Prices and Wages in the OECD Area 1913 – 1980

A Study of the Time Series Evidence*

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The dominating time series patterns of the yearly rates of price and wage inflation in 17 developed western economics from 1913 to 1980 are investigated. On the basis of an economic model the corresponding univariate time series (Final Equations) are analyzed together with the socalled Autoregressive Final Form. In addition the lead-lag relations between wage and price inflation are examined by use of tests for Granger non-causality.

I. Introduction

This paper reports on an attempt to find the dominating time series patterns of price and wage inflation in 17 developed western economies during the last 68 years, and to interpret these patterns in economic terms. The series used are:

$\dot{p}$, percent rises in consumer prices.[1]

$\dot{w}$, percent rises in nominal wage rates for workers in manufacturing.[2]

Wage inflation $\dot{p}_w$ is related to price inflation $\dot{p}$ and to wage rises $\dot{w}$ through the following two identities — taken to be linear

(1a) $\dot{p}_w = \dot{w} - \dot{g}$, where $\dot{g}$ is productivity growth

(1b) $\dot{p} = \dot{p}_w - \dot{l}_w$, where $\dot{l}_w$ is wage share changes.

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1 For the period 1948/50 - 80 we use the implicit consumer price index in the OECD Tables of National Accounts and before that such consumer price indices as are available.

2 The wage series are taken from the ILO-yearbooks, linked up with national sources. Note that the series are for manufacturing only, so that, strictly speaking, the l_w in relation (2) should be for workers in manufacturing only.

Table 1

The p and w series covered 1913 - 1980

Country	Missing observations	Main deviations from average pattern as shown on Figure 1
1 Australia[a)]	none[b)]	*VR*, low 50 - 70, peaks in 51 and 73
2 Belgium	b 20,30/47	High in late 20s, strange peak in mid 60s
3 Canada	none	*VR*, low 50 - 73
4 Denmark	none	High early 20s, peak 40, high mid 50s to 72
5 Eire	b 22	Low till 60, 2-year cycles in 60s, high since 70
6 Finland	b 15	Wild 15 - 21 and 40 - 52, *R* since 52
7 France	none	High 15 - 30 and 35 - 52, *R* since 52
8 Germany[a)]	b 15, 43/47[c)]	Wild 15 - 25, 31/32, low since 70
9 Holland[a)]	none	*VR*, some large fluctuations in 50s
10 Italy	b 14	*R*, but with peaks 16/21, 29, 43/4, 74/77
11 Japan	none[c)]	*R*, but peaks 18/19 and 44/50
12 New Zealand ..	none	*VR*, but low throughout
13 Norway	none	*VR*, but high 17/20, low 22, 25/26
14 Österreich[a)] ...	b 19, 34/47	*R* since 50
15 Sweden	none	*VR*, high 17/20 and low 22
16 UK	none	*R*, high 15, 18, 40, 75 and low 21/22
17 USA	none	*R*, but jumpy till 50 and low since

Altogether $\Sigma = 1101$ — "*VR*" means that Fig. 1 is "very representative"

Missing is 4.8%[b)] — "*R*" means that Fig. 1 is "representative"

Sources ref. *Paldam* and *Madsen* (1978) and *Pedersen* (1981). "bn" means that data begins in *n*.

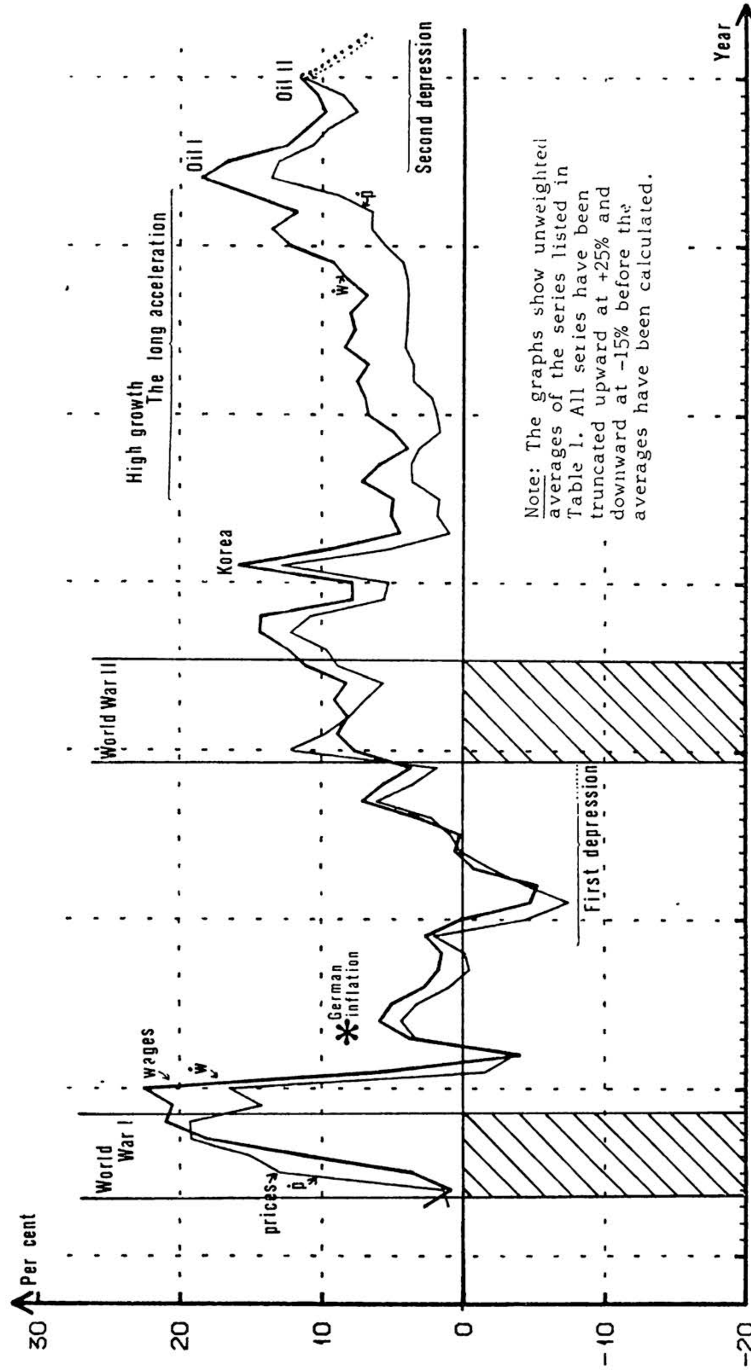
a) Germany is GFR only from 46, The Netherlands are termed Holland and Austria appears as country 14, not to be mixed up with 1.

b) From 1913 to 80 are 68 years, hence the maximum available would have been $17 \cdot 68 - 1156$ observations.

c) In post-war runs we start in 1950 for Germany and Japan, further it is noted that the Japanese $\dot{p}$ series starts in 23.

In Section II we shall take a look at the data, as presented in Table 1 and Figure 1. It is argued that $\dot{g}$ is fairly constant implying that we may study wage inflation in the directly available $\dot{w}$ series as well as in the $\dot{p}_w$ series. If, furthermore, $\dot{l}_w$ could be taken as constant, $\dot{p}$ and $\dot{w}$ are the same except for a constant. In this situation he have one rate of inflation on the two markets as is often presumed. However, since $\dot{l}_w$ is not constant the *one-rate-presumption* is a dubious one.

Figure 1: The Path of Price and Wage Rises in the OECD Area 1913 - 80



Therefore there are good reasons to analyse the dynamics of the $\dot{p}$ series and the $\dot{w}$ series in isolation. This is done in Section IV. The next step is then to analyse the pattern of interdependence between the two series, see Section V.

Finally Section VI gives a brief summary of the main economic implications of our findings.

A vast literature discusses the economics of price and wage inflation and this literature contains many controversies. Some of these concern the relationship between our two variables and other variables, such as the money stock, *not* covered by the present paper. But we hope to throw light over some of the remaining debates. Section III gives a brief survey of the more relevant theoretical discussion pointing out what to look for in the following sections.

II. A Look at the Time Series

The paths of our $\dot{p}$ and $\dot{w}$ series in the average OECD country are displayed in Figure 1. The two curves are unweighted averages. In Table 1 the coverage of the series analysed is listed and the main deviations from the pattern of Figure 1 are mentioned. It appears that Figure 1 is very representative for the price-wage inflation in each of the countries. In other words: both price and wage rises contain *large international elements*; but they will not be our concern at the moment.[3]

For our purpose the following four observations are the essential ones:

(ts 1) Price rises $\dot{p}$ and wage rises $\dot{w}$ have a fairly *parallel* development over time.

(ts 2) The two inflation rates display *large fluctuations* in the period considered.

(ts 3) A lot of the action in the series appears in connection with specific *political events*.

(ts 4) There are *no* clear *long run trends* over the full 68-year span covered — but it is easy to find sub-periods (covering one or more decades) with strong trends.

In view of the importance of these points they are worth elaborating a little. To discuss (ts 1) we have to return to the two identities from the introduction:

[3] See here *Paldam* (1983 c) and *Paldam* (1980) for a discussion.

