5

How the Rational Expectations Revolution has Changed Macroeconomic Policy Research*

John Taylor
Stanford University, USA

The rational expectations hypothesis is by far the most common expectations assumption used in macroeconomic research today. This hypothesis, which simply states that people's expectations are the same as the forecasts of the model being used to describe those people, was first put forth and used in models of competitive product markets by John Muth in the 1960s. But it was not until the early 1970s that Robert Lucas (1972, 1976) incorporated the rational expectations assumption into macroeconomics and showed how to make it operational mathematically. The 'rational expectations revolution' is now as old as the Keynesian revolution was when Robert Lucas first brought rational expectations to macroeconomics.

This rational expectations revolution has led to many different schools of macroeconomic research. The new classical economics school, the real business cycle school, the new Keynesian economics school, the new political macroeconomics school, and more recently the new neoclassical synthesis (Goodfriend and King (1997)) can all be traced to the introduction of rational expectations into macroeconomics in the early 1970s (see the discussion by Snowden and Vane (1999), pp. 30–50).

In this chapter I address a question that I am frequently asked by students and by 'non-macroeconomist' colleagues, and that I suspect may be on many people's minds. The question goes like this: 'We know that many different schools of thought have evolved from the rational expectations revolution, but has mainstream policy research in macroeconomics really changed much as a result?' The term 'mainstream' focuses the question on the research methods that are used in practice by macroeconomists – whether they are at universities, research institutions or policy agencies –

* I am grateful to Jacques Drèze for helpful comments on an earlier draft.

when they work on actual policy issues; perhaps the phrase 'practical core' of policy evaluation research in macroeconomics would be a better description than 'mainstream'.

My answer to this question is an unqualified 'yes' and my purpose is to explain why. It would be surprising if mainstream macroeconomics had not changed much since the rational expectations revolution of 30 years ago. After all, mainstream macroeconomics changed greatly in the three decades after the Keynesian revolution. Path-breaking work by Hansen, Samuelson, Klein, Tobin, Friedman, Modigliani and Solow immediately comes to mind. Yet the question indicates a common scepticism about the practical implications of the rational expectations revolution, so my 'yes' answer must be accompanied by a serious rationale.

I try to show here that if one takes a careful look at what is going on in macroeconomic policy evaluation today, one sees that there is an identifiable and different approach that can be accurately called the 'new normative macroeconomics'. New normative macroeconomic research is challenging both from a theoretical and empirical viewpoint; it is already doing some good in practice. The research does not fall within any one of the schools of macroeconomics; rather, it uses elements from just about all the schools. For this reason, I think it is more productive to look at individual models and ideas rather than at groupings of models into schools of thought. As I hope will become clear in this lecture, the models and concepts that characterize the new normative macroeconomics represent one of the most active and exciting areas of macroeconomics today, but they were not even part of the vocabulary of macroeconomics before the 1970s. This suggests that the rational expectations revolution has significantly enriched mainstream policy research macroeconomics.

The new normative macroeconomic research can be divided into three areas: (i) policy models, (ii) policy rules, and (iii) policy trade-offs. This chapter considers each of these three areas in that order.

5.1 The policy models: systems of stochastic expectational difference equations

Because people's expectations of future policy affect their current decisions and because the rational expectations hypothesis assumes that people's expectations of the future are equal to the model's mathematical conditional expectations, dynamic macroeconomic models with rational expectations must entail difference or differential equations in which both past and future differences or differentials appear. In the case of discrete time, a typical rational expectations model therefore can be written in the form:

$$f_i(y_t, y_{t-1}, \ldots, y_{t-p}, E_t y_{t+1}, \ldots, E_t y_{t+q}, a_i, x_t) = u_{it} \quad (1)$$

for $i = 1, \ldots, n$ where y_t is an n-dimensional vector of endogenous variables at time t, x_t is a vector of exogenous variables at time t, u_{it} is a vector of stochastic shocks at time t, and a_i is a parameter vector.

The simplest rational expectations model in the form of (1) is a single linear equation ($i = 1$) with one lead ($q = 1$) and no lags ($p = 0$). This case arises for the well-known Cagan money demand model (see Sargent (1987) for an exposition) in which the expected lead is the one-period-ahead price level. In many applications, the system of equation (1) is linear, as when it arises as a system of first order conditions for a linear quadratic optimization model. However, non-linear versions of equation (1) arise frequently in policy evaluation research.

Many models now used for practical policy evaluation have the form of equation (1). Examples include a large multicountry rational expectations model that I developed explicitly for policy evaluation (Taylor (1993b)), and the smaller optimizing single-economy models of Rotemberg and Woodford (1999) and McCallum and Nelson (1999) also developed for policy research. Such rational expectations models are now regularly used at central banks, including the FRB/US model used at the Federal Reserve Board (see Brayton, Levin, Tryon and Williams (1997)); smaller models – Fuhrer/Moore and money supply rules (MSR) models used for special policy evaluation tasks at the Fed (see Fuhrer and Moore (1997) and Orphanides and Wieland (1997)); models used at the Bank of England (see Batini and Haldane (1999)), the Riksbank, the Bank of Canada, the Reserve Bank of New Zealand, and many others.

