Acta Universitatis Sapientiae

Economics and Business

Volume 2, 2014

Sapientia Hungarian University of Transylvania
Scientia Publishing House

Contents

Acta Univ. Sapientiae, Economics and Business, **2,** (2014) 5–19

Socio-Economic Status and the Structural Change of Dietary Intake in Hungary

Zoltán BAKUCS
Centre for Economic and Regional Studies,
Hungarian Academy of Sciences, Corvinus University of Budapest
E-mail: zoltan.bakucs@krtk.mta.hu

Imre FERTŐ
Centre for Economic and Regional Studies,
Hungarian Academy of Sciences, Corvinus University of Budapest
E-mail: imre.ferto@krtk.mta.hu

Cristina Galamba MARREIROS
Centro de Estudos e Formação Avançada em Gestão e Economia (CEFAGE-UE),
University of Évora, Portugal
E-mail: cristina@uevora.pt

Abstract. Typically, big changes in the economic system lead to alterations on families' disposable income and thus on their spending for different types of products, including food. These may imply in the long run a structural modification of the population's diet quality. After the fall of the socialist system, in the past two decades, Central and Eastern European countries, including Hungary, went through a profound and sometimes difficult transition of their political and economic systems, shifting from a centralized plan to an open-market economy, and, perhaps more importantly, the European Union integration. Economic change in lower-income and transitional economies of the world appears to coincide with increasing rapid social change. With respect to nutrition, there is evidence that these countries are changing their diets and that changes seem to happen at a faster pace than ever before (e.g. Ivanova et al., 2006). In this paper, we analyse the evolution of Hungarian dietary patterns based on socio-economic status (SES) data between 1993 and 2007. Data allows defining and profiling several clusters based on aggregated consumption data, and then inspecting the influence of SES variables using OLS and multinomial logit estimations.

Keywords and phrases: Transition economy, food consumption patterns, cluster analysis, logit analysis.
JEL Classification: I15, C25, D1

Introduction

In most Central and Eastern European post-communist economies, food expenditures constitute the second largest expenditure position for private households (overshadowed only by expenditures for housing). A significant welfare loss due to increased nutrition-related expenditures was recorded in the transition period (see Huffman 2005 for the Polish example). Nevertheless, food expenditure shares as well as absolute expenses per household are declining. In 1995, for Hungarian households, this represented 23.3% declining to 17.50% on average by 2008 versus 14.5% and 12.7% for EU-27, respectively. A comparison of consumption behaviour between East and West Germany reveals a clear tendency of convergence for most products (Grings, 2001).

Moreover, in a study of food expenditures across 47 countries, Regmi et al. (2008) found significant convergence of consumption patterns for total food, cereals, meats, seafood, dairy, sugar and confectionery, caffeinated beverages and soft drinks. According to the authors, this convergence reflects consumption growth in middle-income countries – to which Hungary also belongs – due to the rapid modernization of their food delivery systems as well as to global income growth. Quoting Regmi and Gehlhar (2005), this study concludes that consumers in developing countries have used their growing incomes to upgrade diets, increase their demand for meats, dairy products and other higher-value food products.

Several studies, however, (e.g. Irala-Estévez et al., 2000; James et al., 1997; Arija et al., 1996; Ross et al., 1996) show that there are large variations between individuals with respect to the quantity and quality of the food consumed. Despite the fact that lower-income consumers make bigger changes in food expenditures as their income levels change (Seale et al., 2003), there is empirical evidence (e.g. Hulshof et al., 2003; Cavelaars et al., 1997; Adler et al., 1994; Hoeymans et al., 1996) that in most European countries there are still great disparities in nutrition and health with respect to socio-economic status (SES).

In general, less educated and lower-income groups appear to consume less healthy diets (Hulshof et al., 2003). According to the studies of Dowler et al. (1997) and James et al. (1997), poverty and low income may restrict the ability to buy food on the basis of health and limit access to healthy food. According to Hulshof et al. (2003), particularly in the North and West of Europe, a higher SES is associated with a greater consumption of low-fat milk, fruit and vegetables (e.g. Irala-Estevez et al., 2000). Additionally, those with higher education tend to consume less fat and oil but more cheese (Hulshof et al., 2003; Roos et al., 1999). Prattala et al. (2003) confirmed this finding, concluding that higher and lower socio-economic groups have different sources of saturated fats.

A previous research also concluded that consumers with a higher educational level tend to be more aware of the characteristics of a healthy diet (Margetts et al., 1997) and have more knowledge about food items which are healthier (Martinez-Gonzales et al., 1998; Hjartaker and Lund, 1998; Margetts et al., 1997). Although not directly related to this study, the issue of perceived food healthiness or the subjective diet awareness needs to be mentioned (see, for example, Provencher et al., 2008 or Carels et al., 2007). Although Hulshof et al. (2003) state that this might partly explain the differences in food consumption between SES classes, the differences in food consumption patterns between SES may also be explained by the findings of Prattala et al. (2003) that higher social classes prefer modern foods whilst lower classes traditional foods. This conclusion is in line with Grignon's (1999) emphasizing that higher social classes consume more food items, indicating an increasing trend compared to lower classes. According to the authors, these findings are explained by the Bourdieu's theory that the socio-economically better-off are the first to adopt new food habits (Bourdieu, 1989).

To further understand the role of SES in food consumption, in this paper, we analyse the differences in dietary intake between adults with different socio-economic statuses (SES) and trends over time. Using family food consumption household data from the beginning of the transition period (1993) and from after the EU accession (2007), we analyse the declared consumption of the main food groups, looking into the differences of the diets of consumer groups with different SES in Hungary. This study allows for the analysis of the convergence of the Hungarian diet with the diets of other European countries and the identification of possible measures to improve the dietary intake of consumers.

This paper is organized as follows: after this introduction, a brief description of the research methodology is presented; the empirical results of the study are discussed in Section 3, followed by summary, conclusions and recommendations. The conclusions stress the main findings and discuss implications for food policies in what concerns the improvement of the Hungarian diet. Several directions for possible further research in this topic are outlined at the end of this study.

Data and Methodology

The Hungarian Household Budget Survey (HBS) has been conducted annually by the Hungarian Central Statistical Office since 1993. The survey covers the Hungarian population living in private households. The unit of sampling is the dwelling and the unit of observation is the household. The survey contains 7,000 to 10,000 households annually. The survey is partly based on monthly household records and partly on post facto annual interviews, providing detailed information both on income and the structure of expenditures. Own consumption of self-produced food and beverages and net farm revenue are also reported.

The empirical analysis employs three multivariate techniques. First, cluster analysis is used to group households according to their food consumption habits. Then, a more detailed multivariate regression analysis follows, where healthy and less healthy food consumption habits are regressed on variables defining SES. Thus, dependent variables include quantities of fat, sugar, alcohol, various meats, fruit and vegetables consumption, whilst independent variables include household size, age and education of the household head, location, income, employment and quality of house/flat (number of rooms, existence of bathrooms, etc.).

Several different measures of socio-economic status, such as education, location, house characteristics, were examined in this study. The aim was to compare the direction and magnitude of associations for each measure of socio-economic status with the fruit and vegetable intake. Educational level, cultural expenditures or the geographical location (Budapest or other large cities) may have important influences on the socio-economic status. Higher levels of education may increase the ability to obtain or to understand health-related information in general, or dietary information in particular, needed to develop health-promoting behaviours and beliefs with respect to food consumption habits. Analyses, which have taken into account education, occupation, income and employment status alike, have shown that education is usually the strongest determinant of the socio-economic differences. The other socio-economic variables have a similar but weaker effect than education (Roos et al., 1996).

Multivariate regressions differ from multiple regressions in that several dependent variables are jointly regressed on the same explanatory variables. Although direct comparison of 1993 and 2007 regression coefficients should be done with care since variables are not entirely the same in the two databases, the analysis gives insight not only into consumption and dietary habit differences across SES groups, but also into their change in time. The latter is a rather important issue in the post-communist economies, where the economic transformations that started in 1990 had a deep impact upon population purchase power, income and, indeed, food consumption habits (Ivanova et al., 2006). Finally, a multinomial logit analysis is performed. Using information from the first part of the empirical analysis, cluster numbers employed as dependent variables are regressed upon SES variables.

Empirical Results

Descriptive Statistics

First, a number of SES variables were selected for the analysis. The descriptive statistics of the most important ones are presented in Table 1: education of household head (*Edu*), income of household (*Inc*: monthly total personal income of household head in 1993 and the deciles the household belongs to based on net income per person for 2007), location (*Loc*: 1 – Budapest, 2 – major city, 3 – town, 4 – village), number of people in the household (*Num*), number of larger than 12 m^2 rooms and number of 4 to 12 m^2 rooms in the household (*R1* and *R2*, respectively), bathroom and toilet facilities in the household (*BR*), agricultural income (*AInc*) and cultural expenditures (*Cult*). Nine aggregated food consumption variables were created, based on individual food item consumption data. Number of observations, mean values, standard deviation, minimum and maximum values of the aggregated variables for 1993 and 2007 are presented in tables 2 and 3, respectively.

The last column of tables 2 and 3 shows the percentage of aggregated consumption variables within total food consumption (sum of all 9 categories). Surprisingly, the structure of food consumption remained almost unchanged during the 14 years time span. There is more consumption of red and white meats in 2007, but a shift from animal to vegetable fats may also be observed. The share of vegetables in total consumption had been massively reduced by 2007; however, the share of fruit consumption remained stable. With the increase of the 2007 carbohydrates and alcohol intakes, one may conclude that dietary habits in Hungary shifted towards less healthy consumption patterns.

Cluster Analysis of Food Consumption Patterns

Cluster analysis was applied as a two-stage process to the following 9 aggregated food intake variables*: red meats*, *white meats*, *egg and milk products*, *animal fats*, *vegetable fats*, *vegetables*, *fruits*, *carbohydrates* and *alcohol*. In the first stage, a hierarchical analysis was employed to provide an indication of the appropriate number of clusters. Hair et al. (1998) suggests a procedure based upon the inspection of the distance information from the agglomeration schedule. Following this procedure, the appropriate number of clusters is suggested at the stage where there is a 'large' increase in the distance measure, indicating that a further merger would result in decrease in homogeneity. However, Hair et al. (1998) also point out that 'the selection of the final cluster solution requires substantial researcher judgement and is considered by many to be too subjective'. Following the hierarchical analysis, and the exclusion of outliers in both databases, the K-Means optimization procedure was employed – together with the consideration of relative cluster size and the desire for parsimony – to generate a three-cluster solution for 1993 and a two-cluster solution for 2007. Information about cluster membership, in the form of a nominal cluster identity variable, and distance to the cluster centre were saved for posterior analysis.

F-tests were performed to the cluster variables. These are based upon differences between clusters, on the basis of a null hypothesis that average variable scores for each cluster are equal against an alternative hypothesis that they are not. Results indicate that the 9 variables have significantly different patterns between groups. Therefore, the criteria used to cluster consumers can be considered meaningful. The next step of the analysis is to profile the clusters. A profile of each of the groups is established from the mean of the food intake variables and from the identification of the SES variables for which there are significant differences between groups at a 5% level of significance on the basis of a chi-square contingency test for nominal variables, and an F-test for metric variables.

Of the 3 clusters found in the 1993 panel, Cluster 3 is the biggest cluster with more than half of the households (62.3%), followed by Cluster 2 (34.5%) and by a quite small Cluster 1 with only 2.7% of observations. Analysing the profiles of the clusters, significant differences at the 5% level were found in all food intake variables and in SES variables in analysis, except for the amount spent for culture (proxied by concert and theatre expenditures).

Cluster 3 has the lowest scores in all food intake variables as well as in the income variable, partly explained by the fact that families of this cluster are smaller (average size of 2.32 members vs. 3.28 in Cluster 2 and 3.65 in Cluster 1). These families live in smaller houses (flats) than families in the other two clusters and spend relatively less on books. Additionally, they tend to live relatively more in Budapest and other cities (27.5% vs. 16.3% in Cluster 2 and 10.8% in Cluster 1) and to have a woman as head of the household (34.7% vs. 10.8% in Cluster 2 and 8.2% in Cluster 1). The head of the household is relatively older than in the other two clusters (54.6 vs. 50.22 in Cluster 2 and 47.93 in Cluster 1). With respect to education level, the profile of this cluster is somewhat mixed, since it has the highest proportion of people with less than 8 years of school (25.25 vs. 15.8% in Cluster 2 and 14.8% in Cluster 1) and, at the same time, with a university or college education (8.6% vs. 7.1% in Cluster 2 and 5.1% in Cluster 1).

As it can be understood form the previous paragraph, Cluster 1 is more different from Cluster 3 than Cluster 2 in terms of both food intake and socio-economic profile. This rule does not apply to the consumption of fruits, where Cluster 2 has the highest score, followed by Cluster 1 and then Cluster 3. The same is true for the number of rooms in the household smaller than 12 m^2, where the mean value of Cluster 2 is higher. It is also important to notice that Cluster 1 is the cluster with a higher proportion of people living in the countryside (59.7% vs. 52.1% in Cluster 2 and 40.5% in Cluster 3) with 8 to 10 years of school (36.7% vs. 31.5% in Cluster 2 and 29.6% in Cluster 3) and with a man as the head of the household (91.8% vs. 89.2% in Cluster 2 and 65.3% in Cluster 3).

The profiles of the 2007 clusters show that Cluster 1 is the smallest one, with 26.5% of observations. The mean value of the food intake variables is always higher in this cluster. When compared to Cluster 2, consumers in Cluster 1 are characterized by relatively lower education levels and live relatively more in rural areas and small cities (71.8% vs. 53.9% in Cluster 2). They live in bigger households and spend more on education, culture and holidays. These may be explained by the fact that they tend to have bigger families than consumers in Cluster 2 (mean value of 3.41 vs. 2.3). The per capita total income is relatively lower in this cluster – the percentage of observations in deciles 1 to 7 is significantly higher for this group. The head of the household tends to be younger than in Cluster 2 (mean value of 50.3 vs. 52) and it is a man (83.3% versus 62.3%).

To conclude, it can be stated that this cluster is composed of more traditional families, with relatively lower per capita income, that live in the countryside, have more children and a relatively young man as head of the household, with a medium level of education.

Regression Analysis of Food Consumption on SES Variables

OLS regressions of aggregated consumption variables on cluster data and SES variables are performed next. Table 4 presents regression coefficients and corresponding significance levels for 1993, whilst Table 5 does so for 2007.

For 1993, the coefficients of determination (adjusted R^2) vary considerably between regressions, from 6% (fruits, alcohols, vegetable fats and animal fats) to 30% (carbohydrates) or even 66% (egg and milk products). Similarly dispersed, albeit somewhat higher R^2 values were obtained for 2007, ranging from 7% (alcohols) to 15-20% for meat, vegetable and fruit products, 48% (carbohydrates) and 64% (egg and milk products).

Explanatory variables are generally highly significant and their sign is persistent from 1993 to 2007 regressions. For 1993, the cluster analysis revealed that households in Cluster 1 consume the most, followed by clusters 2 and 3. For the 2007 data, Cluster 1 consumes more than Cluster 2. The finding is reflected by the negative coefficients of the cluster variable in every regression for both 1993 and 2007. The gender variable is negative for all categories, implying that households managed by women consume less. Education, coded from 1 (less than 8 classes) to 8 (PhD), significantly reduces consumption except for vegetable fats and fruits, possibly suggesting more health-conscious eating habits for highly educated households.

For 1993, the income variable is only significant (positive) for red meats, vegetable fats, fruits and alcohol, the more expensive food categories. For 2007, the income variable is significantly positive for all food categories except the cheaper and possibly less income-sensitive ones, such as animal fats and carbohydrates. The higher number of food categories, where the variable is significant in 2007 compared to 1993, might suggest the growing importance of household income when purchasing food, i.e. the increase of the food demands' income elasticity coefficient. Location (from 1: Budapest to 4: village) has significantly positive (e.g. white meats, egg-milk products, animal fats and carbohydrates for 1993) and negative effects (vegetable fats, consumed more in larger localities) depending on food category. For 2007, the variable suggests increased consumption of most food categories in smaller localities compared to bigger ones, with the exception of vegetables, fruits and alcohols. With the exception of alcohols (negative for 1993, not significant for 2007), the number of household members positively influence all aggregated food categories. The negative sign of alcohols indicates that households with larger families (more children) tend to spend less on such items. The number of smaller and larger rooms (R1 and R2) is generally significant and increases the consumption of all food variables. The picture is less obvious for the number of bathrooms/toilets in the household. Agricultural income seems to be an important determinant in both years, with mostly significant positive coefficients (correlation coefficient between net income and agricultural sales/income is close to 0). There is an extra variable included in the 2007 regressions, not available for the 1993 data: the cultural, artistic expenditures (*cult*). With the exception of alcohols and fruits, where it is significantly positive, it has negative effects upon all other food consumption categories. Perhaps those willing to spend more on culture, arts and, ultimately, going out, tend to consume more alcohol in and outdoors, and, at the same time, reduce their intake of other food items.

Analysis of Cluster Selection on SES Variables

A multinomial logit analysis is run for 1993 with the dependent variable being the cluster (1, 2 or 3). For the 2-cluster solution in 2007, a logit regression is performed. Results for 1993 and 2007 are presented in tables 6 and 7, respectively.

The coefficients of the multinomial logit regression fit the cluster profiles presented in Section 3.2: Cluster 3, the base is the cluster with the lowest food intake, smaller houses (*R1*, *R2* positive in clusters 1 and 2 versus the base), live mostly in Budapest or bigger cities (positive coefficient for location in both clusters vs. Cluster 3), smaller families (variable *Num* positive). In a similar fashion, those in Cluster 1 are more likely to live in rural areas than those in Cluster 2 or 3 (positive location and agricultural income coefficients), and they are more likely to have a man as household head.

Conclusions

Our results emphasize the major post-1990 socio-economic changes in the Hungarian society. Dietary intakes vary considerably across SES and also in time. Similarly to the Bulgarian findings of Ivanova et al. (2006), a general deterioration of post-transition dietary habits is observed; however, some SES groups managed to shift their food consumption towards healthier intake patterns.

Due to increasing household incomes and the openness of the Hungarian economy, the consumption patterns of Hungarian families tend to converge. While in 1993 three distinct clusters of food consumption patterns were identified, in 2007, only two groups could be found. Nevertheless, the great majority of the variables that used to define the SES have a significant impact on food consumption patterns in both years, confirming previous studies on this issue and showing that, besides income, other variables, such as education, gender, type of household etc., are also pertinent to understanding food consumption behaviour.

It is also important to emphasize and understand the change of food consumption patterns in Hungary after the economic transition and the EU accession. As expected, with a growing economy, people spend more on meat products (both red and white), converging towards the EU average. Concerning health-conscious food consumption behaviours however, mixed results were obtained. On the one hand, there is a tendency to replace animal fats with vegetable fats, along with increased fruit consumption. On the other hand, there is a sharp decrease of the share of vegetables in total consumption and an increase of the share of alcohols. It can be said that, at least partially, the convergence of Hungarian diet with the European one is bringing new issues with respect to the quality of the population's diet and its possible impacts on health.

Results are equally relevant for healthcare professionals, farmers, agro-food enterprises and different public bodies that need to know how much and what the population of a region or a country eats. Nutrition, or rather poor nutrition, is the main cause of morbidity and mortality in Europe and, consequently, successful nutritional policies might prove to be a fundamental step for the improvement of health in Europe. The success of these policies depends on a clear understanding of the dietary patterns of the population and how different socio-economic factors influence these patterns. This study hopefully adds to that understanding in the context of a European transition economy.

There is, of course, room for further research on this topic such as the comparison of the dietary changes in Hungary with the changes experienced by neighbouring and other European countries. It would also be interesting to analyse the Hungarian diet according to the WHO recommendations and to cross the data of the household panel with health data, most importantly with food-consumption-related diseases such as obesity or coronary diseases.

