Chapter 7 Model properties

This chapter presents the results of a series of model simulations to illustrate the properties of BEQM. Section 7.1 sets out some introductory remarks on the nature of the simulations and interpretation of the results, which are described in Section 7.2. Finally, Section 7.3 summarises.

7.1 Interpreting the responses

The shock responses shown in Section 7.2 are intended to highlight specific mechanisms of the model, and so we focus on a few stylised experiments. Several points are worth noting about the nature of these results.

First, we assume that the economy is at its long-run equilibrium when the shock hits.[(1)] This is a different type of exercise from forecasts, which can be thought of as showing how an economy that is away from a sustainable long-run equilibrium could move towards such a position.

Second, we generally assume that the shocks are unanticipated, but once they occur they are recognised immediately and fully understood. In other words, there is no assumption of partial information or learning (discussed in Chapter 5), apart from in the variant of the interest rate shock (shown in Figure 7.2) that we use to illustrate the effect of changing assumptions about agents' expectations.

Third, each shock represents an isolated change to a single exogenous variable, which helps clarity but is a simplification compared with most forecast issues or historical episodes, which often involve simultaneous shocks to a number of exogenous variables. Moreover, in the simulations presented here, the rest of the world is assumed not to react in any way. For example, we shock (exogenous) world prices and world demand (see Sections 7.2.4 and 7.2.5), but no other world variables are assumed to change in the experiments presented here. In many cases, we would expect other variables to change in a well articulated story about economic shocks, depending on the ultimate source of the shock.

Fourth, policy assumptions are important. In the first shock – designed to illustrate the impact of interest rate changes – we shock monetary policy directly. But interest rates are an endogenous variable, typically moving in response to some change in the economy. This shock represents an erratic deviation from the normal policy reaction function, which is different from most policy changes.

The other simulations are run under the assumption that policy reacts immediately: we do not condition on a particular path for short-term interest rates or fiscal variables. Differences in policy assumptions can have a significant impact on the responses, so it is important to interpret the reactions to shocks in the light of the policy reaction functions used in the simulations. Here, we assume that the monetary authority targets inflation using short-term nominal interest rates and a Taylor-type reaction function;[(2)] and a lump-sum household tax adjusts to ensure fiscal solvency, given policy targets for government expenditure, debt, transfers and other taxes.

(1) The model's decision rules are written in levels. The curvature of the assumed utility, production and demand functions imparts a mild non-linearity to the whole system. Shock responses therefore always depend on the starting point. Testing has indicated that reasonable differences in the initial steady-state equilibria are unlikely to make a qualitative difference to the overall response.

(2) The version we use gives some weight to lagged interest rates. See Appendix A for full details of the reaction function we use for these simulations.

Finally, it matters whether the shocks are permanent or temporary. As explained below, the interest rate shock used here is a temporary shock, so that the model can return to equilibrium. The other shocks are configured as permanent shocks, in order to show how the model moves from one steady-state equilibrium to another. This has implications for behaviour, particularly through the behaviour of agents' expectations and asset prices. Shocks that are understood to be temporary tend to have smaller effects on asset prices, because there is no long-term movement in asset prices (unlike the results of the permanent shocks discussed in Sections 7.2.2 to 7.2.6).

7.2 Shock responses

This section discusses the behaviour of the full model in the face of shocks to monetary policy, productivity, government spending, the terms of trade, world demand, and labour supply. We have chosen these shocks to illustrate the interactions of households, firms and policymakers in goods, labour and financial markets. The temporary monetary policy shock is described by the impact of the initial shock and how the economy returns to equilibrium. However, we find it more intuitive to describe the other, permanent shocks by starting with the determination of the new steady-state equilibrium, and then the short-run dynamics. Where possible, we discuss the responses in the light of the conclusions of directly comparable empirical literature.

For each shock, we show a standard set of eight charts (using the same scales for each shock); for the permanent shocks in Section 7.2.2 to Section 7.2.6 we show some additional detail to help illustrate the particular effects. The new steady state in the permanent shocks is shown as a dashed line. All the shocks discussed in this chapter start with the economy at a steady-state equilibrium.

Some asset stocks, especially net foreign assets, are quite slow to get to their new steady-state equilibrium positions in the face of most of the permanent shocks. So flows can be very close to their long-run equilibrium positions, but it may take some time before stocks reach equilibrium. In the case of net foreign assets, adjustment occurs through net trade and the short-run trade responses can be quite different from the long-run balance required for a sustainable equilibrium. In general, the persistence of expenditures means that we often see short-term overshooting in net foreign assets.[3]

7.2.1 An interest rate shock

Figure 7.1 illustrates the effect of a 1 percentage point rise in nominal interest rates for four quarters. It is designed to show the direct impact of interest rate changes on the model economy. In the other simulations presented in this section, interest rates *react* endogenously to movements in inflation and output that come about because of some other shock. But here, we *start* with an interest rate movement and follow the reaction of the rest of the model. In particular, we assume that monetary policy can be described by a simple Taylor-type reaction function in which nominal interest rates react to inflation and output gaps, and we fix the nominal interest rate by shocking the monetary policy reaction function directly.[4]

(3) Eigenanalysis of the model confirms that it is stable, but the estimated dynamics imply that convergence is slow.

(4) The mechanics of implementing the shock are described in Box 11 on page 80.

Implemented this way, using the recursive simulation technique discussed in Chapter 5, the shock can be thought of as a sequence of unanticipated deviations from the monetary policy that would be expected on the basis of private agents' understanding of the economy and, in particular, the monetary policy reaction function. This is not the same as exogenising monetary policy by removing the monetary reaction function. In each period, agents see interest rates that do not accord with their understanding about how monetary policy is usually set;(5) they nonetheless expect monetary policy in subsequent periods to be set according to the normal reaction function, and remain confident that inflation will remain anchored at the original target in the long run.

The responses to this shock reflect the theoretical structure of the model discussed in Chapter 3. Optimal decisions are made on the basis of *relative* prices, taking account of the general level of prices. This ensures long-run neutrality of monetary policy so that the only long-run change is that nominal prices all move by the same proportion. Relative prices are unaffected in the steady state, so there are no long-run effects on real expenditures or the rate of inflation, which is brought back to target by the monetary reaction function.

But there are potentially significant effects in the short run. The model incorporates a number of rigidities that reflect costly adjustment of prices and quantities. Broadly speaking, the balance of these rigidities determines the extent to which a monetary policy shock will affect inflation or real activity in the short run.(6) For example, we assume that it is costly for firms to adjust their factor inputs and nominal prices. Firms balance the costs of adjusting factors of production and of adjusting prices, so that the overall price/quantity response will depend on the relative costs of adjustment. There is a variety of other rigidities that also affect the overall output/inflation response. And there are additional channels of short-run 'non-neutrality' of monetary policy shocks. For example, changes in nominal interest rates may affect real consumption growth in the short run, to the extent that they represent changes in the credit constraints faced by consumers.

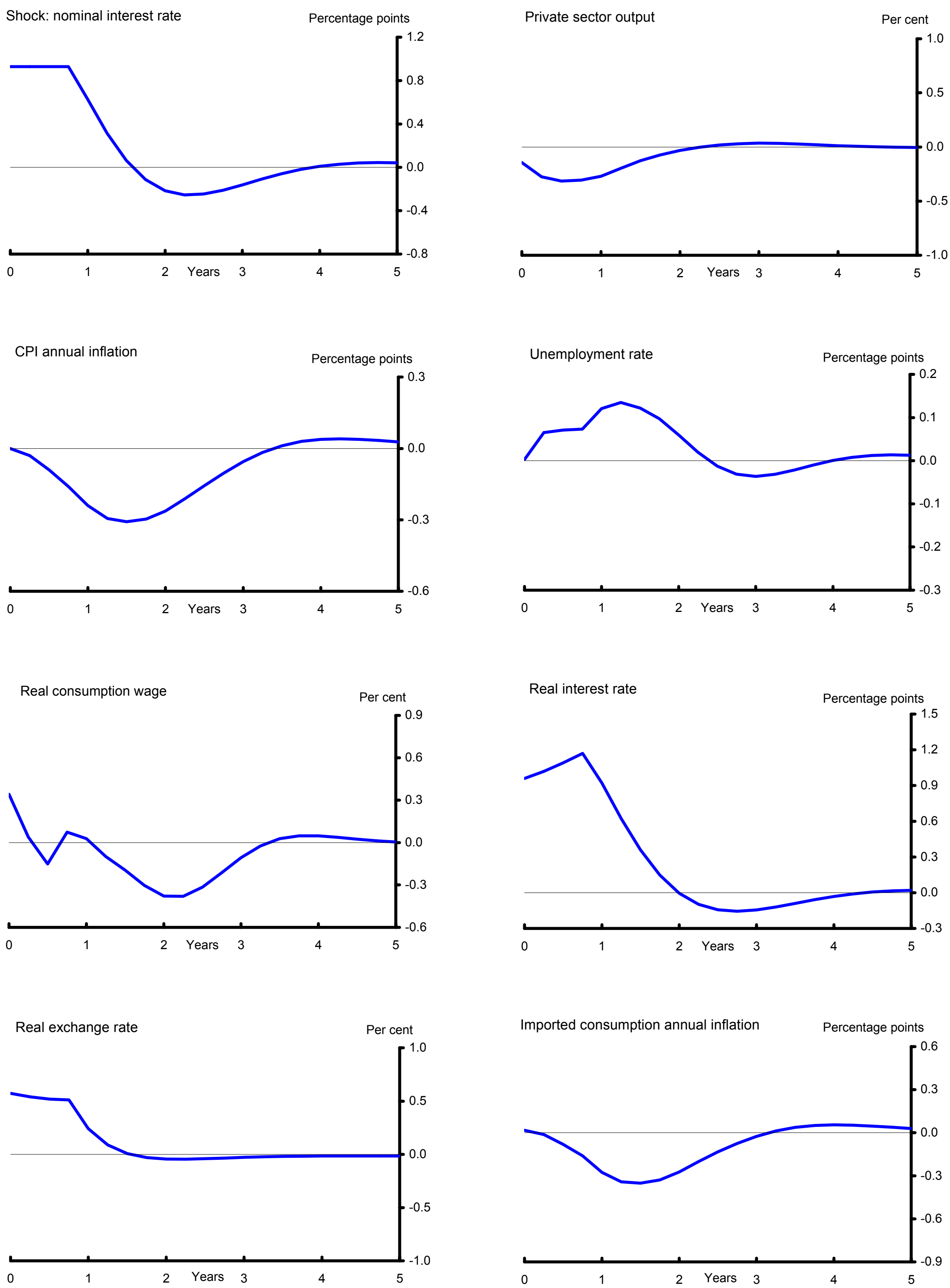
Because nominal prices and wages are assumed to be sticky and inflation is assumed to be persistent, the increase in the nominal interest rate leads to an increase in the *real* interest rate, and hence the cost of borrowing to finance consumption and investment. The nominal exchange rate immediately appreciates with the increase in nominal interest rates, in line with uncovered interest parity.(7) This has two effects. First, domestic price stickiness means that there is a real exchange rate appreciation, which reduces the demand for exports. Second, the nominal appreciation puts downward pressure on import prices, which feeds through gradually because of price stickiness. Other things equal, this effect would increase the demand for imports, but the income effect from lower demand dominates in the short run.

