Macroeconomic Frictions: What have we learned from the Real Business Cycle research program?

Jean-Pierre Danthine — UNIVERSITY OF LAUSANNE & CEPR

John B. Donaldson — COLUMBIA UNIVERSITY

This version: November 19, 1999

Abstract

One interpretation of the RBC research program is that it was meant to identify and incorporate into dynamic general equilibrium models those market imperfections which are most relevant for macroeconomic theory and policy. This paper reviews the methodological basis for this interpretation. It then discusses the empirical foundations for some of the many frictions that have found their way into RBC models including efficiency wages, labour contracts, nominal price rigidities, limited market participation, imperfect competition and expectational errors. We find that the 'necessity' of these frictions is better established in some cases than in others. While one is lead to the prediction that the 'next neo-classical synthesis' will be a dynamic stochastic general equilibrium with frictions, it is premature to decide which specific friction will necessarily be taken on board.

Keywords: Business cycle; neo-classical synthesis; market frictions
JEL code numbers: B41; E10; E32

1. Two quick answers to the question at hand

Two extreme, definitive, answers to the question posed in the title and one more murky, incomplete, one can be contemplated. The first holds that we have learned nothing from the Real Business Cycle (RBC) program on the subject of frictions simply because it has nothing to teach us: the RBC program is the wrong research program, a mistaken route in our attempt to understand short run macroeconomic phenomena. One stated reason for such a view, phrased by Bob Solow in this volume, is that the underlying neo-classical growth model was designed to be a model for the long run, a time horizon at which one may hold that all the necessary price and wage adjustments have been made. It is thus not an appropriate model for studying short run phenomena, fluctuations occurring at quarterly frequencies, a time horizon where, to the contrary, the flex wage and price hypothesis must be a priori ruled out.

At the other extreme of the spectrum, there is another definitive answer, one naturally arising from a narrow, yet frequent, interpretation of the RBC program. In that restrictive view, within which the RBC approach is often confined (see most recent macro textbooks, e.g. Burda and Wyplosz, 1997), the RBC program would have taught us that most macro phenomena can be understood with the help of a perfect market frictionless model, a close cousin of the neo-classical stochastic growth model. If one accepts this claim, what we would have learned from the RBC program is that the world is frictionless!

We would have learned moreover that business cycles are real: real productivity shocks, as opposed to monetary shocks or preference shocks (animal spirits or information shocks) are the dominant source of business cycle fluctuations. Real business cycle theorists would in a sense have established the triumph of new classical macroeconomics and the futility of macroeconomic stabilisation policies.

2. … with which we cannot be satisfied

The basis for these claims is the fact that key business cycle facts appear to be "surprisingly" well accounted for by the moneyless neo-classical growth model with technology shocks. Table 1 illustrates the dimensions on which this claim is usually made. It compares the standard deviations, and correlations with output, of output itself, consumption, investment, employment, and productivity for the U.S. economy and for the model economy. The artificial economy here is the neo-classical stochastic growth model enriched with preferences over leisure as well as consumption. It is meant to represent an economy in dynamic competitive equilibrium. This decentralised interpretation is possible thanks to the use of the first welfare theorem (Prescott and Lucas, 1972). In this world, the representative agent optimises along two margins, the choice between labour and leisure, and the choice between consumption on the one hand, savings and investment on the other. There are no frictions, perfect Walrasian markets, and the equilibrium is a Pareto optimum. The illustrated properties correspond to those of a fully calibrated model; i.e., the model is parametrised so as to respect a number of important long run regularities and relevant information found in parallel studies (See Cooley, 1997).

An alternative way to evaluate the basic model's performance consists in comparing the output generated by the model with its real world counterparts. This is done in Figure 1, which shows the results of inputting estimated Solow residuals over the period 1948 to 1996 into the artificial economy model. The latter acts as a propagation mechanism transforming these 'productivity' shocks into time series for the major macro-aggregates. The fit with the data is close, with a correlation between the two output curves of 0.79.

There are several reasons why we will not satisfy ourselves with the above view, suggesting as it does that all that can be said has been said in business cycle theory. The first resides in the fact that the list of standard deviations and correlations contained in Table 1 lacks ambition. In the language we shall use in a moment, the congruence between model and reality, when limited to the stylised facts of Table 1, is not sufficient to give us confidence in the appropriateness of the underlying model. This assertion is confirmed by the fact that, at this level of observation, the expanded neo-classical growth model and a variety of other, very different, models with strongly diverging policy implications are observationally equivalent. Thus, Table 2 provides similar data for two alternative models. The first (panel A) is a wage contracting model proposed by Dow (1995). The only amendment proposed to the neo-classical growth model is that firms and workers have to agree on a wage one period ahead, thus before knowing the exogenous productivity shock. The second (Panel B) is a model with efficiency wages of the shirking type. In this model, proposed by Danthine and Donaldson (1995), there are three types of workers, the young, the old with experience and the old without experience. The overall level of unemployment is 13 percent. Unemployment among the young is 23 percent. This equilibrium is not Pareto optimum. It is it is hard to imagine a model more at variance with the original RBC model. Yet in terms of the basic data of Table 1 it produces more or less the same results.

Another reason to question the success of the benchmark RBC model is provided by the many 'puzzles' that have been uncovered by various authors since the inception of this research program.

These puzzles are typically stylised facts outside the list of Table 1 which falsify the simple model or one of its extension in a robust way. A number of these puzzles will be discussed in what follows.

