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A Flexible Adjustment Model of Employment with Application to Zimbabwe's Manufacturing Industries

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ABSTRACT

This paper presents a dynamic adjustment model of employment. The adjustment process is both industry and time-specific. The adjustment parameter is specified in terms of factors affecting the speed of adjustment. The model is applied to a panel of ten Zimbabwean manufacturing industries observed over the period 1970-1993. A labour requirement function is specified to model the optimal level of employment. The empirical results show that in the long-run, employment demand responds greatest to wages, followed by capital stock changes, and least by output. We further examined labour-use efficiency over time and across different industries.

Keywords: Dynamics, employment, labour-use, panel data, manufacturing, adjustment.
JEL Classification Number: C23, J23, L60

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1. INTRODUCTION

Analysis of the way policy changes affects labour demand over time requires a model that incorporates the dynamic adjustment process of employment. Models that include dynamic adjustment are not new in literature. But, more often the speed of adjustment is modelled as a constant parameter. This is the case even with panel data models where other variables vary with time and units of analysis. In this paper, we present a model of employment demand that incorporates a speed of adjustment which is both time and industry-variant, i.e. a flexible adjustment model. The model is applied to a panel of ten Zimbabwean manufacturing industries observed during the period 1970 to 1993. The Zimbabwean manufacturing sector makes a good case study since it has evolved through periods of stiff regulations as well as trade liberalisation.

The manufacturing sector has been a subject of various shocks and policy related changes.[1] During the Unilaterally Declared Independence (UDI) period (i.e. 1965-1979) the sector experienced three major shocks.[2] First, there were the sanctions imposed on the Rhodesian government by the international community in 1965. Second, the liberation war which brought Zimbabwe's independence escalated between 1975 and 1979. This disrupted the economy and inevitably manufacturing production. Third, there was the oil crisis of 1974/75. After independence the manufacturing evolved through a highly regulated economic environment. These controls had a direct or indirect bearing on how the manufacturing sector used resources. In the labour market, for example, the government set minimum and maximum wages. Employers could only dismiss workers with ministerial approval - a cumbersome and costly process (Hawkins et. al. 1988 and Fallon and Lucas 1993, Knight 1996). Other than labour market controls, there were price, foreign currency and investment controls.

In 1991 the economy was liberalised. One of the main aims of this liberalisation programme was to encourage growth and efficiency in the manufacturing sector. In the labour market wages and employment conditions were determined through collective bargaining. At the

[1] For a detailed study of the manufacturing sector in Zimbabwe, see Braunerhjelm and Fors (1995) and Mlambo (1995).

[2] The Rhodesian government unilaterally declared independence from British rule in 1965. Before independence Zimbabwe was called Rhodesia.

outset of the programme employers took the opportunity to adjust their employment levels in response to, *inter alia*, changing costs. Between 1991 and 1995 the manufacturing industry as a whole reduced its labour force from 192000 to 167300 - a 13% decline. The reductions at industry levels were as follows; foodstuffs (15%), tobacco (22%), textiles (31%), clothing (8%), paper (17%), chemicals (16%), non-metallic products (4%), metal and metal products (12%) and transport (23%). Industries that recorded employment growth during the same period were wood (22%) and "other" manufacturing (66%).

The shocks and policy changes above give rise to a study of the adjustment process of factor input utilization at different manufacturing industries becomes essential. Industries undertake adjustments with the objective to improve on the usage of resources and profitability. Labour is one essential resource in the production process and the speed of adjustment of employment in manufacturing industries is crucial for their performance. Thus, labour-use efficiency is an important integral part of the adjustment process worth considering. By labour-use efficiency we refer to the industries' ability to use minimum amount of labour that is technically necessary to produce a given level of output. Labour-use inefficiency therefore implies that more labour is used than is technically necessary.[3]

The literature on dynamic labour demand (see Hazledine 1981 and Hamermesh 1993 for detailed summaries) and on dynamic adjustment in a panel data framework is extensive (e.g. Arrelano and Bond 1991, Judson and Owen 1996, Nerlove 1996, and Baltagi and Griffin 1997). However, incorporation of a flexible adjustment parameter and integration of this with labour-use efficiency is a new development. Kumbhakar, Heshmati and Hjalmarsson (2002) used a similar model to analyse labour-use efficiency in the Swedish banking industry. In the present paper we specify a similar dynamic labour demand model with a flexible speed of adjustment parameter. As labour alone is assumed to be flexible, this means that it is a labour requirement function (see Pindyck and Rotemberg 1997, Kumbhakar and Hjalmarsson 1995).

Knowledge of the adjustment process is essential when evaluating policies that are designed to enhance the flexibility of labour markets and industrial performance. Flexible labour markets are an essential element of policy reforms and subsequent generation of employment

[3] This approach is different from the stochastic frontier approach of measuring efficiency in the sense that industries' performances is compared to own optimal level of labour-use which is both industry and time-specific and no distributional assumptions are imposed on the over-use of labour. However, in estimation of observation-specific optimal we account for in the sample industries' best practice technology.

and profitability. A general model that allows the adjustment parameter to be industry and time-variant is therefore more informative. The main features of the model are as follows. First, the observed level of employment is not necessarily the optimal level. Second, it sheds light on the nature of the dynamic adjustment in employment by manufacturing industries. Third, the adjustment parameter is specified in terms of determinants of optimal employment and factors that affect the speed of adjustment. The model accommodates the possibility of non-optimality of employment at any point in time and that industries differ in their speed of adjustment towards the optimal level. Fourth, the optimal level may change over time for the same industry. The application of this methodology and the empirical finding shows that it is a significant contribution to labour demand literature in general and Zimbabwe's manufacturing in particular.

Our methodological approach and model is summarised in Section 2. The issues of estimation are discussed in Section 3. In Section 4 we describe the variables used in the analysis. This is followed in Section 5 by the discussion of the results. Section 6 is the conclusion.

