3

Trade-offs between Output and Inflation Variability

3.1 Introduction

Modern macroeconomics in general and DSGE models in particular have provided the intellectual foundation of inflation targeting. Until the eruption of the financial crisis in 2007, inflation targeting strategies had become the undisputed policy framework modern central banks should adopt. And most did. The official holders of macroeconomic wisdom declared that this step towards inflation targeting constituted a great victory of macroeconomics as a science (Woodford 2009). From now on we would be living in a more stable macroeconomic environment, a "Great Moderation." How things can change so quickly.

Inflation targeting, of course, does not imply that there is no role for output stabilization. New Keynesian DSGE modelers have always stressed that wage and price rigidities provide a rationale for output stabilization by central banks (see Clarida et al. 1999; Galí 2008). This idea has found its reflection in "flexible" inflation targeting (Svensson 1997; Woodford 2003). Because of the existence of rigidities, a central bank should not attempt to keep inflation close to its target all the time. When sufficiently large shocks occur that lead to departures of inflation from its target, the central bank should follow a strategy of gradual return of inflation to its target. The rationale is that in a world of wage and price rigidities too abrupt attempts to bring inflation back to its target would require such high increases in the interest rate as to produce overly strong declines in output.

Output stabilization in the DSGE world, however, is very much circumscribed. The need to stabilize output arises because of the existence of rigidities in prices that makes it necessary to spread out price movements over longer periods. The limited scope for output stabilization is based on a model characterized by a stable equilibrium. There is no consideration of the possibility that the equilibrium may be unstable or that fluctuations in output have a different origin than price rigidities. Should the scope for output stabilization be enlarged? This is the question we try to answer in this chapter. In order to shed some light on this issue we derive the trade-off between output and inflation variability in the context of our behavioral model, and we formulate some policy conclusions.

3.2 Constructing Trade-offs

The trade-offs between output and inflation variability are constructed in the following way. The model was simulated 10,000 times and the average output and inflation variability were computed for different values of the Taylor rule parameters. Figure 3.1 shows how output variability (panel (a)) and inflation variability (panel (b)) change as the output coefficient (c_2) in the Taylor rule increases from 0 to 1. Each line represents the outcome for different values of the inflation coefficient (c_1) in the Taylor rule.

Panel (a) showing the evolution of output variability exhibits the expected result, i.e., as the output coefficient (c_2) increases (i.e., inflation targeting becomes less strict) output variability tends to decrease. One would now expect that this decline in output variability resulting from more active stabilization comes at the cost of more inflation variability. This is what is generally found in mainstream new Keynesian rational expectations models (see Galí 2008). This, however, is not found in panel (b). One observes that the relationship is nonlinear. As the output coefficient is increased from 0, inflation variability first declines. Only when the output coefficient increases beyond a certain value (in a range 0.6–0.8) inflation variability starts increasing. Thus the central bank can reduce both output *and* inflation variability when it moves away from strict inflation targeting ($c_2 = 0$) and engages in some output stabilization. Not too much though. Too much output stabilization turns around the relationship and increases inflation variability.

Figure 3.1 allows us to construct the trade-offs between output and inflation variability. These are shown in figure 3.2 for different values of the inflation parameter c_1. Take the trade-off AB. This is the one obtained for $c_1 = 1$. Start from point A on the trade-off. At point A, the output parameter $c_2 = 0$ (strict inflation targeting). As output stabilization increases we first move downwards. Thus increased output stabilization by the central bank reduces output and inflation variability. The relation is nonlinear, however. At some point, with too high an output stabilization parameter, the trade-off curve starts increasing, becoming a "normal" trade-off, i.e., a lower output variability is obtained at the cost of increased inflation variability.

