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Amit K. Bhandari
Almas Heshmati

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# Labour Use and Its Adjustment in Indian Manufacturing Industries

**Amit K. Bhandari**
*University of Kalyani*

**Almas Heshmati**
*MTT Economic Research, Seoul National University*
*and IZA Bonn*

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IZA

P.O. Box 7240
53072 Bonn
Germany

Phone: +49-228-3894-0
Fax: +49-228-3894-180
Email: iza@iza.org

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# ABSTRACT

## Labour Use and Its Adjustment in Indian Manufacturing Industries

This study provides an empirical investigation of the adjustment process of labour in Indian manufacturing industries, which evolved through structural transformation in the era of globalization. The analysis is based on a dynamic model applied to a panel of 22 two-digit manufacturing industries for the time period of 22 years covering 1980/81 to 2001/02. We assume that as competition increases industries adjust their employment to a desired level which is both industry and time specific. The results indicate that the manufacturing sector has shown a considerable dynamism in adjusting its workforce. The long run labour demand responds greatest to the output, followed by capital and least by wages. It is observed that Indian manufacturing is not inefficient in labour use as modest speed of adjustment has led employment size closer to the optimal level.

JEL Classification: C23, J23, L60

Keywords: labour use, employment, adjustment, globalization, manufacturing, India

Corresponding author:

Amit K. Bhandari
Department of Economics
University of Kalyani
West Bengal–741 235
India
Email: amitbhandari2@rediffmail.com

## 1. INTRODUCTION

Like many other developing countries India's reform process was principally based on the objective to save crisis. In early 1990s, India unfolds major reform measure in their economic system to rescue from financial and balance of payment abyss. But an important objective was to remove all irritants and stumbling blocks for opening up of the economy, which was marked as a major push towards greater liberalization and globalization process. Business environment changed drastically as there was a shift in the policy of regulation to market orientation, exposing the industries to greater competition. This is turn creates pressure on the industrial units to pay more attention on product quality, price etc. Trade reform allows cheaper import of intermediate and capital inputs which substitute for the services of domestic labour. (see Rodrik, 1997) Like other factors of production labourers in the industries are to bear the burnt of the structural reform. The organized manufacturing sector covers only a tiny segment of India's massive workforce, providing about 10 per cent employment as a whole. The justification for looking at the organized manufacturing labour stems primarily from the fact that they are encircled by various rules and regulations compared to other sectors of the economy, which guaranteed their rights of job security. As a result of increased competition labour market also undergoes structural adjustment which is required for facilitating economic restructuring. Therefore, one can view the changes that went on in the labour market after the adoption of structural reform in India through the lens of the organized manufacturing sectors.

The impact of structural reform on labour is a contentious issue. The advocates of reform believe that the removal of legislative and institutional constraint has helped in achieving labour market flexibility and also increased employment potential. The antagonist of reform associates economic reform with employment loss because of large scale restructuring of enterprises to achieve competitive advantage.[1] Overall the employment generating potential of the organized manufacturing industries witnessed a significant drop over the past three decades, although it recovered to some extent after the reforms were undertaken. There was a marked acceleration in the employment growth during the first half of 90s, which might be thought as a result of economic reforms. (Goldar, 2000) Total share of manufacturing workers to the entire workforce recorded a decline from 16.8% in 1977-83 to 15.3% in 1983-88 and then declined further to 8.5% in 1988-94. In contrast, between 1994 and 2000 (reform period) employment share has bounced back to 13.9%. (see Deshpande, 2002)

Costs of an individual firm can be divided into two parts - labour and non labour input costs. Firms can not adjust its non labour input cost easily and directly in the short run as they face market determined prices for them and these factors are quasi-fixed in the short run. Moreover, the non labour cost is directly linked with the quality of the product. So firms are might go for adjusting costs by cutting down its employment size. This has become more evident especially for those firms which had a good deal of overstaffing especially evident to those of public sector units. Revision of labour costs downward warrants two-pronged strategy. One is related with the immediate short term which in turn affects the structure of employment, labour rules and regulations. And the other is to do with the labour productivity, which in the mainstream literature is often

[1] For optimistic view of the impact of structural reform on employment see Joshi and Little (1998) and Goldar (2000) and for pessimistic view see Bhattacherya and Mitra (1993) and Nagraj (1994).

cited as "labour use efficiency". In the incidence of excess labour, the speed of adjustment of the workforce is related with labour market flexibility, that is, the freedom of the employer to adjust their workforce according to their wish. (Treu, 1992) This requires elimination of rigid regulations without impairing workers security of livelihood. The features of rigid labour market comprised of some collections of legislations related to employment securities, minimum wage and agreements for collective bargaining. All these legislations affect labour use, its efficiency and flexibility.

However, flexible labour market promotes new employment and production at the cost of reduced job security.[2] In the short run, downward revision of wage share in output value is not possible with permanent wage contract. The only option open is to shift towards contractual employment on a temporary basis to avoid formal labour rules and regulations.[3] These developments favour employers towards greater labour market flexibility to achieve international competition. However, casualization of labour is beneficial for industry's competitiveness but it is a matter of concern for the workers as the incidence of poverty is highest among the casual workers. Hence, in the post-reform period the major concern, therefore, is not the capacity of employment generation in the organized sector but the quality of employment. The search for labour market flexibility in Indian manufacturing led labour intensive firms and those engaged in the production of consumer non-durables to subcontract and outsource their production to the unorganized sectors. (Ramaswamy, 1999)

A number of studies attempt to analyze the dynamic labour demand and its adjustment procedure (Hazledine, 1981)[4]. In the presence of labour adjustment costs firms lay off fewer workers than in the absence of adjustment costs and would carry excess labour through a slump period as cited by Nickell (1986). Roy (2004) studied the impact of Industrial Dispute Act 1976 and 1982 on the dynamics of employment adjustment through a disaggregated study of 16 industry groups in the Indian manufacturing sector. His finding provides the evidence that there is a significant lag in employment adjustment. Production workers fall in higher adjustment path compared to supervisors indicating the higher use of contract workers and overtime hours for the previous groups. Overall, the impact of job security regulations on employment dynamics has not been severe as it was believed. Masso and Heshmati (2004) studies the issue of optimality and efficiency of labour in a dynamic framework for Estonian manufacturing industries. Using firm level data they showed that long run employment respond greatest to wages and least by capital stock. Haouas *et al* (2003) investigates the speed of adjustment and the degree of labour use efficiency to find the empirical support that labour market become more flexible under the liberalization period of Tunisian manufacturing industries. The evidence of labour market rigidities and its adjustment raises the possibility of labour hoarding in the 1970s as referred by Nagaraj (1994). Nickell (1979) and Burgess (1988) links slow adjustment of labour to the

[2] It is believed that flexible labour market creates more employment (Tella, 2003).

[3] For detailed discussion see Elger (1987), Morginson (1991) and Rifkin & Heilbroner (1995).

[4] Important contribution on dynamic adjustment of labour has been made by Kumbhakar et al. (2002), Judson and Owen (1999), Bhalotra (1998), Baltagi and Griffin (1997), Hamermesh (1993), and Arrelano and Bond (1991).

imposition of a variety of labour market policies that make it more difficult for the firms to shed extra labour.

Industries undertake adjustment in its resource use with an objective to improve efficiency and profitability. To understand the effect of policy changes on labour demand it is required to incorporate dynamic adjustment process in the analysis of labour use. Using panel data, a flexible adjustment model is employed incorporating a speed of adjustment model which is both industry and time variant. The present study focuses on the adjustment of labour use in the regime of economic reform. In this context, we estimate the optimality and efficiency of labour usage among Indian manufacturing industries. In addition, the study also provides an insight into labour demand elasticity with respect to wages, output and capital, both over time and across industries. We estimate the result for both pre and post reform period and compare their changes.[5] Hence, the paper contributes to the existing literature on the recent development of the Indian labour market. The results can be useful in understanding the path of development and the design of policy measures to combine industrial development, skill upgrading with welfare enhancing programs in the era of reform.

The paper proceeds as follows. In Section 2 the basic model of our empirical analysis is spelt out. This is followed by the description of data and empirical results in the subsequent sections respectively. The major findings of the study are summarized in the concluding section.

## 2. THE MODEL

The demand for labour is a derived demand, which depends on the change in demand for final product, performance of the firm, degree of capital utilization, technology etc. Several attempts have already been made to derive labour demand using different types of production function. Arrow (1961) attempted in this regard by employing CES production function. Given the limitations of CES function fixed coefficient Leontief function was employed by Diewert (1971). In the present study, following Christensen, Jorgenson and Lau (1973), we propose to employ translog function because of its lesser number of restrictions over both CES and Leontief types of functions.

Assume that labour market is adjusted instantaneously. There is no supply side constraint on labour, which is valid under the labour surplus situation. Under the equilibrium condition, the observed level of employment ($L_{it}$) should be equal to the optimal level of employment ($L*_{it}$) for industry $i$ in period $t$. In reality, the process of adjustment is costly where the labour market does not allow for full adjustment. Under the circumstances we adopt partial adjustment model of actual and desired level of employment:

$$\frac{L_{it}}{L_{it-1}} = \left( \frac{L^*_{it}}{L_{i,t-1}} \right)^{\delta_{it}} \qquad (1)$$

[5] The pre and post comparison is the crudest method of assessing the impact of any changes. We prefer it because it is simpler than other alternatives.

This is the equation of non-full adjustment of labour where $L_{it}^{*}$ represents the optimal level of employment. $\delta_{it}$ denotes the adjustment parameter. The degree of adjustment depends on the size of the adjustment parameter. Higher the value of $\delta_{it}$ indicates higher the speed of adjustment whereas lower the value ensures slower speed of adjustment. $\delta_{it}$<1 implies that there is only partial adjustment, $\delta_{it}$=0 means no adjustment of labour and $\delta_{it}$=1 implies full adjustment is done in a single period. An inefficient industry will try to adjust its labour use to the desired level $L_{it}^{*}$ from its actual level of employment $L_{it}$.

Taking log of both sides of the equation (1),

$$InL_{it} - InL_{it-1} = \delta_{it}\left(InL_{it}^{*} - InL_{i,t-1}\right) \tag{2}$$

Rearranging above equation and appending an error term we get:

$$InL_{it} = (1-\delta_{it})InL_{i,t-1} + \delta_{it} InL_{it}^{*} + \varepsilon_{it} \tag{3}$$

$$\varepsilon_{it} = \mu_i + \lambda_t + \nu_{it} \tag{4}$$

Where, following the tradition in the panel data literature the error term is decomposed into three components: $\mu_i$ is industry specific effects, $\lambda_t$ are time-specific effects and $\nu_{it}$ are random error components which are assumed to be independently and identically distributed with mean zero and constant variance. The industry and time effects are incorporated in the optimal labour segment of the model.

Assume L* is the minimum amount of labour required to produce a given level of output and L is the actual amount of labour used into the production. At equilibrium, L = L* implies that for a given technology there exists an efficiency in use of labour. We use translog form of an inverted factor requirement model to estimate the labour demand. Here labour is a decision variable, while capital is quasi-fixed and output is exogenously determined.[6] The optimal level of labour is modelled as follows:

$$\begin{aligned} \ln L_{it}^{*} &= \beta_0 + \beta_W \ln W_{it} + \beta_Y \ln Y_{it} + \beta \ln K_{it} + \textstyle\sum_t \lambda_t D_t \\ &+ 1/2\left[\beta_{WW}(\ln W_{it})^2 + \beta_{YY}(\ln Y_{it})^2 + \beta_{KK}(\ln K_{it})^2\right] \\ &+ \beta_{WY} \ln W_{it} \ln Y_{it} + \beta_{WK} \ln W_{it} \ln K_{it} + \beta_{YK} \ln Y_{it} \ln K_{it} \\ &+ \beta_{WT} \ln W_{it} t + \beta_{YT} \ln Y_{it} t + \beta_{KT} \ln K_{it} t + \textstyle\sum_i \mu_i D_i + \nu_{it} \end{aligned} \tag{5}$$

where W, Y and K are real wage, value added (or output) and capital respectively, $D_i$ represents industry specific effects, $D_t$ represents time-specific effects or year to year shifts in technology, $t$ is a time trend, and $\nu$ is random error term with mean zero and constant variance.

The objective of firm or industry is to minimize the labour cost of producing a given level of output conditional on the level of wages, quasi-fixed capital and technology. It

[6] The inverted factor demand is derived from a production function where the dependent variable output is function of production factor inputs including capital, labour, intermediate input (material and energy), as well technology.

is reasonable to assume that wages is exogenous in the short run and key determinant of the demand for labour. As mentioned previously the manufacturing is mostly organised and due to skill intensive production technology wages are competitive and vary in a given and smaller range than in the non-organised sector. Capital is also exogenous after the investment decision is made determining in turn the production capacity and production technology. The output is exogenously determined by the price and quality of products.

