DOES DIVERSIFICATION CONES SIGNS FOR REDUCTIONS IN BRAZILIAN WAGE INEQUALITY? A REGIONAL APPLICATION TO THE HECKSCHER-OHLIN MODEL

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Abstract

Through a diversification cone model, this article seeks to highlight the changes in wages between workers in manufacturing industries for the Northeast and Southeast regions of Brazil. To establish the model of cones we used data of labor, capital and product in 1997 and 2007 from the Annual Survey of Industry - PIA / IBGE. The analysis was performed with 27 industries and 19 federal units of manufactured good. The overall objective is to locate the positions of states in the Northeast compared to other states that have similarities in factor endowments. With appropriate specifications, both wage changes between the regions are explained as the effects of trade on the salaries of factors must be provided. The findings lead us to the model of Romer (1986), in the sense that growth can be generated from increases in physical capital.

Key words : Paths of development, Diversification cones, Wage inequality

The Heckscher and Ohlin's theory is that countries export goods that use inputs in the production that it has in abundance and import the rest. Here this theory is discussed in a regional sense, taking into account the the states of Brazil. Motivation came from the model developed by Davis (1996), where the author advocates the use of cones of diversification to identify changes in patterns of income. For cones of diversification he meant the area in terms of geometric factors of production where the equality of factor prices occurs. We develop here an empirical work in order to test the Davis (1996) model and point out that the wage impact of the Brazilian Northeast states would suffer as a result of interstate commerce.

In the purpose to find relationships that intertwine theory and empirical data, we propose to compare the factor endowments of each state within its own cone. The objective is to identify cones of diversification and thus describe the trajectory of development of the industries under review. We took as a model an economy in three sectors and two production inputs. Through regression method SUR (Seemingly Unrelated Regressions) with data in cross-section, we estimated three production functions and one wage equation. These equations were constructed with the method of Schott (2003) clusters of Heckscher and Ohlin[1]. The data used included labor, capital and production of twenty-seven federal units and nineteen industries. The production functions are modeled *à la Leontief* to deal with the adjustment of wages. We question that not all states in the Northeast are in the same cone so there are wage differences

[1] Details will be described by the methodology.

even among the northeastern states. In addition, we investigate how trade should affect the wage level, is increasing or decreasing as states intensify their business relationship.

First section will have a literature review, followed by the methodology, results from regression and at last, conclusions.

1. Review on Diversification Cones

Davis (1996) argues that for the theorem of Stolper and Samuelson to become observable in empirical work, it should not be guided only by the factor endowments of a region relative to the other, but it should be driven, however, by the relative allocations of a region only compared with the others who have similar endowments. To identify these groups the author uses the concept of diversification cones. He explains that the factor endowments between countries suppress the equality of factor prices[2]. Therefore, since equality is not guaranteed, it can happen the formation of more than one cone of diversification. In other words, it is not possible to draw a single line of isocost that touches the isoquants of industries for all regions examined. Soon it will be necessary more than one isocost line, it means not only one cone of diversification.

According to Davis and Weinstein (2001), when working with the hypothesis of more than one cone, it is possible to identify the validity of the Heckscher and Ohlin theorem empirically. Although there are studies that model economies as a single cone, as in Trefle (1995), since Davis and Weinstein (2001)[3] articles that shape the economy over a cone gained greater visibility. Although articles with multiple cones are still few in the world and scarce in Brazil. Among these we may cite Demiroglu and Debaere (2003), who estimate an empirical model based on Deardorff's lens condition[4]. These authors use data on capital, labor and production from UNIDO and the Penn World Table for twenty-eight countries and twenty-eight sectors. The analysis is done for the year 1990 and the authors estimate the capital data using the perpetual inventory method, with fifteen years of observations of gross fixed capital formation and depreciation rate of 13.3% for all countries. With this, the authors confirm that developed and developing countries are not in the same cone, while the OECD countries are in the same cone. The reason is that the endowments for all countries in the analysis are very different to allow for equality of factor price, for the set of all countries. However, among the OECD countries is possible to notice a certain similarity in endowments, which allows them to line up and belonging to the same cone.

Another work in this area is that of Xiang (2007), which uses a model with capital and labor data from Davis and Weinstein (2001), for a non-parametric estimation. It takes as sample, ten OECD countries to conclude that they would form three cones of diversification. The author has achieved this result by estimating the cumulative density functions of each country and compared them pairwise. Next, observed the existence of a standard stochastic dominance for each pair, and when unable to determine a dominant cdf, they concluded that the country relating thereto was located in a cone

[2] Levisohn and Leamer (1995b) lead to change the term equalization for equality. Because it is a consequence rather than a process.
[3] An exception to previous work will Davis and Weinstein (2001) hypothesize that as the economy entered into a model of multiple cones is Leamer (1987).
[4] The model of Deardorff lens brings a different approach to analyze our cones of diversification. For details, see Deardorff (1994).

with a higher rate of labor for capital. When the absence of such dominance, concluded that the country belonged to the same cone.

Schott (2003), based on Leamer (1987), used data on capital, labor and production, respectively, from Maskus (1991), World Bank and UNIDO[5], to assess whether countries are located in more than one cone of diversification in the year 1990. The author evaluates statistics tests to find that the sample countries are divided into two cones only. Countries may be in the cone that uses intensively the labor input or the cone that uses intensively the capital input. According to Schott (2003) countries should always be within some of these and never between two cones or outside. This configuration comes from the assumption that technologies are Leontief type.

