

# **APPLICATION OF SPC AND GROWTH MODELS ON THE ECONOMIC TRAJECTORY OF THE LEATHER AND FOOTWEAR INDUSTRY**

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## **ABSTRACT**

The paper shows the relation among the number of small, medium, and large companies in the leather and footwear industry in Croatia, as well as the relationship among the number of their employees by means of the Spearman and Pearson correlation coefficient. The data were collected during 21 years. The warning zone and the risk zone were determined by means of the Statistical Process Control (SPC) for a certain number of small, medium, and large companies in the leather and footwear industry in Croatia. Growth models, based on externalities, models based on research and development and the AK models were applied for the analysis of the obtained research results.

The paper shows using the correlation coefficients that The relation between the number of large companies and their number of employees is the strongest, i.e. large companies have the best-structured workplaces. The relation between the number of medium companies and the number of their employees is a bit weaker, while there is no relation in small companies. This is best described by growth models based on externalities, in which growth generates the increase in human capital, i.e. the growth of the level of knowledge and skills in the entire economy, but also deductively in companies on a microeconomic level. These models also recognize the limitations of accumulated knowledge after which growth may be expected. The absence of growth in small companies results from an insufficient level of human capital and failure to reach its limit level which could generate growth.

According to Statistical Process Control (SPC), control charts, as well as regression models, it is clear that the most cost-effective investment is the investment into medium companies. The paper demonstrates the disadvantages in small, medium, and large companies in the leather and footwear industry in Croatia. Small companies often emerge too quickly and disappear too easily owing to the employment of administrative staff instead of professional production staff. As the models emphasize, companies need to invest into their employees and employ good production staff. Investment and support to the medium companies not only strengthens the companies which have a well-arranged technological process and a good systematization of workplaces, but this

also helps large companies, as there is a strong correlation between the number of medium and large companies.

**Keywords:** *control chart, warning zone, risk zone*

## **INTRODUCTION**

The leather and footwear industry participates in the Croatian processing industry with 1.22% companies, 3.89% employees and 1.84% revenue (Croatian Chamber of Economy, 2016). The main characteristic is labour intensiveness, export character, insufficient investment in technologies and high regional concentration (75% of companies are located in the Northwest of Croatia). The domination of small companies is also evident, 93.8% of companies have less than 50 employees, but, on the other side, less than 10% of the companies are employing more than 90% of the employees. Tendency noticed is also that number of employees in middle and large companies is constantly increasing since 2009. And the number of employees in small companies stagnates, or even despite the growing number of companies itself.

Statistical process control (SPC) is a major topic in statistical quality control. This is a statistical procedure which using a control chart to see the functioning of any part of a process [10]. Process control is achieved by plotting the value of periodic samples on a chart, to see if the process is within statistical control limits. If a sample point is outside the limit, the process may be outside the control limits. The Seven Basic Tools of Quality is helpful in troubleshooting issues related to quality [4]. They are called basic because they are suitable used to solve the vast majority of quality-related issues. One of them is a control chart. Control charts are graphs that visually show if a sample is within statistical control limits. For attribute control (quantitative data), mainly p-chart and c-charts are used. The formulas for conducting upper and lower limits in control charts are based on a number of standard deviations "z" from the recommended values according to a normal distribution [7].

After a control chart is established, it is used to determine when a process goes out of control and corrections need to be made. Correlation is an agreement of values from two data sets, and it expresses the degree of association between investigated phenomena [9].

## **DATA COLLECTING AND PROCESSING**

The data used in the paper were obtained through the data mining process from the Croatian Chamber of Economy database [3]. The data collected were related to the number of small, medium and large companies in the leather and footwear industry in Croatia and the number of employees in the small, medium and large companies for the period of 1995 – 2015 (Table 1).