5.1.1 Similarities and differences

That all these policy evaluation models are in the form of (1), with lead terms as well as lagged terms, demonstrates clearly how the rational expectations assumption is part of mainstream policy evaluation research in macroeconomics. There are other similarities. All of these models have some kind of rigidity – usually a version of staggered price and wage setting – to explain the impact of changes in monetary policy on the economy, and are therefore capable of being used for practical policy analysis. The monetary transmission mechanism is also similar in all these models; it works through a financial market price view, rather than through a credit view.

There are also differences between the models. Some of the models are very large, some are open economy, and some are closed economy. The models also differ in the degree of forward looking or the number of rigidities that are incorporated.

There is also a difference between the models in the degree to which they explicitly incorporate optimizing behaviour. For example, most of the disaggregated investment, consumption, and wage and price setting equations in the Taylor (1993b) multicountry model have forward-looking terms that can be motivated by a representative agent's or firm's intertemporal optimization problem. However, the model itself does not explicitly describe that optimization. The smaller single economy models of Rotemberg and Woodford (1999) and McCallum and Nelson (1999) are more explicit about the representative firms or individuals maximizing utility. One of the reasons for this difference is the complexity of designing and fitting a multicountry model to the data. Given the way that the models are used in practice, however, this distinction may not be as important as it seems. For example, the equations with expectations terms in the Taylor (1993b) model are of the same general form as the reduced form equations that emerge from the Rotemberg and Woodford (1999) optimization problem. Since the parameters of the equations of the Rotemberg and Woodford model are fixed functions of the parameters of the utility function, they do not change when policy changes. But neither do the parameters of the equations in the Taylor (1993b) model.

5.1.2 Solution methods

A solution to equation (1) is a stochastic process for y_t. Obtaining such a solution in a rational expectations difference equation system is much more difficult than in a simple backward-looking difference equation system with no expectations variables. This difficulty makes policy evaluation in macroeconomics difficult to teach and requires much more expertise at central banks and other policy agencies than had been required for conventional models. This complexity is also one of the reasons why rational expectations methods are not yet part of most undergraduate textbooks in macroeconomics.

Many papers have been written on algorithms for obtaining solutions to systems like equation (1). In the case where $f_i(.)$ is linear, Blanchard and Kahn (1980) showed how to get the solution to the deterministic part of equation (1) by finding the eigenvalues and eigenvectors of the system. Under certain conditions, the model has a unique solution. Many macroeconomists have proposed algorithms to solve equation (1) in the non-linear case (see Taylor and Uhlig (1990) for a review). The simple iterative method of Fair and Taylor (1983) has the advantage of being very easy to use even in the linear case, but less efficient than other methods (see Judd (1998)). Brian Madigan at the Federal Reserve Board has developed a very fast algorithm to solve such models. I have found that the iterative methods work very well in teaching advanced undergraduates and beginning graduate students. They are easy to programme within existing user-friendly computer programmes such as Eviews. I also use iterative methods to solve my own rather large-scale multicountry rational expectations model (Taylor (1993b).

I think more emphasis on solving and applying expectational difference equations should be placed in the economics curriculum. Many graduate students come to economics knowing how to solve difference and differential equations, but expectational difference equations such as (1) are not yet standard and require time and effort to learn well. It is difficult to understand, let alone do, modern macro policy research without an understanding of how these expectational stochastic difference equations work.

5.2 Which is the best policy rule? A common way to pose normative policy questions

The most noticeable characteristic of the new normative macroeconomic policy research is the use of policy rules as an analytically and empirically tractable way to study monetary and fiscal policy decisions. A policy rule is a description of how the instruments of policy should be changed in response to observable events. This focus on policy rules is what justifies the term 'normative'. The ultimate purpose of the research is to give policy advice on how macroeconomic policy *should* be conducted. The policy advice of researchers becomes, for example, 'Our research shows that policy rule A works well'. (The word 'normative' is used to contrast policy research that focuses on 'what should be' with positive policy research that endeavours to 'explain why' a policy is chosen.)

To be sure, the study of macroeconomic policy issues through policy rules began before the rational expectations assumption was introduced to macroeconomics (see work by Friedman (1948) and A.W. Phillips (1954), for example). Policy rules have appealed to researchers interested in applying engineering control methods to macroeconomics.

But the introduction of the rational expectations assumption into macroeconomics significantly increased the advantages of using policy rules as a way to evaluate policy. With the rational expectations assumption, people's expectations of policy have a great impact on changes in the policy instruments. Hence, in order to evaluate the impact of policy, one must state what that future policy will be in different contingencies. Such a contingency plan is nothing more than a policy rule. One might say that the use of policy rules in structural models is a constructive way to deal with the Lucas critique.

The use of policy rules in macroeconomic policy research has increased greatly in the 1990s and represents a great change in mainstream policy evaluation research. There is much interest in the use of policy rules as guidelines for policy decisions and the staffs of central banks use policy rules actively in their research. The starting point for most research on policy rules is that the central bank has a long-run target for the rate of inflation. The task of monetary policy is to keep inflation close to the target without causing large fluctuations in real output or employment. Alternative monetary policies are characterized by monetary policy rules that stipulate how the instruments of policy (usually the short-term interest rate) react to observed variables in the economy.

