International Research Journal of Finance and Economics
ISSN 1450-2887 Issue 159 January, 2017
http://www.internationalresearchjournaloffinanceandeconomics.com

Labour Demand, Employment Variance and Efficiency in the Tunisian Manufacturing Industries

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Abstract

This paper specifies a flexible model of labour demand in Tunisian manufacturing industries. The model is further extended to incorporate a risk function part which allows identifying the determinants of both level and variations in employment. The risk function is important when designing public policies. It allows for the identification of industries suitable for targeting policies. The paper looks at the efficiency of the manufacturing industry in their choice of level of employment necessary to produce a given level of output. The results show that labour demand responds mostly to wages, followed by capital stock changes, and level of output.

Keywords: Labour demand, Employment efficiency, Risk function, Employment variance, Manufacturing industries, Tunisia
JEL classification: C23, C51, D24, E24

1. Introduction

The Tunisian manufacturing sector has been the subject of various shocks and public policy-related changes since 1971. During the import substitution or protection period (1971–1986), the manufacturing sector evolved through a highly regulated economic environment. These controls had both a direct and an indirect bearing on how the manufacturing sector used its available developmental resources such as labour. The low degree of competition that characterised this period resulted in the

quality of Tunisian products to be below international standards. Also, there was little incentive for firms to compete on the basis of quality, and were largely dependent on market niches with short term perspectives, low growth potential and high market risks (Haouas et al. 2003).

In the labour market, for example, the introduction of minimum wages and a rigid wage structure by the government prevented a close linkage between base wages and performance-based bonuses. In addition, dismissal of employees was adopted as a measure to cut costs, and changing the skill mix of a firm's workforce required authorization that was not easily obtained, and entailed substantial severance payments. The effect is that laziness and absenteeism became difficult to punish, resulting in lower labour productivity and growth and deteriorated national and international competiveness. (Haouas et al. 2003)

The Tunisian manufacturing sector has been studied extensively, specifically looking at its evolution over time (e.g. Nabli 1981, Morrison 1987, Abdennadher et al. 1994, Sekkat 1996 and Boughzala 1997). The findings from these studies indicate that the period characterised by government regulations fostered some satisfactory results, until 1986 when the outcomes became less favourable due largely to some shocks, notably between 1984 and 1986. These include, the fall in oil prices, the repatriation of 30,000 workers from Libya, and conflicts between the government and trade unions in 1978, 1980, and 1984. However, government response was to embark on a comprehensive public investment policy based on massive borrowing. This approach almost plunged the county into a deep financial crisis.

In 1987, in exchange for financial assistance from the World Bank and the International Monetary Fund (IMF), the government accepted conditions which led to the adoption of a structural adjustment program, featuring liberalization of the economy and a redirection of national development strategy towards the private sector. In addition, the liberalisation policy culminated into accession of Tunisia to the General Agreement on Tariffs and Trade/World Trade Organization (GATT/WTO) and membership of the Maghreb Customs Union in 1995.

It is clear from the above that the policies pursued by Tunisia during the period of protection (1971-1986) were different from the policies pursued in the period of liberalisation (i.e. post 1986). Whereas the former was characterised by excessive government regulation, the latter was characterised by policies designed to benefit the economy. Despite these important differences, only a few studies have examined the impact or the beneficial of the liberalisation regime relative to the protection regime in Tunisia. The benefits to Tunisia from trade liberalization were expected to be substantial, and through various channels (e.g. Papi and Zazzaro, 2000). On the other hand, trade liberalization can also entail costs to the economy; for example, in terms of lower prices for export goods.

The central objective of this study is to examine the impact of liberalisation in Tunisia, specifically looking at: (i) the response of labour demand to factors: wages, output, capital, and technical change; (ii) variation in employment, associated determinants and how these vary across industries, and (iii) efficiency of the Tunisian industries in their choice of the level of employment that is technically optimal to produce a given level of output. The liberalisation regime was expected to result in increased employment, higher productivity increased foreign and domestic investments and efficient allocation of labour resources. (Haouas et al., 2003)

The questions that we seek to address in this paper include: (i) what are the consequences of liberalisation on the Tunisian manufacturing?; (ii) what are the determinants of the level of employment in the Tunisian manufacturing and how do these differ between pre– and post-liberalisation periods?; (iii) what factors affect the variations in employment in the Tunisian manufacturing and what is the impact of post-liberalisation on the variations?; and (iv) how efficient was the Tunisian manufacturing and do they differ between the pre- and post-liberalisation period? Addressing these and other questions is important for policy making in several ways. Firstly, understanding the factors determining the level of employment will inform about policies designed to enhance employment and the impact of the change in economic regimes on employment. Secondly,

understanding the factors affecting the variations in employment will inform about effects of policies designed to reduce variation in employment or increase employment.

In modelling labour demand in the Tunisian manufacturing sector we distinguish between two policy regimes, namely Pre-period (i.e. the period of import substitution, heavy regulation of industry, and protectionism, 1971-1986), and Post-period (i.e. the period of liberalisation, post-1986). This distinction allows us to examine the impact of liberalisation on the employment outcomes of interest.

The modelling and estimation follow two stages. In the first stage, we modelled labour demand in the traditional manner as a function of wages, output, quasi-fixed capital, and a time trend variable (e.g. Layard and Nickell, 1986, Symons, 1985). In the second stage, a variance function was then incorporated into the employment relationship, including factors thought to influence variations in employment. This is similar to a labour demand model that exhibits heteroscedasticity of known form. In modelling the level and variance of employment we take advantage of and generalize some techniques that have been used earlier in labour studies (e.g. Just and Pope 1978; Tveteras 1997, 1999, 2000; Tveteras and Heshmati 2002; Heshmati and Ncube (2004)).

