

Oil Price Shocks and the NAIRU

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Abstract

Based on a model of a small open economy with imperfect competition on goods and labor markets the impact of oil price shocks on equilibrium unemployment is analyzed. One aim of this analysis is the identification of the main channels by which the NAIRU, i.e. the non-accelerating inflation rate of unemployment, is affected by oil price shocks. It is shown that the change in the NAIRU depends on parameters of the supply as well as the demand side. To make a quantitative assessment possible, the theoretical analysis is supplemented by simulation experiments. The second aim of the paper is the discussion of several policy measures by which the NAIRU could be stabilized if the economy was hit by adverse oil price shocks. Simulation experiments suggest that the most recommendable policy response consists of a combination of supply-side and demand-side policies.

Keywords: Unemployment, NAIRU, Oil Price Shocks, Imperfect Competition, Open Economy

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1 Introduction

The oil price increase in the year 2000 brought back gloomy memories of the three previous oil price shocks in the early and late 1970s and in 1990, which were accompanied by a significant slowdown in economic activity and a corresponding increase in unemployment across OECD countries. From the end of 1998 to autumn 2000 oil prices more than tripled. Measured in terms of industrial commodity prices, the real price of oil in autumn 2000 was again as high as it was in the wake of the first oil crisis (cf. Matthies (2000)). Since the beginning of 2001 oil prices have significantly decreased. However, OPEC has already decided to reduce oil supply in order to stabilize oil prices at a higher level. In recent years oil consumption has also been higher than the discovery of new oil reserves. Furthermore, the exploration of new oil reserves is getting more and more expensive. Some analysts therefore view the higher volatility of oil prices as a clear sign that the days of cheap oil may soon be a thing of the past. Even if this pessimistic view is not shared, there is the serious threat that oil prices in the next few years may be significantly higher than in the second half of the nineties. This could be enough to do serious damage to the world economy.¹

To judge whether and to what extent economies might be affected by oil price shocks, a thorough theoretical understanding of the relevant parameters determining the shock transmission is necessary. Based on a theoretical model of a small open economy with imperfect competition on goods and labor markets, the impact of oil price shocks on equilibrium unemployment is analyzed in this paper. One aim is the identification of the main channels by which the NAIRU, i.e. the non-accelerating inflation rate of unemployment, is affected by oil price shocks. It is shown that the change in the NAIRU depends on parameters of the supply as well as the demand side. To make a quantitative assessment possible, the theoretical analysis is supplemented by simulation experiments. The second aim of the paper is the discussion of several policy measures by which the NAIRU could be stabilized if the economy was hit by adverse oil price shocks. The theoretical analysis is again accompanied by simulation experiments, which suggest that the most

¹See, for instance, the concerns expressed in the Economist, September 9th 2000, p. 17.

recommendable policy response consists of a combination of supply-side and demand-side policies.

There is a huge amount of empirical literature dealing with the question whether and how oil prices influence the level of economic activity and unemployment. However, this literature is mainly based on estimations of Vector Autoregressive Equation Systems and Granger Causality Tests which do *not* rely upon structural models of oil price shocks.² On the theoretical level there are surprisingly few attempts to capture in a single model the main channels by which oil prices may affect the NAIRU. Very often oil price shocks are simply treated as some other type of supply shock in a model of an otherwise closed economy. For example, in Carruth *et al.* (1998) it is assumed that oil prices affect labor demand but not the wage-setting process since only a standard efficiency-wage model of the closed economy is considered. In Layard *et al.* (1991) and Christini (1999) an opposite strategy is followed by assuming that due to wedge effects the wage-setting curve is affected by oil price shocks, whereas labor demand remains unaffected.

In all these analyses it is not taken into account that adverse oil price shocks lead to a decline in aggregate demand due to higher income transfers to oil-producing countries.³ This may be due to the fact that in virtually all closed-economy models aggregate demand has no effect on the NAIRU in the longer run, since in the absence of nominal rigidities the real variables are determined by the supply side alone.⁴ However, in an open economy the real exchange rate additionally enters the labor demand and wage-setting equation along with real wages and unemployment, implying that also in the longer run the supply-side relationships no longer suffice to determine the real variables of the model. It is sometimes objected that also in the open economy aggregate demand has no (long-run) impact on real variables since the condition of balanced trade acts as an additional supply-side constraint (cf. Layard *et al.* (1991) and Carlin, Soskice (1990)). Although being a theoretically valid

²An overview of the empirical literature can be found in the introduction of Hamilton (2000).

³The decline in world demand depends on how much oil-producing countries save of their windfall. An exception to the claim that aggregate demand effects are not taken into account is the important contribution of Bruno and Sachs (1985). Their insights seem to be somewhat ignored in the more recent literature focusing on the labor market consequences of oil price shocks.

⁴For a discussion of the role of aggregate demand in NAIRU models see also Beissinger, Möller (2000).

argument, from an empirical point of view the requirement of balanced trade seems to be overly restrictive. For most industrialized countries it is possible to sustain imbalances in the current account for long periods of time. Since an adverse oil price shock may only last for a couple of years, it seems unjustified to ignore aggregate demand effects of oil price shocks by imposing the balanced-trade restriction, which would only be meaningful as a necessary condition for the “very long-run” solution of the model. In this paper the focus is on the “medium run”, which is characterized by the fact that the current account is not necessarily balanced and the stock of capital is exogenously given.⁵ In contrast to a short-run analysis it is assumed that expectations are correct and nominal rigidities play no role. As a consequence, monetary policy has no effect on the real side of the economy but only governs the path of the nominal variables. Since money is neutral, it is neglected altogether in the model.

The remainder of this paper is organized as follows. In section 2 the theoretical framework for a small open economy with imperfectly competitive labor and product markets is introduced. Section 3 derives the consequences of adverse oil price shocks. The comparative-static analysis provides the basis for the simulation experiments which are performed in section 4. Section 5 deals with the question of how economic policy should react to adverse oil price shocks. A summary and some conclusions can be found in section 6.

2 The theoretical framework

An adverse oil price shock is often viewed as a nominal phenomenon which leads to higher inflation in the domestic economy and induces the central bank to raise interest rates, thereby curbing economic activity. Even though this interpretation is not incorrect, it obscures the *real* problem lying behind adverse oil price shocks. If oil prices rise then firms’ real costs and consumers’ real expenditures for oil rise as well. Hence, the real

⁵The view that the balanced-trade restriction should not be imposed in an analysis of the medium run is supported by Harrigan *et al.* (1993), who criticize the NAIRU model of the open economy developed by Layard *et al.* (1991).

wage the firms are willing to pay declines, while real wage claims of labor unions are increasing. At a given real exchange rate (which is later endogenously determined) the claims of firms and labor unions can only be reconciled if unemployment increases. Besides unemployment, the real exchange rate is a second mechanism which, by influencing the real price of oil, could in principle equilibrate the claims of firms and unions. On the other hand, changes in the real exchange rate also affect net exports and hence aggregate demand. All these effects must be simultaneously taken into account to see how oil price shocks affect the NAIRU.