(5) Leeper and Zha (2003) make the distinction between the 'direct' effects of a policy intervention, which are the usual reactions when the regime is held fixed, and the 'expectation-formation' effects that are introduced by changes in agents' beliefs about the policy regime. In their language, the simulation shown in Figure 7.1 is assumed to be a 'modest' intervention, where there are no expectation-formation effects.

(6) If all prices were completely flexible, then temporary monetary policy shocks would lead to an immediate change in all nominal prices, without any effect on real expenditure. The long-run effects of the shock would be observed immediately.

(7) The exchange rate appreciation follows from the fact that higher domestic interest rates, relative to interest rates on equivalent foreign-currency assets, make sterling assets more attractive to international investors. Uncovered interest parity implies that the exchange rate moves to a level where investors expect a future depreciation just large enough to make them indifferent between holding domestic and foreign-currency assets. When used for forecasting, alternative paths for the nominal exchange rate are typically used, as discussed in the box 'The exchange rate in forecasting and policy analysis' on page 48 of the November 1999 *Inflation Report*.

Figure 7.1: Effects of an interest rate shock



All of these effects act to reduce aggregate demand. In the face of unchanged potential supply, firms immediately reduce factor utilisation and start to reduce employment and investment. Though prices are sticky, they are not fixed and inflation falls below the starting rate as firms react to the fall in demand. Real consumption wages rise in the very first period, but fall back quickly as a result of lower demand for labour. Fiscal policy reacts by increasing the lump sum tax rate to preserve tax revenue as nominal GDP falls in the short run.

The shock lasts for four periods. In the fifth period, monetary policy reverts to its standard reaction function. Faced with a negative output gap and inflation below target, nominal interest rates gradually fall below their long-run equilibrium to bring inflation back to target. The economy is close to equilibrium after five years.

The responses shown here accord qualitatively with the broad conclusions from the empirical literature on monetary policy shocks: following an unanticipated monetary policy tightening, interest rates rise, output contracts, profits and real wages fall, and inflation (eventually) falls. Output, consumption, investment and inflation are 'hump-shaped' and highly persistent, with the peak effect on inflation lagging the peak effect on real variables.(8) The behaviour of the model for this shock is broadly similar to that of the previous MTMM model(9) and qualitatively close to other studies of the UK economy.(10)

The simulation shown in Figure 7.1 is based on the assumption that the unexpected change in interest rates does not affect agents' long-run inflation expectations. But the response of the economy to a change in interest rates depends on the credibility of the inflation target. In particular, as inflation expectations become more firmly anchored around the inflation target – the target becomes more credible – a change in the short-term interest rate is likely to have less impact.

To illustrate the sensitivity of these simulations to assumptions about expectations, Figure 7.2 shows how the effect on inflation and private sector output differs if agents wrongly perceive that the unexpected increase in interest rates may have been triggered by a reduction in the targeted rate of inflation. The blue line is the same as in Figure 7.1 and the black line is based on the assumption that agents revise down their expectation of the targeted rate of inflation and expect a prolonged period of tighter policy in order to achieve that perceived lower target.(11)

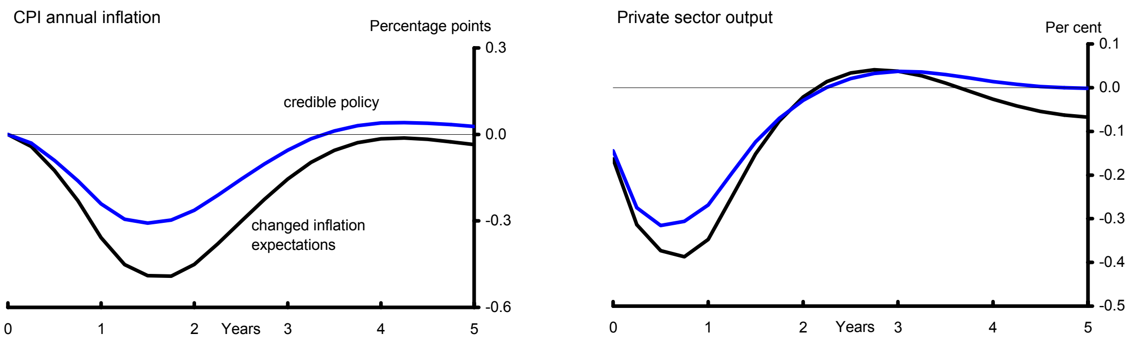
(8) See, for example, Leeper, Sims and Zha (1996), Leeper and Zha (2003) and Christiano, Eichenbaum and Evans (1997, 1999).

(9) See Bank of England (2004).

(10) See, for example, Batini, Harrison and Millard (2003), Bean, Larsen and Nikolov (2002) and Dale and Haldane (1995). In many of these studies, the responses are very persistent – more than we judge to be plausible. Bean (1998) estimates an IS curve and Phillips curve instead of a VAR; in that model output drops immediately and there is no effect on inflation for one year. But the signs and ordering of output and inflation responses in these studies are otherwise the same.

(11) This simulation is sensitive to the precise assumptions made about the change in expected inflation. Here we assume that the unexpected increase in interest rates causes agents to revise down their expected level of inflation in the long run by around 0.2 percentage points by the end of the first year.

Figure 7.2: How expectations can affect shock responses



The response of inflation when agents believe the target has been reduced is much sharper, reflecting the effects of lower expected inflation on price setting. After the first four quarters, the absence of further policy surprises (relative to an unchanged target inflation rate) leads agents to correct their expectations gradually towards the true target.[12] In BEQM, the effect of expectations about the long-run inflation rate mainly comes through nominal variables. The effect on real variables is somewhat smaller but consistent with that on inflation: the initial fall in private sector output is sharper, though there is little difference between the two lines by the end of the third year.

The larger response of inflation when agents perceive that the target has been reduced both illustrates how different assumptions about expectations can affect key model properties and underlines the importance of monetary policy credibility in determining the sensitivity of the economy to changes in interest rates.

(12) We use the approach of Erceg and Levin (2003) to model how agents realise their mistake and gradually correct their expectations over time.

7.2.2 A productivity shock

Figure 7.3 shows the effects of a permanent 1% increase in the level of labour productivity.[13] This simulation is of particular interest because it highlights the importance of stock-flow dynamics and the wealth dimension of the model, and illustrates how demand and policy react to supply shifts.

In the long run, with the new steady-state shown by the dashed line in Figure 7.3, the increase in labour productivity is accompanied by a rise in wages paid by firms. Desired capital and potential supply also increase (although proportionately less than the size of the productivity shock, due to the second round effects on supply discussed below).

Households increase their consumption, given higher wages. Aggregate import levels rise with the increase in consumption and capital investment. The economy must export more to restore external balance, and a real exchange rate depreciation is required. Steady-state external balance is brought about by an increase in the trade surplus (or reduction in deficit), offset by a fall in net foreign asset levels.[14]

We could also tell this story equivalently in terms of stocks. The increase in productivity raises the long-run value of equities[15] and corporate debt; and government debt rises broadly in line with output. Some of the increase in domestic financial assets is sold to overseas residents, which results in a decrease in net foreign assets. An increase in net exports is needed to service the extra debt and so the real exchange rate depreciates.

This depreciation has two 'second-round' effects on the real economy, through labour supply and capital, which reduce the overall impact on long-run supply.

First, we make a distinction in BEQM between real consumer wages and real producer wages. The long-run real consumption wage rises unambiguously, but by less than the real producer wage, because the exchange rate depreciation causes an increase in total consumption prices (including imported goods) relative to domestic producer prices. At the same time, the reservation wage rises fully in line with the increase in labour productivity.[16] The combined effect is sufficient to cause a small long-run *fall* in labour supply and employment, which mitigates the output increase from the productivity shock.

