An Econometric Model of Employment in Zimbabwe's Manufacturing Industries*

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ABSTRACT

This paper is concerned with the estimation of employment relationship and employment efficiency under production risk using a panel of Zimbabwe's manufacturing industries. A flexible labour demand function is used consisting of two parts: the traditional labour demand function and labour demand variance function. Labour demand is a function of wages, output, quasi-fixed inputs and time variables. The variance function is a function of the determinants of labour demand and a number of production and policy characteristic variables. Estimation of industry and time-varying employment efficiency is also considered. The empirical results show that the average employment efficiency is 92%.

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Key words: Labour demand, variance, efficiency, manufacturing industries, Zimbabwe.

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1. INTRODUCTION

The objectives of this paper are threefold. First, it is concerned with estimating an employment relationship. Second, in coming up with an employment relationship we seek to account for the variation in employment. Finally, the paper addresses the issue of employment efficiency. The focus is on Zimbabwe's manufacturing industry. This is an important area of research considering that the sector has evolved through a series of economic regimes and policies mostly of an experimental nature and with unknown expected outcomes. The manufacturing sector in Zimbabwe is well developed and diversified by African standards. It is one of the main employers, accounting for 16% of formal sector workers. It contributes almost a quarter of gross domestic product. In the past three decades the sector has evolved through three major economic regimes i.e., (i) the Unilateral Declaration of Independence (UDI) period[1] (1965-1979), (ii) the first decade of independence (1980-1990), and (iii) the economic structural adjustment phase (1991-1995).

When the settler regime declared independence in 1965, international sanctions were imposed, isolating the economy for the next fifteen years. This isolation forced the government to adopt an import-substitution industrialisation strategy. Every possible policy measure was pursued to make the strategy work and make the economy self-sufficient and self-sustaining. The first decade of UDI saw rapid product and infrastructural development in the manufacturing industry. However, the oil crisis of the mid-1970s and the liberation war in the late 1970s plunged the economy and the manufacturing sector in particular, into serious trouble. Between 1976 and 1978 the economy went into recession, with growth rate averaging -3% per annum.

Zimbabwe gained its independence in 1980, after a long and protracted war. The first decade of independence, 1980-1990, was characterised by controls and regulations right across the board. The new government saw it necessary to control and regulate the economy that a few whites had dominated for a long time. The tight control on the economy was widely seen as an effective way of ensuring that resources previously owned by a few, were redistributed with ease. The government adopted a "growth with equity" strategy. The first two years of independence seemed to augur well for this strategy, thanks to an unprecedented boom in 1980-1981. This boom was a result of renewed access to international markets after fifteen years of sanctions, good rains and massive aid inflows. To achieve an equitable

[1] The first period 1965-1979 is conventionally known as the settler regime Unilateral Declaration of Independence from the British crown.

distribution of resources, the government increased public expenditure on social services, including education and health. This was directed mainly at improving the living conditions of the marginalised black population.

After 1981 the economy began to face severe problems associated with the foreign currency market. Demand for foreign currency outstripped supply, as industry previously cut off from international markets sought more foreign currency to replenish its obsolete equipment. The government responded to this by tightening foreign currency regulations and restricting imports through a quota system. Because of foreign currency shortages, which translated itself into shortages of inputs and replacement equipment, many industries operated with excess capacity. Exports were encouraged through various export incentives, but with limited success. An industry protected for a long time could not compete effectively on the international market. The overvalued exchange rate also hindered exports. In the domestic market, interest rates were controlled at low levels. Domestic prices were also controlled to maintain a cheap food policy and to reduce inflationary pressures. The other market heavily regulated was that of labour. Maximum and minimum wages were imposed in 1980 to achieve an equitable distribution of wage incomes. In addition, employers were not entirely free to adjust their labour force as firing of workers could only be done following ministerial approval, a process that was cumbersome and costly.

This elaborate system of controls and regulations was not conducive to economic growth. As the first decade of independence came to a close, the economy was in a vicious circle of low growth, escalating unemployment, inflationary pressures, and a growing budget deficit. Economic growth averaged 3.9% in the decade,[2] unemployment increased from 10% in 1980 to 20% in 1990, inflation averaged 12.2% in the 1980s up from 9% in the 1970s, and the budget deficit averaged 10% during the 1980s. It was against this backdrop that in 1991 the government embarked on a five-year economic structural adjustment program (ESAP).

The system of controls dating from 1965 concealed and contained many imbalances in the economy. The reforms introduced in 1991, inevitably, exposed these imbalances. ESAP involved the liberalization of the trade regime, financial sector, and deregulation of investment and foreign currency controls. In the labor market the determination of wages and employment conditions was left to the local units of employers and workers representatives. In the product market prices were also decontrolled. The removal of wages and price controls

[2] After excluding the boom years of 1980-1981, the rate of economic growth averaged less than half of this figure.

coupled with a huge deficit triggered off inflation. Tight monetary policy was the main policy instrument of reducing inflation. By the end of the program other economic indicators were also pointing to an economy in serious trouble. Economic growth averaged 0.7 % during ESAP. Inflation and the budget deficit averaged 27.6% and 10.9%, respectively. The unemployment rate rose from 21.4% in 1992 to 30% in 1995. Manufacturing output declined by 5% per annum during the reform period, while manufacturing employment declined by 1.8% per annum.

To summarise, during the period 1965-1979 the manufacturing sector benefited from the protection and consequently developed into one of the most sophisticated industrial bases in Sub Saharan Africa. In the second period, 1980-1990 it continued to be protected, but the easy stages of import substitution were over and its obsolete equipment needed to be replaced. Shortages of foreign currency constrained the sector from replacing its old equipment and from importing necessary inputs, forcing the industry to operate at low levels of capacity utilization. The deregulation of the economy, in the 1990s exposed the industry to international competition and (having been protected for a long time), the sector was inevitably vulnerable. These different policy regimes, somehow, influenced the choice of inputs and output in the manufacturing sector. The industry evolved and operated in an environment of uncertainty and thus production risk becomes an important research subject. Changes in the economic policy conditions and the production environment can also have some bearing on the efficiency of the industry.

