Labor-Use Efficiency in Saudi Manufacturing Sectors

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Abstract: This paper seeks to examine the process of adjustment in labor and to measure labor-use efficiency in Saudi manufacturing sectors. The theoretical framework is based on a dynamic flexible adjustment model applied to a panel of seven Saudi industries observed from 2007 to 2015. It investigates the process of adjustment in labor Saudization level toward a desired level. The adjustment process is both industrial and time-specific, and is expressed in terms of factors affecting the speed of adjustment. The empirical results show that, in the long run, labor Saudization responds greatly to gross domestic product, followed by unit Saudi wage and least by non-Saudi labor. In addition, labor over-use in Saudi manufacturing sectors is reduced after application of Nitaqat program.

Keywords: Labor Saudization, Labor-use efficiency, Panel data, Saudi, Speed of adjustment, Technical change.

1. INTRODUCTION

In the last decades, most of the GCC countries are engaged in a series of measures of labor nationalization. Nationalization, such as Saudization, Kowaitization, Bahrainization…, is a governmental initiative devised to increase the number of citizens employed in public and private sectors. The structural policies of this program have focused on the reduction of foreign labor and encourage national's employment in the private sector. The "Nationalization" policy with ambitious targets was aimed at replacing expatriates upon whom the labour market has traditionally relied upon since last four decades with the locals.

In this context, Saudia Arabia is engaged in structural policies, known collectively as "Saudization", to encourage the employment of Saudi nationals in the private sector. These policies aim to increase Saudi employment by reducing the number of foreign workers, who currently make up 40 percent of the population and about half the labor force, in the public and private sectors. The seventh national developmental plan (2000-2004) declared that one quarter of all positions in the private domain were to be taken up by locals. Progress was reviewed and revised and targets were set in the seventh national development plan, which stated that Saudi nationals were to occupy at least 25% of private sector jobs by 2004.

To enhance the effectiveness of "Saudization" policy, in June 2011 the "Nitaqat" scheme is promulgated. The "Nitaqat" scheme literally means evaluating private sector establishments based on the percentage of its local workforce so as to entitle them with certain codes based on their performance. The rationale of this scheme is based on achieving success in workforce nationalization process. The primarily motive behind this scheme is economic, but there are also underlying social and political underpinnings. The "Nitaqat" scheme is designed to boost employment among locals and attempt to protect wages among expatriates. Due to all these changes, it is worthwhile to analyze the impact of Saudization process on Saudi manufacturing private sector by the development of the structural determinants of the speed of price adjustment at the industry level. The Saudi manufacturing private sector makes a good case study since it has evolved through periods of labor market regulations, as well as Saudization.

In the context of Saudia Arabia, there is a few works discuss the implementation process and results of nationalization policy of labor in Saudi private sector (Alshanbri and al. (2015), Abouraia (2014), Sadi (2013) …). These studies examine the macroeconomic effect of Saudization using a descriptive and inferential statistics technic. In our knowledge, there isn't any study that based on sectors data or econometrics techniques to understand the results of implementation of nationalization policy of labor in Saudi private sector. However, understanding the way policy changes affect labor over time requires a model that incorporates the dynamic adjustment process of employment. Models that include dynamic adjustments are certainly not new in the literature. Many studies attempt to analyze the effect of structural transformation on labor-use and on labor adjustment procedure (Hazledine, 1981). Kumbhakar and Zhang (2013) analyse labor-use efficiency and employment elasticity in Chinese

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manufacturing. The results indicate that the labor-use efficiency gains over time in Chinese manufacturing and employment elasticity varies extensively across industry. Bhandari and Heshmati (2005) investigate an empirical investigation of the adjustment process of labour in Indian manufacturing industries, which evolved through structural transformation in the context of globalization. The authors found that the long run labor responds greatest to the output, followed by capital and least by wages. They conclude that Indian manufacturing is not inefficient in labor use as modest speed of adjustment has led employment size closer to the optimal level. Masso and Heshmati (2004) provide the efficiency of labor in Estonian manufacturing industries. The results indicate that long run employment in Estonian firms responds greatest to wages and least by capital stock. In the same context, Haouas *et al*. (2003) investigates the speed of adjustment and the degree of labour use efficiency to find the empirical support that labour market become more flexible under the liberalization period of Tunisian manufacturing industries.

Similarly, literature on dynamic adjustment in panel data framework is extensive (e.g. Arrelano and Bond, 1991; Baltagi and Griffin, 1997; Judson and Owen, 1999; Nerlove, 2000). However, incorporating a flexible adjustment parameter (as opposed to a restricted constant one) and integrating this with labor-use efficiency is a recent development. Kumbhakar and al. (2002) used a similar model to analyze labor use efficiency in the Swedish banking industry, and Bhandari and Heshmati (2005) to analyze the adjustment in employment in Indian manufacturing industries.

In this paper, a dynamic labor demand model is specified with a flexible speed of adjustment parameter making the model a labor requirement function (see Pindyck and Rotemberg, 1997; Kumbhakar and Hjalmarsson 1995). Shifts in the labor requirement function are allowed to capture non-neutral shifts referring to adjustments other than those related to technological change. This approach permits evaluation of policies that are designed to enhance Saudization and Nitaqat programs, labor market flexibility, and industrial performance. The application of this methodology and the empirical findings show that it is a significant contribution to labor demand literature in general, and Saudi's industries in particular.