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

2. Model

2.1. Conceptual Framework

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

$$L= f\,(Y, W, K, t; \alpha) \tag{1}$$

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 time trend representing technology, respectively. This relationship in (1) is similar to an inverted production function or input requirement function introduced by Diewert (1974) and Pindyck and Rotenberg (1983).

Next, the level of employment is assumed to depend on productions technology $f(.)$, technical inefficiency (μ) and a random component industry (v) capturing other factors that affect the industry's demand for the labour, but which are beyond the control of the industry. Examples of the factors contained in the random component include external or internal shocks such oil crises, labour market conflicts, and unanticipated government policies. Thus, including the random error term capturing efficiency differences in use of labour across industry sectors and random shocks, the relationship in (1) can be rewritten as:

$$L = f\,(Y, W, K, t; \alpha)\, exp(\varepsilon) \tag{2}$$

where $\boldsymbol{\varepsilon = \mu + v}$. The random component ($v$) can be either positive or negative, i.e. $-\infty \leq v \leq \infty$. Following Aigner, Lovell and Schmidt (1977), μ is one-sided, and $\mu \geq 0$ implies the degree of overuse of labour compared to the reference unit with best technology. For an industry that is 100% efficient in the usage of labour, i.e. $\mu=0$, and the relation in (2) becomes the standard average labour demand function. Here the fully efficient unit is used as a reference unit in minimizing the use of labour in producing a given level of output and for a given technology.

Following Kumbhakar (1993)[1], the labour demand relation which accounts for employment variance can be stated as:

$$L=f(X; \alpha)\, exp\,(g(X, Z; \beta)\varepsilon) \tag{3}$$

where $X=(Y, W, K, t)$, and $f(X;\alpha)$ is the deterministic part of the labour demand function and $g(X, Z; \beta)$ represents the variance function of the labour demand, where Z is a vector of industry characteristics

[1] Kumbhakar (1993) models production risk and technical efficiency in production.

and regulatory regimes that may influence the variation of labour demand other than the *X*-variables. These include, export, money supply, exchange rate, government expenditure, saving, credit, foreign direct investment, industry value added, and GDP growth variables,

Transforming the combined labour demand and risk function into a logarithmic form reduces the model to a linear relation in parameters:

$$ln\ l = ln\ f(x;\ \alpha) + g(X,\ Z;\ \beta)\varepsilon \quad (4)$$

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 demand 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 the model (4) are, respectively:

$$E(l)=f(x;\ \alpha)\ exp\ (g^2(.)/2);\ \text{and} \quad (5)$$

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

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

$$MR_j=\frac{\partial V(l)}{\partial xj}=2\ f(.)\ exp(g^2(.)/2)\ [f_j(.)\{exp(g^2(.))-1\}+f(.)g(.)g_j(.)\{2\ exp(g^2(.))-1\}] \quad (7)$$

where $f_j(.)$ and $g_j(.)$ are respectively partial derivative of the $f(.)$ and $g(.)$ functions with respect to x_j. From equation (7), the marginal risk with respect to x_j can be either positive or negative depending on the sign of the $g(.)g_j(.)$ term, which varies with x_j across industry and overtime. For $g(.)g_j(.)>0$, the marginal risk with respect to x_j is unambiguously positive, and for $g(.)g_j(.)<0$, it is unambiguously negative, and the second term in [.] is greater (in absolute value) than the first term.

2.2. Econometric Specification

The log transformation of the labour demand and employment variance function in equation (4) allows for a flexible function form of the econometric specification such as the translog. Assuming a translog specification is used to approximate $f(x;\alpha)$ and a linear form for $g(X,Z;\beta)$. Thus, the econometric specification corresponding to equation (4) is expressed as:

$$ln\ l_{it} = \alpha_0+\alpha_y\ lny_{it}+\alpha_w lnw_{it}+\alpha_k lnk_{it}+\lambda_t+1/2\{\alpha_{yy}lny^2{}_{it}+\alpha_{ww}lnw^2{}_{it}+\alpha_{kk}lnk^2{}_{it}\}+$$
$$\alpha_{yw}lny_{it}lnw_{it}+\alpha_{yk}lny_{it}lnk_{it}+\alpha_{wk}lnw_{it}lnk_{it}+\alpha_{yt}lny_{it}t++\alpha_{wt}lnw_{it}t+\alpha_{kt}lnk_{it}t\ +$$
$$\{\beta_y Y_{it}+\beta_w W_{it}+\beta_k K_{it}+\sum_j\beta_j Z_{jit}+\beta_t t\}\ [\mu_i+v_{it}] \quad (8)$$

where l, w, y and k are in log form and as previously defined and i indexes industries $(i=1,2,\ldots,N)$, t indexes time periods $(t=1,2,\ldots,T)$, λ represents policy regime dummy, and μ_i is the industry-specific fixed effect. Estimation of equation (8) follows a four-step generalized least squares estimation procedure proposed in Just and Pope (1978) and Griffiths and Anderson (1982). Equation (8) is estimated by ordinary least squares (OLS) and the residuals are obtained to estimate the variance part of the model, using a non-linear estimation technique.

In order to aid interpretation, the estimated coefficients are the elasticities of labour demand with respect to output, wages and quasi-fixed capital input are obtained. We expect a positive relationship between labour demand and increase in output, and a negative relationship between demand for labour and wages. A positive capital elasticity will indicate complementarily between labour and capital, while a negative will indicate substitutability. The elasticity of labour demand with respect to time interpreted as shift in the labour demand over time are also obtained.