This short discussion makes it clear that the most natural way to think about the effects of oil price shocks on the NAIRU is a model of an open economy with imperfect competition on goods and labor markets, where the labor market relationships represent the real wage concessions of firms and the real wage claims of labor unions. In the theoretical model a small open economy is considered for which the world price of oil, the real interest rate and the price of foreign consumption goods is exogenously given. It is important to note that the results in this paper do *not* depend on the exchange rate regime. The exchange rate regime would only have an impact on the nominal variables, which is not the focus of this paper.

2.1 The demand for labor and oil

The explicit consideration of oil in the production process makes it necessary to distinguish between gross output and value added. In this paper the value added specification is justified by assuming separability of labor and capital from other inputs, as suggested by Arrow (1975).⁶ The production technology for gross output can then be written as a two-level production function. On the first level capital and labor are employed to generate value added, and on the second level value added and other factors of production are

⁶Alternatively, the Leontief aggregation condition requires factors other than capital and labor to vary in fixed proportions with output, whereas the Hicksian aggregation condition requires prices of factors other than capital and labor to change in fixed proportions with the price of output. Both conditions seem to be overly restrictive for an analysis which scrutinizes the consequences of oil price shocks and the resulting factor substitution.

combined to yield gross output. Since it is well-known from empirical studies that the substitution elasticity between oil and value added is much lower than unity, a simple specification for the second-level production function of the representative firm i is a CES function of the form

$$Q_i = [\delta S_i^{-\rho} + (1 - \delta)Y_i^{-\rho}]^{-\frac{1}{\rho}}, \quad 0 < \rho < \infty, \quad (1)$$

where Q denotes gross output, Y value added and S imported oil used in the production process.⁷ The substitution elasticity σ between S and Y is given by $\sigma = 1/(1 + \rho)$ and is assumed to be significantly lower than one. The value added production function is described by the following Cobb Douglas function

$$Y_i = N_i^\alpha K_i^{1-\alpha}, \quad (2)$$

where N denotes labor and K the exogenously given stock of capital, respectively.⁸ In the small open economy under consideration the number of firms is exogenously given, which may be due to barriers to market entry provoked by sunk costs. On the goods market monopolistic competition prevails. The demand of each firm is given by the Blanchard, Kiyotaki (1987) type function $Q_i^d = (P_i/P)^{-\eta} \tilde{Q}^d$, where P_i is the price of the i -th firm's gross output, P the aggregate price level and \tilde{Q}^d denotes aggregate demand divided by the number of firms in the respective economy. The elasticity of the demand for goods is constant and equal to η (in absolute values), with $\eta > 1$. In general equilibrium aggregate demand is itself an endogenous variable (which will also depend upon the real exchange rate), but from the firm's point of view it is taken as exogenous. The reason for this is that the single firm has a negligible influence on the aggregate variables due to the assumed large number of firms. By choosing the price P_i each firm decides which share of aggregate demand it will obtain. The combined actions of all firms determine the aggregate price level P . As will be explained later, the price of domestic goods relative to foreign goods then influences the level of aggregate demand. In this model there is no rationing, so production Q_i is always equal to demand Q_i^d .

⁷Appendix A.1 provides a list of symbols used in the theoretical model.

⁸The combination of a CES function for gross output and a Cobb Douglas function for value added was previously employed, for instance, by Hof (1993), Marston, Turnovsky (1985) and Bruno (1984). In Bruno, Sachs (1985) also the production function for value added is modeled as a CES function.

The first-order conditions for a profit maximum require that

$$\frac{W_i}{P_i} = \kappa \frac{\partial Q_i}{\partial Y_i} \frac{\partial Y_i}{\partial N_i} \quad \text{and} \quad \frac{P_s}{P_i} = \kappa \frac{\partial Q_i}{\partial S_i}, \quad \kappa \equiv \frac{\eta - 1}{\eta}, \quad 0 < \kappa \leq 1, \quad (3)$$

where W_i denotes nominal wages and P_s the price of imported oil in domestic currency. The parameter κ can be interpreted as indicating the degree of competition in the goods market, with $\kappa = 1$ representing a situation with perfect competition. Using the production functions (1) and (2), the first-order conditions can be written as

$$\frac{W_i}{P_i} = \alpha \kappa (1 - \delta) \left(\frac{Q_i}{Y_i} \right)^{1+\rho} \left(\frac{K_i}{N_i} \right)^{1-\alpha} \quad \text{and} \quad \frac{P_s}{P_i} = \kappa \delta \left(\frac{Q_i}{S_i} \right)^{1+\rho}. \quad (4)$$

Since all firms (and labor unions) are identical, in equilibrium all firms face the same wage $W_i = W$ and set the same price $P_i = P$. The aggregate relationships which correspond to eqs. (4) are then simply obtained by omitting the index i from all variables. Writing the resulting expressions in relative changes and taking account of the definition of σ leads to

$$\widehat{N} = -\frac{1}{1-\alpha} (\widehat{W} - \widehat{P}) + \frac{1}{\sigma(1-\alpha)} (\widehat{Q} - \widehat{Y}) \quad (5)$$

and

$$\widehat{S} = -\sigma (\widehat{P}_s - \widehat{P}) + \widehat{Q}, \quad (6)$$

where a hat over a variable denotes relative changes. Since $\widehat{K} = 0$ by assumption, the production function for value added in relative changes is

$$\widehat{Y} = \alpha \widehat{N}. \quad (7)$$

With this equation the production function for gross output can be written as

$$\widehat{Q} = \varepsilon \widehat{S} + (1 - \varepsilon) \alpha \widehat{N}, \quad (8)$$

where ε and $(1 - \varepsilon)$ denote the elasticity of gross output with respect to imported oil and value added, respectively. Hence $\alpha(1 - \varepsilon)$ denotes the elasticity of gross output with respect to employment. From the aggregate versions of the first order conditions (3) it follows that ε and $\alpha(1 - \varepsilon)$ are proportional to the share of imported oil and labor in gross output, respectively, since

$$\varepsilon = \frac{1}{\kappa} \frac{P_s S}{P Q} \quad \text{and} \quad \alpha(1 - \varepsilon) = \frac{1}{\kappa} \frac{W N}{P Q}. \quad (9)$$

Inserting eqs. (7) and (8) into eqs. (5) and (6) and solving the resulting expressions for \widehat{N} and \widehat{S} leads to the following aggregate factor demand functions

$$\widehat{N} = -\frac{1}{1-\alpha}(\widehat{W} - \widehat{P}) - \frac{\varepsilon}{(1-\alpha)(1-\varepsilon)}(\widehat{P}_S - \widehat{P}) \quad (10)$$

and

$$\widehat{S} = -\frac{\alpha}{1-\alpha}(\widehat{W} - \widehat{P}) - \frac{\alpha\varepsilon + (1-\alpha)\sigma}{(1-\alpha)(1-\varepsilon)}(\widehat{P}_S - \widehat{P}). \quad (11)$$

As a result, both an increase in real wages and in the real price of oil lead to a lower demand for labor and oil. Of special interest is the impact of oil price shocks on labor demand. From eqs. (10) and (9) it is obvious that an increase in oil prices results in a decline in labor demand, which is the stronger the higher the share of oil and labor in gross output.⁹

The solutions for \widehat{Y} and \widehat{Q} consistent with maximum profits are obtained by inserting the factor demand equations into eqs. (7) and (8). If the real price of oil increases, both value added and gross output decline. The relationship between \widehat{Q} and \widehat{Y} is given by

$$\widehat{Q} = \widehat{Y} - \frac{\varepsilon\sigma}{1-\varepsilon}(\widehat{P}_S - \widehat{P}). \quad (12)$$

The decline in gross output is greater than the decrease of value added. The reason is that a rise in (P_S/P) leads to a substitution of oil by value added. The relationship between \widehat{Q} and \widehat{Y} in eq. (12) makes it possible to transform a model which is formulated in terms of gross output into a model in terms of value added.