The rest of the paper is organized as follows: Section 2 presents Saudi policy environment. The basic methodological approach, together with specification and estimation of the model, are discussed in Section 3. Section 4 describes the data and variables used in the analysis. This is followed, in Section 5, by discussion of the empirical results. Section 6 is the summary and conclusion.

2. SAUDI POLICY ENVIRONMENT

In the last decades, Saudi Arabia is engaged in a series of measures of labor nationalization, called as Saudization program. The term "Saudization" refers to the various initiatives of the government of Saudi Arabia to encourage the employment of Saudi nationals in the private sector. The Saudi Arabian government has introduced several initiatives to nationalize private sector jobs in the past. The idea of improving local participation in private sector jobs was introduced in the first five-year development plan (1970–75), during which the government decreed that 75% of workers should be Saudis and 51% of total salaries should be paid to local employees.

However, the policy became a priority only in late 1990s when the Kingdom faced budget deficits and high rates of unemployment. In the late 1990s, a number of programs and targets were launched to reach one goal, which was to increase the Saudi workers' employment share in the private sector by substituting foreign workers with Saudis. As part of the sixth development plan (1995–2000), the government aimed at creating nearly 319,500 jobs for Saudi nationals. Since the previous five-year plans proved to be ineffective in increasing the participation of the nationals in the private sector, and realizing the difficulties in correcting the imbalance, the government set a supposedly more realistic target of 25% Saudization in the private sector by 2002 during its seventh five-year development plan (2000–05). The target was later altered to a blanket of 30% for all companies. However, just a third of the target was achieved after years of implementation.

Few sectors in the Kingdom such as Building and Construction; Agriculture, Forests and Fishing; and Finance, Insurance and Real Estate (except Banking, which has a Saudization rate of about 86%) are heavily dependent on foreign employees; representation of expatriates in these sectors is above 90%. However, with such heavy dependence on foreign employees, it would be impossible for these sectors to sustain a 30% quota for Saudis. Unrealistic target was one of the reasons for the unsuccessful implementation of the Saudization program.

To enhance the effectiveness of "Saudization" policy, in June 2011 the "Nitaqat" program is promulgated. The "Nitaqat" literally means evaluating private sector establishments based on the percentage of its local workforce so as to entitle them with certain codes based on their performance. The rationale of this program is based on achieving success in workforce nationalization process. The primarily motive behind this program is economic, but there are also underlying social and political underpinnings. The "Nitaqat" program is designed to boost employment among locals and attempt to protect wages among expatriates.

The "Nitaqat" system evaluates private sector entities based on their nationalisation achievements and classifies them into groups, Excellent, Green, Yellow, and Red, according to their Saudization performance. The enterprises that situated in the green and excellent ranges have achieved reasonable and acceptable rates of localization, while, the enterprises that are located in the yellow and red zones, they did not employ Saudis, or that the Saudization rate is less than acceptable and they are given sufficient time to correct their positions in order to move to the green and the excellent zones by the Saudi ministry of Labour. The firms that engaged with Nitaqat and within the excellent and the green zones will be provided with a package of facilities and motivations, making it easier for dealings with their employees and worker unions and gives them sufficient flexibility to achieve the levels of growth.

Due to all these changes, the Saudi manufacturing private sector makes a good case study and it is worthwhile to analyze the determinants of labor Saudization and its impact on labor-use and on the process of adjustment in labor in Saudi manufacturing sectors.

3. ECONOMETRIC METHODOLOGY

3.1. The Model

The present study suggests to analyze the determinants of labor Saudization and measuring the labor-use flexibility in Saudi manufacturing sectors, covering the period 2007 to 2015. Understanding the way policy changes affect labor demand over time requires a model that incorporates the dynamic adjustment process of employment. Models that include dynamic adjustments are certainly not new in the literature.

Assume that labour market is adjusted instantaneously. Under the equilibrium condition, the observed Saudi employment, LS_{it}, should equal the optimal Saudi employment, LS_{it}^{*}. In a dynamic setting, this implies that changes in employment from the previous to current period should equal the changes required for the industry to be optimal at time t, i.e.

$$LS_{it} - LS_{it-1} = LS_{it}^{*} - LS_{it-1} \tag{1}$$

However, if adjustment is costly or sluggish, the labor market does not allow for full adjustment and partial adjustment will be undertaken. This non-full adjustment can be represented as:

$$\frac{LS_{it}}{LS_{it-1}} = \left(\frac{LS_{it}^{*}}{LS_{it-1}}\right)^{\theta_{it}} \tag{2}$$

where θ_{it} is the adjustment parameter, which varies both over time and across industries.

In logarithms, and appending a fixed effect two-way (industry and time) error component structure, the model in equation (2) can be rewritten as:

$$\ln LS_{it} = (1-\theta_{it}) \ln LS_{it-1} + \theta_{it} \ln LS_{it}^{*} + \varepsilon_{it} \tag{3}$$

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

where all variables are defined as in above, μ_i are unobservable industry-specific effects capturing industry's labor heterogeneity, λ_t are unobservable time-specific effects reflecting temporal variations in price, and v_{it} is the statistical random error term capturing random shocks and left out variables assumed to be identically and independently distributed with mean zero and constant variance.