3. Data

The data used in this study were industry level data assembled from the national accounts of the Tunisian National Statistics Institute (INS), industry statistics from the Quantitative Economy Institute (IEQ) and economy wide indicators from the World Bank Indicators Database (2009). The data comprise of a balanced panel data of six Tunisian manufacturing industries observed from 1971 to 2009. These industries include: (i) food processing, textiles, clothing and leather industry, (ii) chemical

industry, (iii) construction material, (iv) ceramics and glass industry, (v) mechanical electric industry, and (vi) other manufacturing industry.

The dependent variable (*L*) is total employment measured as the total number of employees in each industry. The vector of independent variables (X) in the labour demand part of the model are export (*EXP*), money supply (*MON*), government expenditure (*GOV*), gross savings (*SAV*), domestic credit to private sector (*CRE*), foreign direct investment (*FDI*), industry value added (*VAL*), and *GDP* growth (*GDP*)[2]; and wages (*W*), capital (*K*), and output (*Y*) .

For each industry, the variable average wages is measured as the ratio of total wages to the total number of employees, deflated by the consumer price index. Capital is measured as value of capital equipment. Output is measured by the output index of each industry, based on the value-added obtained from value of production less material and energy expenses. Export is measured as the total value of export in 1971 constant prices. Money supply is proxied by *M2*. The values of output, export, money supply, and capital stock are deflated by the GDP deflator.

In addition, government expenditure is measured in Tunisian Dinars, deflated by the consumer price index. Gross savings is calculated as gross national income less total consumption, plus net transfers. Domestic credit to private sector refers to financial resources provided to the private sector, including loans, purchases of non-equity securities, trade credits and other accounts receivable items. Moreover, industry value added corresponds to ISIC divisions 10-45 and includes manufacturing (ISIC divisions 15-37). It comprises value added in mining, manufacturing, construction, electricity, water, and gas. GDP growth is annual percentage growth rate of GDP at constant market prices.

Finally, year dummies and time trend were created to capture the exogenous rate of technical change in the labour demand function. Industry dummies were created to capture industry-specific effects. Regime dummy variables were also created in order to distinguish between the two policy regimes, namely; Pre- period (i.e. the period of import substitution, heavy regulation of industry, and protectionism, 1971-1986), and Post-period (period of liberalisation, post-1986). This distinction allows us to examine the impact of liberalisation on the employment outcomes of interest. In line with the introductory section, we also examine the specific years or periods capturing key shocks in Tunisia within the Pre-liberalisation period, namely: the period 1984-1986 capturing the period of fall in oil prices and the return of 30,000 workers from Libya; and years 1974, 1980, and 1984 capturing the period of the conflicts between the government and trade unions.

4. Results

4.1 Summary Statistics of Variables

Table 1 presents the summary statistics of the variables, specifically comparing the pre-, post-liberalisation and all time periods. The upper part of the table shows the labour demand variables. On average, employment and output increased significantly between the pre-and post-liberalisation periods. Specifically, average level of employment in post-liberalisation period is about twice as large as the level in the pre-liberalisation period, whilst capital increased four folds. For employment and output, the mean values for the post-liberalisation period are higher than all-time values. However, average wage and capital declined between the pre-and post-liberalisation periods. For these variables, the mean values for the post-liberalisation period lower higher than all-time values. Also, there is little difference in variations (by standard deviation) in employment across sectors between the periods but variations in output is much greater in the post-period compared to the pre-period.

[2] The inclusion of the determinants in the variance function is justified on the basis of the need to capture policy and the environmental variables that may affect the variation of employment (e.g. see Layard and Nickel (1986) and Symons (1985).

Table 1: Summary statistics of the Tunisian's manufacturing industry data, 1971-2009, Pre- and post-reform 1995, 234 observations

Variable		Mean	Std dev	Minimum	Maximum
A. Labor demand variables:					
PRE					
e	Employment	36.29	12.44	18.17	55.52
w	Average wage	7912.89	8104.68	4177.19	38120.20
y	Output	246.80	113.56	105.20	480.66
k	Capital	2532.19	374.29	1889.23	3012.74
POST					
e	Employment	79.84	13.05	57.35	100.44
w	Average wage	5440.90	688.22	4538.94	6926.36
y	Output	990.96	321.43	491.77	1613.05
k	Capital	1662.90	402.73	1152.69	2659.76
ALL					
e	Employment	61.97	24.98	18.17	100.44
w	Average wage	6455.05	5342.76	4177.19	38120.20
y	Output	685.66	447.84	105.20	1613.05
k	Capital	2019.54	579.74	1152.69	3012.74
B. Variance function variables:					
PRE					
g	Govt. expenditure	2817.07	1643.05	1893.48	8846.15
m	Money supply	5016.11	1586.07	2514.19	7525.71
x	Exports	2.52	0.87	1.23	4.22
s	Saving	23.63	2.16	19.29	27.42
cr	Credit	49.41	11.04	33.70	71.19
FDI	Foreign direct investment	1.82	0.97	0.68	4.18
Indva	Industry value added	27.78	4.35	20.06	33.50
gdpg	GDP growth	5.89	4.50	-1.45	17.74
t	time trend	8.50	4.63	1.00	16.00
POST					
g	Govt. expenditure	4434.01	1111.32	2912.59	6393.81
m	Money supply	15855.65	6710.96	8222.94	30957.28
x	Exports	1.85	0.38	1.25	2.50
s	Saving	22.12	1.17	19.59	24.27
cr	Credit	63.58	5.25	51.43	68.50
FDI	Foreign direct investment	2.83	2.18	0.60	10.56
Indva	Industry value added	29.41	1.41	28.09	33.85
gdpg	GDP growth	4.65	2.02	0.07	7.95
t	time trend	28.00	6.66	17.00	39.00
ALL					
g	Govt. expenditure	3770.65	1569.13	1893.48	8846.15
m	Money supply	11408.66	7487.07	2514.19	30957.28
x	Exports	2.12	0.71	1.23	4.22
s	Saving	22.74	1.80	19.29	27.42
Cr	Credit	57.77	10.71	33.70	71.19
FDI	Foreign direct investment	2.42	1.85	0.60	10.56
Indva	Industry value added	28.74	3.08	20.06	33.85
Gdpg	GDP growth	5.16	3.32	-1.45	17.74
t	time trend	20.00	11.28	1.00	39.00

