TRADE LIBERALIZATION, TECHNOLOGY IMPORT AND EMPLOYMENT: EVIDENCE OF SKILL UPGRADING IN THE TUNISIAN CONTEXT

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Abstract **-** *There are increasing studies that address the skill upgrading in developing countries. If the theoretical analyses yield different results about the factors of skill upgrading, the issue is mainly empirical questions. This paper contributes and adds to the growing literature on labor market by investigating the impact of trade openness and technology change on employment for skilled and unskilled labor in Tunisia. In this study, we make use of a manufacturing industries annual database of 6 manufacturing industries over the period 1983-2007, provided by the Tunisian National Institute of Statistics, the Quantitative Economic Institute and the Comtrade base of United Nations. Our main empirical result indicates that trade and technology change positively affect absolute and relative skilled labor employment. This result is consistent with studies which support the idea that in developing countries trade liberalization induces skill-biased technology changes.*

Key-words **-** TRADE LIBERALIZATION, TECHNOLOGY CHANGES, SKILLS

JEL Classification **-** F16, J23, J24, O33, C2.

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1. INTRODUCTION

This paper contributes to the growing literature on labor change in developing countries by examining the relationship between trade openness, technology adoption and the relative demand for skilled labor in Tunisian manufacturing industries. Tunisia has started a process of liberalization in the 80s under the Structural Adjustment Program conducted by the International Monetary Fund and World Bank. This policy has raised volumes of exports and imports and has made Tunisian economy more integrated within the world market. An important aspect of this process could be its impact on labor demand for different skills, and its impact on the relative demand for skilled labor. However, the Tunisian labor market recorded a shift of demand toward more skilled labor over the same period. Whether these two simultaneous phenomena are linked has not been established yet.

Economic literature theoretically offers different predictions about the coincidental juxtaposition of openness of many developing economies and the observed change in the demand structure of labor market. On the one hand, the Heckscher Ohlin's theorem and its Stolper-Samuelson corollary framework constitute the main analytical tool to investigate the impact of trade liberalization on labor market. This analysis considers two countries, two goods and two factors: an industrialized country with a comparative advantage in the production of skill-intensive goods, and a developing country (DC) with a comparative advantage in unskilled intensive goods. According to the traditional trade theory, we may expect a relative increase in the demand for unskilled-workers. Indeed, trade liberalization should benefit a country's relatively abundant factor, because trade specialization should favor sectors with the abundant factor. As suggested by the Stolper-Samuelson theorem, trade liberalization raises the relative price of the abundant factor in developing countries (unskilled labor), and reduces the relative wage of the skilled and, by extension, produces wages inequalities. This means that wage differential should decrease in developing countries and should increase in developed countries. Increasing capital imports from developed countries will lower domestic prices of capital in developing countries, which will generate more demand for capital. Then, demand for highly-skilled labor will also increase if capital-skill complementarities hold[3]. On the other hand, in the presence of technology gap between developed countries and DC, trade may facilitate technology transfer from industrialized countries to DC. News theoretical analysis has proposed some mechanisms through whish news technology can increase relative demand of skilled workers in DC (see a recent complete review of the literature in Goldberg and Pavnick, 2007). Meschi and Vivarelli (2009) explained increase in relative demand for highly skilled labor in DC by the fact that trade liberalization comes generally with a simultaneous process of technological modernization and deepening of capital. The inflowing technology is assumed to be skill-biased because it is mainly designed and developed in the

[3] Goldin and Katz (1998) present the possibility that capital-skill complementarities exist in developing countries. Increased demand for capital will also increase demand for skilled labor, and if demand grows faster than supply, their wages will also increase.

industrialized world with skill intensive technology and skill-biased new technology (Berman et al., 1998). The new technologies will therefore favor skilled workers and increase their demand. If large enough, this increase can outweigh the reduction in the demand for skilled labor that is predicted by traditional trade theory. Robbins (1996, 2003) has termed the effect of the inflowing technology resulting from trade liberalization the 'skill-enhancing trade hypotheses'. When the gap between existing and newly imported technology is large, trade reform could have an even greater effect on skill demand in a developing country than it does in an industrialized country (O'Connor and Lunati, 1999). Goldin and Katz (1998) reach a similar conclusion; they argue that the demand for skilled labor can follow a technological cycle. However, many other studies have suggested that this increase of wages inequalities and demand for skilled workers is temporary. This comes from the fact that the demand for skilled-workers rises first, when the countries open its economy, because new technologies and machinery are skill-biased. Then, by a learning process, unskilled-workers will be able to use new equipments and the demand on skilled-workers falls (see for instance Pissarides (1997). These latter results lead to two conclusions: The first one question the importance of traditional theory of international trade to explain this increase of wage differentials in the short term. The second is that the traditional theory of international trade can be verified for the case of developing countries only in the long term. Hence, it is an empirical question whether employment of skilled and unskilled labor in developing countries will increase or not after trade liberalization.

In the empirical literature, several studies have confirmed the unpredictable result that when developing countries open their economies no dropping in inequality wage has been detected (see for instance Currie and Harrison (1997) for the case of Morocco and Hanson and Harrison (1999) (HH) and Robertson (2000) for the case of Mexico). HH (1999) found a significant increase in skilled workers' relative wages. The same results have been reported by Cragg and Epelbaum (1996). Robbins (1994) and Gindling and Robbins (2001) show that the increase of the relative demand for skilled workers in Chile is positively correlated with trade openness variables and, in particular, with technology transfer from abroad[4]. However, a second evidence reported by Fuentes and Gilchrist (2005) and Pavnick (2003) show different results in Chile, and argue that correlation between skill upgrading and proxies for technology transfer disappears after controlling for plant-fixed effects. Many other economists have investigated the effects of trade on developing countries by examining its impact on employment (see for instance Maia (2001) among others). Most empirical works indicate that trade destroys more unskilled than skilled jobs.

This paper discusses and examines the impact of trade liberalization on the aggregate labor market for the Tunisian manufacturing industries using a panel data method. Specifically, we try to assess the impact of trade liberalization and technology change in explaining the growing demand for skilled labor (i.e. skill upgrading). In particular, we suspect that trade openness and techno-

[4] This result is also emphasized by Pavnick (2003) and Sanchez-Paramo and Schady (2003).

logical change are the two most common channels behind changing patterns in labor demand and wage (Fuentes and Gilchrist, 2005; Sanchez-Paramo,and Schady, 2003; Pavnick, 2003 and Robbins, 1994 for Chile and Görg and Ströbl, 2002 for Ghana). Our empirical strategy is in twofold. First, we estimate separately the absolute equation of skilled and unskilled labor. To this end, we employ the methodology used in previous literature by deriving employment by skills in the context of a Cobb-Douglass production function (see appendix 2 for derivation of empirical equations). Second, we suppose to estimate the relative employment of skilled labor.

The rest of the paper is organized as follows. Section 2 briefly presents Tunisia's trade liberalization process and labor market evolution. Section 3 describes the empirical specification. Estimation results are discussed in section 4. Concluding remarks with policy implications and limitation of this study are presented in section 5.

2. TUNISIAN ECONOMY: TRADE LIBERALIZATION AND LABOR MARKET

Since 1986, Tunisian policy makers have adopted unprecedented reforms in order to facilitate the integration of the Tunisian economy within the world market. From 1986 to 1995, many economic measures involving trade liberalization have been undertaken. In 1986, Tunisia adopted the Program of Structural Adjustment (PSA). In 1989, it joined the General Agreement on Terms of Trade (GATT) and to the World Trade Organization (WTO) in 1994. In 1995, Tunisia's policy makers ratified the free-trade agreement with the European Union.