The intent of this paper is to model labour demand in the manufacturing sector.[3] We go further than other studies as we not only seek to explain what determines the level of employment but also to identify the factors that affect the variance of employment. This is important because employment in the manufacturing sector has not only expanded sluggishly, but it has also exhibited great variation over time. This is important when designing policies that are geared at reducing the variance of employment or those policies that seek to increase employment. A high variance is an indication of a vulnerable labour market. The vulnerability arises in cases where stabilisation of the labour market is desirable to avoid high rates of unemployment. Since the variance function is both industry- and time-specific, it allows for the identification of industries that are vulnerable and policies can be targeted at specific segments of the manufacturing industry. In addition, the paper looks at the efficiency

[3] The employment is equivalently defined as the labour demand. The use of labour demand is perhaps more appropriate in relation with firm level data. Since we use an aggregate data at manufacturing level throughout the paper we use the term employment as well.

of the manufacturing industry in the choice of the level of employment that is technically necessary to produce a given level of output. In applying this model to the manufacturing sector we add another dimension to the literature on the estimation of a labour demand relationship.

Labour demand is modelled in the traditional manner as a function of wages, output, quasi-fixed capital and time variables (see Layard and Nickell 1986 and Symons 1985). The variance function incorporated multiplicatively to the employment relationship includes the above variables plus other factors that may influence variations in employment. This is similar to a labour demand model that exhibits heteroscedasticity of known form.[4] In modelling the level and variance of employment we generalise some techniques that have been used earlier in the studies of labour demand, labour use, production risk and efficiency.

The issue of incorporating the variance function and its specification was championed by Just and Pope (1978).[5] Since the Just and Pope study is on production, the variance function is appropriately referred to as the production risk function. Kumbhakar (1993) extended the production risk model to incorporate production efficiency. Kumbhakar and Hjalmarsson (1995) studied labour use efficiency in the public insurance industry. The labour use model is a special case of the labour demand model. The labour use approach is found to be appropriate in the analysis of service industries where labour is the dominant factor of production. The labour demand and labour use efficiency combined with employment variance is applied to Swedish Savings banks by Heshmati (2001). Our study is the first attempt to apply this methodology to the manufacturing industry and to a developing country.

The rest of the paper is organised as follows. The employment model is presented in Section 2. Section 3 contains the description of the data. Section 4 presents the model specification and the estimation procedure. The results are discussed in Section 5 and the main findings of the study are summarised in Section 6.

2. THE MODEL

Let the labour demand or employment relationship for Zimbabwe's manufacturing industry be represented by

[4] For a detailed discussion of heteroscedasticity of known and unknown forms, see Kmenta (1986, Chapter 8) and Heshmati (1994).

[5] For a comprehensive discussion of the issues of risk/variance in production, a survey on various estimation methods and their properties with an application to the Norwegian Salmon aquaculture, see Tveterås (1997). For a discussion on firm's response to risk, see Robinson and Barry (1987).

(1) $l = f(y, w, k, t; \alpha)$

where f is the production technology, l is the level of employment (measured as number of persons) used in the production of a given level of output, y, and α is a vector of unknown parameters to be estimated. The variables w, k and t are wages, capital inputs and a time trend, respectively.[6] This relationship is similar to an input requirement function introduced by Diewert (1974) and Pindyck and Rotemberg (1984). The employment function (1) defines the amount of labour that is required to produce a given level of output. However, labour resources may be used more than what is technically necessary to produce a given level of output. Thus, the level of employment depends on production technology *f(.)*, technical inefficiency (μ) and other factors that have both positive and negative impacts on the industry's demand for labour (v), but that are beyond the control of the industry. Examples of the factors contained in this random component *(v)* are *inter alia*, the oil crises, the droughts, labour market conflicts, unanticipated government policies, etc. We can therefore rewrite equation (1) as

(2) $l = f(y, w, k, t; \alpha)\exp(\varepsilon)$

where $\varepsilon = \mu + \nu$. The random element (v) can be either positive or negative i.e. $-\infty \leq \nu \leq \infty$. Following Aigner, Lovell and Schmidt (1977), $\mu \geq 0$. For the industry that is 100% efficient in the usage of labour, i.e. $\mu = 0$, the relation in (2) becomes the conventional average labour demand function.

The relation above ignores the issues of production risk or heteroscedasticity denoted earlier as the variance of employment. However, in some industries where risk is important, a labour demand function that ignores production risk is restrictive. The inclusion of production risk improves the stochastic component of the labour demand function. In addition, the incorporation of risk is important in cases where the knowledge about the variance of employment can play a major role in the design and evaluation of labour policies that seek to improve employment conditions. Consider, for example, the case of the textile industry in 1993, which suddenly faced unanticipated high duties by its greatest export

[6] Capital variable *(k)* is introduced to capture variation in the production structure between industries.

market South Africa. This inevitably, influenced the choice of inputs for this industry. So, in this industry, a model that includes the risk element is more informative.

To derive the implications of the presence of risk following Kumbhakar (1993)

(3) $$l = f(x;\alpha)\exp(g(x,z;\beta)\varepsilon)$$

where $x = (y, w, k, t)$, $f(x;\alpha)$ is the deterministic part of the labour demand function and $g(x,z;\beta)$ represents the variance function of the labour demand. In the variance function the z vector represents industry characteristics and regulatory regimes such as export, sales, money supply, government expenditure and interest rate variables, that may influence the variation of labour demand, other than those that explain the demand for labour, i.e. the *x*-variables. This is an attempt to relate risk/variance with output and/or input decisions made by the industries. A failure to capture risk in the model reduces the problem to that of simple heteroscedasticity and the degree at which it is related to output, inputs and other exogenous variables. The objective is to analyse how riskiness affects input use and production. Industries should care about risk in making output and employment decisions. It is desirable to have a model that incorporates risk.

Taking logs of this equation, we get

(4) $$\ln l = \ln f(x;\alpha) + g(x,z;\beta)\varepsilon \, .$$

This specification has three attractive features. First, *lnf(.)* can be expressed in a flexible functional form such as a translog. Second, the expected value of the labour function *E(l)* and its variance *V(l)* are both affected by risk. Third, the specification accommodates both positive and negative marginal risks even if *g(.)* is a linear function of input variables.

The expected value and variance of model (3) is

(5) $$E(l) = f(x;\alpha)\exp(g^2(.)/2)$$

and

(6) $$V(l) = f^2(.)\exp(g^2(.)\left[\exp(g^2(.)/2) - 1\right]$$

If $E(l) \geq f(x;\alpha)$ then the marginal risk function is

$$MR_j = \frac{\partial V(l)}{\partial x_j} = 2f(.)\exp(g^2(.)/2)$$

$$\left[f_j(.)\left\{\exp(g^2(.)) - 1\right\} + f(.)g(.)g_j(.)\left\{2\exp(g^2(.)) - 1\right\}\right] \quad (7)$$

where $f_j(.)$ and $g_j(.)$ are respectively partial derivatives of the $f(.)$ and $g(.)$ functions with respect to x_j. From equation (7), it can be seen that the marginal risk with respect to x_j can be either positive or negative depending on the sign and size of the $g(.)g_j(.)$ term that varies with x_j across industry and over time. If $g(.)g_j(.) > 0$, the marginal risk with respect to x_j is unambiguously positive and on the other hand, it is unambiguously negative if $g(.)g_j(.) < 0$ and the second term under [.] is greater (in absolute value) than the first.