We wonder if a model of two cones is able to explain wage changes between the regions of the country, so as for the effects of trade on wages and therefore on the distribution of income. A good question to ask ourselves is: are all the states that comprise Northeast region of Brazil located in a different cone of the Southeast states?

2. Methodology

2.1 Data

To establish the model of cones we used Brazilian economy data of labor, capital and product in 1997 and 2007 from the Annual Survey of Industry - PIA / IBGE. The analysis was performed with 27 industries and 19 federal units of manufactured goods[6]. The variable value of manufacturing was used as a proxy for capital data, after being reduced wages of labor from it.

2.2 Econometric Model

Here we follow the work of Schott (2003) and Kiyota (2008), to define the model of two cones[7] based on the Heckscher-Olhin model of two inputs, three products and n countries. Spline functions are used to incorporate the restrictions that valid the model. These restrictions stem from the need of the lines that define the cones cross the point of maximum profit for the industry. As Schott (2003) noted initially and Kiyota (2008) confirmed that there are problems of heterogeneity in the model by taking the regression based on industrial classification according to intended use of the products. It would be a misunderstanding if we considere that all products that have the same intended use, regardless of where they are produced, have the same quality[8]. We use, therefore, the definition developed by Schott (2003) of Heckscher Olhin (HO) aggregates. Thus, goods are grouped, not according to intended use, but according to the intensity of use of capital input. For this to be possible, define the variable

[5] United Nations Industrial Development Organization.
[6] Industries: Food and Beverages, Tobacco, Clothing, Textiles, Wood, Paper, Print, Fuel, Chemicals, Rubber, non-metallic minerals, basic metals, fabricated metal, machinery, electronics, medical instruments, vehicles, furniture and recycling.
[7] We assume that our model is formed only by two cones.
[8] By quality, we define the intensity of use of capital input for the production of good. The higher the quality, the more intense use of capital input in the production of good.

$$k_{is} = \frac{K_{is}}{L_{is}} \qquad (1)$$

as the rate of labor for capital to **i** industry in **s** state.

To establish the two cone equilibrium it is necessary to form three aggregates, since the number of cones is the number of clusters minus one[9]. Soon, we define three clusters called:

- **Aggregate HO-1**, the one that makes intensive use of labor input
- **Aggregate HO-2**, the one that makes intermediate use of capital input
- **Aggregate HO-3**, the one that makes intensive use of capital input

Once all k_{is} rates are calculated for the 19 industries of the twenty seven federal units, intervals of separation $h_1\ and\ h_2$ are defined for HO aggregates as follows:

$$\begin{cases} \mathrm{k_{is}} < \mathrm{h_1} \Rightarrow \text{Industry } \mathbf{i} \text{ from the } \mathbf{s} \text{ state will belong to aggregate } \mathrm{HO-1} \\ \mathrm{h_1} \leq \mathrm{k_{is}} \leq \mathrm{h_2} \Rightarrow \text{Industry } \mathbf{i} \text{ from the } \mathbf{s} \text{ state will belong to aggregate } \mathrm{HO-2} \\ \mathrm{k_{is}} > \mathrm{h_2} \Rightarrow \text{Industry } \mathbf{i} \text{ from the } \mathbf{s} \text{ state will belong to aggregate } \mathrm{HO-3} \end{cases}$$

With this classification, three aggregates are formed. When a state has more than one industry in a certain aggregate, we added the production of all industries in that state to form its production data for the aggregate. After we set the intervals that make up the aggregates, we define also the cones that separate them, considering the estimated levels of capital for labor in the country, denoted by:

$$k_s = \frac{K_s}{L_s} \qquad (2)$$

The regression equations come from spline functions, and therefore dummy variables are incorporated into the model[10]. In order of increasing use of labor for capital, we use the following regression equations for aggregates:

$$y_{1c} = \beta_1(k_c - t_1)d_1 + \varepsilon_{1c} \qquad (3)$$

$$y_{2c} = \beta_2\left[k_c d_1 + \frac{t_1}{(t_1 - t_2)}(k_c - t_2)d_2\right] + \varepsilon_{2c} \qquad (4)$$

$$y_{3c} = \beta_3(k_c - t_1)d_2 + \varepsilon_{3c} \qquad (5)$$

$$w_s = -\beta_1(t_1)d_1 + \frac{1}{(t_2 - t_1)}\{\beta_3(t_2 - t_1) - \beta_2 t_1\}d_2 + \varepsilon_{4s} \qquad (6)$$

knots t_1 e t_2 will take as value:

$t_1 = 2300$ e $t_2 = 77000$, in 1997

$t_1 = 6300$ e $t_2 = 149800$, in 2007

[9] See Feenstra (2004)

[10] For further information see Greene (2003) pages 121 to 122.

To choose the optimal values of $t_1, t_2 \; e \; h_1, h_2$ we used Akaike[11] criterion.

The dummy variables take the values:

$$d_1 = 1, if \; t_0 < k_c \leq t_1$$
$$d_1 = 0, \quad otherwise$$
$$d_2 = 1, if \; t_1 < k_c \leq t_2$$
$$d_2 = 0, \quad otherwise$$

With $t_0 = 0$.

