Robert Schuman Centre

A Business Cycle Model with Keynesian Micro-Foundations: The Policy Implications for Unemployment

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EUROPEAN UNIVERSITY INSTITUTE, FLORENCE

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1. Introduction

A long standing question in macroeconomics is whether the business cycle is endogenously or exogenously generated, with the majority of the profession having been inclined towards the latter position. This is particularly the case in recent years given the proliferation of work on real business cycles which rely on technology shocks, even though these models have been subjected to serious criticism from within mainstream economics. Krugman (1994), for example, describes the approach as being 'deeply implausible', and a number of papers (eg: Cogley and Nason (1995), Eichenbaum (1995), Rotemberg and Woodford (1996) and Watson (1993)) have drawn attention to the fact that real business cycle models appear to be unable to generate key time-series properties of post-war American business cycle data.

Many economists supportive of the real business cycle approach may sympathise with the sentiments of Wickens (1995): 'For many the appeal of Keynesian economics over neoclassical economics is the supposed greater realism of its assumptions. We all know that markets are not complete, that people are not rational, make myopic decisions and lack full information, that one agent is different from another, and that a model built on microeconomic foundations cannot be aggregated to the level of conventional macroeconomic variables. The problem is that building models with these features is virtually an intractable problem'.

In this paper, we develop a model with many of these features. It is a microeconomic model of short-term output growth based upon interacting, heterogeneous individual agents operating under uncertainty on Keynesian principles. The aggregate output growth series which emerges from their activities has time-series properties which, on a wide range of criteria, are very similar to the cyclical properties of post-war US GNP growth.

It is not necessary to invoke any form of exogenous shock in the model, and the cycle is purely endogenous, essentially arising from the existence of heterogenous agents operating under uncertainty.

Section 2 of the paper sets out the economic basis of the model, and Section 3 describes the simulation properties of the model, particularly with respect to comparisons with actual American output data. The Appendix outlines technical details of how the simulations are carried out. Section 4 of the paper considers the policy implications for unemployment.

2. The microeconomic model of interacting Keynesian agents

All the agents in our model are companies, which is very much in keeping with Keynes's view that the primary source of fluctuations over the course of the business cycle is the corporate sector.

The model is populated by heterogeneous individual companies operating under uncertainty. Each individual firm decides its own rate of growth of output and its own rate of change of sentiment about the future. The model evolves in discrete time steps, and in each of these steps (periods) the majority of agents update their previous decisions on output and sentiment.

A key feature of the model is that firms interact with each other by taking account of the decisions of other companies in their own decisions on the output and sentiment variables. In general equilibrium theory, agents' tastes are given, and they react indirectly via the price mechanism to the actions of others. But in our model, the preferences of each agent are not fixed, but are altered directly by observing the behaviour of others.

The key question which every firm must decide during any particular period is the rate of growth of the output which it will produce in the next period. Once this decision has been made, the firm is stuck with it. When in the process of time the company arrives in this next period, it is allowed to decide a different growth rate for the period afterwards, but not to revise the previous decision on this period's growth. Obviously, this is somewhat artificial, but it is not completely unreasonable. For in the very short-run, there are often substantial costs involved in altering previous decisions about how much to produce. Contracts have been placed with suppliers, the workforce has been alerted as to how much effort will be needed, indeed employees may have been either taken on or sacked depending upon the circumstances, the marketing programme will be committed, and so on and so forth.

In these circumstances, agents act according to a straightforward rule in order to decide how quickly output should either be expanded or contracted in the next period. They are very short-sighted, and look no further ahead than this. In other words, they are satisficers and not maximisers.

One factor which weighs in a company's decision on how much to alter the amount produced in the next period is the rate of growth at which output is actually changing during the current period. There are costs and difficulties of altering the amount which a firm is producing by large amounts, whether up or down. So a certain amount of inertia is built into the system.

But, in addition and more importantly, in deciding the rate at which its own output is to change in the next period, each firm pays great attention to the general level of sentiment, the degree of optimism or pessimism, about the future, and how this is changing. This is very much in the spirit of Keynes, who set great store on the role of expectations and the general level of confidence in determining the outcome of the economy, both in the short-run and, through decisions on investment, in the longer-term.

In terms of the formal model, we let $X_i(t)$ be the growth rate of output of agent i at time t, and XBAR(t) the overall growth of output of the population at time t, weighted according to the sizes of the agents. In other words, XBAR(t) is simply the weighted sum of the individual $X_i(t)$.

The degree of optimism or pessimism about output growth in the future held by the i'th agent at time t is given by $Y_i^s(t)$, and the (weighted) aggregate of these individual decisions by $YBAR^s(t)$.