5.2.1 The timeless method for evaluating policy rules

How are policy rules typically evaluated? The method can be described as a series of steps. First, take a candidate policy rule and substitute the rule into the model in equation (1). Second, solve the model using one of the rational expectations solution methods. Third, study the properties of the stochastic steady-state distribution of the variables (such as inflation, real output, unemployment). Fourth, choose a policy rule that gives the most satisfactory performance; here one uses, implicitly or explicitly, the expected value of the period (instantaneous) loss function across the steady state (stationary) distribution. Fifth, check the results for robustness by using other models.

Observe the special nature of the optimization in this description. Policy rules are being evaluated according to the properties of the *steady-state stochastic distributions*. This can be justified using a multiperiod loss function with an infinite horizon with no discounting. But the key point is that the research method views the policy rule as being used for all time. Stationary means that the same distribution occurs at all points in time. Michael Woodford uses the adjective 'timeless' to refer to this type of policy evaluation because of its stationary character. The timelessness or stationarity is needed in order to evaluate the policy in a rational expectations setting and also to reduce the problems of time inconsistency which would arise if one optimized taking some initial conditions as given.

There are many examples of this type of policy evaluation research. McCallum (1999) provides a useful review of the research on policy rules through 1998. Let me discuss some more recent research, starting with a research project on robustness of policy rules which nicely illustrates how the timeless policy evaluation method works. I then discuss some particular applications to policy.

5.2.2 A comparative study with robustness implications

This project is discussed in detail in a recently published conference volume (Taylor (1999)). This summary of the study is drawn directly from my introduction to that volume. The researchers who participated in the project investigated alternative *monetary* policy rules using different models as described earlier. The following models were used: (1) the Ball (1999) Model, (2) the Batini and Haldane (1999) Model, (3) the McCallum and Nelson (1999) Model, (4) the Rudebusch and Svensson (1999a) Model, (5) the Rotemberg and Woodford (1999) Model, (6) the Fuhrer and Moore (1997) Model, (7) the MSR used at the Federal Reserve, (8) the large FRB/US model used at the Federal Reserve, and (9) my multicountry model (Taylor (1993b)), labelled TMCM in the tables. For more details on these models, see the references below or the conference volume itself.

It is important to note, given the purpose of this chapter, that two of the models in this list are not rational expectations models. The Ball (1999) model is a small, calibrated model and the Rudebusch and Svensson (1999a) model is an estimated time series model. I think it is useful to compare the results of such models with the formal rational expectations models; both these and the rational expectations models are approximations of reality. For small changes in policy away from current policy, the non-rational expectations models may be very good approximations. Note, however, that the method of policy evaluation with the non-rational expectations models is identical to that of the rational expectations models: stochastically simulating policy rules and observing what happens.

Five different policy rules of the form

$$i_t = g_\pi \pi_t + g_y y_t + \rho i_{t-1} \quad (2)$$

were examined in the study. In equation (2) the left-hand side variable i is the nominal interest rate, while π is the inflation rate and y is real GDP measured as a deviation from potential GDP. The coefficients defining the five policy rules are:

	g_π	g_y	ρ
Rule I	1.5	0.5	0.0
Rule II	1.5	1.0	0.0
Rule III	3.0	0.8	1.0
Rule IV	1.2	1.0	1.0
Rule V	1.2	.06	1.3

Rule I is a simple rule that I proposed in 1992. Rule II is like Rule I except that it has a coefficient of 1.0 rather than 0.5 on real output. For policy Rules III, IV, and V the interest rate reacts to the lagged interest rate, while for Rules I and II it does not. Rule V is a rule proposed by Rotemberg and Woodford (1999). This rule places a very small weight on real output and a very high weight on the lagged interest rate. These policy rules do not exhaust all possible policy rules, of course, but they represent some of the areas of disagreement about policy rules.

How are these policy rules evaluated with the models? The typical method is to insert one of the policy rules (that is, equation (2) with the parameters specified) into a model, which has the form of equation (1) stated above. The rule then becomes one of the equations of the model and the model can then be solved using the methods discussed earlier. From the stochastic process for the endogenous variables one can then see how different rules affect the stochastic behaviour of the variables of interest such as inflation or real output. One can either examine the realizations of stochastic simulations or compute statistics that summarize these realizations. Tables 5.1 and 5.2

report the results of the simulation or analytical computations of the standard deviations of inflation and output.

Consider first a comparison of Rule I and Rule II. Table 1 shows the standard deviations of the inflation rate and of real output for Rule I and Rule II. These standard deviations are obtained either from the simulations of the models or from the calculated variance covariance matrix of y_t. The table also shows the rank order for each rule in each model for both inflation and output variability. The sum of the ranks is a better way to compare the rules because of arbitrary differences in the model variances.

For all the models, Rule IV results in a lower variance of output compared with Rule III. But for six of the nine models Rule IV gives a higher variance of inflation. Apparently there is a trade-off between the variance of inflation and output, a point that I come back to later in the chapter.