5. Results

Once k_{is} rates were defined, we organized the data so that the equations (3) - (6) were estimated. The initial question was on the effectiveness of the model in explaining salary variations between the Northeast and Southeast. Tables 1 and 2 show the results of the regressions and the t test statistics, we discard the hypothesis that the coefficients are zero. This means that states are not grouped within a single cone, but in two.

The coefficients β_1 and $\beta_2 \, and \; \beta_3$ indicate the slopes of the trajectories of development[12] of clusters HO-1, HO-2 and HO-3, respectively; denoted in the figures (1) - (6). The states are grouped into two cones, according to figures (7) and (8). We nominate southern cone the figure formed by the axes $t_0 0 t_1$ and north cone figure formed by the axes $t_1 0 t_2$.

Since it is possible to allocate the states of Brazil in a model of two cones, we asked if all the Northeastern states are in the same cone. Figures (7) and (8) show that both for the year 1997 as the year 2007, all states in the Northeast are located in the southern cone except the State of Bahia. Together with the Southeastern states, Bahia state is located in the northern cone. This result is not strange and corroborates the macroeconomic data. According to the IBGE[13] only Bahia is responsible for 31.2% of GDP per capita in the Northeast. The northeastern states that have more similar performance in share of GDP is Pernambuco (18.8%) and Ceará (15.8%).

Observe the participation of states in gross value added of the brazilian manufacturing industry[14], the state of Bahia accounts for 2.8 and 3.4% in 1997 and 2007, respectively. If the differences in product volume and value added of Bahia are eye popping compared to other northeastern states, what about the differences of numbers between São Paulo state and the rest of the country. The latter state has a percentage of 47% and 44% in the share of value added of manufacturing industry of Brazil for the years 1997 and 2007, respectively. That is, a single state makes up nearly half of all industrial production in the country. Figures 7 and 8 shows that this is a fact proven by the results of this paper. The distance from Sao Paulo to all other states of the cone model is so large that it could be treated as another country.

In contrast, most of northeastern states are justaposed in an aggregate almost at the bottom of the Southern Cone. Pernambuco and Ceará are the Northeastern states more

[11] This criterion returns a value for each regression model, generated with the different nodes. At the end of the model that returns the lowest AIC value should be chosen.
[12] By development path it is defined only the accumulation of capital and everything else remained constant, according to Leamer (1987).
[13] For details see table 3.
[14] According to table 4.

closely in the appropriations of the southeastern states. These states had performance similar in gross value added of Espirito Santo state. In a comparative analysis of figure 7 and 8, we see that both Pernambuco and Ceara, walk north toward the cone.

It can be seen in figure 8A (which is only a zoom of Figure 8), the Southern Cone was also divided into three regions marked with the characters - and 0 +. Being in the area marked with zero (or null zone) means, according to Davis (1996), states that the sample did not suffer losses or gains of trade. That is, in this case the wages of workers in industries not change due to trade for that year of analysis. Fits this case the states of Maranhão, Pernambuco and Ceará. Similarly, in the area marked with a plus sign are the states that have expanded the wages due to the increase of trade between states. The beneficiaries would be the northeast: Alagoas, Paraiba, Rio Grande do Norte, Sergipe and Piaui.

As for the wage differences between regions, there are figures 9 and 10. The lower dotted lines represent the average annual salaries of the states of the Southern Cone and the lines above, the average wages of the cone north to the respective years. In 1997 and 2007 the average monthly wage in the states of the Southern Cone were R $, and $ 390.55, 482.90, while the northern states of the cone R $, and $ 849.67, 992.41 respectively.
The annual salary range between the cones at constant prices of 2007, 1997 and 2007[15], was R $, and $ 10,776.00: 6,114.00 in order. In other words, there was according to the model cones 56.73% a reduction of disparities in wages between the cones in the ten years of analysis. This is in line with income figures calculated for Brazil in this period. The Gini coefficient in this period was downward trend falling from 0.6 in 1997 to 0.55 in 2007. In fact the period of this study was lucky for the reduction of income inequalities. Purpose of this paper is not to explain the reason for this reduction, but may be cited Gasparini and Lustig (2011) and Barros et al. (2010). These authors indicate that 40 to 50% of the decline in inequality is explained by changes in autonomous income distribution (mainly public transfers like Family Allowance and Countinous Cash Benefit). While 31 to 46% reduction of income inequality is given to labor income growth, which more specifically dealt with in this article. The factors that led to increased income from work were: the fall of the skill (Skill Premium) given a combination of demand and supply factors, the reduction of sectoral and spatial segmentation of the labor.

