Technological Unemployment in the Mexican manufacturing sector. An Analysis of Structural Decomposition

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Abstract. It is known that the introduction of new technologies and techniques can lead to the displacement of workers, nevertheless, according to classical economics, there are several compensation mechanisms that enable to offset such negative effects. The aim of this paper is to determine if the net effect of the technical change on the Mexican manufacturing level of employment is positive or negative. For this purpose, the magnitudes of the displacement and compensation effects were measured through the structural decomposition of two pairs of input-output matrices, 2003- 2008, and 2008- 2012. The findings suggest that between 2003 and 2008 the capacity of the compensation mechanism to offset the displacement effect was higher than between 2008 and 2002.

Keywords: technological unemployment, displacement effect, compensation effect, structural decomposition.

JEL Codes: O33, C67, J23

1. Introduction

The insufficient capacity to generate jobs is an issue that not only the developed economies are facing, developing and underdeveloped economies are also dealing with this matter. It has been argued that the low generation of employment is a matter related to the lack of demand; nevertheless, it has also been found that low levels of employment are the consequence of factors related to the supply such as the choice of technique. Therefore, the aim of this paper is to know if the technical change has contributed to the low job generation phenomenon. In the Mexican manufacturing sector the employment generation is increasingly lower, between 1999 and 2015 labor in the manufacturing sector grew at an average rate of 0.81%.

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2. Technological unemployment

As has been demonstrated in several works, the technological progress[4] has a positive effect on the economic growth, nevertheless the impact that the technological progress has on the level of employment seems not to be clear, the discussion related to this matter is mainly divided in two groups.

The first group establishes that the technological progress has negative effects on the level of employment due to the fact that through the incorporation of new and better techniques, labor productivity increases and leads to the diminution of labor requirements. This idea emerges from the argument that the current shapes of technical change[5] have weakened and even eliminated the positive relationship between growth and employment. Authors such as Çetindamar-Karaömerlioglu and Ansal (2000), Pianta (2000), Rifkin (1997), Vivarelli (1995), among others, argue that the technical progress has negative effects on the level of employment.

In the second group we find those who believe in the positive effect that the technical change has on the level of employment and that argue that there is no causal relationship between labor productivity and employment growth. Basically affirm that technical change is essential to the economies competitiveness and that there are several mechanisms that prevent the negative effects that the technical change could have on the level on employment. In this group we find Miller and Atkinson (2013).

According to Cahuc and Zylberberg (2004) the technological progress significantly contributes to output's growth but its effect on employment is a priori ambiguous. On the one hand, it is through the increase of labor productivity that the technological progress increases profits and encourages labor generation. But on the other hand, it destroys jobs where the technique is obsolete and doesn't

[4] Technical progress is a term applied to refer to the improvements in total factors productivity due to the application of new technical and scientific knowledge, to the improvement of productive processes and to the emergence of new products and services.

[5] Technical change is defined as all the changes or improvements in how the theoretical and practical knowledge is combined, leads to the displacement of existing techniques and can be seen in the increase of efficiency and in new goods and processes (see Vegara, 1989)

generate profits; therefore, the technological progress leads to a process of job generation and destruction, whose outcome isn’t known in advance.

Several authors such as Vivarelli (1995), Pianta (2000), Rifkin (1997) and Simonetti, et al. (2000) refer to the technological unemployment as the negative effect that the technical change has on the level of employment. Such concept mainly refers to the diminution of job generation as the outcome of the rise in labor productivity due to the incorporation of new and better techniques.

Therefore the technological unemployment is the unemployment generated by the incorporation of new means of production that economize the use of employment overcoming the speed at which new uses of labor are discovered.

However, the concern about the negative effect that the technical change could have on the level of employment is not new, on the contrary, arises since times of the classical economics, for instance David Ricardo and Marx did not refer specifically to the term of technological unemployment but doubtless referred to the negative effect that the technical change could have on the level of employment, this negative effect defines the technological unemployment and we have found that there are three market forces that intrinsically incite to the utilization of labor saving techniques, and these are, the increase in demand, the relative increase in wages and the labor shortage.

The classical economists such as Smith, Ricardo, Marx and Schumpeter recognized the role of the technical change in the study of the employment, specially recognized that the technical change and progress has a negative effect on the level of employment, which we will call *displacement effect*, but also argued the existence of a number of mechanisms that allow the technical change to have a positive effect on the level of employment, which we will call *compensation effect*, even believed that the compensation effect was large enough to entirely offset the displacement effect.