2. THE MODEL

Assume that the economy operates with some firms/industries using more labour than what is technically necessary to produce a given vector of output Y_0. This is possible at any point in time due to the existence of variations in performance of firms, inoptimal capacity utilization and sluggish labour market conditions. But firms in general operate with the objective of minimizing the amount of labour used to produce Y_0. In other words, there is a labour requirement frontier which is the target of every firm. Denote this target level by L^* and the actual labour used by *L*. We assume labour is the only variable input used in the production of output Y. If $L > L^*$ it means there is an over-use of labour or employment inefficiency, i.e. the amount of the labour used is more than the minimum required. If $L = L^*$ then employers are using labour efficiently and are on the labour requirement frontier. Assuming panel data exits, the labour requirement frontier is defined as

(1) $$L_{it}^* = f(W_{it}, Y_{it}, Z_{it}, t: \theta)$$

where as has been noted above, L_{it}^* is the minimum amount of labour required to produce a given level of output; W_{it} and Y_{it} are real wages and output; Z_{it} consists of variables that characterise the production; variable t represents technology; and θ is a vector of unknown parameters to be estimated. In an industry such as manufacturing a good candidate to enter *Z* is capital stock (K_{it}). The justification for the inclusion of *K* is that when manufacturing industries move towards the target, the structure of capital stock is important.[4] In addition to capital input, production characteristics, economic policy, time and industry-specific variables may also enter *Z*. The indexes *i* and *t*, represent industries (i = 1, 2, ..., N) and time periods (t = 1, 2, ..., T).

Given the variables *W* and *Z*, an industry may not be able to achieve the labour requirement frontier when producing *Y*. This implies that the industry is found to be inefficient as more labour is used than necessary. Kumbhakar and Hjalmarsson (1998) have modelled the relationship between the actual labour used and the required labour as

$$(2) \qquad L_{it} = L_{it}^{*} e^{u_{it}}$$

The $u_{it} > 0$ is interpreted as technical inefficiency. In other words, *u* captures the percentage by which the labour input is used in excess to the minimum amount required to produce a given level of output. For example, a value of $u_{it} = 0$ implies that the employer uses labour efficiently. The model in (2) can be rearranged to show that labour-use inefficiency can be defined as $(L_{it} / L_{it}^{*}) \geq 1$ for all *i* and *t*. Similarly, labour-use efficiency is $(L_{it}^{*} / L_{it}) \leq 1$.

However, the model in (2) does not take into account any adjustment process. In the present paper industries adjust labour to catch up with the labour requirement frontier. Under ideal conditions, the observed employment should equal the optimal employment. In a dynamic setting, this implies that changes in employment from previous to current period should equal the change required for the industry to be at optimal at time *t*, i.e. $L_{it} - L_{i,t-1} = L_{it}^{*} - L_{i,t-1}$. However, if adjustment is costly or sluggish, the labour market does not allow for full adjustment and partial adjustment will be undertaken. This can be represented as

$$(3) \qquad (L_{it} / L_{i,t-1}) = (L_{it}^{*} / L_{i,t-1})^{\delta_{it}}$$

4 Here the capital is considered to be quasi-fixed in long-run. In a factor requirement model (Diewert 1974) only one factor (labour in the current case) is allowed to be variable.

where δ_{it} is the adjustment parameter, which varies both over time and across industries. Taking into account the adjustment process which is industry and time variant, an inefficient industry follows an adjustment process best described by the above partial adjustment model where L_{it} adjusts to its desired level L^*_{it} at a flexible rate δ_{it}. The size of δ_{it} $(0 \leq \delta_{it} \leq 1)$ determines the degree of adjustment. It can be viewed as the speed of adjustment, a higher δ_{it} denoting a higher speed of adjustment. If $\delta_{it} = 1$, then the entire adjustment is made within one single period. Since the optimal employment itself may shift over time, at any intermediate time a value of one does not have any implications for future optimalities. If $\delta_{it} < 1$, the adjustment is only partial and finally if $\delta_{it} = 0$, there is no adjustment and the industry is at the optimal level of employment.

In this model each industry follows its own adjustment path in catching up with the labour requirement function. The path taken by each industry depends on circumstances that may be peculiar to each employer or conditions that affect all employers similarly. Changes in the determinants of the target may cause the target to shift as well. Allowing the speed of adjustment to vary with *i* and *t* is justified in that in reality different industries are bound to adjust their labour-use differently over time (Kumbhakar, Heshmati and Hjalmarsson, 2002). There is perhaps stronger evidence that adjustment costs are not constant over the business cycle and in particular, they vary e.g. with the tightness of the labour market. It is therefore important to improve on the flexible modelling of the adjustment process.

In a standard partial adjustment model δ and L^* are constant for all *i* and *t*. There is some rigidity in the convergence process, i.e. the movement from L_{it} to L^*_{it}. $L_{it} \rightarrow L^*_{it}$ when $t \rightarrow \infty$ and $0 \leq \delta \leq 1$. An inefficient industry may take long time to attain L^*, unless δ is close to unity. Convergence of L_{it} to L^*_{it} is thus asymptotic. In our case, this rigidity is relaxed by allowing δ to vary over time and industry. An inefficient industry may reduce its inefficiency faster by adjusting some of the factors that cause this inefficiency. Industries control their speed of adjustment to attain the target level L^*_{it}. The speed of adjustment is therefore expressed as

(3) $\delta_{it} = g(Z_{it}, t\colon \gamma)$

where γ is a vector of the fixed coefficient associated with the determinants of adjustment, Z_{it}, the Z variables which are partially overlapping with those in (1). Time (t) represented as a trend or time dummies is an important element in the function and captures neutral shifts in the speed of adjustment over time. It is to be noted that although γ is fixed, δ varies over i and t.