3. 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 1970 to 1993. The data contains information on inputs, output, industry characteristics and a number of policy variables. The summary statistics of the data are reported in Table 1.

The dependent variable is total employment (*l*), and independent variables in the labour demand part of the model are average wages (*w*), capital stock (*k*) and output (*y*). The variance part of the model, in addition to *w*, *k*, and *y*, includes sales (*s*), exports (*x*), money supply (*m*), government expenditure (*g*) and interest rates (*r*).[7] The employment variable is total number of employees in each industry. *Wages* are defined as total wages in each industry divided by the total number of employees in that industry. Thus, the wage variable is industry specific. The average wages are then deflated by the product prices. *Capital* is

[7] The justification for including x, s, m, g and r in the variance function is that this function has to capture policy and environmental variables that may affect the variation of employment. Take for example sales, one would expect the fluctuations in sales to cause some fluctuations in employment. The same applies to x, m, g and r. Some of these variables have been added in employment functions, e.g. Layard and Nickel (1986), Symons, (1985).

measured using the perpetual inventory method; $k_{it} = k_{it-1}(1-\delta_i) + I_{it}$ where k_{it-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 δ_i is the average rate of depreciation and is constant over time, but varies by industry. The variable I_{it} represents investment measured as total expenditure on capital and buildings. *Output (y)* is measured by the output index of each industry.

The variable *sales* is measured in Zimbabwe dollars and was deflated by the GDP deflator. *Exports* are calculated as the ratio of total manufacturing exports to manufacturing GDP. *Money supply* is M2. *Government expenditure* is measured in Zimbabwe dollars and is deflated by the GDP deflator. *Interest rates* are represented by the lending rate. The real interest rate was found to be negative in a number of years, thus, we used nominal rates instead of real rates. A vector of *T-1* time dummies are used to represent the exogenous rate of technical change and a time trend is used to capture possible shifts in the variance function over time. In addition, *N-1* industry dummies are used to capture industry specific effects.

4. ESTIMATION PROCEDURE

Since model (3) assumes no a priori functional form, a less restrictive translog specification is used to approximate $f(x;\alpha)$ and a linear form for $g(x,z;\beta)$. Assuming panel data (see Baltagi, 1995) are available, the model in (4) is expressed as

$$\begin{aligned}
\ln l_{it} = {} & \alpha_0 + \alpha_y \ln y_{it} + \alpha_w \ln w_{it} + \alpha_k \ln k_{it} + \lambda_t \\
& + 1/2 \left\{ \alpha_{yy} \ln y_{it}^2 + \alpha_{ww} \ln w_{it}^2 + \alpha_{kk} \ln k_{it}^2 \right\} + \alpha_{yw} \ln y_{it} \ln w_{it} \\
& + \alpha_{yk} \ln y_{it} \ln k_{it} + \alpha_{wk} \ln w_{it} \ln k_{it} + \alpha_{yt} \ln y_{it} t + \alpha_{wt} \ln w_{it} t + \alpha_{kt} \ln k_{it} t \\
& + \left\{ \beta_y y_{it} + \beta_w w_{it} + \beta_k k_{it} + \sum_j \beta_j z_{jit} + \beta_t t \right\} \left[\mu_i + v_{it} \right]
\end{aligned} \qquad (8)$$

where *l*, *w*, *y* and *k* are as previously defined and *i* indexes industries *(i=1,2,.....N)*, *t* indexes time periods *(t=1,2,.....T)*, and λ_t represents time dummies. In order to reduce the number of parameter estimates, since we have a few observations, the interactions between the right hand explanatory variables with the time effects are left out and instead a simple time trend is used.

Following Just and Pope (1978) and Griffiths and Anderson (1982), a four-step generalized least squares estimation procedure is used to estimate models (8.a) and (8.b).[8] The steps are:

Step 1. The g(.) function is ignored and models (8.a) and (8.b) are estimated by ordinary least squares. Besides the α coefficients, the μ and λ are respectively estimated from *N-1* and *T-1* industry and time dummies. Since $E(v) = 0$, the ordinary least squares estimates are consistent but inefficient because the error term is heteroscedastic.[9]

Step 2. The estimates of α, λ and μ from step 1 are used to obtain residuals as shown in equations (9) as follows

$$
\begin{aligned}
e_{it} = {} & \ln l_{it} - (\alpha_0 + \alpha_y \ln y_{it} + \alpha_w \ln w_{it} + \alpha_k \ln k_{it} + \lambda_t \\
& + 1/2\left\{\alpha_{yy} \ln y_{it}^2 + \alpha_{ww} \ln w_{it}^2 + \alpha_{kk} \ln k_{it}^2\right\} \\
& + \alpha_{yw} \ln y_{it} \ln w_{it} + \alpha_{yk} \ln y_{it} \ln k_{it} + \alpha_{wk} \ln w_{it} \ln k_{it} \\
& + \alpha_{yt} \ln y_{it} t + \alpha_{wt} \ln w_{it} t + \alpha_{kt} \ln k_{it} t + \mu_i). \qquad (9)
\end{aligned}
$$

The estimates of the residuals in (9) are then used to estimate the variance part of labour demand by non linear techniques as[10]

$$
\ln e_{it}^2 = -1.2704 + \ln\left\{\beta_y y_{it} + \beta_w w_{it} + \beta_k k_{it} + \sum_j \beta_j z_{jit} + \beta_t t\right\}^2 + \ln v_{it}^2. \qquad (10)
$$

Step 3. Asymptotic efficient estimates of α and β are obtained by performing generalised least squares on models (8.a) and (8.b). This is similar to estimating models (8) by ordinary least squares after dividing both sides of it by the estimate of $g(.)$.

Step 4. Steps 1-3 are repeated until convergence is obtained.

The fixed effects obtained from the *N-1* industry dummies are used to calculate employment efficiency. Employment efficiency is measured relative to the industry with the

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8 See Just and Pope (1978) and Griffiths and Anderson (1982) for details and properties of the estimates.