The negative effect that the technical change has on the level of employment can be identified in two stages. In the first one, the use of capital goods encourages the increase in labor productivity, however, in the first stage, the increases in labor productivity are not due to the role of the new machines but to the role of labor. A greater specialization allows a better utilization of machinery and equipment. In this stage the nation's output can be increased through the skills, dexterities and judgment of the labor force. There are three elements that increase labor productivity and that lead to the division of labor; the first one is related to the improvement of labor dexterity as a result of the degree of specialization, the second one refers to the time saved due to elimination of the changes from one activity to another, and the third one, the invention of machinery simplifies the production processes. Under this logic, the increase in the degree of specialization and the division of labor leads to the realization of greater output with lower requirements of labor, in other words, leads to the displacement of workers.

The second stage is related to the labor substitution by machines, the introduction of capital goods besides of increasing the level of production, simplifies the process of production and therefore leads to lower requirements of labor per unit of output. The labor force becomes more productive and the machines carry out an important part of the productive process, and therefore the requirement of labor diminishes (Smith, 1776; Ricardo 1951-1973, and Marx 1959).

Besides, the continuous introduction of machinery involves the loss of skills and the degradation of a part of the working population since not all are qualified to use the new machines (see Smith, 1776), at the time, this generates a reduction in the job opportunities of the less qualified labor in this kind of activity.

It is also argued that if output demand does not increase at the same proportion in which the increases labor productivity then some workers will be excluded of the labor market (seen Ricardo, 1951-1973). Nevertheless according to classical economics, this unemployment generated by the utilization of new machinery, in the worst of the cases generates frictional unemployment but never structural unemployment.

The technical and organizational changes generate winners but also losers, Schumpeter admits that the outcome of the innovative process is the creative destruction, which applies not only to goods and services markets but also to the labor market, generating unemployment (Schumpeter, 1911).

In the frame of the classical school, it seems like labor force and machinery are in constant competition, an increase in machinery would lead to the diminution of labor and to a greater division of labor, but we can also think that the constant specialization of the labor force will also lead to the division of labor among industries. And therefore, since the specialization does not occur at the same time and speed in all industries, then the division of labor can lead to disparities in labor productivity among industries and to an uneven distribution of the means of production.

The classical economists[6] believed that the disequilibrium in the labor market was temporary and irregular, and that the technical change could bring along some compensation mechanisms that in the long run could generate that the disequilibrium in the labor market could disappear. That is, the displacement of labor force generated in some industries could be offset by the generation of jobs in other industries, so that the net effect between the displacement and compensation would be null or positive but never negative. According to classical economics, these mechanisms work efficiently and assure the full reabsorption[7]. The compensation mechanisms are the following (see Kalmbach and Kurz, 1992):

a. New machines: the process of technical change that displaces workers generates new jobs in the sector of capital goods where the new machines are produced.
b. Diminution of prices: the technical change generates labor displacement but at the same time generates the diminution of labor costs and hence of total costs. In the competitive world of the classics, this implies a reduction in prices, an increase in demand and thus an increase in production and employment.

[6]Except for Marx
[7] The full operation of the compensation mechanisms is based on the existence of the assumptions of the perfect competition

c. New investments: in this mechanisms, during the competitive gap between the diminution of costs and the consequent fall in prices, additional profits are accumulated and invested, thus new productions and jobs are created.
d. New products: the technical change also leads to the production of new goods and the creation of new markets. In this case, new industries emerge and totally brand new jobs are created. Schumpeter in particular was very optimistic in the fact that in the long run the product innovations could compensate the negative effects that the technical change has on the level of employment.
e. Wage reduction: the technical change generates an increase in labor supply and leads to the reduction of wages. The cheapening of the labor force would encourage the labor demand to increase.

3. Structural decomposition

The central idea of the analysis of structural decomposition is that the changes in a given variable could be decomposed, in the addition of the changes the determining factors of itself (Schuschny, 2005). In this case we are interested in analyzing the changes in the Mexican manufacturing levels of employment in order to identify the magnitudes if the displacement and compensation effects and therefore determine the effect that the technical change has had on the level of employment of the manufacturing sector. Thus in our model it is defined that the level of employment is determined by the coefficient of labor use multiplied by the level of production:

$$l_t = \hat{\lambda}_t x_t \qquad (1)$$

where l_t is the column vector of labor in each subsector, $\hat{\lambda}_t$ is the diagonalized vector of the labor use coefficients and x_t is the column vector of output. Therefore the change in the level of employment can be decomposed in the sum of the changes in the labor use coefficient and in output, considering the model in (1) for *t* and *t-1* we have:

$$\Delta l = l_t - l_{t-1} = \Delta\hat{\lambda} x_{t-1} + \hat{\lambda}_t \Delta x \qquad (2)$$

$$\Delta l = l_t - l_{t-1} = \Delta\hat{\lambda} x_t + \hat{\lambda}_{t-1}\Delta x \quad (3)$$

The decompositions in (2) and (3) indicate that the change in labor (Δl) is the outcome of two effects, the change in the labor coefficient $\Delta\hat{\lambda}$ and the change in output Δx. When the change in the labor coefficient is negative, it means that labor use has been displaced by the use of other factors, that is, the displacement effect is the outcome of adopting labor-saving techniques. If the change in output is positive, compensates the displacement effect through a compensation effect that can be originated by changes in demand or supply.