2.1. Exports Structure

Table 1 below shows the evolution of the structure of Tunisian exports from 1993 to 2006. It shows that the share of primary goods has been reduced, though, until 1990, this structure did not change much. Textile, Clothes and Leather (TCL) constitutes the dominant categories which represent half of the exports, 48,2 % for the period 1993-1995 and 47,3% for the period 2000-2002. This share in exports fell to 33,6 % in 2006. Decrease of exports in this industry is predictable due to terminating the Multi Fiber Agreement in January 2005. In addition, garments represent more than 90% of total textiles and clothing exports. Exports of mechanical and electrical products have become more important. Their share rose from 12,9 % to 18,2% for the same period, reaching 25,2% in 2006, at the expense of food products and mining. Despite development of these products, TCL was still the largest exports category in manufacturing with 45,3 % in 2006.

2.2. Imports Evolution

Imports liberalization in Tunisia was pursued in two stages. The first phase was implemented during the early 1990s, and was accomplished by liberalization of import licensing and reduction of tariff rates. Both of these measures were intended to provide competitive pressure on domestic industries. The second phase of imports liberalization was launched in 1995 and took the form of a new five-year tariff reduction program. During this period, a more extensive and accelerated tariff reduction program has been implemented. This decrease of tariff contributed to technology transfer in the form of machines, equipments and intermediate goods. Inflowing of technology is assumed to be skill-biased because it is mainly designed and developed in the industrialized world with skill intensive technology (see Berman et *al.* (1998)). The incorporation of new technologies will therefore be accompanied by a change in labor demand in favor of skilled workers.

Table 1. Structure of Tunisian exports, 1993-2006 (%)

Sector	1993-1995	2000-2002	2005	2006
Food processing	11,5	8,1	10,7	12,2
Energy and lubricants	10,0	10,2	12,9	13,2
Mines, phosphates and derivatives	9,8	8,1	7,0	6,8
Textiles, Clothing and Leather (TCL)	48,2	47,9	7,7	33,6
Electrical and mechanical industries	12,9	18,2	23,1	25,2
Other manufacturing industries	7,5	7,5	8,6	9,0
Total merchandises	100	100	100	100
Total non-food manufacturing	68,7	73,6	75,8	74,2
Share of textiles, clothing and leather in manufactured products	70,3	65,1	50,0	45,3

Source : Central Bank of Tunisia (Annual report).

Figure 1 reports the evolution of competitiveness in the domestic market, measured by the rate of import penetration of each sector. If Q, X and M stand, respectively, for output, exports and imports under each sector, domestic demand D will be equal to D = Q–X+M, and the rate of import penetration is calculated as M/ D. It should be emphasized that a low level of penetration does not necessarily mean that there are barriers to entry. The chart reveals a very high import penetration mainly in Electric and Mechanic industry, Chemical industry and Textiles, Clothes and Leather industry.

Figure 2 reports the evolution of annual import of machinery and equipment in Tunisian manufacturing industries. This chart shows that imports of machinery and equipment increased gradually over the period. The value rose from 453 MD in 1983 to 3726 MD in 2007. The free trade agreement with the EU in 1995 played an important role in this evolution. This means that firms in manufacturing industries shifted to modernize their production process with new machinery and equipment in order to cope with competition on the international market. This upgrade is made possible by using mainly the structural adjustment program.

Figure 1. Rate of imports penetration by industry

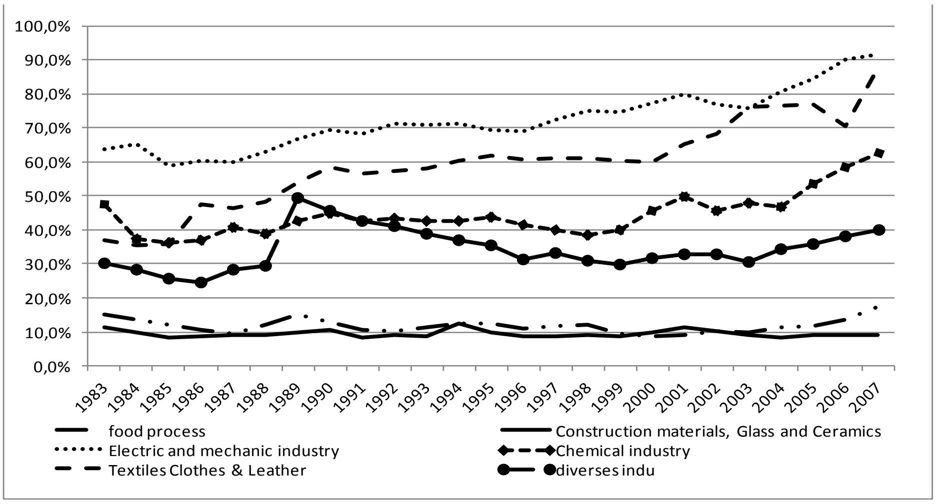
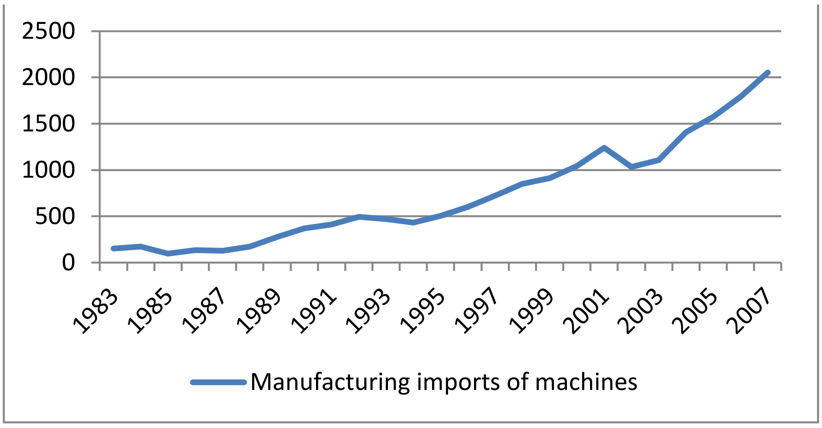


Figure 2. Importation of machines (in Millions of constant dinars)



2.3. Employment in Tunisian manufacturing industries

Table 2 summarizes the share of employment by education level in the case of Tunisia. Employment trends by level of education shows a particular evolution. We notice that employment of workers with secondary education has multiplied by 2.5 from 1983 to 2007. During this period, the share of employment of workers with secondary education increased from 17.7% to 44.2%. In contrast, the share of employment of workers with higher level, has multiplied by 4 over the same period. It increased from 1.4% in 1983 to 5.8% in 2007. The share of workers with primary education remained constant over the period

1983-2007, against a significant decline in workers with no education level. The decline is almost 30 percentage points between 1983 and 2007.

Table 2. Share of employment by education level in manufacturing industries *(%)*

	1983	1994	1997	1999	2004	2007
No level	34,8	15,6	12,0	10,2	6,6	4,7
Primary	45,9	52,1	52,2	51,6	47,9	45,1
Secondary	17,8	29,4	23,8	34,5	40,4	44,3
Tertiary	1,4	2,7	3,3	3,7	5,0	5,8

Source : Tunisian National Institute of Statistics.

Broadly speaking, the shares of the two last education levels, (Secondary and Tertiary), register a change almost opposite to those of primary education and no education level. This trend can be explained by the gradual change of structure of demand for labor to a more educated workforce. A progressive replacement of low-skilled with more skilled workforce took place in almost all manufacturing sectors and the remaining sectors of the economy as well, either protected or competitive. Such a substitution can be done mainly as a result of global competition, technological change and social changes experienced by the country especially after opening of trade. However, it is believed that structural changes in the economy have contributed to break employment of highly skilled employees by encouraging the competitive sector to the detriment of the protected.