(1a) $\dot{p}_w = \dot{w} - \dot{g}$ and (1b) $\dot{p}_w = \dot{p} + \dot{l}_w$

Two of the other papers in our project analyse $\dot{g}_w$ and $\dot{l}_w$ on the data for the same countries and years:

In *Paldam* (1984 a) we analyse the time series of the rate of unemployment u and the real growth rate $\dot{y}$. The relevant finding here is that, except for a couple of shifts, $\dot{y}$ comes remarkably close to being white noise around country specific long-run growth rates.

However, these long-run growth rates are rather constant and they deviate from $\dot{g}$ for two reasons: (d_1) different growth rates of the labour force, (d_2) the amount by which technical progress differs from Harrod neutrality. The sum $d_1 + d_2$ is likely to vary little relative to the size of the long-run growth rate and hence we conclude that $\dot{g}$ may be taken to be rather constant. From this follows that we may take it for granted that $\dot{p}_w$ and $\dot{w}$ are essentially the same series — so that we can analyse the dynamics of inflation on the labour market by analysing the $\dot{w}$ series.

While, therefore, (1a) is unproblematic, (1b) is not. In *Paldam* (1979) it is demonstrated that wage shares are *far from constant*. The average value of $|\dot{l}_w|$ on annual data comes to no less than 1.25 % (percentage points of net national income). About half of that is of a long run character — between 1949 and 1975 wages shares rose by about 20 % (of net national income), but the rest is of a short run character. As the long-run averages of $\dot{w}_w$ and $\dot{p}$ are around 4 -5 %, we know that it is problematic to build on the one-rate presumption of inflation:

(ts 5) Price and wage inflation deviate by an average amount of 25 to 30 %, where half is a long-run deviation. When, nevertheless, (ts 1) holds this means that the feed back mechanisms between $\dot{p}$ and $\dot{w}$ extend over more than one year. Also it strongly suggests that there are feed back effects between the inflation rates at the two markets.

One main purpose of writing this paper is to analyse these mechanisms — they will be the theme of Section IV below.

From Figure 1 it is possible to argue that there is a weak upward trend in the long run inflation rates, but this tendency is dubious and certainly it is dwarfed by large fluctuations, so we shall stick to the formulation (ts 4).

In the time series tradition the combination of trendlessness and large fluctuations call for an analysis of the cyclical structure of the series. This, however, appears less interesting for the economist when reference is made to the *exogenous* character of the "political" events generating a great deal of the fluctuations.[4]

Lots of entertaining stories have been told about the wild price-wage fluctuations following World War I, and the altogether different adjustments after World War II, where wild price-wage movements only occurred in a few countries — especially Japan, Germany, Italy and France. Then there is the seemingly totally unpredicted Korean War price explosion 1950/51 and the causally rather different price explosion after the Yom Kippur War of 1973 involving the OPEC cartel and later the second oil price hike after the Iranian revolution.

In addition to these "world events" there are a number of country specific historical events where some crises occurred that had to be accomodated by a round (or some rounds) of inflation. The most extreme case being the German inflation of 1923/24, but most countries have experienced mild cases — the typical ones being like the French ones of 1936 after the victory of the Front Populaire. 1957/58 during the Algerian crisis where De Gaulle took over, and the "events" of May 1968. Many of those events have included large scale labour unrest, as is evident from *Paldam* and *Pedersen* (1984), and political changes, so there are many stories that beg to be told, but we shall, for the present, resist the temptation.

The large fluctuations generated by political and other exogenous events — each having its own complex explanation — suggest a highly irregular cyclical structure of the series. This, indeed, is what we find, as we shall return to in Section IV. When the cyclical structure becomes less interesting to study, the crucial points instead become: Firstly, the dynamic structure of the processes taking the series into such big swings once they are hit by an exogenous event. Secondly, the centrifugal forces letting price wage movements return to the moderate long run path. Here it is worth remembering that it is no law of nature that inflation has to come down once it goes up — in several Latin American countries inflation rates have continued for several decades around 50 % per year. Also it is worth noting how large the latest big inflation wave has been.

Our main object of study will be the first of these points — the structure of autocorrelation in the series and cross correlation between the series. We have argued that there are no long run trends in the series,

[4] Digging one step deeper one may argue that there are economic factors involved causally in many of the political events mentioned below. However, they are different economic events — often of a long run nature — and they are probably in most cases only minor factors, so for any realistic analytical purpose it is better to cut the causal structure here.

but obviously lots of dynamics. To keep things simple we will work with subperiods without trends too. We have chosen to consider the following three periods:

(P 1) The full period 1913/18 - 80. Here consistent series exist for 14 countries. The main problem is that the 1918 - 21 fluctuations are so wild and unique. Whether or not they are included makes an impact on some of the results.

(P 2) An early period 1923/24 - 54. Here the series exist for (the same) 14 countries. The main problem is the post World War II inflations in a few countries.

(P 3) A later period 1948/50 - 80, excluding the post war inflations. Here consistent series are available for all 17 countries.

The reader should note that (P 1) and (P 2) have some variation in the starting year — the one used for each country is found in Table 1.

Finally, the second point — e.g. the forces returning the inflation rates to their long run averages: Here there is little doubt that the main forces are associated to economic policy making. Governments and (their) central banks clearly want inflation to be strictly limited and so do the populations.[5] The returning pattern, hence contains endogenous policy reactions likely to appear as autocorrelations in the residuals. Therefore, we have two kinds of "policy" elements — the exogenous ones previously discussed and the endogenous ones that come to influence the time series processes estimated.

III. The Theories — what Patterns to Expect

There is a huge literature dealing with the macro dynamics of price and wage rises, see e.g. *Santomero* and *Seater* (1978) and *Chan-Lee* (1980) for surveys. However, the very fact that new work keeps pouring out points to the lack of basic agreement in the field. We shall not attempt to provide another survey of the literature, but only draw a few main lines. A main notion is the one distinguishing between the following three types of terms in price-wage models:

Pull-terms, Π. They are normally taken to be functions of unemployment (u) and related terms (...). At the goods market the basic formulation is the "naive" Keynesian two gap model, and the analogous formulation at the labour market is the "simple" Phillips curve.

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[5] The is a large literature on the relation between the changes in economic conditions and changes in the popularity of government. The most relevant article perhaps is *Hibbs* (1979) and the summary in *Paldam* (1983 b).

Push-terms, ψ. Here two schools exist. In one school the main reason, why people push, is that they expect inflation — i.e. we here use *expected inflation* $\dot{p}^e$ as the argument. The other school tries to identify *actual push variables.* It has come up with a large bag of mixed ad hoc variables of which some are truly exogenous, while most may be causally related to the $\dot{p}^e$ variable. On the goods market we may use import prices ($\dot{p}_M$), the degree of monopoly, etc. On the labour market we may use some expression for the *power* of trade unions, for the *labour market climate* (such as the number of industrial conflict, c_n) or for *policy influences* on the push. The latter being e.g. tax rates, τ, the degree of compensation in unemployment relief payments, various incomes policy proxies etc.

Cross-terms, R. When keeping track of both the goods and the labour market, we need to model how the rate of inflation at the two markets influence each other.[6]

Hence, by presuming the terms to be additive, we have as our basic 'frame' the following model:

(2a) $$\dot{p} = \Pi_p(u, \ldots) + \psi_p(\dot{p}^e, \dot{p}_M, \ldots) + R_p(\dot{w}, \dot{w}_{-1}, \ldots,) + \varepsilon_1$$

(2b) $$\dot{w} = \Pi_w(u, \ldots) + \psi_w(\dot{p}^e c_n, \tau, \ldots) + R_w(\dot{p}, \dot{p}_{-1}, \ldots) + \varepsilon_2$$

(2c) $$\dot{w} = \dot{p} + \dot{g} + \dot{l}_w$$

The model in (2) is obviously a nasty one to work with: It is *simultaneous,* almost *symmetrical,* so that certain effects are likely to be very hard to ascribe to the right equation, and finally it contains variables (such as p, w and p^e) that are likely to be very *collinear*. In short, (2) is an inoperative model for applied work.

However, (2) does contain a number of often discussed issues. As (2) is simultaneous one immediately asks for the reduced form. By linearization of the cross terms:

(3) $$\partial R_w / \partial \dot{p} = \alpha \quad \text{and} \quad \partial Rp / \partial \dot{w} = \beta$$

one obtains the following reduced form:

(4a) $$\dot{p} = \gamma_0 [(\Pi_p + \beta \Pi_w) + (\psi_p + \beta \psi_w)] + \varepsilon_1'$$

(4b) $$\dot{w} = \gamma_0 [(\Pi_w + \alpha \Pi_p) + (\psi_w + \alpha \psi_p)] + \varepsilon_2' ,$$

where $\gamma_0 = 1/(1 - \alpha\beta)$.

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[6] Many terminologies are in use in these matters, and the reader should note ours, especially since we distinguish between push-terms and cross-terms that are merged by most writers. Note that wage indexation is contained in the R_w-term.