In order to recognize the compensation effects that are originates in the demand and supply sides, the structural decompositions of output by demand and supply will be done. Considering that the changes in output come from the demand, the accounting identity is the following:

$$x_t = n_t + pc_t + gc_t + fkf_t + in_t + e_t - m_t \quad (4)$$

where: x_t is the column vector of output, n_t represents the vector of intermediate demand, pc_t is the vector of private consumption, gc_t is the vector of government consumption, fkf_t is the vector of fixed capital formation, in_t is the vector of changes in inventories, e_t is the vector of exports and m_t the vector of imports. When we assume that the output is produced using a linear technique by process, identity (4) can also be expressed as:

$$x_t = (I - A_t)^{-1}(pc_t + gc_t + fkf_t + i_t + e_t - m_t) \quad (5)$$

where A is the matrix of technical coefficients, Ax_t represents the vector of final intermediate demand n_t and $(I - A)^{-1}$ is the Leontief's inverse (L). The variations in output can be decomposed in the variations of each component of the final demand. Therefore, if we consider equation (5) for *t* and *t-1* the variation in output is $\Delta x = x_t - x_{t-1}$ and the two polar decompositions of output by demand are obtained:

$$\Delta x = \Delta L\, pc_{t-1} + L_t\Delta pc + \Delta L\, gc_{t-1} + L_t\Delta gc + \Delta L\, fkf_{t-1} + L_t\Delta fkf + \Delta L\, in_{t-1} + L_t\Delta in + \Delta L\, e_{t-1} + L_t\Delta e - \Delta L\, m_{t-1} - L_t\Delta m \quad (6)$$

$$\Delta x = \Delta L\ pc_t + L_{t-1}\Delta pc + \Delta L\ gc_t + L_{t-1}\Delta gc + \Delta L\ fkf_t + L_{t-1}\Delta fkf + \Delta L\ in_t$$
$$+L_{t-1}\Delta in + \Delta L\ e_t + L_{t-1}\Delta e - \Delta L\ m_t - L_{t-1}\Delta m \qquad (7)$$

Besides, it can be verified that the variation in the Leontief's matrix is $\Delta L = L_t - L_{t-1} = -L_{t-1}[L_t^{-1} - L_{t-1}^{-1}]\, L_t = L_{t-1}\Delta A\, L_t$. Substituting equations (6) and (7) in (2) and (3) it will be possible to obtain the decomposition of labor variations by the determining factors of demand.

Considering the fact that the structural decompositions are not unique, in several works it has been demonstrated that the average of all possible decompositions approximates to the average of the two polar decompositions (see Dietzenbacher and Los, 1998) that are obtained exchanging the periods of time. Thus the average decomposition of output by demand is shown in table 1 that shows that the variations in labor are the result of variation the labor coefficient and in each of the demand components.

Table 1. Decomposition of labor according to changes in demand

$\Delta l =$	$\frac{1}{2}\Delta\hat{\lambda}\,(x_{t-1} + x_t)$	Labor coefficient
	$+\frac{1}{2}(\hat{\lambda}_{t-1}L_t\Delta pc + \hat{\lambda}_t L_{t-1}\Delta pc)$	Private consumption
	$+\frac{1}{2}(\hat{\lambda}_{t-1}L_t\Delta gc + \hat{\lambda}_t L_{t-1}\Delta cg)$	Government consumption
	$+\frac{1}{2}(\hat{\lambda}_{t-1}L_t\Delta fkf + \hat{\lambda}_t L_{t-1}\Delta fkf)$	Fixed capital formation
	$+\frac{1}{2}(\hat{\lambda}_{t-1}L_t\Delta in + \hat{\lambda}_t L_{t-1}\Delta in)$	Changes in inventories
	$+\frac{1}{2}(\hat{\lambda}_{t-1}L_t\Delta e + \hat{\lambda}_t L_{t-1}\Delta e)$	Exports
	$-\frac{1}{2}\,(\hat{\lambda}_{t-1}\,L_t\Delta m + \hat{\lambda}_t\,L_{t-1}\Delta m)$	Imports
	$+\frac{1}{2}(\hat{\lambda}_{t-1}\,L_t\Delta A\,x_{t-1} + \hat{\lambda}_t\,L_{t-1}\Delta A\,x_t)$	Technical coefficients