Second, the long-run price of imported goods rises relative to domestically produced goods. This reduces slightly the ratios of imported to domestically produced consumption and capital goods, but imports of capital goods still rise in absolute terms.[17] This relative price effect raises the overall cost of capital goods, which also offsets part of the increase in capital and output from the productivity shock.[18]

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(13) It is implemented as a 1 percentage point increase in the growth rate of labour productivity for one period.

(14) Figure 7.1 shows that there is little change in the steady-state ratio of net foreign assets to GDP. The initial equilibrium has a negative level of net foreign assets. It is the combination of a fall in the level of net foreign assets (thus becoming more negative) and a rise in GDP that leaves the steady-state ratio of the two virtually unchanged.

(15) The long-run value of the firm is equal to the value of the capital stock plus the expected stream of discounted supernormal profits. The value of equity increases by slightly less than the value of the capital stock because the exchange rate depreciation means that value-added prices fall relative to consumer prices. This reduces real average profitability in terms of consumer prices.

(16) We assume that unemployment benefits move in line with the real product wage, and hence labour productivity. This is a necessary assumption to prevent the long-run natural rate of unemployment trending above 100% or below zero in the long run.

(17) Imported and domestically produced capital goods are assumed to be complements.

(18) The amount of the increase in the desired capital stock depends on the share of imported capital in the capital aggregator, the elasticity of substitution between imported and domestic capital goods, and the elasticity of export demand.

The exchange rate movement is associated with some permanent shifts in relative prices, but inflation and nominal interest rates return to the initial equilibrium implied by the inflation target and world nominal interest rates, leaving the real interest rate unchanged. There is little fiscal policy reaction: government transfers spending and debt are all assumed to rise in line with output, and tax revenues rise broadly in line with output too.[19]

In the long run, therefore, there is no change in the inflation rate and nominal interest rates, with an overall increase in output flows. The economy exports more and holds more foreign debt, with a depreciation in the real exchange rate. The fact that output does not rise by exactly 1% is due to the second-round impacts of the real exchange rate on desired labour supply and capital.

Turning to the short run, firms are immediately able to produce more output, for given inputs of capital and labour. But sluggish adjustment means that aggregate demand does not immediately increase and so factor utilisation falls sharply. This encourages firms both to reduce prices to stimulate demand and to reduce their demand for labour in the short run. The real exchange rate immediately depreciates close to its new long-run level and this is gradually passed through into higher import price inflation. Consumer price inflation falls because the effect of temporarily reduced domestic prices outweighs the effect of higher import prices. Unemployment rises in the short run, as firms begin to reduce employment in response to the fall in factor utilisation. The fall in employment (and rise in unemployment) is relatively short lived, however, as higher real wages mean that demand rises steadily, bringing utilisation back to normal levels. Monetary policy responds to low inflation and output below potential by cutting interest rates to stimulate demand. This prevents inflation from falling further, and the inflation rate gradually rises back towards the target.

There is a large body of empirical literature that aims to identify the responses to a productivity shock. The responses here are consistent with the findings from that literature: investment, consumption and output all increase.[20] However, there is some disagreement over labour market responses, especially whether hours worked rise or fall.[21] The responses here are also consistent with the initial responses from the MTMM model: output rises gradually to a higher level, and inflation falls quickly before rising back to its starting point. Work applying the methods of Bayoumi and Eichengreen (1992) and Monticelli and Tristani (1999) to UK data also corroborates this finding in the data.

(19) Real lump-sum taxes do not move by exactly the same amount as real domestic output, because the government spending and debt targets are expressed in terms of ratios to the value of private sector output, and the GDP deflator changes a little because of the permanent effects on the real exchange rate.

(20) See, for example, Christiano, Eichenbaum and Evans (2001).

(21) In a widely cited paper, Galí (1999) reports that hours worked fall after a positive productivity shock. Several studies have affirmed this proposition – see, for example, Basu, Fernald and Kimball (1998). But Christiano, Eichenbaum and Vigfusson (2003) argue that hours worked rise, consistent with the neoclassical model.

Figure 7.3: Effects of a productivity shock

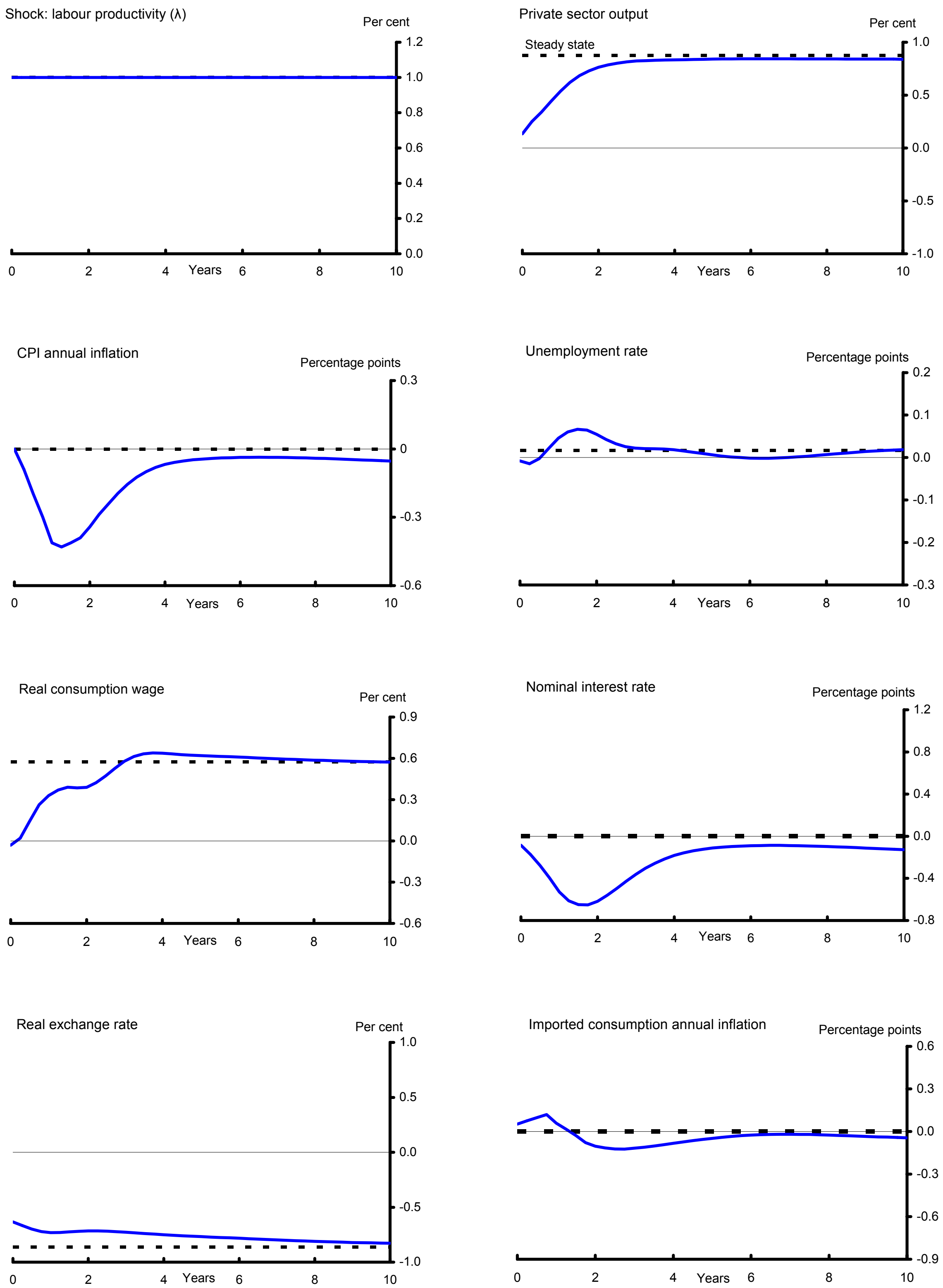
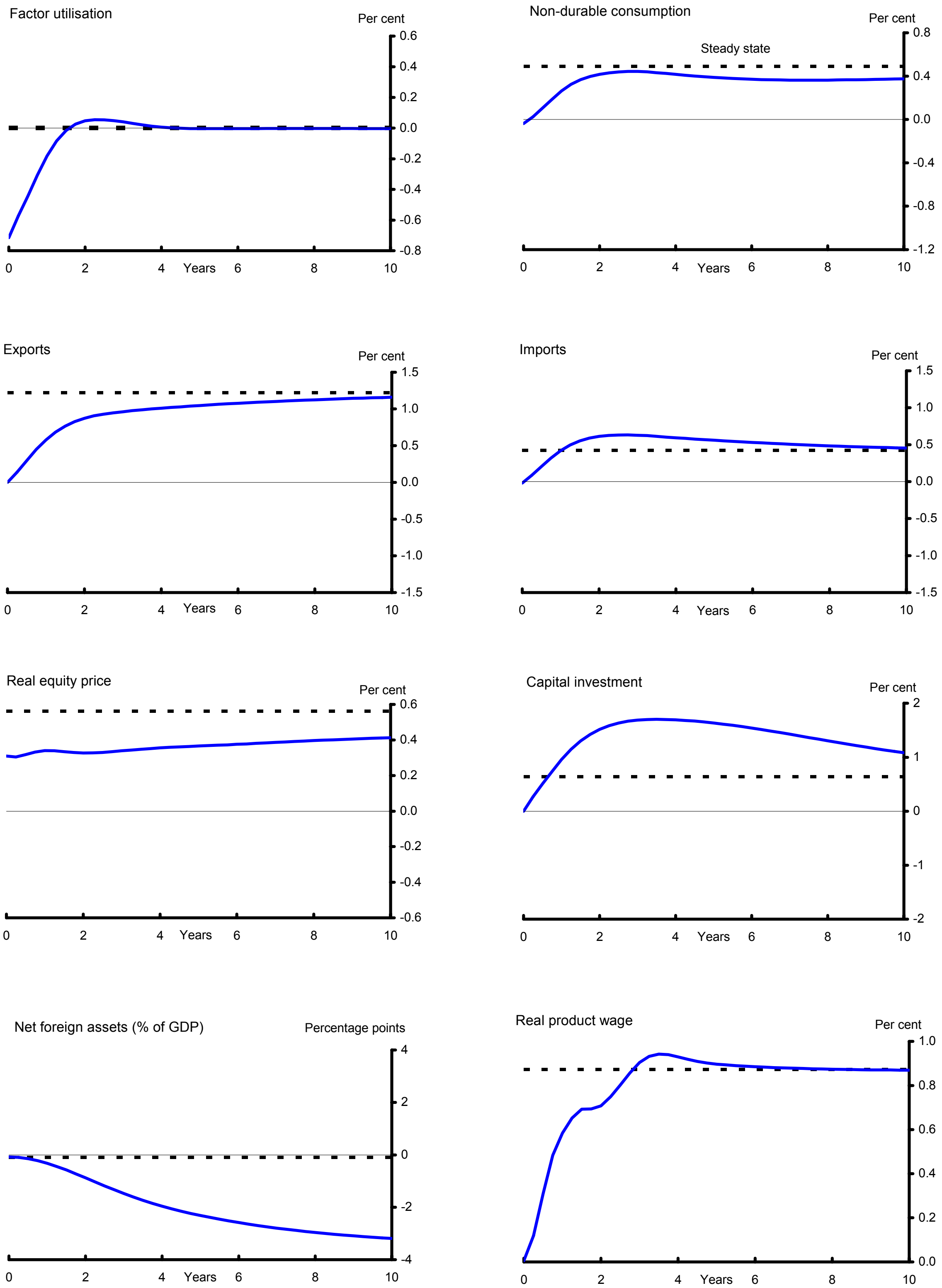