Assume LS_{it}^{*} is the minimum quantity of labour required to produce a given level of output and LS_{it} is the actual quantity of labour used into the production. At equilibrium, $LS_{it} = LS_{it}^{*}$ implies that for a given technology there exists an efficiency in use of labour. The optimal level of labour, LS_{it}^{*}, is approximated by a flexible translog function as shown:

$$\begin{aligned} \ln LS_{it}^{*} = {} & \beta_0 + \beta_L \ln LNS_{it} + \beta_G \ln GDP_{it} + \beta_W \ln WS_{it} + \beta_T T \\ & + \frac{1}{2}\left\{\sum_{j}^{J}\sum_{k}^{K} \beta_{jk} \ln X_{jit} \ln X_{kit} + \beta_{TT} T^2\right\} + \sum_{j}^{J} \beta_{jT} \ln X_{jit} T + \mu_i \end{aligned} \tag{5}$$

where LNS, GDP and WS are respectively non-saudi labor, gross domestic product and real Saudi wage. The term $\{...\}$ contains the square and interaction terms associated with the matrix $X = \{LNS, GDP, WS\}$ of J explanatory variables defined previously. The β are

constant unknown parameters to be estimated. Their subscript indicates which X variable they are associated with. The square terms capture non-linearities in the determinants' impacts on labor, while their interaction indicates substitution or complementarity among the explanatory variables.

The technical change (TC), will be decomposed into pure or neutral component, non-neutral component and scale augmenting components. A positive rate of TC indicates that labour using technology is employed, implying synonymously as technical regress. On the other hand, negative rate of TC indicates labour saving technology, which implies technical progress or downward shift in the labour function over time.

In addition, the rigidity of speed of adjustment will be relaxed by allowing for a flexible speed of adjustment and which varies over time and across industries (θ_{it}). An inefficient industry must try to adjust its labour requirement to an optimal level by adjusting its factor of production. An inefficient industry may take long time to adjust its labour requirement to the optimal level (LS_{it}^{*}) until the value of θ_{it} is close to unity.

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

$$\theta_{it} = \gamma_0 + \gamma_T T + \gamma_{TT} T^2 + \sum_i \gamma_i ID_i \tag{6}$$

where ID_i, T and T^2 are respectively vectors of industry dummy variables, a time trend and its square. Since the focus is on the behaviour of θ_{it} over time and across industries, it has been specified as a flexible function of time by relating it to time trend and industry dummies. It should be noted that for the estimation, we do not impose any restriction on the time effects in the optimal Saudi labor and those of the speed of adjustment. These time effects are allowed to be different across the two equations (5 and 6).

3.2. Interpretation of the Results

The log derivative of optimal Saudi labor with respect to log explanatory variables interpreted as elasticities of optimal Saudi labor with respect to changes in non-Saudi labor and gross domestic product and real Saudi wage are derived from equation (5) as:

$$E_{LNS} = \frac{\partial \ln LS_{it}^{*}}{\partial \ln LNS_{it}},\ E_{GDP} = \frac{\partial \ln LS_{it}^{*}}{\partial \ln GDP_{it}},\ E_{WS} = \frac{\partial \ln LS_{it}^{*}}{\partial \ln WS_{it}} \tag{7}$$

In the present model, the dynamic Saudi labor function (5) is allowed to shift over time. This, as has been noted, captures the effect of technological change on the level of Saudi labor. Thus, the exogenous rate of technological change is defined in terms of a shift in the price function. From model (5) technological or trade policy change (TC) or shift in the optimal Saudi labor equation over time is derived as the log derivative of price with respect to time as:

$$TC = \frac{\partial \ln LS_{it}^{*}}{\partial t} = (\lambda_t - \lambda_{t-1}) + \beta_{LNST} \ln LNS_{it} + \beta_{GDPT} \ln GDP_{it} + \beta_{WST} \ln WS_{it} \tag{8}$$

If the rate of TC is positive, it implies that technology is regressive from a domestic market welfare point of view resulting price increase, and when negative it indicates technical progress with price declines as a result.

In this study, we aim to test the direct effect of exogenous changes on optimal Saudi labor among industries. In similarity with a production case notation, the overall optimal Saudi labor effect can be decomposed into three components. The pure or neutral component, which derives as $PTC_t = \lambda_t - \lambda_{t-1}$, and it captures the year to year erratic changes in Saudi labor. It reflects shift in the Saudi labor function over time due to technological advancement and not necessarily linked to any specific underlying factor. The non-neutral component is function of the determinants of optimal Saudi labor and derives as $NTC = \beta_{LNST} \ln LNS_{it} + \beta_{WST} \ln WS_{it}$. It reflects shifts over time associated with specific non-Saudi labor and Saudi wage factors.

The gross domestic product augmented component of the change is derived as scale technical change, $STC = \beta_{GDPT} \ln GDP_{it}$. It detects changes introduced through economic growth.