If we now consider that the output is determined by supply factors, for practical purposes our model suffers a slight modification and becomes $l_t^{\prime} = \lambda_t^{\prime}\,\hat{x}_t$. The decompositions of this version of the model are:

$$\Delta l' = \; l'_t - l'_t = \lambda'_{t-1}\,\Delta\hat{x} + \Delta\lambda'\,\hat{x}_t \qquad (8)$$

$$\Delta l' = \; l'_t - l'_t = \lambda'_t\,\Delta\hat{x} + \Delta\lambda'\,\hat{x}_{t-1} \qquad (9)$$

When the changes in output come from the supply side, the accounting identity is

$$x'_t = cn'_t + ntgs'_t + w'_t + gos'_t + nto'_t \qquad (10)$$

where cn'_t represents the row vector or intermediate consumption, $ntgs'_t$ is the row vector of net taxes on goods and services, w'_t is the row vector of wages, gos'_t is the gross operating surplus and nto'_t are the net taxes on output.

Intermediate consumption cn'_t and wages w'_t can be written as the result of the parameters of the direct technological requirements of inputs and output, that is $cn'_t = \iota' A_t \hat{x}_t$ and $w'_t = \omega'_t \hat{l}_t = \omega'_t \hat{\lambda}_t \hat{x}_t$ where ω'_t is the row vector of unit wage. Replacing these expressions in the accounting identity given by (10) we obtain

$$x'_t = (\iota' A_t + \omega'_t \hat{\lambda}_t)\hat{x}_t + ntgs'_t + gos'_t + nto'_t \qquad (11)$$

post-multiplying both sides of equation (11) by $\hat{x}_t^{-1}$we get

$$\iota' = \iota' A_t + \omega'_t \hat{\lambda}_t + \; \tau\beta'_t + \gamma\sigma'_t + \tau\rho'_t \qquad (12)$$

where $\tau\beta'_t$ is the proportion of net taxes on goods and services per unit of output, $\gamma\sigma'_t$ is the proportion of the gross operating surplus per unit of output and $\tau\rho'_t$ is the proportion of net taxes on output per unit of output. Thus, the variation of equation (10) becomes:

$$0 = \Delta\iota' = \iota'\Delta A + \Delta(\omega'_t \hat{\lambda}_t) + \; \Delta\tau\beta' + \Delta\gamma\sigma' + \Delta\tau\rho'$$

where $\Delta\big(\omega'_t \hat{\lambda}_t\big)$ can be decomposed in two ways $\Delta\big(\omega'_t \hat{\lambda}_t\big) = \Delta\omega' \hat{\lambda}_{t-1} + \omega'_t \Delta\hat{\lambda}$ or in $\Delta\big(\omega'_t \hat{\lambda}_t\big) = \Delta\omega' \hat{\lambda}_t + \omega'_{t-1}\Delta\hat{\lambda}$ and as a result, there are two ways of expressing the variation of equation (12). Leaving in the left side of equations the coefficients $\omega'_t\Delta\hat{\lambda}$ or $\omega'_{t-1}\Delta\hat{\lambda}$ and post-multiplying each equation by $-\widehat{\omega}_t^{-1}$ or $-\widehat{\omega}_{t-1}^{-1}$ as the case may be, it is possible to obtain the two polar decompositions of $\Delta\lambda'$:

$$\Delta\lambda' = -\iota'\Delta A\widehat{\omega}_t^{-1} - \Delta\omega'\hat{\lambda}_{t-1}\widehat{\omega}_t^{-1} - \Delta\tau\beta'\widehat{\omega}_t^{-1} - \Delta\varepsilon\beta'\widehat{\omega}_t^{-1} - \Delta\tau\rho'\widehat{\omega}_t^{-1} \qquad (13)$$

$$\Delta\lambda' = -\iota'\Delta A\widehat{\omega}_{t-1}^{-1} - tc(\omega')\hat{\lambda}_t - \Delta\tau\beta'\widehat{\omega}_{t-1}^{-1} - \Delta\varepsilon\beta'\widehat{\omega}_{t-1}^{-1} - \Delta\tau\rho'\widehat{\omega}_{t-1}^{-1} \qquad (14)$$

Replacing equations (13) and (14) in (8) and (9), the two decompositions of labor are obtained, also by obtaining the average of each pair of coefficients it will be possible to disaggregate the variations of employment according to variations of supply as shown in table 2.