In the labor demand equation employment can be substituted by the unemployment rate u , since $N = (1-u)L$, where L denotes the exogenously given labor supply. It follows that

$$\widehat{N} = -\frac{1}{\beta}\widehat{u}, \quad \text{with } \beta \equiv \frac{1-u}{u}. \quad (13)$$

⁹This analysis also sheds light on some erroneous specifications in the literature. For instance, in the theoretical analysis of Christini (1999) labor demand is not influenced by oil price shocks. This is (wrongly) justified by the separability of oil from value added in the gross output production function.

Inserting this equation into eq. (10) and solving the resulting expression for real wages leads to

$$\widehat{W} - \widehat{P} = \frac{1 - \alpha}{\beta} \widehat{u} - \frac{\varepsilon}{1 - \varepsilon} (\widehat{P}_S - \widehat{P}). \quad (14)$$

In this form the labor demand equation can be interpreted as an equation for the real wage, which the firms are willing to concede. As a shortcut eq. (14) is called price-setting equation. This equation can be further transformed by introducing the real exchange rate θ , which is defined as $\theta \equiv P^* E/P$. In this definition P^* denotes the world price for consumption goods and E the nominal exchange rate. To simplify the resulting expressions it is assumed that P^* is constant. In this case $\widehat{\theta} = \widehat{E} - \widehat{P}$. Denoting the world price of oil as P_S^* , eq. (14) can be written as

$$\widehat{W} - \widehat{P} = \lambda_1 \widehat{u} - \lambda_2 \widehat{\theta} - \lambda_2 \widehat{P}_S^*, \quad \lambda_1 \equiv \frac{1 - \alpha}{\beta} \text{ and } \lambda_2 \equiv \frac{\varepsilon}{1 - \varepsilon}. \quad (15)$$

The parameter λ_1 determines the change in firms' real wage concessions in response to changing unemployment. The real wage reaction is stronger the lower the elasticity of value added with respect to employment, α , and the higher the unemployment rate in the initial equilibrium, i.e. the lower β . The reaction of real wages to changes in the real exchange rate or the world price of oil depends on the parameter λ_2 . Due to eq. (9) it holds that $\lambda_2 = \alpha P_S S / (WN)$, i.e. λ_2 and hence the real wage reaction are the higher the greater the oil costs compared to the wage bill.

2.2 The wage-setting equation

It is well known from the literature that different microeconomic foundations of the wage-setting curve, based for instance on efficiency wage considerations or wage bargains between firms and unions, all lead to rather similar aggregate wage-setting equations. In a typical equation the real consumption wage depends on the unemployment rate and an array of institutional variables describing all kinds of labor market regulations and the generosity of the social security system. In the following it is assumed that the supply side of the labor market can be described by an aggregate wage-setting equation which

may be due to wage bargains between firms and labor unions and is of the form

$$\frac{W}{P_c} = H(u, B), \quad \frac{\partial H}{\partial u} < 0, \quad \frac{\partial H}{\partial B} > 0, \quad (16)$$

where P_c denotes the price level relevant for consumers. B comprises all institutional and wage-policy variables which influence the bargained real wage besides unemployment. The variables contained in B are defined such that $\partial H/\partial B > 0$. It is assumed that households import consumption goods and oil from abroad. In this case the consumer price level is given by

$$P_c = (P_S^* E)^{\gamma_2} (P^* E)^{\gamma_3} P^{1-\gamma_2-\gamma_3}, \quad \gamma_2 > 0, \gamma_3 > 0, (\gamma_2 + \gamma_3) < 1, \quad (17)$$

where γ_2 and γ_3 denote the share of oil and foreign consumption goods in the domestic consumption basket, respectively. Inserting eq. (17) into eq. (16) leads to the following wage-setting equation in relative changes:

$$\widehat{W} - \widehat{P} = -\gamma_1 \widehat{u} + (\gamma_2 + \gamma_3) \widehat{\theta} + \gamma_2 \widehat{P}_S^* + \gamma_4 \widehat{B}, \quad (18)$$

where γ_1 and γ_4 describe the elasticity of the wage-setting function with respect to u (in absolute values) and B , respectively.

2.3 Labor-market equilibrium

Labor-market equilibrium prevails if the real wage the firms are willing to pay is equal to the bargained real wage. Such a situation is consistent with constant inflation since neither firms nor labor unions have an incentive to change real wages by changing price or wage inflation.¹⁰ Hence, the unemployment rate which equilibrates the claims of firms and labor unions is the NAIRU. Equating eqs. (15) and (18) leads to

$$\widehat{u} = \frac{\lambda_2 + \gamma_2 + \gamma_3}{\lambda_1 + \gamma_1} \widehat{\theta} + \frac{\lambda_2 + \gamma_2}{\lambda_1 + \gamma_1} \widehat{P}_S^* + \frac{\gamma_4}{\lambda_1 + \gamma_1} \widehat{B}. \quad (19)$$

The impact of the institutional variables B on the NAIRU resembles standard closed-economy results. For instance, an enlargement of unemployment benefits ($\widehat{B} > 0$) *cet.*

¹⁰In such an equilibrium the inflation rate remains unchanged if the growth rate of money supply is constant.

par. leads to $\hat{u} > 0$. The extent of the NAIRU increase depends positively on γ_4 , i.e. the elasticity of the wage-setting function with respect to B , and negatively on λ_1 and γ_1 . The latter parameters describe the responsiveness of firms' real wage concessions and unions' real wage aspirations if unemployment changes. If λ_1 and γ_1 are low, a significant change in the NAIRU is necessary to reconcile the claims of firms and labor unions.