*Table 1 Number of companies and the number of employees in the leather and footwear industry in Croatia*

year	Number of companies				Number of employees			
	Small	Medum	Large	Total	Small	Medum	Large	Total
1995.	160	14	9	183	3 439	3 642	7 716	14 797
1996.	162	15	9	186	3 041	8 071	7 333	18 445
1997.	164	14	8	186	3 765	3 437	5 580	12 782
1998.	152	14	7	173	3 184	2 186	10 183	15 553
1999.	142	14	7	163	3 313	1 642	5 431	10 386
2000.	138	10	6	154	3 326	1 830	4 512	9 668
2001.	125	17	6	148	2 497	2 638	4 432	9 567
2002.	133	17	8	158	2 052	2 691	4 191	8 934
2003.	113	15	7	148	1 933	1 903	3 865	7 701
2004.	128	13	7	148	1 701	1 562	4 117	7 380
2005.	119	16	7	142	1 727	1 741	4 082	7 550
2006.	128	9	2	139	3 148	3 082	1 964	8 194
2007.	119	11	1	131	3 715	2 880	1 862	8 457
2008.	114	9	1	124	4 292	2 146	2 145	8 583
2009.	115	8	1	124	3 913	1 649	2 130	7 692
2010.	116	10	1	127	3 275	2 552	2 954	8 781
2011.	120	8	1	129	3 290	2 605	3 131	9 026
2012.	122	7	1	130	3 395	2 285	2 867	8 547
2013.	123	4	1	128	4 496	1 541	3 750	9 787
2014.	126	4	2	132	4 105	1 574	4 949	10 628
2015.	134	3	2	129	4 063	1 570	4 778	10 411

## CALCULATION AND RESULTS

According to the control chart, Figure 1, the ideal number of small companies in the leather and footwear industry in Croatia ranges between 115 and 147. Anything below 115 indicates that the number of small companies has entered a warning zone, when the establishment of new companies should be stimulated. An increase in the number of small companies above 147 indicates a too large number, resulting in “congestion” and a sudden fall. The warning zone and risk zone are formed by means of the arithmetic mean, which makes the basic axis or the centre, so that the warning zone is situated at a distance of  $\pm\sigma$ , i.e. from the arithmetic mean for the standard deviation upwards and for the standard deviation downwards. The chart shows that unless interventions are made at the time when the number of small companies is within the warning zone and the number increases into the risk zone, a rapid fall will ensue, just like in 1997 when the number of small companies entered into the risk zone, which was followed by several years of decrease until 2001. The number of small companies “recovered” only in 2010, when it started to grow continuously.

The ideal number of medium companies in the leather and footwear industry in Croatia ranges between 7 and 15 (Figure 2). Anything below 7 indicates that

the number of medium companies has entered a warning zone, when the growth of small companies into medium ones should be stimulated. An increase in the number of medium companies above 15 indicates a too large number, resulting in “congestion” and a sudden fall. As opposed to the number of small companies, the number of medium companies is much more unstable, the risk zone is very tight. This is because the number itself is very low with considerable dispersion (visible from the standard deviation as a measure of data dispersion). In 2000, the number of medium companies experienced an (over)accelerated growth, resulting in crossing the line of the warning zone in 2001, which was followed by a fall until 2004. The fall was artificially stopped in 2005, after which the number continued to fall until 2015 bringing the number of medium companies to the lower limit of the warning zone towards the risk zone. If the number of medium companies would enter into the lower risk zone, there would be a real danger of it not being able to return to the desired number of 11 companies.

The number of large companies in the leather and footwear industry in Croatia should be between 2 and 8 (Figure 3). When the number of large companies falls under the lower limit, entering the warning zone, the growth of medium companies into large ones should be stimulated. An increase in the number of large companies above 8 indicates a too large number, resulting in “congestion” and a sudden fall. The control chart in Figure 3 shows that there was a sudden fall in 2005, after which the number of large companies has still not recovered. Unfortunately, the number of large companies in the period of 20 years has been so low that the number of 4 large companies in the leather and footwear industry in Croatia is considered optimal.

