

# INTERACTION BETWEEN SUPPLY AND DEMAND SHOCKS IN PRODUCTION AND EMPLOYMENT

by F.A.G. den Butter and S.J. Koopman\*

## Summary

A major aim of recent empirical modelling of the business cycle is to identify the relative importance of aggregate supply and demand shocks. Supply or technology shocks are associated with permanent (structural) effects on economic activity whereas demand shocks are related to temporary (cyclical) effects. Most studies in this vein use multivariate VAR-models or the common trends-cointegration approach in order to disentangle supply and demand shocks. As an alternative, this paper uses the methodology of unobserved (or structural) components time series models as set out in Harvey (1989) for identification of technology and demand shocks in a two equation system of labour productivity and industrial output. The novelty is the introduction of correlation between the two types of shocks such that the mutual dependency of these shocks can be estimated explicitly. This is because technology shocks will have cyclical (temporary) effects, and demand shocks will have structural (permanent) effects, which are not fully described by the interaction of the endogenous variables in the model. The estimation procedure is set out in Koopman *et al.* (1995). The data is quarterly time series of labour productivity and industrial output for Germany, The Netherlands, the United Kingdom and the United States. Our results show that the covariance of the dynamics of supply and demand shocks appears to be important in these countries. It indicates a good coordination is needed between structural and cyclical policies.

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## 1. Introduction

A major aim of modern business cycle theory is to determine the sources and propagation mechanisms of aggregate demand and supply (or technology) shocks. Following Kydland and Prescott (1982, 1996) the core question of so called Real Business Cycle (RBC) models has been the measurement of the quantitative nature of fluctuations induced by technology shocks. Kydland and Prescott found that about 70% of the business cycle fluctuations in the United States can be attributed to technology shocks. This dominance of technology shocks over other shocks as source for the business cycle has been challenged by a number of other studies as some predictions from standard RBC models are hard to reconcile with observed facts (see Danthine and Donaldson, 1993, for a survey). For instance, Galí (1996) shows amongst others that for a majority of the G7 countries technology shocks appear to induce a negative comovement between

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productivity and employment, counterbalanced by a positive comovement generated by demand shocks.

In the same vein our paper focusses on the propagation mechanisms of supply (technology) and demand shocks to output, employment and labour productivity. However, we do not restrict our empirical analysis to mechanisms described by specific theoretical models, be it the stochastic versions of neoclassical growth models of Kydland, Prescott and others, or Galí's model with monopolistic competition, sticky prices and variable effort, but consider the interaction between cyclical and structural developments in a broad perspective. This refutation of the classical dichotomy between the theory of economic growth and business cycle theory is, by the way, in line with an old tradition of empirical modelling in The Netherlands (see e.g. Van den Beld, 1967, Schouten, 1967, but also Smithies, 1957).

The relationship between technology, employment, macroeconomic activity and productivity also plays a prominent role in models of endogenous technology. These models show that the steering mechanisms of this relationship may be quite complicated. A technology shock which enhances technical progress, will most certainly, due to spill-overs from technical capital to human capital, have a labour saving character and raise labour productivity. Such technology shock is commonly assumed to be persistent and can be associated with structural change. Yet, especially in the case of product innovation it may also induce a rise in demand. Higher demand, either induced by technical progress or by an autonomous shock, will raise labour demand. However, when total demand is given, an increase in labour productivity will lead to a decrease in employment so that the net effect of a technology shock on labour demand is ambiguous. Model simulations for The Netherlands by Den Butter and Wollmer (1996) and Den Butter and Van Zijp (1995) suggest that a technological impulse enhances economic activity but causes a slight fall of labour demand when labour productivity growth is completely recompensed by wage demands.

There are some mechanism at work which may mitigate this direct effect. Firstly, the demand shock may raise technical progress, through 'learning by doing' and additional investments in R&D. This again raises labour productivity. Moreover, a positive demand shock may have, through dishoarding of labour, an immediate positive effect on labour productivity (see e.g. Burnside, Eichenbaum and Rebelo, 1993).

The propagation of technology and demand shocks is also at the core of another branch of recent business cycle theory, namely the flow approach to labour markets which focusses on the processes of job creation and job destruction, and hence on structural change (see Davis, Haltiwanger and Schuh, 1996, for data construction and an analysis of the cyclicity of these processes). Here technology is driven by idiosyncratic shocks at the level of the firm, which, in the aggregate, give rise to specific interactions between structural developments and the business cycle (see e.g. Mortensen and Pissarides, 1994, Caballero and Hammour, 1994, 1996).

The various different theories referred to above all imply that cyclical shocks may be connected with structural technology shocks through other mechanisms than those accounted for in simple

empirical time series models, which, in the vein of RBC models, try to measure the effects of temporary demand and permanent supply shocks. Modelling of this interaction between supply and demand shocks is essential when simple macroeconomic time series models are used to unravel the sources of fluctuations and trends in labour demand and labour productivity growth. Most empirical studies on RBC modelling use multivariate VAR-models or the common trends-cointegration approach in order to disentangle supply and demand shocks (see e.g. Blanchard and Quah, 1989, King *et al.*, 1991, Mellander *et al.*, 1992, Christiano and Eichenbaum, 1992, Fisher Ingram *et al.*, 1994, Karras, 1994, Bergman, 1996). This methodology requires, as identifying restriction, that the two disturbances which are associated with demand and supply shocks, are uncorrelated at all leads and lags (Blanchard and Quah, 1989, see also Gamber and Joutz, 1993 and Galí, 1996). In other words, the identifying restrictions associate supply shocks with permanent effects (on output) and demand shocks with temporary effects. Our present paper pursues a different route by adopting the methodology of structural time series, see Harvey (1989), Harvey and Koopman (1996), for identification of technology and demand shocks. It allows us to estimate the mutual dependency of these two types of shocks explicitly, so that we allow the technology shocks to have temporary side effects and the demand shocks to have permanent side effects.

