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**Abstract.** This paper tries to characterize the Austrian and the German business cycle using the filter proposed by Hodrick and Prescott (1980). We give four interpretations of this filter and analyze its effects in practice. The application of this filter technique produces a list of stylized facts which are related to the existing Real Business Cycle Literature. The main results are that the variability of GNP (GDP) is higher in Germany than in Austria; that monetary policy is more important in Germany; that real wages and hours (employment) are positively correlated in Germany but acyclical in Austria; that saving and investment are positively correlated; and that both output measures are positively correlated whereas the consumption series are unrelated.

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## 1. Introduction

The notion of "stylized facts" plays an important role in Macroeconomics. One may even say that it serves to define the field, in the sense that stylized facts describe what phenomena are to be explained by theoretical modeling. Based on this concept, Lucas (1977) supplied in his programmatic article "Understanding Business Cycles" the theoretical foundations of a successful research strategy which came to be known as "Real Business Cycle" theory. It uses dynamic general equilibrium simulation models instead of structural econometric models. The quality of these simulation models is judged by how well they replicate the stylized facts of an actual economy (Prescott 1986).

The notion of stylized facts[1] has its roots in the work of Burns and Mitchell (1946) whose basic idea was to provide "model free" observations. This view was forcefully challanged by Koopmans (1947) who argued that economic theory must enter in two ways. First, economic theory serves as a device to differentiate the important facts from the unimportant ones. Second, purposeful descriptions of economic phenomena can not be made without specifying structural econometric models based on supply and demand schedules. With Kydland and Prescott (1990) we accept the first criticism but reject the second one. We think that it is still a meaningful excercise to provide basic statistical properties of economic time series without pretending to have too much a priori economic theory.

Instead of Burns and Mitchell's "chartist approach", modern time series analysis suggests to summarize movements and comovements of economic time series in terms of autocorrelations and cross-correlations. These statistical measures can, however, only be applied to stationary stochastic processes. As one intrinsic characteristic of most economic data is their pronounced trend and seasonality, some prior transformations are necessary to obtain stationary time series.

In this paper we use the two-sided filter proposed by Hodrick and Prescott (1980) to extract the trend component. The residual part is called the cyclical component and is used to characterize the business cycle. This filter (called henceforth HP-filter) has several attractive features. First, it can be implemented mechanically without the need for judgemental interventions. This filter is therefore well suited for comparison purposes across time, countries, and scientists. Second, it extracts stochastic trends with an order of integration higher than one. It can therefore accommodate time series with changing mean growth rates, like productivity which started to grow at lower rates around 1970.

[1]The term "stylized facts" was first introduced by Kaldor (1961).

Third, the filtered series come close to what economists have described as business cycle movements.

One disadvantage of the HP-filter is that it is "optimal" only for a restricted class of models. Thus a better approach would be to extract the business cycle component on the basis of an elaborated model fitted individually to each time series or set of time series. Beveridge and Nelson (1981), for example, propose a decomposition based on a fitted ARIMA model for each individual series. Although attractive, this approach is very time consuming when a large set of variables is involved. Alternatively, Blanchard and Quah (1989) and Shapiro and Watson (1988) have provided estimates of the business cycle component based on multivariate methods. This approach, however, requires explicit, but probably controversial, identifying restrictions.

Singleton (1988), and King, Plosser and Rebelo (1988) criticized the filtering approach from a general point of view. They argue that economic growth and cyclical fluctuations do not arise from independent sources and must therefore be analyzed simultaneously. A decomposition of a time series into a growth and a cyclical component on purely statistical grounds is, according to their view, a fruitless excercise.

Despite these objections HP-filtering has been widely used, especially in the context of the Real Business Cycle literature. The reason for this wide acceptance is that "facts" about non-stationary time series have to presented in any case and that the HP-filter is simple to use and "superior" to other filters, like for example first differencing. The definition of the business cycle provides a further, deeper justification. If we define the business cycle, as suggested by Lucas (1977) and Sargent (1987), through the coherence between time series at certain frequencies, filtering out those frequencies is of special interest.

We follow this line of research to establish stylized facts for Austria and Germany (FRG).[2] Schebeck and Tichy (1984) looked at a similar data set, but used exponential smoothing combined with first differencing to extract the trend. Their attention was directed to the question whether the list of stylized facts encountered in the literature is complete and whether it remains unchanged across countries. In our approach we take as given the set of variables, those encountered in most macroeconomic models, and establish the relations among them. Moreover, we are not only interested in the correlations within countries but also across countries. This should shed some light on the transmission of shocks. We then try to give an economic interpretation to these relations. The study by Backus, Kehoe and Kydland (1989) is closest in spirit to ours. We do, however, not propose a simulation model in this paper to rationalize our findings.

[2]Danthine and Girardin (1989), and Englund, Persson and Svensson (1990) perform similar strategies to characterize the Swiss and the Swedish business cycle, respectively.

We also deliberatly left out any policy conclusion. Rather, we interpret our results in the light of the existing literature.

The plan of the paper is as follows. Section 2 discusses the properties of the HP-filter and presents four alternative interpretations. Section 3 analyzes the movements and comovements of aggregate time series from Austria and Germany. Section 4 tries to establish stylized facts related to the transmission of business cycles from one country to the other. Finally, a conclusion closes the paper.

## 2. The Hodrick-Prescott filter

### *2.1 Theoretical exposition*

Suppose we have observations $y_1, \ldots, y_T$ on a non-stationary time series $\{y_t\}$.[3] Consider the problem of decomposing this time series into a growth component $\{g_t\}$ and a cyclical component $\{c_t\}$ such that

$$y_t = g_t + c_t \tag{2.1}$$

Viewed as a projection of $\{y_t\}$ on $\{g_t\}$, equation (2.1) is meaningless without imposing some restrictions on the problem. Following a suggestion going back to Whittaker (1923), Hodrick and Prescott (1980) propose to approximate $\{y_t\}$ by a smooth curve. They constrain the smoothness of the growth component by setting the sum of squares of its second order differences equal to some number $\mu$. This results in the following constrained least squares problem:

$$\sum_{t=1}^{T}(y_t - g_t)^2 + \mu \sum_{t=2}^{T-1}[(g_{t+1} - g_t) - (g_t - g_{t-1})]^2 \rightarrow \min_{\{g_t\}} \tag{2.2}$$

The objective function (2.2) consists of two terms. The first one is a measure of fit. It is minimized for $y_t = g_t$ for all $t$. The second term is a measure of smoothness. It becomes zero when the change in $g_t$ is constant for all $t$, i.e. when $\{g_t\}$ is linear. Thus there is a trade-off between the two objectives fit and smoothness and one must decide how much weight to place on each goal. The weighting factor is given by $\mu$ which is the Lagrange multiplier associated with the smoothness constraint. It must be set a priori. Below we shall give an interpretation which motivates our particular choice.

[3]In this paper we restrict ourselves to non-stationarities arising from trend. But, as Akaike (1980) and Kitagawa and Gersch (1984) have shown, the principles outlined below can be easily adapted to extract a seasonal component.

The solution for $\{g_t\}$ is obtained by investigating the first order conditions of the optimization problem. Let $y$ and $g$ denote the $T \times 1$ vectors of observations on $\{y_t\}$ and $\{g_t\}$. The solution is then given by

$$g = (X'X + \mu K'K)^{-1}X'y \tag{2.3}$$

where $X$ is the $T$-dimensional identity matrix and where the $(T-2) \times T$ matrix $K$ is defined as:

$$K = \begin{pmatrix} 1 & -2 & 1 & 0 & 0 & \dots & 0 & 0 & 0 \\ 0 & 1 & -2 & 1 & 0 & \dots & 0 & 0 & 0 \\ 0 & 0 & 1 & -2 & 1 & \dots & 0 & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & 0 & 0 & \dots & 1 & -2 & 1 \end{pmatrix}$$

The presentation and notation of the solution (2.3) was chosen to highlight its relation to the standard least squares formula.

The idea of approximating $\{y_t\}$ by a smooth curve is appealing but does not help in chosing the weighting factor $\mu$. Akaike (1980) has presented a Bayesian interpretation to overcome this problem. He considered $\mu$ as a hyperparameter which can be obtained by maximizing an appropriately specified likelihood function.[4]

In this paper we will not pursue this line further. Instead, we follow King and Rebelo (1989) and interpret the decomposition (2.1) as a signal extraction problem. This will not only provide an interpretation of $\mu$ but will also show for what class of ARIMA models the HP-filter is optimal in the mean square error sense.[5] For this purpose we assume that the growth component $\{g_t\}$ is the noise and follows an integrated process of order $n$ and that the cyclical component $\{c_t\}$ represents the stationary signal. In particular, we postulate that they follow given ARIMA respectively ARMA processes:

$$\begin{aligned} A_g(z)(1-z)^n g_t &= B_g(z)\epsilon_{gt} \\ A_c(z)c_t &= B_c(z)\epsilon_{ct} \end{aligned} \tag{2.4}$$

where $z$ denotes the lag operator; and where $\{\epsilon_{gt}\}$ and $\{\epsilon_{ct}\}$ are the innovations of the two processes with corresponding variances $\sigma_g^2$ and $\sigma_c^2$.

Without imposing further structure on this problem, this unobserved component model is unidentified and there is no unique decomposition (2.1).[6] In the univariate framework considered here, one possibility to achieve identification is to assume that both innovations are perfectly correlated.[7] The growth and the cyclical component then become

[4] See also Kitagawa and Gersch (1984).

[5] See Muth (1960) for an early application of this inverse filter problem to exponential smoothing.

[6] See for example the related discussion in Watson (1986). He analyses the case $n = 1$, $A_g(z) \equiv B_g(z) \equiv 1$, and $\{c_t\}$ represented by its Wold representation.

[7] For solutions in a multivariate context see Quah (1988).

inextricably linked because there is really only one source of disturbance. There is in this case no theoretical justification for a decomposition (2.1). Singleton (1988) and King and Rebelo (1989) have argued in this way in the context of the Real Business Cycle literature.

Alternatively, when the two shocks $\{\epsilon_{gt}\}$ and $\{\epsilon_{ct}\}$ are independent, it is possible to adapt the classical signal extraction formula for stationary time series (Whittle 1983) to the non-stationary case. Under certain conditions concerning starting values, Bell (1984) shows that the optimal estimate of $c_t$, given the entire doubly infinite realization of $\{y_t\}$, is given by:

$$E(c_t|y_t, y_{t\pm1}, y_{t\pm2}, \ldots) = \sum_{i=-\infty}^{\infty} \Gamma_i y_{t-i}$$

where

$$(2.5) \qquad \Gamma(z) = \sum_{i=-\infty}^{\infty} \Gamma_i z^i = \frac{\sigma_c^2(1-z)^n(1-z^{-1})^n A_g(z)A_g(z^{-1})}{\sigma_c^2(1-z)^n(1-z^{-1})^n A_g(z)A_g(z^{-1}) + \sigma_g^2\Phi(z)\Phi(z^{-1})}$$

with $\Phi(z) = A_c(z)B_g(z)/B_c(z)$. To obtain the HP-filter further restrictions on (2.4) are necessary. Take first $n = 2$. Then assume that the second difference of the growth component is a moving average process of finite order, i.e. $A_g(z) \equiv 1$. The above formula then simplifies to:

$$(2.6) \qquad \Gamma(z) = \frac{(1-z)^2(1-z^{-1})^2}{(1-z)^2(1-z^{-1})^2 + (\sigma_g^2/\sigma_c^2)\Phi(z)\Phi(z^{-1})}$$

The HP-filter is finally obtained by setting $\Phi(z) \equiv 1$ and $\mu$ equal to $(\sigma_c^2/\sigma_g^2)$. Viewed from economic theory, this restriction is implausible because it implies that $(1-z)^2 g_t$ and $c_t$ have the same Wold representation. Most of the literature followed Hodrick and Prescott (1980) that "a five percent cyclical component is moderately large as is a one-eighth of one percent change in the rate of growth in a quarter" and sets $\mu$ to $1600 = (\frac{5}{1/8})^2$. However, the signal-to-noise ratio is defined as the ratio of innovation variances and not as the ratio of the components' variances. Therefore the value of 1600 for $\mu$ needs further justification.