A third and final reason to contest the position associated with the pure real business school is linked with the interpretation of Solow residuals as productivity shocks. One way of summarising this line of criticism is to say that "too much is stuffed into the black box" we call Solow residuals. One reason to suspect that the role proposed to Solow residuals is excessive is the observation, first made by Hall (1990), that Solow residuals are in fact correlated with demand side variables and that it is thus unwarranted to interpret them as exogenous productivity shocks. Another, more intuitive, expression of the same idea is the oft-expressed opinion that Solow residuals are unplausibly large and variable, and moreover that they are often negative, an observation which is hard to rationalise (e.g. Summers, 1986). The flip side of the same criticism is the observation that the simple R.B.C. model constitutes a weak propagation mechanism. In several respects what one gets out, the characteristics of the output process, is very similar to what one feeds in, the Solow residuals. This is particularly true of the degree of persistence of the output process (See Cogley and Nason, 1995).

In this perspective, model enrichments that help strengthen the propagation mechanism are particularly welcome. One can think of introducing increasing returns to scale and/or imperfect competition, two properties that tend to enhance the propagation mechanism and that we will discuss later on. Similarly, models with a credit multiplier and several models with non-Walrasian labour markets such as the Dow and the Danthine and Donaldson models of Table 2 have stronger propagation mechanism as well. One must realise however, that neither credit-multiplier, nor non-Walrasian models provide effective guidance as to how to correct for the estimation of productivity shocks from Solow residuals. In fact, all models built on the standard aggregate production function are equally subverted by the doubtful identification of Solow residuals with exogenous productivity shocks. On the contrary, models with variable factor utilisation come with instructions as to how to go from Solow residuals to productivity shocks. And they are quite successful at that. King and Rebelo (1999), for example, show that the twin assumptions of indivisible labour (to be detailed later on) and variable capital utilisation perform extremely well in terms of the criteria of Table 1. And this performance is achieved with much smaller estimated productivity shocks (see Figure 2 for a comparison of Solow residuals with the productivity shocks estimated with the King-Rebelo model). These productivity shocks are practically always positive and they are uncorrelated with demand side variables. Yet, King and Rebelo's economy, while not frictionless because of the indivisible labour assumption, is in fact a high substitution economy; another margin of substitutability rather than an extra friction has been added: within a quarter, firms can adjust the intensity with which they use their capital stock.

Before leaving this subject, it is useful to comment on the interpretation of technology shocks. In business cycle models as well as in growth theory, we have come to associate Solow residuals with changes in the stock of knowledge, which over time make it possible to produce more output at unchanged input levels. In this narrow sense, negative residuals, implying a decrease in the stock of knowledge, are indeed difficult to justify. Hansen and Prescott (1993), however, propose that we should adopt a broader view of what underlies the output variations left unexplained by changes in factor usage. Without questioning the necessity to account as well for possible changes in factor utilisation rates, as King and Rebelo (1999), Finn (1995), Burnside, Eichenbaum and Rebelo (1993) and others do, they argue that the relationship between inputs and output is affected also by changes in the legal and regulatory system of a country and in the non-traded, and thus non-measured, factors of production. They argue "*that the reason for the huge difference [in productivity] between United States and*

India must be that India has been less successful than the United States in setting up economic institutions conducive to development." And, that when" *pollution rights are not traded and the government imposes constraints on firms with regard to the amount of pollution, this represents a technology shock, since the amount of output that can be produced from given quantities of market inputs changes.*"

3. The RBC research program as a mechanism for identifying necessary frictions

In the preceding section, we have sought to explain why we could not consider as definitive the frictionless view of the world promoted by a straightforward interpretation of the benchmark R.B.C. model. In so doing, we have been confronted with the fact that not all amendments to the basic model will necessarily lead to the introduction of market frictions. We now want to make precise the process by which such enrichments should be guided. In our view, the distinguishing feature of the R.B.C. program is not some prior insistence on the pre-dominance of technology shocks, or the religious belief that labour and product markets always clear. Rather it is the view that the workhorse model for modern macroeconomics will be a dynamic stochastic general equilibrium model of one form or another, together with the experimental view of model building proposed by Lucas (1980). In Lucas' words, "*one of the functions of theoretical economics is to provide fully articulated , artificial economic systems that can serve as laboratories in which policies that would be prohibitively expensive to experiment with in actual economies can be tested out at much lower cost. …We need to test models as useful imitations of reality by subjecting them to shocks for which we are fairly certain how actual economies, or part of economies, would react. The more dimensions on which the model mimics the answers actual economies give to simple questions, the more we trust its answers to harder questions.*"

The keyword in the quoted text is the word 'trust'. Models are our experimental tools, our laboratories. In order to trust the answers a model would provide to hard policy questions, we need to be confident in the model itself. How do we build confidence? Lucas' introductory sentence provides one direction: test models by subjecting them to shocks for which we are fairly certain how actual economies would react. We can, however, take a broader stance on this issue. We will more easily trust models which to a larger extent share the general properties of the data. In that view, much of what is known as ‘calibration’ is part of a "building confidence" exercise. We know actual economies appear to follow balanced growth paths, with important ratios remaining approximately constant over the long run. These ratios are identified, for example, with the Kaldor facts (Kaldor, 1957). Similarly, Lucas (1977) identified a set of properties generally associated with business cycles. He stressed that these regularities are independent of time and places and, as such, could reasonably be viewed as defining the business cycle. The quantification of these regularities constitutes the basis for the standard deviations and correlations found in Table 1.

But, as already suggested, congruence between model and reality should not be limited to the stylised facts of Table 1. They are not sufficient to give us confidence in the ability of the model to answer hard economic policy questions. It is thus natural to go beyond them. The most frequently travelled avenues consist in comparing impulse response functions and looking at conditional as well as non-contemporaneous correlations. It is important, however, to remember here that models are abstractions, and that they cannot conform to reality on each and every dimensions. We believe the key to success consists in isolating what we will call ‘significant facts’. By facts, we mean characteristics of real economies known with some degree of confidence. By significant, we mean that these facts should be important enough to justify being featured in a good macro model. There is a good deal of subjectivity in this process which is at the heart of model selection. It depends on the question being addressed since the latter conditions the characteristics we would insist the model should possess.

