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THE WAGE-PRODUCTIVITY HYPOTHESIS IN A SMALL DEVELOPING COUNTRY: THE CASE OF BARBADOS

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ABSTRACT

This paper examines the relationship between wages and productivity using a bargaining framework. The empirical estimation uses the theory of cointegration. The data do not support the efficiency wage hypothesis which suggests that the wage rate has a direct positive impact on labour productivity. Some support is found for a sequential approach to bargaining where productivity targets are set and realised values are incorporated into the wage determination process.

1. INTRODUCTION

In a series of papers Stiglitz (1974, 1976, 1982, 1986) examined the relationship between the wage rate and productivity in developing countries within a dual (urban-rural) labour market framework. In his specification of the "wage-productivity" hypothesis, Stiglitz posited a number of reasons why an increase in the wage rate may have a positive effect on labour productivity. These reasons fall within the general framework of "efficiency wage" models of the labour market (see Akerlof and Yellen (1986), Katz (1986), Carmichael (1990)).[1] Efficiency wage-productivity models tend to rest on two basic assumptions: employers have less information about the productivities of their individual workers than those workers have, and employers make the wage and employment decisions unilaterally (see Blanchard and Fischer (1989)). Although these models provide a link between wages and productivity (work effort) they have two main drawbacks. First, they ignore the fact that a major labour institution, the trade

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union, is involved in the setting of wage rates and conditions of service which affect labour productivity. Second, "efficiency wage" models suggest that causality runs from the wage rate to labour productivity with no feedback (or bi-directional) mechanism. There is need to relax the second assumption of the efficiency wage models and to incorporate a bargaining framework into the specification of the wage-productivity hypothesis.

The main purpose of this paper is to examine the wage-productivity hypothesis within a bargaining framework using a small developing country (SDC), Barbados, as a case study. From a methodological perspective, the bargaining framework provides a unifying structure within which the wage-productivity relationship can be specified. In this paper, the relationship is developed at a macroeconomic or aggregate level, thus ignoring the urban-rural emphasis in the Stiglitz-type models.[2]

There are a number of assumptions relating to a SDC which guide the analysis in this paper. First, the SDC has a fixed exchange rate with its main trading partner. Second, both import and export prices are exogenously determined in the world market. Third, the SDC imports a substantial degree of its intermediate and capital goods. Finally, wages negotiated by unions and employers dominate the labour market (that is, there are spillover effects into the non-unionised labour market). These characteristics permit the incorporation of "international economy" variables into a bargaining specification of the wage-productivity relationship.

The structure of the paper is as follows. First, a model of the "wage-productivity" relationship is specified using a bargaining framework. The output of this section is the wage and labour productivity equations which can be estimated at the macroeconomic level. Second, the econometric framework used in the paper is outlined. The econometric modelling framework used is based on cointegration theory which seeks to identify whether a model consisting of a set of variables suggested by economic theory has a "long run equilibrium" and is thus "well defined" (see Engle and Granger (1987), Johansen (1989)). The procedure also serves as a simplifying device in model design, permitting the separation of the "long-run equilibrium" information in the data from the "short-run" dynamic adjustment behaviour of the relationship. Third, the wage-productivity model is estimated for Barbados over the period 1955-1990. Finally, the implications of the results are explored.

2. THEORETICAL FRAMEWORK

(a) Wage-Productivity Bargaining

While standard models in the bargaining literature focus on collective bargaining over wages and/or employment, that is, labour demand and contract (efficient bargain) models (see Oswald (1985), Faber (1986)), recent attempts have been made by Rosen (1989) and Johnson (1990) to formulate models based on bargaining over wages and labour effort or productivity. In wage bargaining models, changes in labour productivity are used as one of the criteria in determining the final wage outcome. As Wiseman (1956) notes, the "basic requirement of a non-inflationary wage is that in a long-term trend money wages for the economy as a whole should not rise faster than average productivity per worker-hour in the economy as a whole" (p.261). Trade union negotiators are particularly interested in maximising the welfare of the general membership by ensuring that productivity gains are incorporated into the negotiated wage outcome.

In the wage-productivity models outlined by Rosen (1989) and Johnson (1990) productivity is considered as an explicit bargaining issue. Unions submit a package of proposals for both wage increases and improved conditions of service to employers. Improved conditions of service can result in an increase in labour productivity or work effort which are later incorporated in future wage proposals and outcomes. Union negotiators may be willing to discuss a trade-off between the wage and non-wage components of the package. Employers in conceding to an increase in wages may seek to obtain an assurance from the unions that labour productivity (work effort) would be increased. Productivity may also be an explicit bargaining issue especially when it is linked to the unions' response to changes in technology or to the employers' desire for flexibility in the use of labour (see Craypo (1986), p.58-63). Bargaining explicitly over some "target" level of productivity (that is productivity bargaining) is said to have a positive effect on the firm by improving morale and cooperation among workers and management and by inducing management to alter production methods and introduce more efficient working practices (see Freedman and Medoff (1984)). In bargaining over wages and (target level) productivity, therefore, both the unions and employers must have an understanding of the factors affecting both variables.