Table 2. Decomposition of labor according to changes in supply

$\Delta l' =$	$\frac{1}{2}(\lambda'_t \, \Delta\hat{x} + \lambda'_{t-1} \, \Delta\hat{x})$	Output
	$-\frac{1}{2}(\iota'\Delta A\widehat{\omega}_t^{-1}\hat{x}_{t-1} + \iota'\Delta A\widehat{\omega}_{t-1}^{-1}\hat{x}_t)$	Technical coefficients
	$-\frac{1}{2}(\Delta\omega'\hat{\lambda}_{t-1}\widehat{\omega}_t^{-1}\hat{x}_t + tc(\omega')\hat{\lambda}_t\hat{x}_t)$	Unit wage
	$-\frac{1}{2}(\Delta\tau\beta'\widehat{\omega}_t^{-1}\hat{x}_{t-1} + \Delta\tau\beta'\widehat{\omega}_{t-1}^{-1}\hat{x}_t)$	Net taxes on goods and services
	$-\frac{1}{2}(\Delta\gamma\sigma'\widehat{\omega}_t^{-1}\hat{x}_{t-1} + \Delta\gamma\sigma'\widehat{\omega}_{t-1}^{-1}\hat{x}_t)$	Gross operating surplus
	$-\frac{1}{2}(\Delta\tau\rho'\widehat{\omega}_t^{-1}\hat{x}_{t-1} + \Delta\tau\rho'\widehat{\omega}_{t-1}^{-1}\hat{x}_t)$	Net taxes on production

The analysis of structural decomposition of employment was made considering two pairs of matrices, in the first pair the Mexican matrices of 2003 and 2008 were considered; in the second pair matrices of 2008 and 2012 were utilized. While matrices of 2008 and 2012 where constructed considering prices of 2008 and quantities in millions of Mexican pesos, the matrix of 2003 was constructed at prices of 2003 in thousands of pesos. Thus matrix of 2003 had to be deflated and reported in millions in pesos, besides slight changes were also required, in appendix A we refer to the several changes that had to be made in all matrices.

Retaking the definitions of displacement and compensation effects considered in the theory of the technological unemployment, our goal is to obtain the magnitudes of each effect and thus determine if the technical change in the Mexican manufacturing sector has led to the generation or destruction of jobs, the table in appendix B shows the description and NAICS[8] code of the 21 manufacturing sectors.

[8] North American Industrial Classification.

Considering all the elements obtained in the structural decompositions of labor, the displacement effect is defined as the outcome of the displacement of workers generated by variations in the labor coefficients $a = \frac{1}{2}\Delta\hat{\lambda}\,(x_{t-1} + x_t)$ and by changes in the technical coefficients $b = \frac{1}{2}(\hat{\lambda}_{t-1}\,L_t\Delta A\,x_{t-1} + \hat{\lambda}_t\,L_{t-1}\Delta A\,x_t)$, thus the displacement effect is: $d = a + b$.

Only when the variations in a and b are negative, they will be considered in the computation of the displacement effect. If the variations are positive, they refer to the generation of jobs led by technical change, which is the opposite of what we are trying to quantify.

For its part, the compensation effect is the outcome of five compensation mechanisms, by means the decompositions of labor only three compensation mechanisms where obtained. The coefficient that refers to the variation of fixed capital formation will be defined as the compensation mechanisms of new machines $m = \frac{1}{2}(\hat{\lambda}_{t-1}L_t\Delta fkf + \hat{\lambda}_t L_{t-1}\Delta fkf)$, the mechanism of diminution of wages is denoted by the coefficient of variation in wages $p = -\frac{1}{2}(\Delta\omega'\hat{\lambda}_{t-1}\widehat{\omega}_t^{-1}\hat{x}_t + tc(\omega')\hat{\lambda}_t\hat{x}_t)$, as the theoretical causal relationship between the unit wage and labor is negative, so is p. And finally the mechanism of new investments is denoted by the coefficient of variation in the gross operating surplus $q = \frac{1}{2}(\Delta\gamma\sigma'\widehat{\omega}_t^{-1}\hat{x}_{t-1} + \Delta\gamma\sigma'\widehat{\omega}_{t-1}^{-1}\hat{x}_t)$, considering to the accounting of institutional sectors it was possible to identify the proportion of the gross operating surplus that was generated by the non-financial corporations and that was re-invested. Between 2003 and 2008, the 60.35%[9] of the gross operating surplus was re-invested and between 2008 and 2012 the 62.88%[10] was re-invested. Thus the compensation mechanisms is defined as: $c = m + p + q$ and as a result, the net effect is $n = d + c$.