6. Conclusions

This work developed an empirical model of two cones of diversification, with two samples in cross section for the twenty-seven federal units in Brazil and nineteen manufacturing industries in 1997 and 2007. It described a model that was based on the theory and Heckscher Olhin and through the estimated development paths by the SUR method we verified: the validity of the model for the Northeast and Southeast, the impact on wages from interstate trade and also variations in income between the cones. We concluded that the model of two cones is valid for the northeast and southeast, but the state of Bahia is the only one which does not obey to the southern cone specifications, and is located in northern cone along with all states in Southeast Brazil. About income variations we come to the conclusion that there was a reduction in work income inequality between the northeastern and southeastern of Brazil during the period

[15] It was Inflated by the INPC index.

of analysis. For the northeastern states that are located in the southern cone an increase of trade would generate increase of wage (keeping everything else constant) for employees of Alagoas, Paraiba, Rio Grande do Norte, Sergipe and Piaui. From the other sise, Pernambuco, Ceará and Maranhão are in the neutral zone for the effects of trade. It means that no gain in wages would occur from trade operations. To increase the income of workers in these states we suggest, just like the conclusion of Romer (1986), that more investments until the rate of capital for labor rises to the point of these states to be located in the positive area of north cone, where the relation flow of trade and wages is increasing.

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Table 1. Regression Model Results – Year 1997

Estimation Method*: Seemingly Unrelated Regression*

Software: Eviews 5

Number of observations: 97

	Coefficient	T Statistics	P Value
$\boldsymbol{\beta_1}$	-0,401	-7,122	0,0000
$\boldsymbol{\beta_2}$	1,047	8,195	0,0000
$\boldsymbol{\beta_3}$	2,946	6,058	0,0000

Table 2. Regression Model Results – Year 2007

Estimation Method*: Seemingly Unrelated Regression*

Software: Eviews5

Number of observations: 104

	Coefficient	T Statistics	P Value
$\boldsymbol{\beta_1}$	-0,192	-7,894	0,0000
$\boldsymbol{\beta_2}$	1,656	8,786	0,0000
$\boldsymbol{\beta_3}$	3,907	11,370	0,0000

Table 3. Percentage Composition of Northeastern States GDP Northeastern States ans relation Northeast / Brazil - 1997 and 2007

Regions / States	1997	2007
Maranhão	7,9	9,1
Piauí	4,0	4,1
Ceará	15,8	14,5
Rio Grande do Norte	6,1	6,6
Paraíba	6,2	6,4
Pernambuco	18,8	17,9
Alagoas	5,3	5,1
Sergipe	4,6	4,9
Bahia	31,2	31,5
TOTAL NE	100,0	100,0
NE/BR	12,5	13,1

Source: IBGE

Table 4. Participation of the Northeast and Southeast states in brazilian's Gross Value Added at basic prices of manufacturing industry - 1997 and 2007

Regions / States	Anos	Anos
Regiões / Estados	1997	2007
NORDESTE	8,3	8,8
Maranhão	0,4	0,6
Piauí	0,2	0,2
Ceará	1,5	1,4
Rio Grande do Norte	0,4	0,4
Paraíba	0,4	0,5
Pernambuco	1,6	1,5
Alagoas	0,5	0,5
Sergipe	0,5	0,4
Bahia	2,8	3,4
SUDESTE	64,1	62,8
Minas Gerais	9,4	10,0
Espírito Santo	1,4	1,9
Rio de Janeiro	6,3	6,5
São Paulo	47,0	44,4

