



DECOMPOSITION ANALYSIS OF FACTORS INFLUENCING INTEREST OF COMPANIES IN CODE SYSTEMS FOR MULTIPLE PACKAGES IN POLAND

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ABSTRACT. Background: Over last years the growing tendency towards the use of barcodes can be observed. They are started to be implemented practically in every activity within the supply chain. The paper presents the analysis of the number of participants of GS1 system in regards to the change of number of companies in Poland and the level of the use of various code systems.

The aim of this paper was to identify the main drivers of changes in the implementation of barcodes for multiple packages and trade items among companies in Poland in years 2006-2016.

Methods: The decomposition was conducted by the use of LMDI method (Logarithmic Mean Divisia Index). The decomposition analysis was made in the relation to the number of companies enrolled in REGON register. Two indices were used: first one shows the interest in barcodes among companies, the second one relates to total number of companies.

Results and conclusions: The results obtained from the decomposition analysis shows factors influencing the interest of companies in code systems: GS1: EAN-13, ITF-14, GS1-128 and SSCC and allows to identify opportunities created by economic growth. They indicate the relationship between the implementation of SSCC identifiers and the interest of companies. The use of GS1 logistics labels should be supported and promoted, and GS1 Poland should play a key role in this activity.

Key words: trade items, multiple packages, logistics standards of barcodes, decomposition analysis, supply chain.

INTRODUCTION

The barcodes play important role in the trade and the distribution of goods within the whole supply chain. International organization GS1 manages barcode systems in 150 countries, where they are implemented in more than 2 M companies [Krasoń-Wałęsiak, 2018, Tengler et al, 2017, Javato-Martín et al. 2017, Smith, 2019]. GS1 Poland manages GSI system in Poland and at the same time represents interest of 23 thousands of companies (participants).

The barcode standards cover the identification of goods and resources and their localization, which is recognized all over the world as well as enable the full traceability within the supply chains, including warehouses.

The presented paper covers the analysis of number of participants of GS1 system in regards to the changes of number of companies in Poland and the usage level of:

- coding of trade items (enabling the identification at cash desks) in EAN-13 barcode,

- coding of variable measure trade items – (packages/containers not scanned in general retail at point-of-sale) in ITF-14 barcode,
- codes belonging to GS1-128 barcodes to present business date connecting with the content of homogeneous and not homogeneous packages creating the logistics units,
- SSCC identifiers (Serial Shipping Container Code) of logistics units of various contents, creating for warehousing and transport purposes.

The aim of this paper was the identification of drivers of changes in the use of barcodes for multiple packages and logistics units by companies in Poland during the period of 2006-2016. The decomposition analysis using Logarithmic Mean Division Index was applied to the analysis of the change of number of companies employing particular code system.

METHODOLOGY

The decomposition analysis using the method of Logarithmic Mean Division Index (LMDI) was implemented in this research. This method is used i.a. in researches for energy use, where the key aim of the decomposition analysis is the determination of structural factors being the drivers for changes of energy input indices as well as environmental impacts indices [Ang 2004, Stachura 2017]. This method is used also to determine drivers for change of SO₂ emission in power stations in Poland in 1995-2008 [Iskrzycki 2011]. Additionally it is used to analyze drivers of greenhouse gases emission e.g. deriving from car transport [Gozdek 2015], as well as to investigate the research and development strategies of Japanese companies concentrated on patent expansion in the area of environment protection [Fujii 2006]. It is also used to trace the added value in Chinese export [Zhao 2018] or economy drivers in China [Wang 2017]. Therefore it seems that the decomposition analysis, which consists in division of changes in total number of companies using the code system for multiple packages into individual factors triggering these changes, can be useful for the

identification of drivers for the implementation of barcodes by companies.

The advantage of LMDI method, comparing to others, is to obtain the perfect decomposition and elimination of the problem of zero values of data. It is achieved by adding small values ranging from 10⁻²⁰ to 10⁻¹⁰ [Ang 2001]. The simple formula used for calculation is also the advantage of this method [Ang 2005]. The formula of method of Logarithmic Mean Division Index is as follows [Gozdek, Szaruga 2015]:

$$\Delta V = \sum_{i=1}^n \left[\frac{V_n^t - V_n^{t-1}}{\ln \left(\frac{V_n^t}{V_n^{t-1}} \right)} \ln \left(\frac{x_i^t}{x_i^{t-1}} \right) \right]$$

where:

- V is determined by n factors (x₁, x₂ ...),
- ΔV is the sum of effects of all factors considered in given period of time [t-1, t],
- t means the present year
- t-1 means previous year

The number of total companies was assumed on the basis of number of companies registered in REGON register from Statistics Poland [GUS 2007-2017]. The number of companies using the barcode systems was taken from the database of GS1 Poland, the manager of GS1 system in Poland. The research covered the period from 2006 to 2016.