We estimate a small, two equation model distinguishing between persistent technology shocks ( $\eta$ ) and demand shocks ( $\kappa^{(1)}, \kappa^{(2)}$ ) for various OECD countries using data on industrial output ( $y$ ) and industrial employment ( $L$ ). Technology shocks can be associated with technical change or change of preferences. Demand shocks may represent a change of the business cycle. As indicated above, the economic theory behind the model can be found either in RBC modelling, in theory of economic growth with endogenous technology or in the business cycle theory of job destruction and creation. Therefore, we do not elaborate on a specific theoretical model which underlies the mutual dependency between technology and demand shocks of our empirical specification.

The remainder of the paper is organised as follows. The following section specifies the model and sketches the estimation method. Section 3 presents the estimation results and section 4 discusses the propagation of the supply and demand shocks through the economy by calculating the impulse responses of simulated standardised shocks. Section 5 concludes.

## 2. The model

The technology shock ( $\eta$ ) influences labour productivity  $k$  (in logs):

$$k_t = \mu_t^{(k)} + \epsilon_t$$

where

$$\mu_t^{(k)} = \mu_{t-1}^{(k)} + \beta^{(k)} + \eta_t$$

so that

$$\Delta\mu_t^{(k)} = \beta^{(k)} + \eta_t$$

where  $\mu_t^{(k)}$  is the trend of labour productivity which consists of a deterministic slope component  $\beta^{(k)}$ , and of the technology shock  $\eta_t$ .  $\epsilon$  is a random disturbance to labour productivity (incidental component) which is unrelated to other variables of the model. We note that by definition  $\eta_t$  is imposed to have a permanent effect on labour productivity. This is our 'identifying' restriction. In this respect our approach of structural modelling of the supply (technology) and demand shocks essentially differs from the approach of the VAR and common trend models which require testing of the persistence of shocks, and of the common roots of trends. Put another way, our structural modelling approach allows us to start of with the 'genuine' or 'pure' supply and demand shocks in the specification of the model as we do not need the identifying restriction that these shocks are uncorrelated. On the contrary, the possible correlation between these two shocks is a main feature of our model and a necessary condition to mimic economic reality<sup>1</sup>.

For demand, represented by industrial output  $y$  (in logs) we have

$$y_t = \mu_t^{(y)} + \psi_t$$

where

$$\mu_t^{(y)} = \mu_{t-1}^{(y)} + \beta^{(y)} + \theta\eta_t$$

Here we have  $\mu_t^{(y)}$  as the trend of industrial output where  $\beta^{(y)}$  constitutes the deterministic component  $\beta^{(k)}$ , and where the technology shock  $\eta_t$  has a direct influence on this trend with parameter  $\theta$ .  $\psi_t$  is the cyclical component which is supposed to have a temporary effect on industrial production only. This cyclical component is generated by second order difference equations which transform the demand shocks  $\kappa_t^{(1)}$  and  $\kappa_t^{(2)}$  to a cyclical pattern

$$\begin{bmatrix} \psi_t^{(1)} \\ \psi_t^{(2)} \end{bmatrix} = \rho \begin{bmatrix} \cos \lambda & \sin \lambda \\ -\sin \lambda & \cos \lambda \end{bmatrix} \begin{bmatrix} \psi_{t-1}^{(1)} \\ \psi_{t-1}^{(2)} \end{bmatrix} + \begin{bmatrix} \kappa_t^{(1)} \\ \kappa_t^{(2)} \end{bmatrix},$$

where  $\psi_t = \psi_t^{(1)}$ ,  $0 < \rho < 1$  and  $2\pi/\lambda$  is the length of the cyclical period.

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<sup>1</sup> Blanchard and Quah (1989, p. 659) consider the assumption that the two disturbances are uncorrelated not to be a restriction to the specification of their model. It is true that in their model this orthogonality assumption does not eliminate the possibility that supply shocks directly affect demand. However, in our structural model it is essential to allow these two types of shocks to be correlated because we do not only assume - in the vein of real business cycle models - that supply shocks affect demand, but also that demand shocks may affect technical progress.

In order to account for labour hoarding, we further assume that actual labour demand,  $L$ , (in logs) is a distributed lag of desired labour demand,  $L^*$ :

$$L = \Xi(B) L^*,$$

where

$$L^* = y - k$$

In the estimation procedure we make the more specific assumption that there is partial adjustment of actual labour demand to desired labour demand:

$$L = \xi L_{-1} + (1-\xi) L^*$$

The value of this parameter  $\xi$  is not part of the estimation procedure but is a priori set to a value of 0.5 in the European countries of our study and to a value of 0.3 in the United States. Hence we do not empirically investigate the sensitivity of technology shocks to labour hoarding as Burnside, Eichenbaum and Rebelo (1993) do.

The random shocks introduced in our model are assumed to be normally distributed with mean 0 and variance  $\sigma^2$ :

$$\begin{aligned} \epsilon_t &\sim N(0, \sigma_\epsilon^2); & \eta_t &\sim N(0, \sigma_\eta^2); \\ \kappa_t^{(1)} &\sim N(0, \sigma_\kappa^2); & \kappa_t^{(2)} &\sim N(0, \sigma_\kappa^2); \end{aligned}$$

We note that the demand shocks  $\kappa_t^{(1)}$  and  $\kappa_t^{(2)}$  are assumed to stem from the same distribution with variance  $\sigma_\kappa^2$ .

The major innovation of our model is, as mentioned before, that the structural time series formulation of our model enables us to consider the mutual influence of technology shocks and demand shocks in a direct manner. This implies that we allow the correlation between  $\eta$  and  $\kappa$  to differ from zero:

$$\text{corr}(\eta_t, \kappa_t^{(1)}) = \phi_1; \quad \text{corr}(\eta_t, \kappa_t^{(2)}) = \phi_2$$

This concludes the specification of our model. The above correlation implicitly assumes that both the technology shocks  $\eta$  and the demand shocks  $\kappa$  consist of an autonomous part and of an induced part. The autonomous parts of these shocks can be considered the 'genuine' technology and demand shocks.