Viewed as a function of the angular frequency $\omega$, (2.6) represents the transfer function of the HP-filter.[8] Setting $z = e^{-i\omega}$ for $\omega \in [-\pi, \pi]$ gives the effects of the filter in the frequency domain:

$$(2.7) \qquad \Gamma(e^{-i\omega}) = \frac{4\mu(1-\cos\omega)^2}{4\mu(1-\cos\omega)^2 + 1}$$

[8]MATLAB routines which implement the filter in the frequency domain are available upon request.

The squared gain of the filter is $|\Gamma(e^{-i\omega})|^2$ which is plotted in figure 1 for the value $\mu = 1600$. This plot shows that the HP-filter has several desirable properties: First, it sets the very low frequencies practically equal to zero; second, it is steepest around the frequency $.0625\pi$ where the gain is approximatively 0.5; and third, it leaves higher frequencies unaltered. The second property provides a further interpretation of the weighting factor $\mu$. With quarterly time series, the filter with $\mu = 1600$ removes all cycles longer than 32 quarters leaving shorter cycles unchanged.

For comparison purposes, figure 1 also shows the squared gain for other commonly used filters, like $(1 - z)$, and single exponential smoothing (ES).[9] They also dampen the low frequencies, but much less so. There is, however, a big difference between the HP- and ES-filter on the one hand and the difference filter on the other. The latter dampens cycles of length 2 to 8 years and amplifies the high frequencies. The difference filter is thus ill-suited to characterize business cycle phenomena. The gains of the HP- and the ES-filter on the other hand are similar. The HP-filter, however, moves up more steeply than the ES-filter and thus separates the secular component more sharply from the business cycle component.

It should be remembered that high pass filters create peaks in the spectrum of the filtered series if the original series has "the typical spectral shape of an economic variable".[10] It is therefore not appropriate to characterize the business cycle by a peak in the spectrum of a HP-filtered series. Rather the business cycle manifests itself through the high coherence between many time series at the business cycle frequencies (Sargent 1987, 282). And indeed the Real Business Cycle literature focuses on explaining the relative amplitudes and cross-correlations of macroeconomic time series.

## *2.2 The Hodrick-Prescott filter in practice*

The HP-filter is now applied to the logged seasonally adjusted real $GDP$ ($GNP$) per capita of Austria and Germany. The figures 2a and 2b show the corresponding time series and their growth components. The secular movement is rather smooth and reveals the acceleration of output growth from the end of the sixties up to 1975 followed by a decelerating which ended in the late eighties.

As we are interested to characterize the business cycle, figures 3a and 3b shows the corresponding cyclical components. In order to get a feeling for the quality of our estimated

[9] The formula for the ES-filter corresponding to equation (2.6) is: $\frac{(1-z)(1-z^{-1})}{(1-z)(1-z^{-1})+\mu}$ with $\mu$ set to 60 to eliminate cycles longer than 32 quarters.

[10] As remarked by Granger (1966), many economic time series have no peaks in their pseudo-spectrum at the business cycle frequencies. Rather the spectrum is flashing downwards having most of its mass at the very low frequencies.

cyclical component, we have marked in the figure for Austria the peaks and troughs by 'o' and 'x'. This business cycle chronology has been determined by the Austrian Institute of Economic Research ("Österreichisches Institut für Wirtschaftsforschung" (WIFO)) using data on industrial production. Breuss (1984) provides also a dating using the NBER methodology of Burns and Mitchell (1946), leading to a similar business cycle chronology.[11] His estimates, however, end in the early 80's. With the exceptions of the peaks in 1976/77 and 1965, the HP-filtered series corresponds surprisingly well to the business cycle chronology used at WIFO. Comparing the cyclical behavior of $GDP$ in Austria and Germany, it is apparent that the amplitude of the fluctuations are much more pronounced in the latter country.

The figures 4a, 4b, and 4c compare the cyclical component of output estimated with the HP-filter with those estimated from exponential smoothing (ES) with $\mu = 60$, first differencing, and a linear deterministic trend. The ES-filter gives a cyclical component similar to the one obtained from the HP-filter. The only major difference being the more pronounced peak in the mid 60's and the deeper trough following the first oil price shock.

Another way of comparing these detrending methods is to analyze the autocorrelations of the corresponding cyclical components. Table 1a and 1b shows these estimates as a function of the smoothing parameter $\mu$. Higher values of $\mu$ lead to a slower decline in the autocorrelation function because the corresponding filter does not eliminate business cycle frequencies longer than 32 quarters. The autocorrelations of the ES-filtered output declines much less rapidly than the HP-filtered one with $\mu = 1600$. The ES-filtered series also has a higher standard deviation.

As displayed in figure 4b, the first difference of output shows very irregular movements unrelated to the business cycle as determined for example by Breuss (1984). This unattractive feature is reflected in the low first order autocorrelation coefficient. Thus the application of $(1 - z)$ leads to implausible low first order autocorrelations. The business cycle frequencies are practically eliminated.

Extracting a linear deterministic time trend has the reverse effect because it does not eliminate the random walk component, thus leaving in the very low frequencies. The autocorrelation function declines therefore only very slowly (see table 1a and 1b). The standard deviation of the "detrended" series then becomes much too high.

As an alternative way to assess the effect of HP-filtering on the autocorrelations, we have set up a Monte Carlo experiment in which the data are generated according to an unobserved component model estimated by Clark (1987) to describe US $GNP$. In this

[11] Following an idea of Adelman and Adelman (1959), one can ask whether a business cycle chronologist equipped with the tools of Burns and Mitchell (1946) would find the same regularities in the time series generated by an artificial economy. King and Plosser (1989) posed this question in the context of Real Business Cycle models.

model the growth component follows a random walk with constant drift and the cyclical component is an AR(2) process. Taking Clark's model as the true one, the HP-filter leads to downward biased estimates of the autocorrelation coefficients of the cyclical component. For example, the first three theoretical autocorrelation coefficients are .96, .88, and .81 whereas the HP-filtered series yield estimates of .84, .62, and .38.

## 3. Within country movements in Austria and Germany

This section analyzes the movements and comovements of representative quarterly Austrian and German time series data. A detailed description of the data set is given in the appendix. All time series have been seasonally adjusted first using Census X-11, then logged (with the exception of the real interest rate), and finally HP-filtered with $\mu$ equal to 1600. The resulting time series form the basis of our investigation. Although it would have been desirable to adjust for seasonality and trend at once, the two step procedure does not affect the results very much because the Census X-11 filter is based on similar principles as the HP-filter. Moreover, it makes the results comparable with those from other countries where seasonally unadjusted data are not available.

### *3.1 General characteristics of the business cycle*

First, we analyze the standard deviations and autocorrelations. The evidence reported in table 2 shows that business cycle fluctuations are much less pronounced in Austria than in Germany, or Switzerland and the US.[12] This fact has also been documented by Tichy (1986) for an even larger set of countries. The standard deviation of gross domestic (national) product is only 1.18 percent for Austria but 1.62 and 1.74 percent for Germany and the US, and 2.38 percent for Switzerland (see also the figures 3a and 3b). These values correspond well to a less volatile investment series in Austria. The standard deviation is 3.64 percent for Austria, 4.57 for Germany, and 5.51 for the US and similarly for Switzerland. The trade balance also shows large fluctuations for both Austria and Germany, much larger than for the US. The standard deviation of net exports over *GDP* (not shown here) is only .61 for the US, but over 1 percent for Austria and Germany. Interestingly, consumption expenditures are more volatile in Austria than elsewhere. The standard deviation for nondurables and services is 1.08 percent in Austria but only .86 percent in the US. Similarly, public consumption has only a standard deviation of .59 percent in Austria but 1.53 percent in Germany, 1.73 percent in Switzerland and 2.4 percent in the US.

[12] If not mentioned otherwise, figures for Switzerland and the US are from Danthine and Girardin (1989) and Backus, Kehoe, and Kydland (1989), respectively.

The results for hours and employment document the important role of labor hoarding in Austria. Whereas employment fluctuates much less than output, hours worked are highly volatile in Austria, much more than in Germany or the US. This, of course, shows up in the behavior of the corresponding productivity series.

The business cycle is not only more damped in Austria but exhibits also less persistence than in Germany or the US. The first order autocorrelation coefficient is only .61 compared to .72 for Germany and .85 for the US. This feature shows up even more dramatically for consumption where the coefficient is .74 in Germany but .26 in Austria. Similar disparities are obtained for real money, the price level, the real wage, and the trade balance. Another important difference relates to the movement of the ex-post real interest rate. The coefficient of first order autocorrelation is significantly negative in Austria whereas the same variable is practically white noise in Germany.

Table 3 reports the cross-correlation of each variable with output at alternative leads and lags. Typically, consumption and investment, and hours and employment are procyclical in all cases. The contemporaneous correlation of these variables with output is, however, stronger for those countries with more pronounced fluctuations. The trade balance varies inversely with output pointing to a strong income effect in import demand.

The negative correlation of $GDP$ ($GNP$) with its deflator is another well established fact for all countries. On the assumption that the covariance of demand and supply shocks is zero, this suggests, contrary to the conventional wisdom, that business cycles can be predominantly described by an aggregate supply schedule moving along a relatively stable demand schedule.[13] It is interesting to note that this correlation was positive in the Interwar and Prewar periods for practically all industrial countries and thus constitutes one of the major structural breaks in the last hundred years (Backus and Kehoe 1989).

### *3.2 Policy related variables*

Concerning variables related to policy Austria and Germany exhibit quite different characteristics although the two countries are thought to be closely related. Public consumption is countercyclical in Austria but acyclical in Germany. As the high negative covariance of this variable with hours and employment documents (see the cross correlations in table 4a and 4b), public expenditures work like automatic stabilizers in the labor market in Austria. This may be one reason for the low amplitude of Austrian business cycles.

For real money balances it is the other way round. This variable is strongly procyclical in Germany but unrelated to output in Austria. Moreover, real money has a much tighter

[13] See Leamer (1981) on the issue of partial identification through a covariance restriction.

negative correlation with the price level in Germany than in Austria (see table 4a and 4b). The behavior of the ex-post real interest rates is also different between the two countries. It is countercyclical in Germany but uncorrelated with output in Austria. This documents the important role of monetary policy for the German economy.

### *3.3 Characteristics of the labor markets*

" ... a traditional litmus test by which aggregate models are judged." (Christiano and Eichenbaum 1990, p.1) is the ability to account for the observation that the correlation between hours and wages fails to be negative.[14] The examination of variables related to the labor market is therefore of special interest. As reported in table 2a and 2b, employment is strongly autocorrelated in both countries with movements in the latter variable being more persistent. Hours on the other hand show much less persistence. Both variables are, of course, procyclical (table 3a and 3b). Interestingly they both lead the changes in output.

Movements in the real wage are autocorrelated, perhaps due to the staggering of wage contracts (Taylor 1980), with higher persistence in Germany than in Austria. In Germany the correlation between the real wage and hours, respectively employment, is highly positive, .60 for hours and .66 for employment. These values come remarkebly close to the values implied by real business cycle models which see the economy solely driven by shocks to the marginal product of labor. In Austria, on the contrary, real wages are acyclical and thus conform to the Dunlop-Tarshis observation. This may be interpreted as evidence that shifts to labor supply are also at work (Christiano and Eichenbaum 1990).

Both labor input variables are unrelated to to their corresponding average productivity measures. The −.75 correlation of hours and average hourly productivity in Austria is an exception to this finding. Typically, both productivity measures behave procyclical lagging the movements in output.