How can we interpret these results? Let us start from the case of strict inflation targeting, i.e., the authorities set $c_2 = 0$. There is no attempt at stabilizing output at all. The ensuing output variability intensifies the waves of optimism and pessimism (animal spirits), which in turn feed back on output volatility. These large waves lead to higher inflation variability. Thus, some output stabilization is good; it reduces both output and inflation variability by preventing too large swings in animal spirits. With no output stabilization at all ($c_2 = 0$) the forces of animal spirits are so high that the high output variability also increases inflation volatility through the effect of the output gap on inflation (supply equation). Too much output stabilization, however, reduces the stabilization bonus provided by a credible inflation target. When the

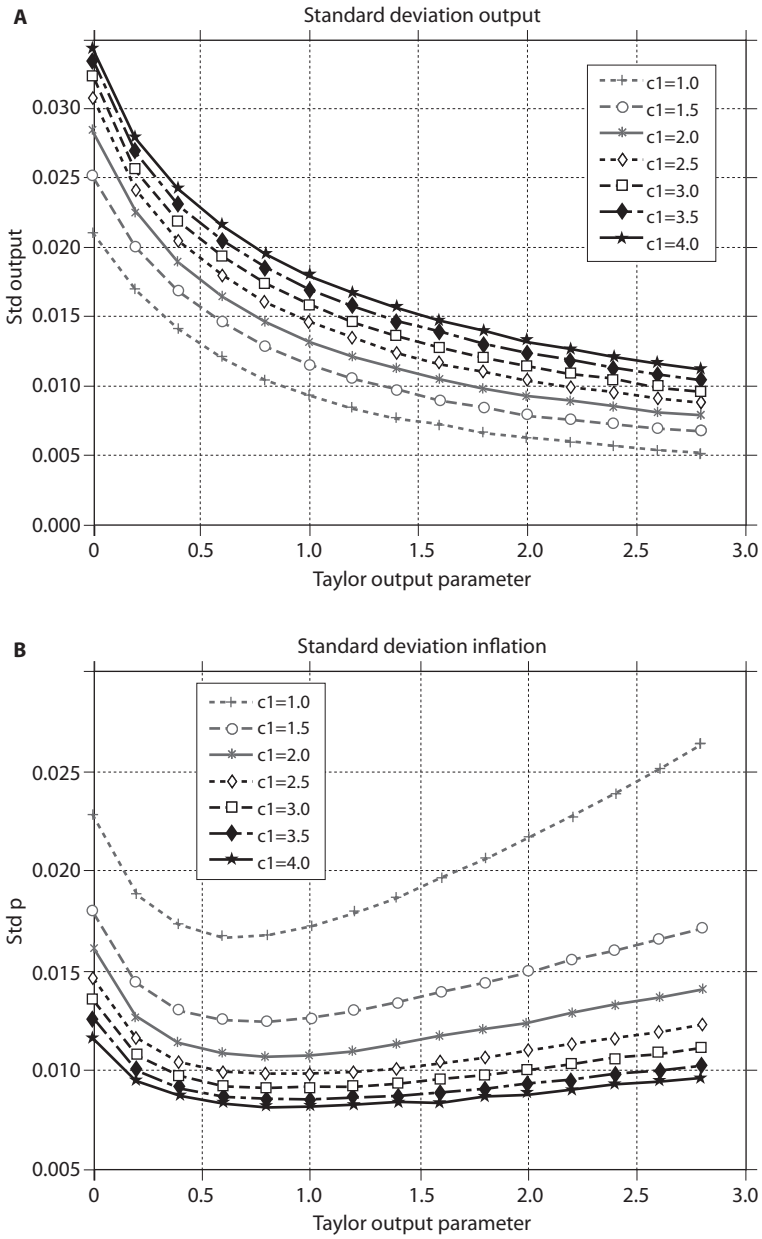

Figure 3.1. Output and inflation variability.

central bank attaches too much importance to output stabilization, it creates more scope for better forecasting performance of the inflation extrapolators, leading to more inflation variability.