The negotiated outcome over wages and productivity (work effort), with the employers determining employment, is given by a Nash bargain which is derived from the maximisation of the product function:

$$V = [N(.) - N_0]^{\beta}.[\Pi(.)\Pi_0]^{1-\beta} \quad (1)$$

where N(.) is the unions' utility function, N_0 is the unions' threat point, that is, the utility obtained in the case of a disagreement; $\Pi(.)$ is the employers' profit function, Π_0 is the employers' fall-back level of profit. The β parameter is the degree of union power or, alternatively, the bargaining parties' different beliefs concerning the probability that the negotiations will break down (see Binmore et al (1986)).[3]

The utility enjoyed by the unions is given by:

$$N = N\left(\overset{+}{W},\overset{+}{E};\overset{\pm}{Z}\right) \quad (2)$$

where W is the money (nominal) wage, E is the target labour productivity level and Z is a set of variables affecting the utility function of the unions. In the bargaining process, trade unions seek to maximise this utility function. Employers on the other hand seek to maximise profit as defined by the function:

$$\Pi = \Pi\left(\overset{-}{W},\overset{+}{E};\overset{\pm}{\Phi}\right) \quad (3)$$

where Φ is a vector of variables affecting the employers' profit function. The signs above the variables indicate the anticipated direction of impact of the explanatory variables on N and Π. The vectors Z and Φ define the set of conditioning variables which unions and employers take into consideration during the collective bargaining process.

If the bargaining outcome is assumed to be Pareto efficient, then the contract curve defining all Pareto efficient solutions can be derived by identifying all points where the employers' iso-profit curve is tangential to the unions' indifference curve within the wage-productivity (W,E) space (see Rosen (1989)).

Differentiating equation (2) conditioned on the Z vector yields:

$$dN|_{Z^*} = N_W dW + N_E dE \quad (4)$$

Setting equation (4) equal to zero and treating the Z vector as a shift parameter, then the slope of the unions' indifference curve in the (W,E) space is given by:

$$\left.\frac{dW}{dE}\right|_{Z^*,N^*} = -\frac{N_E}{N_W} < 0 \quad (5)$$

that is, the unions' indifference curve is negatively sloped or convex to the origin.

Similarly, differentiating equation (3) conditioned on the Φ vector and setting the result to zero gives the slope of the iso-profit curve:

$$\left.\frac{dW}{dE}\right|_{\Phi^*,\Pi^*} = -\frac{\Pi_E}{\Pi_W} > 0 \quad (6)$$

since $\Pi_W < 0$. The iso-profit curve is therefore quasi-concave to the origin.

The Pareto optimal solution on the contract curve is given by the first order condition:

$$\left.\frac{dW}{dE}\right|_{Z^*,N^*} = \left.\frac{dW}{dE}\right|_{\Phi^*,\Pi^*} \quad (7)$$

The specified negotiated outcome on the contract curve, conditioned on Z and Φ, depends on the value of the β parameter, that is, the degree of the bargaining power exercised by the respective parties.

From the first-order condition, reduced form equations can be derived for the wage and labour productivity variables in terms of Z and Φ. A reparameterisation of the reduced form equations can yield structural equations for W and E. The elements of Z and Φ depend on the economic environment which the unions and employers take into consideration when bargaining over wages and productivity. In the case of an SDC both domestic and external factors must be taken into account.

(b) Factors Affecting Wages and Productivity

In their model of wage determination in an SDC, Downes and McClean (1982) identified a set of variables constituting the Z and Φ vectors in the case of wage bargaining. This set of variables can be augmented when bargaining takes place over both wages and productivity. In the case of wage bargaining Downes and McClean (1982), and Downes, Holder and Leon (1990) identified the price of exports (PX), labour productivity (E) and the aggregate price level (P) as having a positive effect on the degree of trade union "pushfulness" in the bargaining process. If the unions can negotiate a wage increase greater than the rise in the price level, then their level of utility increases as the real wage rate rises. If the wage rate increase is equal to the increase in the price level, then the unions' utility function remains unchanged. If the foreign price of exports increases in a fixed exchange rate regime, then export-oriented firms would realise a rise in revenue. The unions will seek to appropriate some of this revenue gain in the form of higher wages, thus increasing their level of utility.

The employers' profit function is inversely related to the price of imported inputs (PM), indirect taxes which affect the cost of production (Γ), and the overall solvency of the firm (Θ). On the other hand, the aggregate price level (P), the price of exports (PX) and labour productivity (E) generally have a positive effect on the employers' profit function.

In an SDC characterised by a high level of unemployment, the unemployment rate can play an important role in the bargaining process. The unemployment rate can be used to capture excess supply conditions in the labour market which affect the demand for output or sales. Downes, Holder and Leon (1990) argued that high levels of unemployment tend to weaken trade unions' pushfulness and strengthen employers' resistance to high wage outcomes. In effect, the unemployment rate has a negative effect on trade unions' pushfulness (and hence utility) and also on the employers' profit function via the sales effect.

In the identification of the variables in the wage bargaining process, Downes and McClean (1982), and Downes, Holder and Leon (1990) treated labour productivity as an exogenous variable; that is, labour productivity is "weakly separable" from the wage determination process. If there is explicit bargaining over labour productivity, then the set of factors affecting labour productivity must be considered in the Z and Φ vectors. Labour productivity depends on a number of economic, technological and organisational factors (see Downes and Nurse (1988)). More specifically, productivity is dependent on technical changes in the production process, on expansion in both domestic and foreign demand for output, on real wage changes (as suggested by the efficiency wage hypothesis), on organisational changes and management practices, and on improvements in human capital. In a SDC, capital and intermediate goods are largely imported so that the technical change embodied in these goods can result in an increase in output with the same or decreasing levels of labour employed. Trade unions are particularly concerned about the employment-displacing effects of technical change and would therefore seek to ensure that there is no reduction in the economic welfare of their members. Employers, on the other hand, view such changes in a positive light since labour productivity is increased, hence resulting in lower prices and an increase in the demand for output.

The expansion of total demand (domestic and external) provides an "economies of scale" argument for changes in the level of productivity as formulated in the so-called "Verdoon's Law" (see Bairam (1987)). This "Law" posits a positive relationship between the rate of growth of output and labour productivity changes. The "law" is based on the existence of "dynamic economies of scale" arising in practice from the division of labour, market and organisational change and "learning-by-doing" effects and, implicitly, from capital accumulation (investment) and the technical changes embodied in new machinery and equipment.