In the rest of this paper, we illustrate how this approach may be used, and has been used, to guide the development of the theory and we discuss to what extent present trends indicate the need to enrich the basic model with macroeconomic frictions. We are not far from accepting the view that the RBC research program is, in fact, an organised research program precisely aiming at deciding which particular friction must necessarily be included in the modelling process. The guiding principle is the capacity of the model, with or without this friction, to explain significant facts. Parsimony requires that only those frictions which prove necessary in this sense should find their way into the final dynamic stochastic model we will use as our benchmark representation of the macroeconomy.

4. Labour markets

Quite naturally if we think of justifying frictions, we start by focusing on the labour market. In the short history of the RBC literature, one significant fact stands out for the role it has played in the process we want to illustrate. It is the observation that the standard deviation of hours is approximately the same as the standard deviation of output, an observation labelled early on as the employment volatility puzzle. This is a fact is well documented for the U.S.; somewhat less so for other countries where the measured ratios (SD(n)/SD(y)) range from 0.50 for Italy to 1.34 for South Africa (Danthine and Donaldson, 1993). Taking this observation as a fact, nevertheless, we can certainly use the adjective 'significant' because it falsifies the neo-classical growth model which could replicate it only if one hypothesises an unplausibly high willingness to substitute labour and leisure across time periods (Indeed the model of Table 1 exhibits a ratio SD(n)/SD(y) = 0.54) . It is significant as well because it questions the benchmark model precisely in a dimension where one would expect it a priori to be the most vulnerable; i.e., in the maintained assumption of clearing (Walrasian) labour markets. For this reason, it provides definite support to proponents of non-Walrasian labour market formulations. Indeed both the shirking and the contracting models of Table

2 pass the employment volatility test. Note, however, that not all non-Walrasian formulations do; see for example Danthine and Donaldson (1990).

It is also the case that the employment productivity puzzle can be simply and elegantly resolved by adopting another (non-Keynesian) friction, the indivisible labour supply hypothesis to which we now turn (Hansen, 1985; Rogerson, 1988). This hypothesis states that agents cannot continuously vary their supply of working hours; i.e., they cannot adjust the length of their working day. In effect, they may work full time or not all (for reasons due to supply – costs of going to work –, or demand – such as fixed costs associated with labour management). This implies that all changes in hours will be done along the extensive margin, that the individual intertemporal elasticity of substitution regarding leisure is immaterial - despite the fact that the aggregate elasticity of substitution is infinite -, and, because of the latter fact, that the quantity of labour employed is exclusively determined by the demand side of the market (a Keynesian property). The literature has tended to prefer the indivisible labour hypothesis to the various non-Walrasian formulations that have been proposed, probably for reasons of parsimony.

Another important labour market observation is related to the co- variation of real wages or productivity with output. Since Dunlop (1938) and Tarshis (1938), it has been taken as a fact that real wages are close to a-cyclical. This observation is significant because it falsifies the indivisible labour model which needs to be rescued by the adjunction of demand shocks. Christiano and Eichenbaum (1992) propose the introduction of government spending shocks while Hansen and Wright (1992) model shocks to the home production function. In both instances, demand shocks are an interesting adjunction from the perspective of the narrow interpretation of the RBC model (business cycles are real).

This observation also provides support to models where wage adjustments are sluggish, be it because of contracts (Dow, 1995; Boldrin and Horvath, 1995), or efficiency wage considerations. Again both models of Table 2 pass this test. So would a gift exchange model with sluggish reference wage such as proposed for instance by Collard and de la Croix (1998) (or the model of section 4.3 in Danthine-Donaldson, 1990).

On this score, we are confronted with the question of whether this discriminating information is indeed a fact. Contrary to the Dunlop-Tarshis observation, studies on longitudinal micro-data appear to indicate that real wages are in fact quite strongly pro-cyclical, a property obscured by a composition bias: the aggregate statistics are constructed in a way that gives more weight to low-skill workers during expansions that during recessions (Solon, Barsky and Parker, 1994; see also Liu, 1999). In the case of models with homogeneous labour, where the composition bias cannot be modelled, these results seem to favour underlying mechanisms generating pro-cyclical real wages.

In most of the RBC literature, the emphasis so far has been on employment rather than unemployment. This is starting to change, see Merz (1995), Andolfatto and Gomme (1996) or Gomes, Greenwood and Rebelo (1997), among several others. New independent 'significant facts' on unemployment are hard to come by, however, except in terms of flows. The latter are usable only if one adopts a search-matching type modelling for the labour market. While attractive, we do not want to postulate that this is to only promising approach for aggregate general equilibrium macro modelling.

In conclusion, we are not yet ready to decide which friction should be part of the right parsimonious description of the labour market in dynamic stochastic general equilibrium models. There is an abundance of observationally equivalent candidates and we are short of discriminating, significant, facts. This is disappointing. Focusing on the labour market seemed a sure recipe for identifying 'necessary' frictions! In this domain, one is forced to accept the view that, at this point, theory is ahead of (significant) business cycle facts (Prescott, 1986).

5. Money

As opposed to the shortage of significant facts guiding the modelling of labour markets, the extension of the RBC literature to the realm of monetary economics provides a perfect example of a discriminating experiment exactly aligned on the recommendation of Lucas. The simple experiment for which we know with some confidence how actual economies would react is an unanticipated increase in the money supply. Indeed, there appears to be a consensus that such a monetary shock is normally followed by a fall in nominal interest rate. Christiano, Eichenbaum and Evans (1998) would even argue that the consensus is broader and also bear on the real effects of such an increase in the money supply - increase in output, increase in employment – and on the resulting behaviour of prices - quasi-stability. On the latter dimensions, however, the consensus is more fragile (see Uhlig (1999)). For this reason we limit ourselves to the implications of the first part of the proposition.