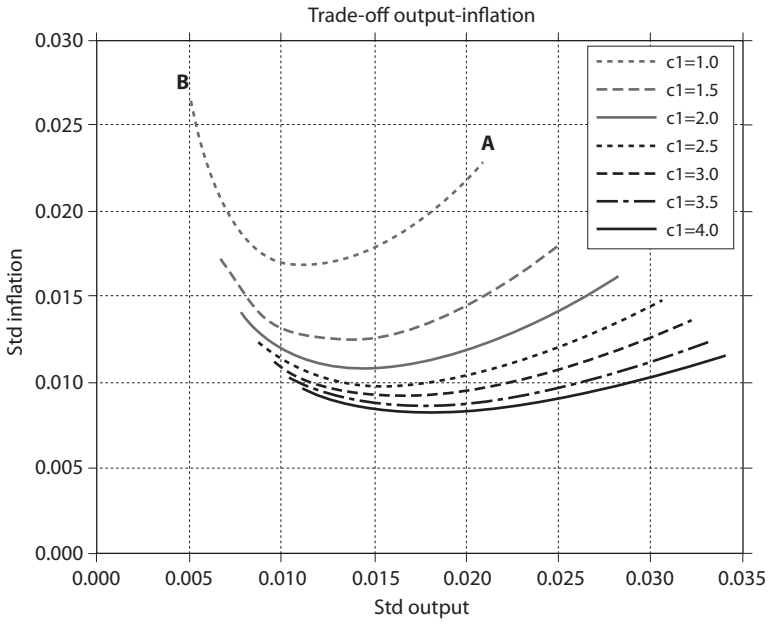

Figure 3.2. Trade-offs in the behavioral model.

Figure 3.2 also tells us something important about inflation targeting. We note that increasing the inflation parameter in the Taylor rule (c_1) has the effect of shifting the trade-offs downwards, i.e., the central bank can improve the trade-offs by reacting more strongly to changes in inflation.[1] The central bank achieves this improvement in the trade-off because by reacting more intensely to changes in inflation it reduces the probability that inflation extrapolators will tend to dominate the market, and as a result it reduces the probability that inflation targeting loses credibility. Such a loss of credibility destabilizes both inflation and output. Thus maintaining credibility of inflation targeting is an important source of macroeconomic stability in our behavioral model.

Note that the downward movements of the trade-offs tend to slow down with increasing values of the inflation parameter in the Taylor rule (c_1). Additional simulations show that when c_1 reaches the value of 6, further increases in this parameter have imperceptible effects on the trade-offs. In other words, the trade-offs converge to a stable position. The minimum point on this trade-off then represents the best possible outcome for a central bank, which focuses on minimizing the variability of inflation. It is the best possible point for a central bank that only cares

[1] A similar result on the importance of strict inflation is found in Gaspar et al. (2006), who use a macromodel with statistical learning. See also Anufriev et al. (2009) for the use of interest rate rules in a model with heterogeneous agents.

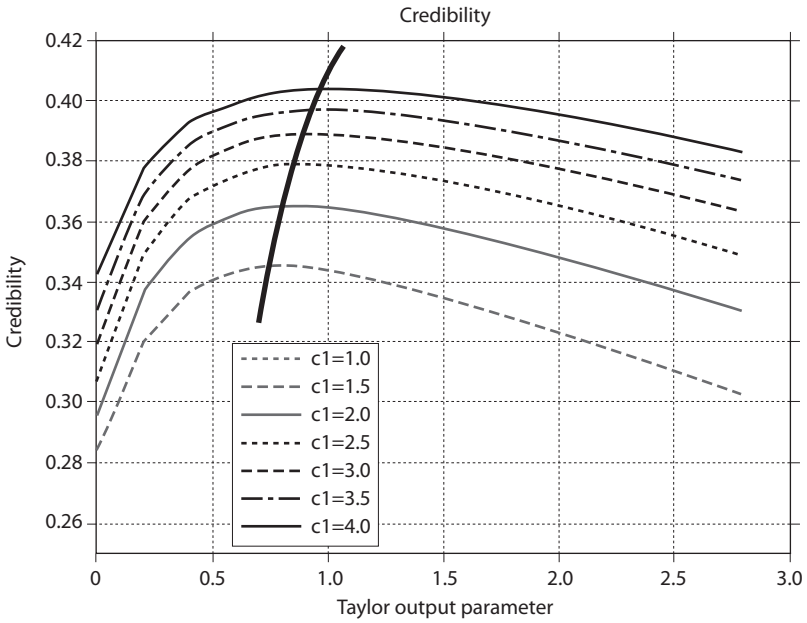

Figure 3.3. Inflation credibility and output stabilization.

about inflation. The interesting implication is that the central bank can only achieve this point if it actively tries to stabilize output.