Source: IBGE

Figure 1. Estimated development path of the aggregate HO-1 for the year 1997

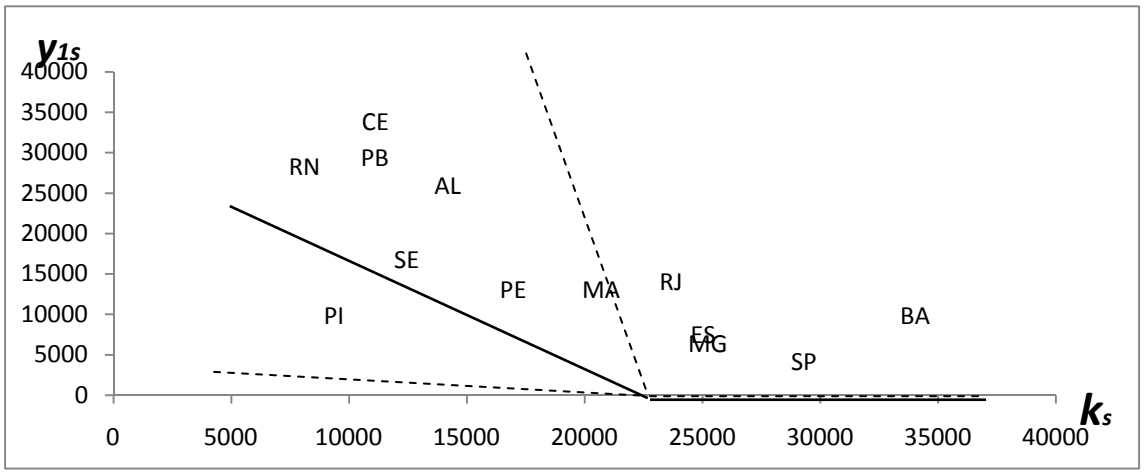

Figure 2. Estimated development path of the aggregate HO-2 for the year 1997

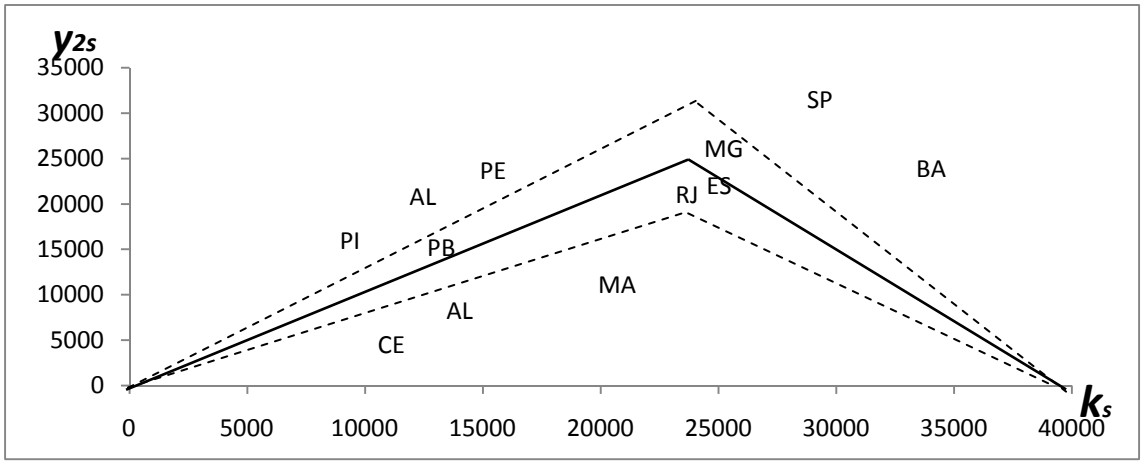

Figure 3. Estimated development path of the aggregate HO-3 for the year 1997

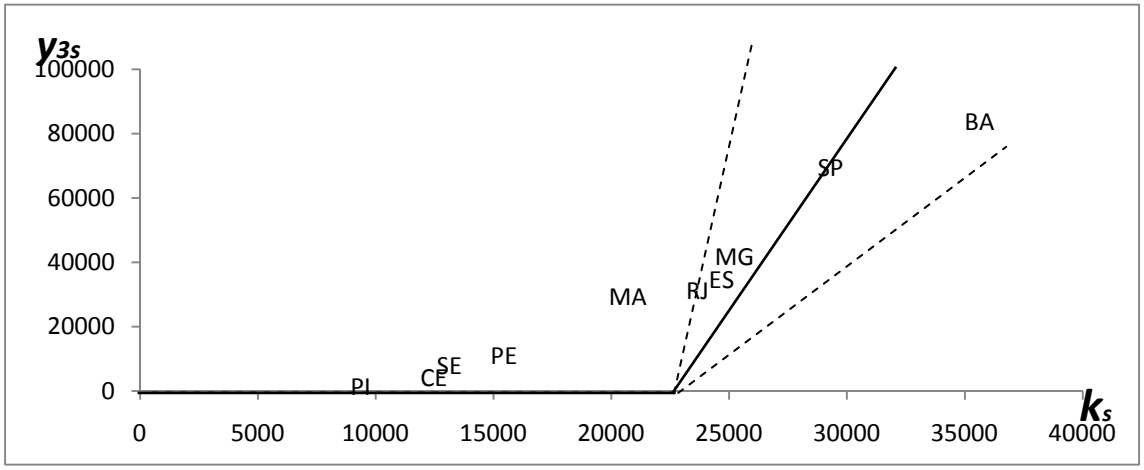

Figure 4. Estimated development path of the aggregate HO-1 for the year 2007