Here γ_0 is the *short-run inflation multiplier*.[7] By taking the lags in the cross terms, and in a few other terms to be discussed, into consideration, we may obtain the delayed multipliers, and the (steady-state) *total multiplier*:

$$\gamma = \sum_{i=0}^{\infty} \gamma_i \qquad \text{where } \gamma_i \text{ is the delayed multiplier with the lag } i.$$

If the γ's are even moderately stable, they are a very important set of parameters to estimate. Our findings below and previous work imply that $\gamma_0 = 1.25$ and $\gamma = 2$ - 3. We shall return to model (2) in a moment, but first it is worth considering the standard trick in about 90 % of the literature operationalizing (2). The trick is to apply the one-rate-presumption of inflation, saying that $\dot{g} + l_w$ is constant. That presumption makes (2a) and (2b) collapse into one equation, so that we need one Π and one γ only. Also the cross terms have to be deleted. This reduces (2) to the much discussed expectation augmented Phillips curve (as originally proposed by *Friedman* (1968) and *Phelps* (1967)):

(5a) $$\dot{p} = \dot{w} - \dot{k} \qquad (k \text{ is a constant})$$

(5b) $$\dot{w} = \Pi(u, \ldots) + \psi(\dot{p}^e, \ldots)$$

Model (5) becomes highly *dynamic* once we make $\dot{p}^e$ a function of previous values of $\dot{p}$ (and $\dot{w}$) and other relevant information I:

(6) $$\dot{p}^e = e(\dot{p}_{-1}, I_{-1})$$

The many versions of (6) have been in the center of macroeconomic research for about 15 years. The minimal information available to those setting $\dot{p}^e$ is the inflationary experience $\dot{p}_{-1}$, $\dot{p}_{-2}, \ldots$, and therefore the first version of (6) was the *adaptive* one:

(7) $$\dot{p}_t^e - \dot{p}_{t-1}^e = (1 - \lambda)(\dot{p}_{t-1} - \dot{p}_{t-1}^e) + \varepsilon_{et} \qquad 0 < \lambda < 1 \, ,$$

where $\varepsilon_{et} \sim$ i.i.d. $(0, \sigma_\varepsilon^2)$ is the error term.

In order to simplify the derivations let us now consider a linearized version of (5) with error terms added, i.e.,

(8a) $$\dot{p}_t = \dot{w}_t - k + \varepsilon_{pt}$$

(8b) $$\dot{w}_t = \alpha u_t + \beta \dot{p}_t^e + \varepsilon_{wt}$$

where $\varepsilon_{pt} \sim$ i.i.d. $(0, \sigma_p^2)$ and $\varepsilon_{wt} \sim$ i.i.d. $(0, \sigma^2)$. Note that we have allowed some "price illusion" as β may be different from 1.

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[7] Sometimes termed the price-price or the price-wage multiplier, it summarizes the price-wage spiral. The effects of indexations on inflation can be made explicit from (3) and the expressions for the γ's.

From (8a) and (8b) we may reformulate (8a) as

$$\dot{p}_t = \alpha u_t + \beta \dot{p}_t^e - k + \varepsilon_{wt} + \varepsilon_{pt} , \tag{9}$$

while the expectation generating mechanism in (7) may be written as

$$\begin{aligned} p_t^e &= \frac{1-\lambda}{1-\lambda L} \dot{p}_{t-1} + \frac{\varepsilon_{et}}{1-\lambda L} \\ &= (1-\lambda) \sum_{i=0}^{\infty} \lambda^i p_{t-i} + \sum_{i=0}^{\infty} \lambda^i \varepsilon_{et-i} , \end{aligned} \tag{10}$$

where L is the lag operator.

By inserting (10) into (9) we get

$$\begin{aligned} \{1 - [\lambda + \beta (1-\lambda)] L\} \dot{p}_t &= -k(1-\lambda) + \alpha (1 - \lambda L) u_t \\ &\quad + \beta \varepsilon_{et} + (1 - \lambda L)(\varepsilon_{wt} + \varepsilon_{pt}) , \end{aligned} \tag{11a}$$

while (8b) becomes

$$\begin{aligned} \{1 - [\lambda + \beta (1-\lambda)] L\} \dot{w}_t &= -\beta k (1-\lambda) + \alpha (1 - \lambda L) u_t \\ &\quad + \beta \varepsilon_{et} + (1 - \lambda L) \varepsilon_{wt} + \beta (1-\lambda) L \varepsilon_{pt} . \end{aligned} \tag{11b}$$

Notice that if u_t is considered exogenous (11a) and (11b) are autoregressive distributed lag models of order (1,1), i.e. they have 1 lag on the dependent variables and 1 on the exogenous variable. In addition the disturbance term will be a moving average process at most of order 1, i.e. *MA* (1) as the sum of independent moving average processes is of an order at most equal to the maximum order of the individual processes. Last but not least, the autoregressive lag polynomials and the lag polynomials on the exogenous variable are identical between (11a) and (11b). This implies that (11a) and (11b) constitute the Autoregressive Final Form, see *Hylleberg* (1984).

The univariate time series representation of $\dot{p}_t$ and $\dot{w}_t$ now depends upon the univariate time series representation of u_t. Let this representation be a stationary and invertible autoregressive moving average process of order (r, s),

$$\Phi(L) u_t = \Theta(L) \varepsilon_{ut} , \tag{12}$$

where $\varepsilon_{ut} \sim$ i.i.d. $(0, \sigma_u^2)$ while $\Phi(L) = 1 - \sum_{j=1}^{r} \Phi_j L^j$ and

$$\Theta(L) = 1 + \sum_{j=0}^{s} \Theta_j L^j .$$

Inserting (12) into (11) gives us

$$\begin{aligned} \Phi(L) \{1 - [\lambda + \beta (1-\lambda)] L\} \dot{p}_t &= -k(1-\lambda) \Phi(1) \\ + \alpha (1 - \lambda L) \Theta(L) \varepsilon_{ut} + \beta \Phi(L) \varepsilon_{et} &+ (1 - \lambda L \Phi(L) (\varepsilon_{wt} + \varepsilon_{pt}) \end{aligned} \tag{13a}$$

and

(13b) $$\Phi(L)\,[1-(\lambda+\beta(1-\lambda))\,L]\,\dot{w}_t = -\beta k(1-\lambda)\,\Phi(1) + \alpha(1-\lambda L)\,\Theta(L)\,\varepsilon_{ut} + \beta\Phi(L)\,\varepsilon_{et} + (1-\lambda L)\,\Phi(L)\,\varepsilon_{wt} + \beta(1-\lambda)\,\Phi(L)\,L\,\varepsilon_{pt}\,.$$

The time series processes in (13) are then seen to be ARMA processes of order (R, S) where $R \leq r+1$ and $S \leq [r+1, s+1]$, and where the autoregressive parts are identical, i.e. (13) constitutes the Final Equations of the model, see *Hylleberg* (1984). From this result several models emerge as special cases. The most interesting case is where u_t is an AR (1) process as seems to be the case — see *Paldam* (1984 a). (13a) and (13b) may then be shown to be ARMA (2,2) processes, unless $\Phi_1 = \lambda$, in which case they reduce to ARMA (1,1) processes. The same is true if u_t is white noise and $\Phi_1 \neq \lambda$.