Figure 7.3: (continued) Effects of a productivity shock



7.2.3 A government spending shock

Figure 7.4 illustrates the effect of a 5% increase in the (exogenous) target level of government spending on private sector goods and services, defined as a ratio of nominal government spending to nominal private sector output.[22] The fiscal instrument – here, for simplicity, modelled as the lump-sum tax on households – then ensures that this new spending target is sustainable. This simulation is particularly interesting because of the shock's direct effect on demand.

In the long run, the model shows conventional crowding-out effects, with reduced consumption because taxes must rise to pay for higher government spending. The higher lump-sum taxes cause households to reduce both non-durable consumption and dwellings investment.

In many textbook open economy models, output would be unchanged in the long run.[23] However, potential supply in BEQM can be affected (albeit only slightly in practice) by movements in the real exchange rate. The long-run change in the real exchange rate depends on the net impact of the shift from private to public consumption on the long-run demand for imports. The import content of *total* government spending (including factor payments) is relatively low, but the intermediate import propensity of government procurement is higher than that of domestically produced private non-durable consumption. So the long-run demand for imports rises, but there is also a fall in direct imports of consumption goods that partially offsets this effect. Overall, the net effect is to *increase* slightly the long-run demand for imports. As a result, the real exchange rate depreciates to raise exports and maintain current account balance.

This depreciation has the same 'second round' effects as seen in the productivity shock, though the effects here are quantitatively very small. First, increases in the price of imported consumption goods lower the real consumption wage and, hence, labour supply and employment. Second, increases in the price of imported capital goods raise the overall cost of capital goods and lower the long-run level of the capital stock. Output consequently falls slightly in the long run.

Despite a fall in the capital stock, the valuation of the corporate sector rises because of an increase in the price of capital goods, which raises the overall (relative) value of the capital stock.[24] There is a slight rebalancing of portfolios – net foreign asset levels fall – but the effect is quantitatively small.

In the short run, government procurement increases immediately, but the crowding out of private consumption takes longer to come through. This reflects the non-Ricardian nature of the model (see Section 3.2.1) and also the existence of habits. The net effect is an immediate rise in aggregate demand and factor utilisation. Higher factor utilisation stimulates the demand for labour (though more gradually) and encourages firms to increase margins. Domestic inflation rises as a result of the increase in factor costs and demand pressures. Imported inflation also rises somewhat due to the depreciation of the real exchange rate. The peak effect on CPI inflation occurs at around six quarters, reflecting nominal rigidities in domestic price setting and gradual pass through of the exchange rate to import prices. Monetary policy responds to the short-run increase in aggregate demand by raising the nominal interest rate to bring inflation back to target. After some time, the crowding-out effect on consumption also

(22) Government spending on private sector goods and services ('procurement') is only part of total government expenditure. The final increase in *total* government consumption, as measured by the National Accounts, is much less than 5%, because procurement does not include wages and salaries paid to government employees or the government's gross operating surplus. For this simulation, the government spending rule was modified to bring spending immediately up to the new target level.

(23) The only net effect would be a reduction in the share of consumption in total expenditure.

(24) There is also a technical effect that comes from our assumption of different mark-ups across expenditure categories as a way of incorporating relative price trends with goods produced by a single production function (as explained in Section 6.3).

reduces aggregate demand, which fully adjusts within four years. Factor utilisation returns to normal but unemployment adjusts more gradually because of rigidities in the labour market.

While there is increasing consensus on the responses of the economy to monetary policy and technology shocks, there is less consensus on the effects of a fiscal policy shock. A major difficulty is in identifying unanticipated shocks to fiscal policy, rather than systematic movements in spending through the business cycle. Moreover, the responses are sensitive to whether an increase in government spending is expected to be matched by higher future taxation or by lower future spending: changes in government spending in practice could be associated with very different beliefs about what will happen in the future and when. So such simulations are not always a good guide to what happens in practice.

Nevertheless, the responses here are consistent with results from event studies of government procurement: increases in government spending are associated with short-lived increases in private sector output.[(25)] In some studies, evidence is found for short-run increases in consumption as well as investment.[(26)] In BEQM, private consumption falls immediately.[(27)] However, robust findings are difficult to come by for the United Kingdom.[(28)] The trade balance immediately worsens, in line with Roubini (1988), but in general there is little agreement on the effect on the current account.[(29)] A textbook result is that output is crowded out by higher public expenditure; this is seen here and in the MTMM model. But 'crowding-in' is a possibility in an open economy.[(30)]

(25) See Burnside, Eichenbaum and Fisher (BEF) (2002), following the methodology of Ramey and Shapiro (1998). The results in BEF indicate that real wages fall following an increase in government procurement. This is not the case here, as there is a rise initially in real consumption wages.

(26) See Blanchard and Perotti (2002).

(27) This accords with the empirical findings reported in Cavallo (2002).

(28) For example, Perotti (2002) finds that the short-run effects of government spending on inflation and output in five OECD economies (including the United Kingdom) has changed substantially over time.

(29) In contrast to Roubini (1988), Roubini and Kim (2003) report that expansionary fiscal shocks tend to *improve* the current account. See Erceg, Guerrieri and Gust (2004) for an assessment and discussion.

(30) See Barry and Devereux (2003).