The lower part of Table 1 shows the variance function variables. On average, macroeconomic indicators such as government expenditure, money supply, credit and FDI increased considerably between the pre-and post-liberalisation periods by 57%, 216%, 28.7%, and 55%, respectively[3]. Other indicators such as saving, export, and GDP growth recorded a decrease between the two periods by

[3] For example, the figure for government expenditure was calculated as (4434.01-2817.07/2817.07)*100.

6.4%, 26.6%, and 21%, respectively. However, industry value added increased modestly by 5.87%. Also, all of these values for the post-liberalisation period were greater than the all-time mean values, except for exports, saving, and GDP growth which are lower than all-time mean values. However, with the exception of government expenditure and money supply which showed strong variations across the sectors, the macroeconomic indicators show little variations across the sectors as well as overtime. This is expected as economy wide variables are expected to affect sectors in the same way.

Some preliminary propositions can be derived from the above statistics. Firstly, the statistics for employment and output, including the significant differences between the variations overtime and across the periods suggest that output may be driving labour demand more in the post-period than in the pre-period. Secondly, the little variations recorded over the periods and overtime across the variance function variables implies that as these are economy wide variables, they are expected to affect sectors similarly. Thus, we do not expect employment variance to vary significantly across the sectors. We go on to examine these propositions in the results from the econometric estimations.

4.2. Econometric Estimation Results

Table 2 presents the parameter estimates from three models, namely; Model 1 is a traditional simple labour demand function, in which $f(x;\alpha)$ is specified assuming a time trend representation of technology; Model 2 combines labour demand and risk model, and the formulation of both $f(x;\alpha)$ and risk function $g(X,Z;\beta)$ whilst technology is represented by a time trend; and Model 3 provides an alternative specification where technology in the labour demand is represented by a vector of annual time dummies, but a trend in the risk function. A trend was included in the variance function to capture neutral shifts in the variance function over time. Table 2 reports the estimates from these models. On the basis of the root mean square errors (RMSE) and the goodness of fit (R^2) criteria, the flexible translog specification (Model 3) appears to provide the best fit relative to the more restrictive Cobb-Douglas functional forms (Model 1 and Model 2).

Table 2: Labor demand and employment variance functions (generalized least squares) parameter estimates, n=234

Basic Time Trend (Model 1)		Time Trend and variance		(Model 2)	Time Dummy and variance (Model 3)	
Parameter	**Estimate**	**Std. Errors**	**Estimate**	**Std. Errors**	**Estimate**	**Std. Errors**
2.a Labor Demand Function						
α_0	-2.405***	0.256	-2.087***	0.259	-0.470*	0.256
α_w	-0.191*	0.113	-0.432***	0.162	-0.389***	0.092
α_y	-0.536**	0.237	-0.282	0.231	0.003	0.151
α_k	-0.243	0.321	0.048	0.228	-0.569***	0.226
α_t	0.142***	0.024	0.112***	0.023		
α_{ww}	-0.004	0.023	-0.019	0.035	-0.099***	0.027
α_{yy}	-0.093*	0.059	-0.054	0.056	0.023	0.038
α_{kk}	0.521***	0.129	0.419***	0.083	0.463***	0.099
α_{tt}	-0.002***	0.001	-0.002***	0.001		
α_{wy}	0.015	0.058	-0.059	0.076	0.128**	0.050
α_{wk}	-0.329***	0.105	-0.088	0.096	-0.130*	0.079
α_{wt}	-0.009*	0.005	0.001	0.006	-0.019***	0.004
α_{yk}	0.059	0.124	0.114	0.091	0.037	0.078
α_{yt}	0.024***	0.009	0.017**	0.008	0.007	0.006
α_{kt}	0.011	0.014	0.003	0.009	0.025**	0.011
μ_{const}	-0.431***	0.082	-0.374***	0.060	-0.371***	0.052
μ_{mecha}	-0.067	0.059	0.035	0.047	0.048*	0.027
μ_{chemi}	-0.790***	0.077	-0.700***	0.065	-0.592***	0.039
μ_{texti}	1.293***	0.071	1.217***	0.065	0.977***	0.034
μ_{other}	0.099	0.092	-0.050	0.072	-0.390***	0.058
λ_{1972}					-0.790***	0.148
λ_{1973}					-1.046***	0.181