Table 1. *Descriptive statistics of some variables*

Variable	Obs.	Mean	Std. Dev.	Min	Max	Obs.	Mean	Std. Dev.	Min	Max
	1993					2007				
Edu	7358	3.065643	1.985173	1	8	7383	4.237302	2.390157	1	10
Inc	7358	14075.39	8848.325	-3100	152710	7383	6.17134	2.826038	1	10
Loc	7358	3.146099	0.937633	1	4	7383	2.71177	1.100519	1	4
Num	7358	2.685648	1.311999	1	10	7383	2.596235	1.382701	1	11
R1	7358	1.793558	0.769598	0	6	7383	1.830692	0.93752	0	6
R2	7358	0.656157	0.750522	0	6	7383	0.83462	0.902079	0	6
BR	7358	1.543218	1.103318	1	4	7383	1.034268	0.364789	0	2
AInc	7358	18665.77	80856.31	0	2849000	7383	68731.7	201412.8	0	4067600
Cult	-	-	-	-	-	7383	148524	204833.8	0	4081308

Source: Hungarian Central Statistical Agency household survey; data cleaned by HAS Institute of Economics' Databank. Own calculations

Table 2. *Consumption patterns in 1993 (kg, l)*

Variable	Obs.	Mean	Std. Dev.	Min	Max	% of totalcons
Red meats	7358	5.517532	5.654177	0	112	3.597
White meats	7358	5.162816	5.119862	0	69	3.365753
Egg and milk prod.	7358	76.13944	55.59158	0	584	49.63697
Animal fats	7358	2.941832	4.728127	0	208	1.917845
Vegetable fats	7358	2.409622	2.785216	0	98	1.570885
Vegetables	7358	25.85159	30.07418	0	509	16.85322
Fruits	7358	9.340038	15.83503	0	200	6.088976
Carbohy	7358	23.02487	15.81856	0	217	15.01042
Alcohols	7358	3.004893	7.072565	0	122	1.958956
Totalcons	7358	153.3926	89.83632	0	827	100

Source: Hungarian Central Statistical Agency household survey; data cleaned by HAS Institute of Economics' Databank. Own calculations

Table 3. *Consumption patterns in 2007 (kg, l)*

Variable	Obs.	Mean	Std. Dev.	Min	Max	% of totalcons
Red meats	7383	4.11378	5.855959	0	157.07	4.325216
White meats	7383	4.101364	4.218907	0	46	4.312162
Egg and milk prod.	7383	47.13215	35.04902	0	369.98	49.55461
Animal fats	7383	0.748988	1.759469	0	35.22	0.787484
Vegetable fats	7383	2.828576	2.669028	0	38.5	2.973957
Vegetables	7383	7.514245	9.902279	0	223	7.900456
Fruits	7383	7.08544	8.523729	0	130	7.449611
Carbohy	7383	17.15278	12.0848	0	190.96	18.03438
Alcohols	7383	4.434215	8.379235	0	159.9	4.662121
Totalcons	7383	95.11154	58.32562	1.6	553.82	100

Source: Hungarian Central Statistical Agency household survey; data cleaned by HAS Institute of Economics' Databank. Own calculations

Table 4. *Food consumption regression analysis for 1993*

Dep. var.	Clus	Gen	Edu	Inc	Loc	Num	R1	R2	BR	AInc	Cons
Red meats	-0.302***	-0.163***	-0.032***	0.080***	0.015	0.130***	0.087***	0.039***	-0.049***	0.029***	1.317***
White meats	-0.369***	-0.160***	-0.025***	0.024	0.078***	0.078***	0.083***	0.068***	0.014	0.023***	1.360***
Egg & milk	-1.028***	-0.032***	-0.006**	0.007	0.019***	0.036***	0.024***	0.000	-0.006	0.007***	3.495***
Animal fats	-0.355***	-0.223***	-0.055***	-0.048	0.125***	0.134***	0.013	0.001	0.048***	0.008***	1.337**
Veg. fats	-0.330***	-0.031	0.010	0.120***	-0.035**	0.053***	0.017	0.004	-0.057***	-0.004	1.747***
Vegetables	-0.680***	-0.105***	-0.025***	0.003	0.008	0.030***	0.066***	0.052***	0.002	0.000	2.608***
Fruits	-0.605***	-0.083	0.013	0.116***	-0.029	0.001	0.091***	0.050*	-0.028	0.016***	2.364***
Carbohy	-0.235***	-0.087***	-0.043***	0.000	0.086***	0.206***	0.003	-0.001	0.030***	0.004***	0.887***
Alcohols	-0.416***	-0.828***	-0.056***	0.099**	0.183***	-0.085***	0.227***	0.131***	-0.008	0.011*	1.527***

Source: Hungarian Central Statistical Agency household survey; data cleaned by HAS Institute of Economics' Databank. Own calculations

Note: *** indicates 1%, ** indicates 5% and * indicates 10% levels of significance, respectively.

Table 5. *Food consumption regression analysis for 2007*

Dep var.	Clus	Gen	Edu	Inc	Loc	Num	R1	R2	BR	AInc	Cult	Cons
Red meats	-0.527***	-0.133***	-0.035***	0.039***	0.056***	0.196***	0.072***	0.023	-0.038	0.067***	-0.054***	1.079***
White meats	-0.562***	0.007	-0.023***	0.018***	0.055***	0.153***	0.046***	0.008	-0.056	0.059***	-0.013	1.334***
Egg & milk	-1.188***	0.009	-0.011***	0.009***	0.016***	0.092***	0.012*	0.002	-0.009	0.016***	-0.012***	2.751***
Animal fats	-0.810***	-0.272***	-0.085***	-0.002	0.054**	0.048*	0.072**	-0.032	-0.391***	0.151***	-0.093***	2.836***
Veg. fats	-0.465***	-0.044*	-0.031***	0.033***	0.054***	0.161***	0.029**	0.047***	0.031	-0.008**	-0.014*	1.081***
Vegetables	-0.553***	-0.060*	-0.023***	0.034***	-0.037***	0.084***	0.086***	0.059***	-0.045	0.089***	-0.001	1.501***
Fruits	-0.521***	-0.035	0.002	0.054***	-0.064***	0.091***	0.056***	0.027	0.077*	0.072***	0.045***	1.192***
Carbohy	-0.336***	-0.014	-0.026***	0.001	0.100***	0.255***	0.016**	0.002	-0.132***	0.017***	-0.030***	0.875***
Alcohols	-0.386***	-0.821***	0.005	0.061***	-0.062***	-0.003	0.060**	0.018	-0.014	0.013*	0.080***	1.513***

Source: Hungarian Central Statistical Agency household survey; data cleaned by HAS Institute of Economics' Databank. Own calculations
Note: *** indicates 1%, ** indicates 5% and * indicates 10% levels of significance, respectively.

Table 6. *Multinomial logit analysis for 1993 (Cluster 3 base outcome)*

Variables	Coef.	Signif.	Coef.	Signif.
	Cluster 1		Cluster 2	
Gen	-0.634	0.024	-0.660	0.000
Age	-0.008	0.205	-0.014	0.000
Edu	-0.119	0.022	-0.012	0.479
Inc	0.154	0.158	0.113	0.017
Loc	0.465	0.000	0.293	0.000
Num	0.740	0.000	0.574	0.000
R1	0.281	0.007	0.200	0.000
R2	0.018	0.868	0.102	0.011
BR	-0.160	0.067	-0.057	0.047
Book	0.000	0.029	0.000	0.712
Cult	-0.001	0.595	0.000	0.579
Mealsg	-0.008	0.377	-0.010	0.004
AInc	0.093	0.000	0.075	0.000
_cons	0.833	0.890	9.618	0.000
Pseudo R^2		0.135		

Source: Hungarian Central Statistical Agency household survey; data cleaned by HAS Institute of Economics' Databank. Own calculations

Table 7. *Logit analysis for 2007 (Cluster 2 base outcome)*

Variables	Coef.	Signif.
	Cluster 1	
Gen	-0.326	0.000
Age	0.013	0.000
Edu	-0.061	0.000
Inc	0.031	0.030
Loc	0.124	0.000
Num	0.583	0.000
R1	0.172	0.000
R2	0.130	0.001
BR	-0.009	0.919
Cult	0.009	0.719
Mealsg	-0.006	0.233
AInc	0.161	0.000
Health	0.062	0.000
_cons	-4.192	0.000
Pseudo R^2	0.16	

Source: Hungarian Central Statistical Agency household survey; data cleaned by HAS Institute of Economics' Databank. Own calculations

References

Adler, N.; Boyce, T.; Chesney, M.; Cohen, S.; Folkman, S.; Kahn, R.; Syme, S. (1994). Socio-economic status and health. *Am. Psychology* 49: 15–24.

Arija, V.; Salas-Salvado, J.; Fernandes-Ballart, J.; Cuco, G.; Marti-Henneberg, C. (1996). Consumo , hábitos alimentarios y estado nutricional de la poblacion de Reus. (IX). *Med. Clin. (Barc)* 106: 174–179.

Bourdieu, P. (1989). Distinction: a social critique of the judgment of taste. London, Routledge & Kegan Paul.

Carels, R. A.; Konrad, K.; Harper, J. (2007). Individual differences in food perceptions and calorie estimation: An examination of dieting status, weight, and gender. *Appetite* 49: 450–458.

Cavelaars, A.; Kunst, A.; Mackenbach, J. (1997). Socio-economic differences in risk factors for morbidity and mortality in the European community: an international comparison. *Journal of Health Psychology* 2: 353–372.

Dowler, E.; Barlosius, E.; Feichtinger, E.; Kohler, B. (1997). Poverty, food and nutrition. In: B. M. Kohler, E. Feichtinger, E. Barlosius, E. Dowler (eds.), Poverty and Food in Welfare Societies. Berlin, Ramer Bohn, 17–32.

Grignon, C. (1999). Long-Term Trends in food consumption: a French portrait. *Food Foodways* 8 (3): 151–74.

Hair, J. F. Jr.; Anderson, R.; Tatham, R.; Black, W. C. (1998). Multivariate Data Analysis. Upper Saddle River, NJ: Prentice Hall.

Hjartaker, A.; Lund, E. (1998). Relationship between dietary habits, age, lifestyle, and socio-economic status among adult Norwegian women. The Norwegian Women and Cancer Study. *European Journal of Clinical. Nutrition* 52: 565–572.

Hoeymans, N.; Smit, H.; Verkley, H.; Kromhout, D. (1996). Cardiovascular risk factors in relation to educational level in 36,000 men and women in the Netherlands. *European Heart Journal* 17: 518–525.

Huffman, S. K. (2005). Evaluation of consumption and welfare changes under economic transition in rural Poland. *Eastern European Economics* 43(3): 5–20.

Hulshof, K.; Brussaard, J.; Kruizinga, A.; Telman, J.; Lowik, M. (2003). Socio-economic status, dietary intake and 10 y trends: the Dutch National Food Consumption Survey. *European Journal of Clinical Nutrition* 57: 128–137.

Irala-Estevez, J.; Groth, M.; Johansson, L.; Prattala R.; Martınez-Gonzalez, M. (2000). A systematic review of socio-economic differences in food habits in Europe: consumption of fruit and vegetables. *European Journal of Clinical Nutrition* 54: 706–714.

Ivanova, L.; Dimitrov, P.; Ovcharova, D.; Dellava, J.; Hoffman, D. J. (2006). Economic transition and household food consumption: A study of Bulgaria from 1985 to 2002. *Economics and Human Biology* 4: 383–397.

James, W.; Nelson, M.; Ralph, A.; Leather, S. (1997). Socio-economic determinants of health. The contribution of nutrition to inequalities in health. *British Medical Journal* 314: 1545–1549.

Margetts, M.; Martinez, J.; Saba, A.; Holm, L.; Kearney, M. (1997). Definitions of 'healthy eating': a pan EU survey of consumer attitudes to food, nutrition and health. *European Journal of Clinical. Nutrition* 51: S23–S29.

Martınez-Gonzalez, M.; Lopez-Azpiazu, I.; Kearney, M.; Gibney, M.; Martınez, J. (1998). Definition of healthy eating in the Spanish adult population: a national sample in a pan-European survey. *Public Health* 112: 95–101.

Prattala, R.; Groth, M.; Oltersdorf, U.; Roos, G.; Sekula,W.; Tuamainen, H. (2003). Use of butter and cheese in 10 European countries. A case of contrasting educational differences. *European Journal of Public Health* 13 (2): 124–32.

Provencher, V.; Polivy, J.; C. Peter Herman, C. P. (2008). Perceived healthiness of food. If it's healthy, you can eat more! *Appetite* 52: 340–344.

Regmi, A.; Takeshima, H.; Unnevehr, L. (2008). Convergence in global food demand and delivery. Economic Research Report No. 56, Economic Research Department, USDA.

Regmi, A.; Gehlhar, M. (2005). New directions in global food markets. AIB – 794, Economic Research Service, U.S.D.A.

Roos, G.; Prattala, R. and the FAIR-97-3096 Disparities Group (1999). Disparities in food habits. *Review of Research in 15 European Countries*. Helsinki, National Public Health Institute.

Roos, G.; Prattala, R.; Lahelma, E.; Kleemola, P.; Pietinen, P. (1996). Modern and healthy? Socioeconomic differences in the quality of diet. *European Journal of Clinical Nutrition* 50: 753–60.

Seale, J.; Regmi, A.; Bernstein, J. (2003). International evidence on food consumption patterns. *Technical Bulletin* No. 1904, Economic Research Service, U.S.D.A.

Acta Univ. Sapientiae, Economics and Business, **2**, (2014) 21–36

Regional Differences in the Capital Structure of Hungarian SMEs

Veronika GÁL
Department of Finance and Accounting, Faculty of Economic Sciences,
Kaposvár University, Kaposvár, Hungary
E-mail: gal.veronika@ke.hu

Katalin GÁSPÁR
Department of Economics, Faculty of Economics and Human Sciences,
Sapientia-Hungarian University of Transylvania, Miercurea Ciuc
E-mail: gaspark@uni-corvinus.hu

Anett PARÁDI-DOLGOS
Department of Finance and Accounting, Faculty of Economic Sciences, Kaposvár University, Kaposvár, Hungary
E-mail: dolgos.anett@ke.hu

Abstract. Small and medium-sized enterprises play an important role in employment and also significantly contribute to GDP production. Therefore, an important function of economic policy in all countries is to create an economic milieu that supports the SMEs' operation. By analysing several economic indices of SMEs in Hungary, we could identify that there are significant differences between the regions. About 40 percent of the enterprises are located in the Central Hungary Region. By examining specific indices of these firms, we can tell that enterprises operating in this region provide higher performance in the point of Return and Gross Value Added. The aim of this study is to assert that regional differences can be found not only in the performance of firms, but also in their capital structure. As a proof of this, we analysed the regional breakdown of capital structure based on a database which contains corporate income tax declaration data of Hungarian joint small and medium-sized enterprises (168,070 firms), and then we separated different financing characteristics by using cluster analysis. Finally, we discovered those endogenous and exogenous factors that could generate the disclosed regional differences and which interact with the performance of enterprises.

Keywords: financing, capital structure indices, cluster, WEKA, determining factors.
JEL Classification: G32

1. Introduction

The role of small and medium-sized enterprises (SME) in the economy justifies that we must give high priority to this sector. But the phrase SME denotes an extremely diversified group of firms. This heterogeneity can be observed not only in their total number of staff, annual turnover or annual balance sheet total – on which the legal demarcation is based – but also in their micro- and macro-milieu and in their activities. Based on this, firms are also faced with different financing problems and opportunities in the course of their operation, and as a result of this their capital structures are dissimilar.

Capital structure is the distribution of the cash flow of a company's investments between the holders of related assets and the long-term financial claims. When the financial officer decides about the financing of a project, he actually determines the combination of the holders of claims. Most frequently, the literature uses the leverage and gearing indices to characterize capital structure. The leverage is measured by the ratio of total (long-term and short-term) liabilities to total assets, while gearing is measured by the ratio of total liabilities to equity (Brealey & Myers, 2005).

The theoretical and empirical literature of determining factors of capital structure is rich and diversified. The classical capital structure doctrines are originated from the authors Modigliani and Miller; their research defines the literature of capital structure to this day. Based on their model with robust suppositions (e.g. the capital market is perfect, and there are no taxes and transaction costs), they were led to the conclusion that the market value of the firm is independent from its capital structure (Modigliani & Miller, 1958). The aim of the majority of capital structure theories inspired by their result was to lift their assumptions. The step-by-step challenging of assumptions brings the theories nearer and nearer to the reality.

Interpreter theories of companies' capital structure have a history of more than fifty years. The earliest and, since then, determining doctrines and empirical results were born in the 50s in the United States. Statistics, which make analyses of Hungarian companies possible, have been compiled in Hungary since the regime change and the birth of the stock exchange. The earliest studies were based on data of large and mainly stock exchange listed companies. Later, analyses concentrated on a particular sector (e.g. manufacturing firms), and began to take notice of companies of all sizes. Papers concentrating on SMEs' capital structure appeared after 2000.

In this study, we focus on Hungarian SMEs' capital structure. In sections 2 and 3, we characterize the SMEs of Hungary. Section 4 describes the material and the methods. In Section 5, we investigate whether the regional differences we have found in the firms' performance also characterize the capital structure of the enterprises. In Section 6, we explore which endogenous (company size, sectoral breakdown, asset's coverage capability, market position) and exogenous (characteristic of input and output markets, macroeconomic characteristics) determinants may have significant effect on the financial decisions of SMEs and which could generate the disclosed regional differences. Finally, Section 7 concludes.

2. SMEs' Definition and Economic Importance

The definition of small and medium-sized enterprises (SMEs) regulates the Hungarian Act XXXIV of 2004 on Small and Medium-Sized Enterprises and the Promotion of Their Development. From the first of January 2005, according to 2003/361/EC Commission Recommendation concerning the definition of micro-, small and medium-sized enterprises, the conceptual demarcations of the law are the followings:

"3. § (1) An enterprise is qualified as SME if its total staff number is fewer than 250 persons and its annual turnover is up to 50 million euros in Hungarian forint, or its annual balance sheet total is up to 43 million Euros in Hungarian Forint.

(2) An enterprise is qualified as a small-sized enterprise if its total staff number is fewer than 50 persons and its annual turnover or its annual balance sheet total is up to 10 million euros in Hungarian forint.

(3) An enterprise is qualified as micro-sized enterprise if its total staff number is fewer than 10 persons and its annual turnover or its annual balance sheet total is up to 2 million euros in Hungarian forint.

(4) Those enterprises do not qualify as SMEs that have a direct or indirect property share of the state or the local government which exceeds, separately or jointly, 25%."

In Hungary, the vast majority of the enterprises belong to the category of SMEs. In 2009, 95 percent of the enterprises belonged to the category of micro-sized enterprises, based on the total staff number distribution. Beyond their numerical superiority, their size basically influences their revenue-generating capability, their contribution to the GDP, to employment and to development.

In 2009, 56 percent of Gross Value Added was produced by SMEs, while they provided jobs to three-quarters of the employed. They give more than 50 percent of the Hungarian firms' net annual turnover and investments. Their role in employment is considerable as they do typically more labour-intensive activities (Kotulics, 2010).

Hungarian SMEs' revenue-generating capability is one-tenth of the EU15's average. Less than 20 percent of the enterprises are bankable (the rate in the EU is 70–85%) and just a negligible number of them has got sensible help from enterprise development systems (NFGM, 2009).

3. Regional Differences of SMEs

Table 1. *Main indices of SMEs, 2009*

Area	Number of SMEs	Number of employees	Gross value added	Sales revenue	Investment	Foreign capital
			Billion HUF			
Central Hungary	274258	834519	3907	24802	887	5678
Central Transdanubia	69597	195457	577	2854	147	502
Western Transdanubia	68314	193928	556	2729	137	292
Southern Transdanubia	58604	159623	389	2059	197	98
Northern Hungary	59396	163291	457	2381	90	245
Northern Great Plain	79365	231014	594	3300	148	164
Southern Great Plain	78592	233932	625	3469	172	159
Hungary total	**688126**	**2011764**	**7105**	**41594**	**1789**	**7137**

Source: KSH 2011

Table 1 contains the Hungarian SMEs' most important economic indices broken down by regions. We can see that the Central Hungary Region excels at all points. It represents more than 50 percent rate in point of gross value added and sales revenue, while in point of foreign capital this rate is about 80 percent.

The differences are even more conspicuous on specific (per unit) data investigation. In point of gross value added and investments per SME, the Central Hungary Region has half as much benefit compared to the other regions. In the case of sales revenue per SME, this difference is more than the double, while in the case of foreign capital it is about sextuple. In point of the average number of employees, there are no significant differences between the regions.

Upon the investigation of the rate of gross value added to sales revenue, as the index of operation's efficiency, we found that this index is also lowest in the Central Hungary Region.

4. Material and methods

Századvég Economic Research Ltd. gave free run of the database, which we used for our analyses. This database contains Hungarian joint SMEs balance sheet and income statement data from their corporate income tax declarations from 2007 to 2011. However, in the course of the present analysis, we concentrate only on the data of the year 2010 because adequate background variables (county code, region code, TEÁOR classification) were available in that year only. To the division of the activities, the TEÁOR (unified sectoral classification system of economic activities) '08 classification's main groups were available.

Firms of the capital city, Budapest, act otherwise in many ways (e.g. type of activities) compared to other enterprises from the region's other settlements. That is why it is justifiable to run Budapest as a separate territorial unit. With the help of the county code, Budapest became isolable from the other settlements of the Central Hungarian Region; so, apropos of territorial differences, next to the seven Hungarian regions, we could represent the capital city's data separately.

The database also contains SME classification given by firms, but that has been in many cases deficient or wrong. Therefore, as the start of the analysis after the replacement and correction of this, we made another classification to the database based on the number of employees. We eliminated enterprises with the total staff number zero or unknown, and those with more than 249 employees. The created categories were: in the case of 1–9 employees "micro-," 10–49 employees "small" and 50–249 employees "medium" enterprises.

To give a presentation of the capital structure, at first, we investigated SMEs' aggregated capital structure. But the interpretation of the results was made difficult by the fact that many firms, mainly micro-enterprises, were characterized by zero or negative equity. Therefore, these firms, although not eliminated, were separated and further on run as a separate group.

To characterize firms with positive equity, we chose the further three capital structure indicators:

1) Equity ratio: we calculated as the ratio of equity and total sources.

2) Long-term debt ratio: we calculated as ratio of long-term debts and durable sources.

3) Accountants payable ratio: we calculated as ratio of accounts payable and total liabilities.

Based on the three indices, we separated different financing characteristics by using cluster analysis. Out of the potential analysing methods, we chose K-means clustering and – based on performed examinations – it was justified to use 6 clusters. We made the analysis with WEKA data mining software. WEKA (Waikato Environment for Knowledge Analysis) is a free, unlimited access package developed by Waikato University in New Zealand. Its open-source code and modular construction enables further developments; therefore, new features are added continuously (Abonyi, 2006).

5. Capital Structure in the Light of the Regions

Figure 1 shows joint SMEs from the database (in total, 168,070 firms) aggregated capital structure by territorial location. We can see that the average ratio of the equity is 37% in Hungary. We found lower ratio in the case of Budapest, as in the case of other regions it is higher. The ratio of long-term debts exceeds the countywide average only in the case of Central Hungary Region; in other regions, its value is significantly behind.

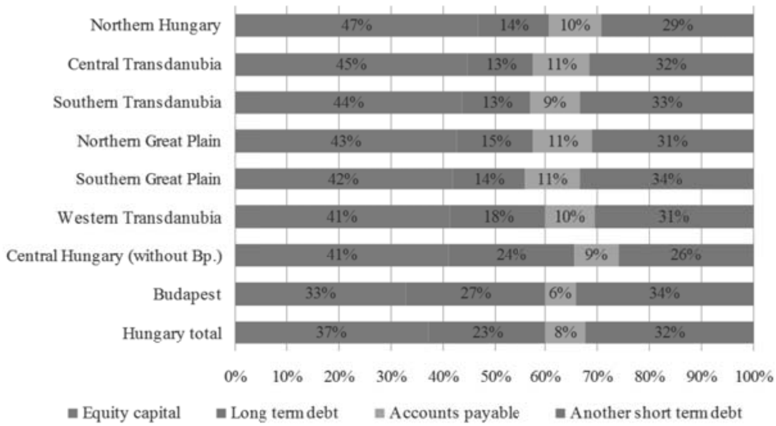


Figure 1. *Regional differences in SMEs' aggregate capital structure, 2010*

Comparing aggregated capital structure's regional data and EU's Development Ranking (Eurostat 2011), we found that in more developed areas (Central Hungary, Western Transdanubia) a lower ratio of equity and a higher ratio of durable liability is typical, more so than in less developed regions (Northern Hungary, Southern Transdanubia). The result is distorted by the firms' data with non-positive equity, whose ratio in the Central Hungary Region is higher than 20 percent.

