income taxation

Denote the income tax rate in period t again by $\tau_t \in [0, 1)$. The net income of young consumers is then $I_t^n = (1 - \tau_t) P_t Y_t$ and the government's budget constraint $M_t = M_{t-1} R_t + P_t g_t - \tau_t P_t Y_t$. Using these two equations, the aggregate demand equation (7) is now replaced by

$$Y_t = \frac{m_t}{(1-c)(1-\tau_t)} \quad . \tag{25}$$

The reservation wage is now $w_t^r = b P_t f(P_{t+1}/(P_t R_{t+1}))/(1-\tau_t)$. These modifications imply that in the equilibrium conditions (3) and (4) the constant b has to be replaced by $b/(1-\tau_t)$. Using the same definitions of α and δ and the fact that f is also Cobb–Douglas, we find that there is an unemployment equilibrium in case of $S_t = \mathrm{R}$ if

$$m_{t+1} - g_{t+1} + \tau_{t+1} Y_{t+1} = \alpha (1-\tau_t)^{1/(c-1)} m_t \quad \text{and} \quad Y_t < AL \ , \tag{26}$$

and that there is a full employment equilibrium in case of $S_t = \mathrm{B}$ if

$$m_{t+1} - g_{t+1} + \tau_{t+1} Y_{t+1} \geq \delta (1-\tau_t)^{1/(c-1)} m_t \quad \text{and} \quad Y_t = AL \ , \tag{27}$$

[18] This result is only valid for a Cobb–Douglas utility function. In the general gross substitutes case, tax multipliers become even larger without government spending.

where Y_t is given by (25).

Consider first a (KBB) policy: $\tau_t \geq 0$ if $S_t = \mathrm{R}$, $\tau_t = 0$ otherwise, $g_t = \tau_t Y_t = \tau_t/(1-\tau_t) \cdot m_t/(1-c)$, and start again from a laissez–faire (k,l) cycle $(m_1^*, \ldots, m_{k+l}^*)$, $(Y_1^*, \ldots, Y_{k+l}^*)$. If $\tau_1, \ldots, \tau_k$ are sufficiently small, the equilibrium conditions (26) and (27) can be solved for a (k,l) cycle in which $m_i = m_i^*$, $i = k+1, \ldots, k+l$, and $m_i = \prod_{j=i}^{k}(1-\tau_j)^{1/(1-c)} m_i^*$, $i = 1, \ldots, k$. Recession outputs are

$$Y_i = (1-\tau_i)^{-1} \prod_{j=i}^{k}(1-\tau_j)^{1/(1-c)} \cdot Y_i^* \quad , \; i = 1, \ldots, k.$$

The first factor is the positive aggregate demand effect of the tax in period i, while the second factor is the negative labour supply effect of the income tax. Not only the higher reservation wage in period i lowers output in period i, but also the higher reservation wages in periods $i+1, \ldots, k$ since they raise inflation in future periods which leads also to higher wage demands in period i. The net effect of the income tax rates on the recession output is unambiguously negative.

Consider next a (KUB) policy: $\tau_k = \tau \geq 0$, $\tau_i = 0$ otherwise and $g_1 = g = \alpha^{1-k}\tau Y_k = \alpha^{1-k}\tau/(1-\tau) \cdot m_k/(1-c)$, $g_i = 0$ else. Similar to the case of a lump–sum tax, the conditions for a (k,l) cycle are now:

$$\begin{aligned}
m_{i+1} = \alpha m_i \quad &\text{and} \quad Y_i = \frac{m_i}{1-c} < AL, \; i = 1, \ldots, k-2, \\
m_k = \alpha m_{k-1} - \tau Y_k \quad &\text{and} \quad Y_{k-1} = \frac{m_{k-1}}{1-c} < AL, \\
m_{k+1} = \alpha(1-\tau)^{1/(c-1)} m_k \quad &\text{and} \quad Y_k = \frac{m_k}{(1-c)(1-\tau)} < AL, \\
m_{i+1} \geq \delta m_i \quad &\text{and} \quad Y_i = \frac{m_i}{1-c} = AL, \; i = k+1, \ldots, k+l-1, \\
m_1 \geq \delta m_{k+l} + g \quad &\text{and} \quad Y_{k+l} = \frac{m_{k+l}}{1-c} = AL.
\end{aligned}$$

If τ is small enough, these conditions can be solved for a (k,l) cycle as follows: $m_i = m_i^*$, $i = k+1, \ldots, k+l$, and in period k, $m_k = (1-\tau)^{1/(1-c)} m_k^*$ and output $Y_k = (1-\tau)^{1/(1-c)-1} Y_k^*$ is falling in τ; the labour supply effect dominates the aggregate demand effect. In period $k-1$ we find $m_{k-1} = (1-\tau)^{1/(1-c)} m_{k-1}^* + \tau(1-\tau)^{1/(1-c)-1} Y_{k-1}^*$ and output is

$$Y_{k-1} = (1-\tau)^{1/(1-c)}\Big(1 + \frac{\tau}{(1-\tau)(1-c)}\Big)Y^*_{k-1} \ . \tag{28}$$

In periods $i = 1, \dots, k-2$, we have $m_i = \alpha^{-(k-i-1)}m_{k-1}$ and so outputs are

$$Y_i = \alpha^{-(k-i-1)}Y_{k-1} = (1-\tau)^{1/(1-c)}\Big(1 + \frac{\tau}{(1-\tau)(1-c)}\Big)Y^*_i \ . \tag{29}$$

In equations (28) and (29), the first factor is the negative labour supply effect, while the second factor contains both the positive inflation effect and the positive aggregate demand effect. It can be checked easily that the total effect is negative, i.e. increases in τ decrease output in periods $i = 1, \dots, k-1$.

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