Measured labour productivity tends to fluctuate pro-cyclically, that is, increasing during expansions and decreasing during contractions. When the economy contracts and there is a fall in the demand for the firms' output, they may either lay off workers or cut back on the length of working schedules. In the latter case, firms may decide to hold excess labour (that is, labour hoarding) if it is costly to hire and fire workers (high labour adjustment costs). These adjustment costs may be embedded in legislation secured by trade unions with a strong political influence. The labour input thus becomes a quasi-fixed factor of production. If the fall in demand is perceived to be more permanent than temporary or associated with "structural change", then labour may be shed. The extent of "labour shedding" will depend on the magnitude and persistence of the decline in demand and on the overall conditions in the economy. In bargaining over some "target" level of labour productivity, both trade unions and employers must take into consideration the performance path of the economy. Since unemployment rises with "labour shedding", changes in measured labour productivity will be indeterminate with respect to changes in the unemployment rate.

In addition to the real wage rate and the rate of unemployment, technical change as embodied in imported inputs (TECH), real government expenditure (RGX) and real exports (RX) — representing the demand influence — also may affect the change in labour productivity. In determining the "target" level of productivity in the negotiation process both parties must take these variables into consideration.

The variables constituting the Z and Φ vectors, that is the conditioning variables in the trade unions' utility function and the employers' profit function, can be summarised as follows:

$$Z = \left\{ \overset{+}{P}, \overset{+}{PX}, \overset{-}{UR}, \overset{\pm}{TECH}, \overset{+}{RGX}, \overset{+}{RX} \right\} \tag{8}$$

$$\Phi = \left\{ \overset{+}{P}, \overset{-}{PM}, \overset{+}{PX}, \overset{-}{\Theta}, \overset{-}{\Gamma}, \overset{\pm}{UR}, \overset{+}{TECH}, \overset{+}{RGX}, \overset{+}{RX} \right\} \tag{9}$$

The signs above the variables reflect the expected direction of change which they have on the unions' utility function via Z and the on the employers' profit function via Φ.

Bargaining over wages and productivity can take place within two frameworks: a simultaneous bargaining framework or a sequential bargaining framework (see Andrews and Simmons (1992)). In the simultaneous bargaining model both the contract wage rate and the level of productivity are jointly determined with equal relative bargaining strength over both variables (that is, $\beta = 0.5$). In the sequential bargaining model different parameter values are assigned to respective bargaining powers. The sequence in the bargaining process can take the following form: the firm and the union bargain over productivity or work effort (at say the plant level); then the wage rate is set by the bargaining process and finally, the firm unilaterally sets the level of employment. Wage bargains are linked to the conditions set over work practices.

A sequential bargaining framework is employed in this paper whereby productivity levels are set prior to wage determination. 'Realised' productivity therefore enters the wage equation. In long-run equilibrium, 'target' and 'realised' productivity levels are equalised.

The negotiated wage outcome (W) and the "target" productivity (E) reduced-form equations are therefore functions of the set of variables in equations (8) and (9) via the first order optimality condition, equation (7). Zero restrictions can be imposed on some of variables in Z and Φ as they relate to the wage rate and productivity equation. A reparameterisation of the reduced form equations can result in the following structural nominal wage and productivity equations:

$$W = W\left(\overset{+}{P}, \overset{+}{PX}, \overset{-}{PM}, \overset{-}{\Gamma}, \overset{-}{\Theta}, \overset{-}{UR}, \overset{+}{E^*} \right) \tag{10}$$

$$E = E\left(\overset{+}{W/P}, \overset{+}{TECH}, \overset{+}{RGX}, \overset{+}{RX}, \overset{\pm}{UR} \right) \tag{11}$$

where E* refers to the "realised" value of labour productivity, which has an effect on the negotiated value E. Equation (10) indicates that labour productivity in addition to other factors is considered a criterion in the wage determination process.

The wage equation can be further simplified by using a traded/non-traded goods framework. The traded goods sector in an SDC consists of exports, imports and import-competing goods and services such as mineral production, agriculture, manufacturing, tourism and off-shore banking. The price indices of imports (PM) and exports (PX) and the vector of indirect tax rates Γ can be taken as the components of the price index of the traded goods sector (PT). Equation (10) can be rewritten as:

$$W = W\left(\overset{+}{P}, \overset{\pm}{PT}, \overset{-}{\Theta}, \overset{-}{UR}, \overset{+}{E^*} \right) \tag{12}$$

The specification of the wage-productivity hypothesis in this paper, equations (11) and (12), suggests that realised changes in labour productivity have a positive effect on the negotiated wage outcome, whilst the negotiated target changes in labour productivity are affected by changes in the (real) wage rate as suggested in the efficiency wage models. As indicated above, there are other factors which affect the wage-productivity relationship. The model examined explores the relationships among domestic and external prices, wages, productivity and unemployment. It also suggests that the variables could form a "long-run" equilibrium subspace. By using cointegration theory, the vector of variables yielding a long-run equilibrium relationship can be established. Further, the existence of cointegration allows inference on the causality structure among the variables.

3. ESTIMATION

Economic theory usually only provides a guide to the long-run relationship between variables but is generally silent on the likely dynamic relationship between the variables chosen as an empirical model. Thus, the researcher has to design a parsimonious model consistent with economic theory but with short-run dynamics that are congruent with the data. Nonstationarities in economic data pose particular difficulties. Various strategies have been proposed to analyse nonstationary economic time series (see for example, Sims (1980), Hendry and Mizon (1992) and Phillips and Loretan (1991)).

Our modelling methodology employs the following steps (see Downes, Holder and Leon (1990); Holden and Thompson (1992)):

i) use economic theory to determine the variables of interest;
(ii) investigate the temporal properties of each series;
(iii) check for the existence of meaningful long-run economic relationships using the Johansen (1988, 1989) method;
(iv) formulate an error correction model that incorporates both the short-run dynamics and long-run tendencies of the relationship of interest;
v) use diagnostic tests and economic-theory-consistency criteria to evaluate the estimated model.