We use the superscript 's' to stand for 'sentiment' to emphasise that it is not the conventional concept of expectations. The $Y_i^s(t)$ should be thought of as expressing sentiment (optimism/pessimism) about change in the future, rather than being based in some sense on 'optimal' forecasts of the rate of growth of output at some specific point in the future. Keynes himself was deeply sceptical about the latter approach, arguing that 'our existing knowledge does not provide a sufficient basis for a calculated mathematical expression'.

In each time period, any firm can in principle decide to change its previous rate of growth of output, $X_i(t-1)$. The growth rate of output of agent i in this period is based on a combination of the firm's output growth in the previous period, and the aggregate sentiment in the previous period about future output growth, i.e.

$$(1-\alpha)\, X_i(t-1) + \alpha\, YBAR^s(t-1) \qquad (1)$$

This represents the rate of growth in the absence of any circumstances which are particular to agent i. The interaction between individual agents takes place through the YBAR variable, so that the sentiment of other agents about the rate of growth of output in the future affects the decision on the rate of growth of output taken by agent i.

An implication of (3) is that firms feel that there are constraints which operate on their output decisions. It is the aggregate state of sentiment, which could be deduced from newspapers such as the *Financial Times* or *Wall Street*

Journal, which is a determinant of any revision to the growth of output of the ith agent. In other words, companies feel that, for example, demand may be a limiting factor on them in the future, and that one way of trying to judge the likely state of demand is via aggregate sentiments about growth in the future.

The general level of business optimism or pessimism about the future is inescapably linked with uncertainty, which in turn leads to the important property of the model that the individual agents each take different decisions at any point in time.. Given the existence of uncertainty about the future and the fact that the agents are heterogenous, each agent may interpret any given level or change in overall sentiment about the future differently, in other words may draw more or less optimistic conclusions from any given value of $YBAR^s(t-1)$.

We do not require that any individual agent is consistently more or less optimistic than any other over time with respect to these interpretations, but simply that at each point in time, because of uncertainty, agents differ. In terms of the $YBAR^s$ variable, there may also be a secondary source of uncertainty. Despite the large amount of information about sentiment available in the financial media, there is no single, published measure of $YBAR^s$ at any point in time, so firms may be uncertain, and hence differ in their intepretations, about the level of $YBAR^s$ at time $(t-1)$.

In short, *uncertainty means that each heterogenous agent operates in a different way to every other.* There is uncertainty at any point in time about the precise level of business sentiment about the future. And there is uncertainty about what any perceived level of sentiment means for decisions by any particular firm about what its rate of growth of output should be in the period immediately ahead.

This is introduced formally into the model by modifying equation (1). The growth rate of agent i is set according to

$$X_i(t) = (1 - \alpha)\, X_i(t - 1) + \alpha\, \{YBAR^s(t - 1) + \varepsilon_i(t)\} \qquad (2)$$

where $\varepsilon_i(t)$ is a random variable with mean zero and variance v_1.

It is important to note, even at the risk of over-emphasising the point, that in each time period companies do *not* share the same ε. The variable ε is *not* a degree of uncertainty which is common to all firms, but each firm in each period has its own ε. In other words, ε must *not* be regarded as a common, exogenous shock which all firms experience.

The sentiment of the ith agent about the rate of growth of output in the future is derived on similar principles, which can be discussed more briefly. In the absence of circumstances particular to agent i, its sentiment is a simple function of the ith agent's sentiment in the previous period, and of the aggregate rate of growth of output in the previous period.

$$(1 - \beta)\, Y_i^s(t-1) \; - \; \beta\, XBAR(t-1) \qquad (3)$$

This differs from (3) in that there is a minus sign in front of the aggregate variable, XBAR. Other things being equal, the faster that aggregate output grows, the more pessimistic become sentiments about future output growth. This follows from Keynes's own definition of the business cycle, or what he called the trade cycle in chapter 22 of the *General Theory*:

> 'By a cyclical movement we mean that as the system progresses in, e.g., the upward direction, the forces propelling it upwards at first gather force and have a cumulative effect on one another but gradually lose their strength until at a certain point they tend to be replaced by forces operating in the opposite direction; which in turn gather force for a time and accentuate one another, until they too, having reached their maximum development, wane and give place to their opposite'.

A mathematical approximation to this description is, of course, that of a simple oscillator, and hence the negative sign on XBAR(t - 1) in (3).

Interaction between agents takes place in (3) through the XBAR term. The decisions of all other agents on the rate of growth if output influences the sentiment of the ith agent about the rate of growth in the future.

Heterogeneity of agents is again introduced, by allowing agents to differ at any point in time on their interpretations of what any given value of XBAR actually implies. The sentiment formed about the rate of growth of output of agent i in the current period is therefore given by

$$Y_i^s(t) = (1 - \beta)\, Y_i^s(t-1) \; - \; \beta\, \{XBAR(t-1) + \eta_i(t)\} \qquad (4)$$

where $\eta_i(t)\}$ is a random variable with mean zero and variance v_2.