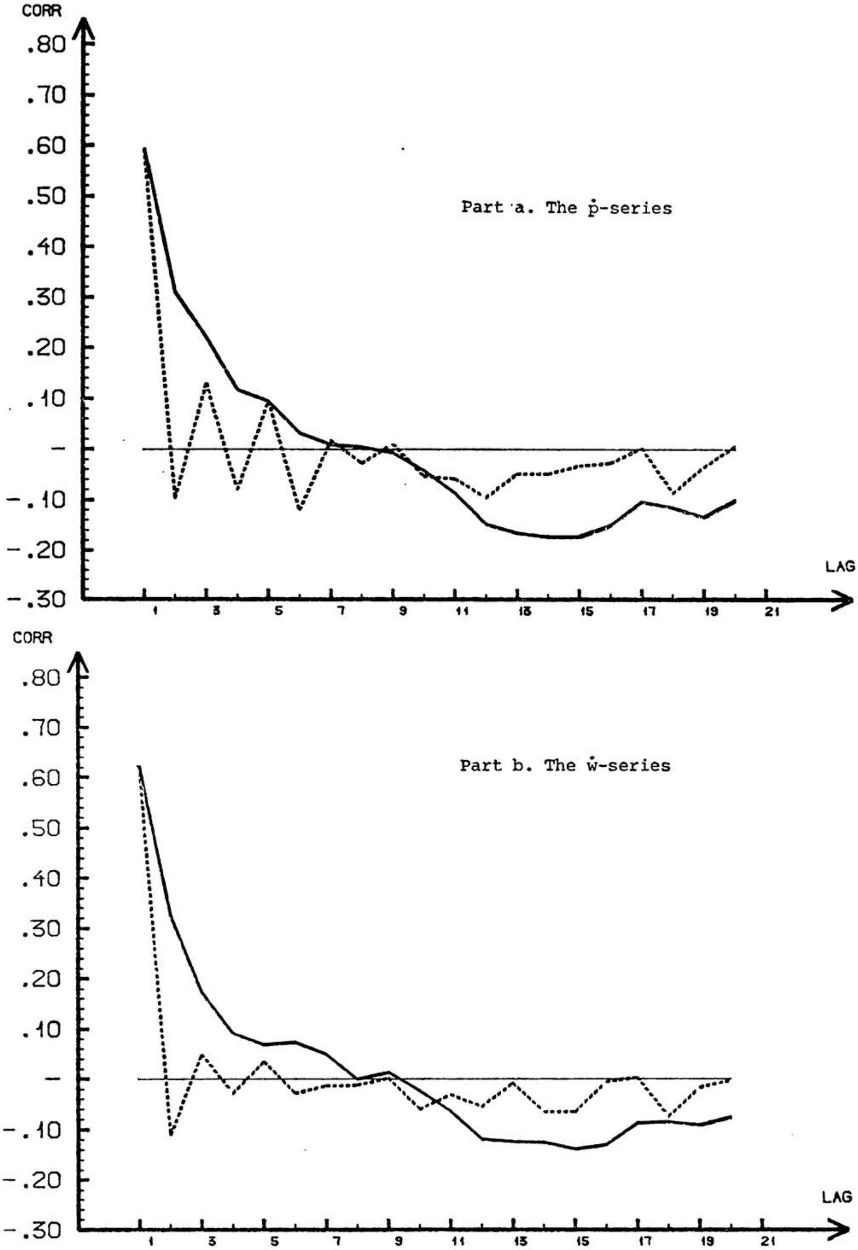
Note that (13) builds on the one-rate presumption that has been *rejected* in Section I. When we *nevertheless* use (13) as the basis for our estimates in Section IV it is because we do not know how the two relationships differ in their dynamics. Our main strategy is that we try to let the data point out the differences in the two processes of the $\dot{p}$ and the $\dot{w}$ series.

Model (13) corresponds to the adaptive model of expectations — being the one extreme end of the spectrum: the LIRE-case, i.e. the Low Information Rational Expectations case, either because people don't care to collect the information or because of the unavailability of the relevant information.[8] In the HIRE-case, the High Information Rational Expectations case, the information I contains the models (5) and (6) also as well as other relevant information. Here the adjustments become fast and irregular and the main time series language message is that we expect *no* stable time series process in the two series.

Therefore we expect, in the RE-theoretical framework to find model (13) as the one extreme and the unstable process as the other extreme. What is really hard to describe are the cases in between. With a little luck (6) might, in these cases, be approximated by another fixed formula, more complex presumably than (7). Then it is in principle straightforward to derive the corresponding time series formulation. The presumptions being that we reach something that contains (13) plus some extra terms of a higher order, which we shall look for in Section IV.

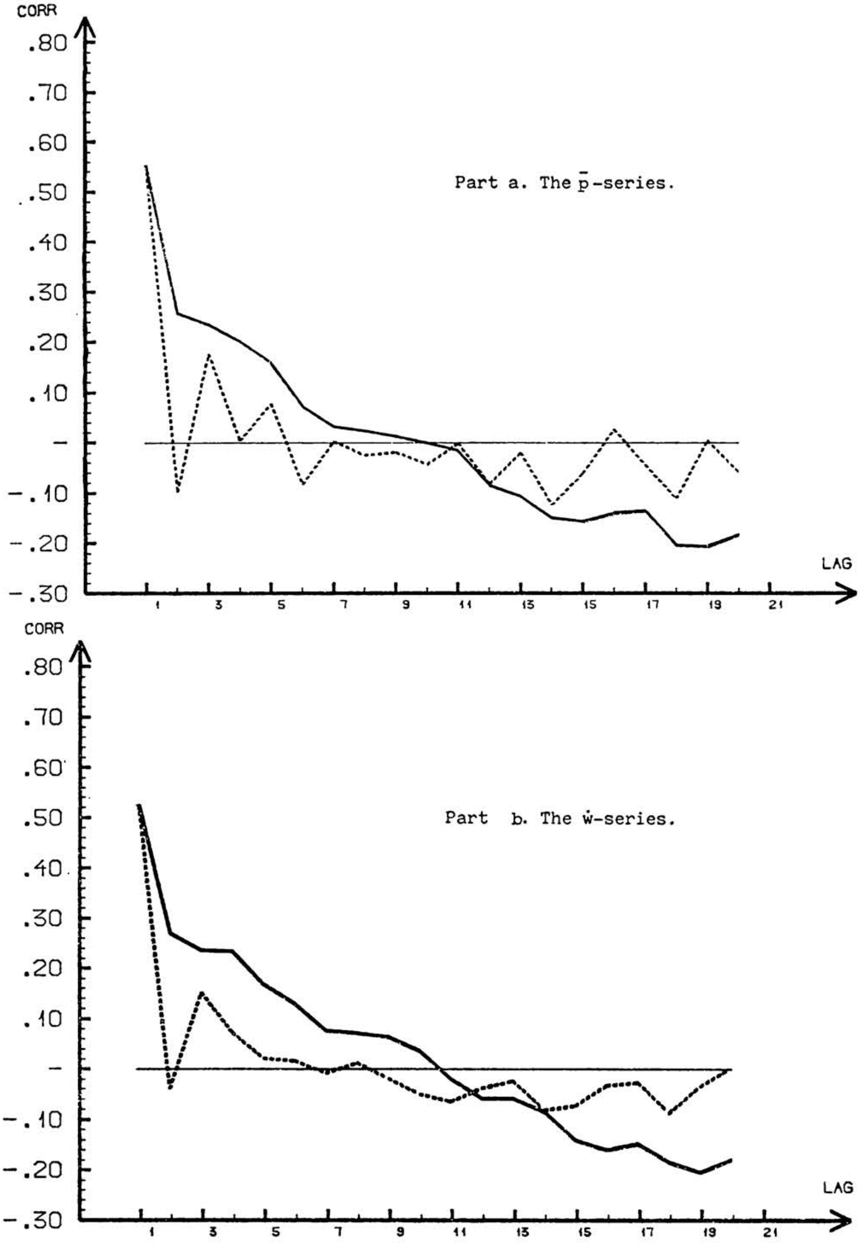
[8] Much depends on the processes revealing the information, and one of the many paradoxes in a *RE*-world is that a sufficient pedestrian information revealing process may give in adaptive adjustment process *even* when the agents take all revealed information into consideration, see the analysis by *Andersen* (1983).

Figure 2 a: The structure of autocorrelation in price and wage rises 1913 - 80 — averages over 14 countries.



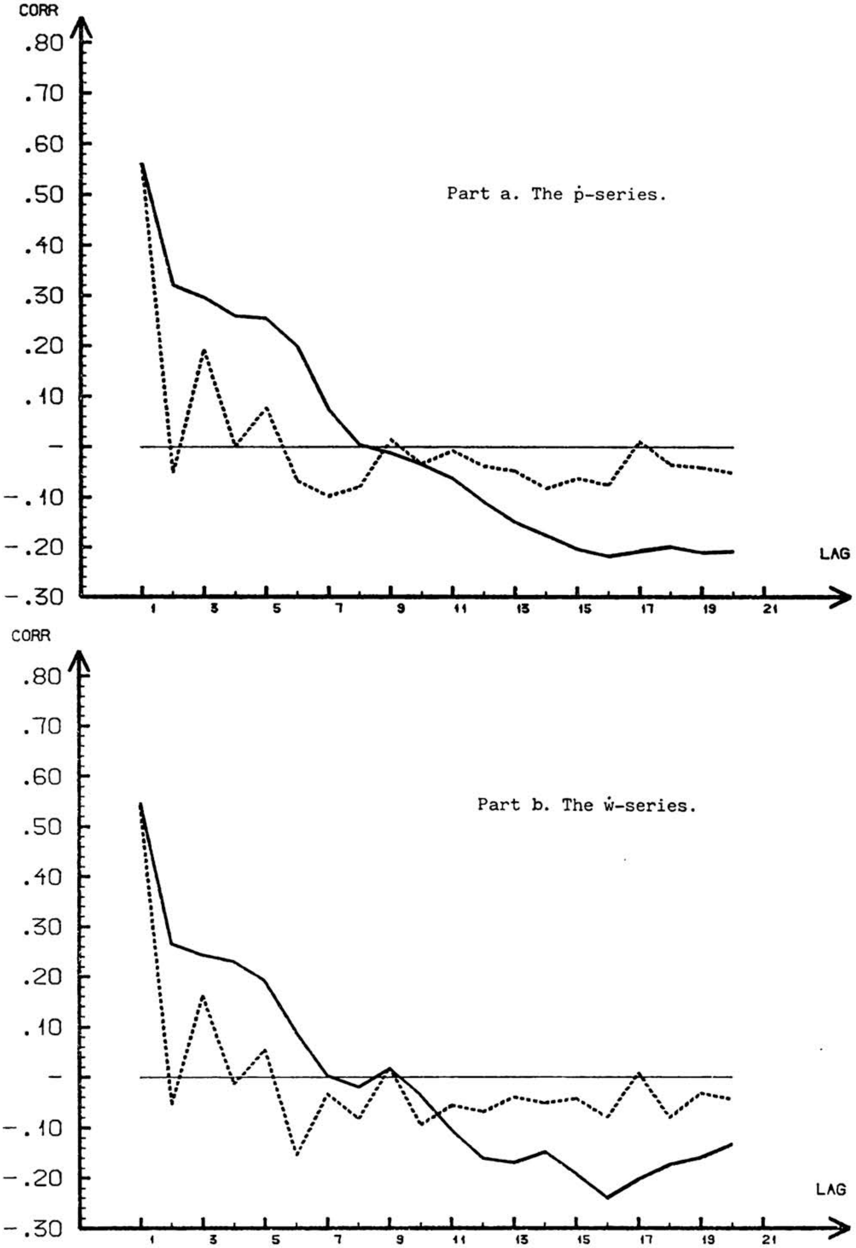
Autocorrelation ————. Partial autocorrelation ....