### *3.4 The saving-investment correlation*

As shown in table 4, the correlation between domestic saving and investment is highly positive in both countries. This result thus confirms the findings of Feldstein and Horioka (1980) who interpret this high correlation as evidence against the view that capital markets are highly integrated. They argued that, in a world of integrated capital markets,

[14]This observation goes back to Dunlop (1938) and Tarshis (1939) and has been discussed eversince (see the references in Christiano and Eichenbaum 1990 and Neusser 1986).

domestic saving just adds to world saving; domestic investment must then compete for funds in this pool of world saving. There should thus be no correlation between domestic saving and investment.

Although the evidence of Feldstein and Horioka has proven to be very robust, their interpretation has been subjected to an intensive discussion (Obstfeld 1986; Dooley, Frankel and Mathieson 1987; Feldstein and Bachetta 1989; Baxter and Crucini 1990). In particular Baxter and Crucini (1990) have shown that the positive correlation between domestic saving and investment is not only compatible but even expected in a real business cycle model with perfect capital mobility. They hold that a positive technology shock raises the marginal product of capital. Investment will therefore be increased to take advantage of the new opportunity which is expected to persist for some time. The same shock makes households which hold the claim to domestic output wealthier. These additional consumption possibilities are, however, not realized immediatly but are spread out over time. Saving must therefore increase along with investment: both variables are positively correlated.

This conclusion holds even stronger for large countries because they face an upward sloping supply schedule for new funds. The correlation between domestic saving and investment should therefore be higher in larger countries than in smaller ones. A fact that is borne out by our results. The correlation is .57 for the FRG but .49 for Austria. Their interpretation, however, implies a positive correlation between output and the current account which does not hold for our two countries (see also Backus, Kehoe and Kydland 1989).

## 4. Cross country movements between Austria and Germany

As reported in table 5, the contemporanous correlation between the gross domestic products in Austria and Germany is highly positive and thus conforms to the evidence presented in Backus, Kehoe and Kydland (1989) or Baxter and Crucini (1990) for a subset of OECD countries. Surprisingly, Austrian output "leads" the German one. A similar pattern emerges with respect to investment and the price level. This result may be, among other things, due to the dominance of basic industries in Austria.

Interestingly, the two consumption series are uncorrelated.[15] This result can be attributed to the unusual behavior of Austrian consumption. Whereas all European countries show a significant positive correlation of their consumption with U.S. consumption

[15] Unfortunatly, we had no data for Germany on durable goods expenditures at our disposal. We can therefore not exclude the possibility that our result is partly due to the behavior of durable goods expenditures which show large swings in Austria as a result of policy measures.

(.44 in the case of Germany and .38 for Europe as a whole), Austria presents an exception to this rule (Backus, Kehoe and Kydland 1989). The corresponding value for Austria is only .09.

From a theoretical point of view one should expect correlations close to one in models with one good and stationary, additively-separable preferences. Thus the empirical correlations are much too low to be consistent with this particular specification. They can therefore be interpreted as evidence against the view that markets are complete or that preferences in consumption and labor supply are separable (Devereux, Gregory, and Smith 1990).

The high correlation between Austrian and German nominal interest rates and real money supply is not surprising given the practically fixed exchange rate between the two countries. The real interest rate and the real wage are uncorrelated between the two countries but are probably related at the lower term frequencies which have been removed by the HP-filter.

## 5. Conclusion

The purpose of this paper has been to establish some "stylized facts" for Austria and the Federal Republic of Germany using a filter proposed by Hodrick and Prescott. With this exercise we follow a growing literature in which dynamic theoretical simulation models are build to capture empirical regularities. To make the comparison more reliable, in particular to remove possible non-stationarities, the moments and cross moments of the model's outputs and of the observed time series are computed from the HP-filtered data. With only a few exceptions, most of the research has been directed to U.S. figures and have emphasized closed economy aspects. We found it thus necessary to extend the approach into the direction of open economies.

Despite the differences in size and in the institutional framework, the "stylized facts" for Austria and the Federal Republic of Germany are surprisingly similar to those found for the U.S. and other industrial countries. There are of course some exceptions. First, the business cycle is much more damped in Austria. Second, public consumption is countercyclical in Austria but acyclical in Germany. For real money it is the other way round. Third, whereas Austria conforms to the Dunlop-Tarshis observation, real wages and employment (hours) are highly positively correlated in Germany. Fourth, consumption expenditures are uncorrelated between both countries.

## References


Adelman, I., and F. Adelman. 1959. The Dynamic Properties of the Klein-Goldberger Model. *Econometrica* 4:596–625.

Akaike, H. 1980. Seasonal Adjustment by a Bayesian Modeling. *Journal of Time Series Analysis* 1:1–13.

Backus, D.K., and P.J. Kehoe. 1989. International Evidence on the Historical Properties of Business Cycles. Working Paper 402R, Federal Reserve Bank of Minneapolis.

Backus, D.K., P.J. Kehoe, and F.E. Kydland. 1989. International Borrowing and World Business Cycles. Working Paper 426R, Federal Reserve Bank of Minneapolis.

Baxter, M., and M.J. Crucini. 1990. Explaining Saving-Investment Correlations. Working Paper No.224, University of Rochester.

Bell, W. 1984. Signal Extraction for Nonstationary Time Series. *Annals of Statistics* 12:646–64.

Beveridge S., and C.R. Nelson. 1981. A New Approach to Decomposition of Economic Time Series into Permanent and Transitory Components with Particular Attention to Measurement of the "Business Cycle". *Journal of Monetary Economics* 7:151–74.

Blanchard, O.J., and D. Quah. 1989. The Dynamic Effects of Aggregate Demand and Supply Disturbances. *American Economic Review* 79:655–73.

Breuss, F. 1984. Konjunkturindikatoren für die Österreichische Wirtschaft. *WIFO Monatsberichte* (8):464–92.

Burns, A.F., and W.C. Mitchell. 1946. *Measuring Business Cycles.* New York: National Bureau of Economic Research.

Clarke, P.K. 1987. The Cyclical Component in US Economic Activity. *Quarterly Journal of Economics* 102:797–814.

Christiano, L.J., and M.S. Eichenbaum. 1990. Current Real Business Cycle Theories and Aggregate Labor Market Fluctuations. Mimeo.

Danthine, J.-P., and M. Girardin. 1989. Business Cycles in Switzerland. A Comparative Study. *European Economic Review* 33:31–50.

Devereux, M.B., A.W. Gregory, and G.W. Smith. 1990. Realistic Cross-Country Consumption Correlations in a Two-Country, Equilibrium, Business Cycle Model. Discussion Paper No.774, Queen's University.

Dooley, M., J. Frankel, and D. Mathieson. 1987. International Capital Mobility: What Do Saving-Investment Correlations Tell Us? *International Monetary Fund Staff Papers* 34:503–30.

Dunlop, J.T. 1938. The Movement of Real and Money Wage Rates. *Economic Journal* 48:413–34.

Englund, P., T. Persson, and L.E.O. Svensson. 1990. Swedish Business Cycles: 1861-1988. Seminar Paper No.473, Institute for International Economic Studies.

Feldstein, M., and C. Horioka. 1980. Domestic Saving and International Capital Flows. *Economic Journal* 90:314–29.

Feldstein, M., and P. Bacchetta. 1989. National Saving and International Investment. Working Paper No.3164, National Bureau of Economic Research.

Granger, C.W.J. 1966. The Typical Spectral Shape of an Economic Variable. *Econometrica* 34:150–161.

Hodrick, R.J., and E.C. Prescott. 1980. Post-War U.S. Business Cycles: An Empirical Investigation. Mimeo.

Kaldor, N. 1961. Capital Accumulation and Economic Growth. In *The Theory of Capital*, eds. F.A. Lutz and D.C. Hague, 177–222. New York: St. Martin's Press.

King, R.G., C.I. Plosser, and S.T. Rebelo. 1988. Production, Growth, and Business Cycles: II. New Directions. *Journal of Monetary Economics* 21:309–42.

King, R.G., and C.I. Plosser. 1989. Real Business Cycles and the Test of the Adelmans. Working Paper No.3160, National Bureau of Economic Research.

King, R.G., and S.T. Rebelo. 1989. Low Frequency Filtering and Real Business Cycles. Working Paper No.205, University of Rochester.

Kitagawa, G., and W. Gersch. 1984. A Smoothness Priors-State Space Modeling of Time Series With Trend and Seasonality. *Journal of the American Statistical Association* 79:378–89.

Koopmans, T.C. 1947. Measurement Without Theory. *Review of Economics and Statistics* 29:161–72.

Kydland, F.E., and E.C. Prescott. 1990. Business Cycles: Real Facts and a Monetary Myth. *Federal Reserve Bank of Minneapolis Quarterly Review* 14:3–18.

Leamer, E.E. 1981. Is It a Demand Curve, or Is It a Supply Curve? Partial Identification through Inequality Constraints. *Review of Economics and Statistics* 53:319–27.

Lucas, R.E., Jr. 1977. Understanding Business Cycles. In *Stabilization of the Domestic and International Economy*, eds. K. Brunner and A.H. Meltzer, Vol.5 of Carnegie-Rochester Conference Series on Public Policy, 7–29. Amsterdam: North-Holland.

Muth, J.F. 1960. Optimal Properties of Exponentially Weighted Forecasts. *Journal of the American Statistical Association* 55:299–306.

Neusser, K. 1986. Time Series Representation of the Austrian Labor Market. *Weltwirtschaftliches Archiv (Review of World Economics)* 122:292–312.

Obstfeld, M. 1986. Capital Mobility in the World Economy: Theory and Measurement. In *National Bureau Method, International Capital Mobility, and Other Essays*, eds. K. Brunner and A.H. Meltzer, Vol.24 of Carnegie-Rochester Conference Series on

Public Policy, 55–103. Amsterdam: North-Holland.

Prescott, E.C. 1986. Theory Ahead of Business Cycle Measurement. *Federal Reserve Bank of Minneapolis Quarterly Review* 10:9-22.

Quah, D. 1988. The Relative Importance of Permanent and Transitory Components: Identification and Some Theoretical Bounds. Mimeo.

Sargent, T.J. 1987. *Macroeconomic Theory.* Academic Press..

Schebeck, F., and G. Tichy. 1984. Die "Stylized Facts" in der modernen Konjunkturdiskussion. Working Paper 2, Austrian Institute of Economic Research.

Shapiro, M.D., and M.W. Watson. 1988. Sources of Business Cycle Fluctuations. In *NBER Macroeconomics Annual 1988*, ed. St. Fischer, Vol.3, 111–48. Cambridge, Massachusetts: MIT Press.

Singleton, K.J. 1988. Econometric Issues in the Analysis of Equilibrium Business Cycle Models. *Journal of Monetary Economics* 21:361–86.

Tarshis, L. 1939. Changes in Real and Money Wage Rates. *Economic Journal* 49:150–4.

Taylor, J.B. 1980. Aggregate Dynamics and Staggered Contracts. *Journal of Political Economy* 88:1–23.

Tichy, G. 1986. Die Amplitude der österreichischen Konjunkturschwankungen im internationalen Vergleich. *Empirica* 13:69–96.

Watson, M.W. 1986. Univariate Detrending Methods with Stochastic Trends. *Journal of Monetary Economics* 18:49–75.

Whittaker, E.T. 1923. On a New Method of Graduation. *Proceedings of the Edinborough Mathmatical Society* 41:63–75.

Whittle, P. 1983. *Prediction and Regulation by Linear Least-Square Methods.* Second Edition, Revised. Minneapolis, Minnesota: University of Minnesota Press.

## Appendix

Annual values for total population (Source: WIFO database) have been interpolated to get a quarterly series for per capita calculations. All series (except the interest rates) have been seasonally adjusted (Census X-11).