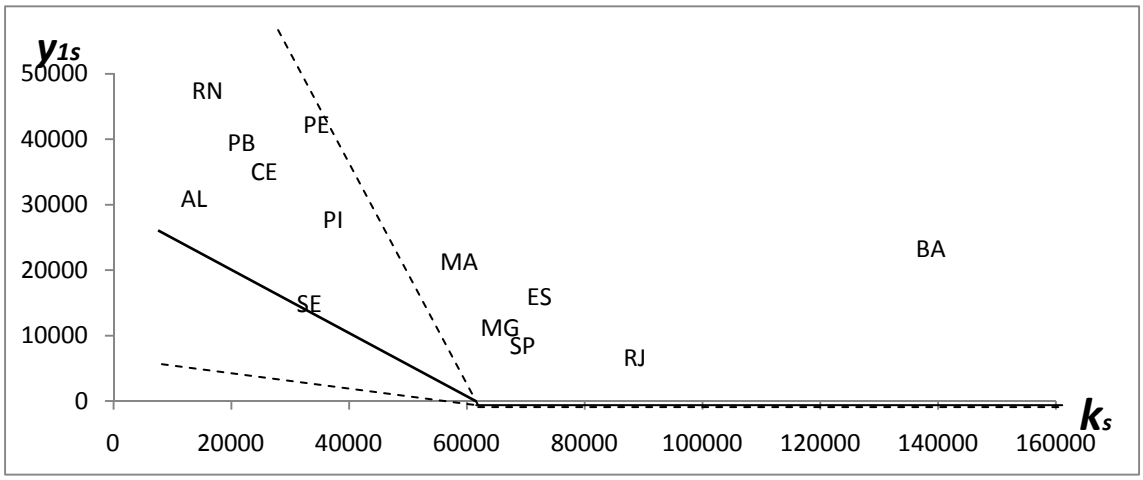

Figure 5. Estimated development path of the aggregate HO-2 for the year 2007

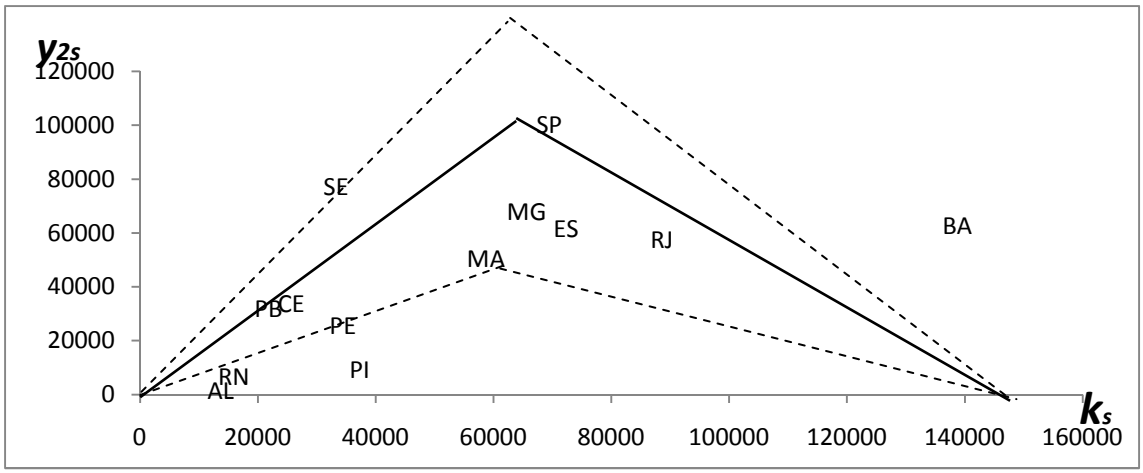

Figure 6. Estimated development path of the aggregate HO-3 for the year 2007

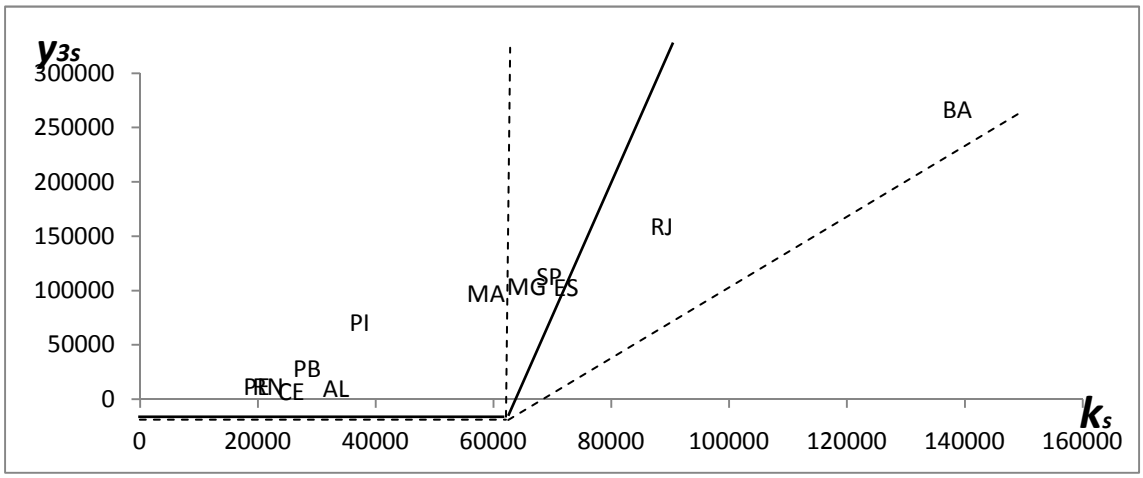

Figure 7 - Empirical model of diversification cones (values in hundreds of thousands of units) for the year 1997