Table 3. Skill upgrading in manufacturing industries

	1983	2007
Food processing	0,27	1,01
Construction Materials, Ceramics and Glass (CMCG)	0,23	0,83
Electrical and Mechanical Industries (EMI)	0,49	1,66
Chemical industries (CI)	0,82	2,04
Textiles, Clothing and Leather (TCL)	0,16	0,87
Manufacturing industries diverse (MID)	0,29	0,86

Author's calculation using Tunisian National Institute of Statistics data base.

Table 3 presents the evolution of employment of skilled workers relative to unskilled workers between 1983 and 2007. During this period, the ratio of skilled to unskilled workers have increased from 0.27 to 1.01 in the AA industry, from 0.49 to 1.66 in the EMI industry and 0.82 to 2.04 in Chemical industry. Workers in the textile sector, the main creator of employment, have a relatively less important education level. In other industries, like CMCG, TCL and MID, this ratio remains below the threshold, suggesting that all these industries still use a higher proportion of unskilled workers than skilled workers.

3. EMPIRICAL SPECIFICATION

3.1. Dataset

The dataset used in this paper is provided by three sources: the Tunisian National Institute of Statistics (*TNIS*), the Economic Quantitative Institute (*EQI*) and Comtrade United Nations base. These bases allowed us to build a statistical industrial data of labor market, trade liberalization and technological change. We have a panel of 6 manufacturing industries[5] annual data observed over the period 1983-2007. This provides us with a number of observations equal to N*T=150 where N is number of manufacturing industries and T is number of years.

The dataset includes: Product (Q) measured as the value of total product produced during a calendar year. Value added (VA) is the total product less materials and energy. Both Q and VA variables are transformed to fixed 1990 prices using the product price index. K is capital stock variable, H is skilled labor variable, L is unskilled labor variable and (H/L) is relative employment variable.

In this paper we use level of education as a proxy of skilled and unskilled labor[6]. We define skilled labor as all people at the age of work and with a secondary and tertiary education level. Unskilled labor is defined as all people who have only primary education level and no education. These variables are merged with technology change indicator which is computed using data obtained from *TNIS* and Comtrade United Nations base.

3.2. Construction of technology change variables proxies

The common problem faced by applied researchers when investigating the impact of trade openness and technology on employment for skilled and unskilled labor in the case of developing countries is the unavailability of exhaustive sources of data that provides an exact and direct measure of the technology change variable. In our case, we propose two ways to measure the role of technology change in explaining skill upgrading in Tunisian manufacturing industries. The first consists of constructing a dummy variable that measures technology intensity by industry. The second way consists of constructing a value of machines imports by industry and year[7]. The aim is to build up a proxy

[5] The six industries are: Foods, Construction and glasses, Mechanics and electronics, Chemical, Textile and Leather and other manufacturing industries.

[6] Economic literature often adopts two competing definitions to proxy skilled labor: occupation and education measures. Gonzaga et al. (2006) suggest that neither occupation nor educational measures provide exact measures of skill intensities; for instance, in countries like Tunisia, the occupational proxy is problematic since there are a lot of non-skilled tasks that do not require particular skills.

[7] Special thank is considered to Ms. Mongi Ben Chaaben for his precious help to make the data available for us.

that can be considered as close as possible to technology change by industry and year[8].

3.2.1. Dummy variable of technology intensity

The first method considers a simple way to assess the expected impact of technology change on skill upgrading, and consists of using a dummy variable to distinguish groups of industries with different levels of technology intensity, see appendix 1. We have classified the six industries according to the OCDE classification of manufacturing industries[9] (OCDE science, Technology and Industry scoreboard, 2007). Our dummy variable is constructed by considering two groups where the variable takes a value of 1 if the industry is "high" or ''medium-high'' technology intensive and 0 if the industry is "low" or ''medium-low'' intensive technology.

$$TC\_Dum = \begin{cases} 1 & \textit{if industry is high or medium} - \textit{high} \\ 0 & \textit{if industry is low or medium} - \textit{low} \end{cases}$$

In our data base, two industries are considered as "high" or ''medium high'' technology intensive (Chemical industry, Electrical and mechanical industry), see for instance Keller (2002). The four other industries are considered "low" or ''medium-low'' technology intensive. With respect to the share of imports in value added we are able to construct an interaction variable between dummy variable and imports by industry, $((M/VA)*TC\_Dum)_i$. We may expect that import's effects on skill upgrading vary across technology intensive industries. By using the ((M/VA)**TC_Dum)* variable, we can test whether imports increase significantly more employment of skilled labor relative to unskilled labor in industries with high technology intensity. Furthermore, we suggest that the imports of these industries are in majority constituted by a capital good embodied by high technology which is biased toward skilled workers.

3.2.2. Imports of machines

The second method consists to merge two available datasets in order to construct a specific data source on machinery imported. We use data on machines imports for the following reason: The majorities of world's capital goods are provided by a smaller number of R&D intensive countries, and most countries in developing world, in particular Tunisia, tends to import a large fraction of their capital goods from the developed world. Eaton and Kortum (2001) also provides evidence that world production of machines is highly concentrated in a

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[8] The values of imports of machines and equipment that supposedly encompass technology are calculated by matching the data sources by corresponding industry.

[9] Technological intensity is defined by OECD Science, Technology and Industry Scoreboard which classifies ISIC sectors according to the three-digit Rev. 3 taxonomy (at four-digit for some specific sub-sectors). Sector conversion from ISIC Rev. 3 to ISIC Rev. 2 is provided by the author. Another source of equivalent information on technological intensity is provided by Keller (2002) which finds that about 80% of all manufacturing expenditure in R&D is conducted in the following industries: Chemical Products, Electrical and Non-Electrical Machinery and Transportation Equipment.

few number of countries and that developing countries are almost invariably net importers of such machines. Hence, imports of capital goods can be a proxy for the investment machines and equipments type that transfers the benefits of advanced technology across borders. Data on machines imports were taken from the UN trade data classified by Standard Industrial Trade Class (STIC) Revision 2, which is merged with data from Tunisian National Institute of Statistics of Tunisia. The later uses the same classification to build the value of machines imports by industry and year[10]. UN trade data base includes bilateral trade flows reported for a wide range of countries at the four digit level[11]. By using these data bases our idea is to derive correspondences at the industry level between categories of machines imported and the industries using them in production. For example, if we are interested in computing the value for the textile, and leather industry, we must aggregate it over all textile and leather machines. We are able to do so at the three Digits (ISIC) industry level by matching data on imports of machines derived from Tunisian National Institute of Statistics and from UN trade data base.

Others proxies are cited in the literature to measure technology change. For instance we can cite royalties' payments for patents, copyrights or trademarks and R&D. Unfortunately; such information is not provided by our database. Therefore, in the case of Tunisia we are able to calculate a value of machinery import by merging two different data base at the same level of classification12. This same proxy, imports of machines and equipments, has been used by Robbins (1996), Pavcnik (2003) and Conte and Vivarelli (2007, 2011).

3.3. Econometric equation

The equations to be estimated come from the demand function of labor which is derived from the Cobb Douglas function (see Greenaway et *al.* (1999) for this derivation). The Cobb Douglas function considered here is $Q_{it} = A_{it}^{\gamma} K_{it}^{\lambda} L_{it}^{\beta} H_{it}^{\alpha}$, where Q_{it} is the production level at time t for industry i, A is a Hicks neutral change that reflects technical efficiency of the production process, L is unskilled labor and H is skilled labor and K is stock of capital. It is supposed that the markets are in perfect competition and that price and wages are exogenous. In this equation the parameters λ, α and β represent the coefficients of factors shares and γ provided for the factors efficiency of the production process.