The difference of eq. (19) to a closed-economy analysis lies in the fact that the NAIRU in the open economy is not unique but depends on the real exchange rate θ , which (in the complete macroeconomic model) is itself an endogenous variable. At the moment only the impact of given exchange rate changes on the NAIRU can be considered. Assume, for example, that the real exchange rate increases. This leads to a rise in the NAIRU, which is stronger the higher $(\lambda_2 + \gamma_2 + \gamma_3)$ is. As noted above, λ_2 is proportional to the share of oil costs relative to the wage bill. Its impact on the change in the NAIRU is due to the fact that for firms the *real* domestic price of oil is relevant. As can be seen from eq. (14) the change in real wages the firms are willing to pay negatively depends on $\hat{P}_S - \hat{P} = \hat{P}_S^* + \hat{E} - \hat{P}$. Since $\hat{\theta} = \hat{E} - \hat{P}$, a rise in the real exchange rate implies that the real price of oil increases. As a result, at the initial unemployment rate firms are trying to lower real wages by pushing up prices. On the other hand, labor unions are trying to increase real wages by raising nominal wages, since the real price of oil and foreign consumption goods increases. The strength of the wage push depends upon the shares of oil and foreign consumption goods in the domestic consumption basket, which are captured by the parameters γ_2 and γ_3 , respectively. Since at the initial unemployment rate the real wage conceded by firms is lower than real wage aspirations of labor unions, the unemployment rate has to rise to reconcile the claims of firms and unions. Note that the impact of the real exchange rate on the NAIRU is also the higher the lower $\lambda_1 + \gamma_1$. According to eq. (19) an increase in the world price of oil causes the NAIRU to rise. The impact on the NAIRU depends on $(\lambda_2 + \gamma_2)$ and $(\lambda_1 + \gamma_1)$. As a result, the higher the share of oil costs relative to the wage bill and the higher the share of oil in the consumption basket, the stronger is the increase in the NAIRU. The rise in the NAIRU would be mitigated by a strong real wage response of firms and labor unions to changes in the unemployment rate.

2.4 Aggregate demand

Considering the demand side again the distinction of gross output and value added turns out to be crucial. Aggregate demand in terms of gross output, Q^d , comprises consumption C , investment I , government expenditure G and net exports of the final good T .¹¹ Taking into account that consumption is a positive function of real disposable income Z and investment a negative function of the real interest rate r , aggregate demand can be written as

$$Q^d = C(Z) + I(r) + G + T(Q, \theta), \quad 0 < C_Z < 1, \quad I_r < 0, \quad T_Q < 0, \quad T_\theta > 0. \quad (20)$$

The sign of the partial derivative T_θ follows from the Marshall-Lerner condition. The real disposable income Z is obtained by subtracting expenditures for imported oil from gross output¹², i.e. $Z \equiv Q - (P_S S)/P$. The variable Z is also called single deflated value added or value added in terms of the domestically produced final good. Z is a reasonable concept for measuring the real income accruing to the domestic factors of production but is not suitable for measuring the value added produced by these factors. The reason for this is that in contrast to Y the variable Z also depends on oil prices, which means that it can not be used as value added production function.¹³ Taking account of eq. (6) when writing Z in relative changes leads to

$$\hat{Z} = \hat{Q} - (1 - \sigma) \frac{\kappa \varepsilon}{1 - \kappa \varepsilon} [\hat{P}_S - \hat{P}], \quad (21)$$

where $\kappa \varepsilon$ denotes the share of imported oil in gross output (see eq. (9)). For a small open economy the interest rate equals the world interest rate, which is assumed to be constant. With eq. (21), the equilibrium condition $Q^d = Q$ and the assumption $\hat{r} = 0$, eq. (20) in relative changes can be written as

$$\hat{Q} = (\psi_1 - \psi_2) \hat{\theta} - \psi_2 \hat{P}_S^* + \psi_4 \hat{G}, \quad (22)$$

¹¹It must be stressed that in the gross output specification of demand only imports of consumption goods but not of oil are subtracted from exports to get net exports T . Hence T does *not* represent the trade balance.

¹²Note that all kind of taxes are neglected in the model.

¹³Bruno, Sachs (1985), Marston, Turnovsky (1985) and Hof (1993) also distinguish between both value added concepts.

where $\psi_1 \equiv \xi (T/Q) \eta_\theta^T > 0$, $\psi_2 \equiv \xi (1 - \sigma)(C_Z \varepsilon \kappa) > 0$ and $\psi_4 \equiv \xi (G/Q) > 0$. The parameter η_θ^T denotes the elasticity of net exports of the final good with respect to the real exchange rate. $\xi \equiv [1 - (1 - \varepsilon \kappa)C_Z - T_Q]^{-1}$ represents the Keynesian multiplier in terms of gross output for an economy which imports oil from abroad. In this expression it is taken into account that a one-percent increase in Z leads to an increase in consumption in terms of gross output by $(1 - \varepsilon \kappa)C_Z$ percent. It may come as a surprise that in spite of the valid Marshall-Lerner condition there is no guarantee that a real devaluation ($\hat{\theta} > 0$) causes aggregate demand to rise. The reason for this is that a real devaluation provokes two opposing effects: on the one hand it increases net exports and on the other hand it leads to a rise in oil prices in terms of the domestic good. The latter effect reduces real disposable income and hence consumption. Only if the impact on consumption is lower than on net exports will a devaluation lead to rising aggregate demand. Taking account of eq. (12) which describes the relationship between gross output and value added, eq. (22) can be transformed into the following value added equation:

$$\hat{Y} = (\psi_1 - (\psi_2 - \psi_3)) \hat{\theta} - (\psi_2 - \psi_3) \hat{P}_S^* + \psi_4 \hat{G}, \quad (23)$$

where $\psi_3 \equiv \varepsilon \sigma / (1 - \varepsilon) > 0$. If a real devaluation leads to a rise of aggregate demand in terms of gross output, then aggregate demand in terms of value added also increases. Empirical studies seem to imply that in the medium run a real devaluation causes aggregate demand to rise. In the following it is therefore assumed that the impact of $\hat{\theta}$ on \hat{Y} is positive. As long as σ is not too great it will also hold that $\psi_2 - \psi_3 > 0$. With the (plausible) parameter values of appendix A.2, which will later be used in simulation experiments, both assumptions hold.

3 The consequences of an adverse oil price shock

In the preceding section the model was reduced to a two-equation system describing the demand and supply side of the economy. This system is now used to scrutinize the impact of an adverse oil price shock ($\hat{P}_S^* > 0$) on the NAIRU and on the real exchange

rate. Solving eq. (19) for $\hat{\theta}$ leads to the following equation for aggregate supply

$$\hat{\theta} = \Lambda_1 \hat{u} - \Lambda_2 \hat{P}_S^* - \Lambda_3 \hat{B}, \quad \Lambda_1 > 0, \Lambda_2 > 0, \Lambda_3 > 0, \quad (24)$$

where $\Lambda_1 \equiv (\lambda_1 + \gamma_1)/\Lambda$, $\Lambda_2 \equiv (\lambda_2 + \gamma_2)/\Lambda$, $\Lambda_3 \equiv \gamma_4/\Lambda$ and $\Lambda \equiv \lambda_2 + \gamma_2 + \gamma_3$. By taking account of eqs. (7) and (13), \hat{Y} can be substituted by \hat{u} in the aggregate demand equation (23), which then can be written as

$$\hat{\theta} = -\Psi_1 \hat{u} + \Psi_2 \hat{P}_S^* - \Psi_3 \hat{G}, \quad \Psi_1 > 0, \Psi_2 > 0, \Psi_3 > 0, \quad (25)$$

where $\Psi_1 \equiv (\alpha/\beta)/\Psi$, $\Psi_2 \equiv (\psi_2 - \psi_3)/\Psi$, $\Psi_3 \equiv \psi_4/\Psi$ and $\Psi \equiv \psi_1 - (\psi_2 - \psi_3)$. Although being denoted in relative changes, eqs. (24) and (25) can be interpreted as representing the equations for the respective aggregate supply (AS) and demand (AD) curve, which are depicted in *figure 1*. It has been argued in section 2.4 that the assumptions $(\psi_2 - \psi_3) > 0$ and $(\psi_1 - (\psi_2 - \psi_3)) > 0$ are plausible. In eq. (25) and the following discussion it is therefore assumed that these conditions hold. The intersection of the aggregate demand and supply curve leads to the following solution for the relative change in the NAIRU:

$$\hat{u} = \frac{\Lambda_2 + \Psi_2}{\Lambda_1 + \Psi_1} \hat{P}_S^* + \frac{\Lambda_3}{\Lambda_1 + \Psi_1} \hat{B} - \frac{\Psi_3}{\Lambda_1 + \Psi_1} \hat{G}. \quad (26)$$