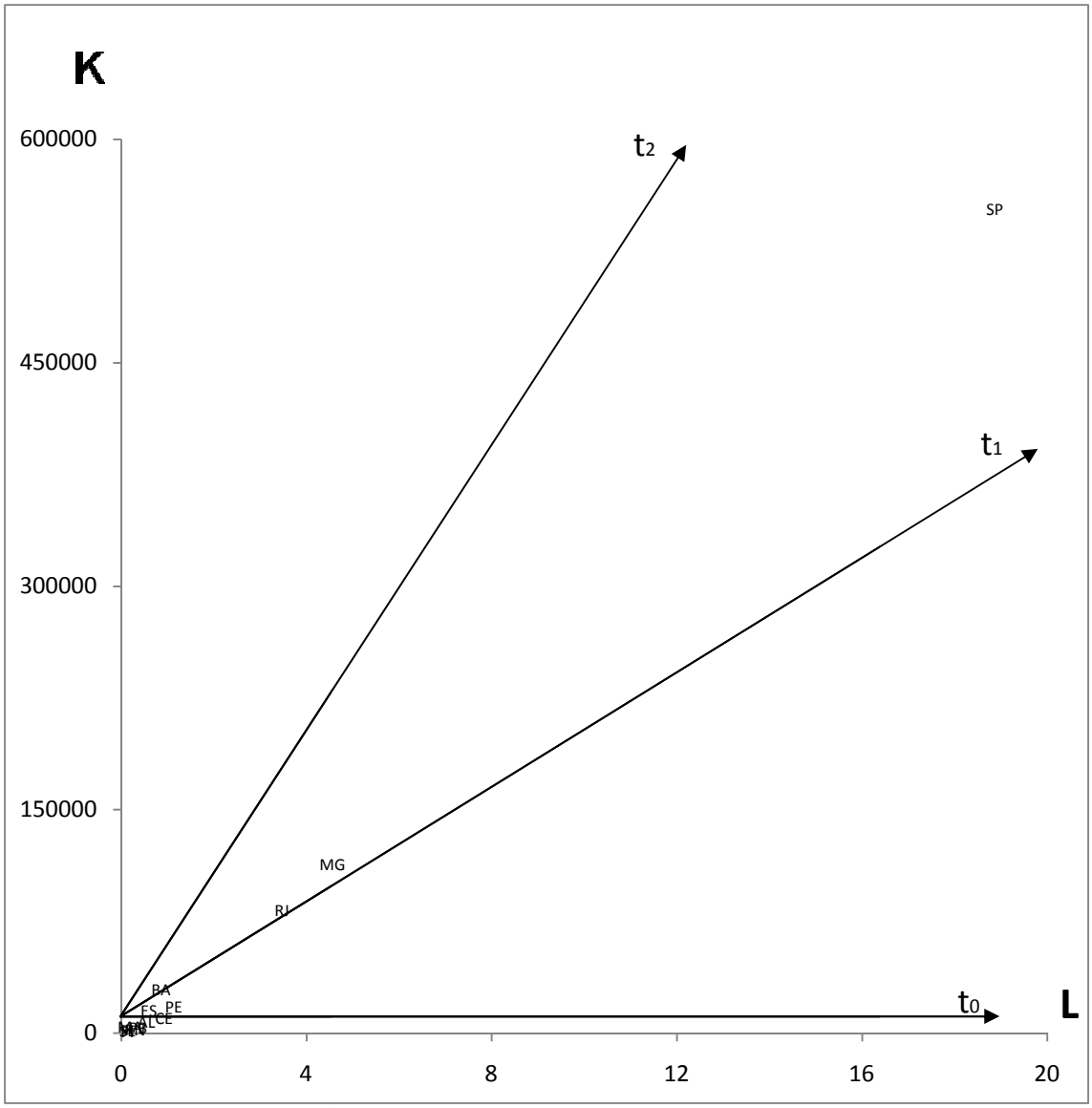

Figure 8 - Empirical model of diversification cones (values in hundreds of thousands of units) for the year 2007