Again, it is important to note that in each period each firm has its own value for η, and this latter variable does *not* have a value which is common across all firms.

In summary, our model comprises equations (2) and (4)

$$X_i(t) = (1-\alpha)\, X_i(t-1) + \alpha\, \{YBAR^s(t-1) + \varepsilon_i(t)\} \qquad (2)$$

$$Y_i^s(t) = (1-\beta)\, Y_i^s(t-1) - \beta\, \{XBAR(t-1) + \eta_i(t)\} \qquad (4)$$

The key economic content of the model is the assumption that agents are heterogenous, which given the existence of uncertainty leads to them behaving differently. This can be seen as follows. Suppose we removed this aspect of the model, and worked instead with equations (1) and (3). Setting the sum of the weights used on individual agents equal to 1, these can be re-written as a simple pair of difference equations in XBAR and $YBAR^s$:

$$XBAR(t) = (1-\alpha)XBAR(t-1) + \alpha YBAR^s(t-1) \qquad (5a)$$

$$YBAR^s(t) = -\beta XBAR(t-1) \quad + (1-\beta)YBAR^s(t-1) \qquad (5b)$$

The dynamics of this system of equations can be analysed quite readily by forming a matrix of its parameters and calculating the eigenvalues. For most economically meaningful pairs of values of α and β (ie: $0 < \alpha,\beta < 1$), the eigenvalues are complex but with real parts which lie between zero and one. Therefore the system of equations given by 5(a) and (b) gives rise in general to damped oscillations. It is the existence of uncertainty and the consequent introduction of the terms $\varepsilon_i(t)$ and $\eta_i(t)$ into equations (2) and (4) which gives to the model a pattern of behaviour which is quite distinct from this.

The model we actually use, namely equations (2) and (4), is still, rather obviously, a dramatic simplification of reality. Two potential extensions spring to mind quite readily. First, each firm plans its rate of growth of output for the forthcoming period on the basis of (2) and, implicitly, carries out this plan regardless of the market conditions which actually obtain. These plans might prove to be unwarranted, but the model does not include any mechanism whereby the agent takes account of this in making decisions about the subsequent period.

Second, it would undoubtedly be more realistic to introduce some local interaction into the model. At present, interaction between agents takes place solely by the reference each agent makes to the global outcome, whether of sentiment or of output. In practice, firms may pay special attention to the decisions of a sub-group of other agents, such as those within its own industry, or those to whom the firm is a major supplier. Such local interactions could possibly be based upon the same principles as those which Kirman (1991, for example) has pioneered.

But, despite its simplicity, the model does capture many of the aspects of economic behaviour which are usually associated with Keynesianism and, as we shall see, its solutions have properties which are very similar to those of actual business cycle data, without having to invoke exogenous shocks of any kind.

3. Model simulations and business cycle data

In this section, we compare the properties of simulations of our model with those of the actual data series on quarterly US real GNP growth over the period 1947Q2 through 1990Q4, used, for example, by Potter (1995). Technical details of the simulations are set out in the Appendix.

The simulations are made over 175 periods, to give data series of the same length as the actual US output growth data examined by Potter. The results we present are, in general, summaries of a total number of 1000 simulations, each carried out over 175 periods.

Our interest is in cyclical fluctuations in growth, and so the model solutions are compared with actual growth net of its mean value. (The actual data are seasonally adjusted. It would be very easy to introduce a seasonal element to our model, but this would not add in any meaningful way to its economic content).

Figure 1a plots the actual data, net of the mean, and Figure 1b a typical model simulation of the growth of output variable. Simple inspection shows that, at the very least, the two series are not markedly dissimilar.

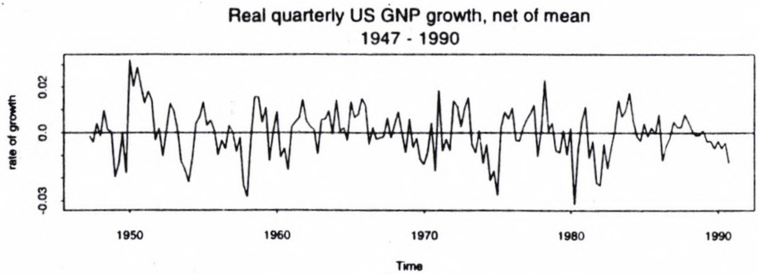

Figure 1a

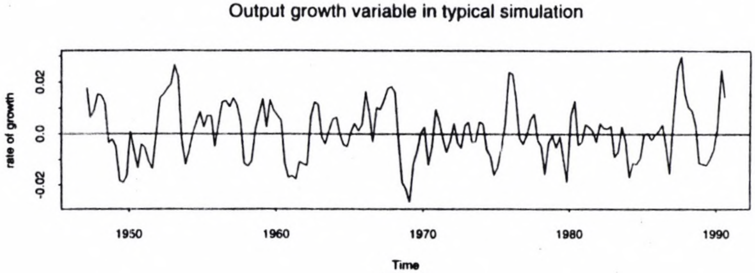

Figure 1b

In the first instance, we discuss the ranges over which both the aggregate output growth and the output growth of individual agents typically move, and examine the typical correlations between the rates of growth of output of individual agents over time. We then move on to discuss the time-series properties of the aggregate output growth variable.