Basic Time Trend (Model 1)		Time Trend and variance		(Model 2)	Time Dummy and variance (Model 3)	
Parameter	**Estimate**	**Std. Errors**	**Estimate**	**Std. Errors**	**Estimate**	**Std. Errors**
λ_{2009}					0.571***	0.208
Ra^2	0.972		0.989		0.998	
2.b Employment Variance Function						
β_w			0.087	0.402	4.517***	1.549
β_K			-6.014***	1.599	3.334	2.277
β_y			0.976*	0.612	6.851***	1.893
β_T			-0.274	0.239	-0.425	0.333
β_X			2.860	2.179	1.561	3.138
β_M			1.481	3.019	7.292	4.842
β_G			3.004**	1.603	-11.855***	2.205
β_S			-0.241	0.265	-0.271	0.436
β_{Cr}			0.413***	0.139	-0.002	0.164
β_{fdi}			0.175	0.209	0.661	0.570
β_{ind}			-0.829***	0.323	0.375	0.407
β_{gdpg}			-0.146	0.166	0.704**	0.305
RMSE	0.159		1.925		2.055	
R^2	0.974		0.309		0.168	
σ^2_v	0.025		3.706		4.222	

The variance functions $g(X,Z;\beta)$ were estimated using non-linear least square methods. In all of the models, most of the coefficients are statistically significant. In Model 2, the coefficients associated with output, capital, government expenditure, credit and industry value added are statistically significant, whilst wages, output, government expenditure and GDP growth are significant in the Model 3.

4.3 Labour Demand Elasticities

Labour demand elasticities with respect to wages, capital and output and time were calculated as shown in Equations A5 and A6, and results are reported in Tables 3a, 3b and 3c, corresponding Model 1, Model 2 and Model 3, respectively. These elasticities are evaluated at the mean values of the relevant variables. In addition to reporting the mean values of the exogenous rate of technical change in the tables, the mean marginal elasticities of labour demand with respect to each risk factor, and the mean efficiency values by industry and over time are also reported in Tables 3b and 3c together with the total variance.[4]

Table 3a: Mean labor demand elasticities (E), Time Trend (Model 1), n=234

	Wage E_W	**Output E_Y**	**Capital E_K**	**Time E_T**
Mean Elasticities by Industry				
Food	-0.403	-0.087	0.013	0.059
Const. material & ceramic	-0.452	0.091	0.129	0.040
Mech. Electric Industry	-0.378	0.014	-0.076	0.045
Chemical	-0.362	0.104	-0.282	0.030
Textile, clothing & leather	-0.360	-0.108	0.239	0.068
Other manufacturing	-0.215	0.008	-0.344	0.043
Mean Elasticities over selected years				
1971	-0.216	-0.111	-0.995	0.072
1976	-0.317	-0.114	0.034	0.087
1981	-0.402	-0.086	0.312	0.080
1986	-0.435	-0.051	0.295	0.067
1991	-0.378	-0.015	0.061	0.051
1996	-0.356	0.036	-0.090	0.034
2001	-0.362	0.103	-0.171	0.016
2006	-0.374	0.188	-0.290	-0.005

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

2009	-0.364	0.215	-0.370	-0.015
Mean Elasticities by Reform Period				
1971-1979	-0.294	-0.119	-0.182	0.084
1980-1999	-0.389	-0.018	0.098	0.064
2000-2009	-0.369	0.158	-0.241	0.02
Overall Mean and Standard Deviations				
Sample Mean	-0.362	0.004	-0.054	0.048
Std. Dev	0.110	0.139	0.401	0.036

Table 3b: Mean labor demand elasticities (E_W,E_Y,E_K), technical change (E_T), marginal risk (MR.) and employment efficiency (EEFF), Time Trend Variance (Model 2)

		Demand Elasticities			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	-0.449	0.034	0.174	0.052	-0.044	0.091	-0.079	-1.283	0.162	0.776
Const. material & ceramic	-0.397	0.158	0.176	0.036	-0.071	-0.036	0.077	-0.473	0.104	0.822
Mech. Electric industry	-0.400	0.095	0.037	0.041	0.115	0.045	0.062	-1.385	0.103	0.824
Chemical	-0.375	0.121	-0.109	0.033	0.001	-0.104	0.036	-0.222	0.120	0.715
Textile, clothing & Leather	-0.399	0.083	0.175	0.051	-2.510	1.467	-0.181	-4.047	0.055	1.000
Other manufacturing	-0.316	0.105	-0.325	0.036	-0.324	0.024	0.217	-1.881	0.055	0.889
Mean Elasticities over selected years										
1971	-0.370	-0.154	-0.401	0.074	1.055	-0.106	0.269	0.004	1.805	0.365
1976	-0.339	0.022	0.061	0.068	-0.471	-0.080	0.063	-0.284	0.101	0.763
1981	-0.375	0.074	0.266	0.062	-0.699	-0.092	0.002	-0.839	0.015	0.896
1986	-0.407	0.092	0.291	0.053	-0.446	0.161	-0.809	-1.157	0.071	0.819
1991	-0.399	0.105	0.094	0.042	-0.769	0.121	0.375	-1.415	0.019	0.903
1996	-0.401	0.130	-0.027	0.031	-0.932	0.418	0.010	-1.888	0.011	0.935
2001	-0.407	0.169	-0.090	0.019	-1.496	0.858	-0.402	-2.666	0.056	0.866
2006	-0.415	0.209	-0.163	0.006	0.617	0.702	0.117	-3.185	0.054	0.857
2009	-0.419	0.223	-0.225	-0.001	0.875	0.887	0.337	-3.514	0.071	0.838
Mean Elasticities by Reform Period										
1971-1979	-0.346	-0.018	-0.036	0.070	-0.186	-0.080	0.056	-0.220	0.298	0.721
1980-1999	-0.397	0.103	0.127	0.045	-0.688	0.147	0.043	-1.407	0.035	0.876
2000-2009	-0.412	0.198	-0.138	0.010	-0.297	0.743	-0.051	-3.026	0.052	0.866
Overall Mean and Standard Deviations										
Mean	-0.389	0.099	0.021	0.042	-0.472	0.248	0.022	-1.548	0.100	0.838
Std. Dev	0.054	0.097	0.307	0.025	1.608	0.994	0.918	1.824	0.313	0.142