Figure 2 b: The structure of autocorrelation in price and wage rises 1922 - 54 — averages over 14 countries.



Autocorrelation ————. Partial autocorrelation ....

Figure 2 c: The structure of autocorrelation in price and wage rises 1948 - 80 — averages over 17 countries.



Autocorrelation ————. Partial autocorrelation ....

There is, however, another mixed possibility that on the face of it appears rather reasonable. We shall term it *the mild RE case.*[9] In this case the information I entering into eq. (6) depends on the efforts made in data collection and analysis — or in other words on the attention given to expectation formation. That attention is likely *to change* over time. Perhaps, under "normal" conditions people do not care much, and we observe that the smiple LIRE-pattern modelled in (13) comes to dominate, but then from time to time events (of transitory character perhaps) occur making people care about inflation so that the HIRE-pattern emerges. This we should observe in the form of a disintegration of the nice and simple pattern (8). In such a mild RE world it is important to note how often breakdowns of such patterns occur, and also it is crucial to learn to identify the types of events making the HIRE instability turn up.

Above it was suggested that the dynamics may involve more variables than $\dot{p}^e$ — in *Paldam* (1983 a) it is demonstrated that the number of industrial conflicts has links to wage inflation both ways and with lags, and more variables may very well enter into the complex dynamics of inflation. Therefore there are no need to identify the dynamics of the two inflation variables with inflationary expectations as we have done in the derivation above.[10] In fact *Paldam* (1984 b) is an attempt to present a dynamic theory of price-wage inflation without expectations, but where the dynamics is carried by wage structure shifts involving industrial conflicts.

IV. The Univariate Time Series Structure of Price and Wage Rates Changes: The Final Equations and the Autoregressive Final Form

In Section III it was argued that the Final Equations for $\dot{p}_t$ and $\dot{w}_t$ are ARMA (R, S) processes with identical autoregressive parts. Furthermore, if the unemployment series are AR (1) processes, which seems to be the dominating feature of the applied data set, the order becomes $R = 2 = S$. To investigate these findings, univariate time series models are formu-

[9] Of course, the *RE*-school is mostly known for exploring the extrem HIRE-case, where the new and striking results have emerged, often of a counter-intuitive or paradoxial character, such as the inefficiency results for economic policies. But, on the other hand, what most proponents of *RE* really seem to have in mind, as their *realistic* version of the *RE*-idea would seem to be our mild *RE*-case.

[10] The $\dot{p}^e$-variable is a measurable variable with a standard polling technique. From the attempts made it appear dubious that this variable is actually able to carry the whole of the dynamics of inflation as it does in our formulation following standard theory, see, e. g., *Sheffrin* (1982) for a survey of the evidence.

Table 2 a: **Autoregressive Moving Average Processes of Order 2,2 for the series $\dot{p}_t$ in the period 1948/50 - 1980***

Model ARMA (2,2): $(1 - \Phi_1 L - \Phi_2 L^2)\,\dot{p}_t = \mu + (1 + \Theta_1 L + \Theta_2 L^2)\,\varepsilon_t,\ \varepsilon_t \sim$ n. i. d. $(0, \sigma^2)$

Country	$\hat{\mu}$	$\hat{\sigma}$	$\hat{\Phi}_1$	$\hat{\sigma}_{\Phi 1}$	$\hat{\Phi}_2$	$\hat{\sigma}_{\Phi 2}$	$\hat{\Theta}_1$	$\hat{\sigma}_{\Theta 1}$	$\hat{\Theta}_2$	$\hat{\sigma}_{\Theta 2}$	$\hat{\sigma}$	ϱ_{13} [Fract.]
1. Australia	1.383	1.507	1.105	.557	− .346	.394	− .212	.592	− .066	.286	3.357	5.57 [.04]
2. Belgium	.778	.277	.492	.257	.463	.354	− .450	.234	− 1.007	.233	2.162	8.24 [.17]
3. Canada	− .085	.659	1.192	.260	− .106	.079	− .636	.356	− .723	.281	1.929	3.53 [.00]
4. Danmark	.058	.364	.544	.255	.529	.322	− .304	.182	− 1.102	.221	1.919	5.58 [.04]
5. Eire	.727	.400	.551	.222	.491	.258	− .247	.143	− 1.107	.170	3.074	12.06 [.48]
6. Finland	7.412	2.130	.819	.235	− .898	.116	− .886	.429	1.176	.231	6.535	3.39 [.00]
7. France	.239	1.527	.534	.422	.442	.260	− .507	.381	− .912	.200	3.068	9.13 [.24]
8. Germany	3.247	1.126	.058	.224	− .146	.103	.907	.299	.645	.292	1.280	12.42 [.51]
9. Holland	.122	.824	.509	.199	.491	.230	− .246	.193	− 1.224	.190	2.199	3.48 [.00]
10. Italy	− .171	.270	.643	.240	.553	.252	− .350	.208	− 1.087	.205	3.219	17.51 [.82]
11. Japan	3.861	2.978	.140	.325	.185	.173	.572	.386	.058	.354	3.515	3.28 [.00]
12. New Zealand	− .093	1.055	.602	.238	.555	.229	− .340	.223	− 1.106	.199	2.530	6.76 [.09]
13. Norway	.683	.495	1.218	.289	− .295	.303	− .511	.263	− .6132	.249	2.921	13.46 [.59]
14. Österreich	3.445	.654	.472	.026	− .355	.018	− .403	.315	1.509	.144	1.452	5.21 [.03]
15. Sweden	.194	.963	.544	.219	.510	.400	− .500	.213	− .864	.357	2.860	6.30 [.07]
16. UK	− .553	1.148	.665	.243	.485	.382	− .490	.226	− 1.074	.315	2.984	5.59 [.04]
17. USA	.090	.288	.595	.131	.491	.235	− .534	.195	− .849	.248	1.557	4.59 [.02]
Average	1.255	.980	.628	.255	.179	.242	− .302	.285	− .491	.246		
(Standard error)	(2.084)	(.734)	(.314)	(.112)	(.446)	(.114)	(.429)	(.114)	(.855)	(.061)		

* L is the lag operator and Q_ν the Box-Pierce test statistic for autocorrelation of order 15. Under the null of no autocorrelation Q_ν is asymptotically distributed as χ^2_ν. The bracketed number indicates the Prob $(\chi^2_\nu \leq Q_\nu)$. Notice that the numbers in the parentheses are the standard errors on the observations and not on the average, and furthermore, $\hat{\mu}$ is not an estimate of the man but an estimate of the mean times $(1 - \Phi_1 - \Phi_2)$.

Table 2b: **Autoregressive Moving Average Processes of Order 2,2 for the series $\dot{w}_t$ in the period 1948/50 - 1980***

Model ARMA (2,2): $(1 - \Phi_1 L - \Phi_2 L^2)\, \dot{w}_t = \mu + (1 + \Theta_1 L + \Theta_2 L^2)\, \varepsilon_t,\ \varepsilon_t \sim$ n. i. d. $(0, \sigma^2)$

