

The Effect of Technological Changes on Employment: Regional I-O SDA Approach

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Abstract

In this study, the Regional Input- Output Structural Decomposition Analysis (I-O SDA) is used to investigate the effects of technological changes on employment in Sistan and Baluchestan Province of Iran during 2006-2011. This paper develops the SDA method to decompose the technological change from two viewpoints of supply and demand for intermediate inputs in each sector. These changes from demand perspective is decomposed into changes in share of each sector in total intermediate inputs that are used by specific sector (input substitution effect) and backward linkage. From supply perspective these change is decomposed to share of each sector in total intermediate demand that is supplied by specific sector (selling structure) and forward linkage. The results show that changes in forward linkages of sectors caused to decrease of 127351 jobs in total employment. The effect of changes in backward linkages is negative in all sectors of economy and caused to decrease of 75581 jobs in regional economy.

Keywords: Input-Output, Technological Changes, Structural Decomposition Analysis.

JEL Classification: I25, I21, Q56.

1. Introduction

There are many factors affecting employment in the economy. One of the most important factors is the change in the technological structure. Technology has increasingly changed in recent years in different countries around the world and related regions. This change has played an important role in changing economic structure and has changed the important economic variables such as output, value added

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and employment. Theoretically, the impact of technological changes on the aggregate employment of an economy is ambiguous and uncertain (Pak and Poissonnier, 2016). A labour intensive technology can increase demand for labour and thus increase aggregate employment of economy. Labour saving technology can reduce demand for labour and thus can reduce aggregate employment. Technological change can also increase demand for high-skilled labour force and reduce demand for low-skilled labour. As a result, the final effect of technological changes in employment will depend on the increase in skilled labor and the reduction of unskilled workforce.

One of the suitable models for investigating the effect of technological changes on employment is input-output. Intermediate input coefficients (technical coefficients) in this model have been accepted as an indicator of the technological structure (Miller and Blair, 2009). When there are two sets of input-output table for an economy, we can disaggregate the total change in gross outputs, and related variables such as employment into its component. On the basis of this method, exports, imports, domestic final demand and technological change would affect directly and indirectly changes in labour demand. There are two main techniques for decomposing economic variables: Index decomposition analysis (IDA) and structural decomposition analysis (SDA). Ang (2004) and Ang and Zhang (2000) reviewed the different approaches in IDA and Miller and Blair (2009) reviewed different approaches in SDA methods. SDA is able to measure the effect of more factors on changes of variables, such as a production technological change and final demand by both sector and demand source (Su and Ang, 2012b). The I-O SDA has also the unique ability to analyze supply and demand factors simultaneously. This model allows to examine the inter-sectoral relationships from the viewpoint of input supply (forward linkages) and input demand (backward linkages) in specific sector. The intersectoral linkages in this model from the viewpoint of supply in particular sector indicate that how many products produced in this sectors, is used intermediately in different sectors, and how much are the shares of different sectors in this product. Inter-sectoral input distribution as well as the share of intermediate and final demand for

the production of sectors will change through the technological changes. The intersectoral linkages in this model from the viewpoint of demand is that how much a specific sector has intermediate demand (intermediate costs), and what is the share of different sectors in total intermediate inputs that are used in this sector. Technological changes will change the share of different sectors in total intermediate inputs in that sector, and consequently production and employment sectors will also be affected. The effects of these changes will depend on the strength of the domestic inter-industry linkages (Pak and Poissonnier, 2016).

I- O SDA approach has been used to decomposition of employment changes. A number of studies examined the effect final demand on its composition and labour demand in sectors. Leclair (2002) examined the effect of export composition of employment in the US during the 1989-1995. Guncavdi et al. (2003) examined the effect of domestic demand and foreign demand for employment changes in Turkish industries. Napoles (2004) calculated the effect of Mexico exports on labour demand. Gu and Rennison (2005) examined the effect of trade integration on demand for skilled workers in Canada. Chen et al. (2012) examined the employment impact of processing exports, non-processing exports and domestic final demand in China. Los et al. (2015) analyzed the impact of foreign demand on Chinese employment by extending the global input-output between 1995 and 2001.