The above correlation between the supply and demand shocks implies a dynamic interaction between the supply shock  $\eta_t$  and the cycle component  $\psi_t$ . This becomes obvious as we write down the ARMA(2,1) representation of the cycle component, that is (see Harvey, 1989)

$$\psi_t = 2 \rho \cos(\lambda) \psi_{t-1} - \rho^2 \psi_{t-2} + \kappa_t^{(1)} - \rho \cos(\lambda) \kappa_{t-1}^{(1)} + \rho \sin(\lambda) \kappa_{t-1}^{(2)}$$

The disturbances  $\kappa_t^{(1)}$  and  $\kappa_t^{(2)}$  are contemporaneously correlated with the disturbance  $\eta_t$  such that the cross-correlations between  $\psi_t$  and  $\eta_t$  can be derived straightforwardly. Figure 1, which depicts these cross-correlations for our estimates illustrates that the cross-correlogram is to show some damped sine wave.

The above model can be put into state space form as follows

$$\begin{bmatrix} k_t \\ y_t \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 1 & 0 \end{bmatrix} \alpha_t + \begin{bmatrix} 1 \\ 0 \end{bmatrix} \epsilon_t,$$

$$\alpha_t = \begin{bmatrix} 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & \rho \cos \lambda & \rho \sin \lambda \\ 0 & 0 & 0 & 0 & -\rho \sin \lambda & \rho \cos \lambda \end{bmatrix} \alpha_{t-1} + u_t,$$

$$\alpha_t = \begin{bmatrix} \mu_t^{(k)} \\ \mu_t^{(y)} \\ \beta_t^{(k)} \\ \beta_t^{(y)} \\ \psi_t^{(1)} \\ \psi_t^{(2)} \end{bmatrix}$$

It should be noted that the cycle specification reduces to an AR(1) model when  $\lambda$  is estimated to be zero (as  $\lambda \rightarrow 0$ :  $\cos \lambda \rightarrow 1$  and  $\sin \lambda \rightarrow 0$ ).

The covariance structure is

$$u_t = N \left( 0, \begin{bmatrix} \sigma_\eta^2 & \theta \sigma_\eta^2 & 0 & 0 & \phi_1 \sigma_\eta \sigma_\kappa & \phi_2 \sigma_\eta \sigma_\kappa \\ \theta \sigma_\eta^2 & \theta^2 \sigma_\eta^2 & 0 & 0 & \phi_1 \theta \sigma_\eta \sigma_\kappa & \phi_2 \theta \sigma_\eta \sigma_\kappa \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ \phi_1 \sigma_\eta \sigma_\kappa & \phi_1 \theta \sigma_\eta \sigma_\kappa & 0 & 0 & \sigma_\kappa^2 & 0 \\ \phi_2 \sigma_\eta \sigma_\kappa & \phi_2 \theta \sigma_\eta \sigma_\kappa & 0 & 0 & 0 & \sigma_\kappa^2 \end{bmatrix} \right)$$

We recapitulate that our model has the following parameter values to be estimated:

- the variance of random shocks to labour productivity,  $\sigma_\epsilon$ , which is in some cases estimated to be equal to zero
- the variance of technology/ supply shocks which have a permanent effect on labour productivity,  $\sigma_\eta$
- the variance of the demand shocks,  $\sigma_\kappa$ , which generate temporary, cyclical fluctuations
- the deterministic trends of labour productivity and industrial output,  $\beta^{(k)}$  and  $\beta^{(y)}$
- the characteristics of the cyclical component,  $\rho$  and  $\lambda$ , where  $2\pi/\lambda$  is the period of the cycle (in quarters)
- the relative size of the direct effect of the technology/supply shock on industrial production,  $\theta$
- the correlation between the technology/supply shocks and the demand shocks,  $\phi_1$  and  $\phi_2$

The estimation of the parameters of the model can be all carried within a state space framework. The Kalman filter is used to calculate the likelihood function. The maximum of the likelihood is found by applying a Newton optimization method. This method of estimation in the time domain uses the smoothing algorithm for the calculation of the score vector developed by Koopman and Shephard (1992). The estimation procedure is set out in Koopman *et al.* (1995).

### 3. Estimation results

The model is estimated using quarterly data on labour productivity and industrial output for Germany, The Netherlands, the United Kingdom and the United States. For data sources and for the reference period used in the estimations we refer to Appendix 1. In most cases our reference period is 1970-1994 so that we avail of 100 observations.

Table 1 gives the estimates and corresponding standard errors for the major parameters of the model. For all countries, with the exception of The Netherlands, the estimates of the variance of the random shock ( $\epsilon$ ) appear to be (approximately) equal to zero. It implies that the supply and demand shocks adequately account for all of the stochastics of the time series under consideration and that we do not need to model the additional random shocks which have no economic interpretation.

We find that, apart from the random shocks, the vast majority of the parameter estimates of our model differ significantly from zero. No big differences appear between the countries considered by us with respect to the parameter estimates of the standard errors of both the supply and the demand shocks ( $\sigma_\eta$  and  $\sigma_\kappa$ ). These parameter estimates indicate that for all countries the variance of the demand shock is somewhat smaller than the variance of the supply shock. The rather low value for the variance of the demand shocks in The Netherlands is remarkable in this case.



The coefficients for the estimates of the deterministic quarterly growth rates of labour productivity,  $\beta^{(k)}$ , and of industrial production,  $\beta^{(y)}$ , show some remarkable differences. In all countries the trend of labour productivity growth is higher than the growth trend of industrial production. This implies a declining trend in employment in industry in those countries. The difference is especially substantial in the United Kingdom, and, to a lesser extent, in Germany. However, an estimation exercise not reported here for Germany showed that the values of the other parameter estimates do not change very much when the two coefficients of the growth rates,  $\beta^{(k)}$  and  $\beta^{(y)}$ , are set equal to each other in the estimation procedure. Furthermore it is noticeable that the trend of growth of labour productivity and industrial production has, according to these estimates, been lowest in the United States. We emphasise that the shocks, which are subject of the impulse-response analysis of this paper, are superimposed upon these deterministic trends. The effects of shocks on production, productivity and consequently employment measured in our analysis may, therefore, differ from the trend development over the reference period.