The interest rate impact of an unanticipated increase in money is a significant fact because it points clearly towards the necessity of introducing nominal frictions into the model. Indeed it falsifies the standard RBC model with money introduced via a cash-in-advance (CIA) constraint (Cooley and Hansen, 1989, 1995). In this model, the main effect of an unanticipated increase in money is to feed inflationary expectations leading to an increase in the inflationary premium and thus a rise in the nominal interest rate.

Two frictions have been suggested to improve model performance: cost of adjusting prices and cost of adjusting portfolios. The former, generally labelled menu costs, may be introduced either in the form of a direct cost of adjustment function or via imposing the constraint that only a fraction of (possibly randomly chosen) firms are allowed to modify their prices in the current quarter (e.g. Calvo, 1983). Obviously, the model context here must be one where firms set prices, i.e. where competition is imperfect. The alternative is to stipulate the existence of costs to adjusting portfolios. Again a cost of adjustment function may be imposed which penalises a quick re-balancing of portfolios by individuals. Alternatively, and interestingly, a financial intermediation sector may be introduced. Monetary policy then takes the form of open market operations. The direct effect of a monetary injection falls on commercial banks, and is entirely transmitted to firms' borrowing conditions because households are precluded from adjusting their portfolios during the period. The latter model are known under the label of “limited participation model of money” (Lucas, 1990; Fuerst, 1992).

There may be other solutions to this puzzle. The fact that the main contenders strongly point towards the introduction of meaningful frictions is significant from the perspective of the question with which we began. So is the conclusion of Christiano, Eichenbaum and Evans (1997) that nominal rigidities of the two types contemplated above will not be enough and that they will have to be complemented with other ‘real’ frictions.

6. Other puzzles

The burgeoning literature based on the neo-classical stochastic growth model is replete with other facts deemed both significant and difficult to explain, hence often promoted to the status of puzzles or anomalies. Let us cite the equity premium puzzle (Mehra and Prescott, 1985), and, in the international arena, the quantity and price variability anomalies (Backus, Kehoe and Kydland, 1992, 1995; Hess and Shin, 1997). Many of these fall under the rubric of "asset pricing puzzles". At the most fundamental level, a successful macroeconomic model should be able to explain the stylised facts of the financial markets as well as the business cycle regularities. The former includes the historical mean equity and risk-free returns and their differences (the equity premium), their volatilities (return standard deviations) and their time series correlation structure. While progress along the business cycle dimensions (described in earlier sections of this paper) has been substantial, the success in exploring financial regularities has been more circumscribed (see Kocherlakota, 1996, for a survey). Promising alternative avenues for improving model performance include habit formation (Constantinides, 1990; Campbell and Cochrane, 1999), so called 'peso' effects (Danthine and Donaldson, 1999), high persistence variation in factor shares (Danthine and Donaldson, 1999), and modelling of the transactions functions implicit in Treasury bills (Bansal and Coleman, 1998). As predicted by Mehra and Prescott (1985), an incomplete markets structure characterises several of the proposed solutions

These anomalies and their resolution are obviously significant for finance. But they may reveal shortcomings relevant for macroeconomics as well. If, for instance, habit formation turns out to be the most robust solution to the equity premium puzzle, the modelling of preferences in macro models will have to be modified accordingly. On the other hand, the international capital market frictions, which may prove necessary to explain the puzzles of international finance may or may not have implications for, closed economy macroeconomics.

7. Two significant presumptions and their implications

In a recent article using a VAR methodology, Gali (1999) claims that identified positive technology shocks have a negative effect on employment. This observation is in stark contrast with the impact of such shocks in the standard RBC model, where of course they stimulate employment. Gali's explanation is that firms are demand-constrained as they would be in a world of imperfect competition with nominal rigidities (temporarily fixed prices). King and Rebelo (1999) suggest that this observation could also be accounted for in a multi-sector model where produced outputs are complements. This possibility notwithstanding, the observation is significant because it reinforces the plausibility of an important friction and because it clearly falsifies the pure technology driven business cycle model. It does not deserve the status of fact yet, however, as it as not been confirmed in other studies using alternative active identification procedures.

Many economists would argue that a wave of consumer pessimism is likely to result in an economic recession. We do not know the extent to which there is a consensus on this view and, indeed, the discussion in the *American Economic Review* of 1993 as to the causes of the U.S. recession of 1991 leads us to doubt that there may be one (Blanchard, 1993; Hall, 1993; Hansen and Prescott, 1993). This doubt notwithstanding, Danthine, Donaldson and Johnsen (1998) tests the reaction of the benchmark model to such a shock proceeding as follows. They identify consumer pessimism with a change in growth expectations from a regime with a zero probability of a long period of stagnation to one where this probability is positive (although very small). In the real business cycle model (a version of the indivisible labour model to allow for such expectations), such a shock leads to a boom in investment, a natural consequence of the pre-cautionary increase in savings, and an increase in employment, an equally natural consequence of the precautionary increase in labour supply. Figure 3 traces these changes, which have long lasting consequences when expectations do not revert to their initial level. All in all, the increase in investment makes up for the shortfall in consumption, and the increased use of factors (fixed capital and increased labour) result in an increase in output. This demonstration is troubling. It relies on an assumption of perfect co-ordination between savings and investment, and on a complete ability of the labour market to adjust in the short run to an increase in labour supply (hence the observed decrease of real wages). At the minimum, the conviction that this is not the way the real economy would actually react to a fall in consumer confidence would lead us to advocate introducing real rigidity in wage adjustments, i.e., some real friction on the labour market. With this modification, the increase in labour supply would provoke an increase in unemployment, likely to weaken further consumer confidence, and output could not increase without a rise in factor utilisation. Again such an amendment goes in the direction of those suggested as likely in the previous two sections.