Since in this section the focus is on the impact of adverse oil price shocks, it is assumed for the moment that $\hat{B} = 0$ and $\hat{G} = 0$. *Figure 1* helps to clarify the effects of an increase in oil prices. In the initial equilibrium oil prices, NAIRU and real exchange rate are constant. In *figure 1* the aggregate demand and supply curve therefore intersect at the origin. In the case of an adverse oil price shock both curves will shift to the right implying an increase in the NAIRU of \hat{u}_1 percent. If oil prices eventually stabilize at a higher level, i.e. $\hat{P}_S^* = 0$ holds again, the AD and AS curve shift back to the initial position intersecting at $\hat{u} = 0$ and $\hat{\theta} = 0$. This implies that the NAIRU stays on a higher level as long as oil prices remain high. The increase in the NAIRU is stronger the more the aggregate demand and supply curve are shifting and the flatter the demand and supply curve are.

The solution in eq. (26) for the change in the NAIRU can be compared with well-known analyses from the literature. For instance, in the empirical analysis of Layard *et al.* [(1991), ch. 9] it is assumed that the impact of oil price shocks on the NAIRU only depends on the

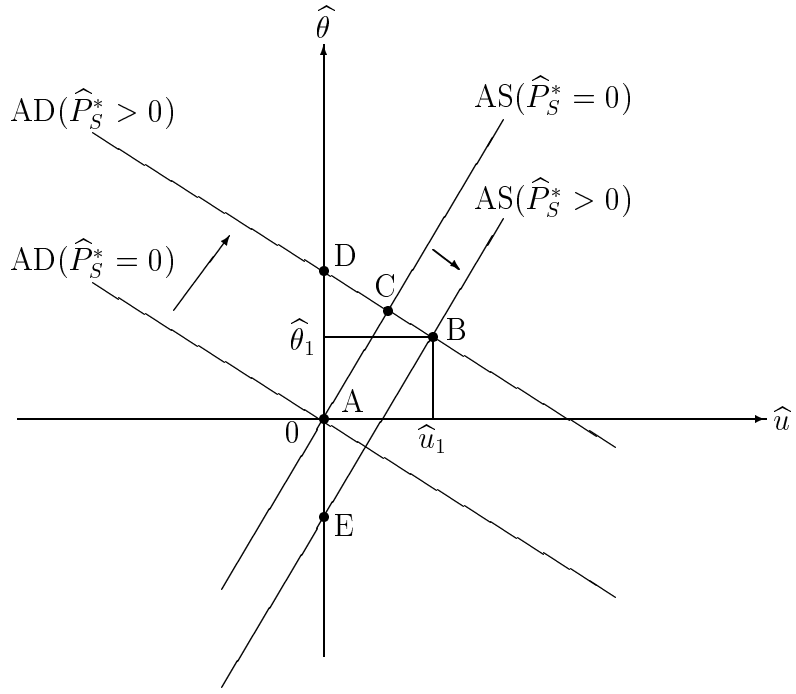


Figure 1: The relative change in the NAIRU and in the real exchange rate due to an adverse oil price shock

expression $(\lambda_1 + \gamma_1)^{-1}$, i.e. on the parameters determining the slope of the price-setting and wage-setting curve in real wage/unemployment space. Layard *et al.* (1991) interpret the expression $(\lambda_1 + \gamma_1)^{-1}$ as a measure for the extent of real wage rigidity prevailing in the economy. From eq. (26) it can be seen that also in the model presented above the increase in the NAIRU positively depends on the degree of real wage rigidity. However, it also becomes evident that the increase in the NAIRU additionally depends on other parameters, which are neglected in the analysis of Layard *et al.* (1991). Moreover, it can be seen that these parameters not only refer to the supply side, but stem from the demand side as well.

The relative change in the real exchange rate provoked by rising oil prices can be written as $\hat{\theta} = \hat{P}_S^* \Lambda_1 \Lambda_2 \Omega / (\Lambda_1 + \Psi_1)$. It follows that an adverse oil price shock leads to $\hat{\theta} \geq 0$ if and only if $\Omega \geq 0$, where Ω is defined as $\Omega \equiv (\Psi_2 / \Lambda_2) - (\Psi_1 / \Lambda_1)$. Hence a *sufficient* condition for a real depreciation is that the shift of the AD curve is greater than the shift of the AS curve and the slope of the AD curve (in absolute values) is less than the slope of the AS curve. If the expression for Ω is simplified, it can be seen that $\Omega \geq 0$

only holds if $\beta(\psi_2 - \psi_3)/\alpha \geq (\lambda_2 + \gamma_2)/(\lambda_1 + \gamma_1)$. The validity of this condition can only be examined by an empirical analysis. If the parameter values of appendix A.2 are inserted, this condition is met. On the other hand, if this condition does not hold, the real exchange rate declines. Since countries may differ with respect to these parameters, it is (at least theoretically) possible that the behavior of the real exchange rate differs, whereas the NAIRU unambiguously increases in all countries.

As well as the change in unemployment, the change in consumers' real wages is of special importance for economic policy. Due to eq. (16) it follows that in reaction to an adverse oil price shock consumers' real wages will decline. The strength of the reaction depends on parameters of the supply as well as the demand side and is given by

$$\widehat{W} - \widehat{P}_c = -\frac{\gamma_1 \beta [(\lambda_2 + \gamma_2) \psi_1 + (\psi_2 - \psi_3) \gamma_3]}{\beta (\lambda_1 + \gamma_1) (\psi_1 - (\psi_2 - \psi_3) + \alpha (\lambda_2 + \gamma_2 + \gamma_3))} \widehat{P}_S^* < 0. \quad (27)$$

4 Simulation results

For economic policy a quantitative assessment about the consequences of adverse oil price shocks is useful. To analyze the impact on the NAIRU, some simulation experiments were performed which were based on the assumption that world oil prices are doubling. The choice of parameter values is described in appendix A.2. In the simulation experiments the impact of oil price shocks on the trade balance F is also taken into account, where F is defined as $F \equiv T(Q, \theta) - (P_S S)/P$. The change in the trade balance in percent of gross output is then computed as¹⁴

$$\frac{dF}{Q} = [\eta_\theta^T (T/Q) - (1 - \sigma) \kappa \epsilon] \widehat{\theta} - [\kappa \epsilon - T_Q] \widehat{Q} - [(1 - \sigma) \kappa \epsilon] \widehat{P}_S^*. \quad (28)$$

In the first term in brackets it is taken into account that a change in the real exchange rate affects net exports of the final good and the real price of oil in terms of the domestic good. The second term in brackets reflects the fact that an increase in gross output increases the import of final goods and oil, and the final term in brackets shows the “direct” impact of an increase in world oil prices on the trade balance.