The estimated value of the parameter  $\rho$  is close to unity for all countries. A major difference in this respect is that the estimated parameter value differs significantly from unity for the United States and not for the other countries. The estimated length of the cycle is somewhat longer than eight years for the United States and Germany, whereas it is rather high for The Netherlands and especially the United Kingdom. We note that the standard errors of these estimates are much higher for The Netherlands and the United Kingdom than for Germany and the United States. It suggests that the cyclical pattern is much more stable in the latter countries.

According to the estimates for parameter  $\theta$  the relative size of the spill-over from the technology shock to the demand shock appears to be almost two times as high for Germany as for the United States and The Netherlands, with the United Kingdom almost in a middle position.

**Table 1. Parameter estimates** (standard errors between parentheses)

Parameters	Germany	Netherl.	United Kingdom	United States
$\sigma_\epsilon$	0.0 (0.0)	0.003 (0.004) (0.0)	0.0 (0.0)	0.0
$\sigma_\eta$	0.0145 (0.0070)	0.0141 (0.0092)	0.0148 (0.0106)	0.0182 (0.0051)
$\sigma_\kappa$	0.0097 (0.0031)	0.0043 (0.0035)	0.0090 (0.0061)	0.0125 (0.0037)
$\beta^{(k)}$	0.0072 (0.0014)	0.0055 (0.0015)	0.0090 (0.0016)	0.0040 (0.0017)
$\beta^{(y)}$	0.0054 (0.0018)	0.0053 (0.0010)	0.0037 (0.0019)	0.0034 (0.0011)
$\rho$	0.966 (0.058)	0.981 (0.012) (0.044)	0.971 (0.022)	0.958
$2\pi/\lambda^*)$	8.8 (0.39)	12.4 (4.12)	14.0 (2.11)	8.6 (0.16)
$\theta$	1.251 (0.43)	0.672 (0.41)	1.078 (0.52)	0.652 (0.21)
$\phi_1$	-0.524 (0.34)	0.199 (0.063) (0.25)	-0.319 (0.15)	0.342
$\phi_2$	0.561 (0.31)	0.137 (0.153) (0.45)	0.685 (0.28)	0.823

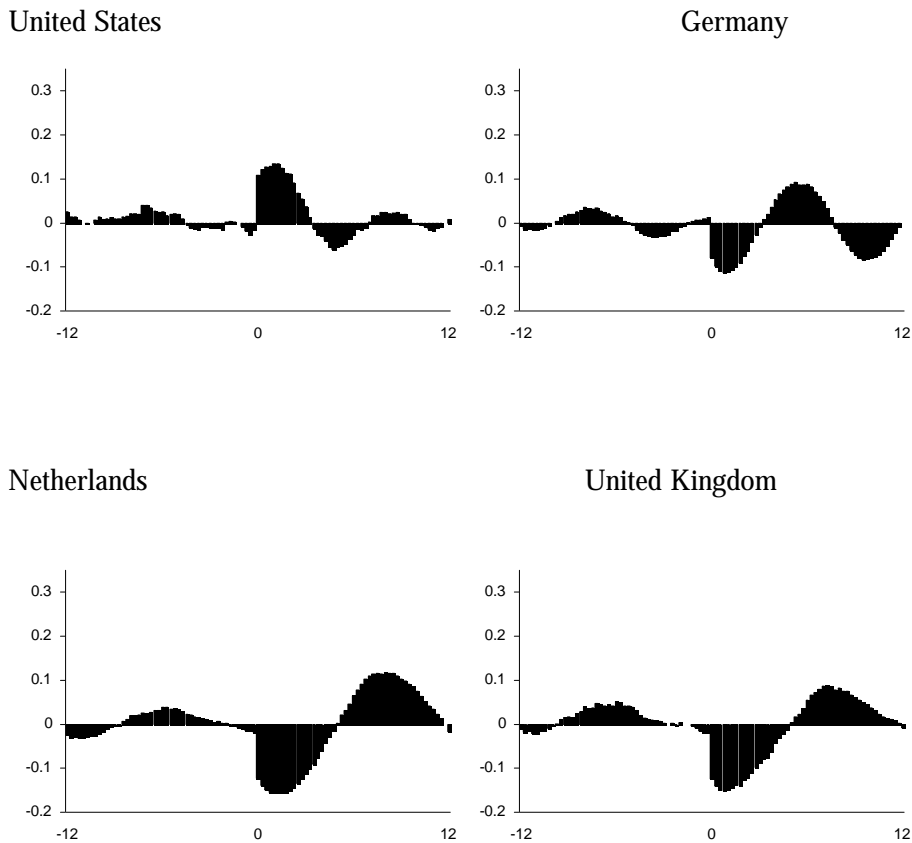
\*) in years

A major difference in estimation is found for the value of  $\phi_1$  which represents the correlation between the technology shock and the demand shock. This parameter appears to have negative values for Germany and the United Kingdom, and positive values for The Netherlands and the United States. The majority of these parameter estimates is significant. As we will see, this divergence in the estimates of  $\phi_1$ , and hence in the interaction between supply and demand shocks, gives rise to considerable differences in the reaction to supply and demand shocks in the

countries considered here. Finally table 1 shows that the estimate of  $\phi_2$ , which also relates to the correlation between supply and demand shocks, is positive in all countries for which estimates could be obtained. Here the parameter estimate is relatively high for the United States and remarkably low for The Netherlands.