The wage-productivity model specified in the previous section has five major variables of interest. W is the wage rate; P is the retail price index: PT is the price of tradeables; UR is the unemployment rate; and E is average productivity measured as real GDP per person employed.

In examining the temporal properties of the data, graphs of the levels and first differences of the logarithms of the series, correlograms, and regression based "Dickey-Fuller" tests were used to determine

whether each series is stationary. If the level of a series is rejected for stationarity then the first difference of that series is tested for stationarity. If the first difference is stationary it is said to be integrated of order zero, I(0), and this implies that the level of the series is integrated of order one, I(1). The Dickey-Fuller class of tests are conducted through the regression model

$$\Delta Y_t = \alpha + \beta t + pY_{t-1} + \sum_{j=1}^{r} \beta_j \Delta Y_{t-j} + \varepsilon_t \qquad (13)$$

The test refers to the hypothesis $\rho=0$ (implies Y is non-stationary) or $\rho<0$ (implies Y is stationary) Zero restrictions on α and β depend on whether the process posited to be generating the data has a non-zero mean and or a time trend; the lagged dependent variable(s) are included to ensure the residuals are not autocorrelated. One or more lagged dependent variables defines an augmented Dickey-Fuller test. The choice of lag length in this paper was based on an F-test on the lagged differences in conjunction with a Lagrange Multiplier (LM) test for serial dependence.

The graphs of the logarithm of the variables appear to be trending in the levels but stationary in the differences. Also, the trend in productivity seems much steeper in the pre-1970 period. In addition, we observe that the growth in nominal wages tends to move together with inflation.

TABLE 1: DICKEY-FULLER TESTS FOR INTEGRATION

Variable	Test	No trend	Trend
LRW	ADF	-2.55	-2.23
LW	ADF	0.20	-2.11
LE	ADF	-1.76	-0.83
LP	ADF	-0.28	-2.19
LPT	ADF	0.35	-2.24
LUR	DF	-2.06	-3.07
DLRW	DF	-4.89	-4.80
DLW	DF	-5.25	-5.18
DLE	ADF	-2.40	-3.02
DLP	ADF	-2.80	-2.74
DLPT	DF	-4.42	-4.40
DLUR	DF	-5.48	-5.43
DDLP	ADF	-6.30	-6.30
DDLE	DF	-14.42	-14.18

The 95 percent critical values for the no trend and with trend statistics are -2.95 and -3.55, respectively. The prefixes L and D before a variable indicate logarithm and difference, respectively. RW is the real wage, defined as the nominal wage deflated by the retail price index.

The integration tests support the hypotheses that the logarithms of both the nominal and real wage, the price of tradeables, and unemployment are non-stationary. The logarithms of the price level and labour productivity appear to be I(2), and unemployment may be stationary around a trend. Given the assertion that structural breaks or regime changes may lead to an overidentification of the order of integration (Perron (1989), Rappoport and Reichlin (1989)), and the potential low power of the tests for near unit roots, we treat the univariate tests as a guide to the nature of the non-stationarity in the data.[4] A better approach is undertake a systems evaluation of the data using the procedure suggested by Johansen (1988). Thus, in our analysis below, each of the series were assumed to be I(1), variables with possible trends.

The existence of a long-run relationship is based on the principle of cointegration. A linear combination of nonstationary variables will, in general, be nonstationary. If a particular linear combination of these nonstationary variables is stationary the set of variables is said to be cointegrated. The cointegrating vector measures the extent to which the variables are in equilibrium and can be characterised as "describing the tendency of an economic system to move towards a particular region of the possible outcome space" [Granger (1986)].

In a multivariate framework, more than one cointegrating vector (equilibrium relationships) may exist. In particular, if more than one cointegrating vector exists, the explicit endogenous-exogenous partition of single normalised regressions may be incorrect. The Johansen procedure (see Johansen (1988, 1989), Johansen and Juselius (1990) and Osterwald-Lenum (1992)) which is based on canonical correlation methods, provides an estimate of the maximum number of cointegrated vectors among a set of I(1) variables and their maximum likelihood estimates. A test for cointegration in that framework constitutes a set of restrictions on a particular parameterisation of an unrestricted vector autoregression. The results are known to be sensitive to the lag length of the autoregression and whether the series of interest are trending or not.

Consider the vector autoregressive process

$$X_t = \Pi_1 X_{t-1}+\cdots+\Pi_k X_{t-k}+\mu+\varepsilon_t \quad (t=1,\ldots,T) \tag{14}$$

where $\varepsilon_1,\cdots,\varepsilon_T$ are $IIN_p(0,\Omega)$ and $X_{-k+1},\cdots,X_0$ are fixed. We can reparameterise the model in terms of the difference operator $\Delta=1-L$ as

$$\Delta X_t = \sum_{j=1}^{k-1}\Gamma_j \Delta X_{t-j}\; \Pi X_{t-k} + \mu+\varepsilon_t \tag{15}$$

where

$$\Gamma_i = -\left(I-\sum_{j=1}^{i}\Pi_j\right),\ (i=1,\cdots,k-1),\ \text{and}\ \Pi = -\left(I-\sum_{j=1}^{k}\Pi_j\right)$$

The matrix Π contains long-run information from the data. Johansen and Juselius (1990) distinguish three possible cases:

(1) Rank (Π) $=p$; the matrix has full rank and the process X_t is stationary.

(2) Rank (Π) $= 0$; the process X_t corresponds to a traditional differenced model

(3) $0<$ rank (Π) $= r>p$; the process is non-stationary, but there exists $p \times r$ matrices α and β such that $\Pi = \alpha\beta'$ with the property that $\beta' X_t$ is stationary. In this case, there are r stationary linear combinations of the X_t and $p-r$ linear combinations that are common stochastic trends of the process.