The decomposition analysis was conducted according to rules presented in Fujii's work [Fujii, 2016].

DISCUSSION OF RESULTS

The number of companies enrolled in REGON register is presented in the Table 1 and the number of companies registered in GS1 database is presented in the Table 2.

Table 1. The numbers of companies in REGON register

	Year										
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Number of companies	3 636 039	3 685 608	3 757 093	3 742 673	3 909 802	3 869 897	3 975 334	4 070 259	4 119 671	4 184 409	4 237 691

Source: Statistical Yearbook 2007-2017

Table 2. The number of companies using coding system of handling units according to GS1 Poland in years 2006-2016

Type of code system	Year										
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
EAN-13	5 360	6 874	7 769	8 101	8 364	8 514	9 331	9 071	9 171	10 826	11 108
ITF-14	112	139	160	172	188	221	269	282	285	315	354
GS1-128	289	356	425	513	621	717	835	949	959	1 181	1 270
SSCC	no data	190	311	448	554	689	842	946	956	1 344	2 034
Total*	5 761	7 437	7 906	8 399	8 883	9 222	9 904	10 303	10 415	12 322	12 009

* Due to fact, that some companies use more than one coding system, the sum of positions in each column is higher than presented in the row "Total".

Source: GS1 Poland database

During the analysis of data in the table 1, it can be observed the systematic increase of number of registered companies from 3 636 039 in year 2006 up to 4 237 691 in year 2016. It means the increase of number of companies by 16%. Only in year 2008 the small decrease in comparison to previous year was observed. The number of companies using code system also was growing systemically from 5 761 to 12 009 participants, but its growth was definitely higher and was equal to 108%. Year 2016 was the only exception in this trend, when the small decrease of number of GS1 Members was observed (from 12 322 to 12 009 companies).

The number of participants using following systems: EAN-13, IF-14, GS1-128 or SSCC identifiers also increased year by year in the analyzed period. The very strong jump in numbers of SSCC identifiers was especially in year 2016, when it was higher than 50%. Relatively fast increase of interest for SSCC identifiers over last few years was the reason that at present they are used more often than GS1-128 system. However it should be emphasized that in absolute values, their application is much lower than codes belonging to EAN-13 system (which amounts to almost 70% of all applications).

The decomposition analysis LMDI was used to identify and clear all factors influencing the number of companies, which use barcodes [Fujii, 2016]. The analysis was conducted in relation to the number of companies enrolled in

REGON register. Two indicators were implemented in this analysis. The first of them (PRIORITY) gives information about increase or decrease of the interest in barcodes among companies. The second one (SCALE) gives information about influence of total number of companies. The indicator PRIORITY means the number of companies using code system for multiple packages by the total number of companies enrolled in REGON register. This indicator increases when the number of companies coding multiple packages increases faster than the number of all companies. It shows that companies focus on the implementation of analyzed standards giving them higher priority. The indicator SCALE gives information about changes in total number of companies.

The decomposition analysis was conducted using the following formula:

$$BARCODE = \frac{BARCODE}{TOTAL} * TOTAL = PRIORITY * SCALE$$

where:

BARCODE means the number of companies using code system

TOTAL means total number of companies enrolled in REGON register

The following formula was used to compare changes in various periods:

$$\frac{BARCODE^t}{BARCODE^{t-1}} = \frac{PRIORITY^t}{PRIORITY^{t-1}} * \frac{SCALE^t}{SCALE^{t-1}}$$

where:

t means present year
 t-1 means previous year

After logarithm and multiplication of both side of the formula by the indicator

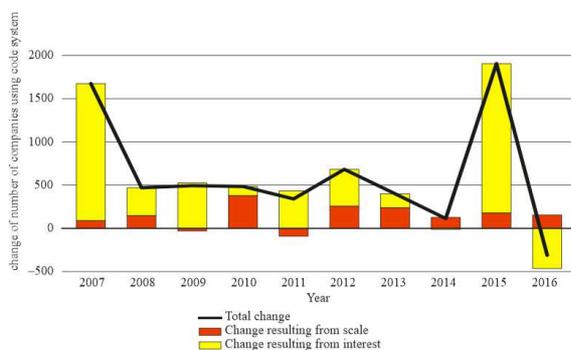
$$\omega^f = \frac{BARCODE^t - BARCODE^{t-1}}{\ln(BARCODE^t) - \ln(BARCODE^{t-1})}$$

the following formula was obtained:

$$\Delta BARCODE^{t,t-1} = \omega^t \ln\left(\frac{PRIORITY^t}{PRIORITY^{t-1}}\right) + \omega^t \ln\left(\frac{SCALE^t}{SCALE^{t-1}}\right)$$

The obtained relation allows to analyze the activity of companies in relation to shown interest in code system and total number of companies. The first component in the right part of the formula shows the priority of coding while the second component shows the influence of the scale effect.