Table 1 sets out the summary statistics for actual growth and for the average of the output growth variable, XBAR, in a 1000 simulations.

Table 1. Summary statistics of real US GNP growth (net of its mean) and the average of 1,000 model simulations

	Real US GNP growth	Simulated growth
Minimum	-0.0317	-0.0291
1st quartile	-0.0066	-0.0074
3rd quartile	0.0063	0.0073
Maximum	0.0321	0.0290
Standard deviation	0.0107	0.0109

There are two aspects of the simulations which concern the results for individual agents. The first of these points can be dealt with briefly. The aggregate output growth variable in the simulations moves within a typical range of around –0.03 to +0.03. The range for the typical individual agent is larger, but not dramatically so, being from –0.09 to +0.09, which seems realistic.

In terms of the second point to make, the model is set up with each of the agents representing a company and taking decisions on short-term output growth, so in its present form the relative volatility of various economy wide aggregates such as consumption and investment is not available.

However, a widely accepted property of business cycles is that output changes across broadly defined sectors move together over time. In its present, basic form, our model does not lend itself to an obvious aggregation of agents into groups representing, say, the car or alcohol producing industries. Any such aggregation would be purely artificial. A possible extension to the model would be to set it up with such sectors, using stochastic graph theory. But with the current model we can examine the cross-correlations in output growth between each of the agents in the population, and these are summarised in Table 2.

Table 2. Summary of cross-correlations between the period-by-period output growth of each of the 500 individual agents

Minimum	–0.08
1st quartile	0.19
Median	0.24
Mean	0.24
3rd quartile	0.29
Maximum	0.51

In other words, there is, almost universally, positive and statistically highly significant correlations between the period-by-period growth of output of individual firms. The correlations are relatively small, but this seems entirely realistic. For example, although firms within the same industrial sector will be affected in similar ways by developments in the aggregate economy, much of their marketing activity is devoted to struggles with their direct competitors over market share, which can and does fluctuate. So correlation of the short-run changes in output between firms in the same sector need not be high.

Our main interest, however, is to compare time-series properties of actual US data and of the aggregate growth of output variable, XBAR. Real business cycle models have been criticised strongly in the recent literature for their inability to replicate key qualitative features of cyclical movements of the actual data. Examples of such criticism are Cogley and Nason (1995), Eichenbaum (1995), Rotemberg and Woodford (1996) and Watson (1993).

There are two serious shortcomings of real business cycle models in this context. Both the autocorrelation function and the spectral properties of their simulated data are quite different from those of the actual data (though given that the power spectrum is the Fourier transform pair of the autocorrelation function, it is not surprising that deficiencies in one of these aspects is reflected in the other).

The simulated data from RBC models is *qualitatively* different from the actual American data. The actual data has low order positive autocorrelation, and then negative but insignificant autocorrelation at higher order. Simulations of RBC models, as noted for example by Cogley and Nason (op.cit.) produce data which is either complete white noise or is negatively autocorrelated at almost every lag.

In terms of its spectral properties, actual data has a power spectrum which is concentrated at the frequencies which correspond to those of the business cycle, noted by Cogley and Nason, for example, to be between 2.33 and 7 years per cycle, with maximum power of the spectrum at roughly 3.2 years per cycle. In general, RBC simulated data has a flat power spectrum, indicating that business cycle components are no more important than components of any other frequency.

We compare both the ACF and the power spectrum of our simulated data with that of actual data.

The first two autocorrelation coefficients of the actual quarterly data over the 1947-1990 period are 0.37 and 0.25 respectively, both of which are significantly different from zero on the usual criteria, given that an approximation to the standard error on the coefficients is $1/\sqrt{n}$, where n is the sample size. The third coefficient has a point estimate of 0.01, and the coefficients at four through eight lags are negative but insignificant.

The ACF of the actual data and the average of the ACFs of the simulated data are plotted in Figure 2. The simulated data clearly replicates *qualitatively* the actual data, exhibiting positive low order autocorrelation, and negative autocorrelation at higher lags. Over the first 8 lags, the coefficients of the ACF of actual data sum to 0.27, and those of simulated data to 0.29.