¹⁴Since trade may be balanced in the initial equilibrium, it is not possible to consider relative changes in the trade balance with respect to the initial level.

In most of the scenarios it is assumed that the initial equilibrium unemployment rate is equal to 7 percent, which can be regarded as a plausible value for the European economies. Scenario I of *table 1* serves as baseline simulation. According to this scenario a doubling of world oil prices would lead to an 20.4 percent rise in the NAIRU, which implies an increase of 1.43 *percentage points*. The real exchange rate would only rise by 0.3 percent and hence remains roughly unaffected. Of special interest also is the change in the real wage relevant to consumers. According to the baseline scenario a doubling of world oil prices would lead to a 2.5 percent decline in consumers' real wages. Furthermore, it can be seen that the trade balance would deteriorate by 0.48 percent in relation to gross output.

Table 1
Simulation results for doubling of world oil prices

Scenario	\hat{u}	Percentage-point increase in u	$\hat{\theta}$	$\widehat{W} - \widehat{P}_c$	dF/Q
I	0.204	1.43	0.003	-0.025	-0.0048
II	0.154	1.08	0.066	-0.037	-0.0044
III	0.294	2.06	0.058	-0.035	-0.0057
IV	0.603	4.22	0.148	-0.072	-0.0162
V	0.205	1.44	0.004	-0.025	-0.0048
VI	0.291	1.16	0.056	-0.035	-0.0045

Notes: The parameters for the baseline scenario (scenario I) are summarized in appendix A.2. In this scenario the percentage point increase in the NAIRU (third column) refers to an initial unemployment rate of 7 percent. The other scenarios have the same parameter values as in scenario I with the following exemptions: In scenario II the parameters λ_1 and γ_1 are doubled. In scenario III it is assumed that $\sigma = 0$ instead of $\sigma = 0.2$. In scenario IV a value $\kappa\varepsilon = 0.042$ is chosen instead of $\kappa\varepsilon = 0.0125$. In scenario V ψ_1 is reduced so that $\psi_1 - (\psi_2 - \psi_3) = 0.010$ instead of 0.042. In scenario VI an initial unemployment rate of 4 percent instead of 7 percent is chosen.

In the last section it has been argued that more flexible responses of real wages to unemployment would dampen the increase in the NAIRU. Labor-market reforms which provoke greater flexibility could therefore prove to be helpful for dampening the effects of adverse oil price shocks. In scenario II the consequences of a doubling of λ_1 and γ_1 are considered. It can be seen from *table 1* that the NAIRU increase then only amounts to 1.08 instead of 1.43 percentage points. However, greater labor market flexibility also implies greater losses in terms of consumers' real wages, which now decline by 3.7 percent. In scenario III

substitution possibilities between imported oil and value added are excluded. In this case the NAIRU would increase by 2.06 percent and consumers' real wages would decline by 3.5 percent. In scenario IV it is assumed that the share of imported oil in gross output is equal to 4.2 percent (instead of 1.25 percent in the baseline scenario). This reflects the situation during the second oil crisis at the beginning of the eighties where the share of imported oil was much higher than it is today. The simulation results imply a significantly higher increase in the NAIRU (4.22 percentage points), a significantly higher decline in consumers' real wages and a stronger deterioration of the trade balance. In this case the change in the real exchange rate is also more pronounced. In scenario V the robustness of the baseline scenario is checked by lowering the responsiveness of aggregate demand to changes in the real exchange rate. The reason is that there is some uncertainty with respect to the correct value of ψ_1 , due to mixed results in empirical studies. However, the change in the NAIRU, the real exchange rate and real wages remain nearly the same as in the baseline scenario. Finally, in scenario VI it is analyzed how the results change if the initial unemployment rate is only 4 percent (which would be a more adequate description of the U.S. situation). In this case a doubling of world oil prices leads to a lower increase in the NAIRU in percentage points (1.16 instead of 1.43). This amounts to a rise in the NAIRU of 29.1 percent instead of 20.4 percent.

5 How to react to adverse oil price shocks?

In the literature oil price shocks are often modeled as shifts of a vertical supply curve (see, for example, Layard *et al.* (1991), ch. 1). The negative impact of an adverse oil price shock on output and employment could then be counteracted by policy measures which keep the aggregate supply curve stable. In terms of the model presented above the variable B could be reduced to diminish wage pressure in terms of producers' real wages accordingly. The reduction in B might be brought about by a retrenchment of the welfare state, as for instance by cutbacks of unemployment benefits, but it could also be interpreted as representing wage policy measures aimed at curtailing wage demands of labor unions. However, *figure 1* reveals that keeping the AS curve stable would not

suffice to prevent the NAIRU from rising. The reason is that the increase in oil prices also reduces aggregate demand. With a stable AS curve therefore only the equilibrium at point C is reached, which would still imply an increase in the NAIRU.

Policy I: Stabilizing the NAIRU by supply-side policy alone: Keeping the NAIRU unchanged by means of supply-side measures requires a more pronounced reduction in variable B with a corresponding *leftward* shift of the AS curve, which would lead to point D in *figure 1*. With $\hat{u} = 0$ and $\hat{G} = 0$ it follows from eq. (26) that the necessary reduction in B amounts to

$$\hat{B} = -(\gamma_4 \Psi)^{-1} [\psi_1(\lambda_2 + \gamma_2) + \gamma_3(\psi_2 - \psi_3)] \hat{P}_S^* < 0, \quad (29)$$

where $\Psi \equiv \psi_1 - (\psi_2 - \psi_3) > 0$. Such a policy leads to a real depreciation, since

$$\hat{\theta} = \Psi^{-1} (\psi_2 - \psi_3) \hat{P}_S^* > 0. \quad (30)$$

Furthermore, it can be concluded that real wages relevant for consumers have to shrink, since

$$\hat{W} - \hat{P}_c = -\Psi^{-1} [\psi_1(\lambda_2 + \gamma_2) + \gamma_3(\psi_2 - \psi_3)] \hat{P}_S^* < 0. \quad (31)$$

Policy II: Stabilizing the NAIRU by demand management alone: Since the AS curve in the open economy is not vertical, the NAIRU could also be stabilized by a demand expansion. With reference to *figure 1*, increases in government expenditure (or tax cuts) must be sufficient to shift the AD curve to the left until point E is reached. With $\hat{u} = 0$ and $\hat{B} = 0$ it follows from eq. (26) that

$$\hat{G} = (\psi_4 \Lambda)^{-1} [\psi_1(\lambda_2 + \gamma_2) + \gamma_3(\psi_2 - \psi_3)] \hat{P}_S^* > 0, \quad \text{with } \Lambda \equiv (\lambda_2 + \gamma_2 + \gamma_3). \quad (32)$$

The demand expansion is accompanied by a real appreciation, since in this case

$$\hat{\theta} = -\Lambda^{-1} (\lambda_2 + \gamma_2) \hat{P}_S^* < 0. \quad (33)$$

Such a policy implies that consumers' real wages remain unchanged which could be seen as a clear advantage of expansionary demand policies in comparison to supply-side policies.