In logarithms, and appending a stochastic two-way error component term, model (3) can be rewritten as

$$\ln L_{it} = (1-\delta_{it})\ln L_{i,t-1} + \delta_{it}\ln L^{*}_{it} + \varepsilon_{it} \tag{4}$$

$$\varepsilon_{it} = \mu_i + \lambda_t + v_{it} \tag{5}$$

where all variables are as defined above, μ_i are industry-specific effects, λ_t are time-specific effects and v_{it} is the random error term assumed to be identically and independently distributed with mean zero and constant variance (σ_v^2). Important features of model (4) worth emphasising are that it is dynamic and adjustment parameter is both time and industry-specific. L^{*}_{it} is also allowed to vary over time and across industries. By allowing δ to vary over time, we capture the effects of technological change on the production process and on the employment decisions of firms.

3. ESTIMATION

For estimation purposes, a translog functional form is used to approximate the optimal level (1) of employment as shown below;

$$\begin{aligned}\ln L^{*}_{it} = {} & \beta_0 + \beta_w w_{it} + \beta_y y_{it} + \beta_k k_{it} + 1/2(\beta_{ww} w_{it}^2 + \beta_{yy} y_{it}^2 + \beta_{kk} k_{it}^2) \\ & + \beta_{wy} w_{it} y_{it} + \beta_{wk} w_{it} k_{it} + \beta_{yk} y_{it} k_{it} + \beta_{wt} w_{it} t + \beta_{yt} y_{it} t + \beta_{kt} k_{it} t \\ & + \sum\nolimits_i \mu_i D_i + \sum\nolimits_t \lambda_t D_t\end{aligned} \tag{7}$$

where w, y and k are logarithms of wages, output, and capital variables, respectively.[5] In turn, the speed of adjustment, i.e. model (3) can be expressed as

[5] In order to avoid over-parametrization of the model, for the interaction terms a time trend (t) is used.

(8) $\delta_{it} = \delta_0 + \sum_i \delta_i D_i + \sum_t \delta_t D_t + \sum_m \delta_m Z_m$

where D_i and D_t are dummies representing unobservable industry- and time-specific effects, and Z is a vector of production environmental factors determining the individual industries' speed of adjustment towards the optimal level of employment.

The elasticities of optimal employment with respect to *w*, *y* and *k* are computed from (7) as

$$\text{(8)}\quad \begin{aligned} E_w &= \partial \ln L^*_{it} / \partial w_{it} = \beta_w + \beta_{wy} y_{it} + \beta_{wk} k_{it} + \beta_{wt} t \\ E_y &= \partial \ln L^*_{it} / \partial y_{it} = \beta_y + \beta_{wy} w_{it} + \beta_{yk} k_{it} + \beta_{yt} t \\ E_k &= \partial \ln L^*_{it} / \partial k_{it} = \beta_k + \beta_{wk} w_{it} + \beta_{yk} y_{it} + \beta_{kt} t \end{aligned} .$$

The expected signs of E_w and E_y are negative and positive, respectively. E_k is positive only if labour and capital are complements and negative when they are substitutes. In the present model, the labour requirement function (7) is allowed to shift over time to capture the effect of technical change on the level of employment. Thus, the exogenous rate of technical change is defined in terms of a shift in the labour requirement function (Kumbhakar and Hjalmarsson 1995, 1998). From model (7) technical change (*TC*) is thus derived as

(10) $TC_{it} = \partial \ln \hat{L}^*_{it} / \partial t = (\lambda_t - \lambda_{t-1}) + \beta_{wt} w_{it} + \beta_{yt} y_{it} + \beta_{kt} k_{it}$.

If *TC* is positive, it implies technical regress (labour using technology is employed) and when negative it is technical progress (labour saving).

Labour-use efficiency is achieved when the actual level of employment is on the labour requirement frontier, i.e. $L_{it} = L^*_{it}$. Labour-use inefficiency or over-use of labour (*INEFF*) is measured by the ratio of the two variables as

(11) $INEFF_{it} = (L_{it} / \hat{L}^*_{it})$

where $INEFF \geq 1$ in excess to one indicates percentage over-use of labour for a given output. Similarly, the ratio $EFF_{it} = (\hat{L}^*_{it} / L_{it}) \leq 1$ is a measure of labour-use efficiency. Efficiency change (catching up effect) can be obtained from the change in the efficiency ratio (11) as

(12) $E\dot{F}F_{it} = \partial EFF_{it} / \partial t = (\partial \ln \hat{L}^*_{it} / \partial t - \partial \ln L_{it} / \partial t)$

which decomposes productivity growth, defined as decline in the rate of labour-use over time into technical change and efficiency change components. It can be shown that efficiency is related to δ. By using (3) and (11) efficiency can be expressed as

$$(13) \qquad EFF_{it} = \left[\frac{L_{it}}{L_{i,t-1}} \right]^{\frac{1}{\delta_{it}}-1}$$

where from (13) it is clear that labour-use efficiency is determined by δ_{it} and the ratio $(L_{it} / L_{i,t-1})$. EFF_{it} and δ_{it} are positively related provided $(L_{it} / L_{i,t-1}) < 1$. If δ_{it} is close to one, or L_{it} is close to $L_{i,t-1}$, then efficiency would be close to 100%. Thus, the time path of efficiency (convergence or divergence) is determined by the behaviour of δ_{it} as well as the inter-periodical changes in employment.

The labour-use model outlined above is dynamic in nature. The dynamic relationship is characterized by the presence of lagged dependent variable among the regressors. The sample is small and closed. In estimation of the relationship in (5) we assume the industry and time-specific effects to be fixed and correlated with the explanatory variables (see Hsiao 2003). The model (5) incorporating optimal labour (7) and speed of adjustment (8) is estimated using iterative non-linear estimation method.

4. THE DATA

The data used is obtained from various issues of the Zimbabwe Quarterly Digest and Census of Production publications. It is a balanced panel of ten manufacturing industries observed during the period of 1970 to1993. The industries included are food, tobacco, textiles, clothing and footwear, wood and furniture, paper, chemicals, non-metallic mineral products, metal and metal products, and transport. The data contains information on inputs, output, industry characteristics and a number of policy variables.