Clusters of Capital Structure

Table 2. *Result of cluster analysis*

Cluster's name	Cluster1	Cluster2	Cluster3	Cluster4	Cluster5	Cluster6	Total
Number of firms	38,358	32,092	16,434	19,691	14,219	15,294	136,088
Rate of firms	28.19%	23.58%	12.08%	14.47%	10.45%	11.24%	100.00%

The result of the clustering is shown in *Table 2*. More than half of the 136,088 enterprises with positive equity came to the first and second cluster, while the size of the other groups is about the same; they contain units between 14,000 and 20,000 pieces.

Figure 2 illustrates the capital structure indicators of the clusters with the help of box plots. In the diagram, the boxes are delimited by lower and higher quartiles, while the total range of the data is observable through the line from the boxes. We can show that, as a result of clustering, we can identify well-separated capital structure characteristics referring to Hungarian SMEs.

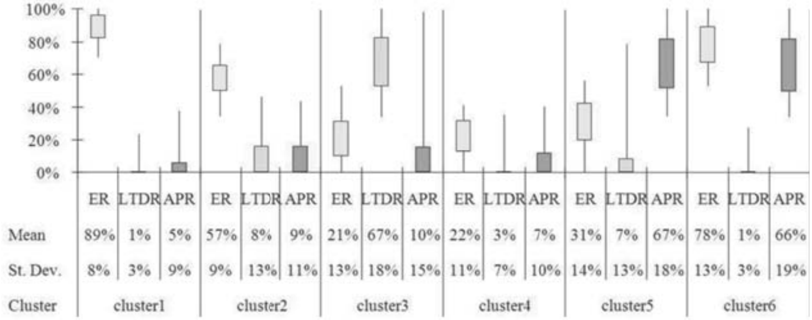


Figure 2. *Equity ratio (ER), long-term debt ratio (LTDR) and accounts payable ratio (APR) by clusters, 2010*

In *cluster1,* the dominance of equity is typical; hence this group's name is "high equity". In *cluster2,* next to the medium ratio of equity, the roles of long-term debts and accounts payable also turn up. This group's name is "medium equity". In *cluster3,* long-term debts dominate; hence, this group's name is "high long-term debt". In *cluster4,* the value of all indices is low; hence, its name is "other source". In *cluster5,* next to equity, the high ratio of trade credit is typical; hence, its name is "high trade credit". In the case of *cluster6,* the ratio of equity and trade credit is also high; hence, this group's name is "high equity and trade credit".

Financing Characteristics in the Regions

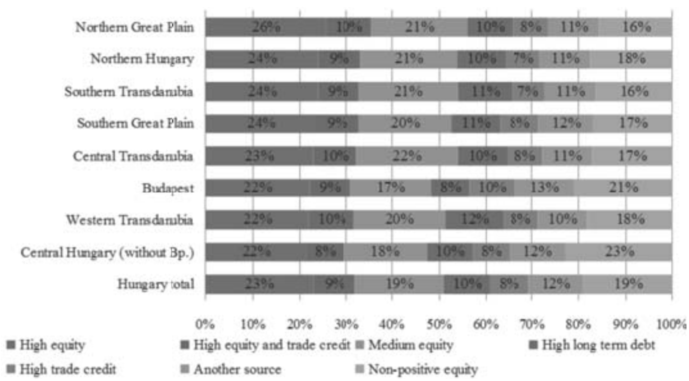


Figure 3. *Capital structure clusters by regions, 2010*

Figure 3 shows that results may be similar to the rank of development by regions. While about 60 percent of the firms in the Northern Great Plain Region finance their operation mainly with equity, this ratio is lower than 50 percent in the Central Hungary Region and in Budapest. Firms operating with high trade credit concentrated in the capital city and its surroundings, and non-positive equity is typical here. Enterprises with high stock of long-term debt are typical primarily in the Western Transdanubia Region.

6. How Can We Explain the Regional Differences?

Henceforth, we present and analyse some factors that influence the capital structures of the firms and through them we interpret the regional differences.

Krénusz (2007) divided the determining factors of capital structure (determinants) into two large groups. She named macro-factors those regional- or country-specific characteristics on which companies have no effect. These factors outwardly influence (exogenously) the financing decisions of firms. The micro-factors (endogenous factors) are the peculiarity of the companies which directly affect capital structure policy.

The literature of micro-factors discusses several determinants, from which we investigated firm size, character of activities, tangibility (coverability) and market position, as the importance of trade credit. With the help of them, we interpret the regional differences of financing characteristics in Hungary.

The literature of capital structure discusses the following macro-factors: macroeconomic characteristics, legal system, development of financial intermediation, tax system, corporate governance and characteristics of input and output markets. Some of these macroeconomic characteristics (mainly GDP per capita) and the characteristics of input and output markets may contain relevant factors if we analyse the differences between the regions.

Effect of Company Size on Capital Structure

Large companies, because of their size and diversified activities, have lower risk in the course of lending; therefore, they get borrowing capital easier. The lower risk means simultaneously cheaper financing sources, which are associated with lower specific transaction costs. The probability of bankruptcy and bankruptcy costs is proportionally much lower for large firms compared to SMEs (Warner, 1977). Therefore, we expect company size to be positively related to leverage.

Empirical studies done with data on small enterprises found the relationship between firm size and total liabilities and long term-debt to be a positive one (e.g. Jensen and Uhl, 2008; Psillaki and Daskalakis, 2009).

Table 3. *Rate of categories by firm size in the regions*

Area	Categories	Micro	Small	Medium	Total
Central Hungary (without Bp.)	number	20,519	2,391	422	23,332
	rate	**88%**	**10%**	**2%**	100%
Budapest	number	47,930	6,451	1,141	55,522
	rate	**86%**	**12%**	**2%**	100%
Southern Transdanubia	number	11,100	1,576	289	12,965
	rate	**86%**	**12%**	**2%**	100%
Northern Hungary	number	10,474	1,468	298	12,240
	rate	**86%**	**12%**	**2%**	100%
Central Transdanubia	number	12,818	1,859	327	15,004
	rate	**85%**	**12%**	**2%**	100%
Western Transdanubia	number	12,280	1,818	383	14,481
	rate	**85%**	**13%**	**3%**	100%
Northern Great Plain	number	14,511	2,183	483	17,177
	rate	**84%**	**13%**	**3%**	100%
Southern Great Plain	number	14,547	2,354	448	17,349
	rate	**84%**	**14%**	**3%**	100%
Hungary total	number	144,179	20,100	3,791	168,070
	rate	**86%**	**12%**	**2%**	100%

In *Table 3*, we can see that, although there are no huge differences between regions in the territories, in more developed regions, the ratio of micro-enterprises is higher, while in less developed regions small and medium-size enterprises are overrepresented as compared to Hungary's average.

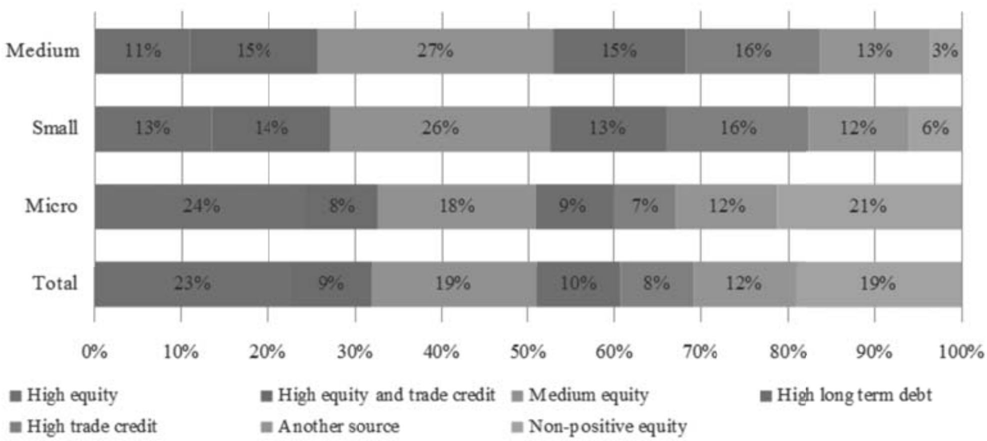


Figure 4. *Distribution of capital structure clusters by firm size, 2010*

Figure 4, which visualizes financing characteristics by company size, also shows huge differences. While every third micro-sized enterprise finances themselves quasi with equity alone, this is typical only for every fourth medium-sized enterprise. With an increase in size, long-term debt acquires higher importance. Trade credit already has a doubled importance in the small-sized category compared to the smallest-sized firm category. Non-positive equity is typical mainly in micro-sized enterprises.

Based on the capital structure clusters, it would be expectable that in more developed regions the ratio of enterprises financed mainly by equity to be higher – namely, the opposite of what we have found; therefore, firm size can not justify regional differences.

Effect of Sectoral Breakdown on Capital Structure

The characteristic of the activity is one of the most important determining factors of capital structure. The capital structures of firms in the same sector are always very similar. And sectors also tend to hold rank of relative leverage over the years. From this conception, we could demarcate firms with low, medium and high leverage (Harris and Raviv, 1991). Enterprises with low leverage are, among others, the cosmetic industry, electronic, food industry, engineering firms and publishing. Enterprises with medium leverage are, among others, pulpwood, construction, petroleum extraction and refining or chemical industry. And high leverage is typical in retail food stores, air transport, electricity and gas supply, telephone services, textile industry or trucking.

Table 4 shows that the four biggest sectors in every region are trade and repairing, professional and scientific activities, manufacturing and constructing. Next to these, other activities play an important role in each region.

Budapest also differs from other regions by activities. Next to the four biggest TEÁOR main groups, there is also a high ratio in the cases of real estate activities, information and communication, and administrative activities. Human health services are concentrated in northern areas, while transportation and storage are mainly in the county's central areas.

Table 4. *Rate of activities in the regions*

Activities	**Central Hungary (without Bp.)**	**Budapest**	**Northern Hungary**	**Northern Great Plain**	**Southern Great Plain**	**Western Transdanubia**	**Central Transdanubia**	**Southern Transdanubia**	**Total**
Trade, repairing	26%	26%	27%	**29%**	**29%**	27%	25%	26%	27%
Professional and scientific activities	11%	**18%**	10%	10%	10%	10%	10%	10%	13%
Manufacturing	13%	**9%**	14%	12%	14%	13%	14%	13%	12%
Construction	13%	**7%**	11%	10%	9%	10%	12%	11%	10%
Real estate activities	5%	**7%**	4%	4%	4%	6%	5%	5%	6%
Human health	4%	4%	**8%**	**7%**	6%	6%	6%	6%	5%
Accommodation and food service	3%	4%	5%	4%	5%	6%	5%	6%	5%
Information and communication	4%	**7%**	3%	3%	3%	3%	3%	3%	5%
Administrative activities	4%	**5%**	3%	3%	3%	3%	4%	3%	4%
Transportation and storage	**5%**	3%	4%	4%	4%	4%	**5%**	3%	4%
Agriculture, forestry, fishing	2%	**0%**	4%	**6%**	5%	4%	3%	**6%**	3%
Other activities	8%	9%	8%	8%	8%	8%	7%	8%	8%

Figure 5 demonstrates the proportion of enterprises in each cluster according to the TEÁOR classification. The ratio of firms financing mainly with equity is low in trade and repairing, transportation and storage or electricity, gas and steam supply. In accommodation and food service, the ratio of equity is also low, but this is the sector where the ratio of enterprises with non-positive equity is the highest, which influences the results. In the sector of agriculture, real estate activities or the information and communication, more than one third of the firms finance themselves mainly with equity. The lowest leverage is typical in professional and scientific activities, arts and entertainment, financial and insurance activities, human health activities and education.

A higher role of debts is noticeable next to firms with low leverage in real estate activities. The role of trade credit is high in construction and trade, repairing, but it is also important in electricity gas and steam supply. It has a lower role in human health activities, accommodation and food services and financial and insurance activities. Our results, due to the dissimilarity of classification, could not parallel the result of Harris and Raviv (1991). But we obtained the same result in the case of the medium leverage of construction and enterprises with high leverage (trade and repairing; electricity and gas supply; transportation and storage).

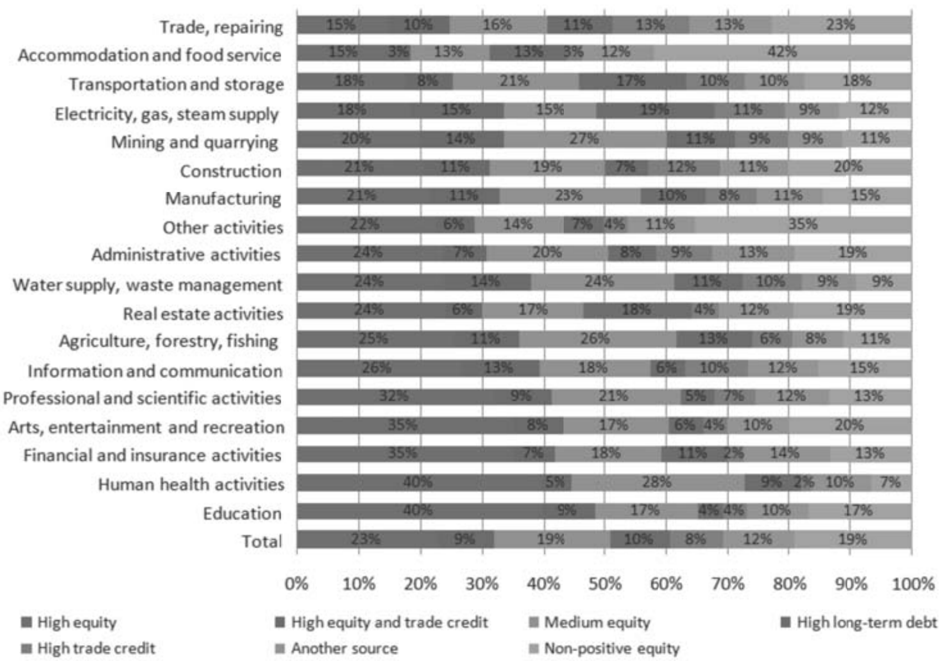


Figure 5. *Distribution of capital structure clusters by activities, 2010*

After comparing the financing characteristics of the biggest sector, trade and repairing (Figure 6), with the total sample, we can say: the territorial differences are the same in this sector as well as in the whole sample.

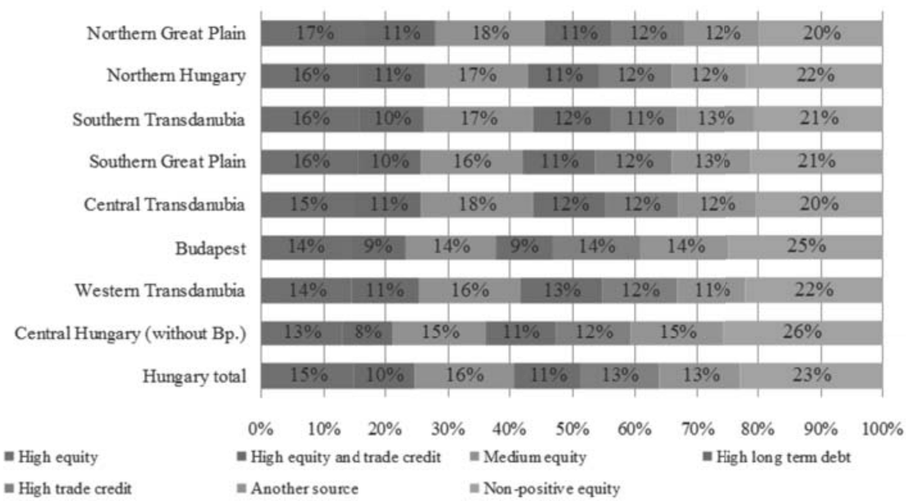


Figure 6. *Distribution of capital structure clusters in the trade and repairing sector, 2010*

Due to the territorial differences of activities, we could not interpret capital structure differences between territorial units. Based on our investigations, our conclusion is that regional differences are also observable in the activities; thus, activity is not an adequate determining factor.

Coverage Capability of the Asset

We can search the coverage capability of the asset with a component of assets, tangibility. The higher the rate of fix assets compared with the total assets, the more creditable the firm, and so the lower the risk to creditors.

In the case of large companies, there is a significantly negative relationship (e.g. Balla & Mateus, 2004) and in the case of SMEs there is a positive relationship (e.g. Sogorb, 2002; Song 2005) between tangibility and total debt. In the case of long-term liabilities, a positive relationship is documented independently from size. Therefore, higher coverability has a significant relationship rather with long-term than with short-term borrowing sources.

The covering function of asset has a greater role in smaller companies because they finance themselves out of durable sources rather than with long-term loans, as larger ones do with retained earnings and share capital.

The value of collateral coated tools is influenced by their marketability. In the case of a machine, it could reduce its value whether it is just due to delay or to high transportation costs. In the case of real estates, it means that real estates with the same parameters represent a higher coverage value in a city than in a little town. It would be the interpretation of our results why do lower typical firms finance mainly with long-term liabilities in less developed regions.

Market Position

Market position, by our reading, is a firm's ability regarding how effectively it can turn in their claims or use opportunity of vendor financing. Trade credit can be seen as the price discrimination's instrument, as marketing instrument or the instrument to reduce specific transaction costs as well. In several cases, the advantage of trade credit is higher than the lost benefit (Kihanga, 2010).

SMEs cannot vary significantly from prompts used in the economic sector because smaller prompt causes market loss, just as with longer prompts further customers can be won; however, this causes deterioration of profitability and, soon, problems with liquidity. Based on *Figure 5*, we found that vendor financing has a higher role in construction and trade.

A high stock of accounts receivable could allude to a wrong market position. A high stock of accounts payable can be interpreted as a mark of good market position and trust between clients, but it could come from wrong payment discipline.

Figure 3 shows that financing with trade credit has a higher proportion in the Central Hungary Region compared to other territories of Hungary. Therewith, it would be interpretable due to the fact that greater competition trade credit plays a higher role as a marketing and price discrimination instrument.

Exogenous Factors

Most of the exogenous determinants (e.g. tax system, law) act the same way on all SMEs in the area of a concrete country, independent from its location. So, these effects on the capital structure cannot be different. Therefore, we deem relevant those exogenous factors in point of territorial differences which we could define not only at the national level but also at the regional level, and it shows significant differences.

Characteristics of Input and Output Markets

At the regional level, one of the most important factors is the characteristics of input and output markets. The competition is higher in central areas in input and also in output markets, which could be reflected in the sources as the higher proportion of account payables. Due to fewer performers in input market, SMEs cannot use longer prompts because they hang on their suppliers out and away. In central regions, most of the suppliers are more easily replaceable; therefore, there are better opportunities to use trade credit.

Macroeconomic Characteristics

Out of the macroeconomic characteristics, we can find territorial differences mostly in regional GDP. GDP per capita is an indicator which measures the relative wealth of territorial units. We suppose that areas with high GDP per capita dispose of more and better financing alternatives; therefore, GDP per capita is positively related to leverage for all types of firms. Bas, Muradoglu and Phylaktis (2009), using data from 25 developing countries, found significant positive relationship between GDP per capita and total debt and also in the case of short-term and long-term liabilities.

So, the most important factor of territorial differences is the region's economic performance, which we could measure with GDP per capita. The EU's development ranking grade regions is also based on this index, and in the early state of analysis it became unambiguous that our results strongly correlated with the EU's ranking.

7. Conclusions

Based on our analysis, we can interpret the regional differences that we have found between the regions' economic indices and we could also investigate the capital structure of enterprises. In more developed regions, firms operate with higher leverage, while in less developed regions they use mainly equity.

With the help of cluster analysis, we identified six specific capital structure types in the case of enterprises with positive equity. Territorial differences were analysed by the frequency of the groups we appointed, and the more developed territorial units we have found, the less incidence of firms which finance themselves mainly with equity.

To explain the regional differences, we analysed the capital structure determining from the point of the relevant factors. The effect of company size and the characteristics of activities revealed themselves by an analysis across the clusters, but they did not furnish an answer to the territorial differences. Asset coverability could account for the differences in long-term liabilities, namely that the higher ratio of long-term debt is typical in more developed regions.

Analysing market position in combination with characteristics of input and output market, we found that, due to higher competition, trade credit plays a higher role in central areas than in other regions of the country. Thus, the differences of short- and long-term debts are already interpreted.

The higher proportion of equity or the lower leverage in the less developed regions is interpretable with the GDP per capita as an index of the relative wealth of territorial units. That is why we have found the EU's development ranking correlated with regional differences in capital structure.

References

Abonyi, J. (2006). *Adatbányászat a hatékonyság eszköze*, Budapest, Computer Books.

Balla, A.; Mateus, C. (2004). Empirikus vizsgálat a tőkestruktúra-döntésekről. *Vezetéstudomány* 35: 24–33.

Bas, T.; Muradoglu, G.; Phylaktis, K. (2009). Determinants of capital structure in developing countries, available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.175.6261&rep=rep1&type=pdf.

Brealey, R. A.; Myers, S. C. (2005). Modern vállalati pénzügyek, Budapest, Panem.

Eurostat (2011). Regional GDP per inhabitant in 2008 GDP per inhabitant ranged from 28% of the EU27 average in Severozapaden in Bulgaria to 343% in Inner London, available at: http://europa.eu/rapid/press-release_STAT-11-28_en.htm?locale=en.

Harris, M.; Raviv, A. (1991). The theory of capital structure. *The Journal of Finance* 46(1): 297–355.