Country	$\hat{\mu}$	$\hat{\sigma}_{\mu}$	$\hat{\Phi}_1$	$\hat{\sigma}_{\Phi 1}$	$\hat{\Phi}_2$	$\hat{\sigma}_{\Phi 2}$	$\hat{\Theta}_1$	$\hat{\sigma}_{\Theta 1}$	$\hat{\Theta}_2$	$\hat{\sigma}_{\Theta 2}$	$\hat{\sigma}$	ϱ_{13} [Fract.]
1. Australia	.229	1.307	.552	.292	.396	.251	– .445	.255	– 1.096	.149	5.323	2.82 [.00]
2. Belgium	.466	.398	.528	.197	.528	.209	– .309	.176	– 1.190	.157	3.923	12.56 [.52]
3. Canada	.891	1.640	1.103	.531	– .221	.334	– .136	.537	– .321	.312	2.507	7.24 [.11]
4. Danmark	.442	.767	.493	.299	.490	.358	– .564	.324	– 1.018	.373	2.532	8.91 [.22]
5. Eire	– .177	1.172	.547	.426	.529	.518	– .824	.341	– .692	.702	3.944	15.91 [.75]
6. Finland	11.422	4.105	.702	.301	– .773	.216	– .378	.363	.651	.290	5.859	9.13 [.24]
7. France	.531	1.908	.505	.250	.493	.193	– .309	.171	– 1.179	.068	4.027	3.45 [.00]
8. Germany	5.752	4.283	.265	.307	.019	.226	.644	.377	.654	.408	2.121	12.44 [.51]
9. Holland	2.432	.643	.421	.308	.409	.356	– .531	.314	– .898	.326	3.970	7.84 [.15]
10. Italy	.500	.445	.561	.181	.525	.209	– .286	.197	– 1.256	.165	4.075	12.71 [.53]
11. Japan	6.486	3.327	.208	.195	.181	.195	.666	.283	– .065	.276	4.248	2.89 .[00]
12. New Zealand	.008	1.111	.527	.586	.501	.691	.584	.509	– .843	.677	4.172	7.15 [.11]
13. Norway	1.402	1.390	.499	.310	.436	.444	– .355	.175	– 1.053	.208	3.394	6.53 [.08]
14. Österreich	8.435	1.550	.245	.100	– .246	.101	.456	.225	.373	.222	2.385	7.36 [.12]
15. Sweden	3.399	1.572	.670	.239	.018	.258	– .280	.121	– .991	.169	3.493	6.92 [.09]
16. UK	.480	.957	.520	.228	.512	.283	– .481	.195	– 1.122	.152	3.057	8.26 [.17]
17. USA	.482	.792	.664	.265	.271	.245	– .191	.321	– .015	.249	1.320	8.42 [.18]
Average	2.450	1.610	.530	.295	.239	.299	– .230	.287	– .592	.288		
(Standard error)	(3.435)	(1.187)	(.204)	(.122)	(.370)	(.143)	(.425)	(.117)	(.667)	(.175)		

See Table 2a for notes.

Table 2 c: **Autoregressive Moving Average Processes of Order 2,2 for the series $\dot{p}_t$ and $\dot{w}_t$ averages***

Model ARMA (2,2): $(1 - \Phi_1 L - \Phi_2 L^2)(\dot{p}_t, \dot{w}_t) = \mu + (1 + \Theta_1 L + \Theta_2 L^2)\,\varepsilon_t,\ \varepsilon_t \sim$ n. i. d. $(0, \sigma^2)$

Period	Series	$\hat{\mu}$	$\hat{\sigma}_\mu$	$\hat{\Phi}_1$	$\hat{\sigma}_{\Phi 1}$	$\hat{\Phi}_2$	$\hat{\sigma}_{\Phi 2}$	$\hat{\Theta}_1$	$\hat{\sigma}_{\Theta 1}$	$\hat{\Phi}_2$	$\hat{\sigma}_{\Theta 2}$
1913/19 - 1980	$\dot{p}_t$	.883 (1.335)	2.050 (3.996)	.802 (.421)	1.307 (3.663)	.124 (.383)	1.213 (3.645)	− .250 (.378)	1.288 (3.646)	− .600 (.297)	1.139 (3.821)
	$\dot{w}_t$	.826 (.818)	.500 (.267)	.884 (.298)	.196 (.039)	.083 (.326)	.196 (.058)	− .438 (.214)	.161 (.062)	− .648 (.334)	.146 (.095)
1922/23 - 1954	$\dot{p}_t$	.312 (.627)	.652 (.480)	.725 (.286)	.338 (.274)	.211 (.299)	.300 (.290)	− .493 (.106)	.322 (.286)	− .973 (.123)	.303 (.294)
	$\dot{w}_t$	.563 (.843)	.608 (.458)	.743 (.242)	.289 (.087)	.171 (.298)	.252 (.123)	− .580 (.112)	.257 (.063)	− .826 (.188)	.280 (.090)
1948/50 - 1980	$\dot{p}_t$	1.255 (2.084)	.980 (.734)	.628 (.314)	.255 (.112)	.179 (.446)	.242 (.114)	− .302 (.429)	.285 (.114)	− .491 (.855)	.246 (.061)
	$\dot{w}_t$	2.450 (3.435)	1.610 (1.187)	.530 (.204)	.295 (.122)	.239 (.370)	.299 (.143)	− .230 (.425)	.287 (.117)	− .592 (.667)	.288 (.175)

See Table 2a for notes.

lated and estimated based on the well-known procedure of *Box* and *Jenkins* (1970). The time series models are constructed for all countries available in the sample for each of the overlapping time periods P1: 1913/19 - 1980, P2: 1922/23 - 1954, and P3: 1948/50 - 1980.

In formulating the time series models, i.e., socalled autoregressive moving average or ARMA models, the usual tools are applied, i.e. the autocorrelation function and the partial autocorrelation function. In addition the estimated spectra are used in order to investigate the possibility for applying an unobserved components model of the time series models. The unobserved components model where the series is assumed to contain two or more additive unobserved components, often denoted the trend, the cycle, and the irregular component, each having an ARMA representation may be seen as a parsimonious formulation of an ordinary ARMA model, see *Hylleberg* (1984) for a detailed discussion.

The main results obtained in the formulation stage are

(C1) the autocorrelation functions and the partial autocorrelation functions are very similar for the two series $\dot{w}$ and $\dot{p}$ for each country.

(C2) the general picture of the autocorrelation functions for the different countries is one where the autocorrelations die out smoothly. The partial autocorrelation functions have large significant peaks at lag 1 and in some cases lag 2 only, see Figures 2a to 2c, where the average results are shown.

This implies that the first model to estimate is an AR (1) process, but a thorough diagnostic analysis of the residuals indicates that this model doesn't produce a satisfactory description of neither the wage nor the price series. Higher order ARMA processes are then estimated and the general results show that the ARMA (2,2) process is second to none although it by no means produces an excellent description for all countries. In addition the parameters vary across countries especially for the price series while the AR parts are not as similar for both series $\dot{w}_t$ and $\dot{p}_t$ for the individual country as could be expected from the theoretical results. However, the average AR coefficient are quite similar. The results for the period 1948 - 1980 are shown in Tables 2a and 2b, while the average results are presented in Table 2c.

In Section III it was also argued that if the unemployment rate is considered exogenous — a reckless assumption of course — the Autoregressive Final Form of the model described earlier consists of two equations where $\dot{p}_t$ and $\dot{w}_t$ are explained by the unemployment rate unlagged and lagged one period and $\dot{p}_{t-1}$ and $\dot{w}_{t-1}$ respectively, while

Table 3 a: **Conditional Maximum Likelihood Estimates of the Autoregressive Final Form for Price Series (period 1926 - 1980)***

Model: $\dot{p}_t = \gamma + \beta_0 u_t + \beta_1 u_{t-1} + \alpha_1 \dot{p}_{t-1} + \varepsilon_t + \Theta\varepsilon_{t-1} \cdot \varepsilon_t \sim$ n. i. d. $(0, \sigma_\varepsilon^2)$

Country	$\hat{\gamma}$	$\hat{\sigma}_\gamma$	$\hat{\beta}_o$	$\hat{\sigma}_{\beta o}$	$\hat{\beta}_1$	$\hat{\sigma}_{\beta 1}$	$\hat{\alpha}_1$	$\hat{\sigma}_{\alpha 1}$	$\hat{\Theta}$	$\hat{\sigma}_\Theta$	$\hat{\sigma}_\varepsilon$	LM_1 [Fract.]
1. Australia	2.633	1.218	– 1.073	.350	.881	.357	.625	.132	.401	.157	2.77	.15 [.30]
3. Canada	2.263	1.244	– .393	.182	.198	.186	.515	.164	.401	.173	2.58	3.85 [.95]
4. Denmark	1.502	1.608	.946	.539	– .913	.549	.653	.156	.050	.204	4.17	5.08 [.98]
5. Eire	– .393	1.045	.465	.481	– .310	.488	.920	.099	– .485	.181	4.56	4.58 [.97]
6. Finland	8.510	4.659	– 2.004	1.810	.530	1.967	.418	.255	.111	.279	10.09	2.46 [.88]
16. UK	.873	.860	– .754	.348	.741	.346	.882	.097	– .200	.177	3.32	3.53 [.94]
17. USA	2.392	1.145	– .627	.160	.517	.161	.444	.146	.611	.132	2.37	.72 [.60]
Average	2.325	1.683	– .491	.553	.235	.579	.637	.150	.127	.186		
(Standard error)	(2.979)	(1.332)	(.975)	(.572)	(.640)	(.628)	(.200)	(.053)	(.381)	(.047)		

* *LM* is the Lagrange Multiplier test for an *MA* (2) error process. Under the null of an *MA* (1), the *LM* statistics is asymptotically χ_1^2, see Hylleberg (1984).