Under the first order condition of profit maximization, the firm will employ the factors when the marginal product of skill and unskilled labor equal the

[10] The new presentation of data from National Institute of Statistics in Tunisia uses the same classification than UN data base and gives large information about imports of machines from 2 to 10 digit level.

[11] A single value for a country is reported for each year and industry code.

[12] Conte and Vivarelli (2011) consider only total imports from advanced countries. Since Tunisia has a weak level of R&D and innovation activities we suppose that most machines and equipments that allow for a technological upgrading is imported from the rest of the world, mainly advanced countries. Most imports (more than 75%) of Tunisia are with the European Union.

price of the factors. Using these latter conditions and after some calculus, the empirical equation to be estimated is given by[13]:

$$\ln(LF)_{it} = \theta_0 + \theta_1 \ln(VA)_{it} + \theta_2 \ln(K)_{it} + \theta_3 \ln(TL)_{it} + \theta_4 \ln(TC)_{it} + D_t + \mu_i + \varepsilon_{it} \qquad (1)$$

Where LF is labor force which takes one of the following two variables H, L and H/L. VA is value added. K is stock of capital. TL refers to trade openness variables. In our estimation we use the two variables to measure TL. The first is the share of exports in value added *(X/VA),* and the second is the share of imports in value added *(M/VA).* TC is the proxy of technology change. As we explained above the two proxies for technology change used in this paper are the interaction term *(M/VA)*TC_Dum,* and the share of machines imports in value added *(ShMI).* μ_i is the fixed individual effects terms, D_t is the time dummies and ε_{it} is error terms. θ_1, θ_2, θ_3 and θ_4 are the parameters to be estimated for each equation of skills. The coefficient θ_1 measures the size of each industry. From an empirical point of view, employment of skilled and unskilled labor is positively correlated with the value added, then we expected $\theta_1 > 0$. The coefficient θ_2 captures the impact of capital stock. When LF is considered as skilled labor (unskilled labor) θ_2 is expected to be positive (negative), and then capital is considered as complementary to skilled labor. The coefficient θ_3 captures the impact of trade liberalization. The expected sign of θ_3 will depend on the imports or exports activities. For instance, the model of Feenstra and Hanson (1996) (*FH*) shows that a country abundant in unskilled labor can export goods that are intensive in skilled labor (Relative to other goods that the country produces) rather than goods intensive in unskilled labor. This change of the structure of exports can be explained by the presence of a shift of some production stages from developed countries to developing countries. The *FH* model shows, after this change, that the demand for skilled labor increases. The coefficient θ_4 captures the impact of technology changes on absolute and relative employment of skills. The sign of θ_4 may be positive, zero or negative and reflects factor biases of technological change. For example, when we estimate the relative employment equation of skilled workers and that $\theta_4 > 0$, the industries use technologies that are more complementary with skilled workers. These complementarities explain the technological change biases towards skilled workers. When $\theta_4 = 0$ technological changes are neutral and if $\theta_4 < 0$, technology is biased towards unskilled workers.

4. EMPIRICAL RESULTS

An important step before estimating equation (1) is to conduct some preliminary tests in order to investigate possible endogeneity of some variables (trade variable here) and possible correlation between individual effects and independent variables (this is done in sub-section 4.1). Then, in sub-section 4.2, 4.3 and 4.4, we discuss the results of estimating the impact of trade and technol-

[13] For details of the mathematical derivation of this equation see Appendix 2.

ogy on employment of skilled workers, unskilled workers and relative employment of skilled labor.

4.1. Preliminary analysis and some statistical tests

4.1.1. Autocorrelation test (Breush-Pagan test)

In this paper, all equations are estimated using a static model, and where we assume that there is no adjustment cost. To estimate the static equation (1), for the different variables $LF \in (H, L, H/L)$ and $TL \in \left(X/VA, M/VA \right)$, two panel data methods frequently applied in the empirical literature are used. The first is within fixed effects estimation and the second is random effects estimation. According to Judge and *al.* (1988*)* there are no significant differences between the fixed effects model and the random effects one when *T* (number of years) is larger than *N* (Number of individuals). Beck and Katz (1995, 2004) argue that the individual random effects model (an estimator based on asymptotic properties) is not appropriate for a panel when *T* is greater than *N*. The use of random effects model, estimated by the Generalized Least Squares or Maximum Likelihood estimation, assumes that the individual effects of each industry are not correlated with explanatory variables, an assumption that may not be retained in several practical cases. It is nevertheless possible that there are industry features, not taken into account in the regression, correlated with explanatory variables. In this case, the appropriate model is a model with individual fixed effects. In order to check for the presence of this correlation, we performed the test of Breusch-Pagan (1980) which is based on Lagrange multiplier. The results of the test, presented in Table 4, indicate that the assumption of no correlation between individual effects and explanatory variables is rejected.

Table 4. Test of Breusch-Pagan (BP) H_0: Variance (fixed effects)=0

The dependent variables	BP test with *ShMI* proxy	BP test with *M/VA*TC_Dum* proxy
$\ln(H)$	480,75 (*p-v*=0.000)	770,7 (*p-v*=0.000)
$\ln(L)$	588,78 (*p-v*=0.000)	914,3 (*p-v*=0.000)
$\ln(H/L)$	291,34 (*p-v*=0.000)	204,39 (*p-v*=0.000)

The BP test uses the Chi-2(1) statistics; the values in parentheses are the p-value. At the 1% level the results reject H_0, which claims that the individual effects and independent variables are not correlated.

As our work covers a relatively long 25 years, then it is likely that the residuals are autocorrelated. In general, autocorrelation of errors led to an under estimation of standard deviations, and therefore, there is an increased likelihood to infer statistically significant effects when they do not. The results of the test that we conducted reject the null hypothesis of no autocorrelation of order 1. Therefore, the equations are estimated using the individual fixed effects model, taking into account the existence of autocorrelation of order 1 in errors. Many other estimation methods are available in the literature when errors are not identically and independently distributed. These methods are consistent when T is large or when T is much larger than N. In our estimation of different equations, we focus on the following two methods to correct this autocorrelation: the procedure of Beck and Katz (1995) (PCSE) and the procedure of Park (1967) (Parks-Kmenta).

4.1.2. Endogeneity test

The potential problem that can be addressed when estimating equation (1) of employment is the possible endogeneity of some variables considered as independent. We suspect that the share of imports in value added (M/VA) and the share of exports in value added (X/VA) are endogenous. The intuition behind the possible emergence of this endogeneity problem is simple. It is possible that some industries have higher employment for skilled workers and higher share of exports (imports) in value added because of trade openness. Besides, a simultaneity bias may be observed given that industries that are more intensive in skilled workers are more likely to have a superior share of exports (imports).

Table 5. Endogeneity test

Equation (2) with *M/VA*TC_Dum* proxy			
Dependent variable	Skilled employment	Unskilled employment	Relative employment
First specification[a]	5.29 (*p-v* = 0.021)	7.71 (*p-v* = 0.005)	3.01 (*p-v* = 0.08)
Second specification[b]	5.35 (*p-v* = 0.02)	18.94 (*p-v* = 0.00)	3.69 (*p-v* = 0.054)
Equation (2) with *ShMI* proxy			
Dependent variable	Skilled employment	Unskilled employment	Relative employment
First specificationa	6.74 (p-v = 0.009)	4.016 (p-v = 0.04)	6.10 (p-v = 0.013)
Second specification[b]	5.35 (p-v = 0.02)	2.79 (p-v =0.094)	4.06 (p-v =0.043)

The Durbin-Wu-Haussman endogeneity test based on $\chi^2(1) = 3.84$ *statistic.*
a:The first specification includes the share of export in value added.
b:the second specification includes the share of import in value added.