In the traditional dynamic partial adjustment model there is some rigidity in the movement from actual to that optimal level of employment. The adjustment parameter is a constant $(\delta)$ implying adjustment takes place at the same rate over time across industries. The rigidity can be relaxed by allowing for a flexible speed of adjustment and which varies over time and across industries $(\delta_{it})$. An inefficient industry must try to adjust its labour requirement to an optimal level by adjusting its factor of production. An inefficient industry may take long time to adjust its labour requirement to the optimal level ( $L_{it}^{*}$) until the value of $\delta_{it}$ is close to unity.

Thus the flexible speed of adjustment can be expressed as function of number determinants:

$$\delta_{it} = \delta_0 + \sum_t \delta_t D_t + \sum_i \delta_i D_i + \sum_m \delta_m Z_{mit} \qquad (6)$$

where D are vectors of the industry and time dummies and the vector Z refers to the production environment, factors determining the industries speed of adjustment to the optimal level of employment. It also contains the absolute distance or gap between actual and optimal levels at the end of the previous period. The speed of adjustment is flexible and varies with both across industries and over time.

Equation (5) allows us to determine elasticity of optimal employment with respect to different variables. Elasticity of optimal employment with respect to wage, output and capital are obtained from taking the derivative of $\ln L^{*}$ with respect to each variable as: $E_w = \partial \ln L_{it}^{*} / \partial \ln W_{it}$ , $E_Y = \partial \ln L_{it}^{*} / \partial \ln Y_{it}$ , and $E_K = \partial \ln L_{it}^{*} / \partial \ln K_{it}$ . The expected sign of $E_w$ is negative since an increase in real wage will tend to reduce the demand for labour. The expected sign of $E_Y$ is positive as more labourers are needed to produce more output whereas the sign of $E_K$ is positive if labour and capital are complements and negative when they are substitutes.

In the present study, we allow the labour demand function to shift over time to capture the effect of technical change on the level of employment. For the intercept we use time dummies, while for the interaction of time with other explanatory variables a time trend. The time dummies capture year to year variations in the labour demand, while the use of time trend interactions reduces the overparametriztion of the model. The technical change can be defined from equation (5) as:

$$TC = \partial L_{it}^{*} / \partial t = (\lambda_t - \lambda_{t-1}) + \alpha_{WT} \ln W_{it} + \alpha_{YT} \ln Y_{it} + \alpha_{KT} \ln K_{it} \qquad (7)$$

The technical change is decomposed into pure or neutral component $(\lambda_t - \lambda_{t-1})$, non-neutral component $(\alpha_{WT} \ln W_{it} + \alpha_{KT} \ln K_{it})$, and scale augmenting components $(\alpha_{YT} \ln Y_{it})$. A positive rate of TC indicates that labour using technology

is employed, implying synonymously as technical regress. On the other hand, negative rate of TC indicates labour saving technology, which implies technical progress or downward shift in the labour function over time.

## 3. DATA AND VARIABLE DEFINITIONS

In India, the basic data source for manufacturing sector is obtained from Annual Survey of Industries (ASI), published by Central Statistical Organization (CSO). In this study we use a panel of 22 two digit industries over the period from 1980/81 through 2001/02. The data covers almost entire organised manufacturing sectors in India. The variables required for the study are employment, wages, output, value added and capital stock. Using the concordance procedure industries are assembled according to the latest available industry classifications. ASI reports monetary value of the data at current period. So, appropriate price deflator is needed to convert them into constant process. The wholesale price index (WPI) series for different industries are use for deflating them at a constant 1993/94 prices.

Employment is defined as the number of workers engaged in any manufacturing activities. The number of workers is calculated as the average mandays per worker during the year. Wage per worker refers to the product wage derived as the total wage bill divided by the number of workers of that industry. Output is measured as the total value of output produced by an industry in a fiscal year. The value added is measured as total value of output minus total value of raw material as well as intermediate inputs. To measure capital stock we derive a series of capital stock at replacement cost. Capital stock for successive years is obtained by using perpetual inventory method, which is obtained as a sum of new investment and the depreciation of adjusted capital stock at the beginning of the period. (Roy, 2004)

The total period of our study is divided into two sub periods – pre-reform period (1980-91) and post-reform period (1991-02). As discussed earlier, India's liberalization and economic globalization was intensified through the policy reforms initiated in 1991. This two sub periods allows investigating the changes caused by trade liberalization and globalization. Since it is not possible to distinguish the effects of economic reform from those of liberalization and economic globalization[7], without counterfactual we use the two terms interchangeably. Significant changes occurred in the manufacturing sectors especially under the competitive environment after globalization. Hence, this two sub period would be an interesting feature to look for.

A simple correlation matrix shows that wages, capital, output and value added are increasing over time, while level of employment is decreasing, but the changes in employment over time is not statistically different than zero. The capital variable is

[7] Globalization can have different dimensions such as: economic, personal, technology, political, environmental and financial market. In several recent studies the economic globalization is proxied by foreign direct investment, openness and capital flows (Mahler 2001 and Bhagwati 2000). James (2002) analysis the causes of globalization in terms of transaction costs and focuses on ICT, technical change and FDI deriving globalization. Heshmati (2003) computes a multidimensional index of globalization and analyzes the impacts of globalization on income inequality across countries. The concern of Milanovic (2002) is on the effects of openness on income distribution, and those of Sen (2002) and Ravallion (2003) on deprivation and rising disparity in the standards of living.

highly correlated with output (0.80) and value added (0.72) suggesting collinearity problem if a production model is estimated and subsequent difficulties to separate their effects. The wage variable is also correlated but at lower rate with output (0.54), with value added (0.66) and with capital (0.56). A summary statistics of the data is presented in Table 1.

The average size is 56 workers per firm in an industry while on an average each worker receives Rs. 29 thousand[8] in a year. In the pre globalization period average employment was 57 per average firm whereas the post globalization employment comes down to 55 per firm. There was an improvement in the average real wage received by the worker from Rs. 24 thousand in the pre reform period to Rs. 33 thousand in the post reform period. One would expect the size of firm to increase over time as a consequence of trade liberalization and globalization. The unexpected negative change in the size of average firm is due to growth of newly established small and medium sized firms reducing the overall size. On the other hand, the real annual wages, value of output, value added and capital stock between the two periods grew by 137%, 80%, 85% and 152%, respectively, and the dispersions around mean also increased significantly over time.

## 4. EMPIRICAL RESULTS

### 4.1 Specification, estimation and testing

We estimate a dynamic model in equation 3 with the error component structure shown in equation 4 assuming the unobserved labour requirement specified in term of observables as in equation 5 and the flexible adjustment parameter in equation 6, which is both industry and time variant. The variation is facilitated by making the adjustment parameter a function of its determinants. The vector of possible determinants include: the absolute distance from the optimal level of employment, industry characteristics, performance indicators, labour and financial market variables, policy variables, unobservable industry effects and unobservable time effects.

The labour requirement function is specified to be a function of wages, value added, capital stock and time trend. Here labour is considered as a variable input, which is subject to adjustment in the short run and a decision variable, while capital stock is quasi-fixed after the decision of investment is made. For sensitivity analysis, results with value added as well as the value of output are also presented. Value added has the advantage that intermediate input which is proportional to the level of production and serves only as a mark up to cost is deducted from production value. On the other hand, the use of value of output accounts indirectly for intermediate inputs as factor of production.

The speed of adjustment is specified as a function of absolute distance between observed and optimal use of labour, capital intensity per employee, labour productivity (defined as output per employee), globalization period, export orientation and import orientation. The pre-globalization period and industries producing for domestic market are also considered as references. Inclusion of industry and time effects on the speed of

[8] One Rupees was 0.022 US$ in April 2004

adjustment caused convergence difficulties and hence excluded from the specific model. A limited degree of industry heterogeneity and time effects are captured by the division of periods and industries in more aggregated groups. The slope variables are continuous variable.

The advantage of using translog function is that it is flexible with smaller standard error and approximated by any second order functional form. It can be tested against nested simpler forms, such as Generalized Cobb-Douglas functional form by setting the interaction terms equal to zero and also Cobb-Douglas by restricting both the squared and interaction terms. A number of F-tests are conducted, based on their residual sum of squares. The test results are reported in Table 2. The results suggest that both Cobb-Douglas and Generalized Cobb-Douglas are rejected in the favour of translog specification. Test results shows also that the industry and time specific effects with few exception individually and jointly are statistically significant and they should both be incorporated in the translog model specification. The translog with industry and time specific effects is the accepted functional form regardless of the choice output variable, namely output or vale added.[9]

For the matter of sensitivity analysis the results of three models are estimated and reported. First, the labour demand model is estimated without any lag adjustment as a static model, but including industry and time specific effects, where it is assumed that observed labour adjusts to the optimal level instantaneously. Second, the model is estimated under assumption of a partial adjustment, where adjustment parameter following the tradition in the literature is restricted to be constant. Finally, we estimate a flexible partial adjustment dynamic model where the speed of adjustment is allowed to be both industry and time variant. The two dynamic models are non-linear in parameters and require iteration process to estimate them, while the static model is linear. They are estimated using non-linear and linear least squares method, respectively. The estimated parameters for alternative specifications of labour demand models based on valued added are presented in Table 3 and those based of value of output in Table 5.

The degrees of generalization from static to restricted and flexible adjustment parameter dynamic models are tested using F-tests. The test results rejected the static and restricted dynamic models in the favour of unrestricted dynamic flexible adjustment model. The higher F-tests and $R^2$ values and the lower RMSE measure in models where value added is introduced as explanatory variable suggest that value added is a better proxy for production than value of output. However, we cannot reject value of output based estimates as such test results of these two models are not nested.

As shown later for a number of reasons, such as violation of regulatory conditions in both value added and output model specifications, we base our analysis on both measure of output. The output measure has the advantage that in a production function approach it provide a better measure of RTS as well as material and energy input elasticities and input bias in technical change. In current case we estimate a labour demand and no such variables enter into the specification. Thus, the difference between

[9] In order to conserve space, the results for restricted and rejected models are not reported here. However, these can be obtained from the authors upon request.

the two variables in terms of generated information like various input elasticity and returns to scale is little.

### 4.2 Labour demand elasticities

The long run value of elasticity with respect to wages, value added and capital are presented in Table 4 for unrestricted dynamic case. The short run elasticity is calculated by multiplying with the speed of adjustment and these are reported in Appendix A. The long run elasticity reflects instantaneous and full adjustments to the desired level of labour use whereas short run response in labour demand reflects inter periodical changes in explanatory variable. Our analysis will be restricted to the long run elasticities as it is more relevant with long run perspective of exogenous changes and the subsequent adjustments in the industrial policy and firm's behaviour. The sign of elasticity of demand for labour with respect to wage rate is expected to be negative, while the output and capital elasticity is positive. The corresponding elasticities based on the static model where output is defined as production value or value added is reported in Appendix C and D. The long run and short run elasticities and other information based on value added is presented in Table 4 and Appendix A whereas results measured in terms of value of output are reported in Table 6 and Appendix B.

The estimate shows that the mean long run labour demand elasticity is -0.274 with the standard deviation of 0.325 (see Table 4). Industry wise break up of elasticity shows that labour demand is more sensitive to wage rate in wood (-0.796), followed by tobacco (-0.780), food and beverages (-0.675), non-metallic mineral (-0.663) and leather (-0.529) industry. These sectors are all labour intensive, which are generally involved in low technology manufacturing and requires unskilled or semiskilled workers. Employment responds positively with wages in motor vehicle (0.117), electrical machinery (0.083), computing machinery (0.080) and petroleum (0.038) industry. These are basically capital intensive industries, where labourers are generally highly skilled and more organized. More industry wise variations are found in the value of elasticities then over time. A time trend in the elasticities suggest that over time there is no systematic pattern observed, although labour demand become more elastic shifting form -0.235 in the pre reform period to -0.317 in the post reform period.

The mean labour demand is found to be less elastic of -0.109 (0.226) with value of output estimates (Table 6). The labour demand varies between -0.625 in tobacco industry to 0.112 in other transport industry. Until 1986-87, the value of elasticities was positive, thereafter, become more elastic and follows a steadily decreasing trend. Periodically, labour demand more sensitive to wages from -0.017 in the pre reform to -0.211 in the post reform period.