Hungarian Act XXXIV of 2004 on Small and Medium-Sized Enterprises and the Promotion of Their Development (2004. évi XXXIV. törvény a kis- és középvállalkozásokról, fejlődésük támogatásáról).

Jensen, N. S.; Uhl, F. T. (2008). Capital structure in European SMEs. An analysis of firm- and country specific variables in determining leverage, Aarhus School of Business, University of Aarhus.

Kihanga, E. P. (2010). Trade credit in the Tanzanian rice market. *Theses in Economics and Business*, Groningen, The Netherlands: University of Groningen.

Kotulics, T. (2010). A KKV-k a statisztika rengetegében, presentation, Budapest: KKV Marketing Expo, 21 January 2010.

Központi Statisztikai Hivatal (KSH) (2011). A kis- és középvállalkozások helyzete. *Gazdaság számokban* 29, available at: http://www.gymskik.hu/download.php?id=4780.

Krénusz, Á. (2007). *A vállalati tőkeszerkezet meghatározó tényezőinek új modellje és annak vizsgálata Magyarország példáján*, Ph.D. dissertation, Budapest: Budapesti Corvinus Egyetem Gazdálkodástani Doktori Iskola.

Modigliani, F.; Miller, M. H. (1958). The cost of capital, corporation finance and the theory of investment. *The American Economic Review* 48(3): 261–297.

Nemzeti Fejlesztési és Gazdasági Minisztérium (NFGM) (2009). *A kis- és középvállalkozások helyzete 2008 jelentés*.

Psillaki, M.; Daskalakis N. (2009). Are the determinants of capital structure country or firm specific? *Small Business Economics* 33(3): 319–333.

Sogorb, F. (2002). How SME uniqueness affects capital structure: evidence from a 1994–1998 Spanish data panel. *WP-EC*, 2002-18, Instituto Valenciano de Investigaciones Económicas.

Song, H.-S. (2005). Capital structure determinants – An empirical study of Swedish companies. *Electronic Working Paper Series* 25: 1–25.

Warner, J. B. (1977). Bankruptcy costs: some evidence. *Journal of Finance* 32: 337–347.

ACTA UNIV. SAPIENTIAE, ECONOMICS AND BUSINESS, **2,** (2014) 37–57

Sectoral Interdependencies and Key Sectors in the Romanian, Hungarian and Slovak Economy – An Approach Based on Input-Output Analysis

Emese BALLA
Department of Juridical Sciences and European Studies,
Faculty of Sciences and Arts,
Sapientia Hungarian University of Transylvania, Cluj-Napoca.
E-mail: ballaemese@kv.sapientia.ro

Abstract. The aim of this paper is to analyse sectoral interdependencies and to identify the key sectors in the Romanian, Hungarian and Slovak economy, drawing a comparison between these three countries. In order to do these investigations, input-output analysis is applied, as it is based on a model which presents interactions between sectors of the economy. This method can also be used for determining the role of each sector in the national economy regarding its contribution to the total output, incomes, export-import and so on, and for quantifying direct and indirect impact on the whole economy caused by any change produced in a sector's activity. As the results of the analyses show, several similarities and differences appear in the economic structure, the sectoral interdependencies and the key sectors of the analysed countries. For example, in Romania, intersectoral transactions are axing mainly on the *Trade* and *Manufacturing* sectors, while in Hungary and Slovakia on the *Manufacturing* and *Other professional, scientific and technical services sectors.* Key sectors – identified by applying output and income backward linkages – also differ as in Romania the output backward linkage is the largest in the case of the *Trade sector*, in Hungary, in the *Food sector* and in Slovakia in the *Electricity, gas, water and waste management sector*. In the case of the income linkages, *Social, collective and personal services* rank in the first place in all three countries.

Keywords and phrases: key sectors, input-output analysis, Romania, Hungary, Slovakia.
JEL Classification: D57, O57

1. Introduction

This study aims at analysing the sectoral interdependencies and identifying the key sectors in Romania, Hungary and Slovakia, three countries situated entirely or partly in the Carpathian Basin, with a significant Hungarian population. Hungary and some parts of Romania and Slovakia had once belonged to the same economic bloc, but since then the different social, demographic and political processes provided different backgrounds for their economic developments. At the same time, differences in the relief and in the availability of the natural resources also influence the economic situation of these countries. However, all of them are Central and Eastern European countries, member states of the European Union; so, many common economic features are expected to be identified.

Investigating some general demographic and economic characteristics of the countries, we highlight the following aspects: the total surface of Romania (238,394 km^2) is more than twice as large as that of Hungary (93,023 km^2) and four times larger than that of Slovakia (49,037 km^2). The land use also shows significant differences: the share of the cropland is much higher in Hungary (47%) than in the other countries (36% in Romania and 28% in Slovakia), while the woodland has the highest share in Slovakia (46%, while in Romania it is 31% and in Hungary 24%), and the share of the grassland is the highest in Romania (25%, while in Hungary and Slovakia it is 19%).[1] Romania has about 20 million inhabitants, Hungary 9.9 million, while Slovakia only 5.4 million inhabitants.[2] Regarding the GDP per inhabitant,[3] relatively high differences appear, as the value of this indicator is the highest in Slovakia (19,400 PPS), being followed by Hungary (17,000 PPS), and it is the lowest in Romania (13,500 PPS).

For investigating the economic structure, the sectoral links and key sectors in the chosen countries, we apply the method of input-output analysis. The study is structured in the following way: in Section 2, we present the methodology of the input-output analysis. This is followed by Section 3 containing results and discussion. In this section, we present a descriptive analysis of the structure of the Romanian, Hungarian and Slovak economy, we characterize intersectoral transactions and direct linkages between the sectors for all three countries, and we present the results of the key sector analysis based on the calculation of some output and income backward linkages in order to identify those sectors which can trigger the largest changes on the economic level. In Section 4, we outline some conclusions and remarks.

1 Eurostat data for year 2012
2 Eurostat data for year 2013
3 Eurostat data for year 2012

2. Material and Methods

Input-Output Analysis

The input-output analysis was developed by Wassily Leontief in the late 1930s, and since then it has become a widely used modelling tool, as it can be applied to reveal sectoral interdependencies in an economy, to analyse the structure of the total output, respectively input, and to identify the key sectors in the national economy from the demand and supply side. Those sectors can be considered as key sectors which can trigger the most significant changes in the national production, value added, income and so on. Due to the above-mentioned opportunities provided by this technique, input-output models can be used as policy tools, too, because they allow the prediction of changes over the output, income or employment level initialized by a certain policy measure that is intended to be applied (Mattas et al., 2006a, p. 55).

The input-output analysis is based on the input-output table, which "is designed to provide a concise and systematic arrangement of all economic activities within an economy. It shows the intersectoral flows in monetary terms for a particular year where the flows represent intermediate goods and services." (Rameezdeen et al., 2005, p. 3) The rows of the input-output table present the structure of the demand for the production of each sector, while its columns present the structure of the resources used by the sectors (Table 1). So, sectoral interdependencies can be analysed both from the demand and the supply side.

The input-output table is composed by three quadrants,[4] which generally contain the following information:

– the first quadrant contains the transaction matrix, which shows the intermediate transactions of the economic sectors;

– the second quadrant (on the right-hand side) contains the final demand (Y) for the output of each sector, including consumption of households, consumption of the government and non-profit organizations, respectively gross fixed capital formation, changes in inventories and export;

– the third quadrant (below the first quadrant) represents the primary inputs (or final payments) (P) coming from the rest of the economy (not from the production of the other sectors): compensations of employees, taxes, subventions or other value-added components, and from imports.

4 The elements of the fourth quadrant representing the transactions of the primary inputs and final demand categories are generally not presented in the input-output tables.

Table 1. *Structure of the input-output table*

	To	Intermediate demand (purchasing sectors)						Final demand	Total output
From		1	2	…	j	…	n		
Intermediate inputs (selling sectors)	1	x_{11}	x_{12}	…	x_{1j}	…	x_{1n}	Y_1	X_1
	2	x_{21}	x_{22}	…	x_{2j}	…	x_{2n}	Y_2	X_2
	…	…	…	…	…	…	…	…	…
	i	x_{i1}	x_{i2}	…	x_{ij}	…	x_{in}	Y_i	X_i
	…	…	…	…	…	…	…	…	…
	n	x_{n1}	x_{n2}	…	x_{nj}	…	x_{nn}	Y_n	X_n
Primary inputs		P_1	P_2	…	P_j	…	P_n		
Total inputs		X_1	X_2	…	X_j	…	X_n		

Source: own creation based on Mattas et al., 2006a, p. 59.

Based on the input-output table, equations (1) and (2) can be written regarding the selling and purchasing activity of the sectors.

(1)
$$X_i = \sum_{j=1}^{n} x_{ij} + Y_i$$

- where X_i represents the total output of sector *i*, x_{ij} is the value of products or services sold by sector *i* for sector *j*, Y_i represents the final demand for products or services of sector *i* and *n* is the number of the sectors of the economy.

(2)
$$X_j = \sum_{i=1}^{n} x_{ij} + P_j$$

- where X_j represents the total input of sector *j*, x_{ij} is the value of the products or services purchased by sector *j* from sector *i* and P_j represents the primary inputs of sector *j*.

Measuring Direct Intersectoral Linkages: The Flow Index

The transaction matrix of the input-output table presents the intersectoral activities within the economy. In this study, we measure the degree of direct relationship between the sectors in the chosen countries using the flow index. The flow index between sectors *i* and *j* can be calculated by taking the average of the share of intermediate uses (x_{ij}) over the total intermediate input of sector *j* and over the total intermediate output of sector *i*. (EC-JRCIPTS,[5] 2007, p. 3.)

If the flow index calculated for two sectors – *i* and *j* – is relatively high, it means that the sectors are strongly interrelated to each other. The interdependence between two sectors can be estimated both from demand and supply side.

5 European Commission – Joint Research Centre's Institute for Prospective Technological Studies

This means that sector *i* is strongly backward interrelated with sector *j* if an important part of sector *i*'s intermediate inputs are purchased from sector *j* and, at the same time, this amount represents a relatively high share in sector *j*'s total intermediate output.

In turn, sector *i* is strongly forward interrelated with sector *j* if sector *j* is an important consumer of the intermediate outputs of sector *i* and, at the same time, these products represent an important share in the total intermediate input of sector *j*.

For example, in the case of Romania, 52% of the total intermediate output of agriculture is used by the *Food products, beverages and tobacco products* sector, which corresponds to the 57% of the total intermediate input of the latter sector. So, the flow index is calculated in the following way: (52% + 57%) / 2 = 54.5%.

Inversely, the food sector delivers 6% of its total intermediate output for the agriculture, which counts 2% in the total intermediate input of the agriculture. In this case, the value of the flow index is 4%. So, it can be concluded that *Agriculture* is strongly forward interrelated with the *Food sector* and relatively weakly backward interrelated with it.

Indirect Linkages

Interdependencies from an economy are represented – besides the direct linkages – by the intensity of the indirect linkages too. These indirect linkages can be calculated and estimated in several ways, as several multipliers and indicators were invented by the specialists of the input-output methodology. Linkage indicators are mainly used to quantify changes in the total national output, income, employment, value added etc. triggered by a change produced in the activity of a certain sector. Sectors with the highest linkage values can be considered key sectors as they can generate the highest changes on the economic level. Kweka, Morrissey and Blake (2001, p. 21.) draw attention to the fact that all the sectors of the economy are somewhat important; so, "identification of key sectors may only be justifiable on ordinal terms".

In this study, we calculate output and income backward linkages proposed by Rasmussen (1956)[6] and Hirschman (1958).[7] Backward linkages show changes at the level of the economy produced by one unit change in a sector's final demand.

The calculation of the backward linkages is based on the total requirements matrix, the so-called Leontief-inverse (B), which is computed as the inverse matrix of the direct requirements matrix (A). The direct requirements matrix contains the technical coefficients, which are calculated according to the formula:

6 *Cited in*: Mattas et al. (2006b, p.104)

7 *Cited in*: Mattas et al. (2006b, p.104)

(3) $$a_{ij} = x_{ij} / X_j$$

where a_{ij} is the respective element of the direct requirement matrix (A), x_{ij} represents the value of sector *i*'s production purchased by sector *j* and X_j represents the total input of sector *j*.

The total requirements matrix (B) is computed using the formula:

(4) $$B = (I-A)^{-1}$$

where *I* is the identity matrix.

The *Output Backward Linkage (OBL)* of sector *j* shows the increase in the total output at the level of the economy which is required for one unit increase in the final demand of sector *j*.

(5) $$OBL_j = \sum_{i=1}^{n} \beta_{ij}$$

where β_{ij} is the respective element of the total requirements matrix (B). (Mattas et al., 2006b, p. 104.)

The *Income Backward Linkage (IBL)* of sector *j* shows the change in the total income at the level of the economy which is required for one unit increase of the final demand of sector *j*:

(6) $$IBL_j = \sum_{i=1}^{n} L_i * \beta_{ij}$$

where L_i is the income coefficient of sector *i*: $L_i = I_i / X_i$ (*I* – income: the compensation of the employees, *X* – total output). (Mattas et al., 2006b, p. 105.)

Source of Data

The source of the input-output tables for Romania, Hungary and Slovakia is the official site of the Eurostat.[8] Most recently available symmetric input-output tables are from the year 2010, including 64 branches. In the study, branches are aggregated for 13 branches:

1. Agriculture, forestry and fishing;
2. Mining and quarrying;
3. Food products, beverages and tobacco products;
4. Manufacturing (excepting food products, beverages and tobacco products);
5. Electricity, gas, steam and air-conditioning; water supply; waste management services;

8 Eurostat -ESA 95 Supply Use and Input-Output tables (Table 17: Input-output table at basic prices), monetary unit: Romania – mio. EUR, Hungary and Slovakia mio. NAC.

6. Constructions;
7. Trade (wholesale and retail);
8. Transport and postal services;
9. Accommodation and food services;
10. Publishing, telecommunication and computer programming services;
11. Financial, insurance and real estate services;
12. Other professional, scientific and technical services (legal, accounting, employment services, travel agencies, a.s.o.);
13. Social, collective and personal services (public administration and defence, educational, health services a.s.o.).

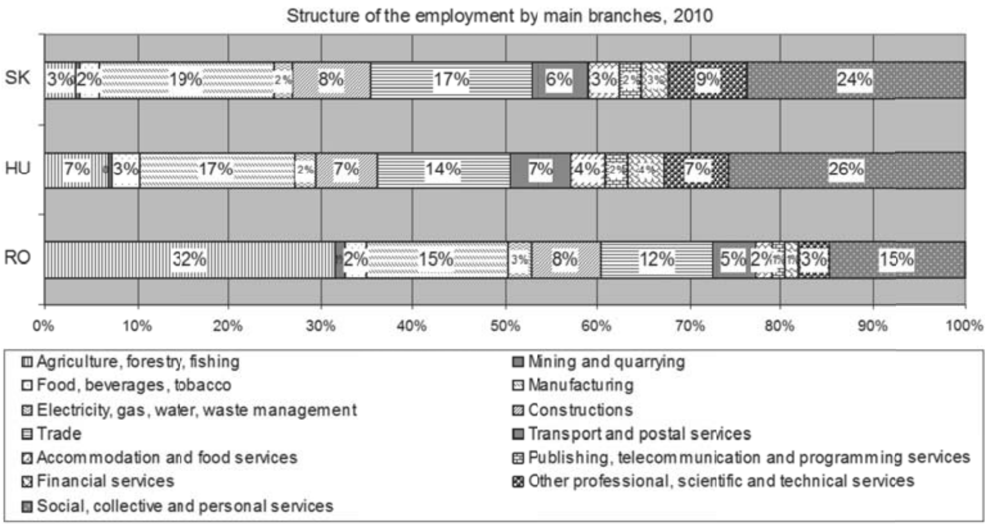
3. Results and Discussion

Structure of the Sectoral Employment and Output

In order to analyse the structure of the economy in the chosen countries, first of all, we investigated the structure of the employment by the main branches. As *Figure 1* shows, high discrepancies between the countries can be observed and especially the case of Romania is different because here the share of employment in agriculture is much higher than in the other countries. In Hungary and Slovakia, the proportion of the employment in the *Social, collective and personal services* (in Hungary, especially from the *Public administration and defence*, while in Slovakia from the *Education* sectors) is in the first place. A high share of the employed persons works in this sector in Romania as well, especially in the *Health services*. The other most important sectors in terms of employment shares are the *Manufacturing* and the *Trade* sectors in all three cases.

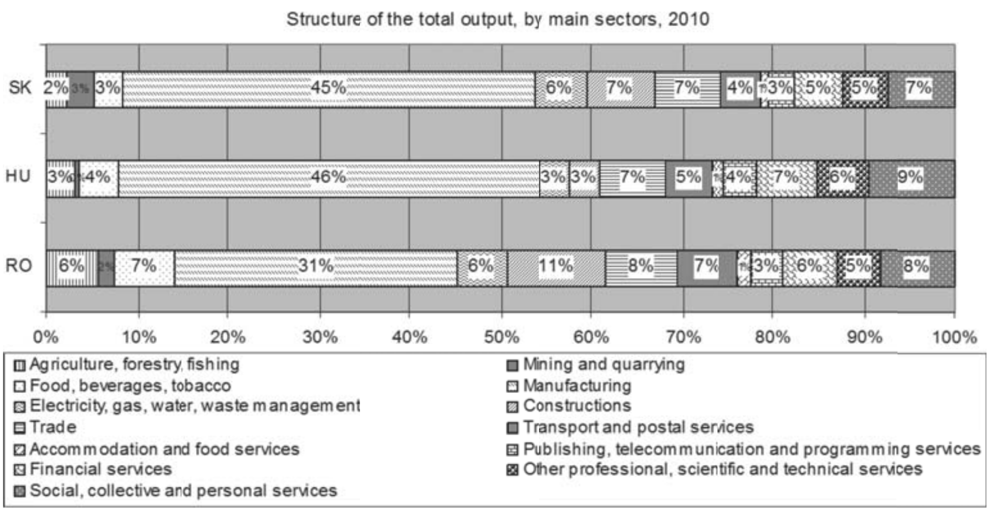
Analysing the structure of the output by main branches – shown in *Figure 2* –, it can be observed that it significantly differs from the structure of the employment by main branches, which is related, first of all, to the labour productivity of the sectors. For example, in Romania, the proportion of the agricultural employment in the total employment is five times higher than the proportion of the agricultural output in the total output. In turn, in Hungary and Slovakia, the difference between these proportions is very small.

Regarding the structure of the total output, the following aspects can be remarked. The *Manufacturing* sector has the highest proportion in all three countries, and within this sector the following branches have the highest importance: in Romania, the share of the *Motor vehicles*, *Basic metals* and *Textiles, wearing apparel and leather products*, in Hungary, the *Computer, electronic and optical products*, *Motor vehicles*, *Coke and refined petroleum products*, and in Slovakia the *Motor vehicles*, *Computer, electronic and optical products* and *Basic metals* is the highest. In the second place, we find the *Construction* sector in Romania, the *Social, collective and personal services* in Hungary and Slovakia, and in the third place the *Social, collective and personal services* in Romania and *Trade* in Hungary and Slovakia.



Source: own calculations based on Eurostat data

Figure 1. *Structure of the employment by main sectors in Romania, Hungary and Slovakia*

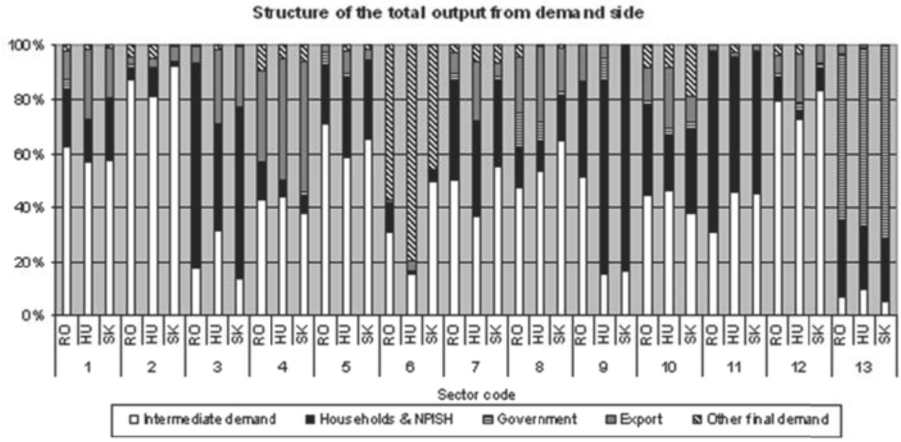


Source: own calculations based on Eurostat data

Figure 2. *Structure of the total output by main sectors*

Structure of the Sectoral Output from Demand Side

The structure of the total output from demand side shows significant differences by sectors and by countries, as well. In the case of the *Agriculture, forestry and fishing* sector, the largest part of the output is consumed by the other sectors (intermediate demand) in all three countries, while about 20% of the products in Romania and Slovakia are consumed by the households. The lowest export activity appears in the case of Romania, which is probably due to the existing inefficiencies in this sector's activity. In Hungary, the share of the household consumption is lower, but the share of exports is higher. Compared to the other sectors, the proportion of the intermediate demand is the highest in the *Mining and quarrying* sector in all three countries. At the same time, a very weak export activity can be observed in all three countries, and especially in Romania. In the case of the *Food sector*, the proportion of the household consumption is the highest in all three countries; however, in Hungary and Slovakia, the relatively high share of the exports must be mentioned. *Manufacturing* products in Romania are used mainly by the other sectors. Although the share of the exports is significant, it is again lower than in the other two countries, where the proportion of the exports is higher than that of the intermediate consumption. The output of the *Electricity, gas, steam and air-conditioning; water supply; waste management services* sector is consumed mainly by the other sectors, but the consumption of the households is also significant in all three countries. In the case of the *Construction* sector, the share of the gross fixed capital formation – especially in Hungary – is the highest. At the *Trade* and *Transport and postal services*, the proportion of the intermediate consumption is the highest in all three countries and a relatively high share of the export in Hungary must be remarked. In the case of the *Accommodation and food services*, the consumption share of the households is much higher in Hungary and Slovakia than in Romania, which is probably due to the untapped opportunities in Romanian tourism. In the *Publishing, telecommunication and computer programming services* sector, the share of the exports is the highest in Hungary again, but the intermediate consumption has the highest share in all three countries. Regarding the *Financial, insurance and real estate services*, it can be seen that the share of household consumption in Romania is higher than in the other two countries, while in Hungary and Slovakia the structure of this sector's output is almost the same. In the case of the *Other professional, scientific and technical services*, the share of the intermediate demand is very high in all three countries, as these are services rendered mainly for enterprises. At the *Social, collective and personal services*, the share of the government consumption is the most important and, at the same time, the structure of the output is very similar in the analysed countries.