9 For discussions on the issues of heteroscedasticity of unspecified form in standard production function framework, see Heshmati (1994). For estimation of efficiency in production assuming heteroscedasticity, see Caudill, Ford and Gropper (1995) and Kumbhakar (1997).

10 Since estimates of the error term converges to $v_{it,}$ which is distributed as Chi squared random variable with one degree of freedom, (under the assumption that $v_{it,}$ is a standard normal random variable), the mean and variance of ln v_{it} ,are -1.2704 and 4.9348, respectively. (See Theorem 2 of Just and Pope (1978, pp 77-79) and Griffiths and Anderson 1982, p 531).

best performance in the sample. The best industry is taken to be 100% efficient or $\mu = 0$. However, over time different industries can come out as the best in the sample. Thus, time variant employment inefficiency (*EINEFF*) is obtained using Schmidt and Sickles', (1984) approach. Employment efficiency is relative to the most efficient industry in each year and is obtained as

$$
\begin{aligned}
EINEFF_{it} &= g(x_{it}, z_{jit}; \beta)(\alpha_0 + \mu_i) - \min_i \left[g(x_{it}, z_{jit}; \beta)(\alpha_0 + \mu_i) \right] \\
&= \left\{ \beta_y y_{it} + \beta_w w_{it} + \beta_k k_{it} + \sum_j \beta_j z_{jit} + \beta_t t \right\} (\alpha_0 + \mu_i) \\
&\quad - \min_i \left[\left\{ \beta_y y_{it} + \beta_w w_{it} + \beta_k k_{it} + \sum_j \beta_j z_{jit} + \beta_t t \right\} (\alpha_0 + \mu_i) \right.
\end{aligned}
\tag{11}
$$

The rate of employment efficiency (EEFF) is given by

$$EEFF_{it} = \exp(-EINEFF_{it}). \tag{12}$$

Since the estimated coefficients of the quadratic and the translog labour demand functions employed are not directly interpretable, elasticities of labour demand with respect to output, wages and quasi-fixed capital inputs are calculated as

$$
\begin{aligned}
E_y &= \partial \ln l_{it} / \partial \ln y_{it} = \alpha_y + \alpha_{yy} \ln y_{it} + \alpha_{yw} \ln w_{it} + \alpha_{yk} \ln k_{it} + \alpha_{yt} t \\
E_w &= \partial \ln l_{it} / \partial \ln w_{it} = \alpha_w + \alpha_{ww} \ln w_{it} + \alpha_{yw} \ln y_{it} + \alpha_{wk} \ln k_{it} + \alpha_{wt} t \\
E_k &= \partial \ln l_{it} / \partial \ln k_{it} = \alpha_k + \alpha_{kk} \ln k_{it} + \alpha_{yk} \ln y_{it} + \alpha_{wk} \ln w_{it} + \alpha_{kt} t
\end{aligned}
\tag{13}
$$

in the case of Kumbhakar model. The elasticity of labour demand with respect to time, interpreted as the exogenous rate of technical change or shift in the labour demand over time are obtained in a similar way as

$$E_t = \partial \ln l_{it} / \partial t = (\lambda_t - \lambda_{t-1}) + \alpha_{yt} \ln y_{it} + \alpha_{wt} \ln w_{it} + \alpha_{kt} \ln k_{it} \tag{14}$$

All elasticities are calculated at each data point, thus the elasticities are both industry- and time-specific.

5. EMPIRICAL RESULTS

The parameter estimates of the demand functions, $f(x;\alpha)$ and the risk functions $g(x,z;\beta)$ are reported in Tables 2. In terms of parameter signs, root mean square errors (RMSE), goodness of fit (R^2) criteria, the more restrictive Cobb-Douglas functional form were outperformed by the translog specifications. In addition, the trended translog was rejected in favour of the time dummy model. For brevity, only the results of the time dummy models are reported in Table 2.

All but six coefficients are statistically significant in at least, 10% levels of significance and all the *x* variables have the right signs. The R^2 is very high (0.99), suggesting a good fit for the data. All, (but one), industry dummies, (compared with the reference food industry) are significant, while all but two time dummies are statistically significant.

The variance functions $g(x,z;\beta)$, were estimated using non linear least square methods as described in the steps of the estimation procedure. Convergence was achieved after seventeen iterations. A trend was included in the variance functions to capture neutral shifts in the variance function over time. Coefficients associated with wages, capital, time trend and interest rates are statistically significant in at least 10% level of significance The R^2 for the variance function i.e. 0.28 is lower than those of the labour demand function.

For the labour demand functions, elasticities with respect to *w*, *k*, *y*, and time were calculated (as in equations 13, and 14) and are reported in Tables 3. In order to conserve space these elasticities are evaluated at the mean values for each year, and industry. In addition, in the same tables we report the mean values of the exogenous rate of technical change. The mean marginal elasticities of labour demand with respect to each risk factor are reported in Tables 3 together with total variance.[11] The mean efficiency values by industry and over time are reported in the last column of Tables 3. The overall sample mean and standard deviations of elasticities, marginal variance and efficiencies are also reported in these tables. In Table 4, the correlation coefficients of the mean elasticities of the labour demand and marginal risk elasticities are presented. In Figure 1 we plot the mean elasticities by industry and in Figure 2 we graph the development of these elasticities overtime. Figure 3

[11] Total variance is calculated as the sum of the marginal risk elasticities (excluding the time effects).

plots employment efficiency by industry i.e., 3(i) and overtime i.e., 3 (ii). Finally, in Figure 4 we present the mean risk elasticities by industry i.e., 4(i) and overtime i.e, 4(ii).

5.1 Labour Demand Elasticities.

The elasticities of labour demand with respect to wages, output and capital are reported in Tables 3. The signs of the elasticities are as expected. The mean wage elasticity, is -0.31. Looking at the individual industries there is much industry variation in labour demand responsiveness to wage changes. Labour demand responsiveness is greatest to wages in the following industries; drink and tobacco (-0.389), textiles (-0.352) and metals (-0.325). There was a continuous increase in responsiveness, however sluggish, up to 1990, and a slow decline in the 1990s. The decline in the 1990s coincided with a period when there was a sharp decline in real wages in the manufacturing industry as a whole. The deregulation of prices under structural adjustment triggered unprecedented inflationary pressures that saw real wages go down to their pre-1980 levels.

The sample mean elasticity of labour demand with respect to output is 0.089 and the standard deviation is 0.071. Responsiveness of labour demand with respect to output is greatest in the food and transport industries. Overtime, responsiveness of labour demand to changes in output increased continuously up to 1990 in both cases, followed by a decline during the structural adjustment period (see Figure 2).