The incorporation of new technologies will therefore be accompanied by a change in labor demand in favour of skilled workers. If large enough, this shift can outweigh the reduction in the demand for skilled labor that is predicted by traditional trade theory. A variation of this theme is the conjecture that, even if the technology to be transferred is neutral, the transitional process of transferring and installing new technologies may be skill-biased (Pissarides, 1997). In this case, the effect on the returns to human capital will be temporary and skilled workers benefit only during the transition period to the new, higher, technological level. Goldin and Katz (1998) reach a similar conclusion; they argue that the demand for skilled labor can follow a technological cycle. The demand rises when new

Table 1: Summary Statistics of the Saudi Data

Variable	Definition	Mean	Std Dev	Minimum	Maximum
A. Dependent variable:					
ts	Saudization rate	0.263	0.254	0.012	0.791
B. Independent variables:					
Lnlns	Non-saudi labor	1.058	0.149	0.656	1.731
Lngdp	Gross domestic product	1.066	0.059	0.901	1.279
Lnws	Saudi wage	0.148	0.157	0.004	0.694
N	Number of industries	7			
T	Number of period	9			
NT	No. of observations	63			

technologies and machinery are introduced, but it declines once the other workers have learned how to use the new equipment.

These theories predict that the effect of the increase in the relative demand for skilled labor will be to increase the relative wages. The magnitude of the effect will vary according to the elasticities of costs of skilled and unskilled labor, and the elasticity of substitution.

4. DATA DESCRIPTION

The data used in this study have been assembled using a diversity of sources, such as the national accounts of the Saudi Arabian Monetary Authority (SAMA) and statistics coming from the Ministry of Labor and Social Development. This was to allow the construction of an integrated database of industrial price and trade statistics. Thus, there is a panel on seven manufacturing industries from 2007 to 2015. These seven industries are included in the Saudization and Nitaqat programs. The industries included are: Agriculture and fishing (AF), Mines and gas (MG), Manufacturing diverse (MD), Electricity and water (EW), Construction and building (CB), Wholesale and retail trade (WR), and Transport and communications (TCM).

The data contain information on Saudi labor, non-Saudi labor, real Saudi wages and gross domestic product. The dependent variable is measured as Saudi labor (LS). The independent variables in the dynamic Saudi labor model are the non-Saudi labor (LNS), Saudi wage (WS) and gross domestic product (GDP).

In the estimation, two economic regimes are accounted for, that is, pre-Nitaqat (before 2011) and Nitaqat (after 2010) periods. The Nitaqat period refers to boost employment among locals and attempt to protect wages among expatriates. These periods are captured separately because they represent different economic regimes. A time trend (t) is used to capture the effects of the exogenous rate of technological change or possible shifts in the Saudi labor over time. In addition, N-1 industry dummies are used to capture unobservable industry-specific effects and T-1 time dummies are used to capture unobservable time-specific effects. The summary statistics are reported in Table **1**.

5. EMPIRICAL RESULTS

The dynamic model in equation (3) is estimated assuming a flexible adjustment parameter (6) which is both industry and time-variant. The variation can be accommodated by making the adjustment parameter a function of the time and industry variant variables. Here for the specification we use a time trend, squared time trend, and industry dummies.

For a comparison, three models are estimated: a time trend static model, a restricted dynamic model where the adjustment parameter is a simple constant and the unrestricted dynamic model where the adjustment parameter is both industry and time-variant.

The time trend static model is to be considered as a benchmark model, while the restricted dynamic model is corresponding to an intermediate model or the inflexible adjustment model found in the literature. The three models are estimated using fixed effects panel data models. The two dynamic models are non-linear and require a non-linear iterative procedure to estimate them, while the static model is estimated using linear

Table 2: Translog Parameter Estimates, Dependent Variable is Saudization Rate

Parameter	Static model	Restricted dynamic model	Unrestricted dynamic model
A. Price equation			
Intercept	-0.3199***	-0.3244***	2.2497***
llns(Non-saudi labor)	0.6735**	0.5988**	1.4967***
Lgdp(Gross domestic product)	0.3758	0.2997	-0.0911
Lws(Saudi wage)	-0.2046***	-0.2029***	-0.2831***
llns2 (Square Non-saudi labor)	0.5662**	0.5407**	0.6742**
lgdp2(Square Gross domestic product)	-1.2515	-1.0129	-0.4138
Lws2 (Square Saudi wage)	-0.0222***	-0.0229**	-0.0091
Llnsgdp (Non-saudi labor)*(Gross domestic product)	-2.4789*	-2.4389	-1.4192
Llnsws(Non-saudi labor)*(Saudi wage)	-0.0134	-0.0128	-0.0696
Lwsgdp (Saudi wage)*(Gross domestic product)	-0.1729	-0.1729	-0.2086
Llnst (Non-saudi labor)*t	-0.1004**	-0.0904**	-0.2952***
Lwst (Saudi wage)*t	0.0001	-0.0002	0.0111***
Lgdpt (Gross domestic product)*t	-0.0874	-0.0797	-0.0175
B.Time effects			
λ_{2007}	-0.0054	0.0056	-2.7946***
λ_{2008}	-0.0239	-0.0163	-2.9108***
λ_{2009}	0.0127	0.0170	-2.6930***
λ_{2010}	0.0562	0.0630	-2.5875***
λ_{2011}	0.0960**	0.1016*	-2.4998***
λ_{2012}	0.1132**	0.1170*	-2.4512***
λ_{2013}	0.1224**	0.1243*	-2.4742***
λ_{2014}	0.1228**	0.1227	-2.4774***
C. industry effects			
$\mu_{\_Mines\ and\ gas}$	0.6751***	0.6802***	0.7193***
$\mu_{\_manufacturing\ Diverse}$	-0.0485	-0.0401	-0.1543
$\mu_{\_Electricity\ and\ water}$	0.6489***	0.6529***	0.7437***
$\mu_{\_Construction\ and\ building}$	-0.1727	-0.1549	-0.4864**
$\mu_{\_Wholesale\ and\ retail\ trade}$	-0.1052	-0.0879	-0.3527**
$\mu_{\_Transport\ and\ communications}$	0.0573	0.0650	0.0445
D. Speed of adjustment equation			
θ_0		0.9548***	-0.8339***
$\theta_{\_Trend}$			0.3786***
$\theta_{\_Trend\ squared}$			-0.0363***
$\theta_{\_Mines\ and\ gas}$			0.6742***
$\theta_{\_manufacturing\ Diverse}$			0.2228**
$\theta_{\_Electricity\ and\ water}$			0.5786***
$\theta_{\_Construction\ and\ building}$			0.2302**
$\theta_{\_Wholesale\ and\ retail\ trade}$			0.5018***
$\theta_{\_Transport\ and\ communications}$			0.4748
Adj R-Sq	0.9613	0.9608	0.9950
RMS error	0.04989	0.0503	0.0179