Sector codes: 1. Agriculture, forestry and fishing; 2. Mining and quarrying; 3. Food products, beverages and tobacco products; 4. Manufacturing; 5. Electricity, gas, water, waste management; 6. Constructions; 7. Trade; 8. Transport and postal services; 9. Accommodation and food services; 10. Publishing, telecommunication and computer programming services; 11. Financial, insurance and real estate services; 12. Other professional, scientific and technical services; 13. Social, collective and personal services.

Source: own calculations based on Eurostat data

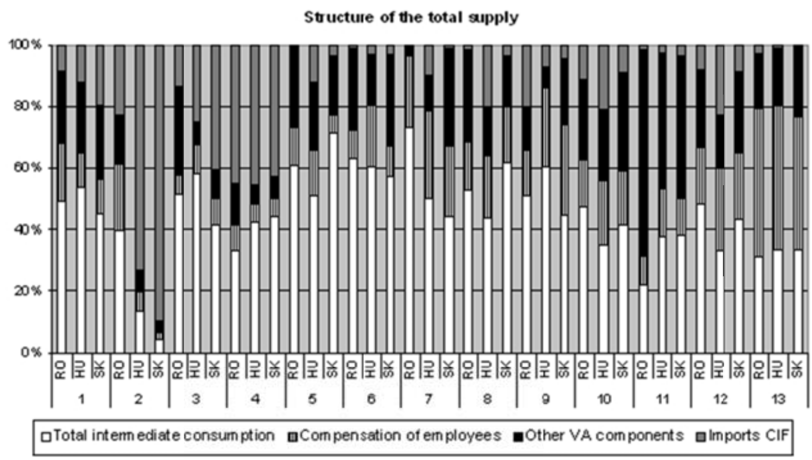
Figure 3. *Structure of the total output from demand side*

Structure of the Sectoral Inputs

Regarding the structure of the sectoral inputs, the following main observations can be made. In the case of the *Agriculture, forestry and fishing* sector, the highest share of the inputs comes from the intermediate resources in all three countries. At the same time, the share of the compensation of the employees[9] is the highest in Romania, which can be explained by the high level of agricultural employment in this country. Agricultural imports have the highest share in Slovakia, being followed by Hungary. In the *Mining and quarrying* sector, intermediate resources have a relatively high share in Romania, while in the other two countries imports are very significant. Regarding the *Food sector*, it is easy to observe that imports have a significant share in the sectoral inputs in Hungary and Slovakia, while this share is lower in the case of Romania. In the *Manufacturing* sector, the share of the imports is almost the same in all three countries, but the share of the intermediate resources is lower in Romania and the share of the compensation of employees and the proportion of the other value-added components are higher here than in the other countries. In the case of the *Electricity, gas, steam and air-conditioning; water supply; waste management services* sector, the proportion of the imports is the highest in Hungary. The structure of the inputs is almost the same in all

9 The compensation of the employees is supplied at current prices.

three countries in the case of the *Construction* sector, and the proportion of the compensation of employees is higher in Hungary than in Romania or Slovakia; however, the share of the employment working in this sector in Hungary is the lowest. In the *Trade* sector, the proportion of the intermediate inputs is the highest in Romania and the value added is lower here. In the case of the *Transport and postal services*, a relatively high share of the imports in Hungary can be observed and the compensation of employees appears with almost the same share in all three countries. In the *Accommodation and food services* sector, the proportion of the import is the highest in Romania, while the share of the intermediate consumption is the highest in Hungary. The compensation of employees in Hungary and Slovakia appears with higher share than in Romania. In the case of the *Publishing, telecommunication and computer programming services*, a relatively high proportion of the imports in Hungary can be observed, while in Romania and Slovakia the structure of the sectoral inputs is very similar. Higher value-added proportion in the case of the *Financial services* can be observed in Romania, while in the other two countries intermediate inputs of this sector have higher shares. Regarding the *Other professional, scientific and technical services*, Romania and Slovakia can be characterized by almost the same input structure, while in Hungary the share of the imports is higher. In the case of the *Social, collective and personal services*, the structure of the inputs is almost the same in all three countries.



Sector codes: 1. Agriculture, forestry and fishing; 2. Mining and quarrying; 3. Food products, beverages and tobacco products; 4. Manufacturing; 5. Electricity, gas, water, waste management; 6. Constructions; 7. Trade; 8. Transport and postal services; 9. Accommodation and food services; 10. Publishing, telecommunication and computer programming services; 11. Financial, insurance and real estate services; 12. Other professional, scientific and technical services; 13. Social, collective and personal services.

Source: own calculations based on Eurostat data

Figure 4. *Structure of the total output from supply side*

Structure of the Export and Import by Main Sectors

The structure of the export and import by the main sectors in Romania, Hungary and Slovakia are presented in *Table 2*. It is easy to observe that the *Manufacturing* sector has the highest proportion in total export and import in all three countries. Entering into details regarding the activity of this sector, the following aspects must be highlighted. In Romania, the highest export appears in the case of the *Electrical equipment* and *Textiles, wearing apparel and leather products*, while in Hungary and Slovakia at the *Computer, electronic and optical products* and *Motor vehicles, trailers and semi-trailers* branches.

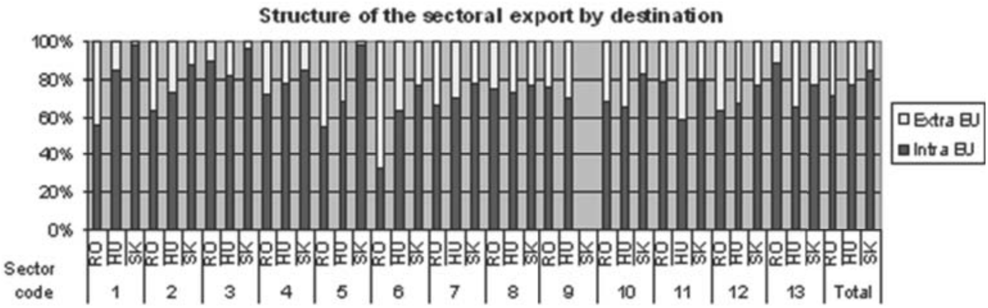
Concerning the structure of the import, in Romania, the *Computer, electronic and optical products*, *Machinery and equipment* and the *Electrical equipment*, while in Hungary and Slovakia the *Computer, electronic and optical products* and *Motor vehicles, trailers and semi-trailers products* have the most significant proportion in the *Manufacturing* sector's import.

Table 2. *Structure of the regional export and import by sectors*

Sector	Romania		Hungary		Slovakia	
	Export	Import	Export	Import	Export	Import
Agriculture, forestry, fishing	4%	3%	3%	1%	2%	2%
Mining and quarrying	0%	2%	0%	1%	1%	11%
Food, beverages and tobacco	3%	5%	4%	4%	3%	5%
Manufacturing	69%	80%	74%	77%	87%	76%
Electricity, gas, water, waste management	1%	0%	1%	1%	1%	1%
Constructions	1%	1%	0%	0%	0%	1%
Trade	4%	0%	6%	3%	1%	0%
Transport and postal services	9%	1%	5%	4%	3%	1%
Accommodation and food services	1%	2%	0%	0%	0%	0%
Publishing, telecommunication and computer programming services	3%	2%	3%	3%	1%	1%
Financial, insurance and real estate services	1%	1%	0%	1%	0%	1%
Other professional, scientific and technical services	2%	2%	4%	5%	1%	2%
Social, collective and personal services	2%	1%	0%	0%	0%	0%

Source: own calculations based on Eurostat data

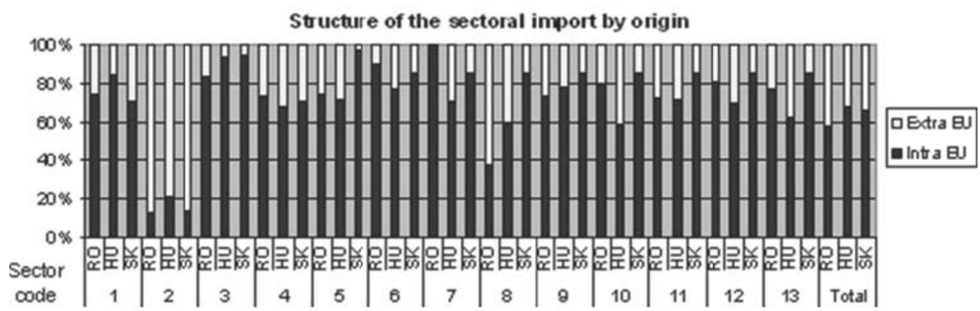
The structure of the sectoral export by destination and the structure of the sectoral import by origin are shown in figures 5 and 6. It is easy to observe that in Romania the share of the export to non-EU member states in most cases is higher than in the other two countries, which probably has to do mainly with the geographical position of the country. The highest proportion of the extra EU exports in Romania appears in the case of the *Construction* and *Electricity, gas, steam and air-conditioning; water supply; waste management services* sectors, in Hungary, for *Financial, insurance and real estate services* and *Construction* sectors, while in Slovakia for *Social, collective and personal services.*



Sector codes: 1. Agriculture, forestry and fishing; 2. Mining and quarrying; 3. Food products, beverages and tobacco products; 4. Manufacturing; 5. Electricity, gas, water, waste management; 6. Constructions; 7. Trade; 8. Transport and postal services; 9. Accommodation and food services; 10. Publishing, telecommunication and computer programming services; 11. Financial, insurance and real estate services; 12. Other professional, scientific and technical services; 13. Social, collective and personal services.

Source: own calculations based on Eurostat data

Figure 5. *The structure of the sectoral export, by destination*



Sector codes: 1. Agriculture, forestry and fishing; 2. Mining and quarrying; 3. Food products, beverages and tobacco products; 4. Manufacturing; 5. Electricity, gas, water, waste management; 6. Constructions; 7. Trade; 8. Transport and postal services; 9. Accommodation and food services; 10. Publishing, telecommunication and computer programming services; 11. Financial, insurance and real estate services; 12. Other professional, scientific and technical services; 13. Social, collective and personal services.

Source: own calculations based on Eurostat data

Figure 6. *The structure of the sectoral import, by origin*

Regarding the origin of the sectoral imports, it can be observed that in the case of the *Mining and quarrying* sector the value of the imported products purchased from non-EU member states is much higher in all three countries than those purchased from EU members. A relatively high share of the extra EU imports can be observed in Romania in the case of the *Transport and postal services*. In the case of the other sectors, the value of the imported goods and services from EU member states is higher than the value of the imports coming from non-EU member states.

Intersectoral Transactions

We estimate the relationships between the main sectors of the economy using flow indexes. Figures 7, 8 and 9 depict the most important direct linkages between the sectors of the economy in Romania, Hungary and Slovakia. Arrows on the figures represent flow indices greater than 0.1, and the direction of the arrows shows the backward or forward character of the intersectoral transactions.

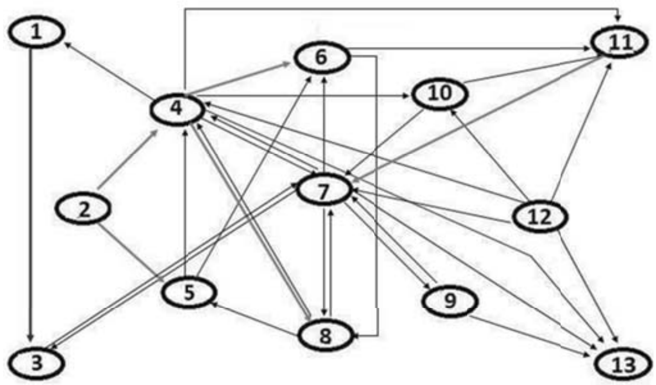
In the case of Romania, the relationships covered by the arrows represent 51% of the value of the intersectoral transactions. It is easy to observe that in Romania intersectoral transactions are axing mainly on the *Trade* and *Manufacturing* sectors.

The strongest relationships (where the flow index is above 0.35) can be considered between the *Agriculture* and *Food sector*, where the first one is highly forward interrelated with the second one. Other strong relationships (where the flow index is between 0.2 and 0.34) can be observed in the following cases: *Manufacturing* and *Electricity, gas, steam and air-conditioning; water supply; waste management services* sectors are highly backward interrelated with the *Mining and quarrying* sector. The *Manufacturing* sector is highly forward interrelated with the *Construction* and the *Transport and postal services* sector, and the *Trade* sector is highly backward interrelated with the *Financial services* sector.

As it is revealed in the followings, in Romania, the transactions with relatively high flow index cover a larger part of the intersectoral transactions than in the other two countries.

Another important aspect worth to be mentioned is that the self-consumption of the sectors covers 26% of the value of the intersectoral transactions.

In Hungary, the intersectoral relationships with the flow index above 0.1 represent 32% of the total intersectoral transactions. The sectors characterized by the largest number of flow indexes having value above 0.1 are the *Manufacturing* and the *Other professional, scientific and technical services* sectors. The strongest intersectoral relationships can be observed in the following cases: similarly to Romania, the *Agriculture, forestry and fishing* sector is highly forward interrelated with the *Food sector* and – what does not appear in the case of Romania – the *Food sector* is highly forward interrelated with the *Accommodation and food services* sector (in both cases, the flow index is above 0.35). Other important relationships (with flow indices between 0.2 and 0.35) are observed in the case of the *Manufacturing* sector, which is highly backward interrelated with the *Mining and quarrying* and *Trade* sectors, and it is highly forward interrelated with the *Construction* sector. The self-consumption of the sectors covers 48% of the total intermediate consumptions.

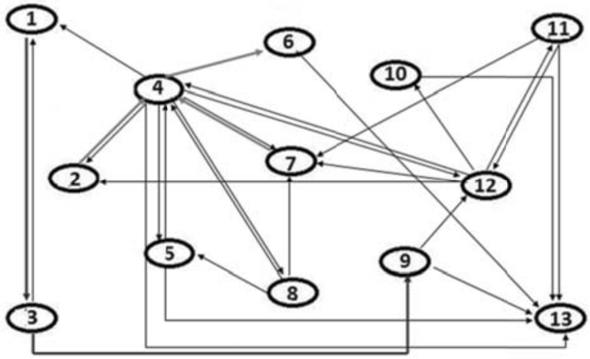


Sector codes: 1. Agriculture, forestry and fishing; 2. Mining and quarrying; 3. Food products, beverages and tobacco products; 4. Manufacturing; 5. Electricity, gas, water, waste management; 6. Constructions; 7. Trade; 8. Transport and postal services; 9. Accommodation and food services; 10. Publishing, telecommunication and computer programming services; 11. Financial, insurance and real estate services; 12. Other professional, scientific and technical services; 13. Social, collective and personal services.

Source: own edition based on Eurostat data

Figure 7. *Flow index, Romania*

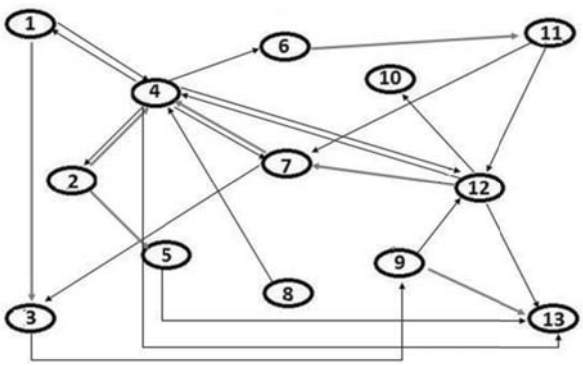
In Slovakia, intersectoral transactions characterized by a flow index above 0.1 cover only 30% of the total intersectoral transactions. Similarly to Hungary, *Manufacturing* and *Other professional, scientific and technical services sectors* can be characterized by the largest number of the flow indices above 0.1. The strongest relationships (with flow indices above 0.2) can be seen in the following cases: similarly to the other two countries, the *Agriculture, forestry and fishing* sector is highly forward interrelated with the *Food sector*, while *Mining and quarrying* sector is highly forward interrelated with the *Manufacturing* and *Electricity, gas, steam and air-conditioning; water supply; waste management services* sectors. The *Manufacturing* sector is backward interrelated with the *Trade* sector and the *Trade* sector is backward interrelated with the *Other professional, scientific and technical services.* The *Construction* sector is highly forward interrelated with the *Financial, insurance and real estate services* and *Accommodation and food services* are forward interrelated with the *Social, collective and personal services*. It is also worth mentioning that although the flow index is below 0.2 an important relationship appears between the *Food sector* and the *Accommodation and food services* sector, which can be seen in Hungary, too, and cannot be observed in the case of Romania. The proportion of the self-consumption in the intermediate transactions is 51%.



Sector codes: 1. Agriculture, forestry and fishing; 2. Mining and quarrying; 3. Food products, beverages and tobacco products; 4. Manufacturing; 5. Electricity, gas, water, waste management; 6. Constructions; 7. Trade; 8. Transport and postal services; 9. Accommodation and food services; 10. Publishing, telecommunication and computer programming services; 11. Financial, insurance and real estate services; 12. Other professional, scientific and technical services; 13. Social, collective and personal services.

Source: own edition based on Eurostat data

Figure 8. *Flow index, Hungary*



Sector codes: 1. Agriculture, forestry and fishing; 2. Mining and quarrying; 3. Food products, beverages and tobacco products; 4. Manufacturing; 5. Electricity, gas, water, waste management; 6. Constructions; 7. Trade; 8. Transport and postal services; 9. Accommodation and food services; 10. Publishing, telecommunication and computer programming services; 11. Financial, insurance and real estate services; 12. Other professional, scientific and technical services; 13. Social, collective and personal services.

Source: own edition based on Eurostat data

Figure 9. *Flow index, Slovakia*

Key Sector Analysis

We identify key sectors in the Romanian, Hungarian and Slovak economy by comparing their backward multipliers. *Table 3* presents the output backward linkages calculated for all three countries as well as the ranking of the sectors according to the value of their linkage indicators. The following aspects can be remarked: in Romania, the *Trade* and *Electricity, gas, steam and air-conditioning; water supply; waste management services* sectors are ranked in the first place regarding their output backward linkage. This means that these are the sectors that can trigger the largest change in the output on the level of the whole economy if one monetary unit change in their final demand (due, for example, to the increase of the households' or the government's demand for their output) occurs. It has to be mentioned that the magnitude of the output backward linkages depends on several factors like the magnitude of the sectoral output compared to the other sectors' output, the structure of the sectoral output from the demand side, how strongly the sector is interrelated to the other sectors and so on. The *Agriculture* and *Food sector* also has relatively large output backward linkages. In the case of Hungary, the largest output backward linkage appears in the *Food* sector, being followed by the *Accommodation and food services* sector, the *Constructions* and the *Agriculture, forestry and fishing*. In Slovakia, in the first place, the *Electricity, gas, steam and air-conditioning; water supply; waste management services* are ranked, followed by the *Transport and postal services, Construction* and *Accommodation and food services.* The lowest output backward linkages in Romania appear in the *Financial services* sector, while in Hungary and Slovakia in the *Mining and quarrying* sector. We can conclude that there are significant differences between the countries regarding their key sectors.

Table 3. *Output Backward Linkages by sectors*

Sector	OBL					
	RO		HU		SK	
	Value	Rank	Value	Rank	Value	Rank
Agriculture, forestry, fishing	1.88	5	1.98	4	1.80	5
Mining and quarrying	1.68	10	*1.22*	*13*	*1.07*	*13*
Food, beverages and tobacco	1.96	4	**2.08**	**1**	1.77	8
Manufacturing	1.55	11	1.72	7	1.77	9
Electricity, gas, water, waste management	2.08	2	1.84	5	**2.35**	**1**
Constructions	2.07	3	2.00	3	2.11	3
Trade	**2.21**	**1**	1.80	6	1.79	7
Transport and postal services	1.87	6	1.70	8	2.21	2
Accommodation and food services	1.80	9	2.07	2	1.81	4

Sector	OBL					
	RO		HU		SK	
	Value	Rank	Value	Rank	Value	Rank
Publishing, telecommunication and computer programming services	1.80	8	1.55	10	1.73	10
Financial, insurance and real estate services	*1.37*	*13*	1.56	9	1.69	11
Other professional, scientific and technical services	1.83	7	1.53	11	1.78	6
Social, collective and personal services	1.53	12	1.49	12	1.58	12

Source: own calculations based on Eurostat data

In the case of the income backward linkages, shown in *Table 4*, *Social, collective and personal services* are ranked in the first place in all three countries. This means that one monetary unit increase in the final demand of this sector can generate the largest increase in total income at the level of the whole economy. In Romania and Hungary, the second highest income backward linkages appear in the case of the *Trade* sector, which in Slovakia is ranked fourth. In Slovakia, the *Accommodation and food* sector is in the second place. In the third place, we find the *Agriculture, forestry and fishing* sector in Romania, while the *Accommodation and food services* in Hungary and the *Transport and postal services* in Slovakia. On the last place, we find *Financial services* in Romania and the *Mining and quarrying* in Hungary and Slovakia.

It needs to be mentioned that in the case of the income backward linkages the value of the linkage depends not only on the backward character or on the magnitude of the sector's output, but also on the number of the employees and the income level in the respective sector.