On the basis of the sample mean values, the results show that a 1% increase in capital stock leads to a 0.08% increase in labour demand. Responsiveness is greatest in the metals industry in both models (see Figure 1). Overtime, (see Figure 2 the responsiveness was greatest after 1990, probably because of the opening up of the economy and the deregulation of the labour market. In addition to these results, the correlation coefficients in Table 4 support the view that an increase in the wages is associated with a fall in capital accumulation.

We now turn to the exogenous rate of technical change. The sample average rate of technical change is very small, i.e. 0.005, but with a relatively large standard deviation of 0.077. There is technical progress (labour saving) in the in wood and non metals industries. The industry with the largest regress is metals followed by the chemicals. The total rate of technical progress is 7%, while the total rate of technical regress is 8%. The years in which there was labour saving technical progress were 1970, 1976, 1978, 1983-85, 1989 and 1991-

93. Technical regress was mainly concentrated in the early 1970s, early and latter part of the 1980s. Technical progress was fastest between 1990 and 1993. This is the period when the economy was liberalised and many companies began to replenish their obsolete equipment. The deregulation of the labour market made it possible and easier to replace labour with machinery.

To summarise, the results suggest that labour demand responds most to wages, followed by capital stock changes, and lastly, output. Large variations in the pattern of the elasticities is found within industries than overtime. The rate of technical regress was fastest during the reforms (averaging about 19.5%).

5.2 Marginal Elasticities

The β coefficients (variance function) are reported in Table 2.Five of the nine coefficients are statistical significant at conventional levels. The variance function coefficients for wages, output, money supply and interest rates are positive. The coefficients for sales, the trend, capital stock, exports and government expenditure are negative. The following variables are statistically significant; wages, capital stock, trend, exports and rate of interest. The estimate of the variance (σ_v^2) is 3.349. It is close to, but less than the asymptotic variance of 4.9348. In other words, this model underestimates the asymptotic variance.

The coefficients associated with the variance function are not directly interpretable. Thus, marginal risk elasticities are calculated as in (7) and are reported in Table 3. An inspection of Table 3a shows that the marginal risk elasticities with respect to wages is relatively small and negative in five of the ten industries (see Figure 4 (i)). Overtime they are all negative except 1971-2, 1980, and 1992-3.

The overall risk elasticity with respect to output is negative and very small. The industries responsible for the negative output-risk elasticities are food, clothing and metals. Overtime, in all but seven years in the sample, is the mean marginal risk elasticity with respect to output negative-but very close to zero. The overall mean risk elasticity with respect to capital is positive suggesting that changes in this variable increase the variance in labour demand.

The rate of technical change increases the variation in labour demand. The overall mean marginal risk with respect to technical change is relatively large (0.754), and with a large standard deviation of 0.905. This increasing effect is more pronounced in the food, textile, clothing and metal industries. Overtime, the mean marginal risk with respect to technical change increases continuously (see Figure 4 (ii)).

In the last but one column, in Table 3 we report the mean total variance. The overall mean is positive 0.025 (0.017). The figure in parenthesis is the standard deviation. The metals, drink and textile industries have the greatest total variation.

5.3 Employment Efficiency

We now discuss the efficiency results.[12] The results computed according to equation (12) are reported in Tables 3, and plotted in Figure 3. This measure captures how technically efficient an industry is in its choice of the optimal size of the labour inputs. It is a relative measure as it relates a particular industry to the most efficient one; in this case, the metals. The sample mean efficiency values is 92% (0.044). In brackets is the standard deviation. Thus, industries that are close to the average can be better off if they reduce their demand for labour by 8%. These are high figures by any standard. They reflect excess labour due to the absence of many years of necessary adjustment in manufacturing employment. Considering the fact that for almost a decade before 1991 adjustment of labour was not possible, then these figures, as they suggest some cumulation of the unadjusted stock of labour of 16% make sense.

According to this model, the industries most closer to the best (metals) are food (95%), followed by clothing (94%) and then textiles (92%). The least efficient industry is the transport at 87,6%.

Over time efficiency increased sharply between 1970 and 1972 (see Figure 3(ii)). This was followed by a fall around 1973/74. After 1974 the model exhibits increasing efficiency levels up to 1981/82. The results show a peak in 1982 which was followed by a steady decline up to 1989. The recovery in 1990, was reversed in 1992.

The correlation coefficients in Table 4 show positive and significant correlations between wages and efficiency suggesting that increases in wages force industries to achieve a technically optimal size of labour. An increase in output or capital is associated with a fall in technical efficiency. The correlation is significant for capital, implying that more investment in capital drives industries away from having the technically optimal size of the labour-force.

[12] A word of caution is in order here. Care must be taken when interpreting efficiency considering the level of aggregation of our data.

The positive (negative) marginal risks imply increases (decreases) in the level of technical efficiency. The correlation between the mean marginal risk with respect to the wage and trend is also negative.

6. SUMMARY AND CONCLUSIONS

The purpose of this paper has been to estimate a labour demand function incorporating the variance function. This is an extension of previous labour demand models found in literature. The inclusion of the variance function in the specification of a labour demand model is aimed at identifying and estimating the effects of factors that cause fluctuations in labour demand. The variance function is incorporated both additively and multiplicatively to the ordinary labour demand function. Labour demand is a function of wages, output, capital and time variables. In addition to these variables, the variance function is specified as a function of sales, exports, money supply, government expenditure and interest rate. The model is non-linear and is estimated using a multi-step generalized least squares method.

The final model is specified as a translog form to represent the underlying functional form. Restricted versions such as the Cobb-Douglas and the translog form with a time trend to represent the exogenous rate of shift in the demand functions were rejected in favour of a translog form with annual time intercepts. The goodness of fit statistic, R^2, for the labour demand models corrected for heteroscedasticity indicate a good fit.

The elasticity with respect to the wages was as expected, negative. The sample mean wage elasticity is –0.37 and the size of the wage elasticities vary more among industries than they do over time. Elasticities with respect to output are relatively small with a mean of 0.09. The output elasticity increased over time up to around 1990. This is an indication that before 1990, adjustment in the demand for labour in response to changes in output was a slow process. Expansions in the level of output could be achieved using excess capacity without equal increases in the labour force. The responsiveness of labour demand to changes in capital is also small- with a sample mean value of 0.08. Responsiveness due to capital was greatest during the structural adjustment period than the period before.

Thus, briefly, labour demand results suggest that labour demand is more responsive to wage changes than it is with respect to the remaining variables i.e. capital and output. This implies that excessive increases in real wages have a negative impact on labour retention in the manufacturing sector, while investment and economic growth are essential for employment creation. Emphasis should be placed on policies that encourage capital accumulation, aggregate demand and overall economic growth.