Change in labour market institutions due to the labour reform carried out may have led to the change in employment elasticity. During pre-reform period large factories were challenged by the power exerted by large scale unionism which made them uncompetitive. Post reform period was marked by the reduced power of labour unions as witnessed by overall decline in union membership. Unions are more powerful in

relatively more capital-intensive industries, as the demand for labour is inelastic compared to labour-intensive sectors.[10]

Mean labour demand elasticity with respect to value added is 0.536 with the standard deviation of 0.120 (Table 4). This implies that if other things remain constant, employment increases by 5.3 per cent with every 10 per cent rise in increase in output. Industry wise the value of output elasticity of labour varies between 0.898 for wood industry and 0.210 for petroleum industry. Over time not much change is found in the value elasticity, although the mean value has increased marginally from 0.530 in the pre reform period to 0.544 in the post reform period.

Turning to the estimates with output reported in Table 6, the mean labour elasticity is found to be 0.431 (0.120). Almost identical industry wise distribution of elasticity value is found. Output elasticity of labour recorded a steady increase throughout the entire time period. The increase is more pronounced in the post reform period. For about 10 per cent increase in output there has been a marginal increase in output elasticity of labour from about 3.8 per cent pre reform period to 4.9 per cent in post reform period.

Positive growth of output elasticity of labour suggests that output growth generates larger employment opportunities. This may be explained by low labour productivity of the workers. For instance, productivity of the Indian worker is half that of the Chinese workers. The work related skill is quite low, only 19.6 per cent for male and 11.2 per cent for female workers in urban areas. (Papola and Sharma, 2003)

The mean capital elasticity is 0.118 with standard deviation of 0.075, that is, a 10 per cent rise in capital increases a very little employment of 1.18 per cent (Table 6). Over time the value of capital elasticity decreased continuously. There is a sharp decline in the capital elasticity from 0.148 in the pre reform to 0.084 in the post reform period. The highest and lowest capital elasticities are found in tobacco industry (0.233) and printing and publishing industry (0.001) respectively. Low capital elasticity indicates that industries are more inclined to use capital intensive techniques of production by employing skilled workers. With value of output the mean responsiveness of labour demand is 0.152 (0.100), which is higher compared to value added based estimates. The positive sign of capital elasticity suggests complementarity relationship between capital and labour. At the same time, decreasing elasticity indicates that production process becoming capital intensive in Indian manufacturing industries. The low and time variant capital elasticity is consistent with our *a priori* expectations.

### 4.3 Technological change

Table 4 also outlines the estimates of technical change and its decomposition into pure, non-neutral and scale augmenting technical change components. The rate of technical change varies substantially over time than across industries. There is a bias towards labour saving technical progress for all industries. The result indicates that mean rate of exogenous technical change is -2.7 per cent with relatively large standard deviation of 10.5 per cent, implies that on an average one year later the same amount of output can be produced with 2.7 per cent less labour. Over time no general trend is observed in the rate of technical change.

[10] For detailed discussion see Bhattacherjee (2004).

The estimate of technical change varies substantially across industry. All industries recorded labour saving technical progress for a given output, wage and capital. The highest rate of technical change is observed in basic metal industry (-0.041) while for tobacco industry (0.004) technical change is regressive. As far as the total study period is concerned labour saving technical progress is observed in both pre and post reform periods but technical progress is little higher in the pre reform period. This suggests the use of more capital in the production structure accompanied by improved labour productivity at the cost of reduced or slow growth in employment.

With value of output the mean technical change indicates that for 10 per cent increase capital increases the employment to 3.3 per cent (Table 6). Technical progress varies between -0.007 for tobacco industry to -0.051 for printing and publishing industry. Over time, no general trend is found in technical change, but post-reform period is more technical progressive than post-reform period.

The decomposition of technical change shows that pure technical change is the primary component that has directed technical change over the entire time period. The pure component of technical change is found negative to be -6.0 per cent where the non-neutral part is very small of 0.006. The pure component reflects labour saving, while the non-neutral component increased capital intensity in production and labour's complementarity with capital. The average scale augmenting technical progress is positive (0.027). Thus, labour demand is more responsive to technology changes in relation with new investment and expansion of production or demand for output rather than the formation of capital. The degree of capacity utilization can vary greatly with demand. The scale augmenting technical change is labour saving because the return to scale in the post reform period is 0.029. Considering the behaviour of technical progress and capital interaction term the result can be interpreted that manufacturing sectors to replaced labour with capital and become more capital intensive which enhance labour use efficiency.

### 4.4 Speed of adjustment in employment

The overall mean speed of adjustment is 0.285 with the standard deviation of 0.191 (Table 4). To state it differently, industries adjust its labour towards optimal level at the rate of 28.5 per cent per year. The speed of adjustment is fluctuating in the initial years of the study period but follows a steady path after the start of the structural reform programme. The results indicate that labour market become more flexible which is modest in the later periods of the study. The average speed of adjustment was 28.1 per cent during the pre-reform period while it has increased to 29.0 per cent in the post-reform period. This difference reflects the desired impact of the reform carried out in the second period. But using value of output, on the other hand, shows a modest increase in the speed of adjustment post reform period (Table 6). So increased adjustment in labour use indicates that labour market become more flexible as low regulations have exposed industrial units to face greater market competition, which could have been the outcome of labour reform carried out during the reform period. The empirical evidence also supports this fact after looking at the recent employment scenario.

We find evidences of heterogeneity across industries with highest employment is found in petroleum industries (52.0%), followed by computing machinery (51.4%), wearing apparel (34.7%), tobacco (34.4%), basic metal (34.2%) industry etc. Machinery industry (8.4%) is slowest in adjusting labour, followed by other transport (13.4%), paper (13.8%), and textile (16.8%) industry etc (Table 4). Thus, no industry wise homogeneity is found, as both capital and labour intensive industries experienced high speed of adjustment in labour use. With value of output there are similarities in industry behaviour of adjustment parameter. The speed of adjustment in employment alone is a function of the gap between observed and optimal levels of employment, access to the type of (skilled) labour needed, forecast and uncertainty in future demand and production of goods and access to capital. Thus, capital and supply of labour could also serve as binding constraints to the speed of adjustment.

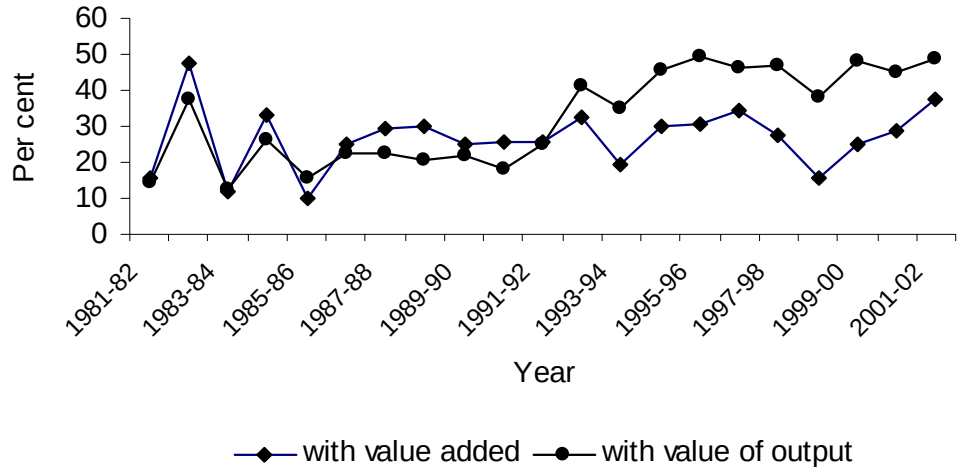


Figure 1: Development of speed of adjustment over time in Indian manufacturing industries.

### 4.5 Optimality of labour use

Efficiency in labour use can be evaluated by estimating the optimal labour requirement for different industries. Efficient use of labour is supposed to be the one of the main concern for the industry in the context of cost restructuring. As stated earlier, the optimality ratio is defined as the ratio of actual labour $L_{it}$ and the long run optimal labour requirement of the firm $L_{it}^{*}$. If the optimality ratio is greater than one, implying there is an overuse of labour for a given level of output produced, capital formation and production capacity and vice versa. If current period labour requirement is greater than previous period, the speed of adjustment ($\delta_{it}$) lies between: $0 < \delta_{it} < 1$. Here optimality in labour use is determined and compared with the optimal or minimum required labour for the same industry as reference.

For all industries the optimality ratio is found to be greater than one. There is, however, not many variations found across industries and over time. The sample mean optimality is 1.108 with the standard deviation of 0.036 (See Table 4) It means that actual amount of labour is 10.8 per cent higher than the optimal level. Industry wise, the optimality ratio varies between 1.064 for fabricated metal industry and 1.142 for other transport industry. High optimality ratio implies that industries are required to adjust downward more their labour force in the future. It is interesting to note that there is homogeneity in labour use over time. Optimality ratio was almost equal of 1.10 for both periods of the study. Based on value of output labour demand the mean optimality is 1.147, which is higher than value added based estimates (Table 6). And also there is no discernible difference exists between pre and post reform period. It is not conceivable to keep the labour size at the optimal level. Keeping in mind the supply constraint of skilled workers and the volatile market demand this marginal overuse is not a cause for concern. A firm has to keep some reserve labour to support in the changing market condition despite the possibility of hiring labour on a contract basis. One would expect some relationship between speed of adjustment and the optimal labour use, that is, industries which are less efficient in labour use would expect faster speed of adjustment whereas industries closer to the labour requirement frontier would expect to have lower speed of adjustment. Due to high fixed adjustment cost, the gap must be sufficiently large for a firm to undertake adjustment. But there is no such relationship exists in Indian manufacturing industries.

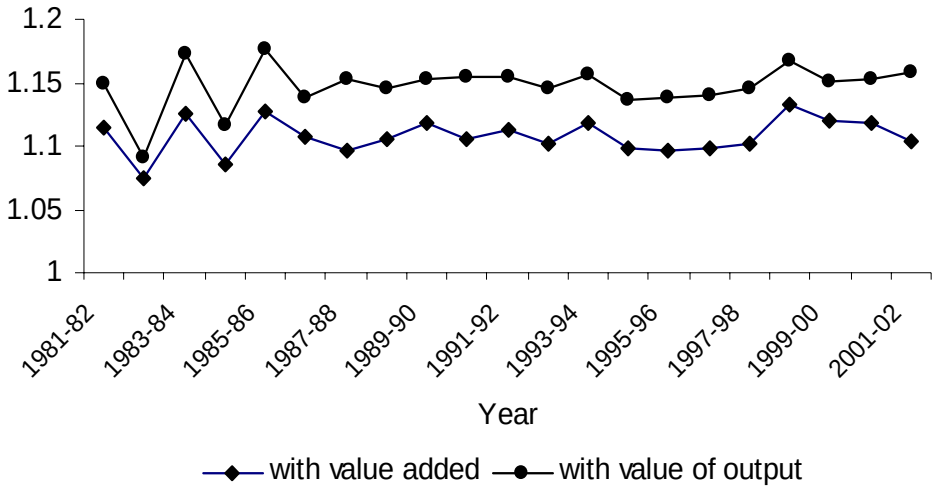


Figure 2: Development of optimality in labour use of Indian manufacturing industries**.**

## 5. CONCLUSION AND RECOMMENDATIONS

This study estimates a dynamic labour demand with flexible adjustment parameter and investigates the issue of optimality for Indian manufacturing industries in the regime of economic reform. Trade liberalisation necessitates adjusting production cost and changes in production structure within and between manufacturing sectors. It is closely associated with the ups and downs in the production process. Some export oriented sectors experienced expansion in production, while other contracts, especially those of basic heavy industries. Labour demand is represented by a labour requirement function, which is a function of wages, value added (or output) and capital stock. The adjustment parameter was modelled to observe the changes in labour demand over time as industries are allowed for a flexible speed of adjustment. The period of study covers both pre and post reform periods of Indian economy and also the current wave of globalization. Employer chooses their own path of adjustment to reach their labour requirement frontier.

The results show that the mean labour demand elasticity is greatest with respect to output followed by capital and least by wages. Own price labour demand become more elastic in the post reform period, which can be explained by growing informalization of the workforce through casualization and contract recruitment, resulted in weakening bargain power of labour unions particularly in the labour-intensive sectors. Increased labour demand with respect to output implies that larger output growth generates larger employment opportunities. Capital and labour have complementary relationship in manufacturing industries. Declining capital elasticity implies that fewer jobs were created over time with the increase in capital stock. Lowering up of tariff rates after liberalization lowers relative price of capital, which leads firms to use more capital than labour in the formation of new production capacity. The rate of technical change is capital using and labour saving in nature. But technical change is more progressive in the post reform period. Opening up of the economy have forced firms to adopt modern technology to pay more attention on quality, price etc.