Table 4. *Income Backward Linkages by sectors*

Sector	IBL					
	RO		HU		SK	
	Value	Rank	Value	Rank	Value	Rank
Agriculture, forestry, fishing	0.33	3	0.23	11	0.20	8
Mining and quarrying	0.33	4	*0.10*	*13*	*0.03*	*13*
Food, beverages and tobacco	0.22	10	0.24	10	0.18	10
Manufacturing	0.15	12	0.13	12	0.13	11
Electricity, gas, water, waste management	0.28	6	0.27	8	0.17	12
Constructions	0.22	11	0.34	5	0.22	7
Trade	0.39	2	0.42	2	0.34	4
Transport and postal services	0.27	8	0.32	6	0.35	3

Sector	IBL					
	RO		HU		SK	
	Value	**Rank**	**Value**	**Rank**	**Value**	**Rank**
Accommodation and food services	0.28	7	0.42	3	0.39	2
Publishing, telecommunication and computer programming services	0.26	9	0.31	7	0.28	6
Financial, insurance and real estate services	*0.15*	*13*	0.25	9	0.20	9
Other professional, scientific and technical services	0.31	5	0.36	4	0.33	5
Social, collective and personal services	**0.56**	**1**	**0.56**	**1**	**0.51**	**1**

Source: own calculations based on Eurostat data

4. Concluding Remarks

Summing up the results of the analysis of the sectoral employment, output and input, the intersectoral transactions and the key sector analysis, we draw the following conclusions.

The structure of the employment by the main branches is significantly different in Romania than in the other two countries, as in Romania a high proportion of the employees work in the *Agriculture, forestry and fishing* sector and in Hungary and Slovakia the highest proportion of the employees belongs to the *Social, collective and personal services* sector.

Regarding the structure of the output, the *Manufacturing* sector stays in the first place. The structure of the output from the demand and supply side shows significant differences in the analysed countries. It can be remarked that the share of the export is generally higher in the case of Hungary.

Analysing sectoral interdependencies, it is easy to observe that – as the value of flow indices shows – in Romania there is generally a larger number of intensive intersectoral relations than in the other two countries. In turn, the proportion of the self-consumption (summed up for the sectors) in the intersectoral transactions is higher in Hungary and Slovakia than in Romania. The sectors characterized by the strongest intersectoral relationships in Romania are the *Trade* and *Manufacturing* sectors, while in Hungary and Slovakia the *Manufacturing* and *Other professional, scientific and technical services sectors.* A number of similarities regarding the character of the intersectoral connections can be observed in the analysed countries:

– *Agriculture* is strongly forward interrelated with the *Food sector* and it is backward interrelated with the *Manufacturing* sector;

– the *Mining and quarrying* sector is forward interrelated with the *Manufacturing* sector;

– the *Manufacturing* sector is forward interrelated with the *Construction* sector and backward interrelated with the *Transport and postal services sector*;

– the *Trade* sector is backward and, at the same time, forward interrelated with the *Manufacturing* sector, and it is backward interrelated with the *Financial services* and *Other professional, scientific and technical services* sectors, too;

– the *Accommodation and food* services sector is forward interrelated with the *Social, collective and personal services*;

– the *Publishing, telecommunication and computer programming services* sector is backward interrelated with the *Other professional, scientific and technical services sector;*

– the *Social, collective and personal services* sector is backward interrelated with the *Manufacturing* and *Accommodation and food services* sector.

At the same time, there can be considered some connections that are important in two countries and they are not as strong in the third country. For example, a strong forward relationship between the *Food sector* and the *Accommodation and food services* sector can be observed in Hungary and Slovakia, while this connection in Romania is not so strong, or the *Construction* sector is forward interrelated with the *Financial and real estate services* in Romania and Slovakia, while this connection is not so strong in Hungary.

The key sector analysis also reveals interesting similarities and differences between the countries. Regarding the output, the demand-driven effects in Romania may be the largest if they are triggered by the *Trade sector*, in Hungary, by the *Food sector* and in Slovakia by the *Electricity, gas, steam and air-conditioning; water supply; waste management services*. In the case of the income linkages, *Social, collective and personal services* are ranked first.

In this study, mainly the primary results of the input-output analysis carried out for the Romanian, Hungarian and Slovakian economy are presented and the analyses refer to aggregated sectors. Thus, some main aspects regarding the economic structure and intersectoral connections in these countries are presented. Further, more detailed results can be obtained by analyses carried out with not aggregated sectoral data and by using some metadata regarding the activity of the sectors.

References

European Commission – Joint Research Centre's Institute for Prospective Technological Studies (EC-JRCIPTS) (2007). Contribution to the Report on Guiding Principles for Product Market and Sector Monitoring, Seville, 27/07/2007, C&S...JRC D(2007), available at: http://susproc.jrc.ec.europa.eu/docs/CONTRIBUTIONTOTHEREPORTONGUIDINGPRINCIPLES_000.pdf, accessed on: 27.2.2014.

Hirschman, A. O. (1958). The strategy of economic development, New Haven: Yale University Press.

Kweka, J.; O. Morrisey; A. Blake (2001). Is tourism a key sector in Tanzania? Input-output analysis of income, employment and tax revenue, TTRI Discussion Paper, No. 2001/1, available at: http://fama2.us.es:8080/turismo/turismonet1/economia%20del%20turismo/turismo%20zonal/africa/IS%20TOURISM%20A%20KEY%20SECTOR%20IN%20TANZANIA.PDF, accessed on: 10.3.2013.

Mattas, K.; S. Loizou; V. Tzouvelekas; T. Meropi (2006a). A common input-output model. In: A. Bonfiglio, R. Esposti and F. Sotte (eds.), Rural Balkans and EU Integration. An Input-Output Approach. Milano: Franco Angeli, 55–74.

Mattas, K.; S. Loizou; V. Tzouvelekas; T. Meropi; A. Bonfiglio (2006b). Deriving regional I-O tables and multipliers. In: A. Bonfiglio, R. Esposti and F. Sotte (eds.), Rural Balkans and EU Integration. An Input-Output Approach. Milano: Franco Angeli, 75–120.

Rameezdeen, R.; N. Zainudeen; T. Ramachandra (2005). Study of linkages between construction sector and other sectors of the Sri Lankan economy, Conference paper: Fifteenth International Input-Output Conference, Beijing, China P. R., June 27–July 1, 2005. Available at: https://www.iioa.org/conferences/15th/pdf/rameezdeen.pdf, accessed on: 7.5.2014.

Rasmussen, P. N. (1956). Studies in Intersectoral Relations (Amsterdam: North-Holland)

Databases

European Commission, Eurostat database, Land-cover data:
http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=lan_lcv_ovw&lang=en, accessed on: 7.5.2014.

European Commission, Eurostat database, Population data:
http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tps00001&plugin=1, accessed on: 7.5.2014.

European Commission, Eurostat database, GDP per inhabitant data:
http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tec00001&plugin=1, accessed on: 7.5.2014.

European Commission, Eurostat database, Input-output tables: http://epp.eurostat.ec.europa.eu/portal/page/portal/esa95_supply_use_input_tables/data/workbooks, accessed on: 15.2.2014.

European Commission, Eurostat database, Employment data: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_nace64_e&lang=en, accessed on: 7.5.2014.

Acta Univ. Sapientiae, Economics and Business, **2,** (2014) 59–74

Changes in Education Funding in Hungary

Attila MADARAS
Kaposvár University,
Szent Benedek High School and Vocational Training School

József VARGA
Corvinus University
Kaposvár University

Abstract. Our study examines some of the key aspects of education funding in Hungary. The theme of this publication is a current issue because the financing of Hungarian education has been dramatically changed from October 2013 on. Enrolment-based funding has been replaced by the average salary-based normative support, and the new "teacher career model" has been introduced. The study demonstrates the changes in financing using a model school, the calculations being based on the Budget Act of each year. We look at the trends of the previous system of financing, analysing the data from 2003 to 2012. We can compare the new, average salary-based funding with the normative support in 2012. By comparing the two types of funding, we attempt to find out whether the changes in Hungarian public education represent an opportunity for true transformation or they will remain a mere alteration in the calculation method of funding.

Keywords and phrases: public education, human capital, normative per capita contribution, teacher career mode
JEL Classification: I2, H5

1. Introduction

The role of human capital is more and more recognized worldwide. Human capital is considered to be one of the key motors of economic development. Adequately trained workforce is needed in the labour market as well as in the society as a whole. Education plays a key role in the improvement of human capital. For this reason, it can be observed, especially in more developed countries, that governments dedicate more and more of their funds to this strategic area. The importance of human capital – the fact that a person's knowledge has economic value – was recognized by early economic science.

Here are some examples of the concept of human capital being considered in early economic science:

In the 17th Century, William Petty used and attempted to define the expression "human capital" and considered it to be a component of national wealth. He estimated the value of human capital to be 80 pound sterling per capita (Varga, 1998).

Adam Smith (1723–1790) did not only consider machinery and tools to be investments that would pay off and produce profits, but he also considered the training of workers as the same kind of valuable investment. The investor can expect similar payoff and profits from his expenditures on the training of workers as from his investment on machinery. He considered the economically useful knowledge and skills of each member of society – that is, human capital – to be a part of the fixed capital (Smith, 1992).

T. R. Malthaus (1766–1834) pointed out that education can elevate lower class citizens of society into the middle class. He asserts that education for life, as part of schooling, has no additional costs; so, funding it is the government's duty. He was an advocate of the introduction of compulsory public education in order to eliminate child labour (Malthaus, 1902).

In the first half of the 19th Century, J. H. Von Thünen (1783–1850) asserted that educated nations produced more income than less educated ones, using the same material resources. "More educated nations own more capital, the benefit of which is expressed in higher levels of productivity." (Varga, 1998, p.11.)

The recognition of the value of human capital developed alongside the formation of the public education system. The early form of public education appeared in Europe in the 18th century. In Hungary, Queen Marie Theresa's *Ratio Educationis* (1777) was the first comprehensive legislation regarding public education. Compulsory education was only introduced in 1868 by József Eötvös's XXXVIII/1868 Act on public school education. Children from age 6 to age 12 (15) were mandated to attend school. Compulsory education and the formation of the school system, ranging from elementary schools to universities, inherently improve the qualification of employees.

By the middle of the 20th century, the concept of human capital had come to the front, asserting that by training individuals make an investment in their own productivity. Similarly to any other investment, education also produces yield (Stiglitz, 2000).

The development of human resources is the basis for modernization. It enables individuals to take part in production and political life, to become active citizens of a democratic system. The development of human capital is a long-term process: beginning with public education, continuing with higher education and trainings, to lifelong learning and self-education. "It is quite obvious that the improvement of healthcare, provisioning and education could be the reason and result of economic growth." (Harbison & Myers, 1966, p 22.)

T. W. Schultz (1902–1998), who analysed the relationship between investment in human capital, the production of physical capital and income, received Nobel Prize for his scientific work. He came to the conclusion that human knowledge plays a key role in the economic value of workforce. Producing knowledge is a lengthy and costly process, most similar to the investment processes regarding physical capital. He also points out that human capital is not considered significant within the total capital – although when human skills do not keep up with the development of physical capital, they may become an obstacle to economic growth (Schultz, 1983).

From the second half of the 1970s, due to the economic recession and the budget deficit following the oil crisis, the issue of system efficiency and education funding was raised. Analysing the cost-efficiency of education means examining the level of expenditures needed to accomplish the desired educational goals. Measuring the expenditures is a simple task because the costs per capita and the expenditures can be calculated based on statistics and budget reports. Measuring the efficiency of education, however, is a much greater challenge (Polónyi, 2002).

From 1 October 2013, the Hungarian system of education funding has been changed. The reason for this change was the introduction of the "teacher career model" as a new element in public education as well as the alterations in laws and legislations.

National and international almanacs only list the total amount of public education funding. This, however, not only contains the funds dedicated directly to schools, but also the expenditures on professional pedagogical services, coaching programmes for struggling learners, professional development programmes, one-time investments etc.

To demonstrate the changes in financing, we model a school. First, we are going to look at the yearly amounts of government support from 2003 to 2012; then we are going to compare the government funding in 2012 with the funding after the introduction of the new "teacher career model" in 2013, assuming the number of students to be constant. The number of full-time students will be 480, each class having 30 students. The school levels will be the following: elementary and middle school (grades 1–8), high school (grades 9–12), vocational training school (grades 1/11–2/12) and vocational secondary school (grades 1/13–2/14) – each grade having one class, totalling 16 classes in the school. This model will be used to demonstrate the financing of public education. In Chapter 2, we are going to look at the financing of public education based on the funding from the central budget and the additional per-capita grant for church schools. The latter amount equals the average funding provided by local governments. At the end of the chapter, we are going to look at the level of total funding.

2. Education Funding from 2003 to 2012

Normative Per-Capita Basic Contribution 2003–2012

The normative per-capita basic contribution is granted by the state to every school proprietor based on the enrolment numbers. This grant represents the most significant budget line within the public education budget. The mode of financing has changed several times in the last 8 years. The grant was sometimes based on the calendar year and sometimes on the school year. To simplify the model and make it more transparent, changes are always taken into consideration as of January 1. The logic of our calculations is different from the build-up of the national budget. The National Budget Law lists the funding of vocational theoretical training under the per-capita basic contributions, but the funding of vocational practical training is listed under "additional normative per-capita contributions." However, for practical training within the school, learning – in training workshops and training offices – usually takes place in the school building and classes are part of the daily schedule. Thus, we are going to list these funds as part of the basic contribution.

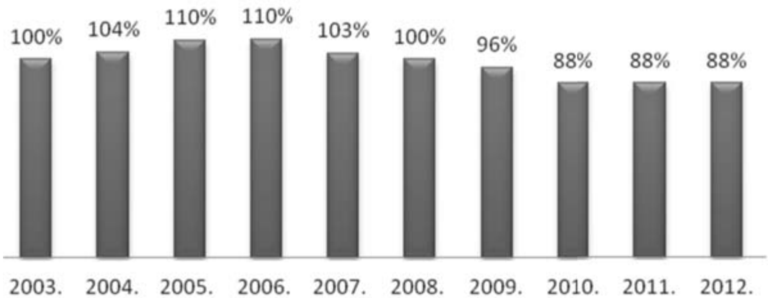
For each year, the amount of government support for the model school is determined according to areas of entitlement, based on the Annual Budget Act.

Table 1. *The nominal values of the per-capita basic contribution from 2003 to 2012 (thousand HUF)*

	Amount of basic contribution	Change compared to base value (2003)	Change compared to previous year
2003	109,56	100%	100%
2004	113,52	104%	104%
2005	120	110%	106%
2006	120	110%	100%
2007	112,487	103%	94%
2008	109,252	100%	97%
2009	105,662	96%	97%
2010	96,442	88%	91%
2011	96,442	88%	100%
2012	96,442	88%	100%

Source: own calculations based on the Annual Budget Act of each year

The amounts in *Table 1* are nominal values. It can be clearly seen that the government support increases at the beginning, but persistently declines from 2006. In 2007, a crisis hit Hungary, and the government announced an educational reform. Looking back, we can now see that the reform primarily consisted of a decrease in funding, with only minor changes in structure and pedagogy. The government support for school proprietors from the central budget has been on a steady decline in the second half of the decade. The effects of the world economic crisis can be most clearly felt from January 2010 on, with the decrease being more than 10%. It is a major concern how school proprietors can make up for the decline of government funding from their own resources in a crisis economy. In 2011 and 2012, the basic contributions remain the same as in 2010.



Source: own calculations

Figure 1. *Normative per-capita basic contribution, changes in nominal values, 2003–2012 (%)*

So far, we have looked at the nominal values of government funding, which are visualized in *Figure 1*. It is worthwhile to examine the trends of government support taking into account the changes of the consumer price index in Hungary in the past 8 years.

Table 2. *Real values of normative per -capita basic contribution 2003–2012 (thousand HUF)*

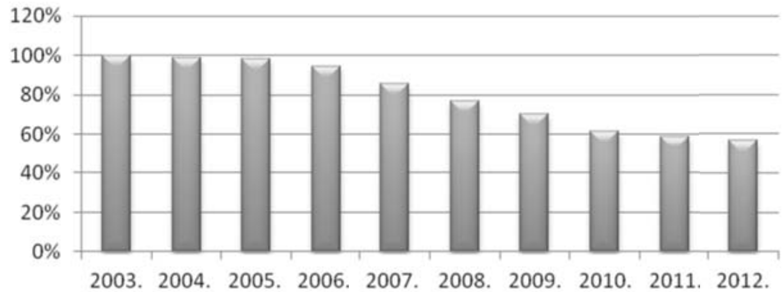
	Desirable support	Consumer price index*	Amount of normative per-capita basic contribution	Normative/ Desirable
2003	109,56	**104.7%**	109,56	100%
2004	114,709	**106.8%**	113,52	99%
2005	122,51	**103.6%**	120	98%
2006	126,92	**103.9%**	120	95%
2007	131,87	**108.0%**	112,487	85%
2008	142,419	**106.1%**	109,252	77%
2009	151,107	**104.2%**	105,662	70%
2010	157,453	**104.9%**	96,442	61%
2011	165,169	**103.9%**	96,442	58%
2012	171,61		96,442	56%

*Source: Hungarian National Bank

Source: own calculations

The amounts of normative basic contribution are the same as in *Table 1*. By adjusting those with the consumer price index, we get the amount the government would have needed to provide from the central budget to keep the funding at the 2003 level. These real values of financing appear in the “desirable support” row.

It is interesting to compare *Table 1* and *Table 2*. Looking at the nominal values, government support seems to increase until 2005, stagnate in 2006, and then decrease. Looking at the real values, however, we can see a decline from the beginning. A drastic decrease was brought about by the “educational reform” in 2007, but the 2010 amount also shows that the government is less and less able to support education during the times of the economic crisis. The funding in 2011 and 2012 is the same as in 2010, but that means a decrease in the real value.



Source: own calculations

Figure 2. *Changes in real values of normative per capita basic contribution, 2003–2012*

As shown in *Figure 1*, the nominal values of normative contribution indicate that the level of support increased at first, then it decreased, and in the last few years there was a stagnation. However, we can clearly see in *Figure 2* that the real values of government support have been on a steady decline.

Additional normative per-capita grants are small compared to the normative basic contributions, but it is important to look at them to see the full picture. These grants are primarily given for specific purposes, and can only be used accordingly.

Table 3. *Additional normative per capita grants 2003–2012*

Areas of entitlement	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Pedagogical professional examination	14,500	15,000	15,000	11,700	11,700	11,700	11,700	megsz.	6,300	6,300
Teacher textbooks*	14,000	14,000	megsz.	megsz.	megsz.	megsz.	megsz.	megsz.	megsz.	megsz.

Areas of entitlement	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Student textbooks	2,400	2,400	2,400	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Free textbooks	5,600	9,600	9,600	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Student sports	1,200	1,300	1,300	430	430	430	430	megsz.	megsz.	megsz.
Professional development	2,617	2,200	2,600	2,600	2 600	megsz.	megsz.	megsz.	1,750	1,750
Pedagogical professional services	720	720	720	720	720	megsz.	megsz.	megsz.	0	0
Professional examination	6,000	10,000	9,700	7,000	12,000	10,000	8,000	6000	8,000	8,000
Cultural and leisure activities	1,000	1,000	1,000	megsz.	megsz.	megsz.	megsz.	megsz.	megsz.	megsz.

Source: National Budget Act of Hungary, 2003–2012

60% of the types of support listed above are no longer available in 2010. This means the school proprietors had to find their own resources to fund these projects. Government support was also on the decline or remained at the same level in all the other areas, so proprietors needed to dedicate more of their own resources for those as well. In 2011, a few areas where government funding had been stopped earlier were supported again. For form-master bonuses, for example, schools received 26,000 HUF/capita/year. This was a very small amount compared to a school's budget, but schools were happy to receive any small amount as they were struggling more and more financially.

Additional Normative Per-Capita Grant for Church Schools

It is important to look at this type of grant because it is the same amount local governments had to add to the funding from the central budget in order to operate their schools. Adding up the funds school proprietors received from the central budget with the additional grant for church schools, we get the amount necessary for the operation of the schools. In the following table, we can see the changes in government funding (normative per-capita basic contribution) and funding by the proprietor (additional normative per-capita grant for church schools) from 2003 to 2012.

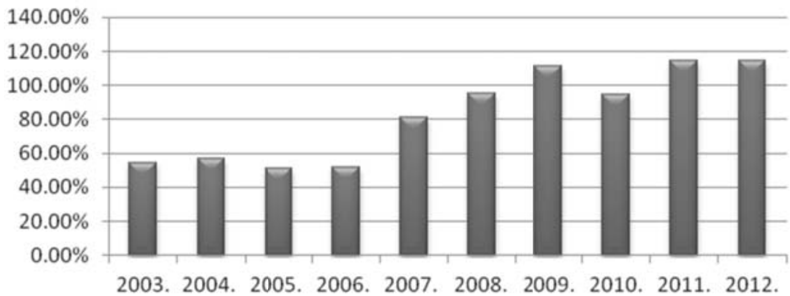
Table 4. *Government and proprietor support for schools 2003–2012 (thousand HUF)*

	Basic contr.	Additional contr. for church schools.*	Total	Additional/Basic.
2003	109,56	59,442	169 002	54.26%
2004	113,52	64,237	177,757	56.59%
2005	120	61,44	181,44	51.20%
2006	120	61,906	181,906	51.59%
2007	112,487	91,2	203,687	81.08%
2008	109,252	104,16	213,412	95.34%
2009	105,662	117,936	223,598	111.62%
2010	96,442	91,200*	187,642	94.56%
2011	96,442	110,400*	206,842	114.47%
2012	96,442	110,400*	206,842	114.47%

Source: own calculations

(* additional contribution is received as an advance payment)

It can be clearly seen that while in 2003 proprietors needed to add 54 HUF to every 100 HUF of government support, by 2012, this amount increased to almost 114 HUF. *Figure 3* makes it even more visible.