In order to test for the endogeneity of trade variables, we re-estimate the different models of table 6 to 11, by using the two-stage least squares (2SLS) estimators with instrumental variables. However, in our data base no exogenous variable can play the role of the instruments variable, neither for the share of exports nor for the share of imports in value added. A possible solution to resolve this problem is to use the share of exports and the share of imports in value added variables lagged by one year as instrumentals variables. Then, to test for endogeneity we use the Durbin-Wu-Haussman (DWH) which follows under the null hypothesis the Chi-2(1) statistic. The empirical result of the DWH test, presented in table 5, shows that the null hypothesis of endogeneity is rejected at the 5% level. Therefore, our main variables are endogenous. As a partial correction for this potential endogeneity problem, we propose to introduce the first lag of (M/VA) and (X/VA)[14] as an explicative variable in the estimated main equations instead of instantaneous value.

The empirical analysis focuses, therefore, on the following stochastic specification of the employment equations:

$$\ln(LF)_{it} = \theta_0 + \theta_1 \ln(VA)_{it} + \theta_2 \ln(K)_{it} + \theta_3 \ln(TL)_{i,t-1} + \theta_4 \ln(TC)_{it} + D_t + \mu_i + \varepsilon_{it} \quad (2)$$

4.2. Trade openness, technological change and employment of skilled labor

In order to assess the impact of openness and technology change on employment of skilled labor, we estimate equation (2) by considering $LF_{it} = H_{it}$, $TL_{i,t-1}=(X/VA)_{i,t-1}$ and $TL_{i,t-1}=(M/VA)_{i,\,t-1}$, *and* $TC_{it} = ShMI_{it}$ *and* $M/VA*TC\_Dum_{it}$. Estimation results are reported in Table 6 and 7 below. The first table reports the estimation of equation that includes technology intensity variable proxy. The second table reports the estimation of equation that includes import share of machine variables proxy.

The estimated coefficients of the value added are positive in all specifications and significantly different from zero. For example, from table 6, an increase of 1% in the value added increases skilled labor employment in average by 0.6%. The results reported in tables 6 and 7 suggest also that the estimated coefficient of capital stock is positive and significantly different from zero. This is consistent with the suggestion that skilled workers intensity and capital move together. In other words, this result is compatible with the existence of possible complementarities between skilled labor and capital. One possible explanation in the Tunisian context is that the removal of inputs and capital barrier has enabled firms to use more capital and other intermediate inputs at low price after trade liberalization. It is worth noting that Tunisian industries, mainly textile industry, rely heavily on importation of raw materials to satisfy production needs.

The results reported in these two tables show also that trade openness variables proxies, the share of imports and exports in value added, have a positive and significant impact on skilled labor employment. This means that, *ceteris paribus*, that trade liberalization induces an increase of employment of skilled workers. This can be explained by the fact that any incentive to open economy should have a stimulating effect on the creation of skilled workers employment.

The result concerning the first proxy, the share of imports in value added, seems to be in line with traditional theory of trade which assumes that imports activities have a positive effect on skilled labor employment, the scare factor in developing countries like Tunisia. A possible explanation of this effect is that decreases in tariffs on imported goods, mainly intermediate goods, have encouraged Tunisian firms to use more skilled workers in order to produce final goods,

[14] This method is used by Carolina Sanchez-Paramo and Norbert Schady (2003) in their paper entitled *"Off and Running? Technology, Trade, and the Rising Demand for Skilled Workers in Latin America*".

see the studies of Feenstra and Hanson (1997), and Mazumdar and Quispe-Agnoli, (2002). The positive effect of the second proxy, the share of exports in value added, can be explained by the fact that the export-oriented production process in some industries began to use new production methods in response to the increase of competition, which requires more skilled workers. However, when we compare the coefficients of these two variables, we notice that the positive effect of the share of imports is slightly larger than the share of exports. In general, we can conclude that after trade liberalization employment of skilled workers has significantly increased.

Table 6. Skilled employment equation estimates with industries' technology intensity

$$\ln(H)_{it} = \theta_0 + \theta_1 \ln(VA)_{it} + \theta_2 \ln(K)_{it} + \theta_3 \ln(TL)_{i,t-1} + \theta_4 \ln(M/VA*TC\_Dum)_{it} + D_t + \mu_i + \varepsilon_{it}$$

	FE/AR(1)[A]		PCSE[B]		PARKS-KMENTA[C]	
ln(VA)$_{i,t}$	0.57*** *(8.94)*	0.55*** *(7.46)*	0.60*** *(12.6)*	0.67*** *(10.38)*	0.59*** *(8.2)*	0.68*** (11.1)
ln(K)$_{i,t}$	0.31* (1.96)	0.28* (1.682)	0.51*** (4.73)	0.30* (1.83)	0.26* (1.86)	0.21* (1.66)
ln(M/VA)$_{i,t-1}$	-----------	0. 12** (2.07)	-----------	0.11** (2.19)	----------	0.4*** (10.17)
ln(X/VA)$_{i,t-1}$	0.15*** (5.10)	------------	0.12*** (4.63)	----------	0.17*** (6.58)	
*ln(M/VA*TC_Dum)*$_{i,t}$	0.036*** (3.59)	0.042*** (3.74)	0.025*** (3.02)	0.033*** (3.36)	0.040*** (4.06)	0.019** (2.11)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Fisher test (fixed effects)	54.5 (*p-v*=0.00)	51.74 (*p-v*=0.00)	Yes	Yes	---------	----------
R^2-within	0.77	0.7	0.93	0.95		
N. observations	138	138	144	144	144	144
Wooldridge test	678.6 (*p-v*=0.00)	489.7 (*p-v*=0.00)	---------	---------	---------	----------

*Notes: t-student are in parentheses: *, **, *** indicate respectively 10%, 5%, and 1% significance levels. The regression includes a constant term. Corresponding results are not reported for space reasons.*

***A** : the estimation is performed by using xtregar, fe that corrects autocorrelation errors. **B** : the estimation is performed by using xtpcse that corrects heteroskedasticity, the individual errors correlation f and serial autocorrelation. We introduce in the estimated equation individual fixed effects. **C** : the estimation is performed by using xtgls that corrects heteroskedasticity, inter-individual errors correlation and errors autocorrelation.*

Looking now to the two proxies' technology variables, the results indicate that technological change increases skilled labor employment in absolute terms. An increase of 1% in the proxies' variables of technology change leads to an increase of a range of 0.02% to 0.06% in skilled labor. According to Berman and Machin (2004), the biases of technological change towards skilled labor have a global characteristic: technology which is produced largely through the research and development in developed countries is designed to be using by skilled workers. Therefore, when it will be imported by developing countries the same factor will be more able to use it. The low prices of machinery and equipment provide an additional incentive for firms in Tunisian industries to adapt new technology, and then increase their demand for skilled labor. The policy of the Tunisian government to reduce customs duties on import of machinery and equipment has enabled Tunisian firms and foreign firms operating in the local market to adapt a new technology, and then increase their demand for skilled labor. This result gives a strong basis for assumptions formulated above on the complementarities between technology import and skilled labor.