### Austria

If not indicated otherwise, data are from the WIFO database.
*Output:* Real gross domestic product ($GDP$), at constant prices 1983, per capita.
*Cons.nondur&serv.:* Real consumption on nondurables and services, at constant prices 1983, per capita.
*Cons.durables:* Real consumption on durables, at constant prices 1983, per capita.
*Consumption:* Real private consumption ($C$), at constant prices 1983, per capita.
*Public cons.:* Real public consumption ($CP$), at constant prices 1983, per capita.
*Fixed Investment:* Real gross fixed investment, at constant prices 1983, per capita.
*Savings:* $GDP - C - CP$, per capita.
*Trade balance:* Export-import ratio.
*Hours:* Average weekly hours worked per employee multiplied with employment, per capita. Source: ÖSTZ (Mikrozensus).
*Employment:* Persons employed.
*Productivity (hour):* Productivity per hour.
*Productivity (empl.):* Productivity per employee.
*Real wage:* Compensation of employees, divided by the deflator of private consumption, per employee.
*Real eff.exch.rate:* Real effective exchange rate.
*Real money supply:* Enlarged monetary base, divided by the GDP deflator, per capita.
*Price level:* Deflator of gross domestic product ($PGDP$).
*Nominal interest rate:* Yield on newly issued bonds ($RN$). Source: OeNB.
*Real interest rate:* Ex post real interest rate, calculated as $\frac{RN}{4} - \frac{PGDP_{t+1} - PGDP_t}{PGDP_t} * 100$.

### Germany

If not indicated otherwise, data are from the DIW database.
*Output:* Real gross national product ($GNP$), at constant prices 1980, per capita.
*Consumption:* Real private consumption ($C$), at constant prices 1980, per capita.
*Public cons.:* Real public consumption ($CP$), at constant prices 1980, per capita.
*Fixed Investment:* Real gross fixed investment, at constant prices 1980, per capita.

*Savings:* $GNP - C - CP$, per capita.
*Trade balance:* Export-import ratio.
*Hours:* Total hours worked, per capita.
*Employment:* Persons employed. Source: Deutsche Bundesbank.
*Productivity (hour):* Productivity per hour
*Productivity (empl.):* Productivity per employee.
*Real wage:* Compensation of employees, divided by the deflator of private consumption, per employee.
*Real eff.exch.rate:* Real effective exchange rate. Source: Deutsche Bundesbank.
*Money supply:* Central bank money, divided by $GNP$ deflator, per capita. Source: OECD.
*Price level:* Deflator of gross national product ($PGNP$).
*Nominal interest rate:* Yield on newly issued bonds ($RN$). Source: Deutsche Bundesbank.
*Real interest rate:* Ex post real interest rate, calculated as $\frac{RN}{4} - \frac{PGNP_{t+1} - PGNP_t}{PGNP_t} * 100$.

Table 1a

Autocorrelation and standard deviation for cyclical components of Austria's *GDP*

| Detrending method | Standard deviation (percent) | lag $j$ 1 | 2 | 3 | 4 | 6 | 8 | 12 |
|---|---|---|---|---|---|---|---|---|
| HP ($\mu = 100$) | 0.90 | .36 | .17 | .02 | -.26 | -.40 | -.33 | .24 |
| HP ($\mu = 400$) | 1.03 | .49 | .30 | .12 | -.17 | -.39 | -.37 | .16 |
| HP ($\mu = 1600$) | 1.18 | .61 | .44 | .28 | -.00 | -.25 | -.31 | -.00 |
| HP ($\mu = 6400$) | 1.32 | .68 | .54 | .39 | .16 | -.09 | -.19 | -.02 |
| ES ($\mu = 60$) | 1.37 | .71 | .60 | .49 | .32 | .13 | .07 | .21 |
| Difference | 1.09 | .18 | .36 | .43 | .20 | .22 | .22 | .35 |
| Linear time trend | 4.49 | .96 | .93 | .89 | .86 | .77 | .69 | .53 |

X-11 adjusted quarterly Austrian data, 1964:1–1989:4.
Values within ±0.19 are not different from zero at a significance level of 5%.

Table 1b

Autocorrelation and standard deviation for cyclical components of Germany's *GNP*

| Detrending method | Standard deviation (percent) | lag $j$ 1 | 2 | 3 | 4 | 6 | 8 | 12 |
|---|---|---|---|---|---|---|---|---|
| HP ($\mu = 100$) | 1.13 | .45 | .12 | .03 | -.10 | -.21 | -.44 | .02 |
| HP ($\mu = 400$) | 1.37 | .61 | .34 | .20 | 0.03 | -.21 | -.47 | -.12 |
| HP ($\mu = 1600$) | 1.62 | .72 | .50 | .36 | 0.18 | -.10 | -.41 | -.29 |
| HP ($\mu = 6400$) | 1.81 | .76 | .57 | .44 | .27 | -.03 | -.33 | -.34 |
| ES ($\mu = 60$) | 1.62 | .72 | .51 | .39 | .24 | -.01 | -.29 | -.21 |
| Difference | 1.24 | .18 | .15 | .29 | .26 | .26 | -.04 | .13 |
| Linear time trend | 3.50 | .92 | .85 | .80 | .74 | .62 | .48 | .35 |

X-11 adjusted quarterly German data, 1960:1–1989:4.
Values within ±0.18 are not different from zero at a significance level of 5%.

Table 2a

Standard deviations and auto-correlations for Austria

| Variable | Standard deviations: percent | relative to Output | lag j: 1 | 2 | 3 | 4 | 6 | 8 | 12 |
|---|---|---|---|---|---|---|---|---|---|
| Output | 1.18 | 1.00 | 0.61 | 0.44 | 0.28 | -0.00 | -0.25 | -0.31 | -0.00 |
| Cons.nondur.&serv. | 1.08 | 0.91 | 0.17 | 0.08 | 0.10 | -0.10 | -0.16 | -0.21 | -0.12 |
| Cons.durables | 6.98 | 5.89 | 0.30 | 0.19 | 0.10 | -0.04 | -0.01 | -0.22 | -0.22 |
| Consumption | 1.47 | 1.24 | 0.26 | 0.12 | 0.05 | -0.08 | -0.06 | -0.19 | -0.15 |
| Public cons. | 0.59 | 0.50 | 0.68 | 0.35 | 0.09 | -0.11 | -0.09 | -0.19 | -0.08 |
| Fixed investment | 3.64 | 3.08 | 0.55 | 0.46 | 0.41 | 0.23 | 0.01 | -0.26 | -0.35 |
| Savings | 4.17 | 3.52 | 0.57 | 0.45 | 0.30 | 0.07 | -0.12 | -0.23 | -0.18 |
| Trade balance | 3.52 | 2.97 | 0.30 | 0.11 | 0.21 | 0.06 | -0.11 | -0.28 | -0.23 |
| Hours | 1.75 | 1.48 | 0.38 | 0.22 | 0.18 | 0.07 | -0.12 | -0.32 | -0.15 |
| Employment | 0.73 | 0.62 | 0.89 | 0.73 | 0.57 | 0.40 | 0.02 | -0.24 | -0.33 |
| Productivity (hour) | 1.65 | 1.39 | 0.20 | 0.12 | 0.09 | -0.16 | -0.07 | -0.29 | -0.02 |
| Productivity (empl.) | 1.03 | 0.87 | 0.49 | 0.32 | 0.14 | -0.13 | -0.24 | -0.24 | 0.07 |
| Real wage | 1.10 | 0.93 | 0.43 | 0.26 | 0.16 | 0.11 | -0.01 | -0.21 | -0.22 |
| Real eff.exch.rate | 1.82 | 1.54 | 0.81 | 0.60 | 0.42 | 0.19 | -0.02 | -0.22 | -0.18 |
| Real money supply | 1.91 | 1.62 | 0.44 | 0.27 | 0.07 | -0.16 | -0.20 | -0.32 | -0.02 |
| Price level | 1.08 | 0.92 | 0.48 | 0.40 | 0.37 | 0.33 | 0.21 | 0.04 | -0.25 |
| Real interest rate | 1.11 | - | -0.40 | -0.06 | 0.04 | -0.02 | 0.05 | -0.07 | -0.07 |

X-11 adjusted and HP-filtered ($\mu = 1600$) quarterly Austrian data, 1964:1–1989:4.
Relative standard deviation of $z$ is $\sigma(z)/\sigma(Output)$.
Values within ±0.19 are not different from zero at a significance level of 5%.

Table 2b

Standard deviations and auto-correlations for Germany

| Variable | Standard deviations: percent | relative to Output | lag j: 1 | 2 | 3 | 4 | 6 | 8 | 12 |
|---|---|---|---|---|---|---|---|---|---|
| Output | 1.62 | 1.00 | 0.72 | 0.50 | 0.36 | 0.18 | -0.12 | -0.41 | -0.29 |
| Consumption | 1.49 | 0.92 | 0.74 | 0.64 | 0.52 | 0.36 | 0.04 | -0.23 | -0.42 |
| Public cons. | 1.53 | 0.95 | 0.41 | 0.23 | 0.20 | 0.13 | -0.02 | -0.30 | -0.24 |
| Fixed investment | 4.57 | 2.83 | 0.65 | 0.51 | 0.46 | 0.35 | 0.08 | -0.24 | -0.43 |
| Savings | 4.85 | 3.00 | 0.64 | 0.37 | 0.21 | -0.05 | -0.31 | -0.49 | -0.13 |
| Trade balance | 4.28 | 2.65 | 0.72 | 0.58 | 0.40 | 0.16 | -0.13 | -0.34 | -0.21 |
| Hours | 1.31 | 0.81 | 0.49 | 0.34 | 0.31 | 0.16 | -0.00 | -0.35 | -0.27 |
| Employment | 1.12 | 0.69 | 0.94 | 0.82 | 0.66 | 0.48 | 0.11 | -0.19 | -0.48 |
| Productivity (hour) | 1.12 | 0.69 | 0.44 | 0.25 | 0.14 | 0.07 | -0.01 | -0.29 | -0.29 |
| Productivity (empl.) | 1.19 | 0.74 | 0.56 | 0.31 | 0.23 | 0.12 | -0.06 | -0.36 | -0.27 |
| Real wage | 1.57 | 0.97 | 0.77 | 0.64 | 0.48 | 0.32 | 0.03 | -0.31 | -0.42 |
| Real eff.exch.rate | 2.83 | 1.75 | 0.80 | 0.54 | 0.27 | 0.00 | -0.27 | -0.45 | -0.09 |
| Real money supply | 1.59 | 0.99 | 0.83 | 0.63 | 0.43 | 0.20 | -0.24 | -0.47 | -0.26 |
| Price level | 0.94 | 0.58 | 0.84 | 0.70 | 0.57 | 0.41 | 0.07 | -0.19 | -0.32 |
| Real interest rate | 0.52 | - | -0.05 | 0.05 | 0.08 | 0.06 | -0.09 | -0.12 | -0.20 |

X-11 adjusted and HP-filtered ($\mu = 1600$) quarterly German data, 1960:1–1989:4.
Relative standard deviation of $z$ is $\sigma(z)/\sigma(Output)$.
Values within ±0.18 are not different from zero at a significance level of 5%.