Some other studies examined the factors affecting the employment changes with emphasizing the role of technological changes. In this line of research Forssell (1990) decomposed the changes in the use of labour by education levels in finish economy and find the technological changes are the major factors in changes of labour demand. Han (1995) used the I-O SDA method to decomposition of Japanese labour force during 1975–85 and found that technical change had the significant role in increase of professional occupations. Ruiz and Wolff (1996) used the I-O SDA to decompose the changes of labour in Puerto Rico for 1967-1987. In this study three factors, including technical changes, final demand and the import leakage are considered as factors that affect the labour changes. Wolff (2006) examined the effect of technological changes on growth of workers in

the US economy during 1950–2000. Jenkin (2008) used Chenery type decomposition analysis of employment change for different types of labour in South Africa. Wydra (2011) used the input- output model to examine the production and employment effects of biotechnological change in Germany. Los et al. (2014) proposed a new method to analyze the changing of employment in countries based on the world input-output during 1995-2008. Changes in technology, trade and consumption are considered as three factors affecting the employment growth. Incera (2017) divided the direct and indirect effect of technological change on labour demands. Changes in direct labour input coefficients are measured as direct effect of technological change and changes in intermediate input coefficients (Leontief inverse) is considered as indirect effect of technological change.

Reviewing the previous studies used the I-O SDA approaches showed there are few studies that focused on the internal decomposition of the intermediate input coefficients (technical coefficients). Tin (2014) used I- O SDA approach to decomposing the labour growth in Malaysia during 1978-2000. In this study technical change within each sector is decomposed into two separate parts, changes in intermediate input using technology and changes in manpower using technology. Pak and Poissonnier (2016) decomposed the employment changes by skill level over the period 1982-2010 in France into three main components. Technology, trade and final consumption. In next step the technical matrix is divided into domestic input coefficients and import input coefficients.

This study differs from the previous studies in two aspects. Firstly, technological changes (changes in technical matrix) are decomposed from two viewpoints of supply (selling structure) and demand for intermediate inputs (cost structure) in sectors. Secondly, from both viewpoints of demand and supply, the technical coefficients are decomposed into two factors. Technological change from the demand perspective is decomposed into changes in share of each sector in total intermediate inputs that are used by specific sector (input substitution effect) and backward linkage. From supply perspective, these changes are decomposed to share of each sector in total intermediate demand that is supplied by specific sector (selling structure) and forward linkage. This decomposition method is not considered in other studies.

The paper contains four sections. Section 2 introduces the methodology and data resources. The results are presented in section 3. Finally, the concluding section ends the paper.

2. Methodology and Data

2.1 Methodology

The SDA approach is employed to measure the effects of technological changes in employment. To do so, the basic input-output model is implemented:

$$X = (I - A)^{-1} \cdot Y = C \cdot Y \quad (1)$$

Where X denotes the sectoral output vector, A refers to the technical coefficient matrix, C is the Leontief inverse matrix and Y is final goods and services vector. Based on Eq. (1) the employment vector of economy is as follows:

$$E = e^{\wedge} \cdot X = e^{\wedge} \cdot C \cdot Y \quad (2)$$

where E denotes the sectoral employment vector and e^{\wedge} is labour coefficients (employment per unit of output). The changes in E in Eq. (2) Can be attributed to the changes in e^{\wedge} and X (Miller and Blair, 2009).

$$\Delta E = \Delta \hat{e} \cdot \left(\frac{X_0 + X_1}{2} \right) + \left(\frac{\hat{e}_0 + \hat{e}_1}{2} \right) \cdot \Delta X \quad (3)$$

The first term in the right hand side in Eq. (3) represents the effect of changes of labour coefficient on employment. The second term shows the effects of changes in outputs.

In similar procedure, we can decompose the sectoral output into two factors as follows:

$$\Delta X = \Delta C \cdot \left(\frac{Y_0 + Y_1}{2} \right) + \left(\frac{C_0 + C_1}{2} \right) \cdot \Delta Y \quad (4)$$

ΔC and ΔY refers to technological structure changes and changes in final demand, respectively. Substitution of Eq. (4) In Eq. (3) Yields:

$$\Delta E = \Delta \hat{e} \cdot \left(\frac{X_0 + X_1}{2} \right) + \left(\frac{\hat{e}_0 + \hat{e}_1}{2} \right) \cdot \Delta C \cdot \left(\frac{Y_0 + Y_1}{2} \right) + \left(\frac{\hat{e}_0 + \hat{e}_1}{2} \right) \cdot \left(\frac{C_0 + C_1}{2} \right) \cdot \Delta Y \quad (5)$$

Based on Eq. (5) Total employment is decomposed into three factors: changes in labour coefficient, technological structure changes and changes in final demand.

Based on contribution of this study, changes in technological changes (Leontief inverse matrix) are further decomposed into two factors from both viewpoints of supply and demand for intermediate inputs.