The $\beta' X_t$ represent the long-run cointegrating relations among the non-stationary variables; the α matrix can be interpreted as the speed of adjustment towards the cointegrating relations. In addition to estimating the maximum number of cointegrating vectors, the framework allows the testing of linear restrictions on β (marginalisation) and α (conditioning). The distribution of the test statistics depends on whether constant terms are included and whether those constants lie in the space spanned by the adjustment matrix. The appropriate choice is important because the distributions generated in the absence of a trend have fatter tails and larger critical values.

The maximum likelihood estimator of Π subject to the rank restrictions on $\alpha\beta'$ is obtained by a reduced rank regression of ΔX_t on

X_{t-k} corrected for lagged differences of $\Delta\text{–}X_t$ and constants. The reduced rank estimators of β are the eigenvectors of

$$|\lambda S_{vv} - S_{vu} S_{uu}^{-1} S_{uv}| = 0 \qquad (16)$$

where

$$S_{ij} = T^{-1} \sum_{t=1}^{T} R_{it} R'_{jt},\ i,j = u,v \qquad (17)$$

When Π is unrestricted, the log-likelihood function depends on $-\frac{1}{2}T\Sigma^p_{i=1}\ln(1-\lambda_i)$, and when Π has rank r, it is a function of the r largest eigenvalues: $-\frac{1}{2}T\Sigma^r_{i=1}\ln(1-\lambda_i)$, $r=0,1,\cdots,p$. Hypothesis tests can therefore be carried out by computing twice the difference of the log-likelihood function under the null and alternative hypotheses.

It can be shown that the test for at most r cointegrating vectors (p-r unit roots) versus the unrestricted alternative is $-T\Sigma^p_{i=r+1}\ln(1-\lambda_i)$, $r=0,1,...,p$. This is called the trace test. The maximal eigenvalue (λ_{max}) test for p-r unit roots versus p-r-1 unit roots (r versus r+1 cointegrating vectors) is $-T\ln(1-\lambda_r)$, where λ_r is the largest eigenvalue. Thus small eigenvalues indicate the presence of unit roots. Further, a test of a trend in the non-stationary process is obtained from $-T\Sigma^p_{i=r+1}\ln\left\{(1-\tilde{\lambda}_i)/(1-\hat{\lambda}_i)\right\}$, where '~' refers to no trend and '^' to the trend estimates.

We estimated unrestricted autoregressions for the five variables of interest and adopted the most parsimonious structure that generated residuals that were normal and did not indicate serial dependence and heteroscedasticity. Our results indicated that two lags were sufficient although the productivity relation may require an additional lag. In addition, the price homogeneity relation in the wage equation could not be rejected. We tested for price homogeneity in the long-run relation normalised on wages by regressing the nominal wage on the other four variables plus the current, lead and lag of the change of these variables. The variance-covariance matrix of that regression was adjusted using the Newey-West (1987) estimator. This procedure provides a consistent test of the coefficients of the long-run relationship. We therefore reduced our modelling space to four dimensions and performed the Johansen procedure on the real wage, unemployment, average productivity and the price of tradeables.

The residuals from equation (15) indicate that the two lag specification was adequate.

TABLE 2: STATISTICS FOR ERROR PROCESSES

	DLRW	DLE	DLPT	DLUR
$\hat{s}_e$	0.04	0.04	0.09	0.13
z_1	4.06	0.49	1.55	1.16
z_2	8.64	10.34	4.41	7.76

where $\hat{s}_e$ is the standard error of the regression;
z_1 is the Jarque Bera Normality test, $\chi^2(2)$, and
z_2 is the Box-Pierce test, $\chi^2(12)$.

Tables 3 and 4 show the number of cointegrating vectors for the four variables of interest. In interpreting the tables, if r is rejected versus r+1 and r+1 is not rejected versus r+2 then we accept the null of at most r+1 cointegrating vectors. For the no trend case, both the maximum eigenvalue and trace tests suggest three cointegrating vectors, although the maximum eigenvalue test fails to reject at zero cointegrating vectors. With a trend in the process,[5] both tests show at most two cointegrating vectors, the second somewhat marginal. We attempted to resolve the ambiguity by further tests and by the interpretability of the coefficients.

TABLE 3: MAXIMAL EIGENVALUE AND TRACE TESTS — NO TREND

Null	λ_{max}	95%	Trace	95%
r=0	27.67	28.14	77.23	53.12
r≤1	25.48	22.00	49.57	34.91
r≤2	20.50	15.67	24.09	19.96
r≤3	3.59	9.24	3.59	9.24

TABLE 4: MAXIMAL EIGENVALUE AN TRACE TESTS —

Null	λ_{max}	95%	Trace	95%
$r=0$	25.48	27.07	56.12	47.21
$r\leq1$	20.98	20.97	30.64	29.68
$r\leq2$	6.74	14.07	9.66	15.41
$r\leq3$	2.92	3.76	2.92	3.76

The first vector of the no trend model did not appear to be stationary; the two others are almost identical to the two vectors in the trend model. With intercept terms approximately zero, the trend model vectors seem appropriate. A test for a linear trend in the non-stationary process versus a constant in the cointegrating vectors favoured the trend model — the chi-square statistic was 14.4 versus a critical value of 5.99. Thus the process has a linear trend but the trend is eliminated by the cointegrating relations.