The previous results suggest that there is a relationship between the parameters c_1 and c_2 in the Taylor equation and the credibility of the inflation target. This relationship can be analyzed in more detail. Inflation credibility can be given a precise definition in the model. It can be defined as the fraction of agents who use the inflation target to forecast inflation ("inflation targeters"). Thus when more agents use the announced inflation target to forecast inflation, credibility increases. Figure 3.3 presents the relationship between inflation credibility and the parameters c_1 and c_2. On the horizontal axis the parameter c_2 (output parameter) is set out; on the vertical axis the inflation credibility. The latter is obtained by simulating the model 10,000 times and computing the mean fractions of inflation targeters for different values of the c_1 and c_2. Each curve represents the relation between credibility and the output parameter (c_2) for different values of the inflation parameter (c_1). It has a nonlinear feature, i.e., when the output parameter c_2 increases this has the effect of first increasing inflation credibility until a maximum is reached. Then credibility starts declining when c_2 increases further. This nonlinear feature is found for all values of c_1. Note that the maximum points obtained in figure 3.3 correspond to the minimum point of the trade-offs in figure 3.2.

These results have the following interpretation. When the central bank increases its effort to stabilize output, this has at first a positive effect on the credibility

Table 3.1. Pairwise Granger causality tests.

Null hypothesis	Obs.	F-Statistic	Probability
Output does not Granger cause optimism	1948	31.0990	5.1E-14
Optimism does not Granger cause output		32.8553	9.3E-15

of its inflation target.[2] The reason, as was discussed earlier, is that by stabilizing output, the central bank also reduces the amplitude of the waves of optimism and pessimism (animal spirits) thereby stabilizing output and inflation. Inflation credibility is maximized when c_2 is in a range between 0.5 and 1. Beyond that range further attempts to stabilize output reduce inflation credibility for the reasons given earlier. The interesting aspect of this result is that the optimal values of c_2 are in a range often found in econometric studies of the Taylor equation. Thus central banks seem to apply a degree of output stabilization that is consistent with our theory of animal spirits.

Finally, figure 3.3 shows that for increasing values of c_1 the credibility curves shift upwards. Thus a central bank can improve its inflation credibility by reacting more strongly to changes in inflation. This feature then underlies the result found in figure 3.2 that higher values of c_1 improve the trade-off between inflation and output variability.

One can conclude that the behavioral model provides a different perspective on the need to stabilize output. This is a model that creates endogenous movements of the business cycle that are correlated with waves of optimism and pessimism. These waves of optimism and pessimism both influence the output gap and in turn are also influenced by the output gap. We show this two-way causality feature in Table 3.1, where the results of a Granger causality test on the output gap and the animal spirits (as defined in chapter 1) are presented. It can be seen that one cannot reject the hypotheses that animal spirits "Granger cause" the output gap and that the output gap "Granger causes" the animal spirits.

This two-way causality between output gap and animal spirits creates the possibility for the central bank to reduce the waves of optimism and pessimism by reducing the volatility of output. In doing so, the central bank creates a more stable macroeconomic environment that also helps to stabilize inflation.

3.3 Trade-offs in the New Keynesian Rational Expectations (DSGE) Model

The trade-offs in the new Keynesian rational expectations (DSGE) model can be computed in a way similar to that of the previous section. Thus we constructed the trade-offs using the rational expectations version of the basic model (see equations

[2] For an interesting analysis of credibility issues in a model with less than full rational expectations, see Ball et al. (2005).

(1.25) and (1.26)).[3] The trade-offs are represented in figure 3.4. The difference with figure 3.2 is striking. First, in the DSGE rational expectations world, trade-offs are uniformly downward sloping. This means that when the central bank increases the intensity with which it stabilizes output it always pays a price, i.e., success in reducing the variability of output is paid by a higher variability of inflation. This implies that if the central bank attaches a high weight to the inflation target it will usually not pay off to try to stabilize output (see Galí 2008, p. 83; Woodford 2003). This contrasts with the result obtained in a behavioral model. There we found that a central bank that only cares about inflation would still want to do a lot of output stabilization because the latter reduces the importance of animal spirits and thus also reduces inflation volatility. That is also why in the behavioral model we find that the central bank can improve its *inflation* credibility by doing more output stabilization. This effect is absent in the mainstream rational expectations model.