The changes in the Leontief inverse matrix can be decomposed from viewpoint of intermediate input demand as follows.

$$C = M \cdot B \quad , \Delta C = \Delta M \cdot \left(\frac{B_0 + B_1}{2} \right) + \left(\frac{M_0 + M_1}{2} \right) \cdot \Delta B \quad (6)$$

M represents the share of each sector in total intermediate inputs of specific sector in which m_{ij} the element of this matrix is equal to $C_{ij} / \sum_i C_{ij}$. Changes in this matrix indicate the input substitution in sectors (changes in cost structure in sectors). B refers to a diagonal matrix, in which its diagonal elements are equal to $\sum_i C_{ij}$. This matrix represents the total domestic intermediate input coefficients that are demanded by any sector or backward linkages.

The changes in the Leontief inverse matrix can be decomposed from viewpoints of intermediate input supply as follows.

$$C = F \cdot Z \quad , \Delta C = \Delta F \cdot \left(\frac{Z_0 + Z_1}{2} \right) + \left(\frac{F_0 + F_1}{2} \right) \cdot \Delta Z \quad (7)$$

F refers to a diagonal matrix, in which its diagonal elements are equal to $\sum_j C_{ij}$. This matrix represents the total intermediate inputs that are supplied by any sector or forward linkage of sectors. Z represents the share of each sector in total intermediate inputs that are supplied by specific sector in which z_{ij} the element of this matrix is equal to $C_{ij} / \sum_j C_{ij}$. Substituting Eq. (7) In second term of Eq. (5) Yields the effect of technological changes from viewpoint of intermediate input demand for employment as follows:

$$\Delta E = \left(\frac{\hat{e}_0 + \hat{e}_1}{2}\right) \cdot \Delta M \cdot \left(\frac{B_0 + B_1}{2}\right) \cdot \left(\frac{Y_0 + Y_1}{2}\right) + \left(\frac{\hat{e}_0 + \hat{e}_1}{2}\right) \cdot \left(\frac{M_0 + M_1}{2}\right) \cdot \Delta B \cdot \left(\frac{Y_0 + Y_1}{2}\right) \quad (8)$$

The first term of the right hand side of Eq. (8) represents the effect of technological changes in sectors on employment. The second term shows the effects of changes in backward linkages on employment.

Substituting Eq. (6) in second term of Eq. (5) Yields the effect of technological changes from viewpoint of intermediate input supply on employment changes as follows:

$$\Delta E = \left(\frac{\hat{e}_0 + \hat{e}_1}{2}\right) \cdot \Delta F \cdot \left(\frac{Z_0 + Z_1}{2}\right) \cdot \left(\frac{Y_0 + Y_1}{2}\right) + \left(\frac{\hat{e}_0 + \hat{e}_1}{2}\right) \cdot \left(\frac{F_0 + F_1}{2}\right) \cdot \Delta Z \cdot \left(\frac{Y_0 + Y_1}{2}\right) \quad (9)$$

The first term of the right hand side of Eq. (9) represents the effect of forward linkage in sectors of employment. The second term shows the effects of changes in share of each sector in total intermediate inputs that are supplied by specific sector of employment.

2.2 Data

In this study the regional input-output tables of Sistan and Baluchestan Province in 2006 and 2011 are used as database of the model. This table were prepared by national input-output tables using the AFLQ method. Before regionalization of national tables, these two national tables is transformed to domestic I- O tables by removing the imports using the method is presented in Miller and Blair (2009). Other data includes the sectoral output in national level and also regional level for construction of regional input-output tables were prepared from the Annual National Accounts and Annual Regional Accounts of Statistics Center of Iran. After construction of regional input- output tables in order to eliminate the effects of price changes, input- output table of 2011 is deflated to 2006 constant prices. To this end, we assume that the sectoral price index is equal at regional and national levels. Therefore, the sectoral price deflator at national level is used to deflate the 2011 regional input output table. The sectoral output in current and constant prices is prepared by Central bank of Islamic Republic of Iran.

3. Empirical Results and Discussion

Sectoral employment in Sistan and Baluchestan Province in 2006 and 2011 is shown in Fig.1. Total regional employment in 2006 was 407939 workers and decreased to 358398 worker in 2011. Three sectors including “Agriculture”, “Construction” and “Trade” had the large share in regional employment in 2006. Share of these sectors in total employment was 19.03%, 14.8% and 13.14%, respectively. “Other industries”, “Mining” and “Basic metal products” had the lowest share of total employment.