However, one must be aware of the disadvantages of such a policy, as for example the increase in the budget deficit. In the simulation experiments performed below it is also shown that the deterioration of the trade balance is more pronounced. It could therefore be suspected that a combination of demand and supply policy might be a reasonable alternative, which mitigates the disadvantages of either policy. Such a policy mix is discussed in the next section.

Policy III: Stabilizing the NAIRU by a policy mix of demand and supply mea-

asures: In this case government expenditures are increased ($\widehat{G} > 0$) and wage pressure is reduced ($\widehat{B} < 0$) in such a way that shifts of the aggregate demand and supply curve are prevented. In *figure 1* this means that despite the oil price shock the equilibrium is stabilized at point A . With $\widehat{u} = 0$ and $\widehat{\theta} = 0$ it follows from eq. (25') that

$$\widehat{G} = \psi_4^{-1} (\psi_2 - \psi_3) \widehat{P}_S^* > 0. \quad (34)$$

From eq. (19') one obtains

$$\widehat{B} = -\gamma_4^{-1} (\lambda_2 + \gamma_2) \widehat{P}_S^* < 0. \quad (35)$$

These policy measures are accompanied by the following change in consumers' real wages:

$$\widehat{W} - \widehat{P}_c = -(\lambda_2 + \gamma_2) \widehat{P}_S^* < 0. \quad (36)$$

Comparison of policy responses to oil price shock: To show the consequences of the three policy measures discussed above, simulation experiments based on scenario I of *table 1* are performed. The results are depicted in *table 2*.

If world oil prices doubled and the NAIRU was stabilized by supply-side policy alone (policy I), the real exchange rate would depreciate by 26 percent and the trade balance would (only) deteriorate by 0.33 percent in relation to gross output. However, the disadvantage of such a policy is the pronounced decline in consumers' real wages (by 17.4 percent). In order to stabilize the NAIRU by a demand expansion (policy II), it would be necessary to increase government expenditure by approximately 5 percent (if the parameter values of the baseline scenario are inserted into eq. (32)). This would imply a significant increase

Table 2

Simulation results if NAIRU is stabilized by different policy measures

Variable	Policy I	Policy II	Policy III
$\hat{\theta}$	0.260	-0.123	0
$\widehat{W} - \widehat{P}_c$	-0.174	0	-0.056
dF/Q	-0.0033	-0.0114	-0.0088

Notes: The results are generated with the parameters of the baseline scenario (see scenario I in table 1 and appendix A.2). A doubling of world oil prices is considered. Policy I: Supply-side policy. Policy II: Expansionary demand policy. Policy III: Demand and supply policy to stabilize NAIRU and real exchange rate.

in the budget deficit. As can be seen in table 2, a further disadvantage of such a policy is the strong deterioration of the trade balance (by 1.14 percent in relation to gross output instead of 0.33 percent in the case of policy I). However, the advantage of such a policy lies in the fact that real consumption wages would remain unchanged. If the NAIRU and the real exchange rate are simultaneously stabilized by a policy mix of demand and supply-side measures (policy III), consumers' real wages would only have to decline by 5.6 percent, which is substantially lower than in the case of policy I. Inserting the parameter values of the baseline scenario in eq. (34), it can be seen that government expenditures would only have to rise by 3 percent. Hence, the increase in the budget deficit would be smaller than in the case of policy II. Also the deterioration of the trade balance would be less pronounced. It may be the case that a decline of 5.6 percent in consumers' real wages and an increase in government expenditures by 3 percent is politically not feasible. This means that economic policy may be able to dampen the effects of oil price rises but is not able to completely stabilize equilibrium unemployment. In any case it follows from the simulation experiments that a combination of demand and supply policies may be a more reasonable response to adverse oil price shocks than solely relying on supply-side or demand-side measures.¹⁵

¹⁵In table 2 only the results for the baseline scenario are presented. However, the conclusion that policy III may be the most preferable policy response is not affected by this particular choice.

6 Summary and conclusions

In this paper the impact of oil price shocks on the NAIRU has been analyzed within a model of a small open economy which is characterized by imperfect competition on goods and labor markets. It was argued that the impact on the NAIRU is not solely a function of parameters of the supply side, as is often suggested in the literature, but also depends on parameters of the demand side. This is due to the fact that the real exchange rate additionally enters the labor demand and wage-setting equation, which implies that the supply-side relationships no longer suffice to determine the real variables of the model. The comparative-static analysis was accompanied by simulation experiments, which allowed a quantitative assessment of the implications of oil price shocks. Taking parameter values which are considered to be representative for European economies in the nineties and assuming an initial equilibrium unemployment rate of 7 percent, a doubling of world oil prices would increase the NAIRU by around 1.4 percentage points. This increase in the NAIRU could be mitigated by enhancing real wage flexibility in the labor market and by promoting technological progress which leads to a higher substitution elasticity between imported oil and value added as well as to a lower share of oil in the production of gross output and in the consumption bundle. It was also discussed theoretically and by simulation experiments how economic policy could stabilize the NAIRU by supply-side or demand-side measures. It has been argued that the most recommendable policy response to oil price shocks is a policy mix comprising both supply side measures which reduce wage pressure and expansionary demand policies.

Appendix

A.1 Definition of symbols

Table A1
Definition of main variables and parameters

Symbol	Meaning
Q	Gross output
S	Oil input in production
Y	Value added
Z	Real disposable income
N	Employment
u	Unemployment rate
T	Net exports of the final good
F	Trade balance
P	Price of domestic goods
E	Nominal exchange rate
P_S	Price of oil in domestic currency
P_S^*	World price of oil
P^*	Price index of imported final goods
P_c	Consumer price index
θ	Real exchange rate
W	Nominal wage rate
B	Institutional variables influencing the wage-setting process
G	Government expenditure
$\kappa\varepsilon$	Share of oil in gross output
λ_1	Elasticity of real wage conceded by firms with respect to u
γ_1	Elasticity of bargained real wage with respect to u
λ_2	Elasticity of real wage conceded by firms with respect to $(P_S^*E)/P$
γ_2	Share of oil in domestic consumption bundle
γ_3	Share of imported final goods in consumption bundle
σ	Elasticity of substitution between imported oil and value added
κ	Degree of competition in the goods market
α	Elasticity of Y with respect to N
$\psi_2 - \psi_3$	Elasticity of demand (in terms of value added) with respect to P_S^*
$\psi_1 - (\psi_2 - \psi_3)$	Elasticity of demand with respect to θ
ψ_4	Elasticity of demand with respect to government expenditures
β	Parameter for transforming relative changes in u in relative changes in N
Λ_1	Slope of AS curve
Λ_2	Shift of AS curve due to changes in \widehat{P}_S^*
Λ_3	Shift of AS curve due to changes in \widehat{B}
Ψ_1	Slope of AD curve
Ψ_2	Shift of AD curve due to changes in \widehat{P}_S^*
Ψ_3	Shift of AD curve due to changes in \widehat{G}

Note: A hat over a variable denotes relative changes of that variable.