Table 3a

Cross-correlations with $Output_{t+j}$ for Austria

| Variable | j | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | -12 | -8 | -6 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 6 | 8 | 12 |
| Cons.nondur.&serv. | -0.08 | -0.25 | -0.15 | -0.01 | 0.21 | 0.11 | 0.24 | 0.40 | 0.21 | 0.17 | -0.05 | -0.01 | -0.15 | -0.12 | 0.11 |
| Cons.durables | -0.07 | -0.07 | -0.01 | 0.02 | 0.12 | 0.13 | 0.20 | 0.50 | 0.11 | 0.09 | 0.00 | -0.10 | -0.12 | -0.14 | 0.12 |
| Consumption | -0.10 | -0.19 | -0.09 | -0.01 | 0.20 | 0.14 | 0.24 | 0.54 | 0.20 | 0.16 | -0.03 | -0.07 | -0.18 | -0.16 | 0.14 |
| Public cons. | 0.14 | 0.26 | -0.00 | -0.22 | -0.26 | -0.28 | -0.22 | -0.18 | -0.29 | -0.33 | -0.35 | -0.27 | 0.04 | 0.10 | 0.16 |
| Fixed investment | -0.10 | -0.22 | -0.16 | -0.02 | 0.12 | 0.27 | 0.41 | 0.74 | 0.47 | 0.44 | 0.43 | 0.26 | 0.06 | -0.15 | -0.21 |
| Savings | 0.06 | -0.21 | -0.21 | 0.04 | 0.20 | 0.42 | 0.52 | 0.70 | 0.55 | 0.40 | 0.35 | 0.07 | -0.14 | -0.23 | -0.14 |
| Trade balance | 0.04 | 0.27 | 0.30 | 0.06 | -0.00 | -0.06 | -0.12 | -0.34 | -0.24 | -0.15 | -0.10 | 0.01 | 0.11 | 0.15 | -0.04 |
| Hours | -0.02 | -0.23 | -0.21 | -0.03 | 0.01 | 0.09 | 0.29 | 0.40 | 0.41 | 0.41 | 0.32 | 0.33 | -0.01 | -0.08 | -0.21 |
| Employment | -0.12 | -0.35 | -0.41 | -0.15 | -0.03 | 0.09 | 0.28 | 0.46 | 0.55 | 0.62 | 0.60 | 0.53 | 0.34 | 0.06 | -0.13 |
| Productivity (hour) | 0.02 | 0.02 | 0.03 | 0.02 | 0.17 | 0.21 | 0.13 | 0.29 | 0.00 | -0.11 | -0.13 | -0.34 | -0.15 | -0.12 | 0.21 |
| Productivity (empl.) | 0.08 | -0.13 | -0.04 | 0.06 | 0.29 | 0.41 | 0.47 | 0.82 | 0.31 | 0.10 | -0.07 | -0.32 | -0.46 | -0.35 | 0.11 |
| Real wage | -0.04 | -0.02 | -0.05 | -0.09 | -0.12 | 0.04 | 0.06 | -0.07 | 0.00 | 0.07 | 0.14 | 0.19 | 0.20 | 0.11 | -0.00 |
| Real eff.exch.rate | 0.18 | 0.06 | -0.06 | -0.14 | -0.14 | -0.19 | -0.16 | -0.20 | -0.14 | -0.06 | -0.05 | -0.09 | -0.20 | -0.09 | 0.28 |
| Real money supply | -0.24 | 0.08 | 0.25 | 0.25 | 0.23 | 0.00 | -0.05 | -0.08 | -0.23 | -0.15 | -0.23 | -0.19 | -0.16 | -0.05 | 0.19 |
| Price level | -0.01 | -0.22 | -0.27 | -0.31 | -0.37 | -0.27 | -0.25 | -0.26 | -0.15 | -0.01 | 0.07 | 0.19 | 0.28 | 0.34 | 0.19 |
| Real interest rate | 0.11 | -0.14 | -0.04 | 0.01 | -0.17 | -0.08 | -0.03 | -0.14 | -0.15 | -0.06 | -0.08 | 0.00 | -0.05 | 0.18 | -0.07 |

X-11 adjusted and HP-filtered ($\mu = 1600$) quarterly Austrian data, 1964:1–1989:4.
Values within ±0.19 are not different from zero at a significance level of 5%.

Table 3b

Cross-correlations with $Output_{t+j}$ for Germany

| Variable | j | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | -12 | -8 | -6 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 6 | 8 | 12 |
| Consumption | -0.25 | -0.27 | -0.03 | 0.24 | 0.38 | 0.46 | 0.58 | 0.69 | 0.55 | 0.49 | 0.38 | 0.30 | 0.12 | -0.16 | -0.37 |
| Public cons. | -0.00 | -0.07 | -0.14 | -0.08 | -0.10 | -0.12 | -0.04 | 0.03 | 0.05 | 0.09 | 0.10 | 0.26 | 0.37 | 0.24 | -0.15 |
| Fixed investment | -0.42 | -0.40 | -0.09 | 0.19 | 0.33 | 0.42 | 0.58 | 0.83 | 0.58 | 0.46 | 0.39 | 0.29 | 0.11 | -0.15 | -0.22 |
| Savings | -0.21 | -0.34 | -0.11 | 0.07 | 0.22 | 0.35 | 0.55 | 0.82 | 0.58 | 0.33 | 0.21 | -0.02 | -0.30 | -0.48 | -0.11 |
| Trade balance | 0.19 | 0.22 | 0.04 | -0.25 | -0.38 | -0.41 | -0.40 | -0.31 | -0.31 | -0.34 | -0.33 | -0.23 | -0.10 | -0.00 | 0.23 |
| Hours | -0.25 | -0.52 | -0.24 | -0.09 | 0.08 | 0.21 | 0.36 | 0.69 | 0.57 | 0.45 | 0.46 | 0.35 | 0.07 | -0.10 | -0.10 |
| Employment | -0.29 | -0.53 | -0.44 | -0.19 | -0.01 | 0.18 | 0.39 | 0.60 | 0.70 | 0.72 | 0.68 | 0.60 | 0.35 | 0.09 | -0.16 |
| Productivity (hour) | -0.17 | -0.08 | -0.01 | 0.26 | 0.33 | 0.39 | 0.57 | 0.64 | 0.41 | 0.25 | 0.07 | -0.04 | -0.14 | -0.39 | -0.26 |
| Productivity (empl.) | -0.16 | -0.16 | 0.14 | 0.32 | 0.40 | 0.43 | 0.56 | 0.79 | 0.34 | 0.06 | -0.07 | -0.22 | -0.38 | -0.55 | -0.20 |
| Real wage | -0.12 | -0.26 | -0.15 | -0.04 | 0.02 | 0.13 | 0.28 | 0.55 | 0.52 | 0.56 | 0.58 | 0.50 | 0.35 | 0.00 | -0.45 |
| Real eff.exch.rate | -0.10 | -0.03 | -0.12 | -0.01 | 0.02 | 0.09 | 0.11 | 0.17 | 0.27 | 0.33 | 0.28 | 0.20 | 0.06 | 0.00 | -0.05 |
| Real money supply | -0.26 | -0.17 | 0.15 | 0.47 | 0.58 | 0.63 | 0.59 | 0.49 | 0.30 | 0.09 | -0.08 | -0.18 | -0.38 | -0.38 | 0.09 |
| Price level | 0.04 | -0.14 | -0.28 | -0.41 | -0.42 | -0.41 | -0.34 | -0.25 | -0.06 | 0.12 | 0.28 | 0.33 | 0.43 | 0.41 | -0.03 |
| Real interest rate | 0.07 | -0.04 | -0.07 | -0.22 | -0.22 | -0.21 | -0.21 | -0.33 | -0.25 | -0.17 | 0.02 | 0.03 | 0.08 | 0.28 | 0.18 |

X-11 adjusted and HP-filtered ($\mu = 1600$) quarterly German data, 1960:1–1989:4.
Values within ±0.18 are not different from zero at a significance level of 5%.

Table 4a

Cross-correlations at lag 0 for Austria

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Output | 1.00 | | | | | | | | | | | | | | | | |
| 2 | Cons.nondur.&serv. | 0.40 | 1.00 | | | | | | | | | | | | | | | |
| 3 | Cons.durables. | 0.50 | 0.32 | 1.00 | | | | | | | | | | | | | | |
| 4 | Consumption | 0.54 | 0.83 | 0.77 | 1.00 | | | | | | | | | | | | | |
| 5 | Public cons. | -0.18 | -0.12 | -0.01 | -0.09 | 1.00 | | | | | | | | | | | | |
| 6 | Fixed investment | 0.74 | 0.26 | 0.49 | 0.44 | -0.19 | 1.00 | | | | | | | | | | | |
| 7 | Savings | 0.70 | -0.20 | -0.09 | -0.20 | -0.21 | 0.49 | 1.00 | | | | | | | | | | |
| 8 | Trade balance | -0.34 | -0.36 | -0.39 | -0.47 | 0.08 | -0.47 | 0.00 | 1.00 | | | | | | | | | |
| 9 | Hours | 0.40 | 0.06 | -0.06 | -0.00 | -0.33 | 0.35 | 0.50 | -0.09 | 1.00 | | | | | | | | |
| 10 | Employment | 0.46 | 0.24 | 0.12 | 0.21 | -0.39 | 0.57 | 0.38 | -0.26 | 0.55 | 1.00 | | | | | | | |
| 11 | Productivity (hours) | 0.29 | 0.22 | 0.43 | 0.39 | 0.22 | 0.17 | -0.02 | -0.16 | -0.75 | -0.23 | 1.00 | | | | | | |
| 12 | Productivity (empl.) | 0.82 | 0.29 | 0.48 | 0.47 | 0.05 | 0.45 | 0.53 | -0.21 | 0.09 | -0.12 | 0.49 | 1.00 | | | | | |
| 13 | Real wage | -0.07 | 0.14 | -0.06 | 0.07 | 0.12 | 0.10 | -0.16 | -0.05 | -0.03 | 0.14 | -0.03 | -0.17 | 1.00 | | | | |
| 14 | Real eff.exch.rate | -0.20 | 0.18 | -0.13 | 0.05 | 0.13 | -0.15 | -0.30 | -0.33 | -0.05 | 0.00 | -0.10 | -0.23 | 0.24 | 1.00 | | | |
| 15 | Real money supply | -0.08 | 0.16 | 0.09 | 0.17 | 0.16 | -0.24 | -0.24 | 0.14 | -0.30 | -0.32 | 0.26 | 0.13 | 0.00 | 0.03 | 1.00 | | |
| 16 | Price level | -0.26 | -0.15 | -0.05 | -0.14 | -0.04 | -0.16 | -0.20 | 0.02 | 0.11 | 0.18 | -0.31 | -0.38 | 0.13 | 0.09 | -0.44 | 1.00 | |
| 17 | Real interest rate | -0.14 | -0.20 | -0.12 | -0.20 | 0.04 | -0.09 | -0.01 | 0.01 | 0.17 | -0.09 | -0.30 | -0.11 | 0.17 | 0.01 | -0.36 | 0.55 | 1.00 |

X-11 adjusted and HP-filtered ($\mu = 1600$) quarterly Austrian data, 1964:1–1989:4.
Values within $\pm 0.19$ are not different from zero at a significance level of 5%.