Table 3 b: **Conditional Maximum Likelihood Estimates of the Autoregressive Final Form for Wage Series (period 1926 - 1980)***

Model: $\dot{w}_t = \gamma + \beta_0 u_t + \beta_1 u_{t-1} + \alpha_1 \dot{w}_{t-1} + \varepsilon_t + \Theta \varepsilon_{t-1} \cdot \varepsilon_t \sim$ n. i. d. $(0, \sigma_\varepsilon^2)$

Country	$\hat{\gamma}$	$\hat{\sigma}_\gamma$	$\hat{\beta}_0$	$\hat{\sigma}_{\beta 0}$	$\hat{\beta}_1$	$\hat{\sigma}_{\beta 1}$	$\hat{\alpha}_1$	$\hat{\sigma}_{\alpha 1}$	$\hat{\Theta}$	$\hat{\sigma}_\Theta$	$\hat{\sigma}_\varepsilon$	LM_1 [Fract.]
1. Australia	4.940	2.352	– 1.332	.582	.961	.590	.506	.210	.177	.248	5.23	1.24 [.73]
3. Canada	3.499	1.342	– .737	.146	.595	.155	.578	.120	.616	.125	2.22	1.23 [.73]
4. Denmark	2.463	1.451	– .356	.420	.063	.454	.846	.097	– .400	.180	3.51	24.50 [1.00]
5. Eire	0.991	1.809	– .315	.355	.248	.342	.968	.041	– .670	.132	4.15	.00 [.04]
6. Finland	1.711	4.005	– 2.871	1.481	2.751	1.715	.906	.179	– .681	.259	11.26	1.27 [.74]
16. UK	.482	.985	– .634	.339	.652	.336	.957	.093	– .644	.170	4.71	.78 [.62]
17. USA	4.809	1.482	– 1.255	.225	1.175	.280	.123	.137	.589	.138	3.34	8.35 [.99]
Average	2.699	1.918	– 1.071	.507	.921	.553	.698	.125	– .153	.179		
(Standard error)	(1.778)	(1.014)	(.888)	(.451)	(.893)	(.534)	(.313)	(.057)	(.586)	(.055)		

* See Table 3 a for notes.

Table 3 c

Estimates of α, λ and β obtained from Tables 3 a and 3 b

Country	Equation	$\hat{\alpha} = \beta_0$	$\hat{\lambda} = -\hat{\beta}_1/\beta_0$	$\hat{\beta} = (\hat{\beta}_0 \hat{\alpha}_1 + \hat{\beta}_1)/(\hat{\beta}_0 + \hat{\beta}_1) = (\hat{\alpha}_1 - \hat{\lambda})/(1 - \hat{\lambda})$
1. Australia	$\dot{p}_t$	− 1.073	.821	− 1.095
	$\dot{w}_t$	− 1.332	.721	− .771
3. Canada	$\dot{p}_t$	− .393	.504	.022
	$\dot{w}_t$	− .737	.807	− 1.187
4. Denmark	$\dot{p}_t$	.946	.965	− 8.914
	$\dot{w}_t$	− .356	.177	.813
5. Eire	$\dot{p}_t$	.465	.667	.760
	$\dot{w}_t$	− .315	.787	.849
6. Finland	$\dot{p}_t$	− 2.004	.264	.209
	$\dot{w}_t$	− 2.871	.958	− 1.238
16. UK	$\dot{p}_t$	− .754	.983	− 5.941
	$\dot{w}_t$	− .634	1.028	2.536
17. USA	$\dot{p}_t$	− .627	.825	− 2.177
	$\dot{w}_t$	− 1.225	.936	− 12.703
Average	$\dot{p}_t$	− .491	.718	− 2.248
		(.975)	(.260)	(3.637)
	$\dot{w}_t$	− 1.071	.773	− 1.672
		(.888)	(.284)	(5.052)

the error processes are first order moving average processes. The autoregressive parts of the two equations are identical here as well, as are the coefficients to the unemployment series. The results of a conditional maximum likelihood estimation of the parameters applying the Gauss-Newton algorithm, see *Hylleberg* (1984), are shown in Tables 3a and 3b, for only 7 countries. For the eighth country, Sweden, the maximum likelihood algorithm doesn't converge while the unemployment series are presently unavailable for the remaining countries, at least for the whole period.

Again the results are somewhat mixed, as the coefficients to the lagged dependent variables, i.e. $\dot{p}_{t-1}$ and $\dot{w}_{t-1}$ are very similar on average at least while the coefficients to the unemployment series are not. For the price equation some of the estimates also exhibit 'wrong' signs although not significantly so.

From (11a) and (11b) it is seen that the estimates of α and λ may be found as $\hat{\beta}_0$ and $-\hat{\beta}_1/\hat{\beta}_0$ respectively and an estimate of β is found as $(\hat{\beta}_0\,\hat{\alpha}_1 + \hat{\beta}_1)/(\hat{\beta}_0 + \hat{\beta}_1) = (\hat{\alpha}_1 - \hat{\lambda})/(1 - \hat{\lambda})$. While the estimates of the adjustment parameter λ look reasonable the estimates of β are implausible. However, it is worth remembering that the variance on these estimates are very high due to the form of the formula $(\hat{\beta}_0\,\hat{\alpha}_1 + \beta_1)/(\hat{\beta}_0 + \hat{\beta}_1) = \hat{\beta}$.

In concluding this section it must be admitted that the 'theories' put forward in section II are only partly supported by the results, and that more analysis is required before any conclusion is drawn.

V. The Interdependence of Price and Wage Rises

In order to throw some further light on the questions already addressed in Section IV a correlation analysis of the lead-lag structure of the series $\dot{p}$ and $\dot{w}$ is undertaken.

The correlation analysis consists of the calculation of the following 7 correlations for our (14 + 14 + 17 =) 45 countries and 3 periods:

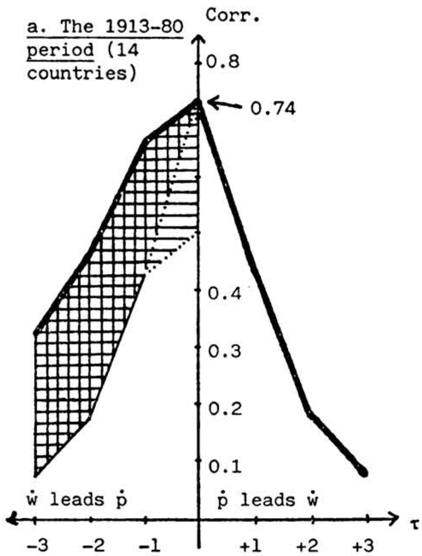
(14) $$r_\tau = r\,(\dot{w}, \dot{p}_\tau), \tau \in [-3, -2, -1, 0, +1, +2, +3]\ .$$

I.e. r_{-2} is the correlation between the $\dot{w}$-series and the $\dot{p}$-series lagged 2 years etc.

If identical univariate time series generate $\dot{w}$ and $\dot{p}$ the correlogram r_τ should be symmetrical around $\tau = 0$ and fall from the axis as the corresponding autocorrelation functions on figures 2a - f. From Figure 3a - c it is obvious that the correlograms are not symmetrical and they indicate that $\dot{w}_t$ leads $\dot{p}_t$ in the periods 1913 - 1980 and 1922 - 1954 but not in 1948 - 1980.

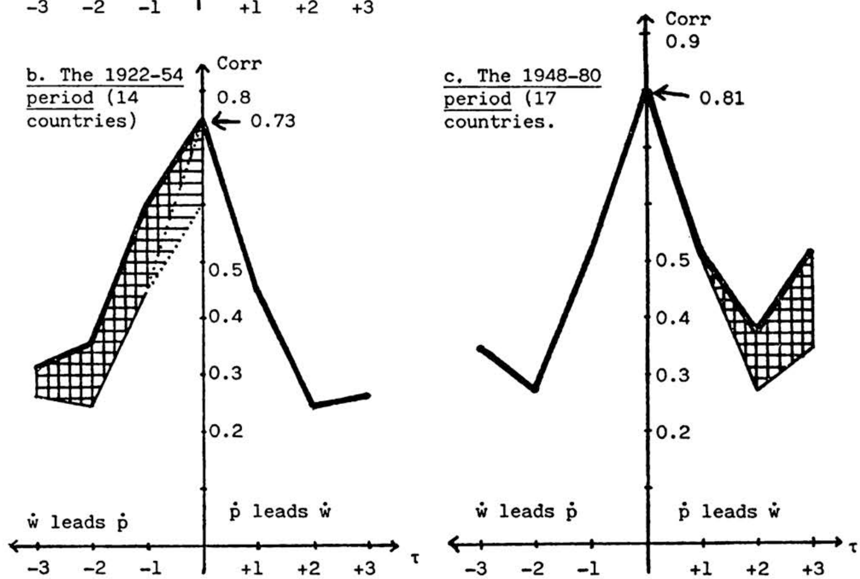
To further investigate this point formal tests for Granger non-causality have been carried out. Three test statistics have been computed, see *Harvey* (1981) in order to test the hypothesis that $\dot{w}_t$ non Granger causes $\dot{p}_{tj}$; i.e. »n.G.c.«. The so-called direct test, Test No. 1, is executed by a regression of $\dot{p}_t$ on lagged values of itself, i.e. $\dot{p}_{t-i}$, $i = 1, 2, \ldots, m_1$ and on lagged values of $\dot{w}_t$ i.e. $\dot{w}_{t-j}$, $j = 1, 2, \ldots, m_2$, testing the joint significance of $\dot{w}_{t-j}$, $j = 1, 2, \ldots, m_2$ by the usual F-test.