A second contrast in the trade-offs of the mainstream new Keynesian rational expectations (DSGE) model and the behavioral model relates to the size of the variability of inflation and output. This is in general significantly lower in the mainstream model than in the behavioral model. Put differently, the trade-offs tend to be located closer to the origin in the mainstream model than in the behavioral model. This result is not due to the fact that the shocks are different. In both models we assume shocks in demand and supply equations that are i.i.d. and which have the same standard deviations. The reason is that the behavioral model creates more endogenous variability, which as was shown in chapter 3 is not normally distributed. This creates more scope for stabilization.

Finally, a comparison of figures 3.2 and 3.4 also reveals that the "efficient trade-off," i.e., the lowest possible trade-off, is reached with lower values of the Taylor inflation parameter in the mainstream model than in the behavioral model. We observe that for values of c_1 exceeding 1.5 very little improvement in the trade-off can be achieved by raising this parameter. In the behavioral model the value of c_1 that leads to the lowest possible trade-off is reached around 4. Thus, in the behavioral model it requires more effort from the central bank to achieve the best possible outcome.

3.4 The Merits of Strict Inflation Targeting

From the preceding analysis it has become clear that a central bank that cares about inflation should also be concerned with output stabilization. Thus, strict inflation targeting in the sense of setting the output coefficient in the Taylor equation equal to zero is never optimal. In this section we further illustrate the non-optimality of strict inflation targeting. We do this in two ways.

[3] As in the previous section we first compute the variability of output and inflation for different values of the output and inflation parameters in the Taylor rule equation. We then plot the variabilities of output and inflation in one quadrant (figure 3.4).

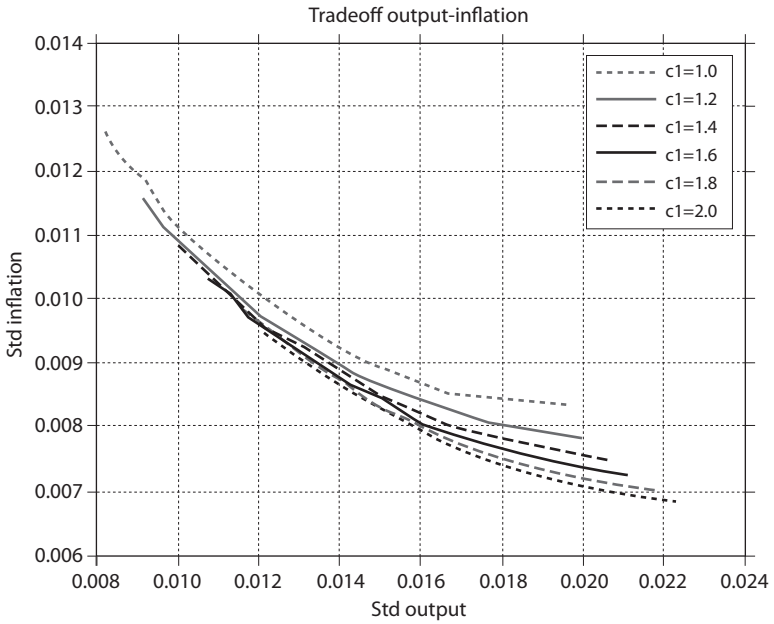

Figure 3.4.

First we simulated the model under perfect credibility and assuming that the central bank ceases to stabilize output. We achieve this by setting the output coefficient in the Taylor equation equal to zero. We will refer to this policy regime as a regime of strict inflation targeting, i.e., the central bank only cares about inflation.[4] We show the result of simulating the model under this regime in figure 3.5. Animal spirits now work with full force. In fact we find them to be stronger than in the case of imperfect credibility with output stabilization (which we discussed in chapter 1, figures 1.7 and 1.8). As a result, fat tails are pronounced leading to large extreme values for the output gap, i.e., large booms and busts. Inflation, in contrast, continues to be normally distributed.