**Figure 1. Dynamics of correlation between cyclical component and technology shocks**  
(lags and leads in years)

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We note that for the interpretation of our estimation results the correlation between the cyclical component  $\psi_t$  and the supply shock  $\eta_t$  is of more relevance than the correlation coefficients between the combined demand shocks  $\kappa_t^{(1)}$  and  $\kappa_t^{(2)}$ , and the supply shock. Hence, the individual estimates of  $\phi_1$  and  $\phi_2$  are less relevant in this respect than the dynamic cross correlations between  $\psi_t$  and  $\eta_t$ , which are a function of the contemporaneous correlations  $\phi_1$  and  $\phi_2$ . The dynamics of this cross correlation between the cyclical component and the technology shocks are depicted in figure 1. The similarity in the pattern of cross correlations for most countries is that the size (in absolute value) of this correlation is much higher for positive lags than for negative lags. This means that the influence of a technology shock on the cyclical component ( $\eta_t \rightarrow$

$\psi_{t+i}$ ) is larger than the propagation of cyclical movements to structural change ( $\psi_t \rightarrow \eta_{t+i}$ ). However, a striking difference in the pattern of correlations shows up between the United States on the one hand, and Germany, The Netherlands and the United Kingdom on the other hand. The contemporaneous cross correlation and the first correlations where technology shocks lead the demand shocks, are positive for the United States, whereas they are negative for the European countries of our study. A second difference is that the dampening of the effects appears to be much larger for the United States than for Germany, The Netherlands and the United Kingdom.

#### 4. Impulse response effects

Table 2 illustrates how the differences in parameter estimates and in the dynamics of the cross correlations between the cyclical component and technology shocks translate to the impulse response effects of a simulated supply shock. The table shows that in the short run such supply shock has a negative impact on the cyclical component in Germany, The Netherlands and the United Kingdom, whereas the short-term impact on the cyclical component in the United States appears to be positive. In the medium run the cyclical response effects of a supply shock become positive in Germany, The Netherlands and the United Kingdom (already after the first year) and negative in the United States. One can only guess about the economic interpretation of these differences. It may be true that in the United States a technology shock causes an upturn of the cycle, whereas in the European countries investigated by us the design and introduction of new technology are, initially, at the costs of the cyclical component. The latter would be in accordance with recent empirical results from business cycle theory (although also for the US) that reallocation and investments in technology take place during recessions as opportunity costs are low in those periods.

By definition the technology shock has a constant and permanent influence on labour productivity. The second part of table 2 shows that the relative effect is largest for The Netherlands. The smallest effect is found for Germany, but it is still larger than 0.5. In this case the differences between the various countries are rather small and the size of the positive effects seems plausible so that there is no problem of interpretation.

The next block of table 2 gives the response effects of the supply shock on industrial production. In all countries the supply shock has a positive effect on industrial production. However, due to the difference in the cyclical dynamics evoked by the supply shock, the response effect is relatively small in Germany and The Netherlands in the first year after the shock and relatively large in the United States. In the medium term - it is after three to five years - the effect is large in Germany, The Netherlands and the United Kingdom, and small in the United States. Partly due to the very long cycle measured for The Netherlands, the effects after five years for this country are highest of all countries considered.

**Table 2. The response effects of a simulated supply/technology shock**  
(the size of the shock is normalized to unity, response effects as ratio of the normalized shock)

		Germany	Netherl.	United Kingdom	United States
Effects on					
cyclical component ( $\psi$ , in % y)					
contemporaneously	-0.309	-0.284	-0.187	0.245	
after 1 yr		-0.015	-0.127	0.005	0.484
after 3 yrs		0.379	0.185	0.245	0.204
after 5 yrs		0.106	0.308	0.238	-0.210
labour productivity (k)					
contemporaneously	0.557	0.706	0.610	0.647	
after 1 yr		0.557	0.706	0.610	0.647
after 5 yrs		0.557	0.706	0.610	0.647
industrial production (y)					
contemporaneously	0.387	0.426	0.470	0.663	
after 1 yr		0.681	0.583	0.662	0.853
after 3 yrs		1.075	0.895	0.902	0.366
after 5 yrs		0.805	1.018	0.895	0.190
employment (L)					
contemporaneously	-0.170	-0.280	-0.140	0.016	
after 1 yr		0.124	-0.123	0.053	0.255
after 3 yrs		0.518	0.189	0.292	-0.025
after 5 yrs		0.245	0.318	0.285	-0.439

Opposite movements in the cyclical pattern are also apparent in the dynamics of the response effects of the supply shock on employment, which are shown in the lower block of table 2. The instantaneous effect of the shock on employment in Germany, The Netherlands and in the United Kingdom is negative because the increase in labour productivity is higher than the increase in the industrial production. However, due to the cyclical upturn in the medium run, the increase in the industrial production outweighs the increase in labour productivity, so that the impact on labour demand becomes positive in the case of the European countries. A reverse pattern can be observed for the United States. The effect on labour demand is positive in the first year after the shock and becomes negative in the medium run.

**Table 3. The response effects of a simulated demand shock**

(the size of the shock is normalized to unity, response effects as ratio of the normalized shock)

		Germany	Netherl.	United Kingdom	United States
Effects on					
cyclical component ( $\psi$ , in % y)					
contemporaneously	1.218	1.183	1.285	0.741	
after 1 yr		0.968	1.069	0.878	0.005
after 3 yrs		-0.451	0.309	-0.066	-0.657
after 5 yrs		-0.890	-0.543	-0.611	-0.110
labour productivity (k)					
contemporaneously	0.226	0.264	0.301	0.331	
after 1 yr		0.226	0.264	0.301	0.331
after 5 yrs		0.226	0.264	0.301	0.331
industrial production (y)					
contemporaneously	1.501	1.483	1.611	0.954	
after 1 yr		1.251	1.369	1.204	0.219
after 3 yrs		-0.168	0.609	0.260	-0.443
after 5 yrs		-0.607	-0.243	-0.285	0.104
employment (L)					
contemporaneously	1.275	1.219	1.310	0.624	
after 1 yr		1.025	1.105	0.878	-0.112
after 3 yrs		-0.394	0.345	-0.066	-0.774
after 5 yrs		-0.833	-0.507	-0.611	-0.227

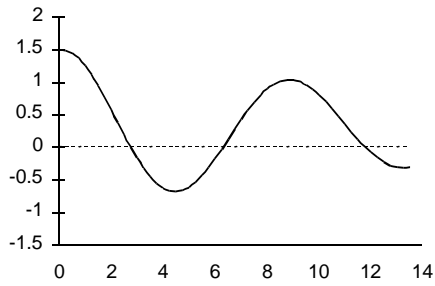
Table 3 gives the response effects of a demand shock. In all four countries it has a positive effect on the cyclical component in the first year after the shock, which seems an obvious result. In the next phase of the cycle the effect of the demand shock on the cyclical component becomes negative in all countries considered in this study. The results in table 3 show that the dynamic reactions of the cyclical component to the demand shock are only slightly different for these countries, albeit that negative values for The Netherlands appear only four years after the shock due to the relative long length of the cycle measured for this country.