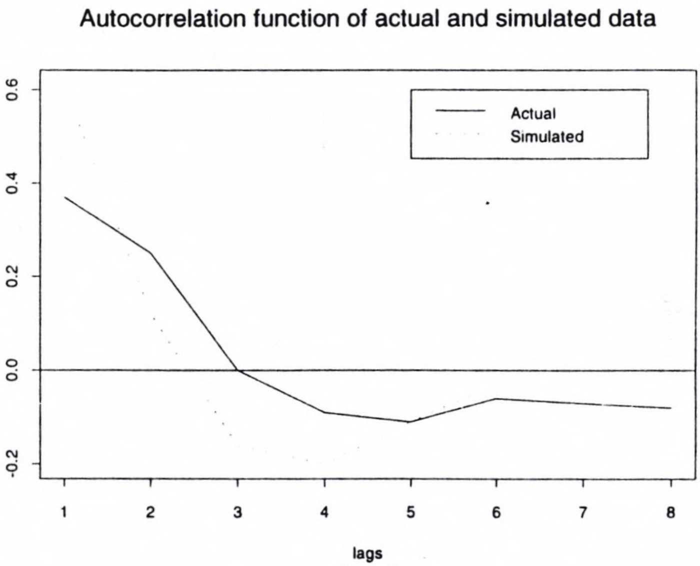

Figure 2

We do not attempt to disguise the fact that the quantitative estimates do not match perfectly, with, for example, the average coefficient of the simulated data at lag one being 0.61 compared to the 0.37 of the actual data, and 0.12 at lag two compared to 0.25. On the formal test proposed by Cogley and Nason, the null hypothesis that the actual and simulated ACFs are identical is rejected. But the simulated data captures the decisive qualitative feature of low order positive and higher order negative autocorrelation in a way which RBC models simply do not.

Figure 3 plots the smoothed periodogram of the actual data and of a typical simulation (the calculations are performed in the statistical package S-Plus, with a split cosine taper being applied to the end points of the data, and a mild amount of smoothing being applied to the raw periodogram through modified Daniell windows in order to bring out the basic pattern more clearly).

Smoothed periodogram: actual and typical simulation

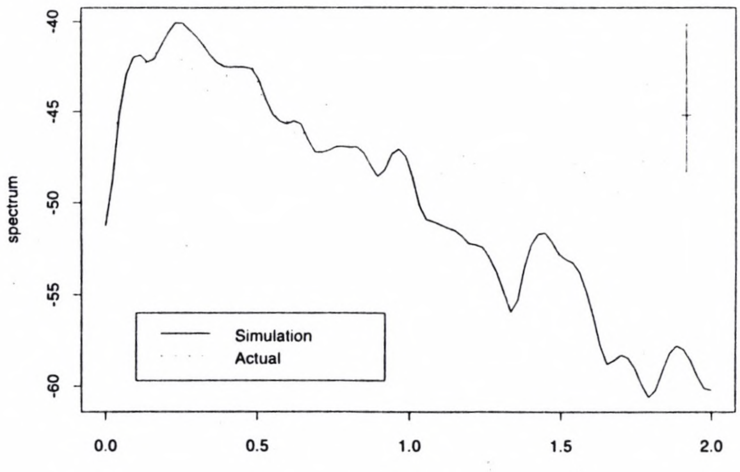

Figure 3

The spectrums of both the actual and simulated data are both concentrated at frequencies which correspond to those of the business cycle, with the simulated being somewhat more concentrated than the actual. But again, as with the ACF, the simulated data reflects clearly the qualitative properties of the actual data.

The degree of concentration of the data at business cycle frequencies is, however, not strong. An important reason why this is the case was advanced many years ago by Burns and Mitchell (1946), in their classic NBER work on the US business cycle, who argued that 'the sequence of changes is recurrent but not periodic; in duration cycles vary from more than one year to ten or twelve years'.

In summary, unlike real business cycle models, our simple model replicates the main qualitative features of actual US output growth. It is deliberately parsimonious in its structure, but nevertheless the calibrations of simulations of the model against actual business cycle data gives the model initial credibility.

4. Implications for unemployment policy

As a first approximation, we assume that unemployment is determined by the state of aggregate demand. In other words, it depends upon thr rate of growth of output. This is contrary to the received wisdom in economics, which sees unemployment as being determined primarily by supply side factors such as the benefit/wage ratio and general labour market 'flexibility'. It is recognised by most economists, however, that during the course of a single business cycle, unemployment is correlated with movements in output. But, as Nickell (1997) for example argues, it is believed that 'business cycle effects and autonomous demand shocks of various kinds should wash out if we take a long enough period'.

On the contrary, the evidence of the past two decades or so in Western economies is that a substantial amount of the increase in unemployment which has taken place can be accounted for by an inadequate growth in demand which has persisted over the course of several cycles.