The results also suggest that during the sample period, for a given level of wages and output there has been some technical progress (labour saving) in the wood and nonmetals. The overall mean rate of technical regress is estimated to be 0.5%. This suggests that the net effect of new technologies being adopted is positive in terms of employment creation. However, over time the rate fluctuates very much. The flexible time effects model specification allowed us to capture the complex patterns of technical change quite well. We observe periodic switches from technical progress to regress and back to progress. Technical progress was fastest during the economic structural adjustment phase (averaging 19.5%) than during the UDI or the first post-independence decade.

Marginal variance elasticities with respect to wages, output, capital and trend were calculated. The sample mean marginal risk elasticities with respect to the wages and output are negative whereas capital and the time trend term gives us positive elasticities. Thus, for those industries close to the sample mean, wages and output decrease the variation in labour demand, whereas capital and the time trend increase the variation. Total variation has a sample mean value of 0.025. This is an indication that all the variables taken together, increase the variance of labour demand.

The sample mean efficiency was found to be 92%. In both models the metal industry is found to be more efficient in all years and thus, it is used as a reference point for efficiency comparisons. The results indicate that employers would be better off if they reduced their labour stocks by 16%. The industries closest to metals in terms of having the optimal size of the labour-force were food, textiles and clothing. We find a positive association between increases in wages and improved efficiency. This means that wage increases force employers to use their labour resources more efficiently. Large fluctuations in efficiency over time is an indication of the absence of the expected positive correlation between efficiency and time.

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Table 1. Summary statistics of the Zimbabwe's manufacturing industry, 1970-1993, in 1990 prices.

Variables	Definition	Mean	Std Dev.	Minimum	Maximum
Labour demand variables:					
e	Employment	15661.81	9629.46	3467.00	44755.00
w	Real Wages	2430.69	811.56	799.07	4335.23
o	Output	105.77	31.12	9.00	226.20
Other variance function variables:					
m	Money supply	788.21	409.64	183.08	1512.91
k	Capital	31975847.46	35829873.07	1352424.61	233928571.40
g	Government Expenditure	543924658.70	28979750.70	74107142.86	869300911.90
r	Interest Rates	12.32	7.75	6.50	37.90
s	Sales	206390.94	162688.20	34897.47	846915.18
x	Exports	24.30	17.01	4.17	56.41
t	Time trend	12.50	6.94	1.00	24.00

The number of observation is 240.

Table 2. Labour Demand and Risk Function Parameter Estimates.

Parameter	Estimate	Std. Errors
2.a Labour Demand Functions:		
α_0	-0.0721	0.0563
α_W	-0.4662***	0.1034
α_Y	-0.0247	0.0559
α_K	0.0492*	0.0277
α_{WW}	0.0349	0.0534
α_{YY}	0.0228	0.0221
α_{KK}	0.0004	0.0100
α_{WY}	0.0436	0.0382
α_{WK}	-0.0702**	0.0307
α_{WT}	0.0109**	0.0042
α_{YK}	-0.0541***	0.0153
α_{YT}	0.0081***	0.0021
α_{KT}	0.0009	0.0014
μ_{drink}	-0.6193***	0.0709
$\mu_{textile}$	-0.2948***	0.0586
$\mu_{clothing}$	-0.0748	0.0660
μ_{wood}	-0.5965***	0.0872
μ_{paper}	-0.7091***	0.0964
$\mu_{chemicals}$	-0.4928***	0.0724
$\mu_{non\ metals}$	-0.9329***	0.0811
μ_{metals}	0.5033***	0.0530
$\mu_{transport}$	-1.1073***	0.0811
λ_{1971}	0.0979***	0.0505
λ_{1972}	0.2203***	0.0509
λ_{1973}	0.2976***	0.0544
λ_{1974}	0.3219***	0.0509
λ_{1975}	0.3388***	0.0482
λ_{1976}	0.2833***	0.0508
λ_{1977}	0.3357***	0.0504
λ_{1978}	0.2667***	0.0573
λ_{1979}	0.3376***	0.0585
λ_{1980}	0.4023***	0.0534
λ_{1981}	0.4906***	0.0487
λ_{1982}	0.5302***	0.0490
λ_{1983}	0.4525***	0.0551
λ_{1984}	0.4500***	0.0554
λ_{1985}	0.4364***	0.0595
λ_{1986}	0.4657***	0.0593
λ_{1987}	0.4713***	0.0614
λ_{1988}	0.5851***	0.0613
λ_{1989}	0.5410***	0.0652
λ_{1990}	0.5911***	0.0646
λ_{1991}	0.5248***	0.0659
λ_{1992}	0.3585***	0.0691
λ_{1993}	0.2015**	0.0974
R^2	0.9853	

Table 2. Continued ...

Parameter	Estimate	Std. Errors
2.b Risk Functions:		
β_0	.	.
β_W	13.3520***	1.6416
β_Y	-0.8453	0.5687
β_K	-1.5487***	0.3546
β_T	-0.5073**	0.1874
β_S	1.2469	1.5277
β_X	-5.5564**	2.4123
β_M	3.4313	4.4571
β_G	-1.5027	2.8905
β_R	6.9152**	1.5880
RMSE	1.8301	
R^2	0.2757	
σ^2_v	3.3490	

* denotes significance at 10% level; **denotes significance at 5% level; ***denotes significance at 1%level.

Table 3 Mean demand elasticities, marginal risk and technical efficiency.