Table 3c: Mean labor demand elasticities (E_W,E_Y,E_K), technical change (E_T), marginal risk (MR) and employment efficiency (EEFF), Time Dummy Variance (Model 3)

	Labor Demand Elasticities				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	-0.789	0.163	-0.014	0.015	-0.078	-0.080	-0.053	-0.592	0.040	0.929
Const. material & ceramic	-0.888	0.104	0.076	0.015	-0.060	0.014	0.012	-0.265	0.057	0.877
Mech. Electric industry	-0.821	0.114	-0.109	0.011	0.127	-0.067	-0.042	-0.896	0.045	0.928
Chemical	-0.930	0.127	-0.238	0.000	-0.042	-0.060	-0.001	-0.105	0.054	0.857
Textile, clothing & leather	-0.571	0.028	0.021	0.032	-0.616	-1.629	-0.407	-3.753	0.026	1.000
Other manufacturing	-0.630	-0.010	-0.468	0.012	-0.046	0.035	-0.043	-1.035	0.036	0.895
Mean Elasticities over selected years										
1971	-0.993	0.130	-0.920	-0.048	-0.021	0.091	-0.338	-0.010	0.194	0.810
1976	-0.629	-0.073	-0.278	0.148	-0.058	0.113	0.025	-0.116	0.075	0.869
1981	-0.649	-0.030	0.015	0.065	-0.104	0.176	0.046	-0.491	0.046	0.898
1986	-0.724	0.049	0.104	0.004	0.095	-0.053	0.249	-1.025	0.057	0.888

	Labor Demand Elasticities				Marginal Risk Elasticities				Efficiency	
	E_W	E_Y	E_K	E_T	MR_W	MR_Y	MR_K	MR_T	TVAR	EEFF
1991	-0.734	0.085	-0.035	0.017	-0.170	-0.053	-1.167	0.019	0.937	-
1996	-0.775	0.131	-0.088	0.023	-0.168	-0.439	-0.080	-1.404	0.012	0.958
2001	-0.841	0.181	-0.074	0.075	-0.873	-0.894	-0.152	-1.702	0.023	0.940
2006	-0.946	0.246	-0.069	0.053	-0.064	-0.849	-0.213	-2.231	0.007	0.967
2009	-0.971	0.276	-0.091	-0.016	0.228	-0.972	-0.288	-2.486	0.019	0.937
Mean Elasticities by Reform Period										
1971-1979	-0.700	-0.030	-0.415	-0.071	-0.052	0.127	-0.009	-0.120	0.101	0.855
1980-1999	-0.738	0.074	-0.019	0.043	-0.111	-0.160	-0.067	-1.076	0.029	0.927
2000-2009	-0.903	0.221	-0.066	0.035	-0.195	-0.956	-0.206	-2.060	0.018	0.944
Overall Mean and Standard Deviations										
Mean	-0.771	0.088	-0.122	0.014	-0.119	-0.298	-0.089	-1.108	0.043	0.915
Std. Dev	0.174	0.123	0.336	0.156	0.608	1.120	0.407	1.603	0.043	0.064

4.4 Wage Elasticity

The negative signs of the elasticities are expected. A relatively larger overall wage elasticity is observed in Model 3 (Table 3a) compared to the other models (i.e. comparing -0.771 with -0.389 and -0.362 in Model 1 and Model 2, respectively). Also, wage elasticity varies across industries, and by model specification. In Model 1 (Table 3a), wage elasticity is highest in the construction material and ceramic industry (-0.452); in the time trend risk model (Model 2, Table 3b) wage elasticity is highest in the food industry (-0.449); and in the time dummy risk model (Model 3, Table 3c), wage elasticity is highest in the chemical industry (-0.930). Comparing across the models, wage elasticity is more than twice as large in Model 3, than in the other less flexible models.

Result shows that the temporal patterns of wage elasticities in absolute values overtime by model specification. The patterns of wage elasticities are different across the models. In the time trend model (Model 1), wage elasticity increased in the early 1970s and generally in the pre-liberalisation period and declined slightly afterwards during the post-liberalisation period (i.e. post-1987). In the time trend risk (Model 2) and time dummy risk (Model 3) models, wage elasticity declined in the early 1970s but then increased generally through to the pre-liberalisation period. However, whilst wage elasticity continued to increase progressively overtime in the time dummy risk model (Model 3), it remained generally constant in the post-liberalisation period in the time trend risk model (Model 2). Generally, these results appear to suggest that the deregulation of prices under structural adjustment in the liberalisation period triggered inflationary pressures that saw real wages to reduce to their pre-liberalisation levels.

Generally, the result shows significant variations in employment elasticity with respect to wages between the two risk models. On average the two risk models were expected to produce similar responsiveness. The difference can be attributed to the fact that time dummy model uses 36 parameters more for the neutral parts while for the interactions in both cases a trend is used to reduce the degree of over parameterisation. Allocation of different weights to these two components may explain the differences in the elasticity. In absolute number the responsiveness is increasing indicating increasing negative relationship between employment and wages in recent years.