The issue of labour use efficiency and labour market flexibility is described by the speed of adjustment and the optimality ratio respectively. Results indicate that, overtime, including both pre and post reform periods, employers were capable of adjusting their employment size closer to the optimal level. The speed of adjustment is marginally higher in the post-reform period compared to the pre-reform period, while value of output based estimation suggests labour market become more flexible in the post reform period. Increased speed of adjustment is an indication of high flexibility in labour use. Labour size of Indian manufacturing remains closer to the optimal level in both pre and post reform periods, which indicates that there is no problem of inefficiency in labour use. This sends out an important signal to the policy makers about how employers evolve its own path of adjustment despite the presence of labour regulations. It seems that there is virtually no impact of job security regulations on employment dynamics. Therefore, the pre reform rigidities and its effect on the adjustment of labour use are not tenable. Alternatively, in the absence of tight job security regulations the speed of adjustment could have been much higher.

For the purposes of sensitivity analysis, both value added and output value based labour demands are estimated. The differences in the result are due to inclusion of the cost of raw material and intermediate goods (material, energy, etc). The material part could

have been the source of differences between before and after reforms. Compared to output based labour demand function, average value of labour demand is more elastic with respect to wages and value added, lower with respect to capital, lower optimality ratio and the speed of adjustment using value added. Most striking difference is found with regard to technological change, which becomes less progressive in the post-reform period.

Lastly, some limitations of the study on its application side are worth mentioning. The present study assumed a homogeneous labour force and within industry firm size groups. If data permits, it would be better to analyze for some heterogeneous groups, for example, blue and white collared workers, skilled versus unskilled workers, different firm sizes within an industry and the like. Secondly, it is assumed that production structures are the same and uses aggregate manufacturing data. A disaggregated for different sub sectors or the application of micro data would be more advantageous as this would capture the differences in the production function. Nevertheless this research has contributed to shed lights on the temporal patterns of labour use in Indian manufacturing by using up-to-date methods of accounting for its dynamic adjustment towards an optimal level of employment, that is changing over time and can be the function of economic policy and industry specific production environmental variables. Future research should emphasize the effects of technology on production and substitutability/complementarity relationship between capital and labour. Another area is to analyse how government policy can enhance industrial competitiveness and employment generation through the access of capital, skill upgrading and trade policy.

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Table 1: Descriptive Summary of the Indian Manufacturing Data.

| Variable | Mean | Std dev | Max | Min |
|---|---|---|---|---|
| A. Pre Globalization Period | | | | |
| Number of Workers | 57.40 | 32.54 | 179.34 | 14.31 |
| Annual wage per workers (in Rs.) | 0.24 | 0.09 | 0.48 | 0.06 |
| Value of output (Rs. lakh) | 351.65 | 578.41 | 4263.53 | 19.67 |
| Value added (Rs. lakh) | 70.95 | 84.00 | 883.37 | 5.80 |
| Capital Stock (Rs. lakh) | 113.86 | 156.72 | 832.11 | 1.23 |
| Number of Industries | 22 | | | |
| Number of periods | 12 | | | |
| Number of observation | 264 | | | |
| B. Post Globalization Period | | | | |
| Number of Workers | 54.74 | 28.62 | 186.84 | 11.16 |
| Annual wage per workers (in Rs.) | 0.33 | 0.14 | 0.74 | 0.08 |
| Value of output (Rs. lakh) | 636.27 | 872.85 | 5270.67 | 25.62 |
| Value added (Rs. lakh) | 131.16 | 137.09 | 851.84 | 4.72 |
| Capital Stock (Rs. lakh) | 287.00 | 482.54 | 4041.69 | 5.36 |
| Number of Industries | 22 | | | |
| Number of periods | 10 | | | |
| Number of observation | 220 | | | |
| C. Total Period | | | | |
| Number of Workers | 56.19 | 30.82 | 11.15 | 186.84 |
| Annual wage per workers (in Rs.) | 0.29 | 0.125 | 0.06 | 0.742 |
| Value of output (Rs. lakh) | 481.03 | 740.10 | 19.67 | 5270.66 |
| Value added (Rs. lakh) | 98.32 | 115.17 | 4.720 | 883.36 |
| Capital Stock (Rs. lakh) | 192.56 | 355.53 | 1.227 | 4041.68 |
| Number of Industries | 22 | | | |
| Number of periods | 22 | | | |
| Number of observation | 484 | | | |

Source: Author's Calculation from ASI data.
Rs is Indian Rupees and one lakh is 1,00,000 Rupees.

Table 2: Testing function form and unobservable effects.

| F-Test based on residual sum of squares | Output | Value Added | Critical value |
|---|---|---|---|
| Generalized CD vs CD | 65.937 | 47.803 | 4.630 |
| Translog vs CD | 31.261 | 21.751 | 3.040 |
| Translog vs Generalized CD | 9.956 | 5.860 | 4.630 |
| | | | |
| Translog with and without industry effects | 90.610 | 87.689 | 1.900 |
| Translog with and without time effects | 12.108 | 6.156 | 1.900 |
| Translog with and without industry and time effects | 93.104 | 82.966 | 1.610 |
| | | | |
| Restricted dynamic vs static translog | 104.833 | 85.091 | 6.660 |
| Unrestricted dynamic vs static translog | 40.512 | 34.253 | 2.820 |
| Unrestricted dynamic vs restricted dynamic | 18.507 | 16.772 | 2.820 |

Notes: In the first group a translog specification is accepted. In the second group a translog form incorporating both time and industry effects is accepted. In the third group a dynamic unrestricted flexible adjustment parameter model is accepted. The later is the final model where the empirical analysis is based on. Critical value is based on the $99^{th}$ percentile of the distribution such that $prob(F_{n1,n2} \leq f)=0.99$.

Table 3: Labour use parameter Estimates (based on value added), NT=22x21=462 obs.

| | Static Model | | Restricted Dynamic Model | | Unrestricted Dynamic Model | |
|---|---|---|---|---|---|---|
| Variables | Estimate | Std error | Estimate | Std error | Estimate | Std error |
| A. Employment function | | | | | | |
| $\beta_o$ | 1.9948a | 0.66744 | 1.4076 | 0.9193 | -0.2856 | 0.8799 |
| $\beta_W$ | 0.9358a | 0.32964 | 0.8488b | 0.4518 | 0.2969 | 0.4188 |
| $\beta_Y$ | 0.9083a | 0.24392 | 1.25575a | 0.3389 | 2.0566a | 0.3097 |
| $\beta_K$ | -0.05671 | 0.12680 | -0.2712 | 0.1772 | -0.4103a | 0.1665 |
| $\beta_{WW}$ | 0.3001a | 0.05422 | 0.3166a | 0.0743 | 0.2828a | 0.0683 |
| $\beta_{YY}$ | -0.057b | 0.02799 | -0.0777b | 0.0385 | -0.1605a | 0.0327 |
| $\beta_{KK}$ | 0.0066 | 0.01424 | 0.01229 | 0.0195 | 0.0145 | 0.0153 |
| $\beta_{WY}$ | 0.1114c | 0.06599 | 0.18944b | 0.0913 | 0.3390a | 0.0796 |
| $\beta_{WK}$ | -0.1301a | 0.04076 | -0.1913a | 0.0567 | -0.2144a | 0.0508 |
| $\beta_{WT}$ | -0.016a | 0.00364 | -0.0187a | 0.00500 | -0.0223a | 0.0049 |
| $\beta_{YK}$ | 0.01030 | 0.03444 | 0.02126 | 0.0472 | 0.0425 | 0.0369 |
| $\beta_{YT}$ | 0.0062a | 0.00268 | 0.00417 | 0.00368 | 0.0065b | 0.0034 |
| $\beta_{KT}$ | -0.0049b | 0.00230 | -0.0030 | 0.00316 | -0.0054b | 0.0029 |
| $\beta_{T3}$ | 0.0146 | 0.03311 | 0.12728a | 0.0489 | 0.12436b | 0.0540 |
| $\beta_{T4}$ | -0.1001a | 0.03928 | -0.1048b | 0.0538 | -0.1793b | 0.0535 |
| $\beta_{T5}$ | -0.1738a | 0.04532 | -0.1329b | 0.0624 | -0.1208c | 0.0734 |
| $\beta_{T6}$ | -0.2474a | 0.05360 | -0.2592a | 0.0735 | -0.3363a | 0.0739 |
| $\beta_{T7}$ | -0.3077a | 0.06191 | -0.2731a | 0.0850 | -0.3342a | 0.0911 |
| $\beta_{T8}$ | -0.3678a | 0.07126 | -0.3440a | 0.0977 | -0.3748a | 0.1062 |
| $\beta_{T9}$ | -0.4362a | 0.07983 | -0.4078a | 0.1095 | -0.4719a | 0.1123 |
| $\beta_{T10}$ | -0.5144a | 0.08959 | -0.5124a | 0.1227 | -0.6048a | 0.1257 |
| $\beta_{T11}$ | -0.5608a | 0.09894 | -0.5638a | 0.1355 | -0.6336a | 0.1433 |
| $\beta_{T12}$ | -0.6144a | 0.10934 | -0.6228a | 0.1498 | -0.7215a | 0.1529 |
| $\beta_{T13}$ | -0.6233a | 0.11940 | -0.6204a | 0.1636 | -0.6866a | 0.1678 |
| $\beta_{T14}$ | -0.7592a | 0.13022 | -0.8030a | 0.1785 | -0.8923a | 0.1856 |
| $\beta_{T15}$ | -0.8023a | 0.14139 | -0.7909a | 0.1937 | -0.8741a | 0.1968 |
| $\beta_{T16}$ | -0.8346a | 0.15238 | -0.8380a | 0.2087 | -0.9164a | 0.2154 |
| $\beta_{T17}$ | -0.9118a | 0.16230 | -0.9383a | 0.2224 | -1.009a | 0.2243 |
| $\beta_{T18}$ | -0.9230a | 0.17293 | -0.9523a | 0.2369 | -1.0166a | 0.2420 |
| $\beta_{T19}$ | -1.0500a | 0.18307 | -1.1116a | 0.2510 | -1.2424a | 0.2567 |
| $\beta_{T20}$ | -1.1067a | 0.19335 | -1.121a | 0.2649 | -1.2670a | 0.2745 |
| $\beta_{T21}$ | -1.1393a | 0.20408 | -1.1720a | 0.2796 | -1.2810a | 0.2873 |
| $\beta_{T22}$ | -1.1546a | 0.21393 | -1.1638a | 0.2931 | -1.2514a | 0.3059 |
| $\beta_{16}$ | 0.7636a | 0.09570 | 0.7936a | 0.1312 | 0.7580a | 0.1172 |
| $\beta_{17}$ | 0.5604a | 0.04330 | 0.5593a | 0.0593 | 0.5691a | 0.0691 |
| $\beta_{18}$ | 0.2764a | 0.04088 | 0.3005a | 0.0561 | 0.3178a | 0.0588 |
| $\beta_{19}$ | 0.1697a | 0.03422 | 0.2053a | 0.0472 | 0.2428a | 0.0591 |
| $\beta_{20}$ | -0.1704a | 0.06875 | -0.0638 | 0.0958 | 0.0632 | 0.0995 |
| $\beta_{21}$ | -0.1819a | 0.04999 | -0.1564b | 0.0686 | -0.0747 | 0.0852 |
| $\beta_{22}$ | -0.2702a | 0.05398 | -0.2082a | 0.0746 | -0.2278 | 0.0811 |
| $\beta_{23}$ | -0.6967a | 0.09343 | -0.7972a | 0.1290 | -0.6657a | 0.1225 |
| $\beta_{24}$ | -0.4608a | 0.05632 | -0.4936a | 0.0773 | -0.4871a | 0.0807 |
| $\beta_{25}$ | -0.4679a | 0.03876 | -0.4308a | 0.0534 | -0.4125a | 0.0631 |

| | | | | | | |
|---|---|---|---|---|---|---|
| $\beta_{26}$ | -0.2691a | 0.03691 | -0.2475a | 0.0507 | -0.1675a | 0.0558 |
| $\beta_{27}$ | -0.1846a | 0.07212 | -0.1969a | 0.0988 | -0.2770a | 0.1117 |
| $\beta_{28}$ | -0.2360a | 0.04775 | -0.1400b | 0.0673 | 0.0391 | 0.0889 |
| $\beta_{29}$ | -0.31053a | 0.04551 | -0.2611b | 0.0629 | -0.3472a | 0.0926 |
| $\beta_{30}$ | -0.38571a | 0.05336 | -0.4271a | 0.0734 | -0.3472 | 0.0696 |
| $\beta_{31}$ | -0.30465a | 0.05006 | -0.3016a | 0.0686 | -0.3159a | 0.0734 |
| $\beta_{32}$ | -0.12666a | 0.05167 | -0.1341b | 0.0708 | -0.1148 | 0.0759 |
| $\beta_{33}$ | -0.23608a | 0.04360 | -0.1952a | 0.0601 | -0.2366a | 0.0626 |
| $\beta_{34}$ | -0.07609 | 0.06023 | -0.0956a | 0.0826 | -0.1327 | 0.0917 |
| $\beta_{35}$ | 0.44245a | 0.05102 | 0.41986 | 0.0700 | 0.2909a | 0.0827 |
| $\beta_{36}$ | -0.06869 | 0.04494 | 0.01081a | 0.0629 | 0.0227 | 0.0666 |
| B. Speed of Adjustment | | | | | | |
| $\delta_0$ | | | 0.6645a | 0.0363 | 0.1782b | 0.0784 |
| $\delta_{\text{Absolute distance}}$ | | | | | 1.2393a | 0.1782 |
| $\delta$capital intensity | | | | | -0.0036 | 0.0084 |
| $\delta$labour productivity | | | | | 0.0142a | 0.0046 |
| $\delta$globalization | | | | | -0.0155 | 0.0738 |
| $\delta$exporting sector | | | | | -0.0624 | 0.0704 |
| $\delta$importing sector | | | | | -0.3624a | 0.0715 |
| C. Model performance | | | | | | |
| F-values | 209.58a | | - | | - | |
| Adj. $R^2$ | 0.9600 | | 0.9668 | | 0.9766 | |
| RMS error | 0.1028 | | 0.0937 | | 0.0843 | |

Notes: Significant at the less than 1% (a), 1-5% (b), 5-10% (c) levels of significance. The subscripts W, K, Y and T represent wages, capital stock, value added and Time Trend variables. The subscripts 15-36 represent industry codes and T3-T22 time dummies. The reference industry is the food and beverage industry, and the reference year 1981. The first year of 1980 is excluded due to the use of lag dependent variable of labour.