[9] Between 2003 and 2008 the 75.73% of the gross operating surplus was generated by the non-financial corporations, and from the gross operating surplus of the non-financial corporations the 79.70% was reinvested (INEGI, 2014)

[10] Between 2008 and 2012 the 77.86% of the gross operating surplus was generated by the non-financial corporations, and from the gross operating surplus of the non-financial corporations the 80.76% was reinvested (INEGI, 2014)

4. Technological unemployment in the Mexican manufacturing sector 2003-2012

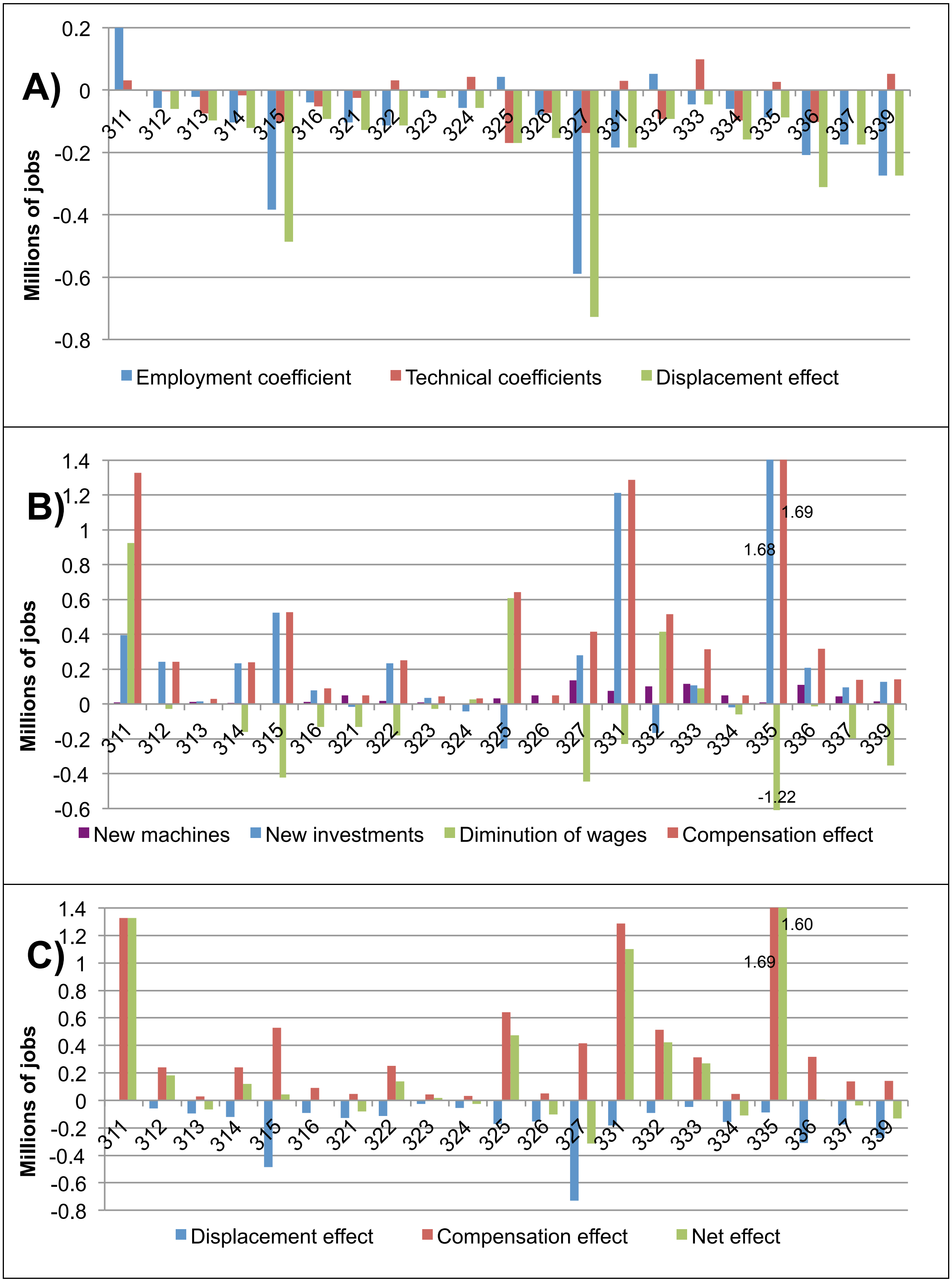
By means of the structural decompositions of employment form the demand and supply sides, it was possible to obtain the magnitudes of the displacement, compensation and net effects between 2003 and 2008 for the 21 subsectors of the Mexican manufacturing sector, the results are shown in graph 1, in panel a) the displacement effect is disaggregated, panel b) shows the components of the compensation effect and in panel c) the displacement and compensation effects are combined in order to obtain the net effect.

As shown in panel c) of graph 1, there are several subsectors in which the net effect turned out to be positive. This is the case of subsectors (311)[11] and (325) in which the significant diminution of wages encouraged the use of labor. The subsectors in which capital goods are produced also reported positive net effects, i.e. sectors (331), (332), (333) and (335) reveal the functioning of the mechanism of new machines through which the subsectors producers of capital goods reabsorb the displaced workers from other industries. There were some of the subsectors related to the textile industry, in which the use of labor is intensive, that also reported positive net effects such as (314), (315) and (316), in this case the new investments originated by the high gross operating surpluses, led to high compensation effects.