Note: *** p<0.01, ** p<0.05, * p<0.1.

least squares dummy variable estimation method. The parameter estimates of the three models are reported in Table **2**.

5.1. The Optimal Level of Saudization Rate

The unobservable optimal level of Saudization rate is estimated using observable determinants for each point of the data. A closer look at the coefficients of the static and dynamic models shows that most explanatory variables, their squares and interactions and parameters associated with industry dummies, time trend, and those associated with the adjustment function, θ_{it}, are statistically significant at conventional levels of significance. Likelihood ratio test results indicate that the unrestricted dynamic model is preferred to the restricted one where the adjustment parameter is constant across industries and over time. The analysis of the results will be subsequently based on the static and unrestricted dynamic model specifications, where the static model serves as a benchmark model.

The parameters of the translog model cannot individually be interpreted directly due to the presence of interaction and square terms. The elasticities of Saudization rate with respect to non-Saudi labor, unit Saudi wage, gross domestic product, and rate of technical change were, therefore, computed. All elasticities evaluated at the mean values for each year, for each economic regime, by industry and at the overall sample mean are reported in Table **3** for the static model and in Table **4** for the dynamic long-run version. Also calculated and reported in the same way in Table **4** is the speed of adjustment parameter (θ_{it}).

5.2. Elasticities and Exogenous Rate of Saudization Rate

This sub-section discusses the elasticities with respect to non-Saudi labor, gross domestic product and unit Saudi wage, reported in Table **3** for the static model and in Table **4** for the unrestricted dynamic case. The short-run elasticities are simply the long-run multiplied by the speed of adjustment. The long-run elasticities reflect instantaneous and full adjustment to desired level of labor-use, while the short-run elasticities reflect the short-run responses in labor demand to inter-periodical changes in the explanatory variables. The subsequent discussion will be based on the long-run elasticities. The long-run perspectives to exogenous changes and subsequent adjustments in industrial policy and firms' behaviour in response to these changes is more relevant and consistent with the objectives of firms and those of this study.

Static Model

The signs of the average elasticities are as expected; non-Saudi labor (LNS) are positive and negative, unit Saudi wage (WS) are negative, and gross domestic product (GDP) are mostly positive. Results in Table **3** show that elasticities with respect to non-Saudi labor (LNS) have a sample mean value of 0.106 (0.305), which show a general positive effect of expatriates labor on Saudization rate. The numbers in parentheses are the standard deviations.

Across industry, results show a positive effect of non-Saudi labor on Saudization in all industries. In addition, Saudization responds greatest to non-Saudi labor in the Construction and building (0.189) and in Agriculture and fishing (0.188), followed by Mines and natural gas (0.145). It is least responsive is in the Transport and communications (0.026) and Electricity and water (0.048).

Over time, during 2007–2010 economic phase, there is evidence that non-Saudi labor exerts a positive effect on Saudization rate, with a simple mean value of 0.327. While, the figure become different during the Nitaqat period and the non-Saudi labor exerts a negative effect on Saudization rate, with a simple mean value of -0.070.

Ours results show that the gross domestic product elasticity has a positive general effect on Saudization rate. The mean value of this elasticity is about 0.129 and a standard deviation of (0.440). By industry, Saudization responsiveness to gross domestic product is more pronounced in Wholesale and retail trade, with elasticity of 0.434, followed by Construction and building, with elasticity of 0.341, and the Manufacturing diverse, with elasticity of 0.291. The gross domestic product elasticity for Agriculture and fishing, Electricity and water, and Transport and communications, unlike other industries, are negative.

Over time, expect 2013 and 2015, all gross domestic product elasticities are positive. In addition, these elasticities are decreasing over time. However, the values of these elasticities are larger in pre-Nitaqat period. The gross domestic product elasticities during Nitaqat period are relatively small with a simple mean value of -0.006.