In the standard Layard-Nickell approach, for example, demand plays no role in determining unemployment over time, although Rowthorn (1996) shows absolutely conclusively that this relies upon making an assumption which is contradicted by the empirical evidence, namely that the elasticity of substitution between capital and labour equals one.

Essentially, Layard-Nickell models take international evidence on unemployment, and relate it to a number of factors such as the benefit system and a set of country-group dummies. The variables on 'centralised wage bargaining' and such are of this latter kind: they say that a group of countries with particular characteristics in common have a different experience of unemployment than countries in other groups.

In the same spirit, we examine the hypothesis that the change in the average rate of unemployment in 20 OECD economies between the periods 1974-94 and 1960-73 depends simply upon the change in the average annual rate of growth. The change in unemployment depends simply on the change in the rate of growth. But, in the spirit of Layard-Nickell, we have some country groups. We have the corporatist economies of Austria and Switzerland - very centralised in many ways, which expelled foreigners; socially cohesive economies of Sweden and Portugal; and the special social cohesive case of Japan. We test the hypothesis that the change in these economies is - for obvious reasons - less than it would be if it were solely determined by the change in growth. This is just what Layard-Nickell models do with their dummies for different types of wage bargaining, and is equally justified.

This is the resulting regression:

$$DU = -0.17 - 2.18DG - 11.89JDUM - 4.86COHDUM - 5.21CORPDUM \quad (6)$$
$$(0.89) \quad (0.35) \quad (1.95) \quad (1.14) \quad (1.10)$$

s.e. = 1.43; $R^2 = 0.799$

where the figures in brackets are standard errors, DU is the change in average unemployment rate 1974-94 on 1960-73 in 20 countries, DG is the change in the growth rate; and there are three dummy variables as discussed above, which are signed in accordance with prior expectations.

This suggests that the change in growth accounts for 80 per cent of the change in unemployment. And for every percentage point fall in a country's growth rate, unemployment was some 2.2 percentage points higher.

We now move to consider the implications of our model for unemployment in terms of the properties of the aggregate growth of output variable, XBAR(t).

A very important implication is that what has come to be seen as 'Keynesian' demand management, in the sense of following counter-cyclical demand policies, cannot succeed. In order to be able to carry out effective counter-cyclical policy, it is necessary to be able to make forecasts which on average are reasonably accurate. Unless the state of demand in, say, a year's time can be predicted with reasonable confidence, it is not possible to decide the appropriate counter-cyclical policy to carry out now.

But the properties of both the XBAR variable in the model and of actual output growth suggest that forecasts cannot be carried out with any meaningful degree of accuracy even over a one-year ahead horizon. This is demonstrated for both the actual and simulated data using techniques of phase space attractor reconstruction by Ormerod and Campbell (1997) and Ormerod (1998), to which the interested reader is referred. It should be said that this is entirely consistent with the actual macro-economic forecasting record. The OECD (1993), for example, surveyed the one year ahead output growth forecasts of the G7 government, the IMF and the OECD, and concluded that they were no better than the naive rule that next year's growth is the same as this year's, a rule which leads to a very poor forecasting record.

But even if forecasts could be made with sufficient degree of accuracy to warrant an attempt at a counter-cyclical fiscal stance, the conventional literature gives little guide as to the appropriate policies to follow. Church et.al. (1993), for example, report the policy simulation properties of the six leading UK macro-econometric models. The models disagree not just on the size but on the *sign* of the conventional public expenditure multiplier in the medium term.

Consider the impact in our model of short-term government fiscal intervention. We can interpret this as an exogenous shock to the outcome which the model itself would generate.

We examined the impact of a large contractionary intervention amounting to a negative impact of 5 percentage points in each of four successive periods. The intervention was assumed to operate in two different ways. First, the impact was purely on the aggregate output variable. Second, the impact was on both the aggregate output and the aggregate sentiment variable.

We carried out 200 simulations of the model in each case, and the results are reported in Table 3. We show summary statistics for the rate of growth of aggregate output in the year (assuming the periods are quarters) in which the intervention takes place, and over the five years after the intervention.

Table 3. Output growth (%) following negative fiscal intervention of 5 percentage points of aggregate output

	Shock to aggregate output only				
	Min	**3rd Quartile**	**Mean**	**1st quartile**	**Max**
Year of intervention	-6.1	-4.6	-4.1	-3.6	-2.0
Next five years	-0.8	0.2	0.3	0.5	1.0

	Shock to aggregate output *and* aggregate sentiment				
	Min	**3rd Quartile**	**Mean**	**1st quartile**	**Max**
Year of intervention	-9.0	-7.6	-7.1	-6.5	-4.8
Next five years	-0.5	0.0	0.2	0.3	1.3

By construction, in the long-term the average rate of growth of output in simulations of the model is zero, for the model is concerned with cycles around the underlying long-run growth rate. So the results must be interpreted bearing this in mind.