Table 7. Skilled employment equation estimates with industries' technology imports

$$\ln(H)_{it} = \theta_0 + \theta_1 \ln(VA)_{it} + \theta_2 \ln(K)_{it} + \theta_3 \ln(TL)_{i,t-1} + \theta_4 \ln(ShMI)_{it} + D_t + \mu_i + \varepsilon_{it}$$

	FE/AR(1)[A]		PCSE[B]		PARKS-KMENTA[C]	
ln(VA)$_{i,t}$	0.41*** *(7.16)*	0.13* *(1.97)*	0.36*** *(8.82)*	0.16*** *(2.97)*	0.69*** *(18.4)*	0.21*** (5.2)
ln(K)$_{i,t}$	0.35** (2.61)	0.46*** (3.2)	0.37*** (3.35)	0.22** (2.10)	0.22* (1.78)	0.30*** (4.51)
ln(M/VA)$_{i,t-1}$	-----------	0.14*** (2.73)	----------	0.17*** (3.54)	----------	0.066*** (3.05)
ln(X/VA)$_{i,t-1}$	0.133*** (4.67)	----------	0.11*** (5.35)	----------	0.20*** (9.44)	
ln(ShMI)$_{i,t}$	0.051*** (4.59)	0.021* (1.73)	0.022** (2.35)	0.06*** (7.47)	0.049*** (4.87)	0.039*** (5.51)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Fisher test (fixed effects)	56.8 (*p-v*=0.00)	68.81 (*p-v*=0.00)	Yes	Yes	----------	----------
R^2-within	0.84	0.82	0.9	0.96		
N. observations	138	138	144	144	144	144
Wooldridge test	953.1 (*p-v*=0.00)	786.3 (*p-v*=0.00)	----------	----------	----------	----------

*Notes: t-student are in parentheses: *, **, *** indicate respectively 10%, 5%, and 1% significance levels. The regression includes a constant term. Corresponding results are not reported for space reasons.*

***A**: the estimation is performed by using xtregar, fe that corrects autocorrelation errors. **B**: the estimation is performed by using xtpcse that corrects heteroskedasticity, the individual errors correlation f and serial autocorrelation. We introduce in the estimated equation individual fixed effects. **C**: the estimation is performed by using xtgls that corrects heteroskedasticity, inter-individual errors correlation and errors autocorrelation.*

4.3. Trade openness, technological change and employment of unskilled labor

Tables 8 and 9 provide estimation results for unskilled labor equation. As in the previous subsection, the same methodologies are employed to test the relationship between trade openness, technology change and employment of unskilled labor. To that end, we estimate equation (2) by considering $LF_{it} = L_{it}$,

$TL_{i,\ t-1} = (X/VA)_{i,\ t-1}$ *and* $(M/VA)_{i,\ t-1}$, and $TC_{it} = ShMI_{it}$ *and* $M/VA*TC\_Dum_{it}$ as before.

Table 8. Unskilled employment equation estimates with industries' technology intensity

$$\ln(L)_{it} = \theta_0 + \theta_1 \ln(VA)_{it} + \theta_2 \ln(K)_{it} + \theta_3 \ln(TL)_{i,t-1} + \theta_4 \ln(M/VA*TC\_Dum)_{it} + D_t + \mu_i + \varepsilon_{it}$$

	FE/AR(1)^A		PCSE^B		PARKS-KAMENTA^C	
ln(VA)$_{i,t}$	0.11*** (6.36)	0.12* (6.33)	0.55*** (7.31)	0.42*** (7.96)	0.17*** (12.21)	0.19*** (11.2)
ln(K)$_{i,t}$	-0.15*** (-3.80)	-0.16*** (-3.48)	-0.32*** (-3.79)	-0.61*** (-4.31)	-0.*13**** (-3.05)	-0.*27**** (-7.71)
ln(M/VA)$_{i,t-1}$	----------	0.032* (1.98)	---------	0.6*** (9.39)	---------	0.029** (2.25)
ln(X/VA)$_{i,t-1}$	0.038*** (4.92)	----------	0.32*** (8.03)	----------	0,04*** (6.67)	
*ln(M/VA*TC_Dum)*$_{i,t}$	0.0096*** (3.61)	0.011*** (4.08)	0.035*** (3.44)	0.02* (1.66)	0.012*** (5.93)	0.017*** (6.04)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Fisher test (fixed effects)	2737.5 (*p-v*=0.00)	2302.9 (*p-v*=0.00)	--------	--------	----------	----------
R^2 –within	0.79	0.76	0.95	0.97	----------	----------
N. observations	138	138	144	144	144	144
Wooldridge test	885,6 (*p-v*=0.00)	708.4 (*p-v*=0.00)	----------	----------	----------	----------

*Notes: t-student are in parentheses: *, **, *** indicate respectively 10%, 5%, and 1% significance levels. The regression includes a constant term. Corresponding results are not reported for space reasons.*
***A**: the estimation is performed by using xtregar, fe that corrects autocorrelation errors.*
***B**: the estimation is performed by using xtpcse that corrects heteroskedasticity, the individual errors correlation f and serial autocorrelation. We introduce in the estimated equation individual fixed effects. **C**: the estimation is performed by using xtgls that corrects heteroskedasticity, inter-individual errors correlation and errors autocorrelation.*

The empirical results show that the coefficients of openness variables are positive. This means that openness variables have positive impact on the employment of unskilled labor and are significantly different from zero. Moreover, the positive impact of imports on unskilled labor employment can be interpreted as an indirect channel. This later result can be explained by the fact that imports of some goods are a necessary component of the production processes of those export-oriented goods relatively intensive in unskilled labor. Thus, in order to increase exports, firms which employ more unskilled labor should increase quantity of imports, and should stimulate employment of unskilled workers.

The coefficient of capital is negative and statistically different from zero. It appears that the use of additional capital in Tunisian manufacturing industries deteriorates employment of unskilled labor. From these tables, an increase of 1% in capital stock reduces employment of unskilled labor at the range of 0.1% to 0.4%. This result is consistent with the theoretical literature following that, in several cases, capital substitutes' unskilled labor. This result can be explained by the fact that a firm’s decision to acquire new capital induces a direct substitution of capital and unskilled labor. Another explanation is the increase of direct foreign investment received by Tunisian manufacturing industries.

Table 9. Unskilled employment equation estimates with industries' technology imports

$$\ln(L)_{it} = \theta_0 + \theta_1 \ln(VA)_{it} + \theta_2 \ln(K)_{it} + \theta_3 \ln(TL)_{i,t-1} + \theta_4 \ln(ShMI)_{it} + D_t + \mu_i + \varepsilon_{it}$$

	FE/AR(1)^A		PCSE^B		PARKS-KAMENTA^C	
ln(VA)$_{i,t}$	0.108*** (7.18)	0.027* (1.73)	0.16*** (6.39)	0.15*** (5.20)	0.3*** (8.1)	0.37*** (6.96)
ln(K)$_{i,t}$	-0.09** (-1.98)	-0.083** (-2.13)	-0.25*** (-8.59)	-0.20*** (-7.19)	-0.37*** (-8.17)	-0.41*** (-2.68)
ln(M/VA)$_{i,t-1}$	----------	0.022* (1.90)	----------	0.036*** (2.09)	---------	0.45*** (7.73)
ln(X/VA)$_{i,t-1}$	0.037*** (4.48)	----------	0.076*** (7.56)	----------	0,06*** (4.25)	-----------
ln(ShMI)$_{i,t}$	0.01*** (3.46)	0.006*** (2.60)	0.021*** (4.41)	0.022*** (4.27)	0.009* (1.82)	0.052*** (4.19)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Fisher test (fixed effects)	2267.95 (p-v=0.00)	2725.5 (p-v=0.00)	Yes	Yes	----------	----------
R^2 –within	0.707	0.78	0.87	0.9	----------	----------
N. observations	138	138	144	144	144	144
Wooldridge test	537,9 (p-v=0.00)	335.7 (p-v=0.00)	----------	----------	----------	----------

*Notes: t-student are in parentheses. *, **, *** indicate respectively 10%, 5% and 1% significance levels. The regressions include a constant term. Corresponding results are not reported for space reasons.*
***A:** the estimation is performed by using xtregar , fe that corrects errors autocorrelation. **B**: the estimation is performed by using xtpcse that corrects heteroskedasticity, individual errors correlation and serial autocorrelation. We introduce in the estimated equation individual fixed effects. **C**: the estimation is performed by using xtgls that corrects heteroskedasticity, inter-individual errors correlation and errors autocorrelation.*

The results concerning technology change variables show that the coefficients are significant and positive. According to the estimates of table 8 and 9, an increase of 1% in one of the proxy variable of technology change increase employment of unskilled labor of about 0.006% to 0.052%.