Source: own calculations

Figure 3. *Additional per-capita grant for church schools (local governments' own contribution) as a percentage of the normative per-capita basic contribution*

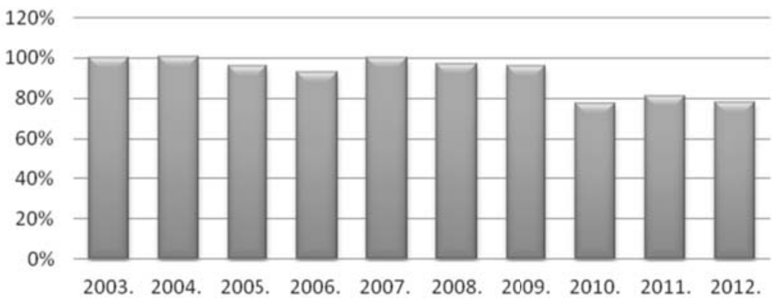
It is interesting to note that in 2010 the government not only decreased the basic contribution, but also cut back the advance payment of the additional church school contribution. This has been beneficial for the central budget in the economic crisis, but made the financial situation of church schools quite difficult. As a result, schools had to add more than 120 HUF instead of 95 HUF to every 100 HUF of government support. Because of the financial challenges, local governments tend to give their schools over to the churches, so that they no longer have to support them financially – because then the schools would get the additional normative church school contribution from the central budget. The government increased the additional per-capita grant for church schools in 2011, but it was still less than in 2009.

From January 1st 2013, the government takes over the operation and also the funding of public schools from the local governments. An advantage of this can be the even distribution of funds between all schools in Hungary. Schools in poorer areas will not have to be affected by the financial struggles of their local government.

Total Financing of the Model School

Total financing in this case means the sum of the basic contribution and the additional per-capita grant for church schools. There are other grants that can be applied for, for specific purposes or the education of disadvantaged students, but these represent an insignificant amount compared to the main two types of government support.

Table 4 shows the amount of total funding received by the school, although the amounts used are nominal values. Taking the level of inflation into account, we get the real values.



Source: own calculations

Figure 4. *Real values of total funding of the model school 2003–2012*

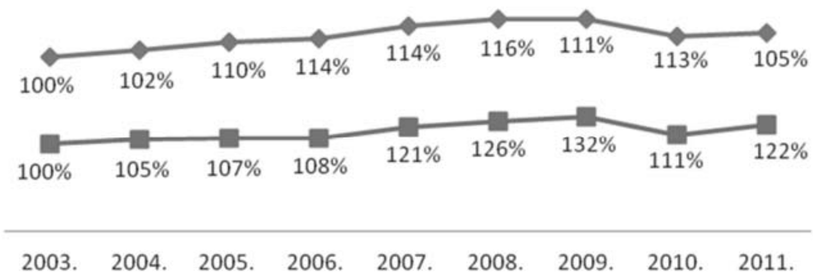
Figure 4 reveals that the total funding of the schools remained at the same level up to the year of the economic crisis. However, the previous charts show that from the year 2007, support from the central budget has decreased, forcing local governments to add more resources of their own.

Due to the economic crisis in 2010, the level of total funding decreased. Support from the central budget dropped again, but also the local governments had less funds to make up for the loss. After the new government had come to power, funding increased to some extent, but it remained the same in 2012 as in 2011 – which means a decrease in real values.

The biggest problem of this financing method is that it is based on enrolment only. For this reason, schools try to maintain their enrolment numbers even if it means giving up on quality. Economically, it is better to have larger classes, even though smaller classes can be taught more efficiently. In this system, expelling students for unacceptable behaviour also leads to money loss.

In the case of vocational training, this system of funding does not take into consideration the expenses of practical training or the sizes of groups. No wonder, vocational training schools have turned away from the demands of the labour market towards courses requiring cheaper practical training. The main issue is that vocations most demanded by the labour market require an expensive training. Schools and their proprietors are no longer able to fund these, especially now that vocational training contributions have been revoked, leaving schools without the extra funds that could be dedicated to refurbish or replace worn equipment. Moreover, students also tend to navigate away from skilled physical labour and look for trainings in office work, IT or economics, creating an excess supply of workforce in these areas. Thus, we can conclude that with the current system of financing, educational goals are taken into consideration to a small extent only.

It is worthwhile to compare the trends of financing education appearing in the statistical yearbooks with the trends showing in our own calculations regarding the model school.



Source: Statistical yearbook 2011/12 and own calculations

Figure 5. *Trends of total public education funding (square) and trends of funding for the model school (rhombus) at current values, 2003–2011*

In *Figure 5*, the trends of total education funding (found in statistical yearbooks) are shown using a blue line and our own calculations are shown using a red line.

Compared to the funding of public education as a whole, the direct financing of schools follows a similar trend. Therefore, direct contributions to schools have been on the increase year by year, compared to other types of support. However, with the economic crisis in 2010, direct funds have been cut back in particular. After the change in government, public education costs have decreased, but direct school funding has increased.

3. The New System of Public Education Funding Established Due to the New "Teacher Career Model"

After the elections in 2010, a new approach to education has been adopted. It includes the view that schools not only have to teach students, but also take part in their character formation at a higher level. The previous system of education was not suitable to fulfil this purpose, so the new government began to reform education. Nurturing the gifted and talented became high priority, but assisting struggling students and integrated education also did not lose significance. The system of vocational education is being reorganized dramatically, following the German and Dutch examples.

In 2013, the whole public education was reorganized. Public schools have been taken over from the local governments under the proprietorship of the state-led Klebersberg Institution Maintenance Centre. From September 1, the new "teacher career model" has been introduced; from October 1, the new, teacher-based system of education funding has been established. The reorganization has fundamentally changed the method and scope of education financing.

The new system, like the previous one, also has two main types of contributions. We can measure the changes in the amount of normative support looking at the level of financing received by state-recognized churches. In the schools maintained by the Klebersberg Centre, teachers as well as employees serving education directly receive their full salaries from the state. Other support staff and operation costs are funded by the state and local governments together. There are no exact calculations available yet on the scope of the latter. However, schools maintained by recognized churches are to receive the same amount of support as state-owned schools. Consequently, we are going to work with the amounts allotted to church schools by the Central Budget Act.

Average Salary-Based Support

Based on enrolment, the National Budget Act determines the number of teachers for each school type, and the average yearly salary of a teacher. The amount calculated based on these numbers gives the average salary-based funding.

In our model school, an elementary school gets the following funds:

– enrolment: 240 pupils

– average teacher number: 11.8 – this means the state budget pays for one teacher after every 11.8 students

– an elementary school teacher's average yearly salary, including affixes is 4,125,200 HUF

From these data, we can calculate that the elementary school gets 83,904,407 HUF funding from the government for a year to cover the salary of teachers and staff directly assisting education.

Similarly to the elementary school, the law determines the average number of teachers and the average teacher salary for every school type. Based on this data, we can calculate the average salary-based funding of our model school:

Table 5. *Salary-based funding of the model school for all school types*

School type	Enrolment	Average teacher nr.	Nr. of teachers	Average teacher salary	Funding
Elementary (1–8)	240	11.8	20.34	4,125,300	83,904,407
High school	60	12.5	4.80	4,252,200	20,410,560
Vocational secondary	60	11.1	5.41	4,252,200	22,984,865
Vocational training school	120	14.7	8.16	4,252,200	34,711,837
Total:				,	**162,011,668**

Source: own calculations

The whole model school gets a total of 162,011,668 HUF average salary-based funding. This type of support also has to cover the 30-35% raise in teacher salaries.

Operating Costs Support and One-Time Additional Funding for Church Schools

From October 1, 2013, the additional contribution for church schools has been replaced by a support for operating costs – which can be received by recognized churches and also school-operating foundations that have signed a public education contract with the government.

Currently, this amount is 160,000 HUF/student/year. In the case of our model school, this type of support would be a total of **76,800,000 HUF/year**.

Church proprietors receive an additional type of support from the central budget to make up for the costs of the increase in teacher salaries. This amount is 24,300 HUF/student/year. This adds a further **11,664,000 HUF/year** to the budget of our model school.

The school gets a total of **88,646,000 HUF/year** to cover operating costs and the salaries of support staff.

Comparison of the Average Salary-Based Funding with the Normative Funding in 2012

Table 6. *Comparison of the normative funding (2012) and the average salary-based funding (2013)*

	(thousand HUF)	
	2012 (old system)	**2013 (new system)**
Basic contribution/average salary funding	96,442	162,011
Additional cost for church schools/ operation cost support	110,400	88,646
Total:	**206,842**	**250,475**

Source: own calculations

The new system of financing provides a yearly funding of 43,633,000 HUF more than the old system. This, however, also has to cover the raise in teacher salaries due to the new "teacher career model". According to statistical yearbooks on public education, schools have to designate almost 70% of their budget to teacher salaries. A 30% raise in salaries amounts to 43,436,000 HUF from the total funding in 2012. This means that on average the government has increased the funds designated to schools with the amount needed to cover the raise in teacher salaries.

4. Conclusion

Education is a strategic area everywhere in the world because the training of the next generation is a key factor of the labour market, among others. In Hungary, between 2003 and 2012, the financing of education was based on enrolment numbers. Schools received a normative basic per-capita contribution from the central budget based on their enrolment, which was complemented by the local governments operating the schools. From the central budget, church proprietors received the average of the support local governments provided to their schools as an additional per-capita contribution for church schools. The sum of these two types of contributions provided the direct funding of the schools. The amount of the support changed according to the economic situation of the country, which determined how much the central budget was able to dedicate to public education. When the country faced an economic downturn, public education was the first to suffer from the cutting back of funds. With time, local governments provided more and more funding for the schools. In the middle of the first millennial decade, local governments took a lot of loans, and found it increasingly difficult to pay them back. As a result, the central budget had to assist them in supplementing the funding of their schools. This has led to the conclusion that if the government has to take over funding why not take over proprietorship as well. From January 1, 2013, the government has taken over the proprietorship of public schools from the local governments, but the new, average salary-based financing came into effect only as of October 1.

Both the macroeconomic calculations and the budget calculations of the model school in our study prove that the new way of financing education has not brought about a dramatic transformation of the system – the change has been only significant with regard to the amounts of funding. Even though the method of calculation is different, the total funding of schools is still eventually determined by the enrolment. This is clearly demonstrated by the comparison of the old and new systems of financing, where we can only see a difference in the amount that funds the raise in teacher salaries, but all other areas are supported to the same extent as earlier. This is particularly true if we assume that teachers consider the raise to be a compensation for the lack of appropriate waging in previous years, and we take into account inflation, the elimination of various bonuses and overtime compensations, and the effect of the increase in the number of classes required to be taught.

Raising teacher salaries by almost one-third is beyond doubt a measure that will increase the prestige of the profession and thus will contribute to a higher quality of education, but we cannot expect it to bring about a breakthrough in public education. We expect the scale of funding to remain similar as in the previous years although the method of calculation has changed. The upcoming years may answer the question whether the financing of public education will be in fact reformed, or the new system introduced from October 1, 2013 will remain only a change in the calculation method.

References

Harbison, F.; Myers, C. A. (1966). Elméletek az emberi erőforrás fejlődéséről, In: Illés Lajosné (ed.), Az oktatás gazdaságossága (Concepts of human resource development, in: The profitability of education; textbook). Tankönyvkiadó. 21–22.

Malthaus, T. R. (1902). Tanulmány a népesedés törvényéről (An essay on the principle of population). MTA Nemzetgazdasági Bizottsága. 514–518.

Schultz, T. W. (1983). Beruházások az emberi tőkébe (Investment in human capital). KJK 47–49.

Smith, A. (1992). A nemzetek gazdagsága (The wealth of nations). KJK. 110, 282.

Stiglitz, J. E. (2000). A kormányzati szektor gazdaságtana (*Economics of the public sector)*. KJK: Kerszöv. 380–390.

Polónyi, I. (2002). Az oktatás gazdaságtana (The economics of education). Osiris.

Varga, J. (1998). Oktatás-gazdaságtan (Education economics). Közgazdasági Szemle Alapítvány, Budapest.

Statisztikai Tájékoztató Oktatási Évkönyv 2010/2011 (2011). (The Statistical Yearbook of Education). Nemzeti Erőforrás Minisztérium, 169–170.

1868. évi XXXVIII. törvénycikk a népiskolai közoktatás tárgyában (Act Nr. XXXVIII on Public School Education, 1868).

1999. évi LXX. törvény a Magyar Köztársaság és az Apostoli Szentszék között a Katolikus Egyház magyarországi közszolgálati és hitéleti tevékenységének finanszírozásáról, valamint néhány vagyoni természetű kérdésről 1997. június 20-án, Vatikánvárosban aláírt Megállapodás kihirdetéséről (Act Nr. LXX/1999 on the agreement between the Republic of Hungary and the Holy See on the financing of the education and public service activities of the Hungarian Catholic Church, and some issues on church property on July 20, 1997).

2002. évi LXII. Törvény a Magyar Köztársaság 2003. évi költségvetéséről (1, 3, 5, 8. számú melléklet) (Act Nr. LXII/2002 on the national budget for the year 2003, appendices 1, 3, 5 and 8).

2003. évi CXVI. Törvény a Magyar Köztársaság 2004. évi költségvetéséről és az államháztartás hároméves kereteiről (1, 3, 5, 8. számú melléklet) (Act Nr. CXVI/2003 on the national budget for the year 2004 and the 3-year frameworks of public finance, appendices 1, 3, 5 and 8).

2004. évi CXXXV. Törvény a Magyar Köztársaság 2005. évi költségvetéséről (1, 3, 5, 8. számú melléklet) (Act Nr. CXXXV/2004 on the national budget for the year 2005, appendices 1, 3, 5 and 8).

2005. évi CLIII. Törvény a Magyar Köztársaság 2006. évi költségvetéséről (1, 3, 5, 8. számú melléklet) (Act Nr. CLIII/2005 on the national budget for the year 2006, appendices 1, 3, 5 and 8).

2006. évi CXXVII. Törvény a Magyar Köztársaság 2007. évi költségvetéséről (1, 3, 5, 8. számú melléklet) (Act Nr. CXXVII/2006 on the national budget for the year 2007, appendices 1, 3, 5 and 8).

2007. évi CLXIX. Törvény a Magyar Köztársaság 2008. évi költségvetéséről (1, 3, 5, 8. számú melléklet) (Act Nr. CLXIX/2007 on the national budget for the year 2008, appendices 1, 3, 5 and 8).

2008. évi CII. Törvény a Magyar Köztársaság 2009. évi költségvetéséről (1, 3, 5, 8. számú melléklet) (Act Nr. CII/2008 on the national budget for the year 2009, appendices 1, 3, 5 and 8).

2009. évi CXXX. Törvény a Magyar Köztársaság 2010. évi költségvetéséről (1, 3, 5, 8. számú melléklet) (Act Nr. CXXX/2009 on the national budget for the year 2010, appendices 1, 3, 5 and 8).

2010. évi CLXIX. Törvény a Magyar Köztársaság 2011. évi költségvetéséről (1, 3, 5, 8. számú melléklet) (Act Nr. CLXIX/2010 on the national budget for the year 2011, appendices 1, 3, 5 and 8).
2011. évi CLXXXVIII. Törvény a Magyarország 2012. évi központi költségvetéséről (1, 3, 5, 8. számú melléklet) (Act Nr. CLXXXVIII/2011 on the national budget for the year 2012, appendices 1, 3, 5 and 8).
2011. évi CLXXXVII. törvény a szakképzésről (Act Nr. CLXXXVII/2011 on vocational training).
2011. évi CXC. törvény a nemzeti köznevelésről (Act Nr. CXC/2011 on national public education).
2012. évi CCIV. törvény Magyarország 2013. évi központi költségvetéséről (Act Nr. CCIV/2012 on the national budget of Hungary for the year 2013).
2013. évi CXXIX. törvény az oktatás szabályozására vonatkozó egyes törvények módosításáról (Act Nr. CXXIX/2013 on the modification of some education laws).
2013. évi CXLIV. törvény Magyarország 2013. évi központi költségvetésének módosításáról (Act Nr. CXLIV/2013 on the modification of the central budget of Hungary for the year 2013).

Acta Univ. Sapientiae, Economics and Business, **2,** (2014) 75–94

Quantifying the Economic Value of Warranties: A Survey

Ede LÁZÁR
Sapientia Hungarian University of Transylvania, Faculty of Economic and Human Sciences, Department of Business Sciences, Miercurea Ciuc
E-mail: lazarede@sapientia.siculorum.ro

Abstract. This paper is a review of the most recent literature regarding the econometric modelling of the impact of warranties on demand. The reviewed literature is limited to the papers that apply the random-coefficient logit model based on Berry, Levinsohn and Pakes (1995) to estimate differentiated products demand. An important feature of these demand system models that is a clear advantage to earlier demand functions is to account for the endogeneity of prices. We focus on those model specifications that take into account endogeneity of both prices and warranty. Another goal for modelling the effect of warranties is to explore the economic rationale for warranty provision. Four theories have been proposed in the literature: insurance, sorting, signalling and incentive theories. This paper aims at decomposing the effect of these theories, to account for different underlying assumptions and to separately determine the implications as presented in the recent literature.

Keywords and phrases: warranties, pricing, structural modelling, random-coefficient logit.
JEL Classification: D8, D12, L11

1. Introduction

Models of differentiated product demand systems based on empirical data play an important role in practical market research. The literature on empirical analysis of demand and consumer behaviour comprehend at least a hundred years, as Nevo (2011) dates the first statistical estimation to Moore (1914). An important milestone in the literature was the recognition of Stone (1954), who specified a system of demand equation for a set of closely related but not identical products. In each equation, the demand is quantified as a linear function of all prices. However, in such a model when there is a large number of products in a market, the number of parameters to be estimated becomes excessively large. Also, heterogeneity in consumer tastes is not taken into account.

Berry, Levinsohn and Pakes (1995, hereafter BLP) introduced a method for the estimation of demand systems nonlinear in the econometric error using aggregate data on prices, market shares and product characteristics across locations or time. This model parameterizes substitution patterns as functions of observed characteristics of products. The underlying random-coefficients logit model is now widely perceived to be the best for estimating differentiated product demand systems, with an econometric specification that is more flexible than the logit or the nested logit models (Crawford, 2012). This model maintains the advantage of the logit model in handling a large number of products. It has a number of advantages compared to previous models because (1) the model can be estimated using only market-level price and quantity data, (2) it deals with the endogeneity of prices and (3) it produces demand elasticities that are more realistic, for example, cross-price elasticities are larger for products that are closer together in terms of their characteristics.

Applications of these methods include the estimation of the effects of taxes and quotas (e.g. Berry, Levinsohn and Pakes, 1999), estimation of own- and cross-price elasticities to analyse pricing or to simulate the effects of mergers (e.g. Nevo, 2000), measuring the welfare effects of new goods (e.g. Petrin, 2002), quantifying the impact of a product characteristic like warranty duration, product quality, maintenance service quality on the demand (Chu and Chintagunta, 2009, 2011; Choi and Ishii, 2011; Guajardo, Cohen and Netessine, 2012).

The first objective of this paper is to present in detail those warranty model specifications which apply random-coefficient logit models accounting for the endogeneity of price and warranty. The other – inseparable – objective is to explore the economic rationale for warranty provision, to determine those model specification details which allow the decomposition of different theories of economic rationales of warranties.

In the literature, four (recently five) theories have been proposed on economic rationales for warranty, but the relevance of these might depend on the product itself. The automobile industry serves as a preferred setting for empirical study of the warranty effect. Standard & Poor's reports that in this industry "product quality and design are becoming less of an issue in differentiating foreign and domestic manufacturers". The trend is a movement from a "pure manufacturing" paradigm to a business model in which a central role is assigned to the service components. The after-sales services of the products represented 8% of U.S. GDP in 2006 (Guajardo et al., 2012).

Thus, services represent an important differentiating factor for automakers; in particular, we could measure the service dimension of a brand by the length of its warranty. The length of warranty defines the period in which repair services are provided by the manufacturer. Firms have been active in adjusting the length of their warranties in the last decade. They face an important trade-off when defining their warranty period: while longer warranties may potentially increase demand, they also generate significant costs, e.g. 2–4% of yearly revenue of U.S.-based automakers.

Choi and Ishii (2010) enumerate several examples from the U.S. automobile market how the extended powertrain warranty of a type increased its market share (Hyundai, Dodge) or how the warranty reduction declined the share (Volkswagen). These examples suggest, but do not conclude, the importance of warranty coverage on consumer demand for new automobiles.

In spite of the extensive literature of the economic rationale of warranties, little empirical work has systematically examined the validity of these theories in actual markets. Our paper focuses on the literature of warranty provision that uses structural demand equation based on nested or random coefficient models.

Chu and Chintagunta (2009) apply BLP to quantify the economic value of warranties in the U.S. server market. They find that manufacturers and downstream firms of the indirect channels benefit from warranty provision and from sorting across heterogeneous customers by offering a menu of warranties. Choi and Ishii (2010) seek empirical evidence on the role of warranties as signals of unobservable quality. They adapt the linear random utility model of consumer automobile demand to investigate the extent to which warranties affect consumer choice and the extent to which this estimated warranty effect is due to risk aversion and signalling motives. The objective of Chu and Chintagunta (2011) is to assess empirically whether the economic roles of the warranties are consistent with the different warranty theories. They examine two different markets in the U.S.: the computer server as a business-to-business market and the automobile market as a business-to-consumer type market. They find evidence for insurance and sorting theories, but not for signalling and incentives theories. Guajardo et al. (2012) formulate and estimate a structural model to measure the impact of service attributes on consumer demand in the U.S. automobile industry.

The rest of the paper proceeds as follows. In Section 2, we present the theoretical background of the economic roles of warranties. In Section 3, we itemize the main and detailed research topics of the theme. Section 4 of the paper contains the model specifications and the list of type and sources of the empirical data. Section 5 contains the major results. We conclude with possible further research topics.

2. Warranty Theoretical Background

Four theories have been proposed in the literature on economic rationales for warranty provision, while the fifth is mentioned but empirically not tested by one of the literature (Choi and Ishii 2010).

Insurance Theory

Warranties provide insurance to customers and work as a risk-sharing mechanism because they oblige the manufacturer or seller to compensate the buyer in the event of product failure (Heal, 1977). According to Chu and Chintagunta (2011), the underlying key assumption of the theory is that customers are risk-averse and the probability of product failure is higher than zero. These two assumptions are met because extended automobile warranties (provided by a third party) are popular and the reliability score of new cars indicate non-zero failure rates of automobiles.