There are several points to make. First, expectations and sentiment are important in determining the size of the short-term multiplier. A negative shock of 5 percentage points to aggregate output alone gives an average multiplier of 4.1/5 = 0.82, whereas if sentiment is also affected negatively by the shock the multiplier is 7.1/5 = 1.42. Second, the estimated size of the multiplier varies according to the state of the economy at the time. When both output and sentiment are affected, for example, the impact multiplier varies between 0.96 and 1.80.

But the third point is the most important for our present purposes. Namely, that the long-run impact of temporary fiscal shocks is essentially zero. The average rate of growth in the five years following the shock is effectively zero. In other words, conventional fiscal policy cannot succeed in altering the longer-term outcome for output and hence for employment.

Governments can influence the rate of growth of output and hence the level of employment/unemployment in the longer run, but only if they are able to create an environment in which the state of sentiment about the future is made more optimistic than it would otherwise be in a sustained way. Table 4 illustrates the effect on aggregate output growth of a sustained positive shock over twenty years of one percentage point to the aggregate sentiment variable.

Table 4. Output growth (%) following sustained positive shock of one percentage point over 20 years to aggregate sentiment

Min	3rd Quartile	Mean	1st quartile	Max
0.1	0.4	0.5	0.6	0.9

Economists offering advice to policy-makers have been accustomed to provide a check-list: 'do A, B and C, and the consequences will be X'. As our model shows, such an approach can be seriously misleading. However, it is hard to translate the concept of a sustained boost to expectations into clear policy advice.

But we can think of the immediate post-war years as a good illustration of the benefits which arise whenever governments are able to create a positive environment in which sentiment about the future is boosted. After the war, there was enormous supply side potential for growth. In Europe in particular, personal consumer spending had been rationed severely for a number of years. There was a pent-up backlog of demand which could, and did, translate itself into a willingness to buy almost anything which was produced. Companies knew this, so their overall level of optimism was potentially high. They had the confidence to invest, which further boosted orders, growth and fed back positively on confidence itself. And, on the Continent in particular, a great deal of the capital stock of industry had been destroyed and needed replacing. The skills of the workforce remained intact, and in many ways were enhanced by the experience of war-time production. Overall, everything was in place on the supply-side to generate the very rapid rates of growth which were observed in the 1950s and for much of the 1960s.

Yet things could have gone seriously wrong. The initial transition of the European countries out of their war economies was hampered by a shortage of finance, and in particular of foreign exchange to pay for imports. The extraordinary generosity and far-sightedness of the American Marshall Plan was a key factor in overcoming this potentially serious hurdle. Perhaps even more importantly, recipients of funds in the Plan had to commit themselves to the principle of the market economy, and to dismantle the extensive planning and control structures assembled during the war. Such a framework can mobilise resources successfully during a crisis, but, as the experience of the Soviet bloc shows only too clearly, eventually proves stultifying.

The international world order could have retreated, as it did so disastrously after the First World War, into protectionism and monetary disorder. But again, mainly due to America's ability to impose its will, a process of dismantling trade barriers was set in motion, and the Bretton Woods agreement imposed order on the world money markets.

This environment created a virtuous circle, in which cycles existed around a level of expectations and sentiment which by historical standards was high. It is this for which governments should aim if they are to have a sustained impact on the rate of unemployment.

5. Conclusion

In this paper, we develop a microeconomic model of short-term output growth based upon interacting, myopic, heterogeneous individual agents operating on Keynesian principles.

The individual agents represent firms which differ in size, and are heterogeneous with respect both to decisions on output and to sentiment about future output growth. The decisions on the output growth of each agent are influenced by aggregate sentiment about the growth of output in the future, so that the decisions of others affects directly the behaviour of each agent. The sentiment on future output growth of each agent depends upon the previous value of his or her sentiment, and on the aggregate rate of growth of output. Again, through this latter term the decisions of other agents affects directly the behaviour of each individual agent.

We compare the properties of the output of 1,000 simulations of the model over 175 periods with that of the post-war US real quarterly GNP growth over the same number of periods, net of its mean. The model is calibrated so that the output growth variable has the same range of movement as that of the actual data.

A widely accepted property of business cycles is that output changes across broadly defined sectors move together over time. In its present, basic form, our model does not lend itself to an obvious aggregation of agents into groups representing different sectors. But the correlations between the growth rates of output of the individual agents in our model are generally positive and substantially different from zero, a result which is compatible with this particular stylised fact about business cycles.

The recent literature shows that the simulated data of real business cycle models does not replicate two key features of US short-term growth, namely the existence of significant positive autocorrelation at low order lags and then negative but insignificant autocorrelation at higher order lags, and the concentration of the power spectrum at frequencies which correspond to those of the business cycle.