Results in Table **3** show a negative general impact of Saudi wage on Saudization rate. The sample mean

Table 3: Static Elasticities of Saudization Rate with Respect to Non-Saudi Labor, Gross Domestic Product, Unit Saudi Wage and Technical Change

Characteristic	E_{LNS}	E_{GDP}	E_{WS}	PTC	NTC	STC	TC
A. Mean by industry							
1- Agriculture and Fishing	0.188	-0.049	-0.148	0.014	-0.006	-0.003	0.005
2- Mines and Natural gas	0.145	0.240	-0.131	0.014	0.001	-0.001	0.014
3- Manufacturing diverse	0.097	0.291	-0.064	0.014	-0.004	-0.006	0.005
4- Electricity and Water	0.048	-0.085	-0.171	0.014	-0.002	-0.005	0.007
5- Construction and Building	0.189	0.341	-0.007	0.014	-0.011	-0.006	-0.003
6- Wholesale and Retail Trade	0.051	0.434	-0.021	0.014	-0.003	-0.007	0.003
7- Transport and Communications	0.026	-0.269	-0.134	0.014	-0.011	-0.010	-0.008
B. Mean by year							
2007	0.429	0.499	-0.100	0.000	-0.002	-0.007	-0.009
2008	0.377	0.279	-0.103	-0.005	-0.007	-0.007	-0.020
2009	0.466	0.159	-0.100	-0.018	-0.013	-0.003	-0.034
2010	0.036	0.253	-0.112	0.037	0.002	-0.009	0.030
2011	-0.009	0.096	-0.121	0.043	-0.001	-0.008	0.035
2012	0.050	0.074	-0.093	0.040	-0.005	-0.004	0.030
2013	-0.006	-0.022	-0.087	0.017	-0.007	-0.003	0.006
2014	-0.207	0.044	-0.081	0.009	-0.001	-0.004	0.004
2015	-0.180	-0.222	-0.075	0.000	-0.010	-0.004	-0.013
C. Mean by period							
1-pre-Nitaqat period	0.327	0.298	-0.104	0.003	-0.005	-0.007	-0.008
2-Nitaqat period	-0.070	-0.006	-0.091	0.022	-0.005	-0.005	0.012
D. Overall sample mean and std deviations							
Mean	0.106	0.129	-0.097	0.014	-0.005	-0.005	0.003
Std dev.	0.305	0.440	0.064	0.021	0.014	0.005	0.027

Notes: Elasticity of output with respect to Non-Saudi labor (E_{LNS}), Gross domestic product (E_{GDP}) and Unit Saudi wage (E_{WS}), Pure or neutral component Technical change (PTC), Non-neutral technical change (NTC), scale technical change (STC) and Technical change (TC).

of unit Saudi wage elasticity is -0.097, with a standard deviation of 0.064. Across industries, the unit Saudi wage elasticities are negative in all industries. Saudization responsiveness to unit Saudi wage is more pronounced in Electricity and water with elasticity of -0.171, followed by Agriculture and fishing with elasticity of -0.148. The least response rate is found in the Construction and building (-0.007).

Over time, the same figure is concluded and the values of unit Saudi wage are negative, which implies a negative effect of unit Saudi wage on Saudization rate. In addition, these elasticities are increased in pre-Nitaqat period and decreased in Nitaqat period, with mean values, respectively, -0.104 and -0.091.

Turning to the exogenous rate of technical change, it can be realized that the static sample mean value presented in Table **3** is very small (0.003) with a standard deviation (0.027). The pure component of technical change is found to be positive (0.014) while the non-neutral component and the scale augmenting component of technical change are negative and close to zero (-0.005). The interpretation is that the exogenous rate of technical change in the static sample is dominated by the pure component of technical change.

The results show that, in static model, in the Construction and building and in the Transport and communications, there was technical progress (decreasing Saudi labor-use for given gross domestic product, unit Saudi wage and non-Saudi labor). In the remaining five industries there was technical regress (increasing use of Saudi labor for given). Over time, there was technical progress during the period of

2007–2009. In the remaining years, expect 2015, there was technical regress.

Dynamic Long-Run Model

In the dynamic long run model, results in Table **4** show that the signs of the average elasticities are as expected; non-Saudi labor (LNS) are positive and negative, unit Saudi wage (WS) are negative, and gross domestic product (GDP) are mostly positive.

The elasticities with respect to non-Saudi labor (LNS) have a general positive effect on Saudization rate, with sample mean value of 0.182 (0.769). The numbers in parentheses are the standard deviations. Across industries, results show a positive effect of non-Saudi labor on Saudization rate in all industries. In addition, Saudization responds greatest to non-Saudi labor in the Construction and building (0.395), followed by Wholesale and Retail Trade (0.247). However, the least responsive is found in Electricity and Water (0.022).

Over time, results show that there is more variation in the non-Saudi labor elasticities than across industry. Indeed, the values of these elasticities range from -0.871 to 1.3. Ours results show also that, during the pre-Nitaqat phase, the elasticities with respect to non-Saudi labor are positive, with a simple mean value of 0.898, however, during Nitaqat period these elasticities are negative, with a simple mean value of -0.390. These results are important, as they give indications that there is a complementary relation between Saudi and foreign labor in pre-Nitaqat period, while, in Nitaqat period, there was a substitution relation.