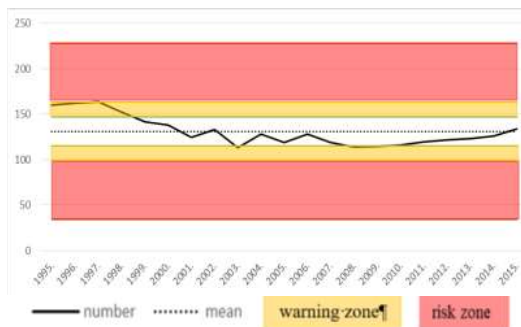


Figure 1 Control chart for the number of small companies

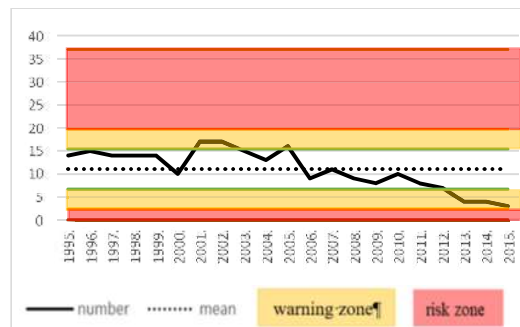


Figure 2 Control chart for the number of medium companies

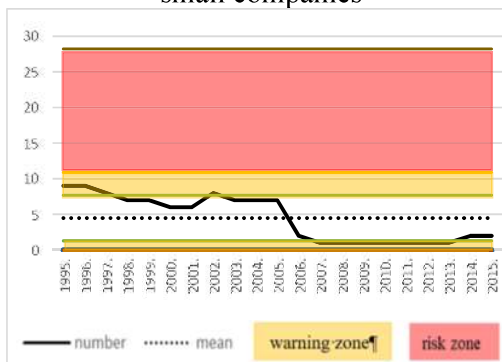


Figure 3 Control chart for the number of large companies



Figure 4 Control chart for the number of employees in small companies

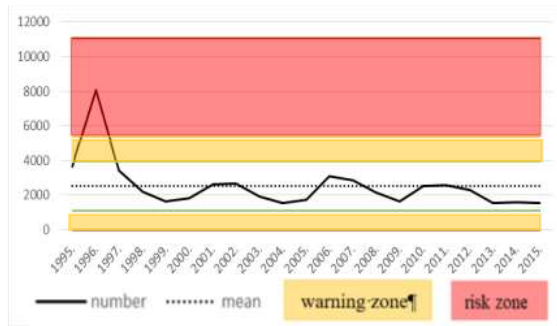


Figure 5 Control chart for the number of employees in medium companies

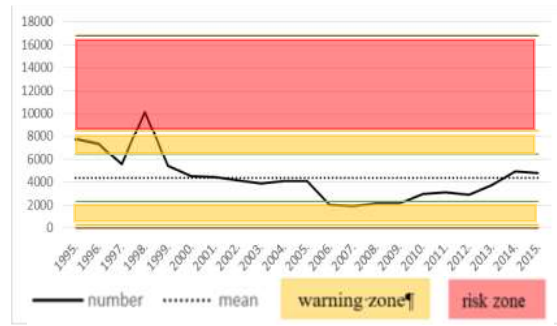


Figure 6 Control chart for the number of employees in large companies

The comparison of the growth and fall in the number of employees in small companies with the number of small companies showed that the values were not in correlation, i.e. that the number of employees in small companies does not influence the number of small companies. The Pearson correlation coefficient value is 0.06 (negligible correlation [5]). Only after stabilizing the sudden leaps in the number of small companies, the number of their employees stabilized in 2010. Unfortunately, the employment in small companies (Figure 4) often does not follow the growth in the number of small companies (Figure 1), so in 2013 there was another sudden growth of employees in small companies which was not followed by the growth in the number of small companies. In 2013, the number of employees crossed into the warning zone, which was followed by a fall.

As opposed to the small companies, the employment in medium companies is “stable”. There was a sudden growth registered in 1996 (entering a risk zone), which was followed by a sudden fall already in 1997. The number of employees varies less and is not so susceptible to changes. The Pearson correlation coefficient value is 0.4 (relatively weak correlation [5]). The control chart for the number of employees in medium companies follows the number of medium companies much better than in the case of small companies. By comparing the control chart of the number of medium companies (Figure 2) and the control chart of the number of employees in the medium companies (Figure 5), it can be observed that over-employment in medium companies in 1996 caused a sudden fall in 1997 that did not stop until 1999.