Table 4b

Cross-correlations at lag 0 for Germany

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Output | 1.00 | | | | | | | | | | | | | | | | |
| 2 | Cons.nondur.&serv. | | | | | | | | | | | | | | | | | |
| 3 | Cons.durables. | | | | | | | | | | | | | | | | | |
| 4 | Consumption | 0.69 | | | 1.00 | | | | | | | | | | | | | |
| 5 | Public cons. | 0.03 | | | 0.23 | 1.00 | | | | | | | | | | | | |
| 6 | Fixed investment | 0.83 | | | 0.73 | 0.06 | 1.00 | | | | | | | | | | | |
| 7 | Savings | 0.82 | | | 0.20 | -0.31 | 0.57 | 1.00 | | | | | | | | | | |
| 8 | Trade balance | -0.31 | | | -0.70 | -0.19 | -0.48 | 0.09 | 1.00 | | | | | | | | | |
| 9 | Hours | 0.69 | | | 0.55 | 0.05 | 0.72 | 0.52 | -0.36 | 1.00 | | | | | | | | |
| 10 | Employment | 0.60 | | | 0.55 | 0.24 | 0.66 | 0.37 | -0.44 | 0.68 | 1.00 | | | | | | | |
| 11 | Productivity (hours) | 0.64 | | | 0.36 | 0.01 | 0.41 | 0.58 | -0.05 | -0.08 | 0.20 | 1.00 | | | | | | |
| 12 | Productivity (empl.) | 0.79 | | | 0.41 | -0.17 | 0.55 | 0.77 | -0.03 | 0.36 | -0.00 | 0.64 | 1.00 | | | | | |
| 13 | Real wage | 0.55 | | | 0.70 | 0.25 | 0.64 | 0.20 | -0.54 | 0.60 | 0.66 | 0.13 | 0.17 | 1.00 | | | | |
| 14 | Real eff.exch.rate | 0.17 | | | 0.22 | 0.04 | 0.18 | 0.09 | -0.20 | 0.20 | 0.31 | 0.02 | -0.05 | 0.40 | 1.00 | | | |
| 15 | Real money supply | 0.49 | | | 0.40 | -0.05 | 0.35 | 0.38 | -0.19 | 0.14 | 0.08 | 0.47 | 0.51 | -0.05 | 0.16 | 1.00 | | |
| 16 | Price level | -0.25 | | | -0.02 | 0.15 | 0.00 | -0.33 | -0.24 | 0.14 | 0.31 | -0.37 | -0.48 | 0.37 | 0.15 | -0.67 | 1.00 | |
| 17 | Real interest rate | -0.33 | | | -0.24 | -0.00 | -0.20 | -0.28 | 0.00 | -0.12 | -0.11 | -0.31 | -0.31 | -0.09 | -0.10 | -0.32 | 0.41 | 1.00 |

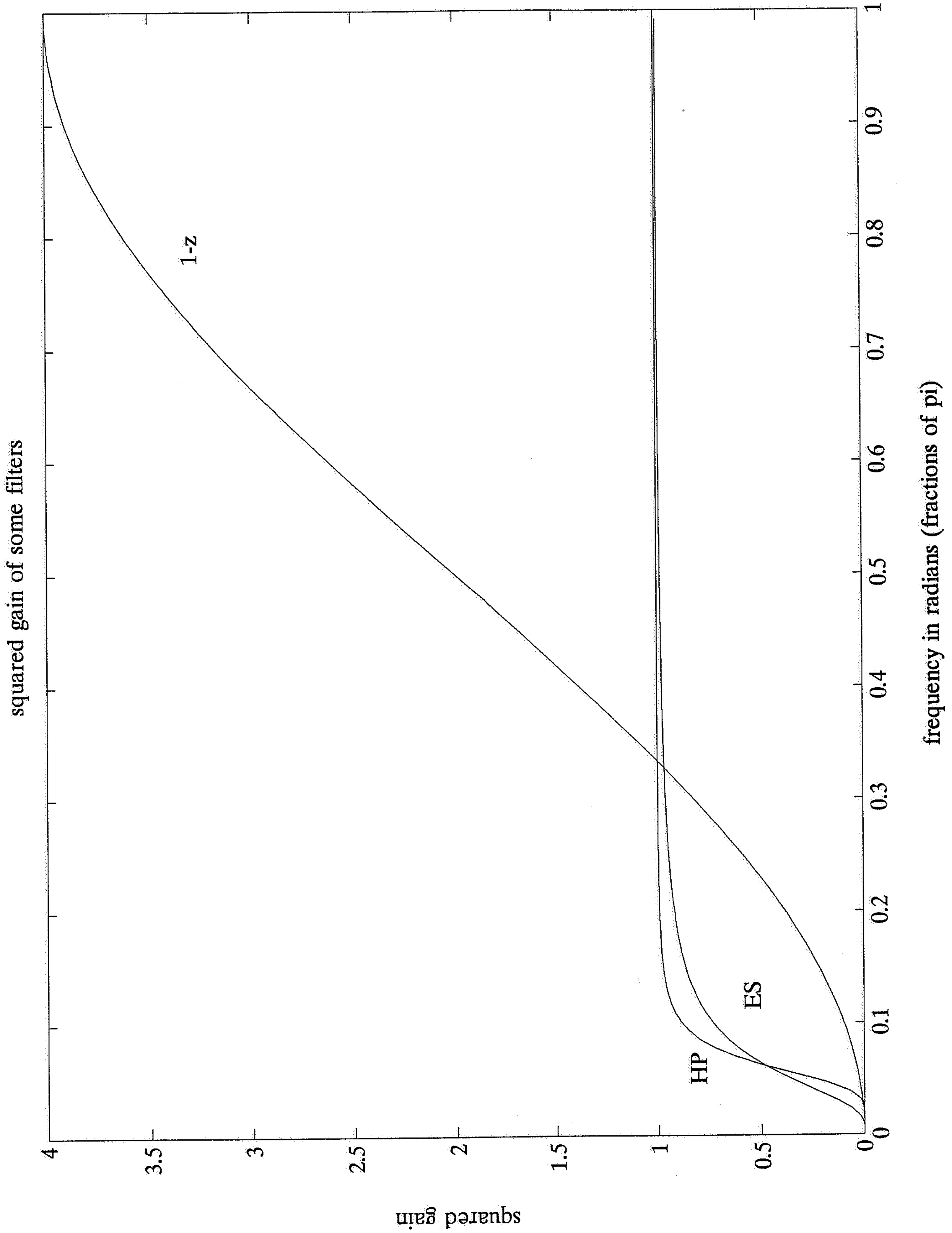
X-11 adjusted and HP-filtered ($\mu = 1600$) quarterly German data, 1960:1–1989:4.
Values within $\pm 0.18$ are not different from zero at a significance level of 5%.

Table 5

Cross-correlations of corresponding variables: $Austria_t$ with $Germany_{t+j}$

| Variable | -12 | -8 | -6 | -4 | -3 | -2 | -1 | j<br>0 | 1 | 2 | 3 | 4 | 6 | 8 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Output | -0.24 | -0.32 | -0.27 | -0.14 | -0.00 | 0.20 | 0.43 | 0.61 | 0.56 | 0.56 | 0.52 | 0.39 | 0.04 | -0.16 | -0.05 |
| Consumption | -0.04 | -0.15 | -0.13 | -0.17 | -0.03 | -0.01 | 0.08 | 0.17 | 0.11 | 0.14 | 0.16 | 0.10 | 0.09 | 0.13 | -0.04 |
| Fixed investment | -0.34 | -0.33 | -0.25 | -0.09 | 0.07 | 0.17 | 0.33 | 0.56 | 0.53 | 0.58 | 0.65 | 0.62 | 0.42 | 0.15 | -0.31 |
| Real wage | 0.06 | -0.09 | -0.21 | -0.11 | -0.07 | -0.06 | -0.03 | -0.01 | 0.07 | 0.14 | 0.21 | 0.22 | 0.23 | 0.15 | 0.11 |
| Real money supply | -0.32 | -0.24 | -0.05 | 0.24 | 0.35 | 0.37 | 0.37 | 0.36 | 0.18 | 0.08 | 0.04 | -0.11 | -0.23 | -0.15 | 0.09 |
| Nominal interest rate | -0.36 | -0.39 | -0.27 | -0.10 | 0.05 | 0.20 | 0.35 | 0.54 | 0.66 | 0.70 | 0.68 | 0.61 | 0.33 | 0.03 | -0.30 |
| Real interest rate | -0.20 | -0.10 | -0.08 | 0.04 | -0.11 | -0.01 | 0.09 | 0.15 | -0.06 | -0.12 | 0.13 | 0.19 | -0.01 | 0.03 | 0.08 |
| Price level | -0.48 | -0.33 | -0.15 | 0.08 | 0.15 | 0.26 | 0.36 | 0.41 | 0.38 | 0.38 | 0.45 | 0.45 | 0.34 | 0.33 | 0.24 |

X-11 adjusted and HP-filtered ($\mu = 1600$) quarterly Austrian and German data, 1964:1–1989:4.
Values within $\pm 0.19$ are not different from zero at a significance level of 5%.



squared gain of some filters
squared gain
frequency in radians (fractions of pi)
1-z
ES
HP
0
0.5
1
1.5
2
2.5
3
3.5
4
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