Now compare Rules III, IV and V. According to the results in Table 5.2, Rule III is most robust if inflation fluctuations are the sole measure of performance: it ranks first in terms of inflation variability for all but one

Table 5.1 Comparative performance of Rules I and II

	Standard deviation of: Inflation	Output	Inflation rank	Output rank
		Rule I		
Ball	1.85	1.62	1	2
Batini-Haldane	1.38	1.05	1	2
McCallum-Nelson	1.96	1.12	2	2
Rudebusch-Svensson	3.46	2.25	1	2
Rotemberg-Woodford	2.71	1.97	2	2
Fuhrer-Moore	2.63	2.68	1	2
MSR	0.70	0.99	1	2
FRB	1.86	2.92	1	2
TMCM	2.58	2.89	2	2
Rank sum	–	–	12	18
		Rule II		
Ball	2.01	1.36	2	1
Batini-Haldane	1.46	0.92	2	1
McCallum-Nelson	1.93	1.10	1	1
Rudebusch-Svensson	3.52	1.98	2	1
Rotemberg-Woodford	2.60	1.34	1	1
Fuhrer-Moore	2.84	2.32	2	1
MSR	0.73	0.87	2	1
FRB/US	2.02	2.21	2	1
TMCM	2.36	2.55	1	1
Rank sum	–	–	15	9

Source: Taylor (1999b).

model for which there is a clear ordering. For output, Rule IV ranks best, which reflects its relatively high response to output. However, regardless of the objective function weights, Rule V has the worst performance for these three policy rules, ranking first for only one model (the Rotemberg-Woodford model) in the case of output. Comparing these three rules with the rules that do not respond to the lagged interest rate (Rules I and II) in Table 5.1 shows that the lagged interest rate rules do not dominate rules without a lagged interest rate.

Table 5.2 Comparative performance of Rules III, IV and V

	Standard deviation of			
	Inflation	**Output**	**Inflation rank**	**Output rank**
		Rule III		
Ball	2.27	23.06	1	2
Haldane-Batini	0.94	1.84	1	2
McCallum-Nelson	1.09	1.03	1	1
Rudebusch-Svensson	∞	∞	1	1
Rotemberg-Woodford	0.81	2.69	2	2
Fuhrer-Moore	1.60	5.15	1	2
MSR	0.29	1.07	1	2
FRB/US	1.37	2.77	1	2
TMCM	1.68	2.70	1	2
Rank sum	–	–	10	16
		Rule IV		
Ball	2.56	2.10	2	1
Batini-Haldane	1.56	0.86	2	1
McCallum/Nelson	1.19	1.08	2	2
Rudebusch-Svensson	∞	∞	1	1
Rotemberg-Woodford	1.35	1.65	3	1
Fuhrer-Moore	2.17	2.85	2	1
MSR	0.44	0.64	3	1
FRB/US	1.56	1.62	3	1
TMCM	1.79	1.95	2	1
Rank sum	–	–	20	10
		Rule V		
Ball	∞	∞	3	3
Batini-Haldane	∞	∞	3	3
McCallum-Nelson	1.31	1.12	3	3
Rudebusch-Svensson	∞	∞	1	1
Rotemberg-Woodford	0.62	3.67	1	3
Fuhrer-Moore	7.13	21.2	3	3
MSR	0.41	1.95	2	3
FRB	1.55	6.32	2	3
TMCM	2.06	4.31	3	3
Rank sum	–	–	21	25

Source: Taylor (1999b).

Table 5.2 also indicates a key reason why rules that react to lagged interest rates work well in some models and poorly in others, in comparison with the rules without lagged interest rates. As stated above, two of the models (Ball (1999) and Rudebush-Svensson (1999a)) that give very poor performance for the lagged interest rate rules are non-rational expectations models. However, the rules exploit people's forward-looking behaviour: if a small increase in the interest rate does not bring inflation down, then people expect the central bank to raise interest rates by a larger amount in the future. In a model without rational expectations, it is impossible to capture this forward-looking behaviour. Because Rule V has a lagged interest rate coefficient greater than one, it greatly exploits these expectations effects; this is why it does not work so well in non-rational expectations models. Again these results underscore the importance of rational expectations ideas for policy evaluation research.

5.2.3 Recent applications

Now let me consider a few of the many recent applications of the research to specific practical policy questions.

Research on the zero interest rate bound

Mervyn King (1999), now the deputy governor of the Bank of England, has used policy rules of the form of equation (2) to examine the important problem of the zero lower bound for nominal interest rates. He simulated a rational expectations model and determined the likelihood that the interest rate will hit zero. He concludes that the probability is very low, assuming that policy does not deviate from a good policy rule for too long. Fuhrer and Madigan (1997) and Orphanides and Wieland (1997) obtained similar results by simulating policy rules in models like (1). Orphanides and Wieland (1999) find the danger of hitting the lower bound calls for choosing a slightly higher inflation target.

Inflation forecast based rules

Svensson (2000) and Batini and Haldane (1999) examine a whole host of policy rules that can be used for inflation by targeting central banks. Some of these bring the forecast of inflation into the policy rule and are therefore called 'inflation forecast based rules'. For example, the forecast of inflation rather than the actual inflation and actual output might appear in equation (2). Thus far, there is no agreement about whether including a forecast of inflation can improve economic performance, though is it clear that a forecast of inflation that is too far out can cause stability problems.