The dependent variable is total employment in each industry (*L*), and independent variables in the labour demand part of the model are average wages (*W*), capital stock (*K*), and output (*Y*). The employment variable is total number of employees in each sector. Wages are defined as average wage per worker. It is obtained by dividing total wages in each industry by the total number of employees in that industry. Thus, the wage variable is industry specific.

Capital is measured using the perpetual inventory method; $K_{it} = K_{i,t-1}(1-\theta_i) + I_{it}$ where $K_{i,t-1}$ is the capital stock in the previous period, and as a starting value, the 1969 book value of machinery and buildings was used. The θ_i is the average rate of depreciation and is constant overtime, but varies by industry. The variable I_{it} represents investment measured as total expenditure on capital and buildings. The output variable is measured by the output index of each industry. The average wages and capital are then deflated by the product prices.

In the estimation, three economic regimes are controlled for, i.e. the Unilaterally Declaration of Independence (UDI) period (1970-1979), the first post independence decade (1980-1990) and the main part of the Economic Structural Adjustment Program (ESAP) period (1991-1993). We capture these periods separately because they represent three different economic regimes. In the first phase the economy evolved through sanctions and a war of liberation. The second phase marks the first post independence decade. The manufacturing sector went through a period of regulations and controls. In the third phase the economy was liberalised. A vector of *T-1* time dummies are used to represent the neutral exogenous rate of technical change and in order to reduce the number of parameters to a manageable level a time trend is used to capture non-neutral (interactive) shifts in the labour requirement function over time. In addition, *N-1* industry dummies are used to capture industry specific effects. The summary statistics are reported in Table 1.

5. EMPIRICAL RESULTS

The labour requirement frontier L^*_{it} was approximated by a translog function. The advantage of this formulation is that it is flexible. It is a function of wages, output, capital and a combination of trend and time dummies. The translog model outperformed the restrictive Cobb-Douglas versions (not reported here). The preferred models had smaller standard errors, higher frequency of statistical significant coefficients and point elasticities consistent with economic theory. The parameter estimates of the models (both static and dynamic) are reported in the Table 2. The static model has 67% of the parameters being statistical significant at the less than 10% level of significant. In the dynamic case, 73% of the parameters are statistically significant at least at 10% level. A closer look at the coefficients of the static and dynamic models shows that the parameters associated with industry and time dummies (for both models) and with the adjustment function, δ_{it} are statistically significant at conventional levels of significance.[6]

The parameters of the translog model due to the presence of squares and interactions cannot be interpreted directly. The elasticities with respect to wages, output and capital stock were therefore computed as per equation (9) and the rate of technical change as in equation (10). All elasticities evaluated at the mean values for each year, for each economic regime, by industry and at the sample mean are reported in Table 3 for the static model and in Table 4 for the dynamic long-run and short-run versions, respectively. Also calculated and reported in Table 4 are the labour-use inefficiency ratios and the speed of adjustment.

5.1 Elasticities and the Exogenous Rate of Technical Change

In this sub-section we discuss the elasticities with respect to wages, capital and output, reported in Table 3 for the static model and in Table 4 for the dynamic case. The short-run elasticities are simply the long-run multiplied by the speed of adjustment. Our subsequent discussion will be based on the long-run elasticities as these reflect the long-run adjustment to optimal level of employment. The static model results serve as a benchmark. The signs of the elasticities are as was expected; wages negative, outputs mostly positive and capital positive.

Wage elasticity:

The elasticities with respect to wages have a sample mean value of -0.357 (0.072) for the static model and -0.365 (0.106) in the corresponding dynamic model. In parentheses are the standard deviations. Employment responds greatest to wages in the wood (-0.501), non-metals (-0.482), textile (-0.408) and clothing (-0.405) industries. It is least responsive in the food (-0.222) and chemical (-0.235) industries. Over time, although a time trend was used for the interaction between wages and time variable, we observe no systematic pattern in the elasticities with respect to wages. There is more variation the elasticities among industries than over time.

Turning to the elasticities by economic regimes, there is evidence that employment was more responsive to wages during the UDI and ESAP periods. During these two economic phases

[6] In modelling the speed of adjustment we also tried to include a number of indicators determining the speed of adjustment. The indicators considered were the sales, exports, government expenditure and interest rate. These variables were found to be either insignificant or resulted in a highly non-linear model with severe problem of convergence. Thus, they were subsequently excluded from the specification of the speed of adjustment.

the elasticities with respect to wages were on average -0.40, almost 21% higher than the post independence decade. A lower responsiveness in the phase 1980-1990 was expected because of the job security regulations in force during this period. Employers could not easily fire workers even if there were increases in wage costs. In the other two periods there were no labour market controls.

Output elasticity:

The output elasticity in the static model has a mean value of 0.105 and a relatively small standard deviation (0.074). The long-run elasticity is slightly small (0.095) but with a slightly large standard deviation of 0.099. It exhibits more over time variation than across industries. Employment responsiveness to output is more pronounced in the transport and food industries - with elasticities of 0.162 and 0.156, respectively. These two industries are followed by clothing, wood, non-metal and metal industries. Least responsiveness is found in the tobacco and textile industries. Over time, there are small surprises in the output elasticities. Between 1971 and 1975 the elasticities are negative, contrary to expectations. It is not obviously clear why this negative association. After 1976 the output elasticities increased continuously, reaching a plateau between 1988 and 1991, before dropping in 1992 and 1993. The output elasticities by economic regimes are relatively small during the UDI era, i.e. 0.008. Compare this with 0.150 and 0.154 during the following two phases, respectively. With sanctions dominating the UDI period, it is not surprising that output growth generated so little employment response. This result also indicates that in a liberalised environment output growth generates a larger employment growth.