**Figure 2. The dynamics of the impulse response effects on industrial production (as ratio of the normalized shock)**

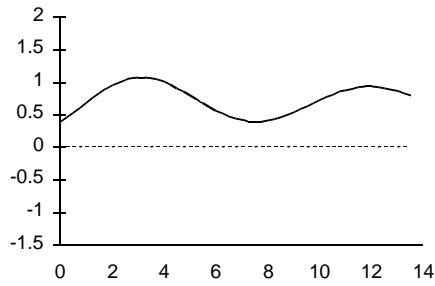
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*Germany*

demand shock

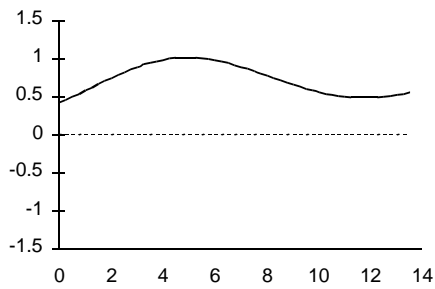


supply shock

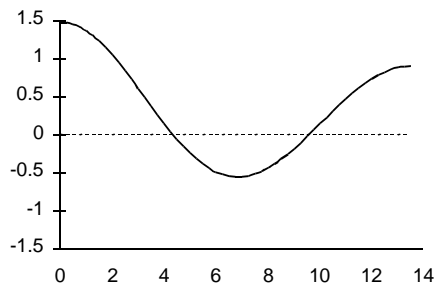


*Netherlands*

demand shock

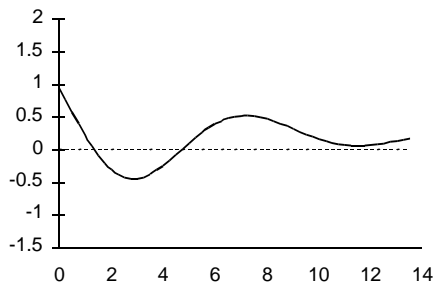


supply shock

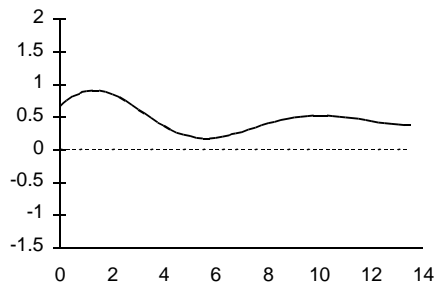


*United States*

demand shock



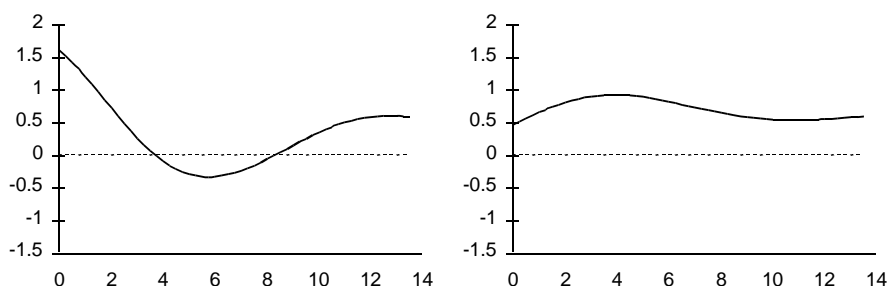
supply shock



*United Kingdom*

demand shock

supply shock



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The next block of table 3 indicates that there is a considerable transmission of the demand shock to labour productivity and hence to structural change. The highest value is found for the United States and the lowest value for Germany. However, these differences are remarkably small. This induced positive technology shock comes as an addition to the increase in industrial production evoked by the demand shock.

The permanent induced supply effect on industrial production in the four countries is, however, not big enough to offset the effect of the demand shock on the cyclical component in those phases of the cycle, where this effect becomes negative. Hence, in all countries the response effect of the demand shock on industrial production becomes negative after some years, whereas it was positive in the first year(s) after the shock. The cyclical pattern, from positive to negative, which is apparent in the response effect of the demand shock on employment, runs, of course parallel to the same pattern in industrial production. Due to the length of the cycle in The Netherlands, the employment effect of the demand shock becomes negative in this country only five years after the shock.

Figure 2 pictures the dynamics of the impulse response effects of demand and supply shocks on industrial production for the period of twelve years after the shock. As already appeared from table 2, a positive supply shock has a positive effect on industrial production, which lasts throughout the whole period. On average, the effect of a demand shock on industrial production is positive as well, due to the positive spill-over to technology, but the effect is temporarily negative in the downturn of the cycle. Figure 2 shows that the dampening of the cyclical movement, induced by the demand shock, is much stronger in the United States than in Germany, The Netherlands and the United Kingdom.

This dampening is also visible for the impulse response effects of demand shocks on employment, which are pictured in figure 3. Moreover, this figure illustrates that, according to our estimation results, the effects of a supply shock on employment are, on average, more favourable in the case of Germany, The Netherlands and the United Kingdom than in the case of the United States.