Should central banks react slowly?

Woodford (1999) uses policy rules to examine the rationale for the sluggishness of changes in interest rates by central banks. Many observers of central bank reactions note that the interest rate seems to react with a lag, as would occur if a lagged dependent variable appeared in the policy rule. There is some dispute about whether that lagged term might represent serial correlation rather than slow adjustment in empirical work. In any case, Woodford presents simulations of some models that show that such slow responses may be optimal.

The role of the exchange rate

Much of the research has focused on economies that have a large domestic sector, such as the United States, and may not be completely relevant for small and very open economies. Ball's (1999) small open economy model study shows that it is useful for central banks to react to the exchange rate as well as to inflation and real GDP in equation (2).

5.3 Policy trade-offs: a focus on variances rather than means

In the years before the beginning of the rational expectations revolution, Milton Friedman and Edmund Phelps threw into doubt the idea of a long-run Phillips curve trade-off between inflation and output or unemployment. Expectations were at the heart of the Friedman-Phelps critique of the Phillips curve trade-off, and it was an attempt to explain the Phillips curve correlations that motivated Robert Lucas to bring rational expectations into macroeconomics in his celebrated paper on 'Expectations and the Neutrality of Money' (Lucas (1972)).

However, along with the rational expectations assumption, Lucas also brought a perfectly flexible price assumption into his model, and together these two assumptions nullified a trade-off between inflation and unemployment, even in the short run, that could represent a meaningful choice for policy makers. Monetary policy was ineffective, as shown by Thomas Sargent and Neil Wallace (1975), who used a simplified model that incorporated Lucas's basic assumptions.

However, if there is some degree of price or wage stickiness, as is assumed in the mainstream models used for policy evaluation today, then there is still a trade-off facing policy makers, even if expectations are rational. But how can this trade-off be described, analysed and estimated? The nature of the trade-off is not between the levels of inflation and output, but between the variability of inflation and the variability of output (Taylor (1979)). Such a trade-off naturally arises in any model in which there is price stickiness and stochastic shocks, which of course is true of virtually all models used for policy evaluation today. This kind of trade-off even occurs in models without rational expectations.

The trade-off is typically represented as a curve in a diagram with the variance (or standard deviation) of inflation around some target inflation rate on the horizontal axis, and the variance (or standard deviation) of real output or unemployment around the natural rate on the vertical axis. Of course in a given policy problem, there may be many other variables of concern, such as the interest rate or the exchange rate, and it is possible to create a trade-off between any two of these variables. However, since the level of the natural rate of unemployment or potential output cannot be affected by monetary policy, these levels should not be in the loss function. The focus of variances makes it clear that the policy problems related to inflation and unemployment are mainly about economic fluctuations rather than economic growth.

A simple example to illustrate the calculation of a variability trade-off is the following model:

$$\pi_t = \pi_{t-1} + by_{t-1} + \varepsilon_t \tag{3}$$

$$y_t = -g\pi_t \tag{4}$$

The first equation is a standard expectations-augmented Phillips curve and the second equation is a shorthand description of macro policy. The negative relationship between inflation and real output in equation (4) combines aggregate demand and a monetary policy rule in which the interest rate is increased (reducing real output) when inflation rises. Different policies can be represented by different choices of the parameter g. For simplicity, I have assumed that there are no demand shocks in equation (4).

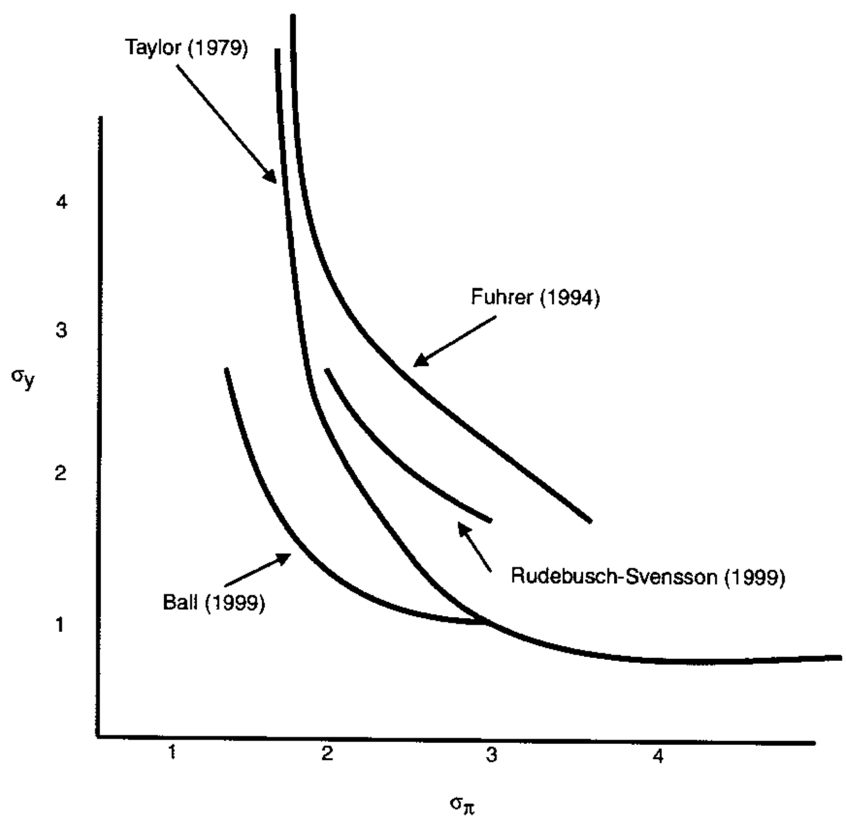
A trade-off between the variance of y and the variance of π can be obtained by substituting equation (4) into equation (3); this results in a first-order stochastic difference equation in π_t from which one can find the steady-state variance of inflation. The steady state variance of output is then obtained from (4). Now as one varies the policy parameter g one traces out different combinations of the variance of inflation and the variance of real output. An increase in the parameter g represents a less accommodative policy. Higher values of g reduce the variance of inflation, but increase the variance of real output. Although this derivation is for a very simple model, it illustrates the nature of the trade-off that arises in most of these models with sticky prices and wages and stochastic shocks. Erceg, Henderson and Levin (2000) provide a careful analysis of the nature of this trade-off in more complex models. For other simple expositions of the output–inflation variability trade-off see Walsh (1998), Bullard (1998), and Dittmar, Gavin and Kydland (1999).