The control chart of employment in medium companies shows regularities of repetitive pattern, with two years of growth (2000 and 2001), one year of stagnation (2002), and two years of fall (2003 and 2004). After that, there is another two-year period of growth (2005 and 2006), stagnation in 2007, and a two-year fall (2008 and 2009). Then again a slight two-year growth, stagnation, and a slight two-year fall. As in time, the frequencies are attenuated, the number of employees in medium companies stabilizes. There was a sudden growth in the number of employees in large companies in 1998, followed by a sudden fall in 1999. In 2006, the economic crisis brought the number of employees in large companies into the warning zone, which lasted until 2010. The Pearson correlation coefficient value between the number of companies and the number of their employees is 0.7 (relatively weak correlation [5]).

It is interesting that the number of employees in medium companies and the number of employees in large companies have a similar pattern of behaviour, except that large companies are “late” and “slow to react”. When we take a look at the period from 1995 to 1997, the number of employees in medium companies shows the same pattern as in large companies from 1997 to 1999 (sudden growth and sudden fall). This is followed by a period of stagnation until 2005, when the crisis hit large companies in particular and the number of employees suddenly fell into the warning zone. Luckily, they recovered which lasted until 2013, when the number of employees in large companies finally evened out to the number before the crisis. The correlation coefficient values show the possibility of converting small companies into medium ones, and medium ones into large companies. Table 2 shows the correlation coefficients.

*Table 2. Correlation coefficients for the companies*

	Small vs. Medium comp.	Medium vs. Large comp.
Pearson correlation coefficient	0.3	0.8
Interpretation	mild/modest correlation	moderately strong to strong corr.
Spearman correlation coefficient	0.2	0.6
Interpretation	weak, slight to mild/modest corr.	moderate to moderately strong corr.

As the relation between the number of small and medium companies is weak, i.e. none, Table 3 provides the correlation coefficients between the number of small and medium companies with a shift of 1 to 5 years.

*Table 3. Correlation coefficient between small and medium companies*

	a shift of 1 year	a shift of 3 years	a shift of 4 years	a shift of 5 years
Pearson correl. coeff.	0.5	0.6	0.7	0.8
Interpretation	moderate correlation	moderate to moderately strong correlation	moderately strong correlation	moderately strong to strong correlation
Spearman corr. coeff.	0.5	0.7	0.7	0.8
Interpretation	moderate correlation	moderately strong correlation	moderately strong correlation	moderately strong to strong correlation

The correlation coefficient values show that only after 3 to 4 years do some small companies convert into large ones, i.e. only after 5 years the number of small companies has a moderate to strong correlation with the number of medium companies. Small companies are expected to grow in time and become medium companies. Unfortunately, most small companies go bankrupt (which can be seen from the control chart of the number of small companies (Figure 1)), therefore, they do not become medium companies. Only after surviving on the market for 5 years, small companies start the process of turning into medium companies. The situation is much better when it comes to the “growth” of medium companies, i.e. there is a correlation between the number of medium and large companies. There

is an even greater discrepancy when it comes to the number of employees. Table 4 shows the relation between the number of companies and the number of employees in the companies.

*Table 4. Correlation coefficients between the number of companies and the number of their employees*

	number of small companies vs. number of employees in them	number of medium comp. vs. number of employees in them	number of large companies vs. number of employees in them
Pearson correl. coeff.	0.1	0.3	0.7
Interpretation	weak, slight correlation	mild/modest correlation	moderately strong correlation
Spearman correl. coeff.	0 (-0.03)	0.5	0.8
Interpretation	without correlation	moderate correlation	mod. strong to strong corr.