Table 4: Dynamic Long-Run Elasticities of Saudization Rate with Respect to Non-Saudi Labor, Gross Domestic Product, Unit Saudi Wage, Technical Change, Labor-Use and Speed of Adjustment

Characteristic	E_{LNS}	E_{GDP}	E_{WS}	PTC	NTC	STC	TC	LU	SA
A. Mean by industry									
1- Agriculture and Fishing	0.162	0.002	-0.213	-0.275	-0.034	-0.001	-0.310	0.179	0.052
2- Mines and Natural gas	0.099	0.187	-0.198	-0.275	-0.014	-0.000	-0.290	0.910	0.583
3- Manufacturing Industries	0.211	0.435	-0.181	-0.275	-0.047	-0.001	-0.324	1.012	0.180
4- Electricity and Water	0.022	-0.047	-0.224	-0.275	-0.015	-0.001	-0.292	0.994	0.487
5- Construction and Building	0.395	0.609	-0.162	-0.275	-0.083	-0.001	-0.359	2.049	0.186
6- Wholesale and Retail Trade	0.247	0.646	-0.166	-0.275	-0.058	-0.001	-0.334	1.008	0.410
7- Transport and Communications	0.141	0.002	-0.222	-0.275	-0.055	-0.002	-0.332	3.556	0.387
B. Mean by year									
2007	1.300	0.357	-0.242	0.000	-0.036	-0.001	-0.037	0.075	0.046
2008	1.063	0.259	-0.235	-2.795	-0.049	-0.001	-2.845	0.963	0.194
2009	0.907	0.178	-0.220	-0.116	-0.065	-0.001	-0.181	4.350	0.363
2010	0.320	0.300	-0.213	0.218	-0.022	-0.002	0.194	1.092	0.482
2011	0.058	0.207	-0.206	0.105	-0.026	-0.002	0.078	0.751	0.534
2012	-0.083	0.256	-0.181	0.088	-0.045	-0.001	0.042	0.707	0.513
2013	-0.333	0.240	-0.167	0.049	-0.052	-0.001	-0.004	0.767	0.419
2014	-0.721	0.335	-0.151	-0.023	-0.035	-0.001	-0.059	0.891	0.273
2015	-0.871	0.225	-0.142	-0.003	-0.064	-0.001	-0.067	2.887	0.112
C. Mean by period									
1- pre-Nitaqat period	0.898	0.274	-0.227	-0.673	-0.043	-0.001	-0.717	1.620	0.271
2- Nitaqat period	-0.390	0.253	-0.169	0.043	-0.044	-0.001	-0.002	1.201	0.370
D. Overall sample mean and std deviations									
Mean	0.182	0.262	-0.195	-0.275	-0.044	-0.001	-0.320	1.387	0.326
Std dev.	0.769	0.335	0.044	0.902	0.045	0.001	0.907	3.395	0.256

Notes: Elasticity of output with respect to non-Saudi labor (E_{LNS}), gross domestic product (E_{GDP}) and unit Saudi wage (E_{WS}), pure or neutral component technical change (PTC), non-neutral technical change (NTC), scale technical change (STC), technical change (TC), labor-use (LU) and speed of adjustment (SA).

Similarly to static model, in dynamic long run model the gross domestic product exerts a general positive effect on Saudization rate. This global effect is about 0.262 but with a slightly large standard deviation of 0.335. Across industry, expect Electricity and Water, all other industries have a positive gross domestic product elasticities. In addition, Saudization responsiveness to gross domestic product is more pronounced in Wholesale and retail trade with mean value of 0.646, followed by Construction and building (0.609) and Manufacturing diverse (0.435). The least gross domestic product elasticity is found in Agriculture and fishing and in Transport and communications, with sample value of 0.002.

Over time, all gross domestic product elasticities are positive. However, the values of these elasticities are switching from increase to decrease. By period, Saudization was more responsive to gross domestic product during pre-Nitaqat. The mean value of gross domestic product elasticities in the pre-Nitaqat period is of 0.274, whereas, in the Nitaqat period, this value is about 0.253.

Ours results in Table **4** show that the unit Saudi wage have a general negative effect on Saudization rate. The mean value is about -0.195 and a standard deviation of 0.044. Across industries, the unit Saudi wage elasticities are negative. Saudization responsiveness to unit Saudi wage is more pronounced in Electricity and water (-0.224) and in Transport and Communications (-0.222), followed by Agriculture and fishing (-0.213). The least response rate is found in the Construction and building (-0.162).

Over time, long-run unit Saudi wage elasticities are negative, in addition, there is a general decline in the unit Saudi wage elasticities, explained by the structural change favourable to branches that made intensive use of skilled labor and technology as opposed to sectors with intensive use of unskilled labor. Consequently, the number of production workers—a large category of workers in Saudi industries—decreased, while skilled labor—a small category—increased.

By period, Saudization is more responsive to the long-run unit Saudi wage in pre-Nitaqat period, with mean value of -0.227, than the Nitaqat period (-0.169).

In the long-run sample, the effect of the exogenous rate of technical change was different compared to the static one. Indeed, the long-run sample mean value presented in Table **4** is negative (-0.320) with a relatively large standard deviation (0.907). The pure component of technical change is found to be negative (-0.275) and the non-neutral component is negative and relatively smaller (-0.044). The scale augmenting component of technical change is negative and close to zero. Thus, the long-run dynamic model shows a general negative effect of technical change on Saudization policies.

The results show that, that there was technical regress, in the seven industries under study. Over time, there was technical progress during 2007–2009 and 2013-2015 periods. In the remaining years there was technical regress.

In summation, the long-run elasticity values show that Saudization is more responsive to gross domestic product, followed by unit Saudi wage and least by non-Saudi labor. The sample mean value of technical change shows technical progress (labor saving). During the 2007–2010 period Saudization was due mostly to non-Saudi labor than gross domestic product. In the Nitaqat period Saudization was mainly from gross domestic product rather than unit Saudi wage and non-Saudi labor. These results are important in the formulation and targeting of policies, as they give indications of Saudi job creation in different industries.