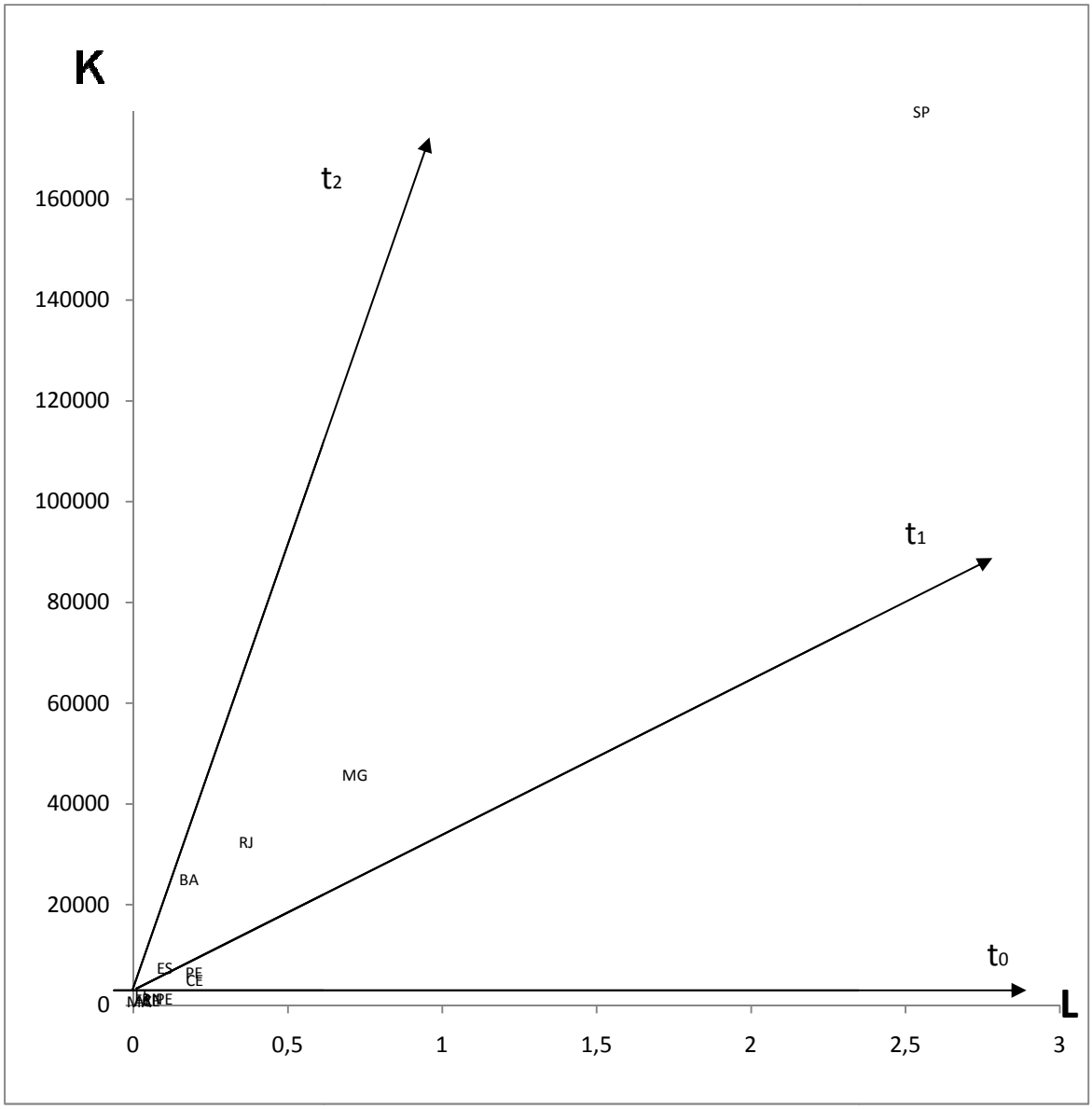

Figure 8A - Empirical model of diversification cones (amounts in millions of units) for the year 2007

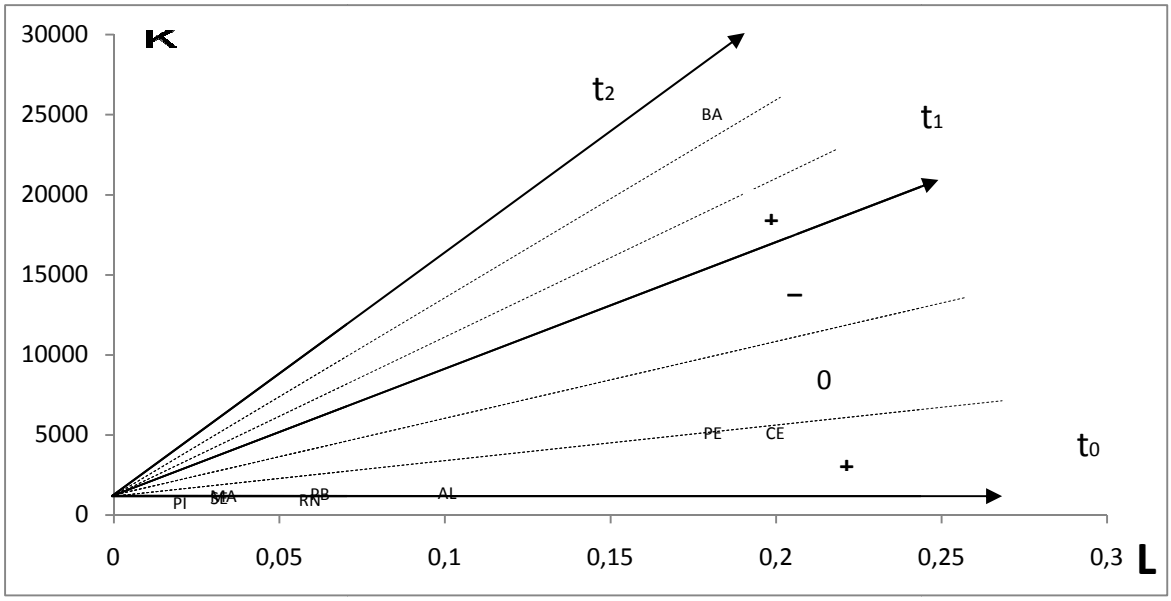

Figure 9. Nominal annual salary variation between cones (in Real) for the year 1997

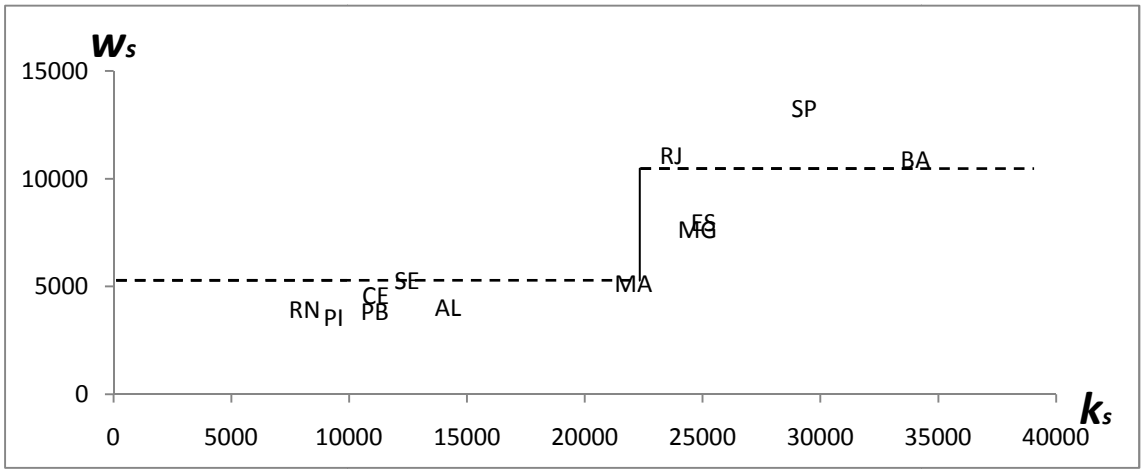

Figure 10. Nominal annual salary variation between cones (in Real) for the year 2007