Capital elasticity:

The sample mean long-run capital stock elasticity is 0.132 with a standard deviation of 0.084. The corresponding figures for the static model are 0.073 and 0.046. The elasticities both across industries and over time are positive, an indication that labour and capital are complements. A 1% increase in capital gives rise to the highest response rate (0.2% increase in employment) in the transport, non-metals and wood industries. This is followed by clothing, paper and textiles- with between 0.10% and 0.19%. The least response rate is found in the food, tobacco, chemicals and metals (less than 0.10%). This result is important in the formulation and targeting of policies, as it gives an indication as to which industries more jobs will be created from more capital investment.

Over time, there is a general decline in the capital elasticities, with small upswings in 1977 and 1984/85. The period elasticities indicate that employment was more responsive to capital accumulation during the UDI era (0.16) followed by the post independence decade (0.12) and least during the ESAP period (0.09). The greatest elasticity during the UDI period is no surprise. The import substitution industrialisation strategy which characterised development in this phase saw unprecedented development and diversification in the manufacturing sector. The government assisted this sector (more than any other sector) through subsidies, tax incentives and development of infrastructure. The ESAP period has the least elasticity values, probably because of the minimal investment experienced during this period.

Technical change:

Finally, we turn to technical change. The long-run sample mean value is very small (0.001) with a relatively large standard deviation (0.26). The pure component of technical change is found to be negative while the non-neutral component is positive. The annual mean exogenous rate of technical change ranges in the interval -0.48 to 0.736. The results show that in the wood, paper, non-metallic and transport industries, there was technical progress (labour saving). In the remaining six industries there was technical regress (labour using). Over time, there was technical progress during the 1974-1976, 1982-1985, 1987 and 1989-1993 periods. In the remaining years there was technical regress.

Summary:

The long-run elasticity values show that employment is more responsive to wages, followed by capital stock and least by output. The sample mean value of technical change shows low technical regress. The long-run wage and output elasticities are closer to the static case while those of capital stock are very different. During UDI employment growth was mostly due to growth in capital and complementarity relationship between capital and labour generating new employment opportunities. In the remaining two periods of post independence and ESAP period employment growth was mainly due to an expansion of output by improvement of in the capacity utilisation rate rather than investment in new capital.

5.2 Labour-Use Inefficiency

Labour-use inefficiency is the ratio of actual to optimal employment. A ratio greater than one means over use of labour for a given level of output produced using industries' own optimal production technology. The inefficiency results are reported in Table 4. The sample mean inefficiency value is 1.074 with a standard deviation of 0.031. This value indicates that industries closer to the mean are on average over-using labour by 7.4%. Among the industries, the period mean labour-use inefficiency ranges between 6.8% and 8.1%. The most inefficient industries are transport, paper, chemicals and non-metals, all which over-use labour by about 8%. On the lower end of the spectrum are tobacco and clothing, which for a given level of output, could be better off by reducing employment by 6.8%. There is a large variation in over time labour-use inefficiency rates, but there is no systematic pattern in the rates. The highest inefficiency levels were recorded in the 1976-77 period - with labour over-use of 14%. On the other hand, industries were more efficient between 1986 and 1989, where only a reduction of labour force by 4% or less could have moved some industries to the labour requirement frontier.

A quite surprising result is found on the inefficiency by economic regime periods. Our expectations were that the ratio could be higher during the first decade of independence than the other two periods. Such an expectation was motivated by the tight labour market regulations in place during the 1980-1990 period that may have forced employers to retain excess labour. The results show that this was not entirely the case. Instead, industries were more efficient during this period of stiff controls. They were better off reducing their labour by 6% during the 1980-1990 period, compared to 9% and 8% in the UDI and ESAP periods, respectively. The explanation for this is not that obvious, but probably this was due to the fact that the private sector never adhered to the dismissal regulations or perhaps they offered more incentives to eliminate excess labour force.

Productivity growth composed of the rate of technical change and change in inefficiency components was calculated. The change in inefficiency was found to be close to zero and within the interval -0.089 to 0.058. Thus, the rate of productivity growth (labour reducing) was mainly determined by the exogenous rate of technical change.

5.3 Speed of Adjustment

The results of the speed of adjustment parameter are reported in Table 4. The sample mean speed of adjustment is 0.36. Industries close to the mean adjust 36% of their deviations off the equilibrium (observed employment equals the optimal) in one year. The median lag length is slightly above six months, i.e. 0.62 years or 2.5 quarters.[7] This means it takes 2.5 quarters for employers to move half way to the eventual equilibrium in response to a shock on labour demand. This is a relatively slow speed, but it compares favourably with other international studies. The studies summarised in Hamermesh (1993) find median lag lengths averaging 5.5 quarters for annual data, 1.4 quarters for quarterly data and 1.2 quarters for monthly data.

There are similarities in the time behaviour of the adjustment parameter among industries. At the same time there is a wider variation in the speed of adjustment across industries. Employment adjustment is fastest in the non-metals (56%), transport (41%) and clothing (37%) industries. The slowest adjusters are food and tobacco industries. Over time there is no clear-cut pattern. Full adjustment (100%) was experienced in the 1971, 1979 and 1983 periods. As expected adjustment was faster during the pre-independence period (36%) and ESAP period (39%). It was slower (35%) during the 1980-1990 phase - most likely reflecting the tight labour market regulations in force. What this implies is that during reform periods labour markets have become more flexible - as the higher speed of adjustment indicates.

From equation (13) one would expect some relationship between the rate of adjustment and the efficiency rate. Industries less efficient would be expected to adjust faster (as they try to eliminate their inefficiency faster) than those most efficient. In other words, industries closer to the labour requirement frontier would be expected to have a lower speed of adjustment than those farther away. This would seem to be true for some industries and not for others. It is true in the case of transport and tobacco. The transport industry is the least efficient industry but one of the fastest adjusters. Similarly, tobacco is one of the most efficient industries, at the same time, the slowest adjusters. In the other industries we found no systematic relationship between efficiency and adjustment. As mentioned previously most of the variables used as determinants of the speed of adjustment were found statistically insignificant and the model did not converge. Thus, we have not been able to identify statistically significant and relevant policy factors that can be used to affect the rate of adjustment in specific industries.