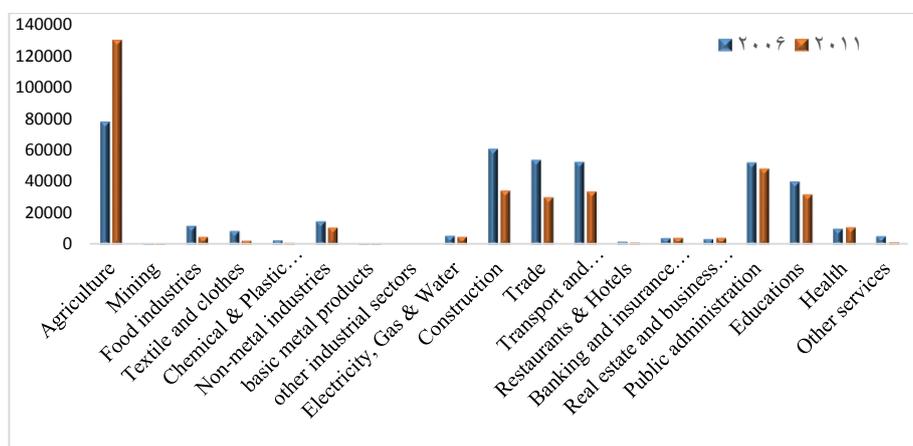


Figure 1: Regional Employment Changes during 2006-2011

Source: Statistical Center of Iran

Sectoral employment in the province is decreased in 2011 in 14 sectors and increased in 5 sectors. As it shown in Fig. 1 employment in “Agriculture” is increased significantly (52105 worker) during 2006-2011. “Agriculture”, “Public administration” and “Construction” are three sectors that have the largest share in total employment in 2011.

Results of decomposition of regional employment (Based on Eq. (5)) is shown in Table 1.

Table 1: SDA of Employment Changes

Sectors	E effect	C effect	Y effect	Total changes
Agriculture	-7992	-28045	88142	52105
Mining	-706	-66	847	75
Food industries	-7530	-5533	6050	-7013
Textile and clothes	-1588	-1732	-2742	-6061
Chemical & Plastic industries	-6251	-331	5015	-1567
Non-metal industries	-15890	-5045	17196	-3738
basic metal products	-2230	-70	1831	-469
other industrial sectors	-549	-12	375	-186
Electricity, Gas & Water	2304	-4026	1224	-498
Construction	-24102	-7187	5278	-26011
Trade	-85618	-8116	70217	-23517
Transport and Communication	-22698	-54337	58556	-18479
Restaurants & Hotels	-203	-17	-438	-657
Banking & insurance services	-2544	-1735	4526	247
business services	1793	-118	-856	819
Public administration	-7630	-500	4474	-3656
Educations	-3656	-290	-4001	-7947
Health	1162	-340	84	906
Other services	-6574	-1501	4181	-3894
Total	-190500	-118999	259958	-49541

Source: Author's Calculations

According to this table, total employment is decreased 49541 workers during study period. Three sectors including "Construction", "Trade" and "Transport and Communication" had the largest decrease in employment, respectively.

Results of SDA show that the effect of changes in labour coefficients and technological changes had employment, reducing effect while changes in final demand helped to increase of employment in regional economy. Decrement of total employment due to changes in labour coefficient is 190500 worker. Effect of this factor is positive in three sectors including "Electricity, Gas & Water" (2303 worker), "Real estate and business services" (1793 worker) and "Health" (1162 worker). Effect of this factor in other 16 sectors is negative. This factor had a reducing effect of 22697 workers in

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“Transport and Communication”, 24102 workers in “Construction” and 85617 workers in “Trade”.

The employment-decreasing effect of technological structure changes had decreased total employment by 118999 workers. Effect of this factor was negative in all sector and caused to reduction of employment. “Trade”, “Agriculture” and “Transport and Communication” had the main negative effect of this factor. Changes of final demand had a positive effect in all sectors except 4 sectors including “Restaurants & Hotels”, “Real estate and business services”, “Textile and clothes” and “Educations”. Total impact of this factor was positive and helped to increase total employment (259958 worker). “Agriculture”, “Trade” and “Transport and Communication” had are the three sectors that had the main positive effect from changes in final demand.

The effects of technological changes in sectoral employment are shown in Table 2. According to the results both demand side factors, backward linkages and input substitution, had negative effect on total employment in this region. Forward linkages had negative effect and changes in share of each sector in total intermediate inputs supplied by sector had positive effect on total employment.