TABLE 5: COINTEGRATING VECTORS

	No Trend			Trend	
X	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\tilde{\beta}_1$	$\tilde{\beta}_2$
LRW	-1.00	-1.00	-1.00	-1.00	-1.00
LPE	0.16	0.77	0.55	0.77	0.54
PLT	0.32	0.02	-0.10	0.02	-0.08
LUR	0.35	-0.56	0.02	-0.56	0.03
Intercept	-3.46	-0.19	-0.71	—	—

The first of the two stationary vectors suggests a long-run relationship among the real wage, labour productivity and unemployment variables, while the second relates the real wage to labour productivity. The adjustment matrix, using the trend model, shows that the first stationary vector has the largest effect in the real wage and unemployment equations; the second eigenvector (stationary linear combination) seems to enter only the unemployment equation, where the adjustment is complete within one time period. The matrix of long-run coefficients further suggests that the price of tradeables is not significant in any of the estimated eigenvectors and that there are no significant long-run relationships in either the productivity or price of tradeables equations.

The above hypotheses, tested by transformation matrices, uses the same maximum likelihood framework outlined above. We tested a structural hypothesis on the long-run vectors, a test for weak exogeneity for the long-run parameters and a combination of both. If we write $\beta = H\varphi$, then $\beta' X_t = j' H' X_t$ and a restriction on X_t can be written in terms of a known matrix H. For example, $\beta_{3,i} = 0, i = 1,\ldots,4$ is written as

$$\beta = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{pmatrix} \varphi,$$ where φ is a 3x4 matrix. Similarly, we test

restrictions on α by writing $\alpha = A\phi$, and choosing B orthogonal to A such that the hypothesis on α can be expressed as $B'\alpha = B'A\phi = 0$. Since a zero row in α implies a zero row in $\Pi = \alpha\beta'$, $\alpha_{s,i} = 0, i=1,\ldots,4$ implies that the cointegrating relation $\beta'_i X_t$ does not enter the s^{th} equation, and is therefore a test of weak exogeneity for the long-run parameters of interest. For example, $\alpha_{2i} = 0$ requires the following A and B matrices:

$$A = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad \text{and} \quad B = \begin{pmatrix} 0 \\ 1 \\ 0 \\ 0 \end{pmatrix}$$

Table 6 shows results for some hypotheses.

TABLE 6: TESTS OF LINEAR RESTRICTIONS

Restriction	Test Statistic	$\hat{a}_{11}$	$\chi^2(\nu)$
$\beta^3 = 0$	4.06	-0.24	2
$\alpha^2 = 0$	3.58	-0.25	2
$\alpha^3 = 0$	1.44	-0.08	2
$\alpha^4 = 0$	13.52	-0.38	2
$\alpha^{2,3} = 0$	5.63	-0.03	4
$\beta^{3,4} = 0$	22.32	-0.23	4
$\alpha^{2,3,4} = 0$	5.90	-0.53	6
$\alpha^{2,3}, \beta^3 = 0$	11.80	-0.09	6
$\alpha^{2,3,4}, \beta^3 = 0$	8.31	-0.39	8

In Table 6, α_j, β_j are the j^{th} rows of H and A, and $\hat{a}_{11}$ refers to the adjustment factor in the real wage equation under the tested restriction; ν is the degrees of freedom for calculating the critical value of the chi-square test. The results show that we do not reject the hypothesis that the real wage-productivity-unemployment relation lies in the space spanned by the eigenvectors. Also, the real wage-productivity relation is found not to lie in the cointegrating space. In addition, we can reject the hypotheses that the restricted cointegrating relation enters the productivity and price of tradeables equations. Although the restricted cointegrating relation cannot be rejected as entering the unemployment equation, we do not reject that the restricted cointegration equation does not enter the productivity, price of tradeables and unemployment equations as a joint restriction. We proceeded on the assumption that the evidence suggests one cointegrating vector relating real wages, average productivity and unemployment, and that the vector only enters the real wage equation.

Following the Engle-Granger (1987) two-step procedure this long-run cointegrating vector was used in formulating an Error Correction Model (ECM). ECMs retain levels information in a non-integrated form and at the same time allow for a flexible lag structure. Starting from an overparameterised model that is data coherent, an economically meaningful reduced model is obtained by a sequence of restrictions on the "less" reduced model.

The estimated long-run relation from the Johansen procedure:[6]

The estimated long-run relation from the Johansen procedure:[6]

$$LRW_t = 0.74LPROD - 0.47LUR \qquad (18)$$

The Error Correction Model obtained for the real wage is:

$$\begin{aligned} DLRW_t = &- \underset{(1.54)}{2.72} - \underset{(8.04)}{15.38}DUM74 + \underset{(2.10)}{0.27}\, DLE_t \\ &- \underset{(2.10)}{0.22}\, DLP_{t-1} - \underset{(3.46)}{0.20}\, ECM_{t-1} \end{aligned} \qquad (19)$$

$n = 34$	$F(4,29) = 14.35$	$NORM\ \chi^2(2) = 0.7$
$R^2 = 0.66$	$DF_{RES} = -6.84$	$SC\ F(1.28) = 1.19$
$ARCH\ F(1,28) = 0.19$	$PRED\ F(2,27) = 0.78$	$HET\ F(1,32) = 0.71$
$RESET\ F(1,28) = 0.72$		

The productivity specification employed is:[7]

$$DLE_t = \underset{(0.80)}{0.54} + \underset{(4.82)}{0.66}\, DLE_{t-2} + \underset{(1.92)}{0.06}\, DLUR_{t-1} - \underset{(5.50)}{0.57}\, D2LP_{t-1} \qquad (20)$$

$n=33$	$F(3,29) = 10.31$	$NORM\ \chi^2(2)=0.60$
$R^2 = 0.516$	$DF_{RES} = -5.72$	$SC\ F(1,28) = 0.01$
$ARCH\ F(1,28) = 2.35$	$PRED\ F(2,27) = 0.83$	$HET\ F(1,31) = 0.88$
$RESET\ F(1,28) = 1.06$		

D2LP refers to the change in the inflation rate and DUM74 is the oil shock dummy. SC is the modified Lagrange Multiplier F-test for autocorrelation. ARCH is the F-version of Engle's k-th order Autoregressive Conditional Heteroscedasticity test. HET tests for heteroscedasticity based on the regression of squared residuals on the squared fitted values. PRED is Chow's test for predictive stability for the last two observations. RESET is Ramsey's specification error test using the square of the fitted values. DF_{RES} is the Dickey-Fuller test for stationarity of the residuals. NORM is the Jarque Beta test for normality which is based on a test of skewness and kurtosis of the residuals.