Figure 7.4: Effects of a government spending shock

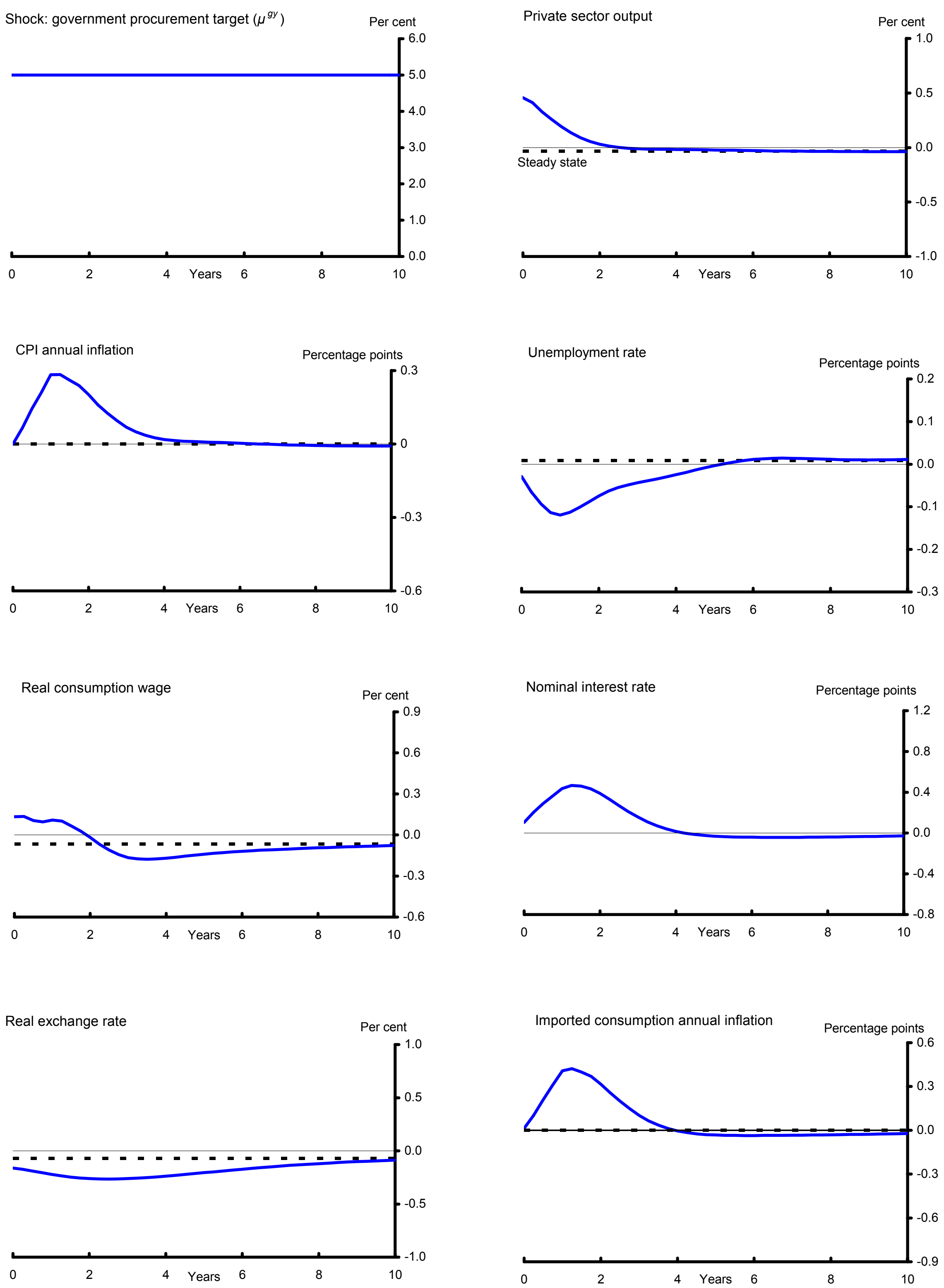
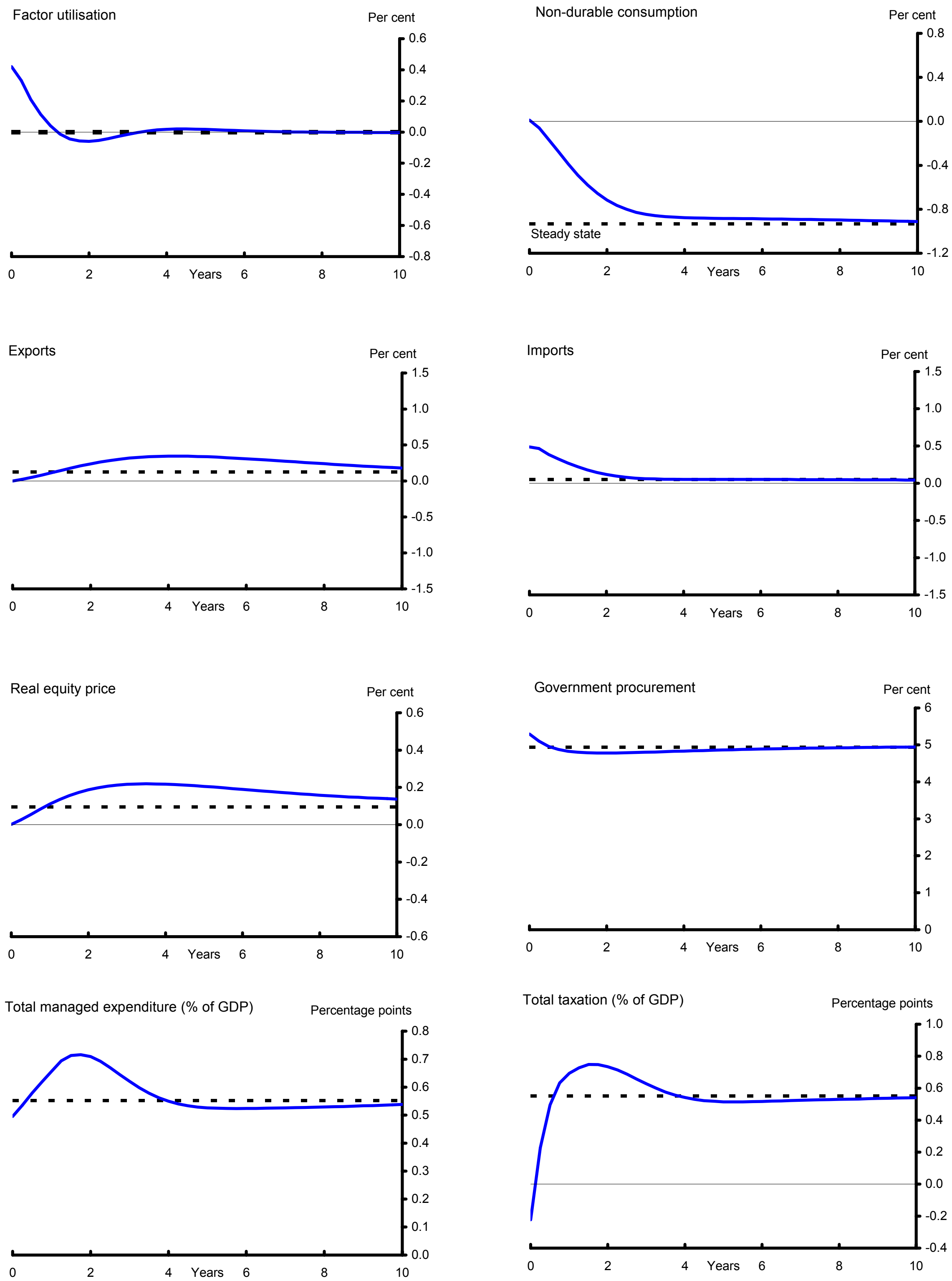


Figure 7.4: (continued) Effects of a government spending shock



7.2.4 A terms of trade shock

Figure 7.5 shows the impact of a permanent, unanticipated 1% decrease in the level of the world price of imported goods (leaving the world price of exported goods unchanged). The model is constructed to allow the basket of goods and services imported by the domestic economy to differ from those exported, so a shift in the relative world price of these different goods and services can have an effect on the domestic economy. Here we look at the effects of the price of imported goods falling relative to the price of exported goods. This simulation is interesting because it highlights how relative price movements lead to reallocations of expenditure.

If the fall in world import prices were matched by a fall in world export prices, the nominal exchange rate would immediately depreciate to offset completely the impact of falling world prices on domestic currency import and export prices, leaving relative prices and activity unchanged. Here, however, we consider an alternative shock that changes the *relative* world prices of import and export goods. An exchange rate depreciation cannot therefore offset the fall in the world price of imported goods without changing the world price of exported goods.

The shock represents an improvement in the terms of trade. Domestic output is now more valuable relative to world production, which increases domestic wealth and hence domestic demand in the long run. In particular, non-durable consumption rises with the increase in wealth. The higher level of long-run consumption is sustained by a higher net foreign asset position, financed by a fall in the long-run value of the trade balance brought about by a rise in the real exchange rate.

The long-run fall in the relative price of imports increases the demand for these goods. Within total imports, imported consumption responds most, reflecting the higher price elasticity of this component. In the long run, the capital stock and labour force participation rise due to the second round effects described in Section 7.2.2, and total output increases.

In the short run, falling world import prices are gradually passed through into falling domestic currency import prices and inflation falls. But the rise in wealth leads to an increase in demand in the medium term. This puts pressure on supply capacity and increases factor utilisation, leading to an increase in margins and labour demand, which reduces unemployment. The upward pressure on domestic prices outweighs the effect from lower import prices over the medium term, leading to an increase in inflation. Monetary policy responds initially by cutting interest rates to offset lower inflation, before tightening in response to the increase in inflation over the medium term.

Empirical studies differ on the contribution of terms of trade shocks to the business cycle. The responses from VAR analysis are highly dependent on the exchange rate regime.[31] Evidence cited in De Gregorio and Wolf (1994) supports the notion that the real exchange rate appreciates following a terms of trade shock.

(31) See Broda (2001).