4.5 Output Elasticity

The sample mean elasticity of labour demand with respect to output for the basic model (Model 1) is 0.004 with a relatively larger standard deviation of 0.139. The corresponding mean (standard deviation) figures for the time trend risk model (Model 2) is 0.099 (0.097) and for the time dummy risk (Model 3) is 0.088 (0.123). Output elasticity also varies across industries, and by model specification. In Model 1 (Table 3a), output elasticity is highest in the textile, clothing and leather industry (-0.108); in the time trend risk model (Model 2, Table 3b) output elasticity is highest in the construction

materials and ceramic industry (0.158); and in the time dummy risk model (Model 3, Table 3c), output elasticity is highest in the food industry (0.163).

The temporal patterns of output elasticities in absolute values overtime by model specification. In similar way, the patterns of output elasticities are different across the models, particularly for the pre-liberalisation period. In the time trend model (Model 1), output elasticity declined generally until 1993 when it started to increase continuously overtime.

In the time trend risk (Model 2) and time dummy risk (Model 3) models, output elasticity declined in the early 1970s but then increased generally through to the pre-liberalisation period. This increase continued and became more stable in the post-liberalisation period. In the time dummy risk model (Model 3), significant fluctuations in output elasticity are observed in the pre-liberalisation period, with no clear pattern. However, output elasticity became more stable and increased continuously during post-liberalisation. Comparing the temporal patterns between the pre-and post-liberalisation periods, a clearer increasing pattern of output elasticity overtime are observed across the models, though this was delayed till 1993 in the basic model (Model 1).

4.6 Capital Stock

On the basis of the sample mean values, the results show that a 1% increase in capital stock leads to a 0.021% increase in labour demand in the risk model (Model 2), while the corresponding numbers for the time dummy risk model (Model 3) is 0.122% decrease in labour demand. Moreover, responsiveness is highest in the textile and construction material industries in all models. The temporal patterns of the labour demand elasticities with respect to capital stock capital (in absolute values) overtime by model specification. Labour demand elasticities with respect to capital stock exhibits similar patterns across all the models in the early 1970s, and a less similar pattern for the two risk models (Models 2 and 3). However, the responsiveness is generally identical across the models in the most part of the post-liberalisation period. The opening up of the economy and the deregulation of the labour market in the liberalisation period seem to be explaining the results here.

The negative capital elasticities reflect substitution between capital and labour and it is a reflection of economic policies of the government in general and the active capital-labour substitution policies in particular. The size of elasticity differs overtime and across industries as a result of targeted incentives provided and heterogeneous technology development amongst the industries regarding substitution possibilities and labour requirements.

4.7 Technical Change

Regarding the exogenous rate of technical change, the sample average rate of technical change for the basic time trend (Model 1) is 0.048 and with standard deviation of 0.036. For the risk model (Models 2) the mean (standard deviation) is approximately about the same level, 0.042 (0.025). In the time dummy risk (Model 3) however, the sample average rate of technical change is only 0.014 with a large standard deviation 0.156. Also, technical progress (labour saving) is fastest in the textile, clothing and leather industry in all of the models.

Result shows the temporal patterns of the labour demand elasticities with respect to technical change overtime and by model specification. Whilst there is little difference in labour saving technical progress between the time trend (Model 1) and time trend risk (model 2), much of the labour saving technical progress are observed in trend dummy risk model (Model 3), particularly in the post-liberalisation period when it became less fluctuated compared to the pre-liberalisation period (i.e. 1971-1974, 1984, and 1987).

4.8 Marginal Risk Elasticities

The lower segment of Table 2 presents the β coefficients from the variance functions in the time trend risk model (Model 2) and the time dummy risk model (Model 3). In the (Model 2, five of the twelve

coefficients are statistically significant and four of the twelve are statistical significant in the Model 3. In Model 2, the variance function coefficients on wages, output, exports, money supply, government expenditure, credit and FDI are positive, whilst they are negative for capital stock, saving, industry value added, and GDP growth. However, only capital, output, government expenditure, credit and industry value added are statistically significant.

In Model 3, the variance function coefficients are positive for wages, capital, output, exports, money supply, FDI, industry value added and GDP growth, whilst they are negative for government expenditure and saving. However, only the coefficients on wages, output, government expenditure and GDP growth are statistically significant. Moreover, the coefficient on the trend variable is negative in both models. In addition, the estimate of the variance (σ^2_v) is relatively lower in Model 2 (3.706) than in Model 3 (4.222).

The middle segment of Tables 3b and 3c report the marginal risk elasticities associated with the variance functions in Model 2 and Model 3, respectively. The marginal risk elasticity with respect to wages is small and negative in four of the 6 industries in Table 3b (Model 2), whilst it is negative in five of the 6 industries in Table 3c (Model 3). Overtime, the marginal risk elasticities are generally negative in Model 2, but are relatively larger in the post-liberalisation period with positive during 2005-09, whilst no clear pattern emerged between pre-and post-liberalisation in Model 3 however.

With respect to output, the overall risk elasticity in the risk model is positive and small, as only two of six industries are negative (i.e. construction and chemical). This suggests that changes in output increased the variance in labour demand. Result shows the variation in the level of employment variance for different industries, which is lower in Model 3 than in Model 2 in all industries. Overtime, the mean marginal risk elasticity with respect to output are generally negative and are close to zero in the pre-liberalisation period but this turned positive generally in the post-liberalisation period. This result suggests that labour demand was more responsive to changes in output in the liberalisation period compared to the pre-liberalisation period.