Estimation by Ordinary Least Squares requires caution in view of the contemporaneous change in the real wage equation. Partitioning the set of variables, we can estimate an equation for the real wage efficiently if productivity is at least weakly exogenous for the parameters of the conditional model (see Engle, Hendry and Richard (1983)).

Weak exogeneity in the ECM requires that the error correction term does not enter the marginal process for the weakly exogenous variables and that the residuals of the marginal and conditional processes are uncorrelated. Since our earlier results indicated weak exogeneity and the real wage does not Granger-cause average productivity, we have strong exogeneity in the conditional process. The F(2,24)-statistic for the deletion of lagged terms in the productivity equation is 1.34. If we required to use productivity as a policy intervention variable, the model would have to also satisfy structural invariance; that is, policy interventions should not cause changes in the parameters of interest. Using the squared residuals from the marginal process for DLE and its lag as omitted variables in the conditional regression for DLRW produced a calculated F-statistic of 1.10, indicating that the estimated equation is structurally invariant and that productivity is superexogenous (see Engle and Hendry (1990)).

The results of the ECM specification show that the estimated models fit the data adequately. The residuals do not indicate any violations of the classical assumptions, and the recursive coefficients and the CUSUM and CUSUMSQ plots show parameter stability. The regression coefficients have a priori signs and the error correction term is significant in the real wage equation, confirming the cointegration relationship. There is a long-run inelastic response of real wages to productivity of 0.74, but a 4 pe4cent increase in productivity yields a one percent increase in real wages in the short-run. Lagged inflation has a negative effect on real wages; a five percentage point increase in inflation reduces the growth rate of real wages by one percentage point in the next time period. Thus, rising inflation generates a downward trend on the rate of growth of real wages. The data supports the expectation that the oil shock had a significant negative impact on the rate of growth of real wages. The equation shows that approximately one-fifth of the disequilibrium from the long-run relation occurs per period. The autoregressive nature of the productivity equation suggests that productivity targets are set with respect to past productivity levels, taking into account changes in inflation and the previous period's unemployment rate. Further, the growth rate of productivity over time is not constant; it has a dampening factor which indicates a steady increase in productivity. Thus, the estimated model suggests that changes in unemployment affect productivity which in turn impacts on real wages. The absence of a direct feedback relation from wages to productivity does not support the efficiency wage hypothesis.

4. CONCLUSIONS

This paper has attempted to analyse a dynamic relationship among real wages, average productivity and the unemployment rate. Our focus of interest was the real wage-productivity nexus as a means of discriminating among wage models. Recent developments in the analysis of nonstationary economic time series are employed.

The results show that real wages, average productivity and the unemployment rate have a long-run relationship. Short-run deviations from that equilibrium impact on changes in the real wage. We find support for a sequential bargaining process whereby target productivity levels, based on recent economic information, are set and which in turn influence the real wage outcome. Further research to incorporate other economic and possibly technological and organisational variables in the productivity relation is clearly required. In addition, an unemployment specification could permit the exploration of other linkages in the real wage-productivity-unemployment relationship.