Figure 7.5: Effects of a terms of trade shock

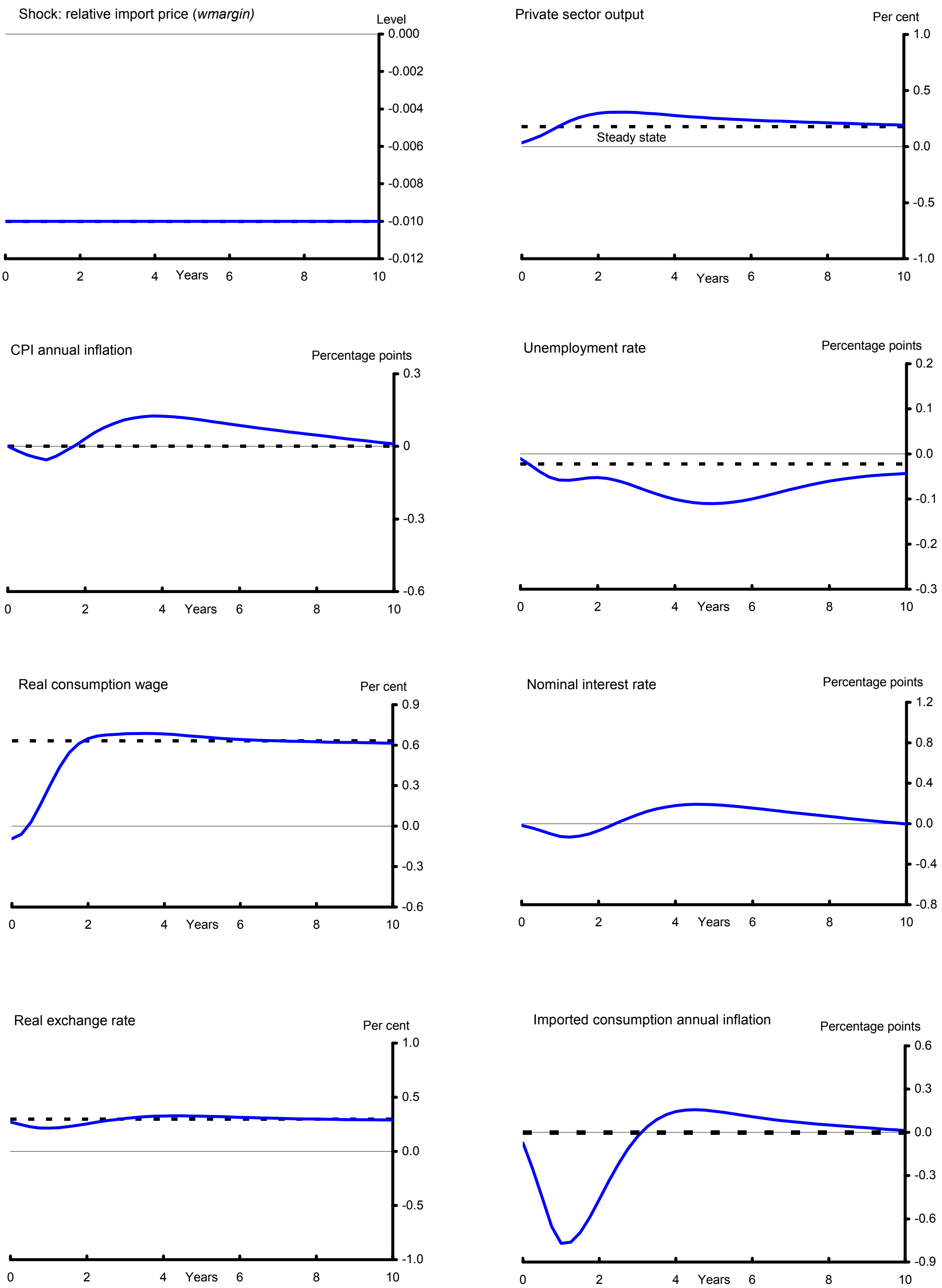
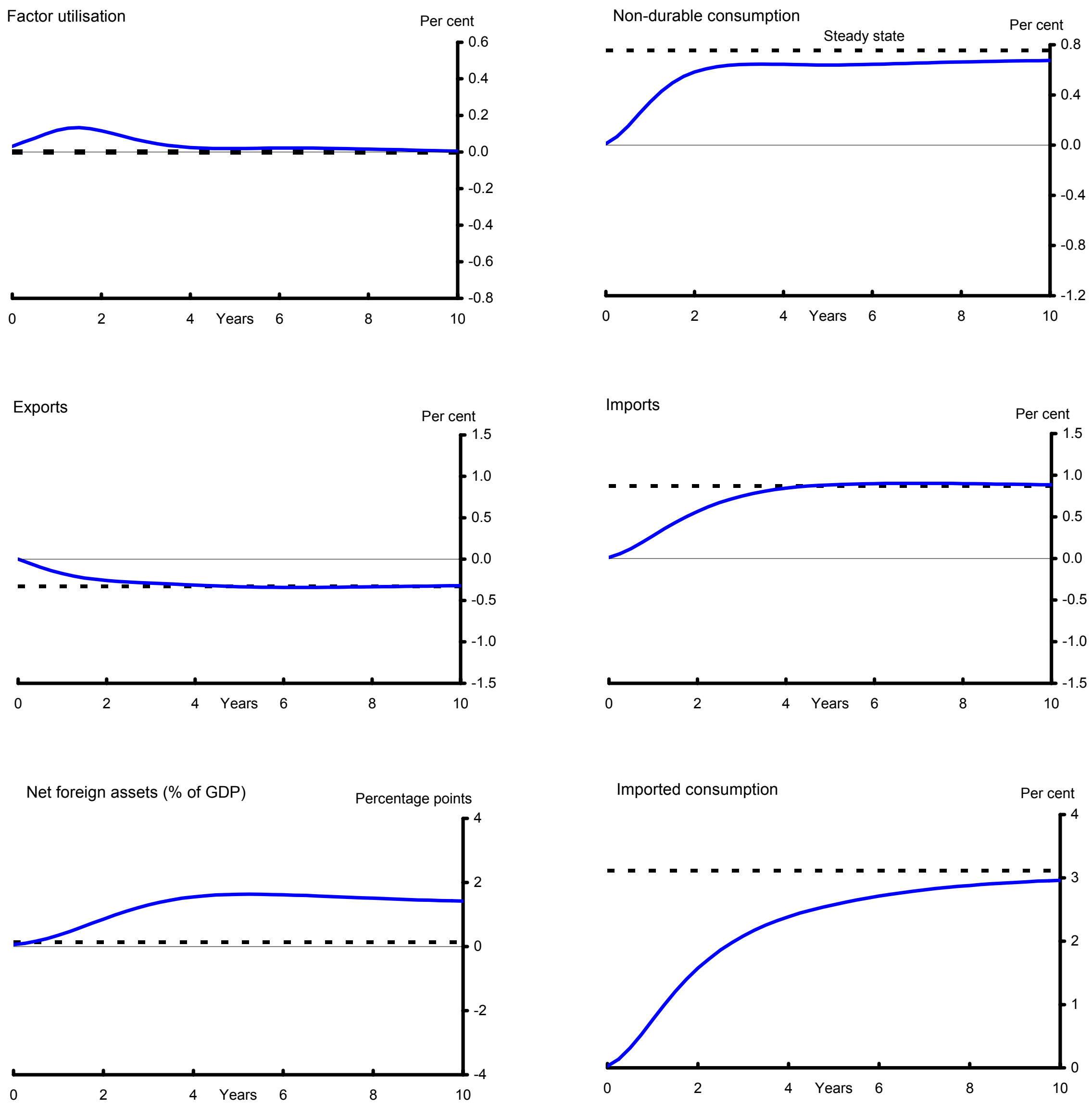


Figure 7.5: (continued) Effects of a terms of trade shock



7.2.5 A world demand shock

Figure 7.6 shows the effects of a permanent, unanticipated 1% increase in the level of world demand for domestic goods. This simulation is particularly useful for highlighting the role of the real exchange rate and imported capital.

In a standard neoclassical model of a small open economy model, long-run supply is anchored by the world real interest rate. An increase in export demand for UK goods and services would not be met by a rise in output but would be completely offset by an increase in the real exchange rate. Neither is there a short-run effect in many simple 'textbook' models, because the real exchange rate appreciation simply offsets the impact of higher world demand.

However, as described in Section 7.2.2, BEQM allows for the possibility that real exchange rate movements can affect long-run supply. In the case of a world demand shock, the real exchange rate appreciates, which acts to reduce the cost of capital goods and raise the desired capital stock. Similarly, real consumption wages rise and labour supply increases. Both effects lead to an increase in output.

The long-run increase in real consumption wages and employment allows greater expenditure by households on non-durable consumption and investment in dwellings. Consumption, investment and government spending move proportionally by slightly more than output.[32] Holdings of net foreign assets rise and the value of imports is lower in the long run (reflecting a relatively low price elasticity of import volumes), so a higher real exchange rate and a fall in export volumes is needed to balance the current account. The shock effectively improves the economy's relative earnings capability and net foreign asset position.

In the short run, the foreign currency price of domestic exports is slow to adjust to the increase in world demand. This fuels a short-run increase in export demand and, given slow adjustment of other demand components, output immediately overshoots its long-run level. Factor utilisation rises as supply capacity is relatively slow to adjust. Firms increase their demand for labour, reducing unemployment, and also increase prices. The exchange rate immediately appreciates close to its new long-run level, though the pass through to lower import prices is gradual. The net effect is for CPI inflation to rise a little above target, to be brought down gradually over the longer term by a rise in interest rates.

(32) The model has a target for the ratio of *nominal* government spending to *nominal* private sector output. The movement of relative prices in this shock means that there are slightly different movements in the *volumes* of government spending and total output.