Table 4: Mean long-run elasticities, optimality and speed of adjustment calculated using unrestricted dynamic model parameter estimates (based on value added)

| Characteristics | Wage | Value added | Capital | Optimality Ratio | Speed | Technical change | Neutral | Non-neutral | Scale augment |
|---|---|---|---|---|---|---|---|---|---|
| A. Mean by industry | | | | | | | | | |
| Food & beverages (15) | -0.675 | 0.513 | 0.197 | 1.111 | 0.215 | -0.015 | -0.060 | 0.021 | 0.023 |
| Tobacco (16) | -0.780 | 0.441 | 0.233 | 1.098 | 0.344 | 0.004 | -0.060 | 0.045 | 0.019 |
| Textiles (17) | -0.286 | 0.499 | 0.134 | 1.109 | 0.168 | -0.028 | -0.060 | 0.003 | 0.029 |
| Wearing apparel (18) | -0.488 | 0.446 | 0.182 | 1.094 | 0.348 | -0.011 | -0.060 | 0.025 | 0.024 |
| Leather (19) | -0.529 | 0.581 | 0.148 | 1.099 | 0.250 | -0.019 | -0.060 | 0.017 | 0.023 |
| Wood (20) | -0.796 | 0.898 | 0.088 | 1.113 | 0.241 | -0.016 | -0.060 | 0.029 | 0.014 |
| Paper (21) | -0.406 | 0.583 | 0.130 | 1.097 | 0.138 | -0.033 | -0.060 | -0.001 | 0.028 |
| Printing etc. (22) | -0.030 | 0.750 | 0.001 | 1.121 | 0.184 | -0.034 | -0.060 | 0.001 | 0.025 |
| Petroleum (23) | 0.038 | 0.210 | 0.176 | 1.097 | 0.520 | -0.038 | -0.060 | -0.017 | 0.039 |
| Chemicals (24) | -0.153 | 0.384 | 0.150 | 1.113 | 0.249 | -0.033 | -0.060 | -0.006 | 0.033 |
| Rubber & Plastic (25) | -0.458 | 0.589 | 0.134 | 1.110 | 0.215 | -0.026 | -0.060 | 0.009 | 0.025 |
| Non met. mineral (26) | -0.663 | 0.584 | 0.174 | 1.094 | 0.311 | -0.022 | -0.060 | 0.013 | 0.024 |
| Basic metals (27) | -0.096 | 0.443 | 0.123 | 1.131 | 0.342 | -0.041 | -0.060 | -0.015 | 0.034 |
| Fabricated metals (28) | -0.372 | 0.767 | 0.057 | 1.064 | 0.209 | -0.026 | -0.060 | 0.012 | 0.021 |
| Machinery (29) | -0.098 | 0.646 | 0.049 | 1.137 | 0.085 | -0.032 | -0.060 | 0.001 | 0.027 |
| Computing (30) | 0.080 | 0.334 | 0.121 | 1.092 | 0.514 | -0.029 | -0.060 | -0.003 | 0.034 |
| Electrical (31) | 0.083 | 0.523 | 0.058 | 1.108 | 0.283 | -0.034 | -0.060 | -0.005 | 0.031 |
| Electronic (32) | -0.016 | 0.431 | 0.108 | 1.102 | 0.261 | -0.033 | -0.060 | -0.005 | 0.032 |
| Pharmaceutical (33) | -0.155 | 0.584 | 0.080 | 1.119 | 0.296 | -0.031 | -0.060 | 0.001 | 0.028 |
| Motor vehicles (34) | 0.117 | 0.446 | 0.079 | 1.117 | 0.244 | -0.038 | -0.060 | -0.012 | 0.034 |
| Other transports (35) | -0.058 | 0.464 | 0.105 | 1.142 | 0.134 | -0.033 | -0.060 | -0.005 | 0.031 |
| Furniture (36) | -0.284 | 0.685 | 0.066 | 1.104 | 0.274 | -0.023 | -0.060 | 0.014 | 0.023 |
| B. Mean by year | | | | | | | | | |
| 1981-82 | -0.341 | 0.532 | 0.202 | 1.115 | 0.157 | 0.042 | 0.000 | 0.020 | 0.022 |
| 1982-83 | -0.238 | 0.489 | 0.191 | 1.074 | 0.477 | 0.165 | 0.124 | 0.016 | 0.024 |
| 1983-84 | -0.235 | 0.537 | 0.168 | 1.126 | 0.120 | -0.266 | -0.304 | 0.014 | 0.024 |
| 1984-85 | -0.224 | 0.525 | 0.163 | 1.086 | 0.333 | 0.095 | 0.058 | 0.012 | 0.025 |
| 1985-86 | -0.257 | 0.557 | 0.151 | 1.128 | 0.103 | -0.179 | -0.215 | 0.011 | 0.025 |
| 1986-87 | -0.218 | 0.551 | 0.138 | 1.107 | 0.251 | 0.037 | 0.002 | 0.010 | 0.025 |
| 1987-88 | -0.200 | 0.546 | 0.129 | 1.096 | 0.295 | -0.006 | -0.041 | 0.009 | 0.026 |
| 1988-89 | -0.198 | 0.529 | 0.128 | 1.105 | 0.297 | -0.063 | -0.097 | 0.007 | 0.027 |
| 1989-90 | -0.220 | 0.531 | 0.124 | 1.118 | 0.252 | -0.100 | -0.133 | 0.006 | 0.027 |
| 1990-91 | -0.208 | 0.510 | 0.121 | 1.105 | 0.256 | 0.005 | -0.029 | 0.007 | 0.027 |
| 1991-92 | -0.245 | 0.519 | 0.118 | 1.113 | 0.259 | -0.054 | -0.088 | 0.006 | 0.028 |
| 1992-93 | -0.281 | 0.517 | 0.118 | 1.102 | 0.327 | 0.069 | 0.035 | 0.007 | 0.028 |
| 1993-94 | -0.282 | 0.514 | 0.112 | 1.119 | 0.192 | -0.172 | -0.206 | 0.005 | 0.028 |
| 1994-95 | -0.313 | 0.532 | 0.105 | 1.099 | 0.297 | 0.049 | 0.018 | 0.003 | 0.028 |
| 1995-96 | -0.275 | 0.507 | 0.099 | 1.097 | 0.308 | -0.011 | -0.042 | 0.002 | 0.029 |
| 1996-97 | -0.279 | 0.499 | 0.096 | 1.098 | 0.346 | -0.063 | -0.093 | -0.000 | 0.030 |
| 1997-98 | -0.318 | 0.561 | 0.076 | 1.102 | 0.272 | 0.020 | -0.008 | -0.001 | 0.029 |
| 1998-99 | -0.347 | 0.577 | 0.068 | 1.133 | 0.158 | -0.199 | -0.226 | -0.002 | 0.029 |
| 1999-00 | -0.314 | 0.554 | 0.063 | 1.120 | 0.251 | 0.002 | -0.025 | -0.004 | 0.030 |
| 2000-01 | -0.397 | 0.591 | 0.059 | 1.118 | 0.289 | 0.011 | -0.014 | -0.004 | 0.030 |
| 2001-02 | -0.361 | 0.587 | 0.046 | 1.103 | 0.378 | 0.055 | 0.030 | -0.005 | 0.030 |
| C. Mean by period | | | | | | | | | |
| Pre-reform period | | | | | | | | | |
| 1980-91 | -0.235 | 0.530 | 0.148 | 1.107 | 0.281 | -0.029 | -0.066 | 0.011 | 0.026 |
| Post-reform period | | | | | | | | | |
| 1991-02 | -0.317 | 0.544 | 0.084 | 1.109 | 0.290 | -0.024 | -0.053 | -0.000 | 0.029 |
| D. Overall mean and standard deviations | | | | | | | | | |
| Mean | -0.274 | 0.536 | 0.118 | 1.108 | 0.285 | -0.027 | -0.060 | 0.006 | 0.027 |
| Std dev. | 0.325 | 0.171 | 0.075 | 0.036 | 0.191 | 0.105 | 0.104 | 0.017 | 0.006 |

Table 5: Labour use parameter Estimates (based on value of output), NT=22x21=462 obs.