In contrast to RBC models, our Keynesian model of interacting micro-agents does replicate qualitatively these key features of actual data.

Moreover, our model does not rely in any way on exogenous shocks. The cyclical behaviour which it exhibits in aggregate arises endogenously from the interaction of individual agents at the micro-level.

Our model is obviously a drastic simplification of reality. But the interaction of individual agents operating on Keynesian principles produces, endogenously to the model, a series for aggregate output growth whose qualitative properties are very similar to those of post-war US quarterly GNP growth.

Despite the Keynesian nature of the micro-foundations of the model, it provides little or no support for the idea that conventional counter-cyclical fiscal policy can affect the level of employment and unemployment in the medium term. The short-term multiplier of fiscal intervention varies very substantially, depending upon whether or not it succeeds in shocking aggregate sentiment and upon the state of the economy at the time of the intervention. But in the medium-term, the fiscal multiplier is zero.

The model allows the rate of growth of output, and hence the demand for labour, to be increased in the medium term if governments are able to create an overall environment, as they did in the immediate post-war years, in which the aggregate state of sentiment about the future is sustained at a level higher than it would otherwise have been.

Appendix: Technical details of model simulations

In order to produce model simulations, we have to decide upon the number of agents in the population and their relative sizes, and upon the parameters α, β, v_1 and v_2 which appear in equations (2) and (4).

The qualitative properties of the model are very similar to those reported in the main text of the paper if we make the assumption that all agents are the same size, but it is more realistic to allow firm size to differ. We choose the relative sizes of the agents in accordance with evidence from the US Fortune 500. In 1994 the top 10 companies had total sales slightly greater than those of the companies ranked 101-200 by size, and the top 100 had total sales quite considerably larger than those ranked 101-500. Although the everyday concept of sales is not the same as the definition of output in the national accounts, it does not seem unreasonable to choose the sizes of the agents in our model according to the power law which describes the distribution of the Fortune 500 companies by size

$$\log(\text{sales}) = 12.757 - \underset{(0.0053)}{0.789}\log(n) \qquad (7)$$

where n is the rank of the firms by size, the figure in brackets is the standard error on the coefficient, and the R^2 of the equation is 0.978. The power law (7) can be used to generate populations of any required size.

In principle, there is an argument for using very large populations, but we make the economic assumption that the overall behaviour of the corporate sector of any developed market economy is well described by the actions of the 500 largest companies.

In terms of parameter values, there is a fairly strong economic case that, in order to reflect the Keynesian spirit of the model, α should be reasonably close to 1. In other words, decisions on output growth are mainly governed by sentiment about the future. There is less economic guidance on the choice of β, but after some initial experimentation we settled on values of $\alpha = 0.80$ and $\beta = 0.275$.

The parameters v_1 and v_2 were chosen (with values 0.025 and 0.10 respectively) in order to give the aggregate output variable, XBAR, a similar range to that of actual quarterly American post-war output growth. These two parameters simply affect the range of XBAR and $YBAR^s$ and make no difference to the overall properties of the simulations, except on a very small-scale. For convenience, we assumed that the terms ε_t and η_t in equations (2) and (4) respectively follow a normal distribution, though in principle any reasonable statistical distribution could be used.

Simulations of the model are obtained as follows. At the outset values for X_i and Y_i^s are chosen at random from an appropriate normal distribution. An agent is chosen at random to update its growth rate and another agent is chosen to update its expectation or sentiment. This step is then repeated a number of times.

The theoretical model does not have a well defined time scale, so we define the period of the model to consist of 800 such steps. The aggregate variables XBAR and $YBAR^s$ are re-calculated only after this number of updates by individual agents. The choice of 800 steps to define the period means that the probability of any individual firm not revising its output decision is simply $((500 - 1)/500)^{800}$, which is approximately 0.20. In other words, around one-fifth of firms do not revise growth rates during any given period, and four-fifths do so revise. The qualitative properties of the simulations are similar for choices of between 500 and 1000 steps, which imply respectively that around one-third and one-eighth of companies do not revise decisions during any given period.

We introduced a facility whereby the revisions of the agents become known immediately to the other agents during that same period, by updating the values of $YBAR^s$ and XBAR immediately. For simplicity, we refer to this variation of the model as 'conferring', although of course this is not intended to suggest actual collusion by firms. In non-conferring simulations, the new $YBAR^s$ and XBAR are computed only at the end of the period. The reality is presumably somewhere between the two. Qualitatively, solutions obtained under these two variations are similar, though the non-conferring one is the better of the two and, accordingly, these are the results which we report below.

We also allow the first k periods of the simulation, following the initial random allocation of X_i and Y_i^s, to be discarded to avoid recording any transient behaviour of the model. We set k at 100 in the reported results, but varying this number appears to make little difference.

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