Figure 1

GDP and its growth component for Austria

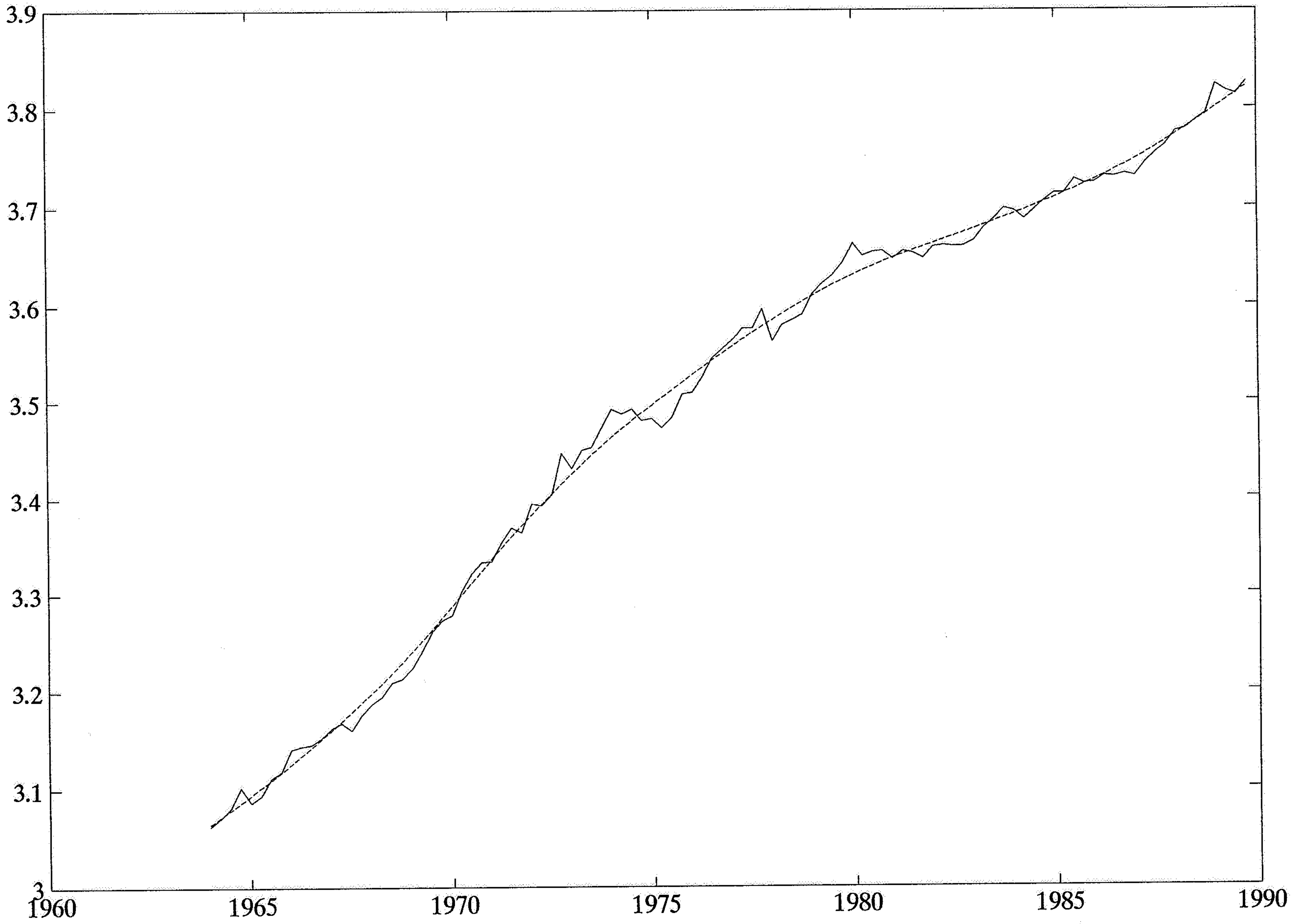



Figure 2a

GNP and its growth component for Germany

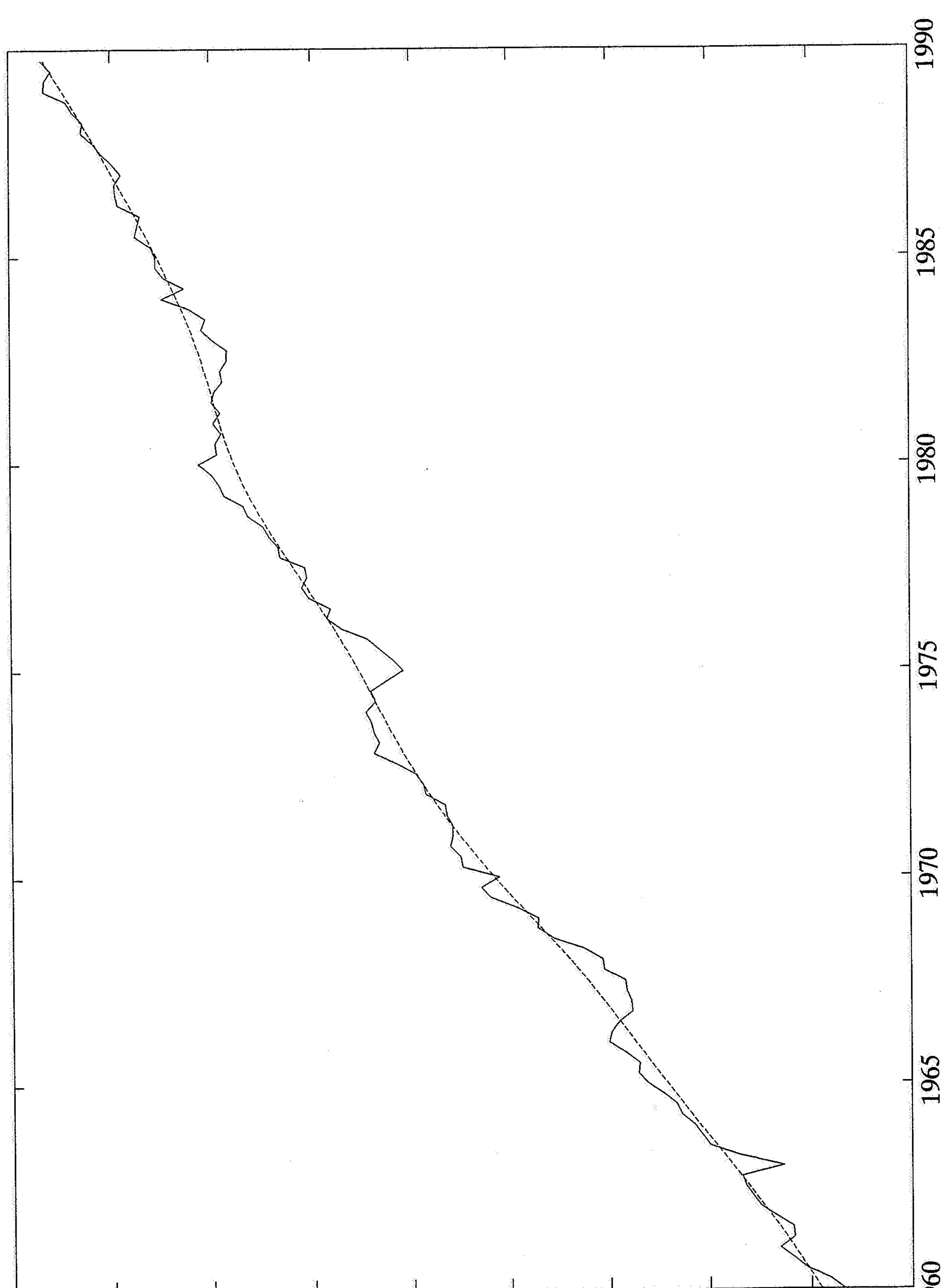



Figure 2b

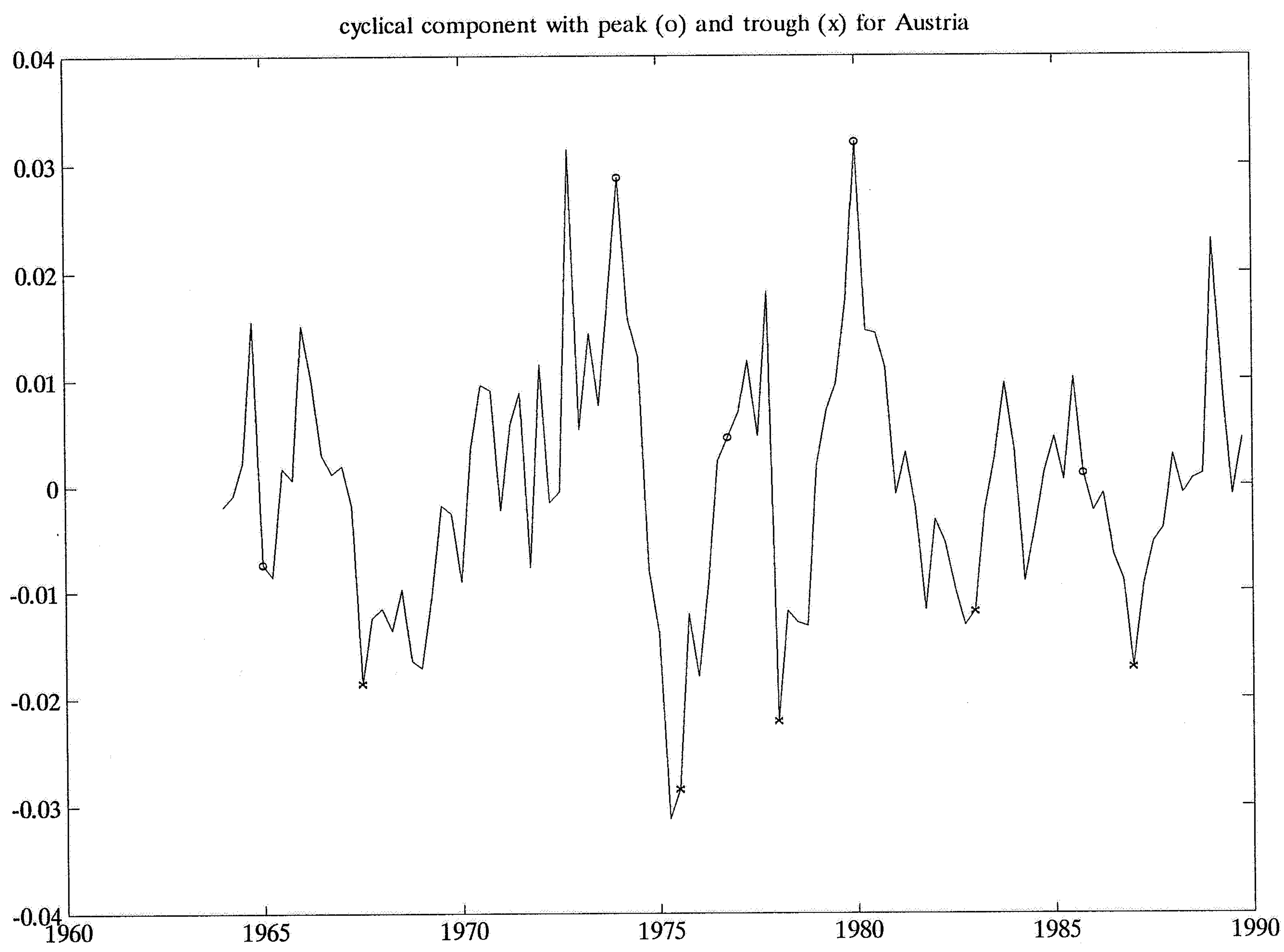

cyclical component with peak (o) and trough (x) for Austria
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
1960
1965
1970
1975
1980
1985
1990

Figure 3a

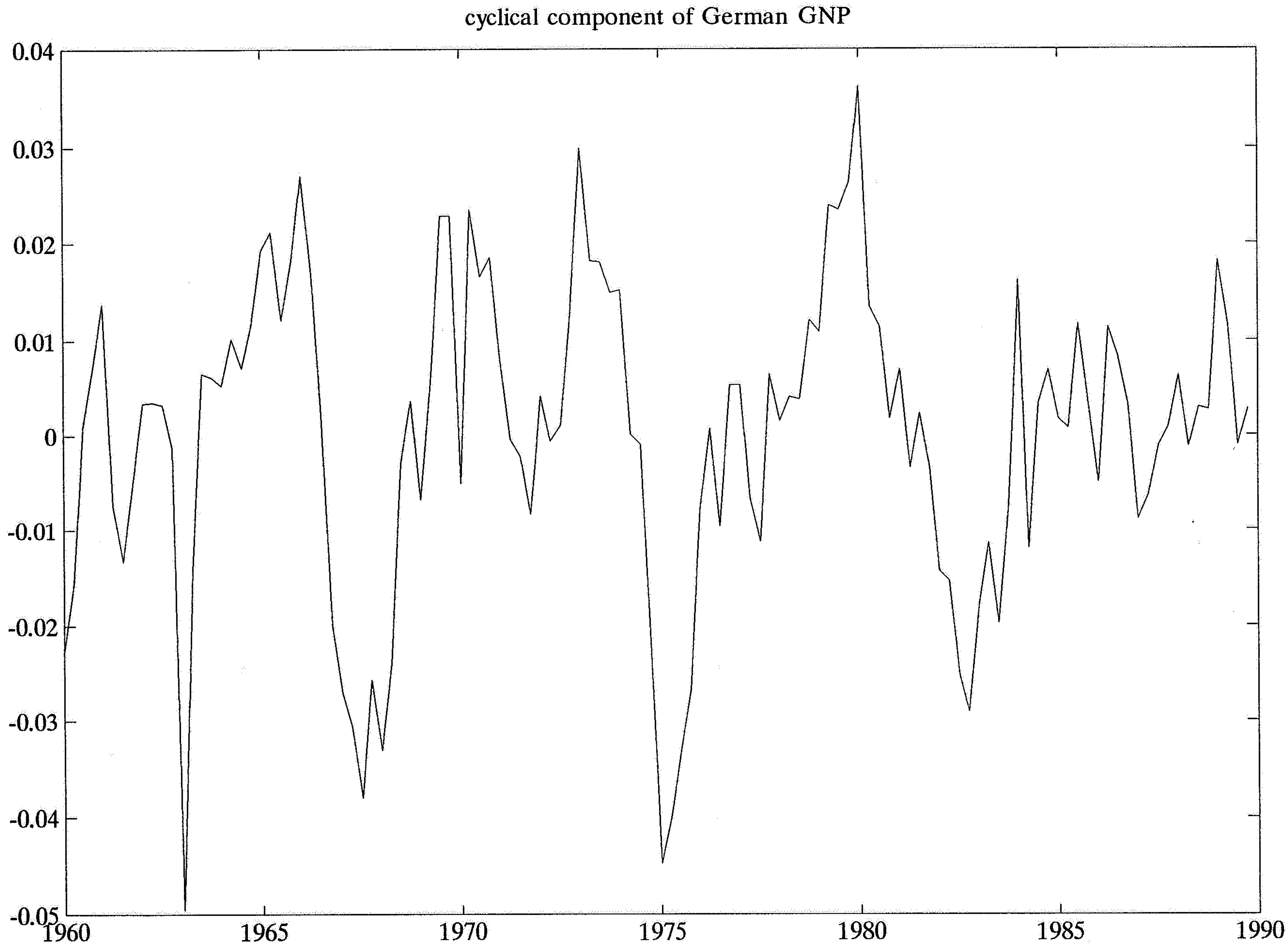

cyclical component of German GNP
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
1960
1965
1970
1975
1980
1985
1990