$\Delta BARCODE^{t,t-1}$ means the change of companies using code system in two subsequent years.



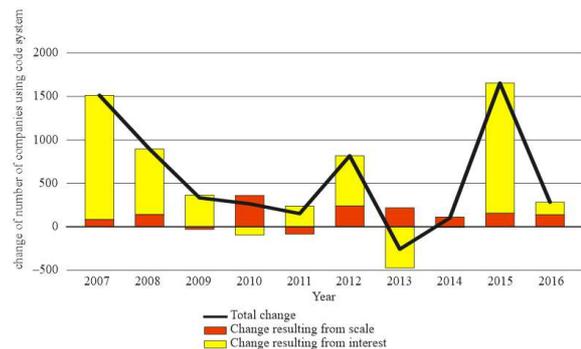
Source: own work

Fig. 1. The influence of interest in coding of multiple packages and total number of companies on the change of number of companies using code systems

It can be concluded from the figure 1, that the increase of number of companies coding collective units results in most of cases for the analyzed period from scale effect i.e. the increase of total registered companies as well as from the significant increase of interest in coding of multiple packages. There were only two years (2014 and 2016) when the increase of companies using code system was smaller than

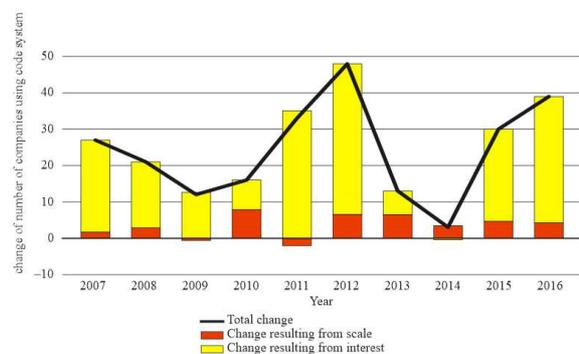
the increase of total registered companies. During all other years the increase of companies using code system results mainly from the first factor, described as PRIORITY. The biggest share of this factor was in years 2007 and 2015. The influence of scale effect (indicator SCALE) was significantly smaller, except from years 2010 and 2014, when it was the most important reason for the increase of companies using analyzed standards. The scale effect shows negative values in years 2009 and 2011. The increase of the number of registered companies in GS1 Poland results mainly from the increase of the interest in such proceedings. The scale effect also causes the increase of the number of registered companies but it is definitely smaller.

The influence of the interest in coding of multiple packages by the use of various code systems as well as total number of companies on the change of the number of companies using code systems was presented in figures 2-5.



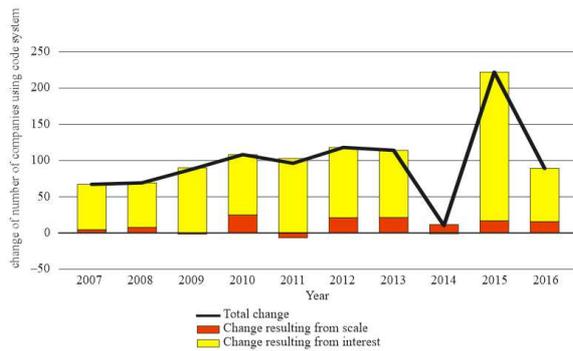
Source: own work

Fig. 2. The influence of interest in coding of multiple packages and total number of companies on the change of number of companies using EAN-13 systems



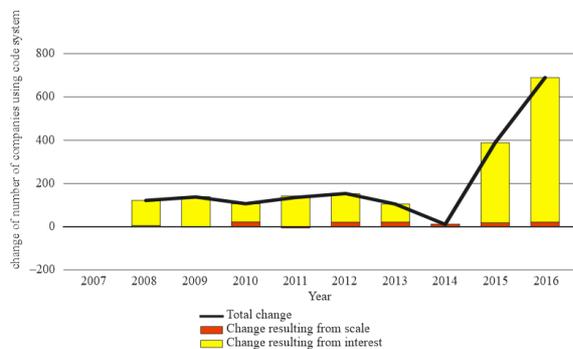
Source: own work

Fig. 3. The influence of interest in coding of multiple packages and total number of companies on the change of number of companies using ITF-14 systems