Figure 7.6: Effects of a world demand shock

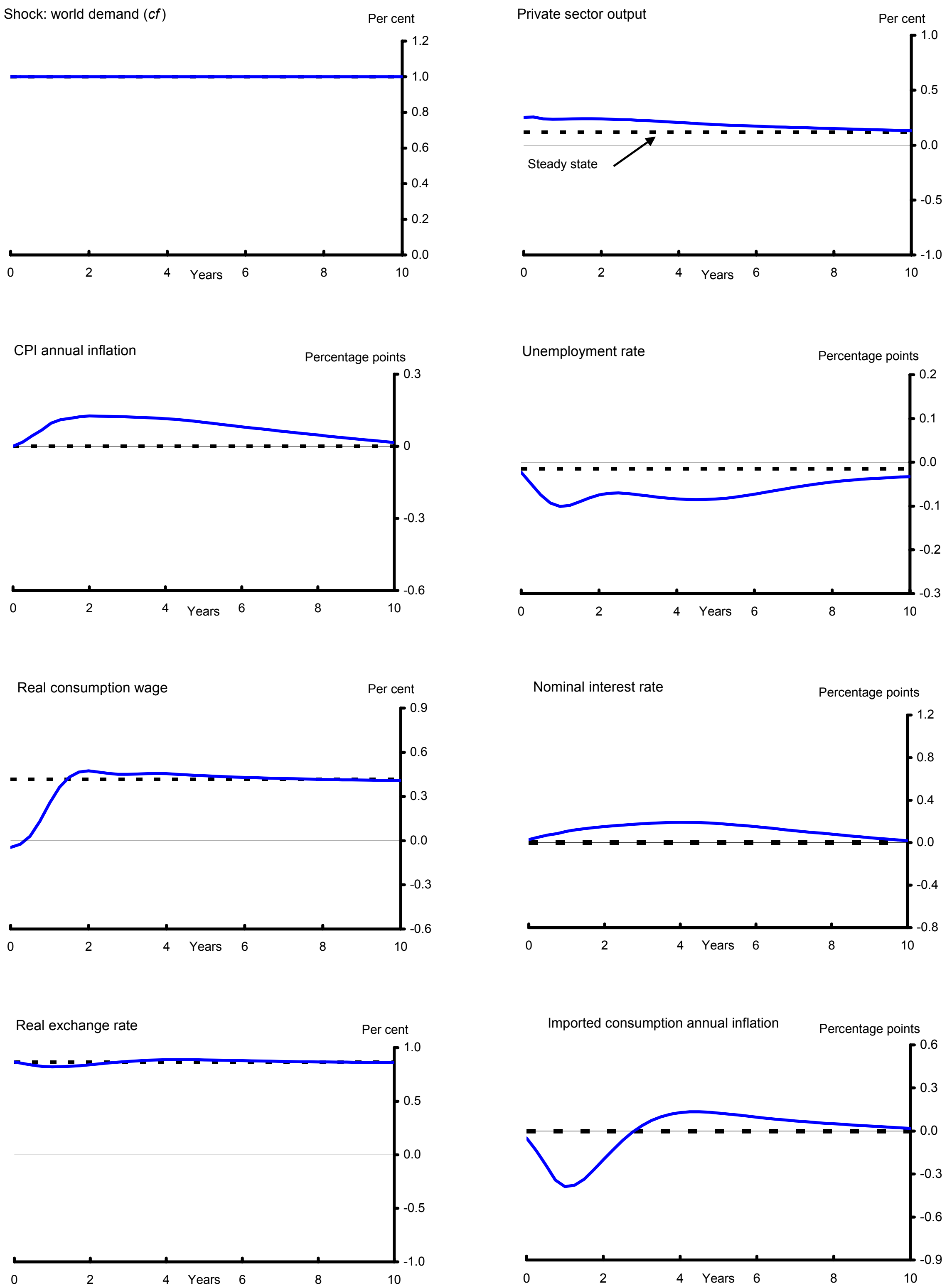
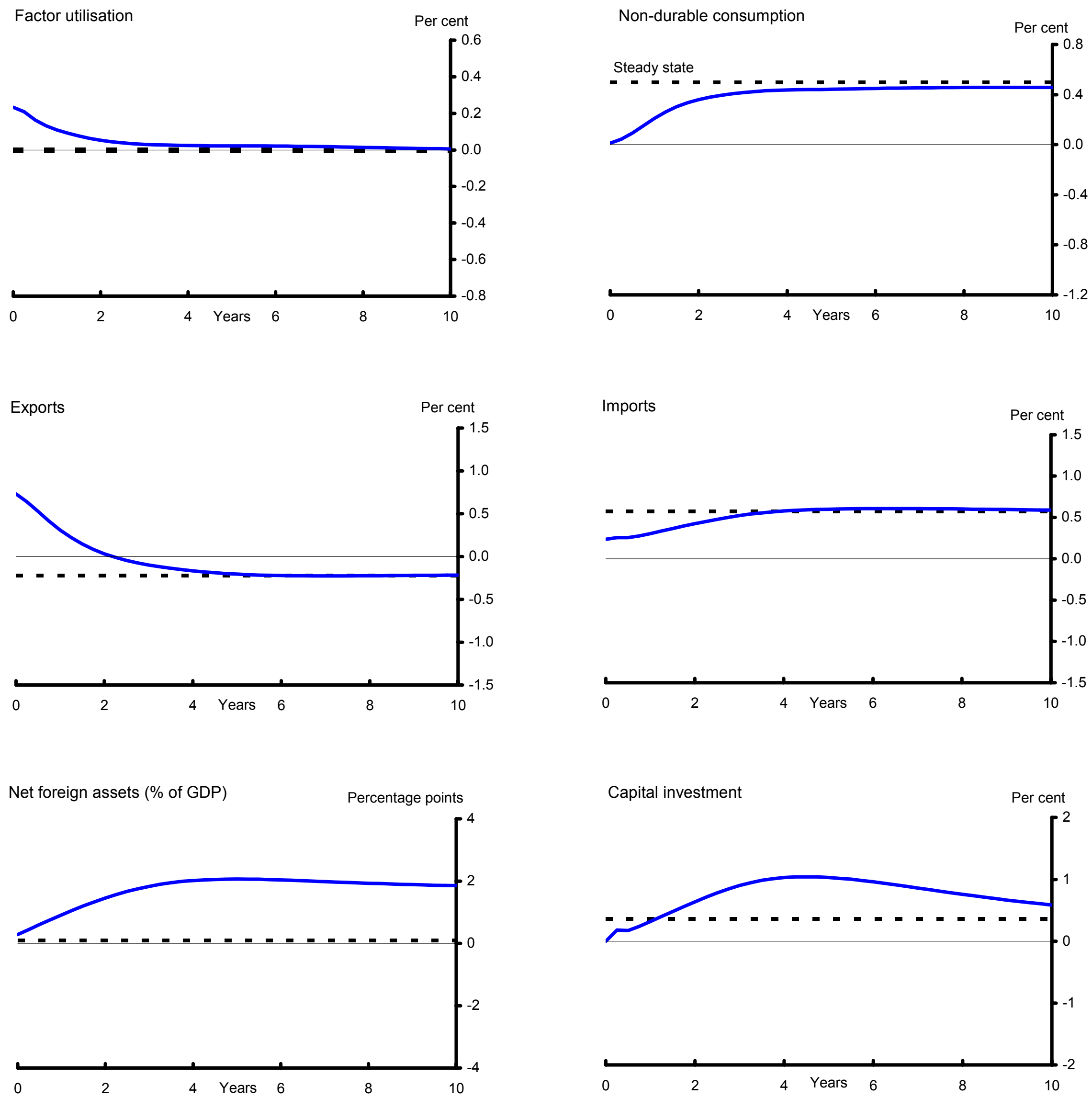


Figure 7.6: (continued) Effects of a world demand shock



7.2.6 A labour market participation rate shock

Figure 7.7 shows the impact of a permanent decrease in labour market participation, such that the participation rate is lower at all real wage rates.(33) The simulation is interesting for the shock's direct effects on supply and the equilibration of demand.

In a standard small open economy model, in which labour supply is exogenous and there is no imported capital, a given drop in employment would be matched in the long run by a proportional fall in capital and output. In BEQM, however, labour supply is endogenous and some final capital goods are imported. Therefore, the interaction between the real exchange rate and long-run supply discussed in Section 7.2.2 means that the decrease in labour supply, employment, capital stock and output is slightly less than 1%. That is because the real consumption wage rises and the cost of capital goods falls.

Long-run aggregate labour income falls because the rise in the real consumption wage is less than the fall in employment. Consumption and housing investment fall, along with investment by firms and government spending.(34) As total consumption and capital expenditures are reduced, imports fall too. But lower exports are needed to preserve external balance, so the real exchange rate appreciates.

As with the other shocks described in this chapter, these long-run effects on expenditure are reflected in changes in asset positions. In addition to lower labour income, margins (and therefore profits and dividends) are squeezed as firms attempt to hold on to market share, so equity values fall. Net foreign assets are also reduced (even though there is a marginal rise in the ratio to output): the aggregate economy, in effect, borrows from overseas in an attempt to support aggregate consumption.

In the short run, the exchange rate appreciates immediately, to close to its new steady-state level. Participation and employment fall sharply over the first two years, along with consumption and investment. The supply of workers at every wage rate falls, so wages rise initially as firms try to prevent employment falling by as much as participation. The fall in labour participation is faster than that of employment, so the unemployment rate falls too in the short term. As employment and demand fall, firms initially reduce factor utilisation.

Import price inflation falls initially, because of the higher exchange rate. But domestic inflation rises as firms have to bid wages up, and the real product wage rises substantially within the first two years. This effect dominates the effect of cheaper imported goods and CPI inflation rises. Interest rates rise to bring inflation back to the target.

The results shown here accord qualitatively with the effects of a labour supply shock identified in Peersman and Straub (2004) for the euro area: hours and output fall, prices and real wages rise, and interest rates rise temporarily. Despite the observed variation of unemployment with output over the business cycle, there are few models that examine the *joint* behaviour of employment, unemployment and labour market participation: Veracierto (2002) is one exception, using a matching framework, but the results did not match observed dynamics in the US labour market.