Regarding to the subsectors in which the net effect was negative, we find that the fabrication of non-metallic minerals (327) and electrical and electronic equipment (334) are activities in which the negative net effect was caused to a large extent by the technical change but also by the intensive use of labor, also the low capacity of the compensation mechanisms to generate jobs aggravated the negative net effects in such subsectors. The sectors that between 2003 and 2008 reported the higher negative net effects were subsectors (327) with 0.31 millions of displaced workers and (324) with 0.11 millions.

[11] See table in appendix B for the description of the industrial classification.

Graph 1. Displacement, compensation and net effects 2003-2008



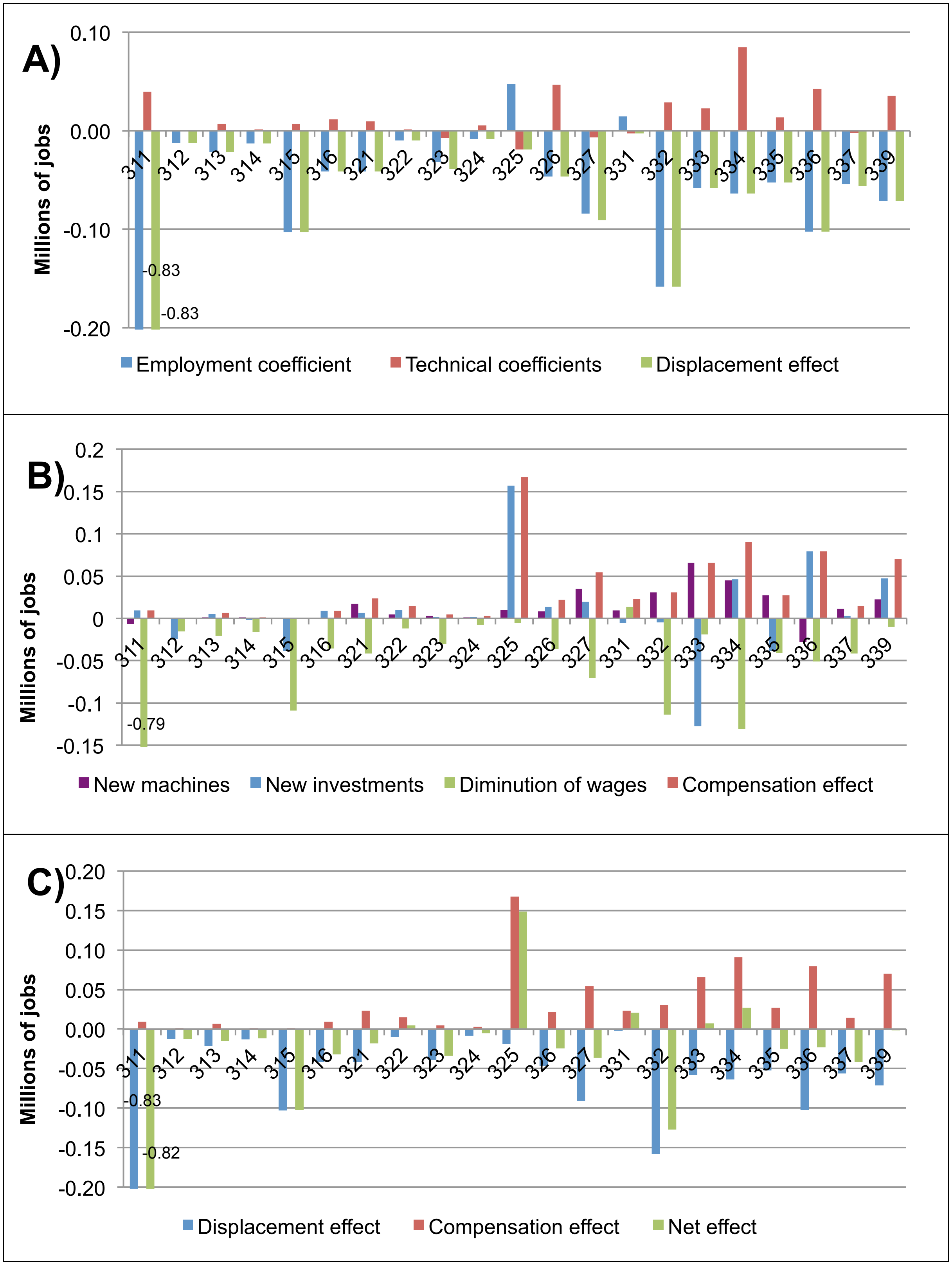
Source: Own estimates with I-O data from INEGI (2016)