The presence of point elasticities with unexpected signs is a consequence of calculation of elasticities at each data point, where at a number of points the regulatory conditions are violated. The smooth switches in the size and signs over time is a consequence of the non-neutral interaction of time trend with the right-hand variables.

5.3. Labor-Use Inefficiency

Labor-use inefficiency is the ratio of actual Saudi labor to optimal level of Saudi labor. A ratio greater than one means over-use of labor for a given level of output produced using industries own optimal production technology. The inefficiency results are reported in Table **4**. The sample mean labor-use inefficiency is 1.387 with a large standard deviation of 3.395. This value indicates that industries closer to the mean are on average over using labor by 38.7% compared to an industry's own best practice technology. Among the industries, labor-use inefficiency ranges from 0.8% to 255.6%. The most inefficient industries are Transport and communications and Construction and building, all over using labor by more than 100%. On the lower end of the spectrum are Wholesale and retail trade and Manufacturing diverse.

Since Saudia Arabia is a labor-abundant country and, with reference to employment data, some industries can be labor-use inefficient. This inefficiency can be explained by the extensive utilization of human capital. The technical infrastructure is used only partially. In these industries, firms prefer to use more labor especially after Saudization program.

In general, there is an increase over time in the labor-use inefficiency rate. The highest inefficiency levels were recorded in the pre-Nitaqat period—with labor over-use of more than 60% on average. In the Nitaqat period the labor over-use of about 20.1% on average. This inefficiency over time is no surprise; expectations were that the ratio could be higher during the Nitaqat period. Such an expectation was motivated by the tight labor market regulations in place (that is the firms' inability to adjust employment by firing excess Saudi labor force) during the pre-Nitaqat period that may have forced employers to retain excess Saudi labor.

5.4. Speed of Adjustment

The results of the speed of adjustment parameter are reported in Table **4**. The sample mean speed of adjustment is 0.326, with a relatively large standard deviation (0.256), indicating the presence of large industrial heterogeneity in the speed of adjustment in Saudization. Industries close to the mean adjust 32.6% of their deviations off the equilibrium (observed Saudization equals the Saudization). Saudization adjustment is fastest in the Mines and gas (more than 58%). The slowest adjusters are Agriculture and fishing.

Over time, there is a general increase in the speed of adjustment in the 2007-2011 period, and a general decrease in the 2012-2015 period. While, Saudization adjustment is faster in the Nitaqat period. In Nitaqat period, industries close to the mean adjust 37% of their deviations off the equilibrium. In the pre-Nitaqat period, Saudization speed of adjustment is about 27.1%. What this implies is that during Nitaqat period, Saudization have become more flexible as the higher speed of adjustment indicates.

6. CONCLUSION

This study was concerned with two important issues. First, modeling dynamic Saudization rate with a flexible adjustment parameter, and secondly, measuring labor-use efficiency in Saudi manufacturing industries. Understanding these issues is important to formulating opinions of how labor markets function, and particularly Saudization, and is useful as a guide to policy formulation and evaluation.

A rate of Saudi labor requirement function was used to represent Saudization. Saudization was modeled as a function of non-Saudi labor, gross domestic product and unit Saudi wage. The adjustment parameter was permitted to change over time as industries allowed for a flexible speed of adjustment. Thus, employers choose their own individual adjustment paths 'to catch up' with the labor requirement frontier. The labor requirement frontier was compared with the actual amount of labor employed to measure labor-use inefficiency or to derive the amount of labor used in excess of that which is technically necessary to produce a given level of output.

The discussion of the results was mainly based on the long-run estimates obtained from the unrestricted dynamic Saudization adjustment model. The long-run sample mean elasticities indicate that Saudization rate responds greatest to gross domestic product, followed by unit Saudi wage and least by non-Saudi labor. The sample mean value of technical change is negative. It shows technical progress (labor saving). During the pre-Nitaqat period Saudization was due mostly to non-saudi labor than gross domestic product. In the Nitaqat period Saudization was mainly from gross domestic product rather than unit Saudi wage and non-Saudi labor.

Industries were least efficient during the Nitaqat period. Indeed, the highest inefficiency levels were recorded in the pre-Nitaqat period—with labor over-use of more than 60% on average. In the Nitaqat period, the labor over-use of about 20.1% on average. The speed of adjustment is not relatively slow—with a sample mean value of 32.6% per annum. It ranges from 4.2% (that is the Agriculture and fishing) to 58.3% (that is the Mines and gas). The speed of adjustment was greatest during Nitaqat period (37%) compared to the pre-Nitaqat period (27.1%).

The results support the conclusion that the relation between Saudization rate and non-Saudi labor is not constant. Indeed, under the pre-Nitaqat period results show a complimentary relation between Saudi and non-Saudi labor, while, in Nitaqat period, we conclude a substitution relation. In addition, in Nitaqat period, Saudization have become more flexible, and that Saudi employers are able to adjust faster.

This study is subject to some caveats worth mentioning, especially on the application side. This study in the absence of firm level data uses sector level manufacturing data. The assumption is that the production structures are the same within the sector. A disaggregation of the data to sub-sectors or an application to firm level data would be advantageous as this would capture heterogeneity in the Saudization functions and Saudi labor market behaviour.

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