An interesting pattern emerges from the comparison of the coefficients of technology change in absolute equations since they yield the same effect on the employment of skilled and unskilled workers. These results mean that there is an indirect benefit of technology changes for employment of unskilled labor. This benefit is less important than absolute biases toward employment of skilled labor.

Table 10. Relative employment of skilled labor equation estimates with industries' technology intensity

$$\ln(H/L)_{it} = \theta_0 + \theta_1 \ln(VA)_{it} + \theta_2 \ln(K)_{it} + \theta_3 \ln(TL)_{i,t-1} + \theta_4 \ln(M/VA*TC\_Dum)_{it} + D_t + \mu_i + \varepsilon_{it}$$

	FE/AR(1)[A]		PCSE[B]		PARKS-KAMENTA[C]	
$ln(VA)_{i,t}$	0.5*** (11.59)	0.62*** (11.3)	0.21* (1.80)	0.31** (2.07)	0.42*** (11.39)	0.57*** (14.1)
$ln(K)_{i,t}$	0.38*** (4.14)	0.28*** (2.65)	0.22** (2.20)	0.401** (2.40)	0.43*** (3.37)	0.34*** (3.53)
$ln(M/VA)_{i,t-1}$	------------	0.14* (1.97)	-----------	0.24*** (2.61)	----------	0.14*** (2.62)
$ln(X/VA)_{i,t-1}$	0.12*** (4.8)	-----------	0.19*** (3.10)	-----------	0.12*** (8.28)	
$ln(M/VA*TC\_Dum)_{it}$	0.03*** (2.90)	0.049*** (4.17)	0.003*** (2.97)	0.06*** (3.16)	0.0106** (2.28)	0.016** (2.24)
Time dummies	YES	YES	YES	YES	YES	YES
Fisher test (fixed effects)	*174.32* (*p-v*=0.00)	129.5 (*p-v*=0.00)	----------	---------	-----------	---------
R²-within	*0.92*	0.87	0.51	0.57	------------	-----------
N. observations	138	138	144	144	144	144
Wooldridge test	925.8 (p-v=0.00)	862.1 (*p-v*=0.00)	--------	----------	------------	---------

*Notes: t-student are in parentheses. *, **, *** indicate respectively 10%, 5% and 1% significance levels. The regressions include a constant term. Corresponding results are not reported for space reasons.*
***A**: the estimation is performed by using xtregar , fe that corrects errors autocorrelation. **B**: the estimation is performed by using xtpcse that corrects heteroskedasticity, individual errors correlation and serial autocorrelation. We introduce in the estimated equation individual fixed effects.*
***C**: the estimation is performed by using xtgls that corrects heteroskedasticity; inter individual errors correlation and errors autocorrelation.*

Two arguments can be advanced to explain this result in the case of Tunisia:

- The Tunisian government has tacked a decision policy to improve ability of unskilled workers to use new technology. This decision has the advantage to enhance competition, and offset the gap of employment between workers.
- In addition, unskilled labor may be complementary to skilled labor for some imported technologies.

4.4. Trade openness, technological change and skill upgrading

In this subsection, we investigate whether there is interdependence in choosing between skilled and unskilled labor. Moreover, we investigate whether trade and technology change results are consistent with estimation results obtained in previous sections. To that end, a relative equation will be estimated. The equation to be estimated is the same as in (2), and as before two cases will be considered where $TL_{i,\ t-1} = (X/VA)_{i,\ t-1}$ *or* $TL_{i,\ t-1} = (M/VA)_{i,\ t-1}$ *and* $TC=ShMI_{it}$ *and* $M/VA*TC\_Dum_{it}$.

Table 10 and 11 show that capital and skilled labor are complementary since the coefficient on capital is positive and significantly different from zero. The coefficient on value added variable is positive and statistically significant. Skilled workers are hired more than unskilled labor in a temporary economic progression.

Table 11. Relative employment of skilled labor equations with industries' technology imports

$$\ln(H/L)_{it} = \theta_0 + \theta_1 \ln(VA)_{it} + \theta_2 \ln(K)_{it} + \theta_3 \ln(TL)_{i,t-1} + \theta_4 \ln(ShMI)_{it} + D_t + \mu_i + \varepsilon_{it}$$

	FE/AR(1)^{A}		PCSE^{B}		PARKS-KAMENTA^{C}	
ln(VA)$_{i,t}$	0.44*** (9.13)	0.48*** (8.97)	0.17* (1.88)	0.59*** (7.92)	0.43*** (11.62)	0.59*** (14.5)
ln(K)$_{i,t}$	0.48*** (5.53)	0.42*** (4.05)	0.27** (2.03)	0.65*** (2.73)	0.56*** (7.26)	0.47*** (4.68)
ln(M/VA)$_{i,t-1}$	------------	0.208*** (3.09)	-----------	0.28*** (3.58)	------------	0.19*** (3.31)
ln(X/VA)$_{i,t-1}$	0.14*** (5.16)	------------	0.27*** (5.59)	------------	0.142*** (8.97)	
ln(ShMI)$_{i,t}$	0.043*** (2.88)	0.065*** (4.33)	0.029* (1.90)	0.0092 (0.39)	0.0304*** (3.38)	0.034*** (3.01)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes
Fisher test (fixed effects)	*187.9* (*p-v*=0.000)	117.2 (*p-v*=0.000)	----------	-----------	----------	----------
R²-within	*0.901*	0.88	0.59	0.62	------------	----------
N. observations	138	138	144	144	144	144
Wooldridge test	278,4 (*p-v*=0.00)	293,3 (*p-v*=0.00)	----------	-----------	----------	----------

*Notes: t-student are in parentheses. *, **, *** indicate respectively 10%, 5% and 1% significance levels. The regressions include a constant term. Corresponding results are not reported for space reasons.*

***A**: the estimation is performed by using xtregar, fe that corrects errors autocorrelation.* ***B**: the estimation is performed by using xtpcse that corrects heteroskedasticity, individual errors correlation and serial autocorrelation. We introduce in the estimated equation individual fixed effects.* ***C**: the estimation is performed by using xtgls that corrects heteroskedasticity; inter individual errors correlation and errors autocorrelation.*

The coefficient of exports share in value added is positive and significant. Export activity by firms in different industries enables learning new production techniques. However, foreign firms in Tunisia produce with a process relatively intensive in skilled labor. An increase in their exportations may cause an increase in relative skilled labor employment. This result is expected as a consequence of the “Adjustment program” which has provided support to almost 3000 private companies, (Bougault and Filipiak, 2005). This program aims at modernizing investments and introducing new technologies and know-how adoption. Furthermore, it’s the opportunity to prepare local firms to enhance their competitiveness and improve skills of their human resources.