NOTES

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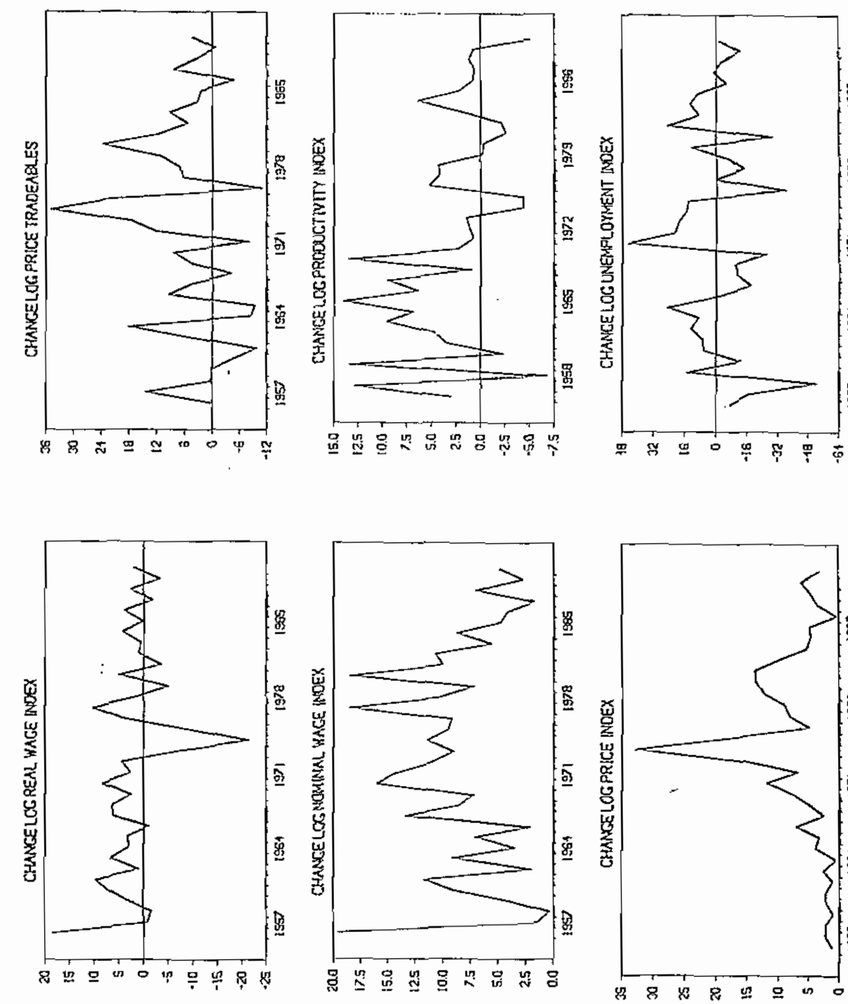
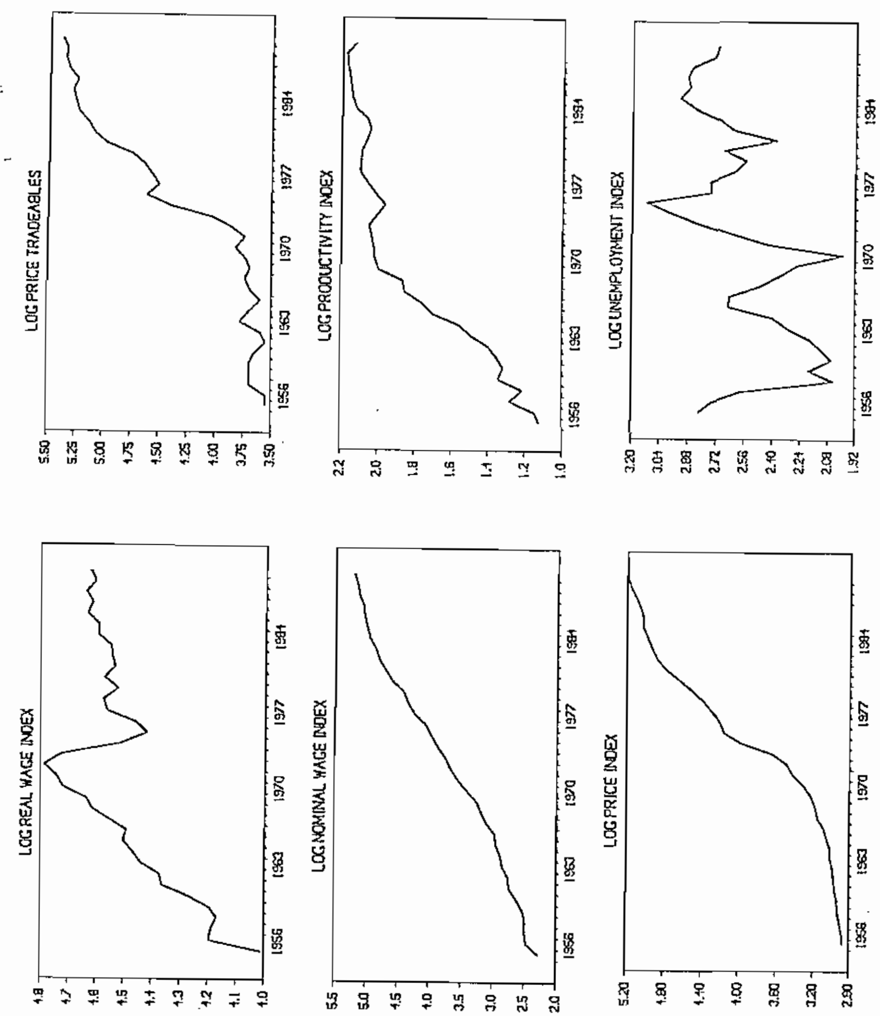
1. There are two variants of the "efficiency wage" model. The nutritional variant is usually associated with developing countries and indicates that if wage rates are increased beyond subsistence levels, then workers would be able to purchase more nutritious food and also look better after their health, thus increasing their productive capacity or work effort (see Leibenstein (1963), Bliss and Stern (1978)). The incentive or motivational variant indicates that higher wage rates reduce shirking, job search and quitting, and raise morale thus increasing labour productivity (see Akerlof and Yellen (1986), Katz (1986), and Carmichaël (1990)).
2. In many SDCs, the geographical size of the country does not permit a useful separation of markets into urban and rural. Barbados is one such example.
3. The trade unions' utility function is assumed to be cardinal, so that there is no unit of measurement.

4. For example, the incorporation of a dummy variable to represent the oil price shock of 1973 reduced the order of integration of the price index to one (DF for DLP = -5.27). Similarly, a dummy variable capturing the period of rapid diversification into manufacturing indicated an order of integration of one for labour productivity (DF for DLE = -7.84). The apparent structural change may also be indicative of statistical measurement differences in the earlier period of the sample. The dummy used was suggested by the split in the data at about 1970 (see charts of the variables).
5. Our model does not allow for a trend in the cointegrating relations; the process is assumed to have at most a linear trend.
6. The estimations were done using MICROFIT 3.0 and RATS 4.10.
7. The inclusion of a structural change dummy for the pre- and post-1970 period yields:

$$DLE_t = -0.18 + 3.22\, DUM70 + 0.52\, DLE_{t-2} + 0.05\, DLUR_{t-1} - 0.53\, D2LP_{t-1} \quad (20')$$
$$(0.46)\quad (1.80)\qquad\quad (2.84)\qquad\quad (3.61)\qquad\qquad (5.29)$$

$n = 33$	$F(4,28) = 10.00$	$NORM\ \chi^2(2) = 2.08$
$R^2 = 0.59$	$DF_{RES} = -7.75$	$SC\ F(1,27) = 1.09$
$ARCH\ F(2,26) = 2.42$	$PRED\ F(2,26) = 1.39$	$HET\ F(1,31) = 0.32$
$RESET\ F(1,27) = 2.47$		





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