8. Towards a new neo-classical synthesis?

The facts and presumption discussed so far have lead quite naturally to an increasing fraction of the RBC literature being devoted to models combining different frictions. We would like to complete our discussion by describing two important research directions that have been suggested and explored. One important direction currently focuses on models combining nominal rigidities with imperfect competition often combined with increasing returns to scale in production and possibly complemented with an assumption of sluggish wage adjustment. Goodfriend and King (1997) grab the promising "new neo-classical synthesis" label and use it for a version of such a model but without the latter feature. How confident are we in these models? Very much so if we judge by the fact that they are being used to provide answers to 'hard' policy questions about the proper conduct of monetary policy. See for instance Clarida, Gali and Gertler (1999), who use it to support a policy of inflation targeting, and Goodfriend and King (1997) who advocate a policy of near-zero inflation aiming to produce a constant path for the average price-cost mark-up. On the other hand, they have not yet passed the traditional tests for confidence building such as those proposed in Table 1. In the words of King and Rebelo (1999), "*this research has not yet produced a business cycle model that performs at the same level as the RBC workhorse*." Moreover, King and Watson (1996) argue such a model cannot explain the observation that high nominal or real rates predict low output two to four quarters in the future, the 'inverted leading indicator' property.

Cooley and Quadrini (1998, 1999) propose an interesting alternative based on the limited participation model of money - with an operative liquidity effect - and on a search formulation for the labour market – where endogenous creation and destruction of jobs can occur in response to both aggregate and firm level shocks. They also use their model to answer 'hard' questions arguing that the optimal monetary policy should be pro- cyclical in the face of real shocks. Table 4 shows that their model accounts well for some basic, traditional, stylised facts of the business cycle. More research will be needed to discriminate among these two possible friction-filled models.

9. Conclusions.

This paper has reviewed work in progress. We are 'en route', and we believe we have taken the right path. If the current state of short run macroeconomics may not be as close to a consensus as the label "new neo-classical synthesis" chosen by Goodfriend and King may suggest, we are nevertheless getting closer and less ideological, and it looks increasingly likely that the resulting consensus will be a friction-filled dynamic stochastic general equilibrium model. The excitement of part of the profession is also palpable in the increasing willingness to use these new models to answer 'hard policy questions'.

References

Andolfatto, D. and Gomme, P. (1996), 'Unemployment Insurance and Labour-Market Activity in Canada', *Carnegie-Rochester Series on Public Policy*, vol. 44, pp 47-82

Backus, D.K., Kehoe, P.J. and Kydland, F.E. (1992), 'International Real Business Cycles', *Journal of Political Economy*, vol. 100, pp 745-775

_______________________ (1995), 'International Business Cycles: Theory and evidence', chapt. 11 in T. Cooley (ed.), *Frontiers of Business Cycle Research*, Princeton University Press, Princeton New Jersey.

Bansal, R. and W.J. Coleman II (1996), 'A Monetary explanation of the Equity premium, Term Premium, and Risk-Free Rate Puzzles,' *Journal of Political Economy* 104, pp. 1135-1171

Blanchard, O. (1993), 'Consumption and the Recession of 1990-91', *American Economic Review*, vol.83, pp.270-274.

Boldrin, M. and Horvath, M. (1995), 'Labour Contracts and the Business Cycle', *Journal of Political Economy*, vol.103, pp 972-1004

Burda, M. and Wyplosz, C. (1997), '*Macroeconomics: a European Text*', Second edition, Oxford University Press

Burnside, C., Eichenbaum, M., and Rebelo, S. (1993), 'Labour Hoarding and the Business Cycle', *Journal of Political Economy*, vol.101, pp. 245-273

Calvo, G.A. (1983), 'Staggered Prices in a Utility-Maximising Framework', *Journal of Monetary Economics*, vol.12, pp. 383 –398

Campbell, J.Y. and Cochrane, J.H. (1999), 'By Force of habit: A Consumption-Based Explanation of Aggregate Stock Behaviour', *Journal of Political Economy*, vol. 107, pp.205-251

Christiano, L. J. and Eichenbaum, M (1992), 'Current Real Business Cycle Theories and Aggregate Labor Market Fluctuations', *American Economic Review*, vol.82, pp. 430-450.

Christiano, L. J., Eichenbaum, M. and Evans, C. L. (1997), 'Sticky Prices and Limited Participation Models of Money: A Comparison', *European Economic Review*, vol.41, pp. 1201-1249.

Christiano, L. J., Eichenbaum, M. and Evans, C. L. (1998), 'Monetary Policy Shocks: What Have we Learned and to What End?', mimeo, Northwestern University.

Clarida, R., Gali J. and Gertler, M. (1999), 'The Science of Monetary Policy: A New Keynesian Perspective', *Journal of Economic Literature*.

Cogley, T. and Nason, J.M. (1995), 'Output Dynamics in Real-Business-Cycle Models', *American Economic Review*, vol.85, pp. 492-511.

Collard, F. and de la Croix, D. (1998), 'Gift Exchange and the Business Cycle: the Fair Wage strikes back', mimeo, Université catholique de Louvain.

Constantinides G.M. (1990), 'Habit Formation: A Resolution of the Equity Premium Puzzle', *Journal of Political Economy* , vol. 98, pp. 519-543

Cooley, T.F. (1997), 'Calibrated Models', *Oxford Review of Economic Policy*, vol.13, no.3, pp. 55-69

Cooley, T.F. and Quadrini, V. (1998), 'A Neoclassical Model of the Phillips Curve Relation', mimeo, Rochester University, forthcoming Journal of Monetary Economics.