| | Static Model | | Restricted Dynamic Model | | Unrestricted Dynamic Model | |
|---|---|---|---|---|---|---|
| Variables | Estimate | Std error | Estimate | Std error | Estimate | Std error |
| A. Employment function | | | | | | |
| $\beta_o$ | 1.8209b | 0.9072 | 1.842 | 1.310 | 0.400 | 1.230 |
| $\beta_W$ | 1.2346a | 0.3510 | 1.406a | 0.507 | 0.870c | 0.507 |
| $\beta_Y$ | 0.5780c | 0.3157 | 0.463 | 0.456 | 0.909b | 0.389 |
| $\beta_K$ | 0.1638 | 0.1818 | 0.195 | 0.262 | 0.271 | 0.227 |
| $\beta_{WW}$ | 0.3006a | 0.0528 | 0.334a | 0.076 | 0.221a | 0.076 |
| $\beta_{YY}$ | -0.0687a | 0.0287 | -0.044 | 0.041 | -0.095a | 0.032 |
| $\beta_{KK}$ | -0.0480a | 0.0179 | -0.038 | 0.026 | -0.061a | 0.022 |
| $\beta_{WY}$ | -0.0274 | 0.0697 | -0.049 | 0.100 | -0.016 | 0.092 |
| $\beta_{WK}$ | -0.0265 | 0.0571 | -0.017 | 0.082 | 0.014 | 0.077 |
| $\beta_{WT}$ | -0.0227a | 0.0036 | -0.029a | 0.005 | -0.029a | 0.005 |
| $\beta_{YK}$ | 0.0853b | 0.0366 | 0.063 | 0.053 | 0.089b | 0.042 |
| $\beta_{YT}$ | 0.0102a | 0.0028 | 0.011a | 0.004 | 0.014a | 0.003 |
| $\beta_{KT}$ | -0.0050b | 0.0024 | -0.005 | 0.003 | -0.004 | 0.003 |
| $\beta_{T3}$ | -0.0117 | 0.0355 | 0.115b | 0.055 | 0.138c | 0.076 |
| $\beta_{T4}$ | -0.1655a | 0.0413 | -0.201a | 0.060 | -0.325a | 0.070 |
| $\beta_{T5}$ | -0.2926a | 0.0490 | -0.293a | 0.070 | -0.327a | 0.088 |
| $\beta_{T6}$ | -0.4090a | 0.0580 | -0.490a | 0.084 | -0.662a | 0.089 |
| $\beta_{T7}$ | -0.5138a | 0.0676 | -0.553a | 0.098 | -0.695a | 0.102 |
| $\beta_{T8}$ | -0.6052a | 0.0785 | -0.670a | 0.114 | -0.874a | 0.120 |
| $\beta_{T9}$ | -0.7179a | 0.0884 | -0.792a | 0.128 | -1.004a | 0.130 |
| $\beta_{T10}$ | -0.8442a | 0.0991 | -0.968a | 0.144 | -1.187a | 0.145 |
| $\beta_{T11}$ | -0.9150a | 0.1108 | -1.057a | 0.161 | -1.308a | 0.160 |
| $\beta_{T12}$ | -1.0049a | 0.1224 | -1.165a | 0.178 | -1.435a | 0.177 |
| $\beta_{T13}$ | -1.0634a | 0.1342 | -1.227a | 0.195 | -1.492a | 0.188 |
| $\beta_{T14}$ | -1.2251a | 0.1473 | -1.458a | 0.216 | -1.730a | 0.209 |
| $\beta_{T15}$ | -1.3081a | 0.1588 | -1.489a | 0.231 | -1.776a | 0.222 |
| $\beta_{T16}$ | -1.3810a | 0.1695 | -1.594a | 0.247 | -1.901a | 0.236 |
| $\beta_{T17}$ | -1.5010a | 0.1807 | -1.754a | 0.264 | -2.068a | 0.252 |
| $\beta_{T18}$ | -1.5968a | 0.1937 | -1.883a | 0.283 | -2.211a | 0.274 |
| $\beta_{T19}$ | -1.7593a | 0.2065 | -2.094a | 0.302 | -2.480a | 0.289 |
| $\beta_{T20}$ | -1.8489a | 0.2184 | -2.143a | 0.318 | -2.551a | 0.301 |
| $\beta_{T21}$ | -1.9472a | 0.2311 | -2.281a | 0.338 | -2.690a | 0.320 |
| $\beta_{T22}$ | -2.0192a | 0.2426 | -2.341a | 0.354 | -2.827a | 0.337 |
| $\beta_{16}$ | 1.0925a | 0.0868 | 0.354a | 0.125 | 1.294a | 0.126 |
| $\beta_{17}$ | 0.7028a | 0.0507 | 0.744a | 0.073 | 0.660a | 0.077 |
| $\beta_{18}$ | 0.4670a | 0.0379 | 0.520a | 0.055 | 0.573a | 0.057 |
| $\beta_{19}$ | 0.2273a | 0.0375 | 0.054a | 0.054 | 0.267a | 0.059 |
| $\beta_{20}$ | -0.0148 | 0.0745 | 0.129 | 0.110 | 0.218c | 0.119 |
| $\beta_{21}$ | -0.0313 | 0.0584 | 0.032 | 0.085 | 0.136 | 0.103 |
| $\beta_{22}$ | 0.0012 | 0.0706 | 0.138 | 0.104 | 0.092 | 0.097 |
| $\beta_{23}$ | -0.6623a | 0.1314 | -0.847a | 0.192 | -0.545a | 0.157 |
| $\beta_{24}$ | -0.2649a | 0.0643 | -0.250a | 0.092 | -0.199b | 0.087 |
| $\beta_{25}$ | -0.3334a | 0.0473 | -0.248a | 0.069 | -0.285a | 0.070 |
| $\beta_{26}$ | 0.0327 | 0.0573 | 0.138c | 0.084 | 0.111 | 0.081 |
| $\beta_{27}$ | -0.0464 | 0.0812 | -0.043 | 0.117 | 0.086 | 0.115 |

| | | | | | | |
|---|---|---|---|---|---|---|
| $\beta_{28}$ | -0.1098b | 0.0543 | 0.026 | 0.081 | -0.024 | 0.097 |
| $\beta_{29}$ | -0.1118b | 0.0561 | -0.001 | 0.083 | 0.0004 | 0.110 |
| $\beta_{30}$ | -0.1659a | 0.0582 | -0.174b | 0.084 | -0.244a | 0.077 |
| $\beta_{31}$ | -0.0980c | 0.0586 | -0.037 | 0.085 | -0.087 | 0.084 |
| $\beta_{32}$ | 0.0981c | 0.0589 | 0.152c | 0.085 | 0.141c | 0.084 |
| $\beta_{33}$ | 0.0211a | 0.0556 | 0.137c | 0.082 | 0.090 | 0.080 |
| $\beta_{34}$ | 0.1116c | 0.0691 | 0.134 | 0.100 | 0.190b | 0.100 |
| $\beta_{35}$ | 0.6274a | 0.0585 | 0.647a | 0.084 | 0.380a | 0.093 |
| $\beta_{36}$ | 0.1002b | 0.0513 | 0.224a | 0.076 | 0.166b | 0.073 |
| | | | | | | |
| B. Speed of Adjustment | | | | | | |
| $\delta_0$ | | | 0.618a | 0.037 | 0.095c | 0.071 |
| $\delta_{\text{Absolute distance}}$ | | | | | 0.667a | 0.130 |
| δcapital intensity | | | | | 0.009 | 0.012 |
| δlabour productivity | | | | | 0.024a | 0.005 |
| δglobalization | | | | | 0.211a | 0.075 |
| δexporting sector | | | | | -0.005 | 0.072 |
| δimporting sector | | | | | -0.340a | 0.063 |
| | | | | | | |
| C. Model performance | | | | | | |
| F-value | 209.58a | | - | | - | |
| Adj. $R^2$ | 0.9543 | | 0.9636 | | 0.9710 | |
| RMS error | 0.1099 | | 0.0982 | | 0.0875 | |

Notes: Significant at the less than 1% (a), 1-5% (b), 5-10% (c) levels of significance. The subscripts W, K, Y and T represent wages, capital stock, value added and Time Trend variables. The subscripts 15-36 represent industry codes and T3-T22 time dummies. The reference industry is industry code 15, the food and beverage industry, and the reference year 1981. The first year of 1980 is excluded due to the use of lad dependent variable of labour.

Table 6: Mean long-run elasticities, optimality and speed of adjustment calculated using unrestricted dynamic model parameter estimates (based on value of output).

| Characteristics | Wage | Output | Capital | Optimality Ratio | Speed | Technical change | Neutral | Non-neutral | Scale augment |
|---|---|---|---|---|---|---|---|---|---|
| A. Mean by industry | | | | | | | | | |
| 15 | -0.366 | 0.401 | 0.206 | 1.157 | 0.338 | -0.014 | -0.135 | 0.038 | 0.082 |
| 16 | -0.625 | 0.485 | 0.325 | 1.132 | 0.286 | -0.007 | -0.135 | 0.065 | 0.062 |
| 17 | -0.095 | 0.424 | 0.119 | 1.164 | 0.319 | -0.033 | -0.135 | 0.016 | 0.086 |
| 18 | -0.369 | 0.406 | 0.258 | 1.127 | 0.359 | -0.016 | -0.135 | 0.041 | 0.077 |
| 19 | -0.271 | 0.427 | 0.206 | 1.145 | 0.314 | -0.023 | -0.135 | 0.033 | 0.079 |
| 20 | -0.346 | 0.625 | 0.226 | 1.149 | 0.284 | -0.036 | -0.135 | 0.045 | 0.054 |
| 21 | -0.066 | 0.492 | 0.053 | 1.119 | 0.135 | -0.038 | -0.135 | 0.012 | 0.084 |
| 22 | 0.059 | 0.492 | 0.183 | 1.151 | 0.306 | -0.051 | -0.135 | 0.011 | 0.073 |
| 23 | 0.070 | 0.168 | 0.079 | 1.145 | 0.615 | -0.021 | -0.135 | -0.005 | 0.119 |
| 24 | -0.016 | 0.397 | 0.064 | 1.139 | 0.545 | -0.034 | -0.135 | 0.007 | 0.094 |
| 25 | -0.166 | 0.481 | 0.126 | 1.150 | 0.396 | -0.033 | -0.135 | 0.023 | 0.079 |
| 26 | -0.255 | 0.589 | 0.071 | 1.163 | 0.323 | -0.034 | -0.135 | 0.029 | 0.071 |
| 27 | 0.097 | 0.386 | 0.019 | 1.128 | 0.268 | -0.040 | -0.135 | -0.004 | 0.099 |
| 28 | -0.125 | 0.499 | 0.203 | 1.150 | 0.137 | -0.040 | -0.135 | 0.025 | 0.070 |
| 29 | 0.007 | 0.449 | 0.169 | 1.128 | 0.210 | -0.043 | -0.135 | 0.012 | 0.079 |
| 30 | -0.000 | 0.318 | 0.160 | 1.168 | 0.483 | -0.031 | -0.135 | 0.008 | 0.095 |
| 31 | 0.069 | 0.371 | 0.166 | 1.149 | 0.424 | -0.041 | -0.135 | 0.005 | 0.088 |
| 32 | 0.027 | 0.394 | 0.108 | 1.141 | 0.430 | -0.038 | -0.135 | 0.006 | 0.090 |
| 33 | -0.023 | 0.477 | 0.131 | 1.144 | 0.366 | -0.043 | -0.135 | 0.013 | 0.079 |
| 34 | 0.122 | 0.354 | 0.105 | 1.133 | 0.242 | -0.041 | -0.135 | -0.002 | 0.095 |
| 35 | 0.020 | 0.391 | 0.113 | 1.214 | 0.199 | -0.038 | -0.135 | 0.007 | 0.090 |
| 36 | -0.152 | 0.447 | 0.248 | 1.148 | 0.369 | -0.035 | -0.135 | 0.027 | 0.073 |
| B. Mean by year | | | | | | | | | |
| 1981-82 | 0.004 | 0.345 | 0.243 | 1.150 | 0.144 | 0.108 | 0.000 | 0.036 | 0.072 |
| 1982-83 | 0.025 | 0.324 | 0.239 | 1.091 | 0.376 | 0.246 | 0.139 | 0.031 | 0.076 |
| 1983-84 | 0.039 | 0.358 | 0.217 | 1.172 | 0.126 | -0.361 | -0.464 | 0.028 | 0.075 |
| 1984-85 | 0.029 | 0.353 | 0.209 | 1.117 | 0.265 | 0.102 | -0.001 | 0.026 | 0.078 |
| 1985-86 | 0.005 | 0.380 | 0.201 | 1.176 | 0.158 | -0.233 | -0.336 | 0.025 | 0.077 |
| 1986-87 | 0.003 | 0.380 | 0.198 | 1.139 | 0.226 | 0.068 | -0.033 | 0.023 | 0.078 |
| 1987-88 | -0.012 | 0.383 | 0.196 | 1.153 | 0.227 | -0.077 | -0.179 | 0.022 | 0.079 |
| 1988-89 | -0.027 | 0.390 | 0.181 | 1.146 | 0.207 | -0.029 | -0.130 | 0.020 | 0.081 |
| 1989-90 | -0.049 | 0.400 | 0.169 | 1.152 | 0.217 | -0.082 | -0.184 | 0.019 | 0.082 |
| 1990-91 | -0.086 | 0.398 | 0.180 | 1.155 | 0.182 | -0.017 | -0.120 | 0.020 | 0.083 |
| 1991-92 | -0.113 | 0.421 | 0.163 | 1.155 | 0.253 | -0.025 | -0.127 | 0.019 | 0.083 |
| 1992-93 | -0.153 | 0.432 | 0.159 | 1.146 | 0.415 | 0.046 | -0.057 | 0.020 | 0.083 |
| 1993-94 | -0.168 | 0.450 | 0.145 | 1.156 | 0.350 | -0.136 | -0.239 | 0.019 | 0.084 |
| 1994-95 | -0.172 | 0.475 | 0.115 | 1.136 | 0.458 | 0.054 | -0.046 | 0.016 | 0.085 |
| 1995-96 | -0.191 | 0.462 | 0.123 | 1.138 | 0.495 | -0.024 | -0.125 | 0.015 | 0.087 |
| 1996-97 | -0.201 | 0.476 | 0.101 | 1.140 | 0.461 | -0.066 | -0.167 | 0.012 | 0.088 |
| 1997-98 | -0.207 | 0.494 | 0.092 | 1.145 | 0.471 | -0.043 | -0.142 | 0.011 | 0.088 |
| 1998-99 | -0.226 | 0.521 | 0.074 | 1.167 | 0.383 | -0.171 | -0.268 | 0.010 | 0.088 |
| 1999-00 | -0.240 | 0.514 | 0.074 | 1.151 | 0.480 | 0.026 | -0.072 | 0.008 | 0.090 |
| 2000-01 | -0.269 | 0.548 | 0.049 | 1.153 | 0.449 | -0.042 | -0.139 | 0.008 | 0.089 |
| 2001-02 | -0.282 | 0.537 | 0.059 | 1.158 | 0.489 | -0.040 | -0.137 | 0.006 | 0.091 |
| C. Mean by period | | | | | | | | | |
| Pre-reform period | | | | | | | | | |
| 1980-91 | -0.017 | 0.376 | 0.200 | 1.146 | 0.226 | -0.027 | -0.130 | 0.025 | 0.079 |
| Post-reform period | | | | | | | | | |
| 1991-02 | -0.211 | 0.491 | 0.099 | 1.149 | 0.446 | -0.040 | -0.139 | 0.012 | 0.087 |
| D. Overall mean and standard deviations | | | | | | | | | |
| Mean | -0.109 | 0.431 | 0.152 | 1.147 | 0.340 | -0.033 | -0.135 | 0.019 | 0.083 |
| Std dev. | 0.226 | 0.120 | 0.100 | 0.041 | 0.209 | 0.125 | 0.124 | 0.020 | 0.015 |