(33) Technically, the shock is implemented as a reduction by 0.01 in the intercept term in the (log) labour supply schedule (equation (A.14) in Appendix A).

(34) In this shock, the government spending target is expressed as a ratio to output, so spending falls in line with output.

Figure 7.7: Effects of a participation shock

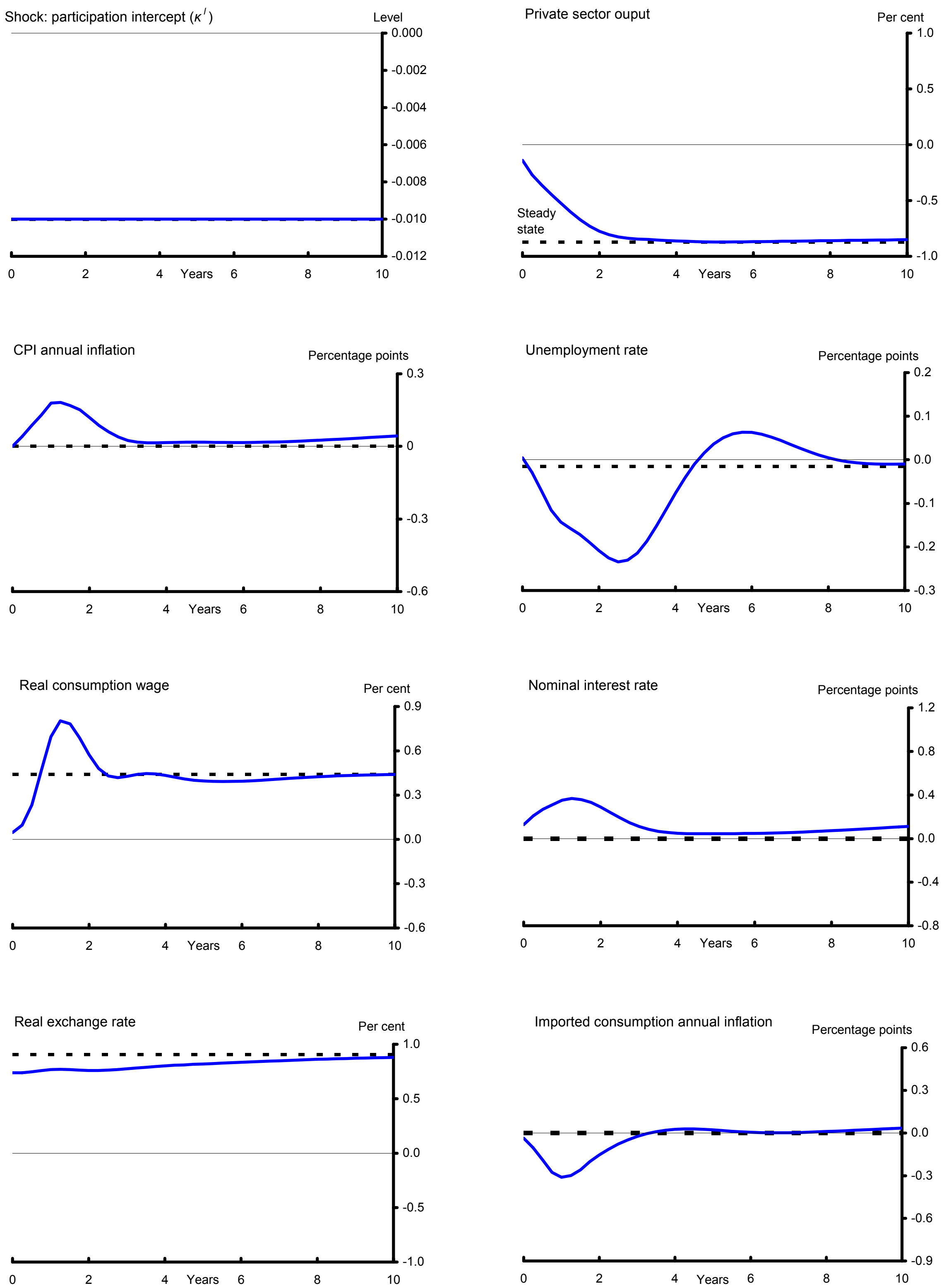
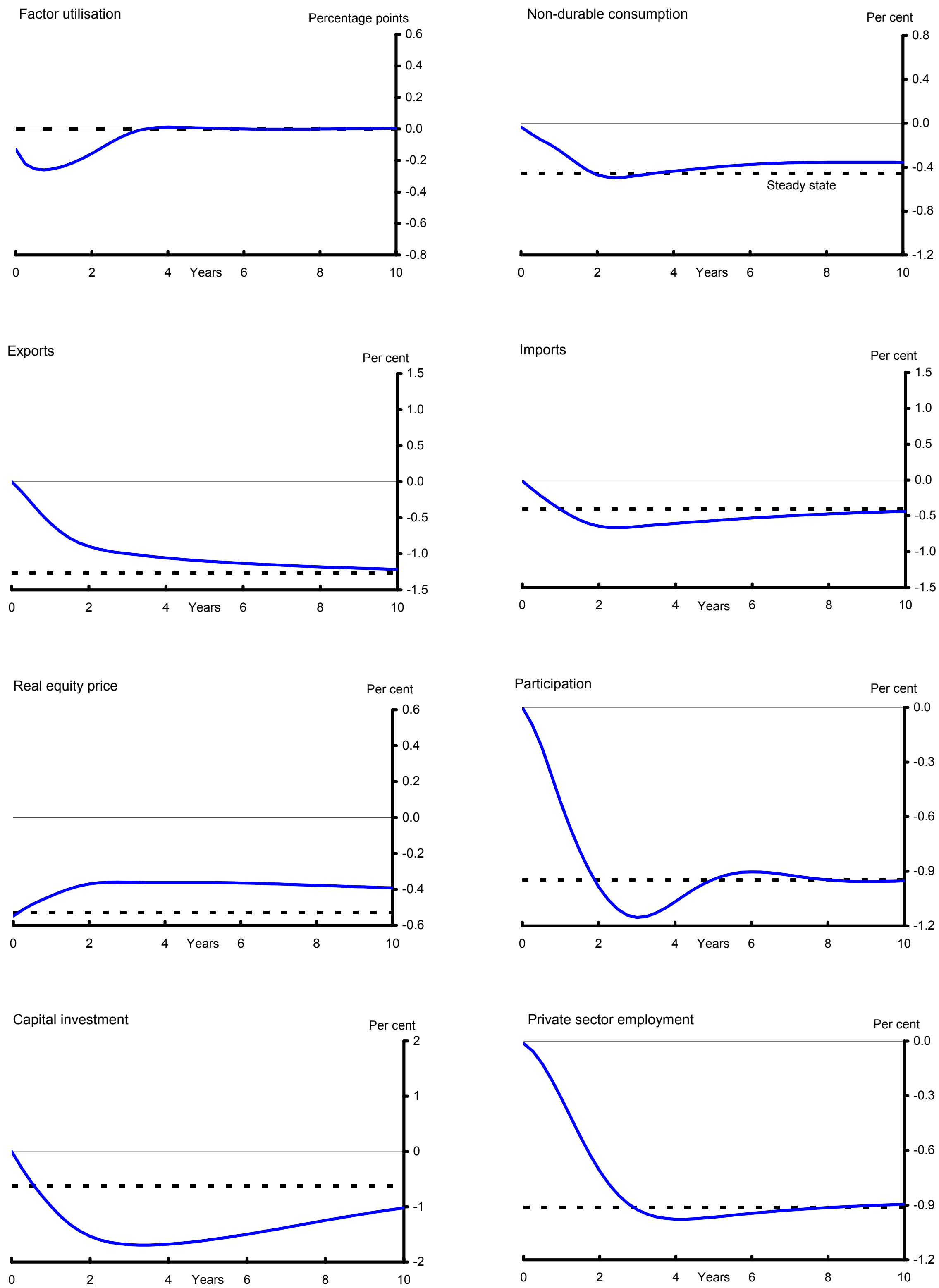


Figure 7.7: (continued) Effects of a participation shock



7.3 Summary

This chapter illustrates the properties of the new model by describing a series of model simulations. The results must be used carefully, because they are stylised experiments that look at the marginal effects of a single change, starting from an equilibrium position. And the effects of changes can be affected significantly by different assumptions about how policy reacts and about agents' expectations.

The reactions to a temporary shock to interest rates correspond to the broad conclusions of the empirical literature on monetary shocks: unanticipated policy tightening reduces output and then inflation. The behaviour is broadly similar to that of the previous MTMM model and close to other studies. As this is a temporary shock, there are no long-run effects on real variables or inflation. The effect of an unexpected change in interest rates on inflation is larger if agents believe that it is associated with a change in the targeted rate of inflation.

We then illustrate the interaction of long-run properties and short-run adjustment through shocks to productivity, government spending, the terms of trade, world demand and labour market participation. As well as the conventional effects that would be expected from simple models, the results show how movements in the real exchange rate can affect potential supply through changes in labour force participation and the desired capital stock: other things being equal, a real exchange rate depreciation leads to a slight reduction in potential supply.

Short-term movements in the face of shocks illustrate the effects of immediate changes in asset prices coupled with sluggish adjustment of employment, capital and prices. The simulations also show how the policy reaction functions that we use outside of the forecast act to ensure fiscal solvency and to bring inflation back to target over the medium term.