5.3.1 How stable is the output-inflation variability trade-off?

The Friedman-Phelps criticism of the original Phillips curve was that it was not stable, and therefore could not be relied on for policy analysis. In fact large shifts in that curve occurred over time as the inflation rate rose and then fell in the 1970s and 1980s. The variability trade-off – viewed as an alternative to the original Phillips curve – would not be of much use for policy research if it also shifted around a lot. Before reviewing how this trade-off is used in policy evaluation research it is important to examine its stability over time.

Comparing estimates of the variability curve in different time periods is a rough way to get a feel for the extent of such shifts. Figure 5.1 suggests a fair degree of stability. It shows several estimates of the variability trade-off for the US estimated at different points in time by different researchers.

Figure 5.1 Comparison of different estimates of inflation-output variability trade-off curves from 1979 to 1999



Notes: Variability is measured by the standard deviation of inflation (σ_π) and the standard deviation of output as a deviation from trend (σ_y). Although the curves in Figure 5.1 are not exactly the same, the differences seem to be well within the estimation errors of the models. Any shifts in the parameters of the models used to estimate the curves are not large enough to have significantly shifted the curves. In fact, the curves estimated with data into the 1990s seem to be spread around the curve estimated in the 1970s.

One of the curves (Taylor (1979)) was estimated using data through the mid-1970s. The other three were independently estimated in the 1990s using data from the 1980s and 1990s as well. These other curves are found in papers by Fuhrer (1994), Rudebusch and Svensson (1999a), and Ball (1999).

5.3.2 Policy applications of the variability trade-off

A brief overview of recent policy evaluation research using this variability trade-off illustrates how it is used in practice.

Money versus the interest rate as the instrument

Rudebusch and Svensson (1999b) have used the trade-off to show how money targeting could lead to a deterioration of macroeconomic performance compared with inflation targeting using an interest rate rule. They do this by deriving a variability trade-off for their model and then showing how monetary targeting is inefficient, leading to a point to the right and above the curve.

Price level versus inflation targeting

Mervyn King (1999) showed how a big decrease in inflation variability might be achieved with only a small increase in output variability by using a policy in which the price level is given some small weight. He shows this by computing a trade-off curve and then showing how the movement along the curve entails big rightward movements and only small downward movements. Dittmar, Gavin and Kydland (1999) reach a similar conclusion using a variability trade-off, though their characterization of price level targeting is different from King's.

Optimal inflation forecast target

Batini and Haldane (1999) and Levin, Wieland and Williams (1999) use the variability trade-off to show how increasing the horizon in an inflation forecast targeting procedure for the central bank has the effect of reducing output variability and increasing inflation variability. They show that the horizon for the forecast should not be too long if forecasts are used in policy rules.

The curvature of the variability trade-off

Batini (1999) estimates trade-off curves for the UK and finds that curvature is very sharp, indicating that the same policy would probably be chosen for a wide variation of the weights on inflation and output. However, King

(1999) emphasizes that the estimates of curvature are very uncertain, and some research on the standard errors of these curves would be worthwhile.

The possibility that the output inflation variability trade-off curve has a sharp turn is very important, because it suggests that the big debates about how large the coefficient on output should be in a policy rule are not so important in fact. If the curve has a sharp turn then there are sharply increasing opportunity costs of reducing either inflation variability or output variability.

5.4 Conclusion

Like any assumption, the rational expectations assumption is a simplifying one, and its success depends both on its plausibility and its predictive accuracy. Clearly, the assumption works better in some situations than in others. And like any other simplifying assumption, researchers are constantly trying to improve on it. Attempts to modify rational expectations to account for learning, for example, are as old as the rational expectations assumption itself: see Evans and Honkapohja (1999). Recent work has endeavoured to find ways to preserve the endogeneity of the rational expectations assumption while relaxing some of the more unrealistic aspects of the assumption (see Kurz and Mototese (1999)).