Effect of Changes in forward linkage on sectoral employment has been shown in column 2 (column DF) in Table 2. According to the results, this factor caused decrement of 127351 jobs in total employment. This factor had a negative effect on employment of all sectors in the regional economy. As it is shown in Table 2. "Agriculture", "Trade" and "Transport and Communication" have had the most negative effect from changes in forward linkage of sectors. Forward linkage coefficient of these sectors has had a sharp decrease during the study period. For example, the forward linkage coefficient of "Agriculture" sector reduced 0.73 units, from 1.84 in 2006 to 1.12 in 2011.

Column 3 (DZ) in Table 2 shows the effect of changes in share of each sector in total intermediate inputs supplied by specific sector. This factor caused to an increment of 8352 jobs in total employment. Although the effect of these factors on total employment is positive, the effect of this factor in some sectors is negative. "Transport and Communication" and "Non-metal industries" have had the most

negative effect of changes of this factor. Unlike these two sectors, "Agriculture" and "Trade" have had most positive effect of this factor.

Column 4 and 5 (DM and DB) in Table 2 show the effect of technological changes from a demand perspective on sectoral employment. According to results, input substitution (DM) caused decrement of 43418 jobs in total employment. This factor had a negative effect on employment of 8 sectors and had a positive effect in other 11 sectors. "Transport and Communication" and "Electricity, Gas and Water" have had the most negative effect from changes of this factor. Unlike these two sectors, "Public Administration" and "Trade" have had the most positive effect of this factor. The effect of changes in backward linkages on sectoral employment is negative in all sectors of the economy.

Table 2: Effects of Technological Structure Changes on Sectoral Employment

Sectors	DF	DZ	DM	DB
Agriculture	-55200	27155	-981	-27063
Mining	-25	-40.467	-39	-26
Food industries	-5269	-264.17	-509	-5024
Textile and clothes	-1161	-570.96	112	-1843
Chemical & Plastic industries	-139	-191.81	616	-947
Non-metal industries	-1556	-3488.7	-1466	-3579
basic metal products	-45	-24.89	217	-288
other industrial sectors	-6	-6.4081	69	-81
Electricity, Gas & Water	-2452	-1573.7	-2776	-1250
Construction	-9660	2473.37	92	-7279
Trade	-25561	17444.8	1591	-9708
Transport and Communication	-22516	-31821	-44333	-10004
Restaurants & Hotels	-36	19.0142	555	-571
Banking & insurance services	-774	-960.85	-1104	-631
business services	-362	243.46	333	-451
Public administration	-944	444.346	3633	-4132
Educations	-612	322.44	937	-1227
Health	-294	-45.96	417	-758
Other services	-739	-761.65	-783	-718
Total	-127351	8352	-43418	-75581

Source: Author's Calculations

Employment of "Agriculture" and "Transport & Communication" have the most decrease due to changes in backward linkages. Backward linkage coefficient of these two sectors is declining sharply during the study period. This indicates that these sectors imported the intermediate inputs from outside of the region. On the other hand, the "Agriculture" is one of the key sectors in this province and the decline in backward linkage coefficients in this sector led to a sharp decrease in the employment of this sector.

4. Concluding Remarks and Policy Implications

This paper has analyzed the effect of technological changes in employment in Sistan and Baluchestan province in Iran during the period 2006-2011 using Regional I-O SDA method. The technological changes show the effects of changes in intermediate input coefficients in the input- output tables. Technological changes are considered from two viewpoints of demand and supply of intermediate inputs. Also, each of these viewpoints is divided into two components.

This paper suggests a more detailed decomposition method to provide more and better information on the factors affecting employment changes in the economy.

The results show that changes in forward linkages had a negative effect on all employment sectors. This is due to reduction of forward linkage coefficients in sectors during the study period. Changes in share of each sector in total intermediate inputs supplied by specific sector caused increment of 8352 jobs in total employment by region. This is due to the increment of share of key sectors of region in total intermediate inputs supplied by specific sector such as "Agriculture".

Input substitution had a negative effect on employment in 8 sectors and had positive effect on employment other 11 sectors. "Transport and Communication" and "Electricity, Gas and Water" have had the most negative effect from changes of this factor. The effect of changes in backward linkage of sectors is negative in all sectors of economy. Employment of "Agriculture" and "Transport & Communication" sectors have the highest decrease due to changes in backward linkages. This is due to reduction in backward linkage coefficients of all sectors in province during study period. On the other hand, regional sectors imported more intermediate inputs from other regions

or abroad. So, Regional policymakers should pursue appropriate policies to increase the backward and forward linkages in regional sectors.

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