A second way to analyze the implications of strict inflation targeting is to analyze the impulse response functions in a regime of strict inflation targeting. We do this in figure 3.6, which shows the impulse response function under the assumption that the central bank uses strict inflation targeting, i.e., sets the output coefficient in the Taylor rule equal to zero in an environment in which its inflation target is imperfectly credible.

From figure 3.6 we observe that the productivity shock introduces a cyclical transmission process. This cyclical adjustment process is not present when the central bank attempts to stabilize output (see chapter 2). In the very long run, the

[4] Note that in chapter 1 we also simulated the model under strict inflation targeting (figure 1.13). However, there we assumed imperfect credibility.

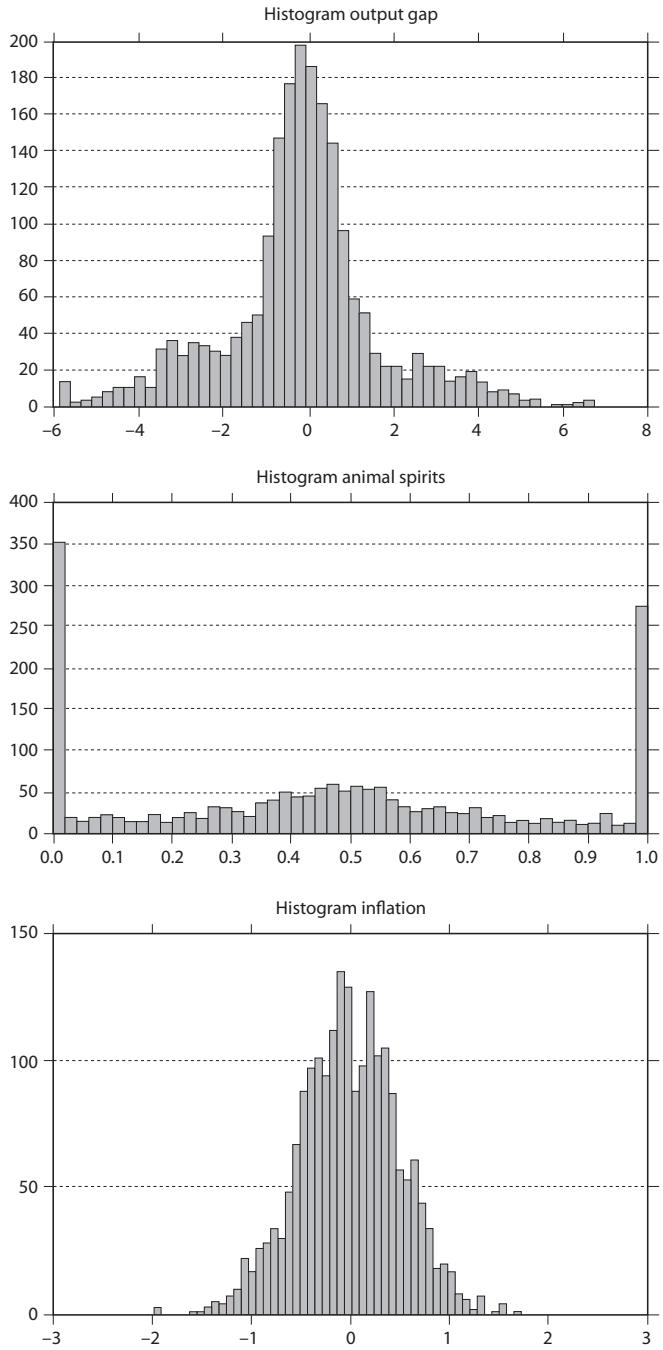

Figure 3.5. Frequency distribution output gap, animal spirits, and inflation in a regime of perfect inflation credibility and strict inflation targeting.