Cooley, T.F. and Quadrini, V. (1999), 'How the Fed should react: Optimal Monetary policy in a Philips Curve World', mimeo, Rochester University, forthcoming Journal of Monetary Economics.

Cooley, T.F. and Hansen, G. (1989), 'The Inflation Tax in a Real Business Cycle Model', *American Economic Review* vol.79, pp.733-747,

Cooley, T.F. and Hansen, G.D. (1995), 'Money and the Business Cycle', chapt. 7 in T. Cooley (ed.), *Frontiers of Business Cycle Research*, Princeton University Press, Princeton New Jersey

Danthine, J.P. and Donaldson, J. (1990), 'Efficiency Wages and the Real Business Cycles', *European Economic Review*, vol.34, pp. 1275-1301.

_____________________(1993), 'Methodological and Empirical Issues in Business Cycle Theory', *European Economic Review*, vol.37, pp. 1-35.

_____________________ (1995), 'Non Walrasian Economies', chapt. 8 in T. Cooley (ed.), *Frontiers of Business Cycle Research*, Princeton University Press, Princeton New Jersey.

_____________________ (1999), 'Non Falsified Expectations and Asset Pricing: the Power of the Peso', *The Economic Journal* forthcoming

_____________________ (1999), 'Labour Relations and Asset Returns', mimeo, University of Lausanne

Danthine, J. P., Donaldson, J. B. and Johnsen, J. (1998), 'Productivity Growth, Consumer Confidence and the Business Cycle', *European Economic Review*, vol.42, pp. 1113-1141.

Dow, J.P. (1995), 'Real Business Cycles and Labour Markets with Imperfectly Flexible Wages', *European Economic Review*, vol. 39, pp. 1683-96

Dunlop, J. (1938), 'The Movement of Real and Money Wage Rates', *Economic Journal*, vol. 48, pp.413-434

Fuerst, T. (1992), 'Liquidity, Loanable Funds and Real Activity', *Journal of Monetary Economics* 29,.

Finn, M. (1995), 'Variance Properties of Solow's productivity Residuals and their Cyclical Implications', Journal of Economic Dynamics and Control vol.19, pp. 1249-1281

Gali, J. (1999), 'Technology, Employment and the Business Cycle: Do Technology Shocks Explain Aggregate Fluctuations?', *American Economic Review*, vol.89, no.1,
pp.249-271.

Gomes, J., Greenwood, J. and Rebelo, S. (1997), 'Equilibrium Unemployment', mimeo, University of Rochester.

Goodfriend M. and King, R. (1997), 'The New Neo-Classical Synthesis and the Role of Monetary Policy', *NBER Macroeconomics Annual*, 1997: pp. 231-283.

Hall, R.E. (1990), 'Invariance Properties of Solow's Productivity Residuals', in P. Diamond (ed.), *Growth/ Productivity/ Unemployment: Essays to celebrate Bob Solow's Birthday*, MIT Press, Cambridge, Mass.

Hall, R.E. (1993), 'Macro Theory and the Recession of 1990-91', *American Economic Review*, vol.83, pp. 275-279

Hansen, G. (1985) 'Indivisible Labour and the Business Cycle,' *Journal of Monetary Economics*, vol.16, pp. 309-327.

Hansen, G.D. and Prescott, E.C. (1993), 'Did Technology Shocks Cause the 1990-91 Recession?', *American Economic Review*, vol.83, pp. 280-286.

Hansen G.D. and Wright, R. (1992), 'The Labour Market in Real Business Cycle Theory', Federal Reserve Bank of Minneapolis Quarterly Review.

Hess, G. D. and Shin, K. (1997), 'International and Intranational business cycles', *Oxford Review of Economic Policy*, vol.13, no.3 pp. 93-109.

Kaldor, N. (1957), 'A Model of Economic Growth', *The Economic Journal*, vol. 67, pp. 59-62

King, R.G. and Rebelo, S. (1999?), 'Resuscitating Real Business Cycles', forthcoming in the Handbook of Macroeconomics, M. Woodford and J. Taylor, (eds).

King, R. G. and Watson, M. (1996), 'Money, Prices, Interest rates and the business cycle', *Review of Economics and Statistics*, vol.78, no.1 pp. 35-53.

Kocherlakota, N. (1996), 'The Equity Premium: It's Still a Puzzle,' *Journal Economic Literature*, vol.34, pp.42-71.

Liu, H. (1999), 'A Cross-Country Comparison of the Cyclicity of Real Wages', mimeo, National University of Singapore.

Lucas, R.E. (1977), 'Understanding Business Cycles' *Carnegie-Rochester Conference on Public Policy*, vol.5, pp.7-29, reprinted in *Studies in Business-Cycles Theory*, MIT Press, pp. 215-239.

Lucas, R. E. (1980), 'Methods and Problems in Business Cycle Theory', *Journal of Money, Credit and Banking*, 12, reprinted in *Studies in Business-Cycles Theory*, MIT Press 1982 : pp.271-296.

Lucas, Robert E. Jr. (1990), 'Liquidity and interest rates', *Journal of Economic Theory,* vol. 50, pp. 237-64.

Mehra, R. and Prescott, E.C. (1985),'The Equity Premium: A Puzzle, *Journal of Monetary Economics*, vol.15, pp.145-161.

Merz, M. (1995), 'Search in the Labour Market and the Real Business Cycle', *Journal of Monetary Economics*, vol.36, pp.269-300.

Prescott E.C. (1986), 'Theory Ahead of Business Cycle Measurement', *Federal Reserve Bank of Minneapolis Quarterly Review*, 10, Fall.