Figure 3b

HP and exponential smoothing (ES) cyclical component for Austria

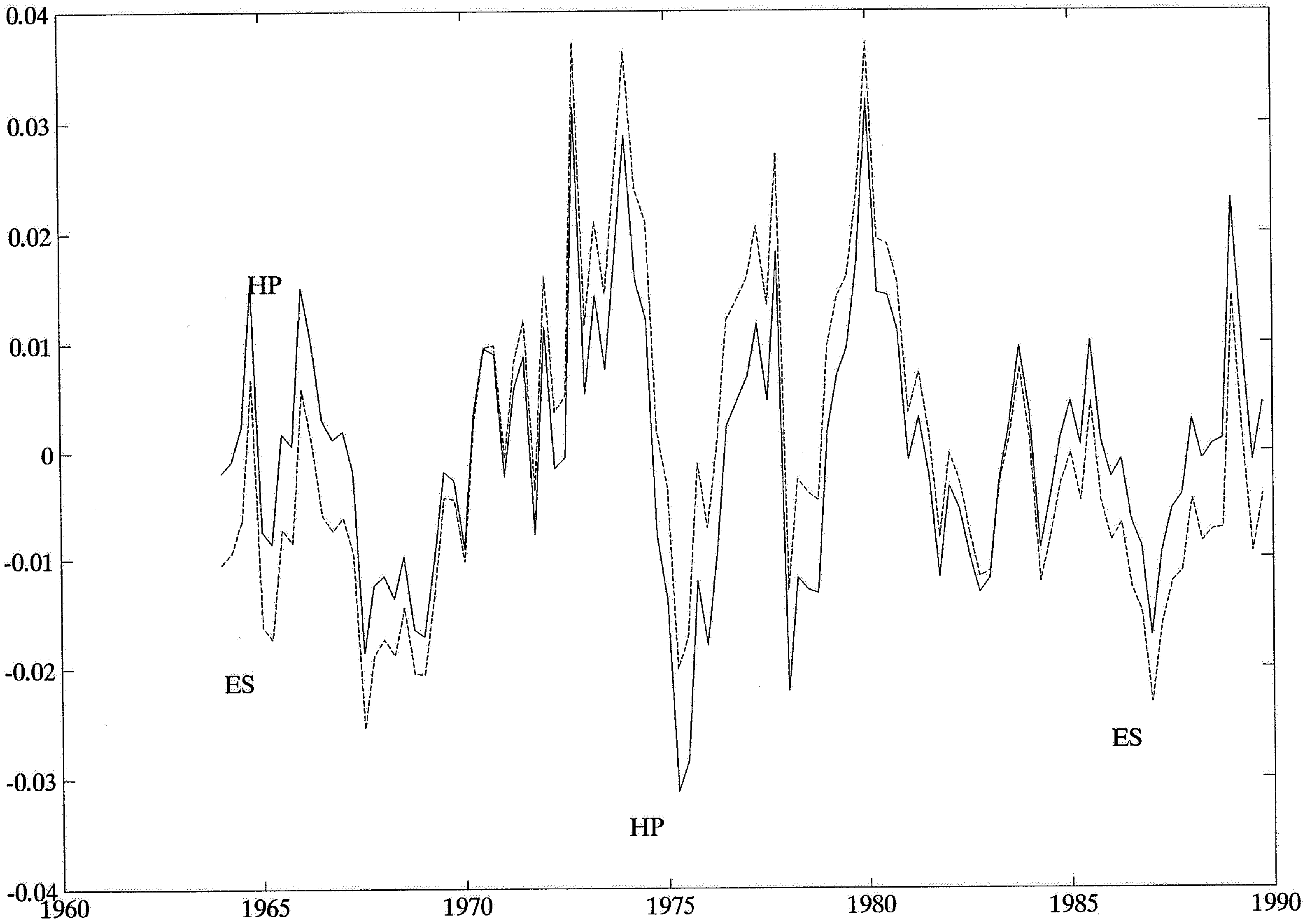



Figure 4a

HP cyclical component and growth rate for Austria

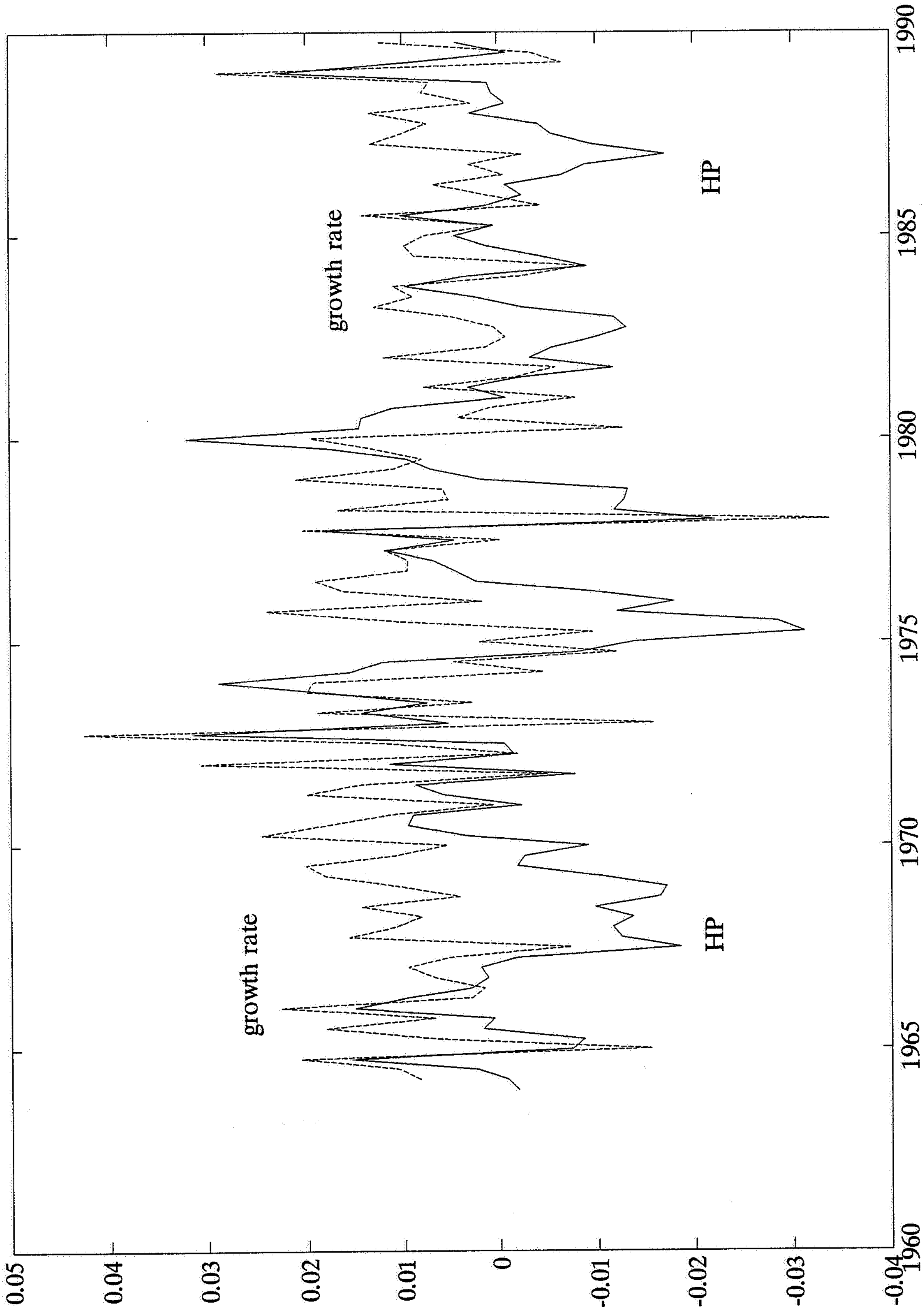



Figure 4b

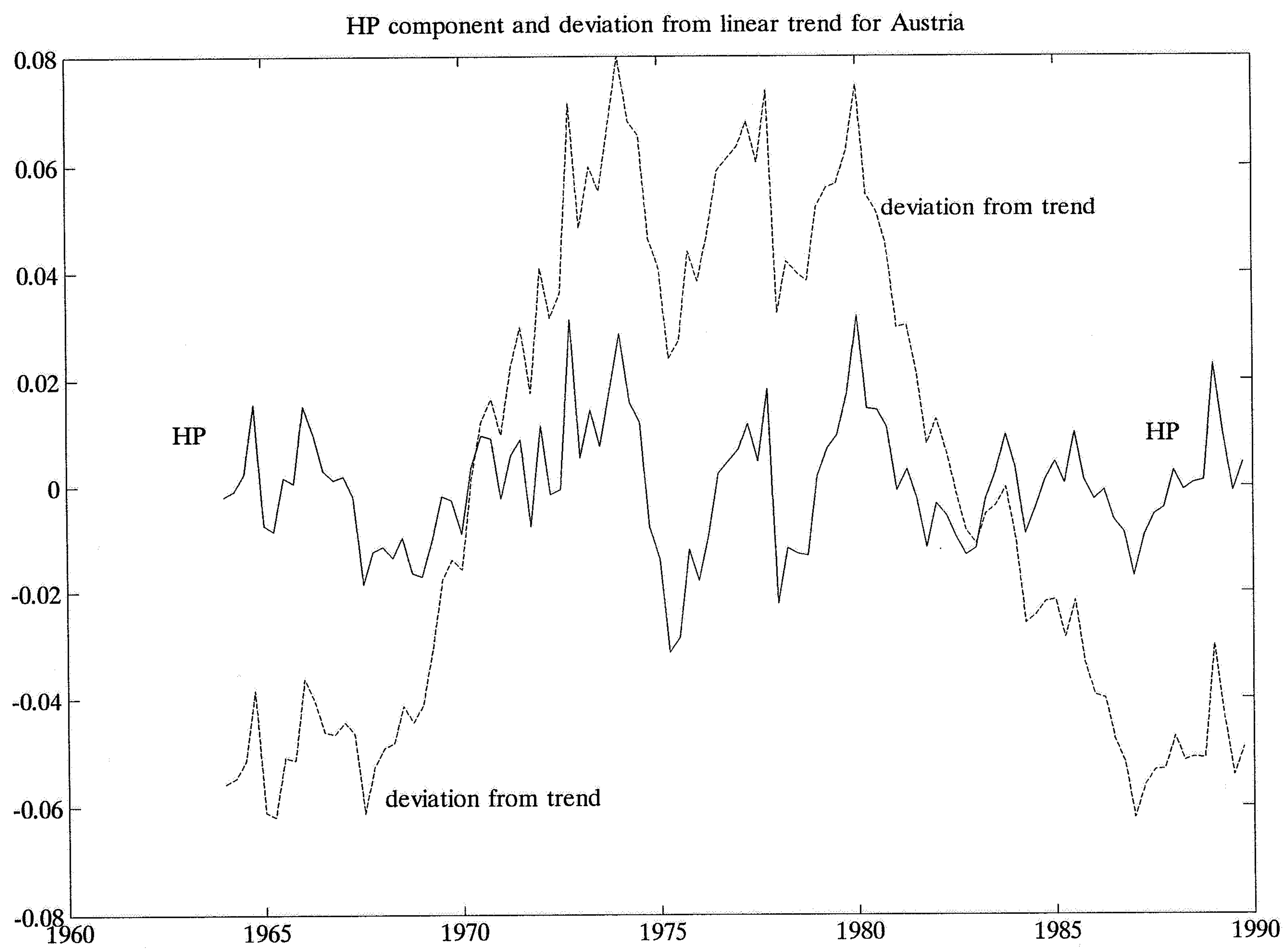

HP component and deviation from linear trend for Austria
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
1960
1965
1970
1975
1980
1985
1990
HP
HP
deviation from trend
deviation from trend

Figure 4c

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Verkaufspreis: S 100,–.