However, thinking of the 'rational expectations revolution' solely in terms of a technical expectations hypothesis runs the risk of missing many of the truly enriching effects that rational expectations research has had on macroeconomics since the early 1970s. In this respect the rational expectations revolution is like the Keynesian revolution: The 'aggregate expenditures multiplier' discovered by Richard Kahn and put forth by Keynes in his *General Theory* was a technical idea. It in turn spurred interest in empirical work on consumption and investment, analysis of difference equations, econometric models, computer algorithms, and innovations in teaching such as Samuelson's Keynesian cross-diagram. Though an integral part of Keynes's theory, the Keynesian multiplier is not a good way to describe the overall impact of the 'Keynesian revolution'.

So, too, it would be misleading to describe the overall impact of the rational expectations revolution solely by the rational expectations assumption itself. One also must include the many empirical policy models with expectational difference equations, such as the ones mentioned in this chapter, as well as the large volume of research on policy rules and policy variability trade-offs. I have argued here that these policy models, policy rules and policy trade-offs represent a whole 'new normative macroeconomics' that includes ideas from many different schools of thought, but which is nonetheless quite identifiable and different from the macroeconomics that existed prior to the 1970s.

References

Ball, L. (1999) 'Policy Rules for Open Economies', in Taylor, J.B. (ed.) *Monetary Policy Rules* (Chicago: University of Chicago Press), pp. 127–56.

Batini, N. (1999) 'The Shape of Stochastic-Simulation Generated Taylor Curves', unpublished paper, Bank of England.

Batini, N. and Haldane, A.G. (1999) 'Forward-Looking Rules for Monetary Policy', in Taylor, J.B. (ed.) *Monetary Policy Rules* (Chicago: University of Chicago Press), pp. 157–201.

Blanchard, O.J. and Kahn, C.M. (1980) 'The Solution of Linear Difference Equations under Rational Expectations', *Econometrica*, vol. 48, pp. 1305–11.

Brayton, F., Levin, A., Tryon, R.C. and Williams, J.C. (1997) 'The Evolution of Macro Models at the Federal Reserve Board', in McCallum, B. and Plosser, C. (eds) *Carnegie-Rochester Conference Series on Public Policy*, vol. 47 (Amsterdam: North Holland, Elsevier Science), pp. 43–81.

Bryant, R., Hooper, P. and Mann, C. (1993) *Evaluating Policy Regimes: New Empirical Research in Empirical Macroeconomics* (Washington, DC: Brookings Institution).

Bullard, J. (1998) 'Trading Tradeoffs', *National Economic Trends* (St Louis: Federal Reserve Bank of St Louis) December.

Clarida, R., Gali, J., and Gertler, M. (1999) 'The Science of Monetary Policy: A New Keynesian Perspective', *Journal of Economic Literature*, vol. 37 (4), pp. 1661–707.

Dittmar, R., Gavin, W.T. and Kydland, F.E. (1999) 'The Inflation–Output Variability Tradeoff and Price Level Targets', *Review* (St Louis: Federal Reserve Bank of St Louis) January–February.

Erceg, C.J., Henderson, D.W. and Levin, A.T. (2000) 'Optimal Monetary Policy with Staggered Wage and Price Contracts', *Journal of Monetary Economics*, vol. 46, pp. 281–313.

Evans, G.W. and Honkapohja, S. (1999) 'Learning Dynamics', in Taylor, J.B. and Woodford, M. (eds) *Handbook of Macroeconomics* (Amsterdam: North Holland), pp. 449–542.

Fair, R.C. and Taylor, J.B. (1983) 'Solution and Maximum Likelihood Estimation of Non Linear Rational Expectations Models', *Econometrica*, vol. 51, pp. 1169–85.

Friedman, M. (1948) 'A Monetary and Fiscal Framework for Economic Stability', *American Economic Review*, vol. 38, pp. 245–64.

Fuhrer, J.C. (1994) 'Optimal Monetary Policy and the Sacrifice Ratio', in Fuhrer, J.C. (ed.) *Goals, Guidelines and Constraints Facing Monetary Policymakers* (Boston: Federal Reserve Bank of Boston).

Fuhrer, J.C. and Madigan, B.F. (1997) 'Monetary Policy When Interest Rates are Bounded at Zero', *Review of Economics and Statistics*, vol. 79, pp. 573–85.

Fuhrer, J.C. and Moore, G.R. (1997) 'Inflation Persistence', *Quarterly Journal of Economics*, vol. 110, pp. 127–59.

Goodfriend, M. and King, R. (1997) 'The New Neoclassical Synthesis and the Role of Monetary Policy', in Bernanke, B. and Rotemberg, J. (eds) *Macroeconomics Annual 1997* (Cambridge, Mass: MIT Press), pp. 231–82.

Judd, K.W. (1998) *Numerical Methods in Economics* (Cambridge, Mass: MIT Press).