Figure 3: Correlograms between the p & w series



Note 1: The figures show the unweighted averages of the underlying 14, 14 and 17 such correlograms calculated.

The shaded areas give the deviations from symmetry as regards the corr-axis. Note the problem with the last line before the axis. The two dotted lines are drawn symmetrically and parallel with the corresponding heavy lines.



Note 2: τ = -3, -2, -1, 0, +1, +2, +3 defines the lead/lag axis where ṗ lags ẇ by 3, 2, 1 and 0 years and then leads by 1, 2 and 3 years.

Table 4 a

Tests for Granger non-causality. Fractile probabilities*

Country	Hypothesis	1913 - 1980			1922 - 1954			1948 - 1980		
		1	2	3	1	2	3	1	2	3
1. Australia	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	.61	.92	.86	.76	.61	.29	.05	.77	.46
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	.99	1.00	.99	.88	.51	.30	.96	.81	.62
2. Belgium	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	—	—	—	—	—	—	.99	.99	.97
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	—	—	—	—	—	—	.89	.68	.68
3. Canada	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	.96	.92	.94	.80	.50	.57	.35	.94	.83
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	.99	.98	.99	.88	.70	.82	1.00	1.00	.99
4. Denmark	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	.95	.96	.61	.56	.14	.28	.25	.06	.11
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	.85	.05	.50	.61	.77	.64	.85	.64	.85
5. Eire	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	.85	1.00	.98	.31	.75	.54	1.00	.89	.73
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	.89	.48	.73	.87	.42	.33	.91	.58	.57
6. Finland	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	1.00	1.00	1.00	1.00	.75	.84	.70	.98	.82
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	.35	.99	.97	.45	.95	.91	.80	.83	.70
7. France	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	.98	1.00	1.00	.97	.99	.98	.80	.99	.91
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	.82	.82	.66	.68	.89	.69	.15	.40	.55
8. Germany	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	—	—	—	—	—	—	.68	.64	.99
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	—	—	—	—	—	—	.59	.07	.42
9. Holland	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	.16	.01	.23	.39	.12	.24	.31	.22	.25
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	.72	.82	.82	.99	.94	.86	.53	.04	.05
10. Italy	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	.12	.03	.20	.00	.49	.65	.65	.98	.97
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	1.00	1.00	1.00	1.00	1.00	1.00	.19	.68	.57
11. Japan	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	.83	.34	.74	.43	.87	.57	.94	.96	.74
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	1.00	1.00	1.00	1.00	1.00	1.00	.76	.96	.97
12. New Zealand	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	.26	.86	.86	.07	.17	.03	.36	.62	.87
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	.72	.84	.58	.81	.74	.51	.68	.98	.94
13. Norway	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	1.00	1.00	.88	.33	.87	.52	.68	.53	.50
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	1.00	.91	.99	.78	.86	.65	.14	.50	.13

Country	Hypothesis	1913 - 1980			1922 - 1954			1948 - 1980		
		1	2	3	1	2	3	1	2	3
14. Austria	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	—	—	—	—	—	—	.72	.68	.73
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	—	—	—	—	—	—	.66	.54	.51
15. Sweden	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	.84	.30	.24	.64	.17	.50	.19	.53	.36
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	1.00	.68	.71	.87	.17	.44	.43	.17	.35
16. UK	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	1.00	.43	.35	.09	.12	.11	1.00	.79	.72
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	.97	.98	.88	.76	.64	.67	.73	.58	.34
17. USA	$\dot{w}_t$»n.G.c.«$\dot{p}_t$	.87	.24	.84	.76	.42	.72	.69	.82	.78
	$\dot{p}_t$»n.G.c.«$\dot{w}_t$	.62	.60	.99	.67	.66	.94	.67	.24	.05

* The fractile probabilities indicate the probability of obtaining a value less than or equal to the *F* statstical computed under the null. The degrees of freedom in the numerator are 8 for the period 1913 - 80 and 5 for the remaining periods. The notation » n.G.c. « indicates "non-Granger causing".

Sims' test, Test No. 2, is based on a regression of $\dot{w}_t$ on $\dot{p}_{t-i}$, $i = 0, 1, 2, \ldots, m_1$ and $\dot{p}_{t+j}$, $j = 1, 2, \ldots, m_2$ and the test statistic is the well-known F statistic for the joint significance of the coefficients to the future values $\dot{p}_{t+j}$, $j = 1, 2, \ldots, m_2$.

In the last test, Test no. 3 or Geweke's test, the set of regressors in Test no. 2 is extended by m_3 lagged values of $\dot{w}_t$, i.e., $\dot{w}_{t-i}$, $i = 1, 2, \ldots, m_3$ and by p_{t-m_1-i}, $i = 1, 2, \ldots, m_3$. This extension is made in order to decrease the sensibility of Test no. 2 to serially correlated errors.

The tests of $\dot{p}_t$ non-Granger causing $\dot{w}_t$ are carried out analogously and the results are shown in Table 4a while Table 4b contains a summary of these results. To explain the results in Table 4a consider the test of the hypothesis HO $\dot{w}_t$ »n.G.c.« $\dot{p}_t$, i.e., w is non-Granger causing p_t for Australia in the period 1913 - 1980. Here Test no. 1 gave an F-value equal to .61 whereby the null hypothesis may be rejected at a level of significance of .39 or higher.

The results in Table 4b show a surprisingly weak indication of causality i.e. prediction ability except for the period 1913 - 80 where the dramatic years following World War I gave some significant results. In that period especially Geweke's test, which may be preferable, indicates a direction of causality from prices to wages, if any. The overal weak indication of the direction of causality may be due to the data being yearly. This conjecture is supported by later works applying quarterly data.

Table 4 b

Summary of the Granger non-causality tests

Hypotheses	Period	Test number	Number of rejections at significance level less than or equal to				Total number
			0.05	0.10	0.15	0.20	
Wages non-Granger Causing Prices $\dot{w}_t$»n.G.c.«$\dot{p}_t$	1913 - 80	1	6	6	8	10	14
		2	5	7	8	8	
		3	2	3	6	7	
	1922 - 54	1	2	2	2	3	14
		2	1	1	4	4	
		3	1	1	1	2	
	1948 - 80	1	3	4	4	5	17
		2	5	6	7	8	
		3	3	4	5	7	
Prices non-Granger Causing Wages $\dot{p}_t$»n.G.c.«$\dot{w}_t$	1913 - 80	1	7	7	9	10	14
		2	6	7	7	10	
		3	7	7	8	9	
	1922 - 54	1	3	3	7	8	14
		2	3	4	6	6	
		3	2	4	5	6	
	1948 - 80	1	2	3	5	6	17
		2	3	3	3	5	
		3	2	3	4	3	

Summary

The results presented above explain why so many controversies have managed to stay alive within the field of price-wage inflation. At the same time it is demonstrated that it is essential to base empirical conclusions on large data sets, since it is quite easy to choose subsets 'confirming' very different views.

Although the dominating feature of the Final Equations for the wage and price inflation seems to be ARMA (2,2) processes corresponding to the

simple adaptive expectation augmented Phillips-curve the exceptions are many. The Autoregressive Final Forms with the unemployment rate as the exogenous variable likewise exhibit considerable variation.

However, in some cases like Germany the deviations from the dominating pattern may be explained by their specific inflationary experience.

At last, the analysis of the lead-lag relation between price and wage inflation also shows a very mixed picture with a surprisingly weak indication of 'causality' in the Granger sense of the word.

Zusammenfassung

Die vorliegenden Ergebnisse erläutern die Ursache der lang bestehenden Kontroverse der Preis-Lohn-Inflation. Die Wichtigkeit von großen Daten-Sätzen in empirischen Resultaten wird durch die Tatsache dargelegt, daß durch entsprechende Wahl von Daten-Untergruppen sehr verschiedene Ansichten bestätigt werden können.

Der ARMA (2,2)-Prozeß erscheint als das Hauptmerkmal der „Final Equation", die der Phillips-Kurve mit adaptiven Erwartungen entspricht. Die Dominanz der ARMA (2,2)-Prozesse ist jedoch nicht sehr ausgeprägt. Auch die ‚Autoregressive Final Forms' mit der Rate der Arbeitslosigkeit als exogener Variablen zeigt große Variationen.

In einigen Fällen jedoch, wie zum Beispiel für Deutschland, können die Abweichungen von dem allgemeinen Muster durch spezifische Inflationserfahrungen erklärt werden.

Schließlich zeigt auch die Analyse der „lead-lag"-Verbindungen zwischen Preis- und Lohn-Inflation ein sehr gemischtes Bild mit einer überraschend schwachen Indikation von „ursächlichem Zusammenhang" im Sinne Grangers.

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