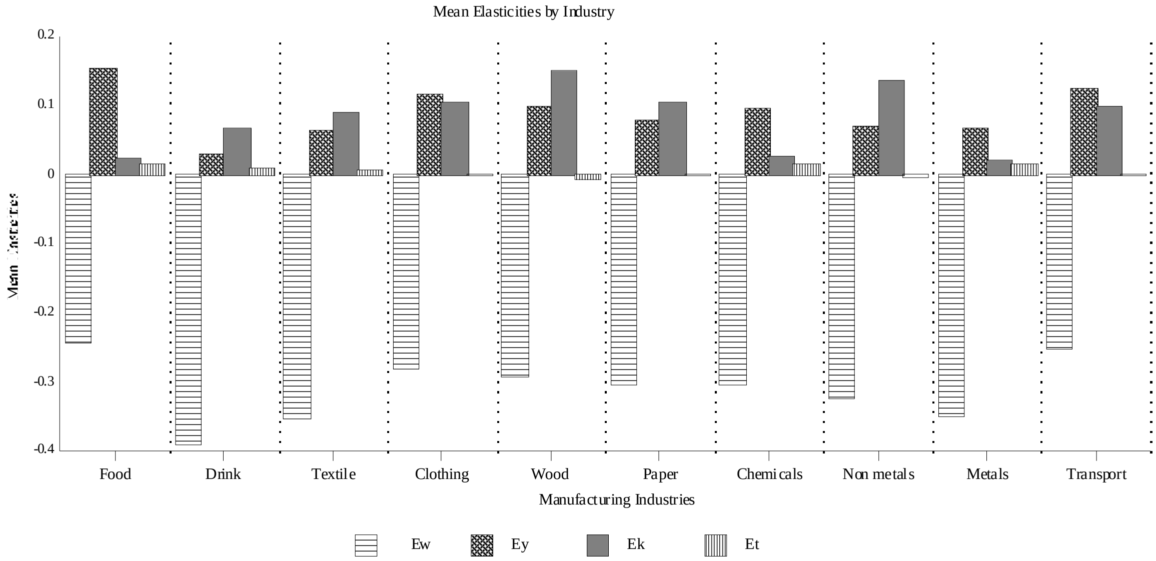
	Demand Elasticties				Marginal Risk Elasticities				Efficiency	
	E_W	E_Y	E_K	E_T	MR_W	MR_Y	MR_K	MR_T	TVAR	EEFF
Mean Elasticities by Industry:										
Food	-0.244	0.153	0.022	0.013	0.178	-0.078	-0.296	1.558	0.018	0.948
Drink	-0.389	0.029	0.067	0.008	-0.424	0.010	0.079	0.458	0.039	0.881
Textile	-0.352	0.062	0.088	0.004	0.286	0.046	0.126	1.000	0.036	0.916
Clothing	-0.280	0.116	0.102	0.001	0.218	-0.090	-0.260	1.129	0.024	0.941
Wood	-0.291	0.099	0.149	-0.007	0.063	0.017	-0.096	0.291	0.023	0.899
Paper	-0.303	0.077	0.104	0.001	-0.030	0.014	-0.014	0.181	0.014	0.904
Chemicals	-0.304	0.096	0.024	0.014	-0.065	0.018	0.020	0.456	0.020	0.912
Non metals	-0.325	0.068	0.136	-0.004	0.027	0.011	-0.031	0.146	0.025	0.870
Metals	-0.350	0.067	0.019	0.015	-1.140	-0.120	0.727	2.234	0.039	1.000
Transport	-0.252	0.123	0.098	0.001	-0.009	0.004	-0.022	0.089	0.016	0.876
Mean Elasticities by Year:										
1970	-0.476	-0.041	0.092	-0.006	-0.132	0.099	0.056	0.032	0.044	0.879
1971	-0.430	-0.004	0.089	0.091	0.025	0.002	-0.016	0.073	0.026	0.917
1972	-0.407	0.014	0.083	0.117	0.088	-0.002	-0.025	0.130	0.026	0.916
1973	-0.386	0.029	0.084	0.072	-0.222	-0.012	0.007	0.208	0.035	0.892
1974	-0.384	0.032	0.088	0.018	-0.202	-0.014	0.029	0.283	0.027	0.899
1975	-0.390	0.025	0.091	0.011	-0.273	0.012	0.062	0.349	0.024	0.904
1976	-0.379	0.034	0.091	-0.061	-0.046	0.000	0.024	0.355	0.025	0.910
1977	-0.336	0.063	0.099	0.045	-0.046	0.002	-0.042	0.382	0.016	0.932
1978	-0.319	0.081	0.085	-0.074	-0.342	-0.023	-0.041	0.425	0.028	0.911
1979	-0.296	0.100	0.078	0.067	-0.029	-0.014	-0.099	0.539	0.027	0.917
1980	-0.301	0.095	0.077	0.061	0.004	0.035	-0.071	0.655	0.018	0.931
1981	-0.308	0.088	0.075	0.085	-0.039	-0.021	-0.019	0.770	0.009	0.950
1982	-0.293	0.099	0.072	0.037	-0.043	-0.021	-0.041	0.841	0.006	0.960
1983	-0.284	0.110	0.068	-0.079	-0.143	-0.054	-0.061	0.871	0.013	0.941
1984	-0.260	0.127	0.066	-0.004	-0.062	-0.028	-0.073	0.898	0.015	0.939
1985	-0.248	0.136	0.075	-0.016	-0.306	-0.230	-0.052	0.950	0.020	0.929
1986	-0.241	0.142	0.077	0.027	-0.026	-0.021	-0.059	1.024	0.021	0.925
1987	-0.246	0.139	0.077	0.003	-0.200	-0.020	-0.004	1.139	0.028	0.913
1988	-0.218	0.157	0.060	0.114	-0.095	-0.059	0.229	1.288	0.029	0.912
1989	-0.227	0.153	0.067	-0.044	-0.284	0.076	0.154	1.361	0.043	0.882
1990	-0.221	0.154	0.068	0.050	-0.072	-0.013	0.105	1.406	0.045	0.884
1991	-0.235	0.145	0.084	-0.069	-0.306	-0.017	0.078	1.502	0.050	0.886
1992	-0.261	0.130	0.092	-0.170	0.273	-0.043	0.196	1.352	0.017	0.917
1993	-0.271	0.127	0.102	-0.161	0.329	-0.037	0.221	1.267	0.020	0.905
Overall Mean and Standard Deviations:										
Mean	-0.309	0.089	0.081	0.005	-0.090	-0.017	0.023	0.754	0.025	0.915
Std Dev	0.092	0.071	0.047	0.077	0.648	0.189	0.385	0.905	0.017	0.044

Glossary of variables:
Mean labour demand elasticities with respect to: wages (E_W), output (E_Y), capital (E_K), rate of technical change (E_T). Mean marginal risk elasticities with respect to: wages (MR_W), output (MR_Y), capital(MR_K), time trend (MR_T), total variance (TVAR) and employment efficiency (EEFF).

Table 4 Pearson's Correlation Coefficients/probability values.