King, M. (1999) 'Challenges Facing Monetary Policy: New and Old', paper presented at Federal Reserve Bank of Kansas City Conference, Jackson Hole, August 1999.

King, R.G. and Wolman, A.L. (1999) 'What Should the Monetary Authority Do When Prices are Sticky?' in Taylor, J.B. (ed.) *Monetary Policy Rules* (Chicago: University of Chicago Press), pp. 349–404.

Kurz, M. and Mototese, M. (1999) 'Endogenous Uncertainty and Market Volatility', Working Paper, Stanford University (May).

Levin, A., Wieland, V. and Williams, J.C. (1999) 'Robustness of Simple Monetary Policy Rules under Model Uncertainty', in Taylor, J.B. (ed.) *Monetary Policy Rules* (Chicago: University of Chicago Press), pp. 263–318.

Lucas, R.E., Jr (1972) 'Expectations and the Neutrality of Money', *Journal of Economic Theory*, vol. 4 (April), pp. 103–24.

Lucas, R.E., Jr (1976) 'Econometric Policy Evaluation: A Critique', *Carnegie-Rochester Conference Series on Public Policy* (Amsterdam: North-Holland).

McCallum, B.T. (1999) 'Issues in the Design of Monetary Policy Rules', in Taylor, J.B. and Woodford, M. (eds) *Handbook of Macroeconomics* (Amsterdam: North Holland), pp. 1483–530.

McCallum, B.T. and Nelson, E. (1999) 'Performance of Operational Policy Rules in an Estimated Semiclassical Structural Model', in Taylor, J.B. (ed.) *Monetary Policy Rules* (Chicago: University of Chicago Press), pp. 15–56.

Orphanides, A. and Wieland, V. (1997) 'Price Stability and Monetary Policy Effectiveness when Nominal Interest Rates are Bounded by Zero', Working Paper, Board of Governors of the Federal Reserve System.

Orphanides, A. and Wieland, V. (1999) 'Price Stability and Monetary Policy Effectiveness when Nominal Interest Rates are Bounded at Zero', Working Paper, Federal Reserve Board.

Phillips, A.W. (1954) 'Stabilization Policies in a Closed Economy', *Economic Journal*, vol. 64, pp. 290–323.

Rotemberg, J.J. and Woodford, M. (1999) 'Interest Rate Rules in an Estimated Sticky Price Model', in Taylor, J.B. (ed.) *Monetary Policy Rules* (Chicago: University of Chicago Press), pp. 57–126.

Rudebusch, G.D. and Svensson, L.E.O (1999a) 'Policy Rules for Inflation Targetting', in Taylor, J.B. (ed.) *Monetary Policy Rules* (Chicago: University of Chicago Press), pp. 203–62.

Rudebusch, G.D. and Svensson, L.E.O. (1999b) 'Eurosystem Monetary Targetting: Lessons from U.S. Data', mimeo, Federal Reserve Bank of San Francisco.

Sargent, T.J. (1987) *Macroeconomic Theory*, 2nd edn (New York: Academic).

Sargent, T. and Wallace, N. (1975) '"Rational" Expectations, the Optimal Monetary Instrument and the Optimal Money Supply Rule', *Journal of Political Economy*, vol. 83, pp. 241–54.

Snowden, B. and Vane, H. (1999) *Conversations with Leading Economists: Interpreting Modern Macroeconomics* (Cheltenham: Edward Elgar).

Svensson, L.E.O. (2000) 'Open-Economy Inflation Targetting', *Journal of International Economics*, vol. 50, no. 1, pp. 155–83.

Taylor, J.B. (1979) 'Estimation and Control of a Macroeconomic Model with Rational Expectations', *Econometrica*, vol. 47, pp. 1267–86.

Taylor, J.B. (1993a) 'Discretion Versus Policy Rules in Practice', *Carnegie-Rochester Conference Series on Public Policy*, vol. 39, pp. 195–214.

Taylor, J.B. (1993b) *Macroeconomic Policy in a World Economy: From Econometric Design to Practical Operation* (New York: W.W. Norton).

Taylor, J.B. (1999a) 'A Historical Analysis of Monetary Policy Rules', in Taylor, J.B. (ed.) *Monetary Policy Rules* (Chicago: University of Chicago Press), pp. 319–47.

Taylor, J.B. (1999b) 'Introduction', in Taylor, J.B. (ed.) *Monetary Policy Rules* (Chicago: University of Chicago Press).

Taylor, J.B. (1999c) 'Staggered Price and Wage Setting in Macroeconomics', in Taylor, J.B. and Woodford, M. (eds) *Handbook of Macroeconomics* (Amsterdam: Elsevier, North Holland), pp. 1009–50.

Taylor, J.B. and Uhlig, H. (1990) 'Solving Nonlinear Stochastic Growth Models: A Comparison of Alternative Solution Methods', *Journal of Business and Economic Statistics*, vol. 8, no. 1, pp. 1–17.

Walsh, C.E. (1998) 'The New Output-Inflation Tradeoff', *Economic Letters* (San Francisco: Federal Reserve Bank of San Francisco), 6 February.

Woodford, M. (1999) 'Optimal Monetary Policy Inertia', mimeo, Princeton University, Princeton, NJ.