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[7] Hamermesh (1993) provides a formula for calculating the median lag length (t*), i.e, by solving for t* in the formula, $\delta^{t^*}=0.5$.

Finally, in Table 5 we report the correlation coefficients between key variables. The most notable results are that; output and employment are positively correlated, while an increase in employment or output is negatively and significantly correlated with labour-use efficiency. In addition, an increase in employment is associated with a decline in the speed of adjustment.

6. SUMMARY AND CONCLUSIONS

This study was concerned with modelling dynamic employment demand with a flexible adjustment parameter, and estimation of labour-use inefficiency. These are important issues in the understanding of how labour markets function and as a guide to policy formulation and evaluation. A labour requirement function was used to represent employment demand. Employment demand was modelled as a function of wages, output and capital stock. The adjustment parameter varies over time and industries allowing for a flexible adjustment. Thus, employers choose their own individual adjustment paths to catch up with the labour requirement frontier. The labour requirement frontier was compared with the actual amount of labour employed to measure labour-use inefficiency, i.e. the amount of labour used in excess of technically required amount to produce a given output quantity.

The long-run sample mean elasticities indicates that employment demand responds greatest to wages, followed by capital and then least by output. The sample mean rate of technical change was close to zero. Over time it varies in the interval -0.48 to +0.74. Mean labour-use inefficiency ranges across industries from 6.8% to 8.1%. The sample mean is 7.4%, implying that industries close to the mean might be better off by reducing their labour stocks by 7.4%. The inefficiency ratio was highest during the UDI period (9%), followed by 7.5% during ESAP. Industries were least efficient during the first decade after independence. The overprotection and subsidies might have contributed to higher inefficiencies in the UDI era. However, we would have expected higher rates during the 1980-1990 period since there were regulations that prevented dismissal of extra labour.

The speed of adjustment is relatively slow - with a sample mean value of 36%. It ranges from 28% (i.e. food and drink) to 56% (i.e. non-metals). The speed of adjustment was greatest during ESAP (39%) compared to the UDI (36%) and the 1980-1990 decade (35%). These results support the conclusion that under ESAP labour markets have become more flexible, i.e. employers are able to adjust faster. As such the results can be used in the debate about labour market flexibility. However, this study is subject to some caveats worth mentioning, especially on the application. First, we assumed a homogenous labour force. If data permits, a better alternative would be to decompose the labour data into heterogeneous groups by skill of labour. The adjustment process of labour market groups is known to be different. Second, but related, this study uses aggregated manufacturing data. The assumption is that the production structures across industries are the same. Again data permitting, an application to micro data would be an added advantage as this would allow to account for differences in the production technology.

In spite of these limitations, the framework developed here is important as it could be used for policy purposes to identify those industries that are inefficient and slow in adjustment. The study also shows that when modelling the adjustment process in a panel data framework, the speed of adjustment must be made flexible. Modelling the speed of adjustment in this fashion offers an added opportunity to estimate the determinants of the speed of adjustment.

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Table 1. Summary Statistics

Notation	Variable	Mean	Std. Dev.	Minimum	Maximum
L	Employment	15662	9629	3467	44755
W	Real Wages	2430	812	799	4335
K	Capital Stock	31975847	35829873	1352424	233928571
Y	Output index	105.77	31	9.0	226
N	Number of Industries 10				
T	Time period (1970-1993) 24 years				
Total number of observations 10 x 24 = 240					

Table 2. Parameter estimates.

	Static Model		Dynamic Model	
Parameter	Estimate	Std. Error	Estimate	Std. Error
A. Employment function				
β_0	7.5976	8.0776	8.2877	12.0012
β_W	-1.4481	1.2597	-2.8308	1.9012
β_y	0.1945	0.7514	-0.4403	0.8891
β_K	0.8639	0.3404	1.8553	0.5626
β_{WW}	0.0814	0.0711	0.0998	0.0994
β_{yy}	0.0257	0.0235	0.0207	0.0328
β_{KK}	0.0078	0.0094	-0.0203	0.0141
β_{Wy}	0.0328	0.0508	0.1240	0.0638
β_{WK}	-0.0387	0.0360	-0.0344	0.0494
β_{WT}	0.0070	0.0043	0.0013	0.0051
β_{yK}	-0.0627	0.0156	-0.0655	0.0209
β_{yT}	0.0075	0.0021	0.0136	0.0029
β_{KT}	-0.0004	0.0014	0.0003	0.0020
μ_{drink}	-0.5945	0.0691	-0.6516	0.0775
$\mu_{textile}$	-0.2547	0.0584	-0.3162	0.0837
$\mu_{clothing}$	-0.0685	0.0688	-0.0751	0.1034
μ_{wood}	-0.6005	0.0907	-0.5514	0.1178
μ_{paper}	-0.6331	0.1063	-0.6681	0.1176
$\mu_{chemicals}$	-0.4299	0.0808	-0.5688	0.0960
$\mu_{non\ metals}$	-0.8731	0.0816	-0.9369	0.1034
μ_{metals}	0.5392	0.0571	0.4793	0.0616
$\mu_{transport}$	-1.0288	0.0859	-1.0464	0.1075
λ_{1971}	-0.0178	0.0584	.	.
λ_{1972}	-0.0400	0.0864	0.1424	0.1458
λ_{1973}	-0.1067	0.1202	0.0046	0.1426
λ_{1974}	-0.2150	0.1570	-0.1754	0.1643
λ_{1975}	-0.3335	0.1979	-0.6101	0.2251
λ_{1976}	-0.5371	0.2335	-1.2650	0.3936
λ_{1977}	-0.6320	0.2710	-1.3416	0.3961
λ_{1978}	-0.8444	0.3066	-1.2555	0.3981
λ_{1979}	-0.9148	0.3457	-1.1717	0.4061
λ_{1980}	-0.9749	0.3888	-1.2598	0.4615
λ_{1981}	-1.0258	0.4316	-1.2970	0.5298
λ_{1982}	-1.1306	0.4726	-1.5186	0.5735
λ_{1983}	-1.3648	0.5053	-1.8059	0.6203
λ_{1984}	-1.5068	0.5461	-2.1404	0.7014
λ_{1985}	-1.6768	0.5811	-2.3235	0.7398
λ_{1986}	-1.7864	0.6218	-1.7665	0.8244
λ_{1987}	-1.9223	0.6621	-2.2129	0.8407
λ_{1988}	-1.9337	0.7146	-2.2118	0.9043
λ_{1989}	-2.1320	0.7438	-2.4767	0.9454
λ_{1990}	-2.2112	0.7964	-2.9349	1.0026
λ_{1991}	-2.4239	0.8235	-3.1254	1.0459
λ_{1992}	-2.7568	0.8522	-3.6518	1.0846
λ_{1993}	-3.0672	0.8828	-4.0565	1.1226