Source: own work

Fig. 4. The influence of interest in coding of multiple packages and total number of companies on the change of number of companies using GS1-128 systems



Source: own work

Fig. 5. The influence of interest in coding of multiple packages and total number of companies on the change of number of companies using SSCC identifiers

As it can be concluded from presented figures, there is a distinctive difference between characteristics of changes for EAN-13 codes and other three ones. In case of GS1-128, IFT-14 and SSCC, the increase of number of companies depends mainly on interest and only in small part on the effect scale. The year 2011 is very interesting one, when the scale effect is of negative values for all analyzed standards. The other strange data can be observed in year 2014, when the increase of the number of registered companies in GS1 Poland results practically only from scale effect.

The diagram presented the influence of different factors on the number of companies using EAN-13 system is more ambiguous. The factors dependent on interest had bigger significance in some years, while in other the factor dependent on the scale is more important.

The interest of using the EAN-13 code system for multiple packages being at the same time the trade units grew in different way. The increase of number of companies using EAN-13 code system for multiple packages is connected with the increase of number of operating companies. It could be caused by the attractive price of goods bought in multiple packages in shops and discounts. The decrease was observed only in 2013 year.

In order to deep the analysis of the influence of particular system on the interest of companies in code system, the following formula was used:

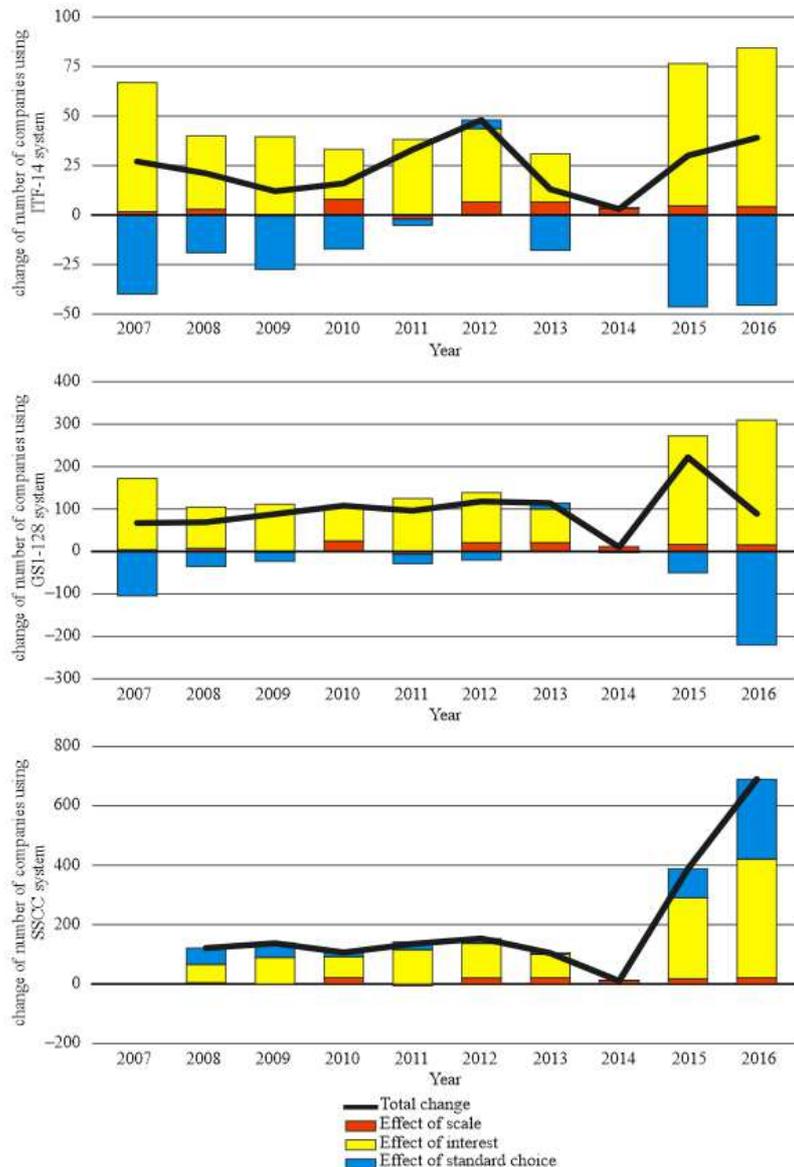
$$BARSTAND = \frac{BARSTAND}{BARCODE} * \frac{BARCODE}{TOTAL} * TOTAL$$

$$= STANDARD * PRIORITY * SCALE$$

where BARSTAND means the number of companies using particular standard, and the compound STANDARD shows the interest of particular system.