Prescott E.C. and Lucas, R.E. (1972), 'A Note on Price Systems in Infinite Dimensional Space', *International Economic Review* 13 (2), pp.416-422

Rogerson, R. (1988)., 'Indivisible Labour, Lotteries, and Equilibrium', *Journal of Monetary Economics*, vol.21, pp.3-16.

Solon, G., Barsky, R. and Parker, J. (1994), 'Measuring the Cyclicity of Real Wages: How Important is the Composition Bias?' *Quarterly Journal of Economics* CIX (1), pp.1-26

Summer, L. (1986), 'Some Skeptical Observation on Real Business Cycle Theory', *Federal Reserve Bank of Minneapolis Quarterly Review, Fall, pp.23-26.*

Tarshis, L. (1938), 'Changes in Real and Money Wage Rates', *Economic Journal*, vol.49, pp.150-154.

Uhlig, H. (1999), 'What are the Effects of Monetary policy ? Results from an Agnostic Identification Procedure', CEPR working paper #2137.

Table 1
Business cycle stylised facts
for the US economy and for the extended neoclassical growth model

	Quarterly US Time series (55.3 – 84.1)			Artificial economy (= Hansen divisible labor)		
Series	(a)	(b)	(c)	(a)	(b)	(c)
Output	1.76	1.00	1.00	1.30	1.00	1.00
Consumption	1.29	0.73	0.85	0.42	0.32	0.89
Investment	8.60	4.89	0.92	4.24	3.26	0.99
Capital Stock	0.63	0.36	0.04	0.36	0.28	0.06
Hours	1.66	0.94	0.76	0.70	0.54	0.98
Productivity	1.18	0.67	0.42	0.68	0.52	0.98

Standard Deviation in percent (a), Relative standard deviation (b) and correlations with output (c)
All statistics detrended with the Hodrick-Prescott filter – Source: Hansen (1985)

Table 2
Business Cycle Properties of two non-Walrasian Models

	Panel A: Wage contracting model[a]		Panel B: Shirking model[b]	
Variable	(a)	(b)	(a)	(b)
Output	1.76	1.00	1.74	1.00
Consumption	0.42	0.62	1.23	0.99
Investment	6.38	0.95	3.32	0.99
Capital Stock	0.31	-0.05	0.30	0.04
Hours, of which	1.85	0.85	1.70	0.98
Old experienced			2.17	0.71
Old inexperienced			8.16	0.03
Young			2.17	0.95
Productivity	0.90	0.17	0.29	0.24

a) Wages set in advance ‘Contracts (II)’ model in Dow (1995)
b) Danthine and Donaldson (1995)

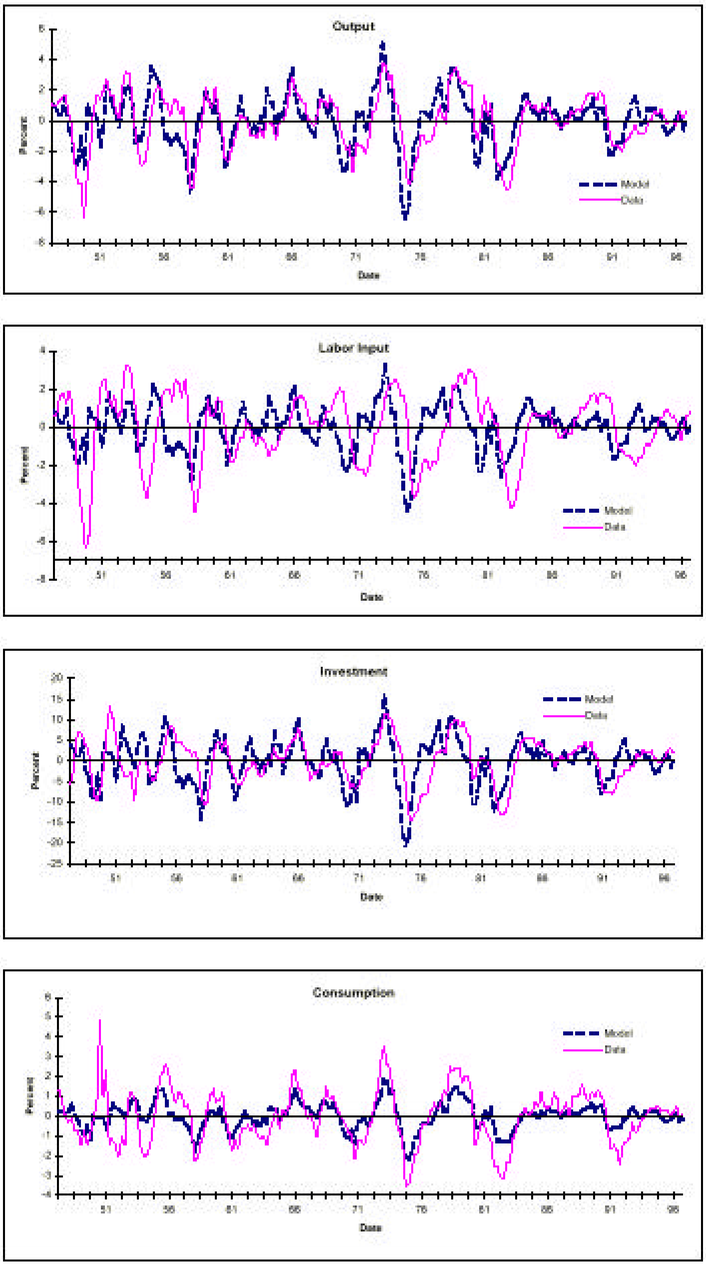
Table 3

Business cycle properties of the matching cum limited participation model

Standard deviations	Artificial Economy	U.S. Economy
output	1.63	1.60
Hours	0.46	0.22
Employment	0.94	0.99
Job creation / Employ	2.16	4.62
Job destruction / Employ	2.23	6.81
Price index	1.72	1.44
Inflation	0.91	0.56
Correlations		
Inflation / Stock returns	-0.38	-0.15
Money growth / Stock returns.	0.19	0.16

Source: Model Economy B (α_u = 0.1; η = 0.01; both monetary and real shocks) in Cooley and Quadrini (1998), see this source for details.