A.2 Parameter values for simulation experiments

Table A2

Parameter values for baseline simulation

Assumed values		Derived values
$\kappa\varepsilon = 0.0125$	$\kappa = 0.8$	$\varepsilon = 0.01563$
$\gamma_2 = 0.04$	$\gamma_3 = 0.4$	$\lambda_2 = 0.01587$
$\lambda_1 = 0.16$	$\gamma_1 = 0.12$	$\psi_1 = 0.05632$
$\sigma = 0.2$	$\alpha = 0.7$	$\psi_2 = 0.01404$
$u = 0.07$	$C_Z = 0.8$	$\psi_3 = 0.00317$
$T_Q = 0.36$	$\eta_\theta^T(T/Q) = 0.03$	$\psi_4 = 0.35088$
$G/Q = 0.2$		$\beta = 13.28571$

Notes: The parameters in the first two columns are derived from German (or sometimes international) data and some empirical studies. The parameters in the right-hand column can be derived from the parameters in the first two columns. According to Sachverständigenrat [(2000), p. 103] in the year 2000 the share of imported oil (with respect to GNP) in Germany was equal to 1.25 percent (whereas in 1973 and 1981 the respective figures were 3 and 4.2 percent). According to Greene *et al.* (1998) the net cost of oil relative to GNP was about 1.8 percent in 1996 in the USA. In IWH (2000) for the European economies as a whole a value of 0.9 percent in 1999 and 1.6 percent in 2000 for the share of oil in GNP is reported. In the (baseline) simulation the value $\kappa\varepsilon = 0.0125$ was taken. It is assumed that $\kappa = 0.8$, which means that competition in the goods market is rather close to perfect competition (in the latter case κ would be equal to 1). For households the share of oil in the consumption bundle in the nineties in Germany was equal to around 4 percent (Statistisches Bundesamt (1999)). It is assumed that the share of imported consumer goods is 40 percent, which is only slightly higher than the actual value for Germany. In Layard *et al.* (1991), ch. 9, appendix A2, for some countries wage equations with $(\log u)$ as dependent variable are estimated. From these estimates follows a long-run elasticity (for γ_1) of 0.13 for the Netherlands and 0.04 for Germany (from 1956 to 1985). It seems plausible that in the nineties also for Germany the value for γ_1 is higher, hence it is assumed that $\gamma_1 = 0.12$. For λ_1 a rather similar value was taken. Clostermann (1996) estimates an import elasticity with respect to income of 1.92 for Germany (from 1975 to 1995). If this is multiplied with the mean import share in GNP for that period, one obtains $T_Q = 0.36$. From empirical studies no clear picture emerges with respect to the numerator of ψ_1 , which is $\eta_\theta^T(T/Q)$. In the baseline simulation the value is chosen in such a way that for $\psi_1 - (\psi_2 - \psi_3)$ a value of 4.2 percent is obtained. The value is slightly higher than the estimate reported in Clostermann (1996). This may be justified by the higher trade exposure of industrialized economies in the nineties. To scrutinize that the results do not depend on this choice, in the paper it is also documented (see scenario V) that the results remain nearly unchanged if a lower value of ψ_1 is chosen leading to $\psi_1 - (\psi_2 - \psi_3) = 0.01$. This is the lower bound of Closterman's (1996) estimates. The value $G/Q = 0.2$ roughly corresponds to the share of government expenditure in GNP in Germany in the nineties.

Literature

- Arrow, K.J., 1975, The Measurement of Real Value Added in: K.J. Arrow (ed.), *Collected Papers of Kenneth J. Arrow*, Vol. 5, Production and Capital, 456–475, Belknap Press of Harvard University Press, Cambridge, Mass. and London.
- Beissinger, T., Möller, J., 2000, Unemployment: Theoretical Explanations, in: H. Wagner (ed.), *Globalization and Unemployment*, 89–133, Springer, Berlin and New York.
- Blanchard, O.J., Kiyotaki, N., 1987, Monopolistic Competition and the Effects of Aggregate Demand, *American Economic Review* 77(4), 647–666.
- Bruno, M., 1984, Raw Materials, Profits, and the Productivity Slowdown, *Quarterly Journal of Economics* 99(1), 1–29.
- Bruno, M., Sachs, J.D., 1985, *Economics of Worldwide Stagflation*, Harvard University Press, Cambridge (Mass.).
- Carlin, W., Soskice, D., 1990, *Macroeconomics and the Wage Bargain*, Oxford University Press, Oxford.
- Carruth, A.A., Hooker, M.A., Oswald, A.J., 1998, Unemployment Equilibria and Input Prices: Theory and Evidence from the United States, *Review of Economics and Statistics* 80(4), 621–628.
- Christini, A., 1999, *Unemployment and Primary Commodity Prices.*, Macmillan, Houndmills and London.
- Clostermann, Jörg, 1996, Der Einfluß des Wechselkurses auf die deutsche Handelsbilanz, Diskussionspapier 7/96 der Volkswirtschaftlichen Forschungsgruppe der Deutschen Bundesbank.
- Greene, D.L., Jones, D.W., Leiby, P.N., 1998, The outlook for US oil dependence, *Energy Policy* 26(1), 55–69.
- Hamilton, J.D., 2000, What Is An Oil Shock?, NBER Working Paper 7755, June.
- Harrigan, F., McGregor, P.G., Swales, K., Yin, Y.P., 1993, Openness, Imperfect Competition and the NAIRU, *Journal of Economic Studies* 20(1/2), 52–72.
- Hof, F.X., 1993, Foreign Supply Shocks, Wage Indexation and Optimal Monetary Policy, in: H. Frisch and A. Woergoetter (eds.), *Open-Economy Macroeconomics*, 70–91, St. Martin's Press, New York.
- IWH, 2000, Die Lage der Weltwirtschaft und der deutschen Wirtschaft im Herbst 2000 [The State of the World Economy and the German Economy in Autumn 2000], *Wirtschaft im Wandel* 14, Institut für Wirtschaftsforschung, Halle.
- Layard, R., Nickell, S., Jackman, R., 1991, *Unemployment*, Oxford University Press, Oxford.
- Marston, R.C., Turnovsky, S.J., 1985, Imported Materials Prices, Wage Policy, and Macro-economic Stabilization, *Canadian Journal of Economics* 18(2), 273–284.
- Matthies, K., 2000, Tight Supply Keeps Oil Prices Soaring, *Intereconomics*, Hamburg Institute of International Economics (HWWA), September/October, 253–256.
- Sachverständigenrat, 2000, Jahresgutachten des Sachverständigenrats zur Begutachtung der gesamtwirtschaftlichen Entwicklung 2000/01 [Annual report 2000/01 of the German Council of Economic Experts], Stuttgart: Metzler-Porschel.
- Statistisches Bundesamt, 1999, Statistisches Jahrbuch für die Bundesrepublik Deutschland [Statistical Yearbook 1999 for the Federal Republic of Germany], Wiesbaden.