Such method of the presentation allows to analyze the activity of companies according to the interest in code system in given standard (STANDARD), interest of coding (PRIORITY) and the number of all companies (SCALE). The figure 6 presents the results of the analysis for ITF-14, GS1-128 and SSCC systems.

EAN-13 system was not taken into consideration because it is the only system offering barcodes, which can be read at the cash points. The other systems are implemented for other purposes. They are used for the identification of units in logistics processes within supply chains, especially in warehouses. It can be concluded during the comparison of GS1-128, IFT-14 and SSCC systems that in case of GS1-128 and IFT-14 systems, the increase depends only on scale effect and total interest in coding. However in case of SSCC system, the increase of number of companies using this type of coding, depends also on the interest on SSC identifier. The special increase of the implementation of SSCC system can result from its multi-purpose nature. The SSCC identifier can be used for many purposes and do not need to be used in the form of a barcode.



Source: own work

Fig. 6. The influence of interest in coding of multiple packages in code systems ITF-14, GS1-128 and SSCC

Additionally there is a common connection between GS1-128 and SSCC identifier. It results from the implementation of logistics labels GS1 in supply chains. Application identifiers presented in GS1-128 system are used on labels. The SSCC identifier is the only compulsory one on the label.

CONCLUSIONS

The use of decomposition analysis for the evaluation of factors influencing the interest of

investigated GS1 standards allows to identify the possibilities resulting from economic development as well as to indicate the possibilities and directions of development and further implementation of code standards. Based on the conducted analysis of the use of code systems by companies, it can be observed the growth of the interest of the implementation of barcodes. The number of companies using EAN-13 code for multiple packages is connected with the total number of companies. Therefore the special efforts should be concentrated to reach new companies which will be new suppliers of commercial nets.

The use of SSCC depends also on the interest of companies in such identifier, therefore it should still be put an effort to increase the knowledge of this system and its advantages in supply chains among producers, logistics operators as well as trade cooperators. The army is another possible customer of this code system. Suppliers are obliged to use GS1 logistics labels. Many of them start to join GS1 system and need a support in the beginning phase of this implementation from the side of manager of this system i.e. GS1 Poland.

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ANALIZA DEKOMPOZYCYJNA CZYNNIKÓW WPŁYWAJĄCYCH NA ZAINTERESOWANIE PRZEDSIĘBIORSTW KODOWANIEM JEDNOSTEK ZBIORCZYCH I LOGISTYCZNYCH W POLSCE

STRESZCZENIE. Wstęp: W ostatnich latach można zaobserwować rosnącą tendencję zastosowania kodów kreskowych praktycznie we wszystkich obszarach w obrębie łańcucha dostaw. W prezentowanej pracy poddano analizie zmiany liczby uczestników systemu GS1 w odniesieniu do zmian liczby przedsiębiorstw w Polsce oraz poziom korzystania z różnych standardów kodowania.

Celem pracy była identyfikacja czynników determinujących zmiany w wykorzystaniu kodów kreskowych stosowanych na jednostkach zbiorczych i logistycznych przez przedsiębiorstwa w Polsce w latach 2006–2016.

Metody: Dekompozycję wykonano metodą logarytmicznej średniej ważonej indeksu Divisia LMDI (Logarithmic Mean Divisia Index). W analizie wykorzystano dwa wskaźniki. Pierwszy z nich odnosił się do wzrostu lub spadku zainteresowania kodami kreskowymi wśród przedsiębiorstw natomiast drugi odnosił się do ogólnej liczby przedsiębiorstw.

Wyniki i wnioski: Wyniki analizy dekompozycyjnej do oceny czynników wpływających na zainteresowanie standardami GS1: EAN-13, ITF-14, GS1-128 i SSCC, pozwalają na identyfikację szans wynikających z rozwoju gospodarczego. Wskazują także na zależność stosowania identyfikatora SSCC od zainteresowania firm. Stosowanie etykiet logistycznych GS1 w obrębie łańcuchów dostaw powinno być wspierane i promowane, gdzie szczególną rolę powinna odgrywać organizacja GS1 Polska.

Słowa kluczowe: jednostki zbiorcze i logistyczne standardy kodów kreskowych, analiza dekompozycyjna, łańcuchy dostaw

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