Appendix A: Mean short-run elasticities and technical change calculated using unrestricted dynamic model parameter estimates (based on value added).

| Characteristics | Wage | Value added | Capital | Technical change | Neutral | Non-neutral | Scale augmenting |
|---|---|---|---|---|---|---|---|
| A. Mean by industry | | | | | | | |
| 15 | -0.145 | 0.109 | 0.042 | 0.003 | -0.007 | 0.005 | 0.005 |
| 16 | -0.276 | 0.156 | 0.079 | 0.009 | -0.012 | 0.015 | 0.007 |
| 17 | -0.058 | 0.089 | 0.018 | 0.002 | -0.003 | -0.000 | 0.005 |
| 18 | -0.172 | 0.148 | 0.070 | 0.005 | -0.012 | 0.010 | 0.008 |
| 19 | -0.131 | 0.137 | 0.040 | 0.003 | -0.007 | 0.004 | 0.006 |
| 20 | -0.162 | 0.208 | 0.021 | 0.003 | -0.007 | 0.007 | 0.004 |
| 21 | -0.043 | 0.070 | 0.023 | 0.007 | 0.003 | -0.000 | 0.004 |
| 22 | 0.008 | 0.134 | 0.002 | 0.001 | -0.004 | 0.000 | 0.005 |
| 23 | 0.063 | 0.095 | 0.084 | -0.010 | -0.021 | -0.010 | 0.021 |
| 24 | -0.041 | 0.092 | 0.039 | 0.004 | -0.003 | -0.001 | 0.008 |
| 25 | -0.100 | 0.121 | 0.029 | 0.003 | -0.004 | 0.002 | 0.006 |
| 26 | -0.206 | 0.180 | 0.051 | 0.007 | -0.004 | 0.004 | 0.008 |
| 27 | 0.012 | 0.132 | 0.062 | 0.052 | 0.021 | -0.002 | 0.011 |
| 28 | -0.068 | 0.154 | 0.016 | 0.011 | 0.004 | 0.003 | 0.004 |
| 29 | -0.009 | 0.049 | 0.012 | 0.014 | 0.005 | 0.001 | 0.002 |
| 30 | 0.049 | 0.151 | 0.062 | 0.003 | -0.012 | -0.003 | 0.018 |
| 31 | 0.029 | 0.146 | 0.015 | 0.001 | -0.006 | -0.002 | 0.009 |
| 32 | 0.004 | 0.109 | 0.028 | 0.004 | -0.003 | -0.001 | 0.008 |
| 33 | -0.030 | 0.165 | 0.024 | 0.015 | 0.006 | 0.000 | 0.008 |
| 34 | 0.056 | 0.097 | 0.018 | 0.018 | 0.009 | -0.003 | 0.009 |
| 35 | -0.010 | 0.071 | 0.002 | 0.005 | 0.002 | -0.002 | 0.004 |
| 36 | -0.068 | 0.178 | 0.019 | 0.006 | -0.004 | 0.004 | 0.006 |
| B. Mean by year | | | | | | | |
| 1981-82 | -0.059 | 0.078 | 0.035 | 0.007 | 0.000 | 0.003 | 0.004 |
| 1982-83 | -0.103 | 0.235 | 0.088 | 0.079 | 0.059 | 0.008 | 0.012 |
| 1983-84 | -0.015 | 0.078 | 0.013 | -0.032 | -0.036 | 0.002 | 0.003 |
| 1984-85 | -0.096 | 0.173 | 0.059 | 0.032 | 0.019 | 0.005 | 0.008 |
| 1985-86 | -0.044 | 0.049 | 0.021 | -0.018 | -0.022 | 0.002 | 0.003 |
| 1986-87 | -0.063 | 0.119 | 0.042 | 0.011 | 0.001 | 0.004 | 0.006 |
| 1987-88 | -0.066 | 0.159 | 0.040 | -0.001 | -0.012 | 0.004 | 0.007 |
| 1988-89 | -0.047 | 0.118 | 0.048 | -0.018 | -0.029 | 0.003 | 0.009 |
| 1989-90 | -0.038 | 0.100 | 0.039 | -0.025 | -0.033 | 0.001 | 0.008 |
| 1990-91 | -0.054 | 0.112 | 0.037 | 0.002 | -0.007 | 0.002 | 0.007 |
| 1991-92 | -0.059 | 0.118 | 0.035 | -0.013 | -0.023 | 0.003 | 0.007 |
| 1992-93 | -0.089 | 0.138 | 0.048 | 0.024 | 0.011 | 0.003 | 0.009 |
| 1993-94 | -0.066 | 0.079 | 0.030 | -0.031 | -0.040 | 0.003 | 0.005 |
| 1994-95 | -0.105 | 0.151 | 0.036 | 0.015 | 0.005 | 0.001 | 0.008 |
| 1995-96 | -0.064 | 0.136 | 0.033 | -0.003 | -0.013 | 0.001 | 0.009 |
| 1996-97 | -0.100 | 0.155 | 0.040 | -0.021 | -0.032 | 0.000 | 0.011 |
| 1997-98 | -0.112 | 0.142 | 0.028 | 0.007 | -0.002 | 0.002 | 0.008 |
| 1998-99 | 0.000 | 0.064 | 0.010 | -0.033 | -0.036 | -0.003 | 0.006 |
| 1999-00 | -0.073 | 0.137 | 0.015 | 0.000 | -0.006 | -0.002 | 0.008 |
| 2000-01 | -0.071 | 0.143 | 0.019 | 0.003 | -0.004 | -0.003 | 0.010 |
| 2001-02 | -0.104 | 0.184 | 0.024 | 0.020 | 0.011 | -0.003 | 0.013 |
| C. Mean by period | | | | | | | |
| Pre-reform period | | | | | | | |
| 1980-91 | -0.063 | 0.134 | 0.046 | 0.008 | -0.003 | 0.004 | 0.007 |
| Post-reform period | | | | | | | |
| 1991-02 | -0.083 | 0.137 | 0.030 | 0.000 | -0.009 | 0.000 | 0.009 |
| D. Overall mean and standard deviations | | | | | | | |
| Mean | -0.073 | 0.135 | 0.038 | 0.004 | -0.006 | 0.002 | 0.008 |
| Std dev. | 0.126 | 0.091 | 0.038 | 0.031 | 0.029 | 0.007 | 0.007 |

Appendix B: Mean short-run elasticities and technical change calculated using unrestricted dynamic model parameter estimates (based on value of output).

| Characteristics | Wage | Output | Capital | Technical change | Neutral | Non-neutral | Scale augmenting |
|---|---|---|---|---|---|---|---|
| A. Mean by industry | | | | | | | |
| 15 | -0.141 | 0.151 | 0.058 | -0.003 | -0.042 | 0.011 | 0.028 |
| 16 | -0.193 | 0.147 | 0.084 | 0.006 | -0.031 | 0.018 | 0.018 |
| 17 | -0.059 | 0.155 | 0.023 | -0.009 | -0.038 | 0.003 | 0.029 |
| 18 | -0.137 | 0.149 | 0.088 | 0.001 | -0.041 | 0.014 | 0.028 |
| 19 | -0.101 | 0.142 | 0.060 | -0.001 | -0.036 | 0.010 | 0.025 |
| 20 | -0.110 | 0.182 | 0.060 | -0.001 | -0.029 | 0.013 | 0.016 |
| 21 | -0.020 | 0.074 | 0.002 | 0.000 | -0.012 | 0.002 | 0.011 |
| 22 | 0.003 | 0.158 | 0.050 | -0.010 | -0.035 | 0.003 | 0.022 |
| 23 | 0.035 | 0.072 | 0.073 | 0.014 | -0.062 | 0.005 | 0.071 |
| 24 | -0.030 | 0.228 | 0.026 | -0.013 | -0.067 | 0.003 | 0.052 |
| 25 | -0.081 | 0.201 | 0.040 | -0.010 | -0.050 | 0.007 | 0.032 |
| 26 | -0.094 | 0.204 | 0.011 | -0.005 | -0.034 | 0.007 | 0.024 |
| 27 | 0.014 | 0.112 | -0.005 | -0.004 | -0.029 | -0.003 | 0.028 |
| 28 | -0.019 | 0.065 | 0.027 | 0.002 | -0.010 | 0.003 | 0.010 |
| 29 | -0.014 | 0.104 | 0.028 | -0.005 | -0.022 | 0.001 | 0.017 |
| 30 | -0.020 | 0.161 | 0.071 | -0.012 | -0.058 | 0.004 | 0.047 |
| 31 | 0.016 | 0.167 | 0.061 | -0.012 | -0.052 | 0.001 | 0.038 |
| 32 | -0.002 | 0.176 | 0.038 | -0.009 | -0.050 | 0.001 | 0.040 |
| 33 | -0.016 | 0.175 | 0.043 | -0.003 | -0.037 | 0.003 | 0.030 |
| 34 | 0.016 | 0.088 | 0.020 | -0.001 | -0.022 | -0.002 | 0.025 |
| 35 | -0.029 | 0.089 | 0.017 | -0.007 | -0.021 | -0.000 | 0.020 |
| 36 | -0.073 | 0.163 | 0.084 | -0.006 | -0.044 | 0.008 | 0.029 |
| B. Mean by year | | | | | | | |
| 1981-82 | 0.001 | 0.046 | 0.036 | 0.016 | 0.000 | 0.005 | 0.011 |
| 1982-83 | 0.010 | 0.119 | 0.091 | 0.093 | 0.052 | 0.012 | 0.029 |
| 1983-84 | 0.010 | 0.042 | 0.027 | -0.046 | -0.059 | 0.003 | 0.010 |
| 1984-85 | 0.005 | 0.088 | 0.056 | 0.028 | -0.000 | 0.007 | 0.021 |
| 1985-86 | -0.001 | 0.046 | 0.029 | -0.036 | -0.053 | 0.004 | 0.014 |
| 1986-87 | -0.005 | 0.075 | 0.046 | 0.017 | -0.007 | 0.005 | 0.019 |
| 1987-88 | -0.005 | 0.076 | 0.047 | -0.017 | -0.041 | 0.005 | 0.019 |
| 1988-89 | -0.016 | 0.082 | 0.042 | -0.005 | -0.027 | 0.005 | 0.016 |
| 1989-90 | -0.013 | 0.086 | 0.035 | -0.018 | -0.040 | 0.004 | 0.018 |
| 1990-91 | -0.017 | 0.073 | 0.033 | -0.003 | -0.022 | 0.004 | 0.015 |
| 1991-92 | -0.021 | 0.091 | 0.041 | -0.006 | -0.032 | 0.004 | 0.023 |
| 1992-93 | -0.075 | 0.180 | 0.068 | 0.020 | -0.024 | 0.009 | 0.034 |
| 1993-94 | -0.072 | 0.157 | 0.055 | -0.047 | -0.083 | 0.008 | 0.029 |
| 1994-95 | -0.082 | 0.223 | 0.049 | 0.025 | -0.021 | 0.007 | 0.038 |
| 1995-96 | -0.100 | 0.227 | 0.064 | -0.011 | -0.062 | 0.008 | 0.043 |
| 1996-97 | -0.100 | 0.231 | 0.044 | -0.031 | -0.077 | 0.006 | 0.040 |
| 1997-98 | -0.105 | 0.229 | 0.046 | -0.020 | -0.067 | 0.006 | 0.042 |
| 1998-99 | -0.074 | 0.192 | 0.031 | -0.066 | -0.103 | 0.003 | 0.034 |
| 1999-00 | -0.112 | 0.250 | 0.033 | 0.012 | -0.034 | 0.004 | 0.043 |
| 2000-01 | -0.129 | 0.250 | 0.021 | -0.019 | -0.062 | 0.004 | 0.040 |
| 2001-02 | -0.138 | 0.265 | 0.032 | -0.020 | -0.067 | 0.003 | 0.044 |
| C. Mean by period | | | | | | | |
| Pre-reform period | | | | | | | |
| 1980-91 | -0.005 | 0.078 | 0.046 | 0.007 | -0.016 | 0.005 | 0.018 |
| Post-reform period | | | | | | | |
| 1991-02 | -0.099 | 0.221 | 0.044 | -0.015 | -0.059 | 0.006 | 0.039 |
| D. Overall mean and standard deviations | | | | | | | |
| Mean | -0.054 | 0.152 | 0.045 | -0.004 | -0.038 | 0.006 | 0.029 |
| Std dev. | 0.091 | 0.104 | 0.041 | 0.038 | 0.044 | 0.007 | 0.021 |