	Year	E_W	E_Y	E_K	E_T	MR_W	MR_Y	MR_K	MR_T	TVAR	EEFF
YEAR	1.000										
	0.000										
E_W	0.724	1.000									
	0.001	0.000									
E_Y	0.728	0.990	1.000								
	0.001	0.000	0.000								
E_K	-0.075	-0.119	-0.207	1.000							
	0.246	0.064	0.001	0.000							
E_T	-0.487	-0.200	-0.208	-0.174	1.000						
	0.001	0.001	0.001	0.006	0.000						
MR_W	0.047	0.153	0.139	0.308	-0.070	1.000					
	0.467	0.017	0.030	0.001	0.280	0.000					
MR_Y	-0.097	-0.137	-0.159	0.150	0.020	0.076	1.000				
	0.130	0.033	0.013	0.019	0.747	0.240	0.000				
MR_K	0.121	-0.252	-0.233	-0.212	-0.065	-0.341	-0.072	1.000			
	0.060	0.001	0.001	0.001	0.315	0.001	0.265	0.000			
MR_T	0.501	0.399	0.479	-0.517	-0.158	-0.161	-0.266	0.274	1.000		
	0.001	0.001	0.001	0.001	0.014	0.012	0.001	0.001	0.000		
TVAR	0.022	-0.357	-0.322	-0.090	0.010	-0.266	0.072	0.502	0.186	1.000	
	0.725	0.001	0.001	0.160	0.870	0.001	0.260	0.001	0.003	0.000	
EEFF	0.001	0.074	0.148	-0.529	0.126	-0.261	-0.238	0.247	0.572	-0.149	1.000
	0.997	0.253	0.021	0.001	0.050	0.001	0.001	0.001	0.001	0.020	0.000

Figure 1. Mean elasticities by manufacturing sector.



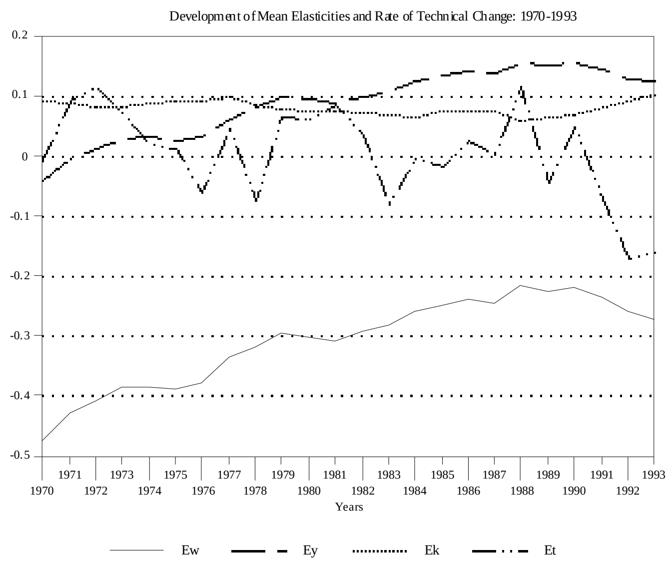


Figure 3(i)

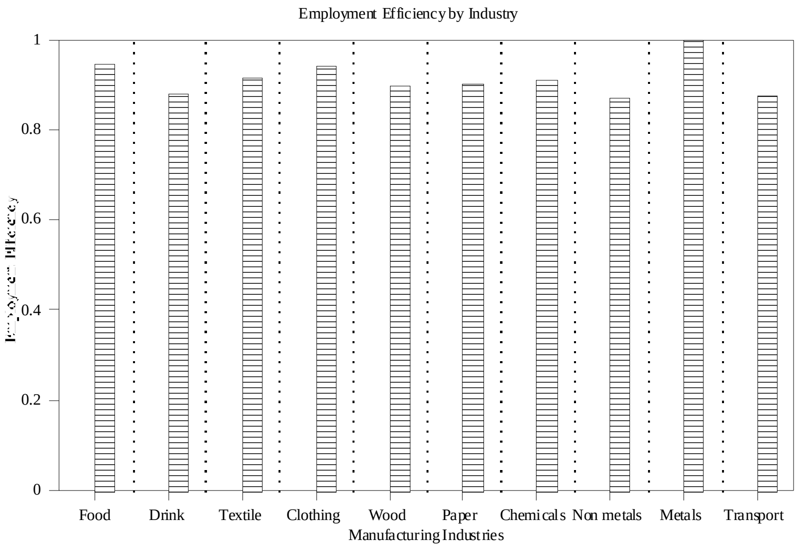


Figure 3(ii)

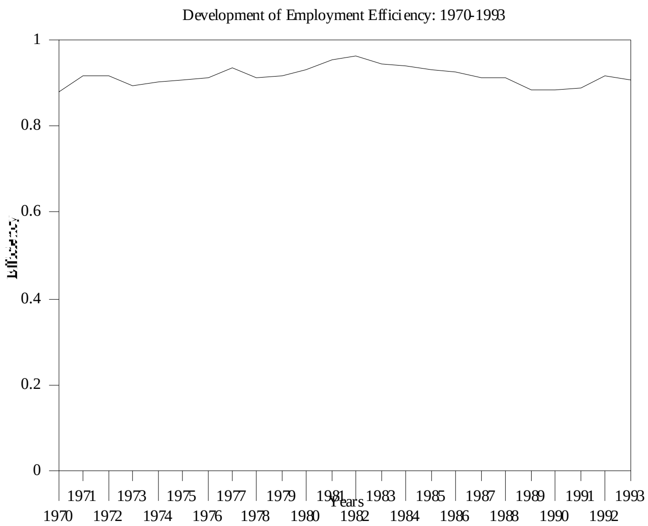


Figure 4(i)

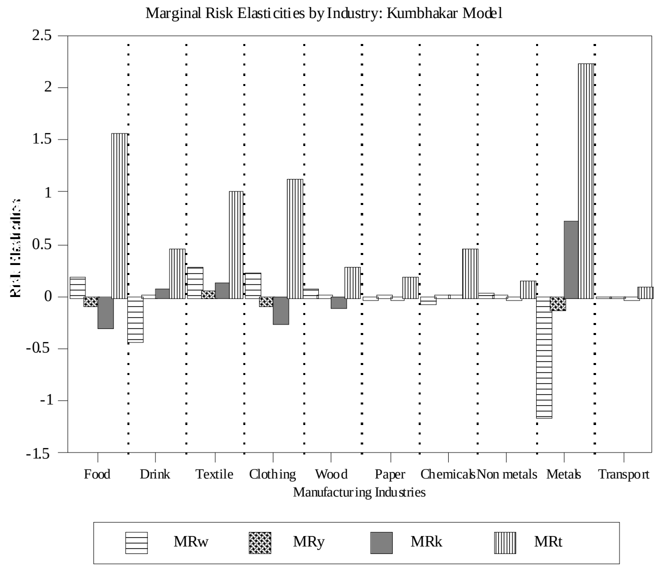


Figure 4(ii)