Table 2. Continued...

	Static Model		Dynamic Model	
Parameter	Estimate	Std. Error	Estimate	Std. Error
B. Speed of adjustment				
δ_0			1.0474	0.2327
δ_{drink}			-0.0210	0.0546
$\delta_{textile}$			0.0328	0.0614
$\delta_{clothing}$			0.1134	0.0662
δ_{wood}			0.0647	0.0585
δ_{paper}			0.0746	0.0651
$\delta_{chemicals}$			0.0602	0.0622
$\delta_{non\ metals}$			0.3331	0.1438
δ_{metals}			0.0950	0.0586
$\delta_{transport}$			0.1600	0.0702
δ_{1972}			-0.8115	0.2683
δ_{1973}			-0.8865	0.2640
δ_{1974}			-0.7958	0.2653
δ_{1975}			-1.3545	0.2732
δ_{1976}			-1.0613	0.2320
δ_{1977}			-1.0544	0.2332
δ_{1978}			-1.0267	0.2496
δ_{1979}			-0.4639	0.4410
δ_{1981}			-0.7097	0.2846
δ_{1982}			-0.5581	0.3103
δ_{1983}			0.3039	0.4688
δ_{1984}			-1.0213	0.2691
δ_{1985}			-1.0180	0.2628
δ_{1986}			-1.0771	0.2305
δ_{1987}			-1.0453	0.2348
δ_{1988}			-0.9976	0.2335
δ_{1989}			-1.0701	0.2333
δ_{1990}			-0.6184	0.2479
δ_{1991}			-1.0554	0.2527
δ_{1992}			-0.5167	0.2673
δ_{1993}			-0.6746	0.2558
$R^2_{adjusted}$		0.9700		0.9900
RMSE		0.0933		0.0529

Note: In the dynamic model 1971 is dropped due to the use of lag dependent variable.

Table 3. Mean elasticities calculated from the Static model parameter estimates.

Characteristics	E_W	E_Y	E_K	TC
A. Mean by Industry:				
Food	-0.318	0.179	-0.002	0.018
Drink	-0.390	0.034	0.080	0.011
Textile	-0.418	0.079	0.074	0.009
Clothing	-0.386	0.143	0.071	0.008
Wood	-0.406	0.125	0.117	0.001
Paper	-0.306	0.085	0.115	0.005
Chemicals	-0.302	0.105	0.033	0.016
Non metals	-0.391	0.084	0.125	0.002
Metals	-0.352	0.076	0.028	0.017
Transport	-0.302	0.141	0.089	0.007
B. Mean by Year:				
1970	-0.458	-0.025	0.110	0.134
1971	-0.443	0.019	0.093	0.117
1972	-0.423	0.037	0.085	0.114
1973	-0.408	0.052	0.084	0.069
1974	-0.410	0.053	0.087	0.027
1975	-0.407	0.043	0.095	0.016
1976	-0.405	0.052	0.091	-0.068
1977	-0.373	0.083	0.096	0.039
1978	-0.368	0.103	0.075	-0.076
1979	-0.352	0.122	0.065	0.067
1980	-0.347	0.114	0.069	0.077
1981	-0.342	0.103	0.073	0.087
1982	-0.328	0.114	0.068	0.033
1983	-0.335	0.126	0.058	-0.095
1984	-0.316	0.143	0.055	-0.003
1985	-0.319	0.153	0.058	-0.032
1986	-0.315	0.158	0.059	0.029
1987	-0.320	0.153	0.060	0.002
1988	-0.272	0.169	0.049	0.129
1989	-0.298	0.165	0.051	-0.058
1990	-0.275	0.161	0.059	0.060
1991	-0.310	0.153	0.068	-0.075
1992	-0.355	0.138	0.071	-0.195
1993	-0.391	0.137	0.072	-0.173
C. Mean by Economic Regime:				
UDI	-0.405	0.054	0.088	0.044
Post Independence.	-0.315	0.142	0.060	0.021
ESAP	-0.352	0.143	0.070	-0.148
D. Overall Mean and Std deviations:				
Mean	-0.357	0.105	0.073	0.009
Std Dev.	0.072	0.074	0.046	0.009

Table 4. Mean short and long-run elasticities, efficiency and speed of adjustment calculated using the dynamic model parameter estimates.