Appendix C: Mean elasticities calculated from the static model parameter estimates (based on value added).

| Characteristics | Wage | Value added | Capital | Technical change | Neutral | Non-neutral | Scale augmenting |
|---|---|---|---|---|---|---|---|
| A. Mean by industry | | | | | | | |
| 15 | -0.515 | 0.400 | 0.221 | -0.020 | -0.055 | 0.012 | 0.022 |
| 16 | -0.664 | 0.390 | 0.261 | -0.005 | -0.055 | 0.032 | 0.018 |
| 17 | -0.203 | 0.383 | 0.166 | -0.030 | -0.055 | -0.002 | 0.027 |
| 18 | -0.412 | 0.379 | 0.212 | -0.016 | -0.055 | 0.016 | 0.023 |
| 19 | -0.372 | 0.423 | 0.191 | -0.023 | -0.055 | 0.010 | 0.022 |
| 20 | -0.452 | 0.546 | 0.182 | -0.022 | -0.055 | 0.020 | 0.014 |
| 21 | -0.249 | 0.411 | 0.164 | -0.034 | -0.055 | -0.005 | 0.026 |
| 22 | 0.096 | 0.476 | 0.098 | -0.034 | -0.055 | -0.002 | 0.024 |
| 23 | -0.056 | 0.265 | 0.158 | -0.036 | -0.055 | -0.019 | 0.037 |
| 24 | -0.140 | 0.336 | 0.161 | -0.033 | -0.055 | -0.009 | 0.031 |
| 25 | -0.301 | 0.420 | 0.176 | -0.028 | -0.055 | 0.003 | 0.024 |
| 26 | -0.463 | 0.420 | 0.203 | -0.026 | -0.055 | 0.006 | 0.023 |
| 27 | -0.058 | 0.351 | 0.140 | -0.039 | -0.055 | -0.017 | 0.032 |
| 28 | -0.167 | 0.488 | 0.142 | -0.029 | -0.055 | 0.006 | 0.021 |
| 29 | 0.001 | 0.438 | 0.122 | -0.032 | -0.055 | -0.003 | 0.025 |
| 30 | 0.005 | 0.321 | 0.145 | -0.030 | -0.055 | -0.007 | 0.032 |
| 31 | 0.091 | 0.389 | 0.115 | -0.033 | -0.055 | -0.008 | 0.029 |
| 32 | -0.020 | 0.354 | 0.140 | -0.033 | -0.055 | -0.009 | 0.031 |
| 33 | -0.068 | 0.415 | 0.137 | -0.031 | -0.055 | -0.003 | 0.026 |
| 34 | 0.095 | 0.356 | 0.118 | -0.036 | -0.055 | -0.014 | 0.032 |
| 35 | -0.038 | 0.367 | 0.140 | -0.033 | -0.055 | -0.008 | 0.030 |
| 36 | -0.142 | 0.460 | 0.146 | -0.025 | -0.055 | 0.008 | 0.022 |
| B. Mean by year | | | | | | | |
| 1981-82 | -0.229 | 0.368 | 0.244 | 0.033 | 0.000 | 0.012 | 0.021 |
| 1982-83 | -0.168 | 0.354 | 0.230 | 0.047 | 0.015 | 0.009 | 0.023 |
| 1983-84 | -0.144 | 0.374 | 0.214 | -0.085 | -0.115 | 0.007 | 0.023 |
| 1984-85 | -0.141 | 0.372 | 0.206 | -0.045 | -0.074 | 0.005 | 0.024 |
| 1985-86 | -0.154 | 0.388 | 0.199 | -0.045 | -0.074 | 0.005 | 0.024 |
| 1986-87 | -0.128 | 0.388 | 0.188 | -0.032 | -0.060 | 0.004 | 0.024 |
| 1987-88 | -0.118 | 0.390 | 0.179 | -0.032 | -0.060 | 0.003 | 0.025 |
| 1988-89 | -0.124 | 0.386 | 0.174 | -0.041 | -0.068 | 0.002 | 0.026 |
| 1989-90 | -0.141 | 0.390 | 0.169 | -0.052 | -0.078 | 0.001 | 0.026 |
| 1990-91 | -0.145 | 0.387 | 0.165 | -0.019 | -0.046 | 0.001 | 0.026 |
| 1991-92 | -0.171 | 0.394 | 0.161 | -0.026 | -0.054 | 0.001 | 0.026 |
| 1992-93 | -0.202 | 0.397 | 0.159 | 0.019 | -0.009 | 0.001 | 0.026 |
| 1993-94 | -0.205 | 0.399 | 0.152 | -0.109 | -0.136 | 0.000 | 0.027 |
| 1994-95 | -0.218 | 0.408 | 0.144 | -0.018 | -0.043 | -0.002 | 0.027 |
| 1995-96 | -0.203 | 0.402 | 0.137 | -0.007 | -0.032 | -0.003 | 0.028 |
| 1996-97 | -0.209 | 0.402 | 0.131 | -0.053 | -0.077 | -0.004 | 0.029 |
| 1997-98 | -0.212 | 0.427 | 0.118 | 0.011 | -0.011 | -0.005 | 0.028 |
| 1998-99 | -0.227 | 0.436 | 0.112 | -0.105 | -0.127 | -0.006 | 0.028 |
| 1999-00 | -0.214 | 0.431 | 0.104 | -0.035 | -0.057 | -0.007 | 0.029 |
| 2000-01 | -0.260 | 0.448 | 0.101 | -0.012 | -0.033 | -0.008 | 0.028 |
| 2001-02 | -0.238 | 0.450 | 0.091 | 0.005 | -0.015 | -0.008 | 0.029 |
| C. Mean by period | | | | | | | |
| Pre-reform period | | | | | | | |
| 1980-91 | -0.151 | 0.381 | 0.193 | -0.027 | -0.056 | 0.004 | 0.024 |
| Post-reform period | | | | | | | |
| 1991-02 | -0.219 | 0.420 | 0.125 | -0.030 | -0.054 | -0.004 | 0.028 |
| D. Overall mean and standard deviations | | | | | | | |
| Mean | -0.183 | 0.400 | 0.161 | -0.029 | -0.055 | 0.000 | 0.026 |
| Std dev. | 0.243 | 0.071 | 0.060 | 0.040 | 0.039 | 0.014 | 0.006 |

Appendix D: Mean elasticities calculated from the static model parameter estimates (based on value of output)

| Characteristics | Wage | Output | Capital | Technical change | Neutral | Non-neutral | Scale augmenting |
|---|---|---|---|---|---|---|---|
| A. Mean by industry | | | | | | | |
| 15 | -0.437 | 0.320 | 0.254 | -0.016 | -0.096 | 0.023 | 0.057 |
| 16 | -0.688 | 0.347 | 0.349 | -0.006 | -0.096 | 0.047 | 0.043 |
| 17 | -0.118 | 0.348 | 0.168 | -0.031 | -0.096 | 0.005 | 0.060 |
| 18 | -0.409 | 0.309 | 0.290 | -0.016 | -0.096 | 0.027 | 0.053 |
| 19 | -0.301 | 0.332 | 0.243 | -0.022 | -0.096 | 0.019 | 0.055 |
| 20 | -0.329 | 0.448 | 0.240 | -0.028 | -0.096 | 0.031 | 0.038 |
| 21 | -0.098 | 0.406 | 0.112 | -0.036 | -0.096 | 0.002 | 0.058 |
| 22 | 0.149 | 0.367 | 0.191 | -0.043 | -0.096 | 0.003 | 0.050 |
| 23 | 0.001 | 0.201 | 0.156 | -0.027 | -0.096 | -0.014 | 0.083 |
| 24 | -0.053 | 0.344 | 0.126 | -0.034 | -0.096 | -0.003 | 0.065 |
| 25 | -0.191 | 0.383 | 0.172 | -0.030 | -0.096 | 0.011 | 0.055 |
| 26 | -0.311 | 0.465 | 0.129 | -0.031 | -0.096 | 0.016 | 0.050 |
| 27 | 0.069 | 0.346 | 0.087 | -0.039 | -0.096 | -0.012 | 0.069 |
| 28 | -0.084 | 0.372 | 0.219 | -0.033 | -0.096 | 0.014 | 0.049 |
| 29 | 0.057 | 0.347 | 0.190 | -0.038 | -0.096 | 0.003 | 0.055 |
| 30 | 0.001 | 0.271 | 0.200 | -0.031 | -0.096 | -0.001 | 0.066 |
| 31 | 0.115 | 0.299 | 0.192 | -0.037 | -0.096 | -0.003 | 0.061 |
| 32 | 0.031 | 0.330 | 0.153 | -0.036 | -0.096 | -0.003 | 0.063 |
| 33 | 0.002 | 0.375 | 0.163 | -0.038 | -0.096 | 0.004 | 0.055 |
| 34 | 0.143 | 0.303 | 0.147 | -0.039 | -0.096 | -0.009 | 0.066 |
| 35 | 0.022 | 0.327 | 0.157 | -0.036 | -0.096 | -0.002 | 0.063 |
| 36 | -0.109 | 0.330 | 0.259 | -0.029 | -0.096 | 0.016 | 0.050 |
| B. Mean by year | | | | | | | |
| 1981-82 | -0.094 | 0.273 | 0.281 | 0.072 | 0.000 | 0.022 | 0.050 |
| 1982-83 | -0.058 | 0.260 | 0.275 | 0.060 | -0.012 | 0.018 | 0.053 |
| 1983-84 | -0.026 | 0.285 | 0.253 | -0.086 | -0.154 | 0.016 | 0.052 |
| 1984-85 | -0.030 | 0.284 | 0.246 | -0.059 | -0.127 | 0.014 | 0.054 |
| 1985-86 | -0.043 | 0.302 | 0.237 | -0.049 | -0.116 | 0.014 | 0.053 |
| 1986-87 | -0.031 | 0.302 | 0.232 | -0.039 | -0.105 | 0.012 | 0.054 |
| 1987-88 | -0.035 | 0.304 | 0.229 | -0.025 | -0.091 | 0.011 | 0.055 |
| 1988-89 | -0.048 | 0.312 | 0.217 | -0.047 | -0.113 | 0.009 | 0.056 |
| 1989-90 | -0.066 | 0.321 | 0.207 | -0.061 | -0.126 | 0.008 | 0.057 |
| 1990-91 | -0.094 | 0.317 | 0.215 | -0.004 | -0.071 | 0.009 | 0.058 |
| 1991-92 | -0.116 | 0.336 | 0.200 | -0.024 | -0.090 | 0.008 | 0.058 |
| 1992-93 | -0.154 | 0.344 | 0.197 | 0.008 | -0.059 | 0.009 | 0.058 |
| 1993-94 | -0.161 | 0.358 | 0.183 | -0.096 | -0.162 | 0.008 | 0.058 |
| 1994-95 | -0.161 | 0.380 | 0.157 | -0.019 | -0.083 | 0.005 | 0.059 |
| 1995-96 | -0.170 | 0.370 | 0.164 | -0.008 | -0.073 | 0.004 | 0.060 |
| 1996-97 | -0.176 | 0.384 | 0.145 | -0.056 | -0.120 | 0.002 | 0.061 |
| 1997-98 | -0.168 | 0.396 | 0.135 | -0.033 | -0.096 | 0.001 | 0.061 |
| 1998-99 | -0.180 | 0.417 | 0.118 | -0.101 | -0.162 | 0.000 | 0.061 |
| 1999-00 | -0.185 | 0.413 | 0.117 | -0.028 | -0.090 | -0.001 | 0.062 |
| 2000-01 | -0.213 | 0.440 | 0.096 | -0.038 | -0.098 | -0.002 | 0.062 |
| 2001-02 | -0.212 | 0.430 | 0.103 | -0.011 | -0.072 | -0.003 | 0.063 |
| C. Mean by period | | | | | | | |
| Pre-reform period | | | | | | | |
| 1980-91 | -0.058 | 0.300 | 0.235 | -0.024 | -0.091 | 0.013 | 0.055 |
| Post-reform period | | | | | | | |
| 1991-02 | -0.178 | 0.393 | 0.142 | -0.038 | -0.101 | 0.002 | 0.061 |
| D. Overall mean and standard deviations | | | | | | | |
| Mean | -0.115 | 0.344 | 0.191 | -0.031 | -0.096 | 0.008 | 0.057 |
| Std dev. | 0.238 | 0.083 | 0.086 | 0.043 | 0.041 | 0.017 | 0.010 |