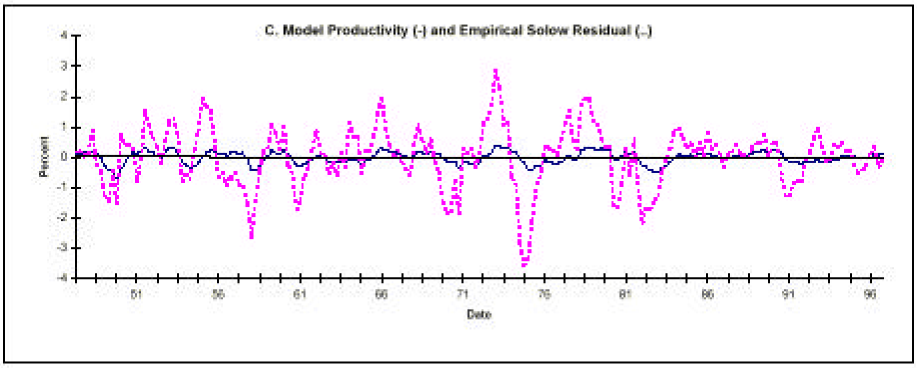
Figure 1



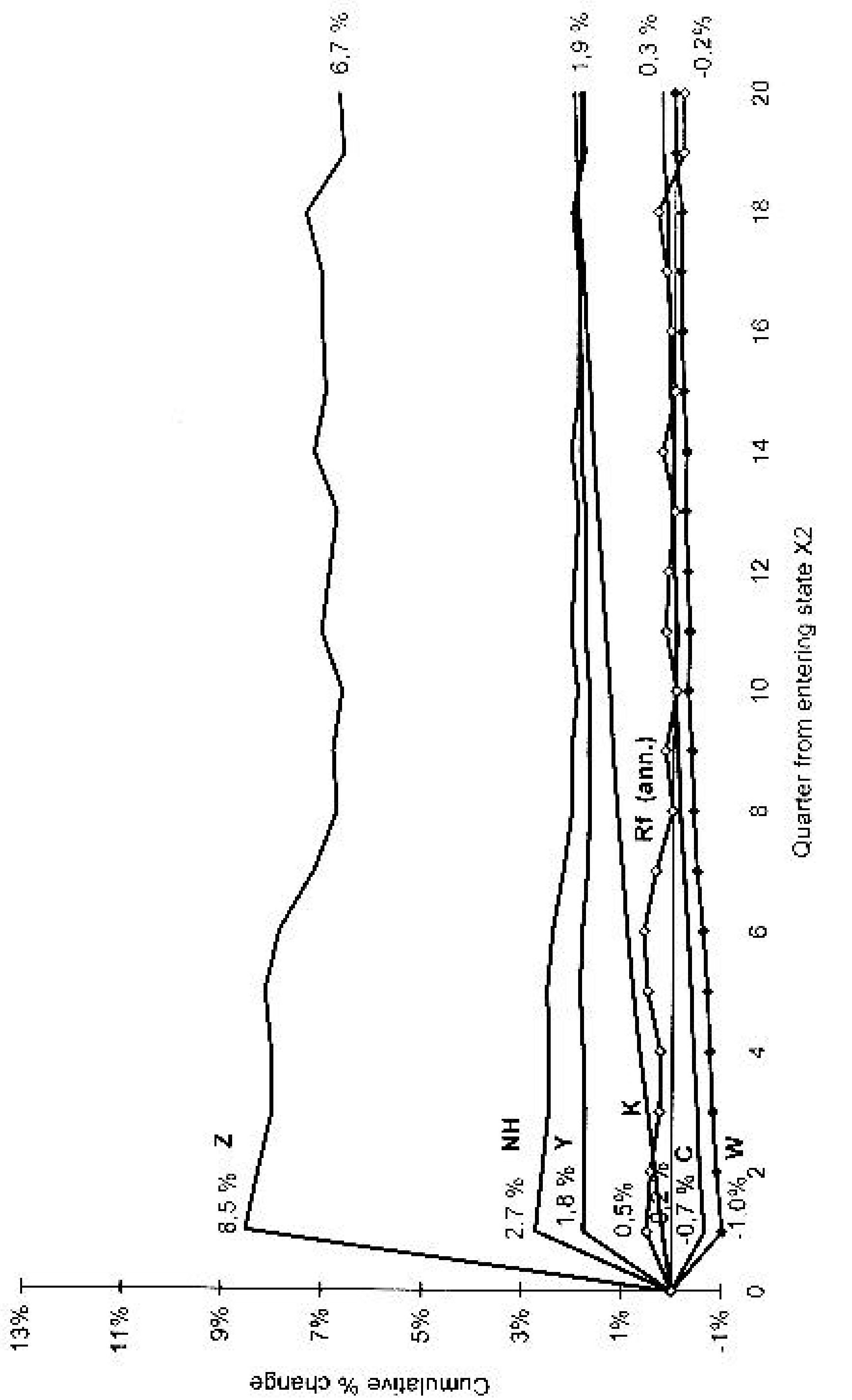
Note: Sample period is 1947:2 - 1996:4. All variables are detrended using the Hodrick-Prescott filter.

Source: King and Rebelo (1999), Figure 7

Figure 2



Source: King and Rebelo (1999), Figure 14



Changes in macroeconomic aggregates following a pure expectations shift