The coefficients on technology change variables proxies are positive and statistically significant. Hence, the technology acts to increase the relative employment for skilled labor. The liberalization process through import seems to be an important channel of technology transfer for Tunisian economy. This result is coherent with the others empirical findings of other developing countries (Meschi et *al*., 2011). The results confirm that technological change is biased towards this factor.

Compared to result obtained by estimating absolute equations, we can suggest that the technology transferred in Tunisia seems to have a temporary effect. However, this means that skilled workers would benefit only during the transition period to the new, higher technological level, yet their relative employment would decline once the other workers have learned how to use the new equipments. This result can be explained by the fact that Tunisia is not a country with heavy industries that may harbor important technology innovations.

5. CONCLUSION

In this paper, we have investigated the impact of trade openness and technology import on labor market in Tunisia using a manufacturing industries database over the period 1983-2007. Empirical estimations show two main results for the case of Tunisia. On the one hand, trade openness measured by share of imports and exports on value added affects positively employment of skilled labor in absolute and relative terms. On the other hand, technology import favors more skilled workers than unskilled workers. This confirms skill biased technology change in Tunisian manufacturing industries. Our findings also confirm that capital and skilled labor are complementary which corroborate the hypothesis of a trade-induced technological change.

Globally, our empirical results show that trade openness has a favorable effect on skilled and unskilled labor factors. Moreover, this effect is relatively biased towards skilled labor as shown by the relative equation estimation. This later result can be explained by the decisions taken by the Tunisian government to prepare the domestic economy to international competition through the ‘‘adjustment program’’. The new policies included in this program have led to an increase in foreign and national investments that are very favorable to employment creation. In comparison with the previous literature, the evidence provided by our paper joins the conclusion that trade and technology may be considered as complementary vehicles for the increase of skilled workers (Meschi et *al*., 2011).

Finally, we should note that the relationship between trade, technology and labor market in developing countries deserves advanced analysis. Then, future research on other DC should enable us to confirm or not these results. Indeed, further empirical research on the transmission channels allowing for new technologies transfer would reinforce current studies on skill-biased technological change. In the same way, in the case of Tunisia, and after the collapse of an infamous dictator regime, further research based on datasets not published before due to political decisions, is necessary, in order to clarify the effects of trade and technology.

ANNEX 1.
Industry classification by technology intensity

ISIC Rev. 2 Sectors	Tech. intensity
Food processing	Low
Glasses and Construction industries	Medium Low
Electronic and mechanic industries	Medium high
Chemical industries	High
Leather and textile industries	Low
Others industries	Low

ANNEX 2.

$$Q_t = A_t^{\gamma} L_t^{\beta} H_t^{\alpha} K_t^{\lambda} \quad (1)$$

The first condition of profit maximization imply that the marginal product of each factor equalize their prices. This gives the following equation for wages of skilled and unskilled workers, respectively:

$$(w_l)_t = p\frac{\partial Q_t}{\partial L_t} = p\beta A_t^{\gamma} L_t^{\beta-1} H_t^{\alpha} K_t^{\lambda} = p\beta Q_t L_t^{-1} \quad (2)$$

$$(w_h)_t = p\frac{\partial Q_t}{\partial H_t} = p\alpha A_t^{\gamma} L_t^{\beta} H_t^{\alpha-1} K_t^{\lambda} = p\alpha Q_t H_t^{-1} \quad (3)$$

where, w_l, w_h, p, $\frac{\partial Q_t}{\partial L_t}$ and $\frac{\partial Q_t}{\partial H_t}$ are respectively, the wage of unskilled workers, the wage of skilled workers, the price of product and the marginal productivity of two factors (H and L).

The relative rapport between equations (2) and (3) gives:

$$\left(\frac{w_l}{w_h}\right)_t = \frac{\beta H_t}{\alpha L_t} \quad (4)$$

Equation (4) gives:

$$H_t = \left(\frac{w_l}{w_h}\right)_t \frac{\alpha L_t}{\beta} \quad (5)$$

Replacing H by its expression in production equation gives:

$$Q_t = A_t^{\gamma} L_t^{\beta} K_t^{\lambda} \left(\frac{w_l}{w_h}\right)_t^{\alpha} \left(\frac{\alpha}{\beta}\right)^{\alpha} L_t^{\alpha} \quad (6)$$

The demand of unskilled worker by taking the log of equation 6 is:

$$\ln L_t = \theta_0 + \theta_1 \ln A_t + \theta_2 \ln\left(\frac{w_l}{w_h}\right)_t + \theta_3 \ln Q_t + \theta_4 \ln K_t \quad (7)$$

Where, $\theta_0 = -\frac{\alpha \ln \frac{\alpha}{\beta}}{\beta+\alpha}$, $\theta_1 = -\frac{\gamma}{\beta+\alpha}$, $\theta_2 = -\frac{\alpha}{\beta+\alpha}$, $\theta_3 = \frac{1}{\beta+\alpha}$, $\theta_4 = -\frac{\lambda}{\beta+\alpha}$

The demand of skilled workers:

$$\ln H_t = \delta_0 + \delta_1 \ln A_t + \delta_2 \left(\frac{w_h}{w_l}\right)_t + \delta_3 \ln Q_t + \delta_4 \ln K_t \quad (8)$$

where $\delta_0 = -\frac{\beta \ln \frac{\beta}{\alpha}}{\beta+\alpha}$, $\delta_1 = -\frac{\gamma}{\beta+\alpha}$, $\delta_2 = -\frac{\beta}{\beta+\alpha}$, $\delta_3 = \frac{1}{\beta+\alpha}$, $\delta_4 = -\frac{\lambda}{\beta+\alpha}$

As Greenaway et *al*. (1999) we suppose that the technique efficiency *(A_t)* depend to trade liberalization:

$A_t = e^{\eta_1 T} LC^{\eta_2}$, $\eta_1, \eta_2 > 0$

$$\ln L_t = \theta_0 + \theta_1(\eta_1 T + \eta_2 \ln LC_t) + \theta_2 \ln\left(\frac{w_l}{w_h}\right)_t + \theta_3 \ln Q_t + \theta_4 K_t \quad (9)$$

$$\ln H_t = \delta_0 + \delta_1(\eta_1 T + \eta_2 \ln LC_t) + \delta_2 \ln\left(\frac{w_h}{w_l}\right)_t + \delta_3 \ln Q_t + \delta_4 K_t \quad (10)$$

Equation 9 and 10 are the bases of our empirical estimated equation in section 4.

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LIBÉRALISATION COMMERCIALE, IMPORTATION DE TECHNOLOGIE ET EMPLOI : UNE MONTÉE EN QUALIFICATION DANS L'INDUSTRIE MANUFACTURIÈRE TUNISIENNE

***Résumé* -** *L'objet de cet article est d'étudier l'impact de l'ouverture commerciale et des importations de technologie sur l'emploi qualifié et non qualifié en Tunisie. Des données annuelles sur six industries manufacturières tunisiennes sont utilisées entre 1983 et 2007. Les résultats de l'analyse économétrique montrent que les échanges commerciaux et l'importation de technologie favorisent l'emploi qualifié. Ces résultats sont cohérents avec l'idée selon laquelle la libéralisation commerciale induit des changements technologiques biaisés en faveur des travailleurs qualifiés.*

***Mots-clés* -** LIBÉRALISATION COMMERCIALE, CHANGEMENT TECHNOLOGIQUE, QUALIFICATION