The overall mean risk elasticity with respect to capital show any clear pattern in the pre-liberalisation period as both negative and positive elasticities are observed in the dummy risk model (Model 3, Table 3c). In the post-period however, the mean risk elasticity with respect to capital stock become generally negative.

The rate of technical change decreases the variation in labour demand in the two risk models. The overall mean marginal risk with respect to time is generally negative but relatively larger in absolute values in the post-liberalisation period than in the pre-liberalisation period. Moreover, the decreasing effect is observed in all of the industries. Result shows the variation in the level of mean rate technical change across different industries. Overtime, the mean marginal risk with respect to time decreases continuously, but is relatively larger in absolute valued in the post-liberalisation period than in the pre-liberalisation period.

4.9 Employment Efficiency

Tables 3b and 3c report the results for employment efficiency computed using equation (A4). The employment efficiency measures how technically efficient an industry is in its choice of the optimal size of the labour input or employment. It is a relative measure as it relates a particular industry to the most efficient one; in this case, the textile and clothing. The sample mean efficiency values are 84% (0.142) and 91.5% (0.064) in Model 2 (Table 3a) and Model 3 (Table 3b), respectively[5]. This implies that an industry that is close to the average can be better off if, for a given level of output, it reduces labour by at most 16.0% and 8.5%, respectively. These rather high numbers reflect excess labour due to the absence of many years of necessary adjustment in manufacturing employment. These numbers can also suggest some accumulation of the unadjusted stock of labour of between 8.5% and 16%,

[5] The standard deviations are in parenthesis.

particularly considering the fact that adjustment of labour was largely impossible in the pre-liberalisation years.

According to the time trend risk model (Model 2), the industries closer to the best or frontier (textile and clothing) are other manufacturing, mechanic and electric and construction material, with efficiency measures at 89%, 83% and 82%, respectively. For the trend dummy risk model (Model 3), the industries closer to the frontier are food, mechanic and electric, other manufacturing and construction material, with efficiency measured at 92.9%, 92.8%, 89.5% and 87.7%, respectively. However, the chemical industry appears to be the least efficient industry with efficiency level measured at 71.5% and 85.7% in Model 2 and Model 3, respectively. Result shows variation in the mean employment efficiency across industries. As the result shows, employment efficiency across industries differs by model specification. Whilst it is higher in four industries (food, construction material, mechanical and electrical, and chemical) the more flexible dummy risk model (Model 3), it appears to be identical across models for other manufacturing and textile and clothing.

Overtime there was no clear pattern of employment efficiency in the pre-liberalisation period, as efficiency increased sharply between 1971 and 1972, but this was followed by a fall generally for the remaining part of the period, and then fluctuated along a constant path during the post-liberalisation period. These results are consistent across the models.

5. Summary and Conclusion

This study examines the impact of liberalisation in Tunisia from the perspective of employment in the manufacturing sector. We address three key questions relating to labour demand elasticities, variation in employment and associated determinants, and employment efficiency in Tunisian manufacturing.

A labour demand function was estimated incorporating the employment variance function. The incorporation of a risk function allowed us to account for heteroscedasticity of known form capturing industry heterogeneity. The modelling approach also provided an opportunity to not only identify the determinants of variability in employment across industries and overtime, but also to estimate the extent of these impacts pre-and and post-liberalisation periods.

Labour demand was specified as a function of wages, output, capital and time, whilst in addition to these variables, the variance function was specified as a function of exports, money supply, government expenditure, saving, credit, foreign direct investment, industry value added, and GDP growth. A flexible translog form with annual time-variant intercepts is accepted as preferred model specification.

The findings with respect to labour demand elasticities suggest that labour demand responded mostly to wages, followed by capital stock changes, and lastly, to level of output. Also, the rate of technical progress was fastest during the post-liberalisation period, ranging between 13.3% in the time trend risk model and 19.5% in the dummy risk model. Specifically, the size of the wage elasticities vary more amongst industries than it does over time. Elasticities with respect to output were relatively small, but increased over time, particularly in the post-liberalisation period. The responsiveness of labour demand to changes in capital stock was also small ranging between mean of 0.021 and -0.122 across models, but it was greater during the pre-liberalisation period than in the post-liberalisation period.

We also found evidence of some level of technical progress (labour saving) for given levels of wages and output in the chemical industry across all of the models and became less fluctuated in the post-liberalisation period. The overall mean rate of technical regress ranged between 4.2% and 1.4% for the time trend risk model and the time dummy risk model, respectively. This implies that new technologies that were adopted in the post-liberalisation period also resulted in additional jobs. Thus, the liberalised economy provided incentive for many companies to replenish their obsolete equipment, and the deregulation of the labour market made it possible and easier to replace labour with machinery.

Turning to the marginal risk elasticities, the results show that labour demand was more responsive to changes in output relative to other factors in the liberalisation period compared to the pre-liberalisation period. Freeing up the economy increased output which in turn implies greater labour

demand. Moreover, the pattern of employment efficiency across industries and overtime showed that industries perform differently in attaining optimal level of employment or labour requirement. Such differences can be attributed to the individual firm's own responses to exogenous changes in the market or a result of endogenous but optimal decisions made by firms. Such differences are also possible if public policies targeting certain industries but ignore others. A generally high level of inefficiency could result from ineffective institutions and inadequate policies. A sufficient large degree of inefficiencies across industries provides an indication of the need for policies and interventions to introduce incentives that enhance employment efficiency and technology spill over across industries.

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