	Long-run elasticities				Productivity, effic. and adjust.			Short-run elasticities			
Characteristics	E_W	E_Y	E_K	TC	Growth	L_{it}/L_{it}^*	δ	E_W	E_Y	E_K	TC
A. Mean by Industry:											
Food	-0.222	0.156	0.071	0.017	-0.009	1.073	0.283	-0.064	0.037	0.017	0.009
Drink	-0.374	0.023	0.063	0.004	-0.004	1.068	0.272	-0.102	0.003	0.018	0.005
Textile	-0.408	0.036	0.104	0.005	-0.005	1.073	0.307	-0.128	0.008	0.035	0.005
Clothing	-0.405	0.098	0.169	0.001	-0.001	1.073	0.374	-0.152	0.034	0.063	0.004
Wood	-0.501	0.086	0.240	-0.010	0.010	1.068	0.333	-0.168	0.021	0.076	0.001
Paper	-0.398	0.121	0.194	-0.011	0.013	1.077	0.342	-0.135	0.037	0.064	0.000
Chemicals	-0.238	0.125	0.055	0.010	-0.010	1.079	0.330	-0.081	0.035	0.018	0.007
Non Metals	-0.482	0.073	0.212	-0.012	0.011	1.076	0.556	-0.270	0.038	0.117	-0.003
Metals	-0.260	0.068	0.010	0.015	-0.015	1.072	0.358	-0.093	0.024	0.006	0.009
Transport	-0.364	0.162	0.206	-0.008	0.008	1.081	0.412	-0.151	0.063	0.084	0.000
B. Mean by Year:											
1971	-0.420	-0.065	0.153	0.174	-0.167	1.076	1.000	-0.420	-0.065	0.153	0.174
1972	-0.398	-0.038	0.150	0.317	-0.296	1.054	0.327	-0.133	-0.012	0.053	0.103
1973	-0.391	-0.013	0.158	0.036	-0.043	1.061	0.252	-0.102	-0.003	0.043	0.009
1974	-0.402	-0.009	0.158	-0.006	0.004	1.063	0.343	-0.141	-0.003	0.058	-0.003
1975	-0.410	-0.009	0.153	-0.262	0.235	1.092	0.003	-0.001	0.000	0.001	-0.001
1976	-0.409	0.002	0.149	-0.481	0.435	1.144	0.082	-0.037	0.000	0.015	-0.040
1977	-0.405	0.050	0.186	0.094	-0.092	1.143	0.088	-0.039	0.004	0.018	0.008
1978	-0.373	0.065	0.160	0.261	-0.223	1.099	0.112	-0.046	0.008	0.022	0.029
1979	-0.352	0.090	0.156	0.261	-0.240	1.077	1.000	-0.352	0.090	0.156	0.261
1980	-0.352	0.093	0.145	0.089	-0.084	1.072	0.675	-0.242	0.063	0.102	0.059
1981	-0.353	0.093	0.133	0.139	-0.132	1.064	0.429	-0.156	0.040	0.061	0.059
1982	-0.339	0.113	0.130	-0.045	0.036	1.073	0.581	-0.200	0.066	0.079	-0.026
1983	-0.334	0.118	0.117	-0.107	0.106	1.074	1.000	-0.334	0.118	0.117	-0.107
1984	-0.321	0.145	0.122	-0.154	0.137	1.093	0.117	-0.042	0.018	0.019	-0.019
1985	-0.337	0.155	0.133	-0.004	0.005	1.091	0.121	-0.045	0.020	0.021	-0.001
1986	-0.339	0.165	0.132	0.736	-0.663	1.015	0.070	-0.027	0.012	0.013	0.051
1987	-0.345	0.162	0.121	-0.266	0.241	1.041	0.095	-0.036	0.016	0.015	-0.026
1988	-0.293	0.206	0.110	0.182	-0.177	1.037	0.141	-0.045	0.030	0.020	0.025
1989	-0.318	0.190	0.101	-0.083	0.082	1.038	0.075	-0.027	0.015	0.011	-0.007
1990	-0.313	0.209	0.106	-0.279	0.245	1.074	0.520	-0.168	0.109	0.059	-0.146
1991	-0.361	0.186	0.108	-0.011	0.020	1.065	0.087	-0.035	0.016	0.013	-0.001
1992	-0.400	0.149	0.087	-0.344	0.332	1.078	0.622	-0.254	0.091	0.057	-0.215
1993	-0.435	0.128	0.079	-0.220	0.217	1.082	0.464	-0.206	0.057	0.038	-0.103
C. Mean by Economic Regime:											
UDI	-0.396	0.008	0.158	0.044	-0.042	1.090	0.356	-0.141	0.002	0.058	0.060
Post Indep.	-0.331	0.150	0.123	0.019	-0.019	1.061	0.348	-0.120	0.046	0.047	-0.013
ESAP	-0.399	0.154	0.091	-0.192	0.189	1.075	0.391	-0.165	0.055	0.036	-0.106
D. Overall Mean and Std deviations:											
Mean	-0.365	0.095	0.132	0.001	0.000	1.074	0.357	-0.134	0.030	0.050	0.004
Std dev	0.106	0.099	0.084	0.260	0.238	0.031	0.329	0.135	0.050	0.061	0.099

Table 5. Spearman correlation coefficients/p-values (Number of observations = 230).

	Employ	Output	L_{it}/L_{it-1}	L_{it}/L_{it}*	δ	TC	ΔEFF	Growth
Employment	1.000							
	0.000							
Output	0.821	1.000						
	0.001	0.000						
L_{it}/L_{it-1}	0.031	0.001	1.000					
	0.636	0.994	0.000					
L_{it}/L_{it}*	-0.057	-0.120	-0.282	1.000				
	0.388	0.068	0.001	0.000				
δ	-0.142	-0.105	0.206	-0.001	1.000			
	0.031	0.111	0.001	0.977	0.000			
TC	0.021	0.016	-0.326	0.288	-0.073	1.000		
	0.740	0.801	0.001	0.001	0.266	0.000		
ΔEFF	0.038	0.012	-0.049	0.310	-0.108	0.821	1.000	
	0.559	0.856	0.455	0.001	0.100	0.001	0.000	
Prod. Growth	0.027	0.026	-0.344	0.280	-0.078	0.997	0.796	1.000
	0.683	0.690	0.001	0.001	0.237	0.001	0.001	0.000

Note: p-values appear below the correlation coefficients.