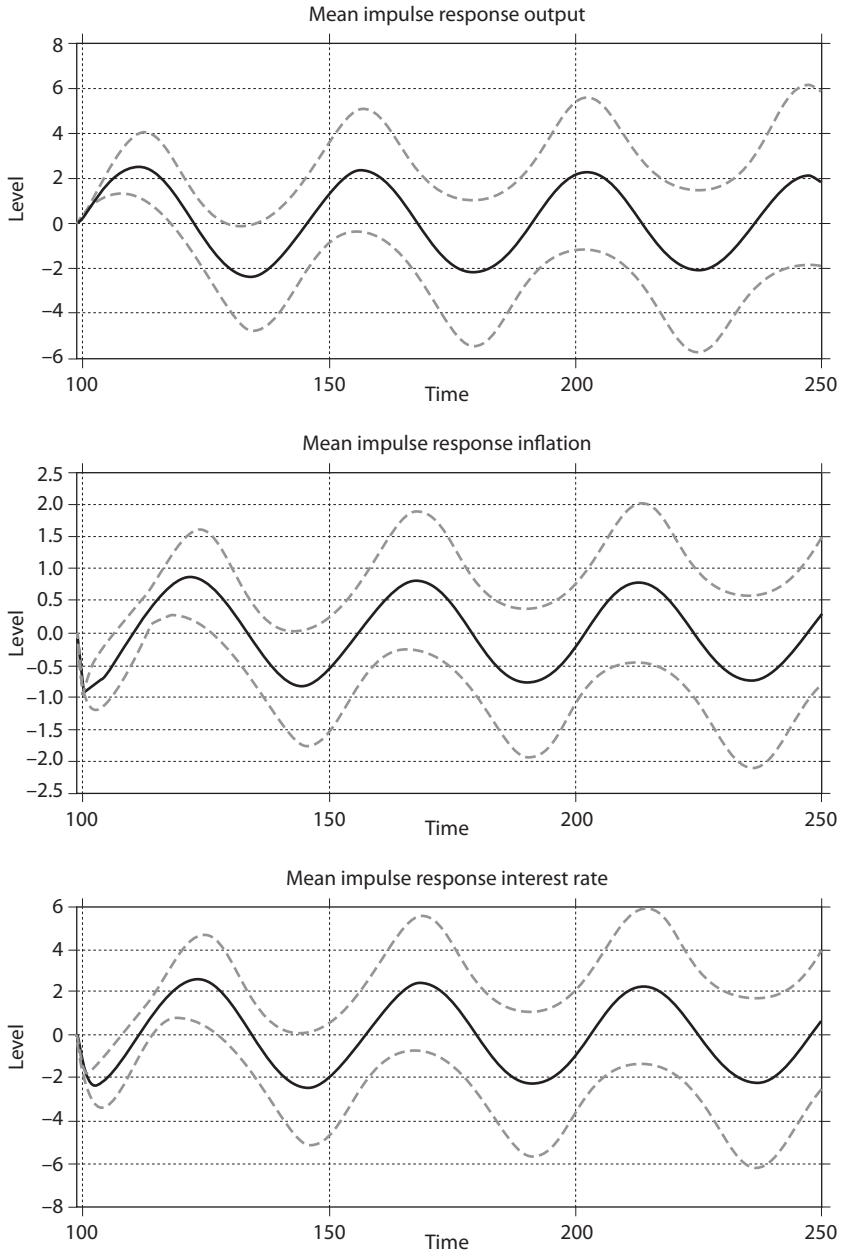

Figure 3.6. Impulse responses to positive productivity shock.

endogenous variables, output, inflation, and interest rate converge to their steady-state values, but this process is very protracted. This cyclical adjustment process is also present in inflation. Thus, by focusing exclusively on stabilizing inflation, the

central bank makes the transmission of the productivity shock on inflation more volatile than in a regime where the central bank does not focus exclusively on inflation. One can conclude that strict inflation targeting is unlikely to be optimal.

As was mentioned in the beginning of the chapter, mainstream new Keynesian rational expectations models come to a similar conclusion, i.e., that strict inflation targeting is not optimal. Central banks are also responsible for some output stabilization. The need for output stabilization, however, arises exclusively because of price and wage rigidities. The latter require the central banks to apply gradualism in pursuing its inflation objective. But this always comes at a cost, i.e., more inflation variability.

We have shown that there is an additional dimension to output stabilization. By reducing output volatility, central banks also help to "tame the animal spirits." This in turn reduces the variability of inflation and helps (rather than hurts) the central bank in achieving its inflation objective.