Unlike the results obtained for 2003-2008, in 2008-2012 only five out of the twenty-one manufacturing subsectors reported positive net effects (see graph 2); the paper industry (322), the chemical industry (325), basic metals (331), machinery and equipment (333) and (334) electronic equipment, and the magnitudes of such positive net effects are considerably smaller than those between 2003-2008. Besides it can also be seen that the main reason why the majority of the subsectors reported negative net effects is that the capacity of the compensation mechanisms to generate jobs decreased considerably. For instance, the compensation mechanism of new machines was almost null in the majority of the capital goods sectors; this confirms the negative effect that the crisis of 2009 had in investment demand. Another interesting feature is the fact that between 2008 and 2012 the unit wage in all manufacturing subsectors except for (331) increased, fact that reduces the incentives to demand higher levels of labor. Besides there were some sectors in which the gross operating surplus suffered a significant diminution and that reduced the capacity to invest and thus generate jobs.

The subsectors in which the negative net effect was greater were (311), (332), and (315). In the case of the food industry (311) the technical change led to a very high displacement effect and given the almost null compensation effect, the net effect became very negative. This time, all the subsectors related to the textile industry such as (315), (313), (314) and (316) reported high displacement effects and they are characterized by the intensive use of labor. The negative net effect in transport equipment subsector (336) was determined by the variations in the technical coefficients that led to a high displacement effect but an interesting fact in this subsector is that investment demand decreased considerably and caused the displacement effect and thus a very small compensation effect.

The subsectors in which the negative effect was higher were (311) with 0.83 millions of displaced workers, (332) with 0.13 millions and (315) with 0.10 millions.

Graph 2. Displacement, compensation and net effects 2008-2012



Source: Own estimates with I-O data from INEGI (2016)

5. Conclusions

The technological unemployment is the unemployment caused by the incorporation of new means of production that economize the use of employment. According to classical economics there are several mechanisms that offset the negative effect that the technical change has on employment.

Between 2003 and 2008, the capacity of the compensation mechanisms to offset the displacement effect worked efficiently in the majority of the manufacturing sectors. Eleven out of the twenty-one manufacturing subsectors reported positive net effects; specifically we found that even when the displacement effects were high in some subsectors, for example in the labor-intensive ones, the compensation mechanisms were high enough to generate positive net effects. The compensation mechanism that significantly contributed to the compensation effect was the gross operating surplus registered in this period; also the subsectors in which the capital goods are produced showed positive net effects.

Furthermore, between 2008 and 2012 the compensation mechanisms decreased their capacity to generate new jobs, fact that caused negative net effects in sixteen out of twenty-one manufacturing subsectors, in particular, the diminution in investment demand and the increase in wages experienced in this period, has been translated into very low compensation mechanisms.

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Appendix A. Data handling

There were some differences between the matrix of 2003 and those of 2008 and 2012. To begin with, the matrix of 2003 was built according to NAICS 2003 while the other two were built according to NAICS 2007. The main differences at the level of disaggregation of 79 subsectors were found and eliminated as shown in table A.1. As the result of the standardization, the input-output matrices now consist of 78 subsectors.

Table A.1 Differences and standardization of NAICS 2003 and 2007

NAICS 2003	NAICS 2007	Standardization
516 Creation and diffusion of content through internet **517** Other telecommunications	**517** Other telecommunications	**517** Other telecommunications
931 Government activities	**931** Government activities **932** International and extraterritorial organisms	**931** Government activities and international and extraterritorial activities

Another important difference between matrix of 2003 and the other two is that the first one reports quantities in prices of 2003 while the other two are at prices of 2008. Therefore, the deflation of the input-output table of 2003 was made considering the method of the double deflation, the deflation of the Z matrix of 2003 was made considering the intermediate demand price index $z^b = \hat{\pi}^t z^t$, the final demand and output was deflated utilizing the output price index $f^b = \hat{\pi}^t f^t$, $x^b = \hat{\pi}^t x^t$. And thus the value added was obtained by difference $(v^b)' = (x^b) - i' z^b$. Finally all entries of the input-output table of 2003 had to be multiplied by 0.001 since matrices of 2008 and 2012 are constructed at thousands of pesos and the matrix of 2003 in millions of pesos

Appendix B. NAICS classification

NAICS	Description	NAICS	Description
311	Food	**326**	Rubber and Plastics
312	Beverages and Tobacco	**327**	Other Non-Metallic Mineral
313	Textile inputs	**331**	Basic Metals
314	Textile products except from clothing	**332**	Fabricated Metal
315	Clothing production	**333**	Machinery and Equipment
316	Leather	**334**	Electrical and Electronic Equipment
321	Wood	**335**	Electrical and Electronic Accessories
322	Paper	**336**	Transport Equipment Production
323	Printing	**337**	Furniture, Mattress and Shutter
324	Products derived from Oil and Coal	**339**	Other Manufacturing industries
325	Chemical Industry		