The correlation coefficient values from Table 4 show that there is a great discrepancy between the number of small companies and the number of their employees. The coefficient values clearly indicate that many small companies were destined for disaster, i.e. that they were unstable. One of the reasons certainly lies in the harmonization of the number of employed expert persons, who are supposed to be the main leaders of production. By comparing the number of employees and the number of companies, it is clear that there is no correlation in small companies. Starting a small company requires a large number of administrative staff, which is incompatible with the number of employees in production. By turning a small company into a medium one, this ratio is reduced and the correlation between the number of companies and the number of their employees` increases. Large companies show a strong correlation, i.e. the technological process, as well as workplaces are clearly and precisely defined. This is further described with the specific models.

The starting point of the growth models, based on externalities, lies in Arrow's "learning-by-doing" hypothesis [1]. According to the Arrow hypothesis, new ideas emerge accidentally while utilizing old ideas, i.e. in regular productive activity. Individuals are better in their work if they produce more, and on the level of an industrial branch, the process works as every producer learns from the experience of all other producers. Precisely the concept of "learning-by-doing", i.e. the differences in the level of accumulated knowledge resulting from it, may explain the intertemporal and international differences in production functions of certain countries [8]. By applying the Arrow model to the number of companies and the number of their employees, it is clear that small companies did not have sufficient knowledge which should have been transferred to the employees. The same conclusion can be reached if the Romer model [6] is applied, whereby the production function for each company may have a regular neoclassical form, taking the capital owned by other companies as set. However, at the same time, the capital productivity of each company may grow with the aggregate capital

owned by other companies. In other words, investments into capital generate externalities, so all the companies together do not face diminishing returns. The essential thing in this model is knowledge which generates externalities and which is identified with the notion of technological progress.

According to Azariadis and Drazen [2], the externalities of investments into human capital are an essential, but insufficient condition for stable growth. To be more specific, the effects of such investments are relatively weak at a low general level of knowledge, but they become stronger with the increase in the overall level of accumulated human capital. Positive externalities from investment into human capital begin only when a certain threshold of accumulated human capital is overcome, which explains the modest growth of small companies., they are the simplest growth models.

## CONCLUSION

The Statistical Process Control was used to determine the warning zones and the risk zones by means of control charts for the number of small, medium, and large companies in the leather and footwear industry in Croatia. At the moment when the number of any of these companies enters the warning zone, the state should intervene. Also, the control charts for the number of employees in small, medium, and large companies clearly show that after entering the warning zone, the number often enters the risk zone, which is followed by a considerable fall. Correlation coefficients prove the relation between the number of medium and large companies, while the relation between small and medium companies can be observed with a shift of 3 or more years. The relation between the number of large companies and their number of employees is the strongest, i.e. large companies have the best-structured workplaces. The relation between the number of medium companies and the number of their employees is a bit weaker, while there is no relation in small companies. This is best described by growth models based on externalities, in which growth generates the increase in human capital, i.e. the growth of the level of knowledge and skills in the entire economy, but also deductively in companies on a microeconomic level. These models also recognize the limit of accumulated knowledge after which growth may be expected. The absence of growth in small companies results from an insufficient level of human capital and failure to reach its limit level which could generate growth. New employments have not resulted in adequate knowledge in order to implement learning by doing.

According to Statistical Process Control (SPC), the most cost-effective investment is the investment into medium companies. The paper demonstrates the disadvantages in small, medium, and large companies in the leather and footwear industry in Croatia. Small companies often emerge too quickly and disappear too easily owing to the employment of administrative staff instead of professional production staff. As the models emphasize, companies need to invest in their employees and employ good production staff. Investment and support to the



medium companies not only strengthens the companies which have a well-arranged technological process and a good systematization of workplaces, but this also helps large companies, as there is a strong correlation between the number of medium and large companies.

The growth models based on research and development set these two elements as essential for achieving growth. Small companies do not have enough capital or human potential at their disposal for investment in research and development. The absence of growth may be explained by the fact that small companies mostly operate on local markets, while they are too weak to appear on the international market. The application of the AK model showed that the absence of growth of small companies results from their weak position on the financial markets and overpriced financial capital, which on the other hand implies the reduction of expenses on human capital by decreasing payments in order to maintain the position in a perfect competition on the market, which is a prerequisite. The imbalance of the two elements, considered as one whole according to the AK models, results in the absence of growth.

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