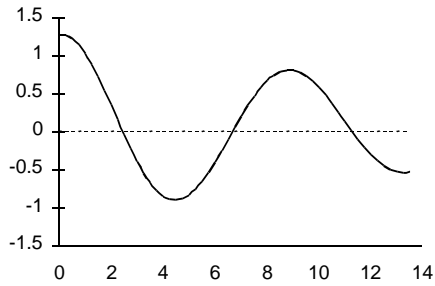


**Figure 3. The dynamics of the impulse response effects on employment**  
(as ratio of the normalized shock)

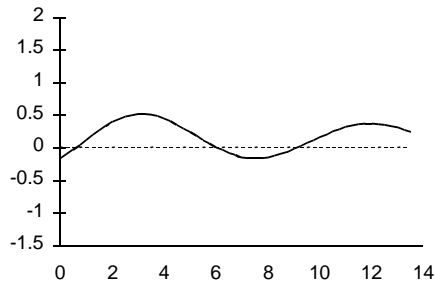
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*Germany*

demand shock

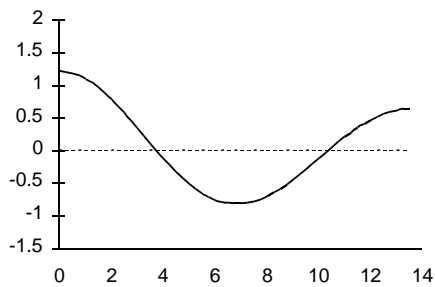


supply shock

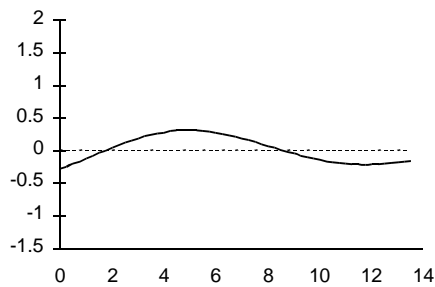


*Netherlands*

demand shock

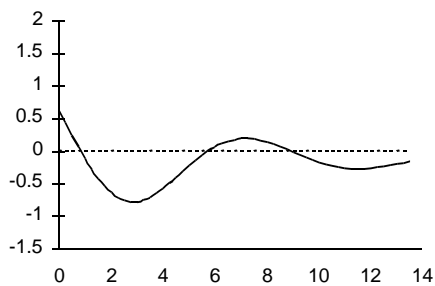


supply shock

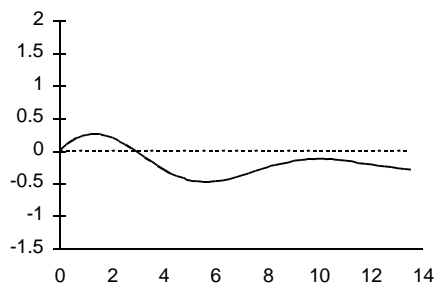


*United States*

demand shock

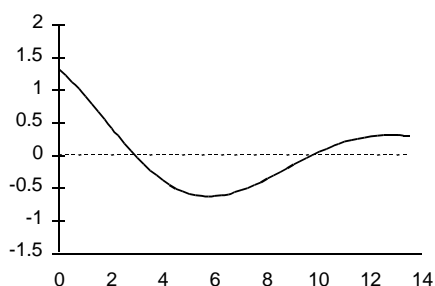


supply shock

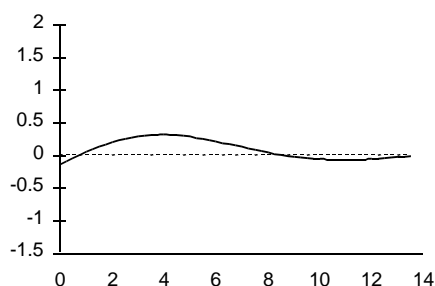


## United Kingdom

demand shock



supply shock



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## 5. Conclusions

This paper investigates the influence of aggregate demand and supply (or technology) shocks on production and employment in a number of industrialized countries using the structural time series modelling approach of Harvey and others (see Harvey, 1989). In contrast with the usual VAR- or common trends cum cointegration methods, the structural time series modelling does not need the identifying restriction of the disturbances associated with (temporal) demand and (permanent) supply shocks being uncorrelated at all leads and lags. Our structural modelling approach as signal extraction method allows us to specify the influence of supply shocks on productivity on the one hand, and of demand shocks on the cyclical component on the other hand as 'pure' or 'genuine' sources of the stochastics affecting the economy. A major novelty of our approach is that, in this structural modelling framework, we are able to model the interaction between demand and supply shocks by calculating the dynamic covariance structure of these two types of shocks with the use of recently developed techniques by Koopman *et al.* (1995). This interaction between demand and supply shocks, and hence between cyclical and structural development, is a major focus of modern theories of the business cycle.

Our empirical analysis, which is conducted for Germany, The Netherlands, the United Kingdom and the United States, confirms that this interaction between supply and demand shocks is important indeed. It appears that in the majority of these countries demand shocks have rather large structural side effects, whereas the supply shocks are of much influence on cyclical developments. Therefore, our decomposition of the stochastics of the economy in supply shocks with temporal side effects and demand shocks with permanent side effects differs considerably from the usual decomposition where demand shocks are associated with temporal shocks on output and supply shocks solely with permanent output shocks.

A remarkable but still somewhat puzzling outcome of our estimations is that the influence of a supply shock on the cyclical component in Germany, The Netherlands and the United Kingdom is the reverse from the effect of such shock on the business cycle in the United States. In the

European countries a supply shock is associated with a downturn of the cycle in the first year after the shock, whereas in the United States such supply shock goes along with a cyclical upturn. A further, but less striking difference between the European countries on the one hand, and the United States on the other hand, is that the effects of a demand shock, and the cyclical spill-overs of a supply shock, appear to dampen much faster in the United States than in these European countries. Obviously these differences in results between the various countries require further investigation. Yet, it illustrates that multivariate structural time series modelling can make an important contribution to the analysis of the business cycle.

From a point of view of labour market policy, our modelling exercise shows that the employment effect of a demand shock is almost neutral in the long run, as the positive spill-over to labour productivity which reduces labour demand is almost offset by the positive effect of this induced productivity increase on production. A positive supply shock has, on average, a positive influence on labour demand in Germany, and to a lesser extent in the United Kingdom and The Netherlands. On the other hand, negative labour demand effects are found for the United States. The complicated mechanisms at work, due to the interaction of supply and demand shocks, need a careful empirical analysis, which goes beyond straightforward answers to questions on, e.g., its implications for the so called job trap. This is the percentage of economic growth which generates jobs and which, according to the European Commission (II/176/1993) is only 0.5% in the USA and 2% in Europe. As the differences between our results for the United States and the European countries indicate, this may depend on the cyclical reaction to a supply shock and on the timing of that reaction.

#### References

**Beld, C.A. van den**, 1967, Dynamiek der Ontwikkeling op de Middellange Termijn, Inaugural Lecture, Rotterdam.

**Bergman, M.**, 1996, International evidence on the sources of macroeconomic fluctuations, European Economic Review, 40, pp. 1237-1258.

**Blanchard, O.J. and D. Quah**, 1989, The dynamic effects of aggregate demand and supply disturbances, American Economic Review, 79, pp. 655-673.

**Burnside, C., M. Eichenbaum and S. Rebelo**, 1993, Labor hoarding and the business cycle, Journal of Political Economy, 101, pp. 245-273.

**Butter, F.A.G. den, and F.J. Wollmer**, 1996, An empirical model for endogenous technology in The Netherlands, Economic Modelling, 13, pp. 15-40.

**Butter, F.A.G. den, and R.W. van Zijp**, 1995, Technologie en Werkgelegenheid (Technology and Employment), Beleidsstudies Technologie Economie nr. 28 (Ministerie van Economische Zaken, Den Haag), 110 pp.

**Caballero, R.J. and M.L. Hammour**, 1994, The cleansing effect of recessions, American Economic Review, 84, pp. 1350-1368

**Caballero, R.J. and M.L. Hammour**, 1996, On the timing and efficiency of creative destruction, Quarterly Journal of Economics, 111, pp. 805-852.

**Christiano, L.J. and M. Eichenbaum**, 1992, Current real business-cycle theories and aggregate labor market fluctuations, American Economic Review, 82, pp. 430-450.

**Danthine, J.P. and J.B. Donaldson**, 1993, Methodological and empirical issues in real business cycle modelling, European Economic Review, 37, pp. 1-35.

**Davis, S.J., J.C. Haltiwanger and S. Schuh**, 1996, Job Creation and Destruction, (MIT Press, Cambridge, Mass.).

**Fisher Ingram, B., N.R. Kocherlakota and N.E. Savin**, 1994, Explaining business cycles; a multiple-shock approach, Journal of Monetary Economics, 34, pp. 415-428.

**Gali, J.**, 1996, Technology, employment and the business cycle: do technology shocks explain aggregate fluctuations?, NBER Working Paper 5721.

**Harvey, A.C.**, 1989, Forecasting, Structural Time Series Models and the Kalman Filter (Cambridge University Press, Cambridge)

**Harvey, A.C. and S.J. Koopman**, 1996, Multivariate structural time series models, London School of Economics Discussion Paper EM/96/307.

**Karras, G.**, 1994, Sources of business cycles in Europe: 1960-1988. Evidence from France, Germany and the United Kingdom, European Economic Review, 38, pp. 1763-1778.

**King, R.G., Ch. I. Plosser, J.H. Stock and M.W. Watson**, 1991, Stochastic trends and economic fluctuations, American Economic Review, 81, pp. 819-840.

**Koopman, S.J.**, 1993, The disturbance smoother for the state space model, Biometrika, 80, pp. 117-126.

**Koopman, S.J. and N. Shephard**, 1992, The exact score for time series models in state space form, Biometrika, 79, pp. 823-826.

**Koopman, S.J., A.C. Harvey, J.A. Doornik and N. Shephard**, 1995, Structural Time Series Analyser, Modeller and Predictor (Chapman and Hall, London).

**Kydland, F.E. and E.C. Prescott**, 1982, Time to build and aggregate fluctuations, Econometrica, 50, pp. 1345-1370.

**Kydland, F.E. and E.C. Prescott**, 1996, The computational experiment: an econometric tool, Journal of Economic Perspectives, 10, pp. 69-85.

**Mellander, E., A. Vredin and A. Warne**, 1992, Stochastic trends and economic fluctuations in a small open economy, Journal of Applied Econometrics, 7, pp. 369-394.

**Mortensen, D.T. and C.A. Pissarides**, 1994, Job creation and job destruction in the theory of unemployment, Review of Economic Studies, 61, pp. 397-415.

**Schouten, D.B.J.**, 1967, Dynamische Macro-economie, Deel I en Deel II, (Stenfert Kroese, Leiden).

**Smithies, A.**, 1957, Economic fluctuations and growth, Econometrica, 25, pp. 1-52.

## Appendix Sources of the data

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	Industrial production source (ref. period)	Employment source (ref.period)
Germany	OECD, Quarterly National Accounts (1968 I - 1994 II)	OECD, Main Economic Indicators (1965 I - 1994 II)
Netherlands	DNB, Kwartaalconfrontaties (1957 I - 1976 IV) ; CBS, Kwartaalrekeningen (1977 I - 1994 IV)	CPB (1969 I - 1986 IV) ; CBS, Arbeidsrekeningen (1987 I - 1994 IV)
United States	OECD, Quarterly National Accounts (1966 I - 1994 II)	OECD, Main Economic Indicators (1965 I - 1994 II)
United Kingdom	OECD, Quarterly National Accounts (1975 I - 1994 II)	OECD, Main Economic Indicators (1965 I - 1994 II)

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### List of symbols

$k$	refers to labour productivity equation
$y$	refers to industrial output equation
$\varepsilon$	noise term in labour productivity equation
$\eta$	noise term of the trend of labour productivity (technology / supply shock)
$\kappa$	noise terms in the equation for the cyclical component (demand shock) (two noise terms in order to account for cyclicity)
$\rho$	damping factor (or AR-coefficient) of cycle
per	period in years of cycle ( $2\pi/\lambda$ ).
$\theta$	direct effect of technology shock on industrial production
$\phi_1$	correlation between technology / demand shock of first $\kappa$ noise term
$\phi_2$	correlation between technology / demand shock of second $\kappa$ noise term
$\beta_1$	deterministic slope of trend of labour productivity
$\beta_2$	deterministic slope of trend of industrial production