An obvious, direct implication of this theory is that the degree of risk aversion and duration of warranty should be positively correlated. A major problem of empirical validation of this hypothesis is how to quantify the risk aversion of the consumer. Chu and Chintagunta (2011) use an indirect way to solve this problem; they base their estimation on known relations of the literature (Dohmen et al., 2005; Jaeger et al., 2007) between demographic attributes and risk attitude, and regress the automobile warranty duration on household demographics. In this manner, they find concave relationship between warranty duration and household income: low-income households are more risk-averse, but they may not be able to afford longer warranties, and the high-income households are less risk-averse, so do not need to buy longer warranties. There is a convex relationship between age and warranty duration, which first decreases and then increases with age.

Sorting Theory

Warranties work as a means for second-degree price discrimination among customers with different risk preferences. It explores how firms design and price a line of products distinguished by different quality and warranty levels to extract the maximum surplus from each consumer type (Kubo, 1986; Matthews and Moore, 1987; Padmanabhan and Rao, 1993).

The key assumption of this theory by Chu and Chintagunta (2011) is the presence of consumer heterogeneity, a feature that is met by the many patterns of the automobile buyers' attributes.

The sorting theory posits that manufacturers should offer a menu of warranties, which is evident, but in our opinion it is not as widely used as other sorting/ price discriminatory tools. There are models and even manufacturers (at least in the period of analysis) who provide only one type of warranty duration (e.g. Audi, BMW, Mercedes-Benz with 6, 23, respectively 12 models in the American automobile market analysed by Chu and Chintagunta, 2011). This seems to contradict the assumption that the product line is primarily differentiated on the basis of warranty coverage and price.

Signalling Theory

Warranties are used to signal product quality to consumers (Spence, 1977; Gal-Or, 1989), just like they signal quality through advertising (Nelson, 1974). This approach examines the information content of warranties under information asymmetry when some informed agents may try to reduce this disadvantage sending signals to the uninformed agents (Akerlof, 1970; Riley, 1979). This theory has its roots in signalling games and was analysed in perfectly competitive markets (Spence, 1977), in monopoly (Grossman, 1981), and duopoly markets (Gal-Or, 1989).

According to Chu and Chintagunta (2011), the key assumption is information asymmetry in the sense that sellers have better knowledge about the product quality than buyers; thus, sellers need to signal product quality through warranties. In other words, buyers may not be adequately informed about the product performance before purchase, so they try to assess this from its price and/or warranty (Spence, 1977). Warranties can be a signal of product quality and can inform consumers because warranties are costly to the seller, and the costs are systematically related to product reliability.

This theory implies a positive relationship between product quality and warranty duration because only high-quality firms can afford long warranties because of their associated costs. In our opinion, the closeness of this relation is probably reduced by the fact that lower product quality and lower price may also have lower repairing cost. The automobile manufacturers control their warranty cost relating it to income. This assumption is handled by accounting for endogeneity of price and warranty duration in model specification.

Choi and Ishii (2010) mention the assumption that a warranty could be a credible signal of unobservable product quality only if the warranty is (relatively) more costly for firms producing “low quality” products. They empirically test the validity of this theory, analyse the degree to which consumers perceive a manufacturer’s warranty as a signal of unobservable product quality and find a stronger role of signalling than risk aversion. Warranties are effective as signals only if manufacturers actually offer different warranty lengths based on their product quality – this assumption could be easily verified by checking the actual market supply. Choi and Ishii considered it important to distinguish only the risk aversion and signalling motives and did not deal with the other two warranty theories. The nature of the analysed powertrain warranties allows them to focus exclusively on these two motives.

Incentive Theory

Warranties work as an incentive mechanism for firms to reveal and improve product quality. The key assumption is risk endogeneity in the sense that sellers’ actions can affect product performance. The probability that a product will break down is a function of its quality which depends on the producers' quality efforts and also on the consumers' maintenance efforts; thus, producers should take moral hazard into account.

Chu and Chintagunta (2011) empirically examine two implications of this theory in the U.S. server and automobile market, namely that quality is negatively correlated with current warranty and quality is positively correlated with past warranties. They did not find significant evidence for these correlations.

Profitable Bundling

Profitable bundling, discussed in short by Choi and Ishii (2010), is the fifth possible motive for automobile warranties; it is not considered in the rest of the literature. Firms may be able to procure cheaper repair service than consumers and practically bundle discounted pre-paid repair with the automobile. The extent of a manufacturer capacity to offer repair will vary geographically, depending mostly on its dealership network. This, combined with the fact that powertrain warranties do not vary geographically, suggests that bundling is not an important motive at least for powertrain warranties.

3. Research Topics in the Literature

This section reviews the research objectives of four relevant papers. The first objective of Chu and Chintagunta (2009) is to quantify the total value of base warranties in the U.S. server market to manufacturers, channel intermediaries (downstream firms) and customers. Although base warranties are characterized by several attributes, the variation across server models is in the duration of the warranty; thus, they aim to quantify the value of base warranty. The second objective is to decompose the value of a warranty only into its insurance value and its sorting/price discrimination value. This implies that the empirical model needs to incorporate consumer's risk aversion and consumer heterogeneity. They exclude the signalling role of server warranties because different manufacturers offer similar warranty durations for their server products; so, the quality information content of warranties is likely to be limited. In our opinion, the explanation relies on the product itself, the information asymmetry in a consumer choice decision of a server is likely to be smaller than in the case of a car because the buyers of the servers are usually experts who are informed about the performance of the main components. The incentive role of warranties is closely related to the signalling role; however, major manufacturers do not change their server warranty policies over time as their product quality improves. The authors use structural modelling (i.e. BLP) and counterfactual experiments.

The structural model contains a demand model derived from a utility function and a pricing model. The demand model accounts for customer's risk aversion to accommodate the insurance role and it incorporates customer heterogeneity to allow for the sorting motive of the warranty. The pricing model accounts for the specialty of the market: the servers are sold both directly and indirectly, and the intermediaries compete among themselves and with manufacturers.

Choi and Ishii (2010) seek empirical evidence for the role of warranties as signals of unobservable quality. They adapt the linear random utility model of consumer automobile demand to investigate the extent to which warranties affect consumer choice and the extent to which this estimated warranty effect is due to risk aversion and signalling motives. Choi and Ishii derive the marginal effects of both the binary and non-binary explanatory variables in the conditional logit and random coefficient logit models. Their results also demonstrate the strong role of brand loyalty, a finding also found by Train and Winston (2007). They also analyse the relation between warranties and brands, where the question is whether the longer warranty offsets the disadvantage in brand reputation. They compare a newer, lower reputation firm brand (Hyundai) to the category leader (Honda) in the small/medium car category, and the same in the luxury category (Lexus versus BMW). In both comparisons, the newer firm offers a two-year longer powertrain warranty. They model these relations at different levels of information asymmetry, and build up three scenarios:

– both models are unrated by *Consumer Reports (CR)* and there is no past purchase experience; thus, the difference in product quality is strictly the difference in brand reputation, as captured by their brand dummies;

– the category leader type is rated by *CR*; thus, the consumer has additional third-party information on the category leader;

– the category leader type is rated by *CR* and the consumer has previously purchased a car from the category leader; thus, the consumer has additional first- and third-party information on the category leader.

The results of the three models contain the estimated brand dummies and the marginal effect of each additional year of powertrain warranty to the indirect utility of the consumer. Based on these estimations, Choi and Ishii calculate how many extra years of warranty should a manufacturer offer to offset the brand reputation's disadvantage compared to the category leader.

Chu and Chintagunta (2011) examine the conditions under which each of the four competing theories on the economic roles of warranties would apply and derive testable implications from the data. Then, they assess whether these theories have empirical support in the U.S. computer server and automobile market in the context of manufacturer base warranties. The two key assumptions underlying the insurance theory is that buyers are risk-averse and the probability of product failure is non-zero. The insurance theory has the implication that the degree of risk aversion and the warranty length should be positively correlated. Therefore, the authors expect that the same customers will buy longer warranties when product failure increases and reliability decreases, and given a particular product failure rate, more risk-averse customers will buy longer warranties.

The key assumption of the sorting theory is the presence of consumer heterogeneity; in equilibrium, firms will offer a line of products distinguished by different quality, warranty and price levels. The sorting theory also implies that, in response to the menu of warranties the firm provides, customers with the same observable attributes (i.e. income) but different degrees of risk aversion choose different warranty contracts.

The signalling approach examines the information content of warranties under information asymmetry which is the key assumption in the sense that sellers have better knowledge about product quality than buyers. Two more trivial assumptions are that warranties are costly to the seller and the costs are systematically related to product reliability. The theory implies a positive relationship between product quality and warranty duration because only high-quality firms can afford long warranties because of their associated costs of fulfilment.

The incentive role on the firms' side involves two aspects: signal product quality to consumers through warranties in the presence of consumer moral hazard and motivate the firm to invest in product quality and supply high-quality products, at least to the extent of reducing the chances of its falling below the warranted level. Chu and Chintagunta (2011) expect a positive relationship between quality and previous warranty terms and a positive relationship between warranty terms and new product reliability.

Guajardo et al. (2012) analyse the warranty in a larger context, together with other service attributes, formulate and estimate a structural model to measure the impact of service attributes on consumer demand in the U.S. automobile industry. The authors establish three important differences compared to earlier researches. First, they focus not only on the effect of firms' warranty length, but also on their service quality. Second, they study the effect on the demand of the interaction between service attributes and product quality in order to help firm decision-making regarding both of them. Third, they specify warranty length as endogenous in addition to price in the demand specification. These authors are the first to empirically analyse the value of service attributes as drivers of demand in manufacturing industries and to analyse complementarities between service attributes and product quality in the context of demand models.

4. Models, Estimation, Identification, Assumptions

Specification

The major problem in model identification of the economic value of warranty is that both price and warranty length may depend on all product characteristics observable to the consumer, including those omitted from the indirect utility specification. Without properly taking into account this endogeneity, some or all of the estimated warranty effect may be biased. Choi and Ishii (2010) summarize the possible solutions.

Much of the empirical work in this research topic avoids this problem because it relies on experimental data where price and warranty exogeneity come from the experimental design (Purohit & Srivastava, 2001; Chatterjee, Kang and Mishra, 2005). One possible solution is offered by BLP, who use instrumental variables for estimating a model of consumer demand and firm supply. In BLP, the endogeneity of product characteristics other than price is not modelled; warranty appears as an unobserved characteristic. It is difficult to adapt the BLP approach to account for both price and warranty endogeneity; the explicit modelling of warranty supply depends on clearly observable cost shifters for the warranty supply decision.

Another strategy is based on Goldberg (1995) and Train and Winston (2007), using cross-sectional variation available in household-level data. They include product-specific fixed effects into the indirect utility in order to control for the mean effect of the omitted characteristics; this reduces price and warranty endogeneity due to correlation with omitted variables. This model identification relies on the assumption that unobserved consumer taste heterogeneity is limited to the additive error. The main drawback of this approach is that it requires rich data to allow for the estimation of product-specific fixed effects, in addition to the other included coefficients. Choi and Ishii build on Goldberg's (1995) approach, which they extend from nested logit to random coefficient logit for household-level data.

Guajardo et al. (2012) follow the former strategy; they formulate a structural model of decision-making by both consumers and firms. They estimate the demand model, and present conceptually the supply model, allowing for warranty-length endogeneity. In addition to the main effect model of the warranty length, the authors specify a model involving two-way interactions between warranty lengths, service quality and product quality.

Estimation of Demand Parameters

In order to estimate their model, Chu and Chintagunta (2009) use a two-step approach by first estimating the demand parameters and then the parameters of the pricing equations. This method is less efficient than a simultaneous estimation approach, but it provides consistent estimates of the demand parameters even in the presence of misspecified pricing equations. They modify the contraction mapping approach from BLP to handle the nonlinear, customer-specific income effect. Regarding this feature, they decompose the price term of the demand function into a mean price effect and a customer-specific price effect. The estimation of demand parameters contains the following steps:

1. Obtain draws for customer *i*'s income (y_i) from the empirical distribution of firm revenue.

2. For each draw of y_i, compute the mean price term and a customer specific price term.

3. Choose starting values for $\overline{\beta}$ and for the nonlinear parameters to compute the individual-specific utility and apply the contraction mapping in BLP to obtain the mean utility.

4. Use GMM to compute the parameters in the mean utility.

5. Replace $\overline{\beta}$ in step 3 with the $\overline{\beta}$ estimate from step 4 and iterate until convergence.

Chu and Chintagunta (2009) apply an instrumental variables technique to account for the potential endogeneity of the retail prices of servers using the following cost shifters as instruments:

– product characteristics including dummies for manufacturer, brand, channel, CPU and time trend;

– current and lagged producer price indices for memory and CPU interacted with manufacturer dummies;

– average weekly wage rates for the computer hardware industry.

Together, these instruments explain 63% of the price variation and 74% of log price variation. The potential market for servers is around 14 million calculated with 7.4 million establishments in the United States in 2004 and assuming two servers per establishment. The demand model had 66 linear parameters and 27 nonlinear parameters to be estimated.

Guajardo et al. (2012) consider a random coefficients logit demand model, where the utility that consumer *i* derives from purchasing vehicle *j* in calendar year *t* depends on the vehicle price p_{jt}, warranty duration w_{jt}, product quality PQ_{jt}, service quality SQ_{jt} and a vector of observable vehicle characteristics x_{jt}, as follows:

$$u_{ijt} = \alpha_i p_{jt} + x'_{jt}\beta_i + h(w_{jt}, PQ_{jt}, SQ_{jt})\gamma + \zeta_{jt} + \varepsilon_{ijt}.$$

The term ξ_{jt} represents unobserved product attributes common to all consumers and ϵ_{ijt} is a type I extreme value idiosyncratic shock. The individual level coefficients α_i and β_i are decomposed into a mean effect common to all consumers (*β's*) and individual deviations from that mean (*σ's*) as it is common in the BLP literature.

Under the linearity assumption for w_{jt}, PQ_{jt}, SQ_{jt} variable, the utility function would take the following form:

$$u_{ijt} = \alpha_i p_{jt} + x'_{jt}\beta_i + \gamma^1 w_{jt} + \gamma^2, PQ_{jt} + \gamma^3 SQ_{jt} + \zeta_{jt} + \epsilon_{ijt}.$$

This formulation captures the main effects and it is also consistent with the linearity assumption made for the rest of the covariates, considering PQ and SQ as exogenous in the demand specification. The identification through instrumental variables to account for price and warranty endogeneity is discussed later.

Estimation of Parameters in the Pricing Equation

The manufacturers' marginal costs consist of the following: the costs of providing the various attributes of the product, warranty costs and other costs. To estimate the cost of warranties, Chu and Chintagunta (2009) first estimate manufacturer marginal costs on warranty duration and other product attributes using a flexible functional form, a semi-log regression that allows warranty coefficients to vary with quarters to account for potentially changing warranty costs over time.

$$\ln(MC^{w}_{\omega dt}) = X_{\omega dt}\mathrm{K}_{0t} + \mathrm{K}_{t} w_{\omega d} I_{qt} + \zeta_{\omega dt},$$

where I_{qt} is a quarter dummy, K_{0t} is the vector of the effect of product attributes on marginal cost and K_t is the effect of warranty on marginal cost. In the cost equation, 88 linear parameters had to be estimated.

Guajardo's (2012) basic assumption on the supply side is that firms compete in prices and warranties. This assumption is consistent with some prior theoretical models (e.g. Spence, 1977; Gal-Or, 1989), which have modelled competition based on these two variables, taking other factors exogenous. The profit function for firm *f* in period *t* is defined as follows:

$$\pi_f = \sum_{j \in J_f} (p_{jt} - mc_{jt} - wc_{jt}) Ms_{jt}(p_t, w_t, PQ_t, SQ_t, x_t, \xi_t; \theta),$$

where J_f represents the set of vehicles produced by firm *f*, mc_{jt} the marginal costs of production of vehicle *j*, wc_{jt} the expected per-unit warranty costs, *M* is the size of the market and s_{jt} the market share of vehicle *j*. Like BLP, they consider a marginal cost function g_1 based on the projection of costs onto observable vehicle characteristics x^S_{jt} and unobservable cost shifters φ_{jt}:

$$mc_{jt} = g_1(x^S_{jt}, \varphi_{jt}).$$

Considering the heterogeneity of the expected cost per event of failure during warranty length across brands, xb_{jt} denotes other observable characteristics that capture part of the brand heterogeneity in warranty costs and ς_{jt} unobservable factors. The warranty cost function can be represented as follows:

$$wc_{jt} = g_2(w_{jt}, PQ_{jt}, SQ_{jt}, xb_{jt}, \zeta_{jt}).$$

Thus, Guajardo et al. (2012) assume that firms compete in both prices and warranties; their supply model provides the fundamentals for the identification strategy for the parameters in the demand model.

Identification

Guajardo et al. (2012) argue for price and warranty endogeneity as well as product and service quality exogeneity. Price endogeneity is accounted for in BLP through a Bertrand-Nash equilibrium assumption. Their proposed set of instruments are widely used in the literature, but Guajardo et al. (2012) – instead of considering the average characteristics for cars of all other firms – compute the average characteristics of other firms' cars in the same market segment (small, middle, large, luxury), which refines the set of instruments by using cars that are closer to one another in terms of characteristics.

The endogeneity of warranty length is explained by the fact that firms can easily set the length of warranty in response to the unobserved factors in ξ_{jt}. A similar observation was made by Menezes and Currim (1992). Conversely, the firms' actions regarding to product and service quality (using better parts/components, redesigning their processes etc.) will be reflected over a term longer than the one-year period of the analysis.

Thus, the exogenous PQ_{jt}, SQ_{jt} and the structure of the supply model could be helpful to derive instruments for the warranty length. Guajardo et al. (2012) use the following logic to define instruments. Consider vehicles *j* and *r*, produced by different brands, and the w_{jt} and w_{rt} warranty lengths are correlated because firms compete on price and warranty, and correlate with the drivers of own warranty costs because firms account for the expected warranty cost. Noting that indirect utility u_{ijt} does not depend on the attributes of vehicle *r*, they conclude that PQ_{rt} is a valid source of instruments, and then apply the same argument to generate instruments using the rest of the drivers of the warranty costs, i.e. SQ_{jt} and xb_{jt}.

Robustness Checks for Estimation Results

Chu and Chintagunta (2009) conducted a series of robustness checks, functional form choices and estimation methods. Their findings are as follows:

– Channel-specific price sensitivity not supported by the data.

– The effect of direct channel entry on shares makes customers slightly less price sensitive, but the difference is not significant.

– The potential market size depends on the number of servers each establishment might use. The authors find the estimates are very robust to this number, it only shifts the manufacturer intercept.

– In accordance with recent literature, the authors assume customer preferences for product attributes and price and warranty coefficients follow continuous distributions. As to whether the main results are sensitive to the assumptions on customer heterogeneity distributions, the authors estimate a two-segment and a three-segment logit model, assuming the main explanatory variables follow discrete distributions. They obtain price and warranty elasticities similar to those from the current model.

Empirical Data Used

According to Choi and Ishii (2010), one reason for the few empirical paper examining warranties is the difficulty in obtaining the necessary data set that combines the appropriate product, manufacturer and consumer information. In *Table 1*, we summarize the variables introduced in the automobile demand models with their definitions and the data sources.

Table 1. *Summary of the variables in various automobile demand models with their definitions and the data sources*

	Definition	Used by	Data source
Manufacturer basic warranty	repairs vehicles for a specific time and mileage	Chu and Chintagunta (2011)	consumerreports.org, manufacturer web sites
Manufacturer powertrain warranty	offers protection beyond the basic warranty	Chu and Chintagunta (2011)	consumerreports.org, manufacturer web sites
		Guajardo et al. (2012)	
	extended warranties	Choi and Ishii (2010)	Warranty Direct.com
Overall quality scores	a 100-point scale based on CR's tests, subscriber survey data and other tests	Chu and Chintagunta (2011)	consumerreports.org, manufacturer web sites
	product quality – nr. of problems per 100 vehicles in the first 90 days, examines 217 vehicles attributes	Guajardo et al. (2012)	J.D. Power's Initial Quality Study (IQS)

	Definition	Used by	Data source
Overall quality scores	Service Quality satisfaction level of the owners in 3 years measured in a 1,000-point scale based on six metrics	Guajardo et al. (2012)	J.D. Power's Customer Satisfaction Index (CSI)
	car ratings	Choi and Ishii (2010)	consumerreports.org,
Accident avoidance	a 5-point composite score based on CR's tests results for braking performance, emergency handling, acceleration, driving position, visibility and seat comfort. Braking and emergency handling carry the most weight.	Chu and Chintagunta (2011)	consumerreports.org, manufacturer web sites
Predicted reliability for new cars	CR's forecast	Chu and Chintagunta (2011)	consumerreports.org, manufacturer web sites
Sales data	monthly data at the make-model level	Chu and Chintagunta (2011)	J.D. Power, Ward's automotive
	household purchases: 1998–2002	Choi and Ishii (2010)	Consumer Expenditure Surveys
Price	real transactional prices after rebates	Guajardo et al. (2012)	J.D. Power
		Choi and Ishii (2010) Train and Winston, (2007)	Automotive News Ward's Automotive Yearbook
Car attributes	e.g. type, make, horsepower, MPG etc.	Chu and Chintagunta (2011)	Consumer Expenditure Surveys
	category dummies, engine size, length / trim-level data	Choi and Ishii (2010)	Automotive News
	brand dummies	Choi and Ishii (2010)	
Consumers' characteristics	income	Choi and Ishii (2010)	Consumer Expenditure Surveys
	risk aversion – vehicle insurance expenditures in the model used warranty * risk aversion quartiles	Choi and Ishii (2010)	Consumer Expenditure Surveys

5. Major Results

Chu and Chintagunta (2009) find several important results applicable by managers. First of all, the validity of their estimates is considered to be confirmed by comparing to benchmark data. For example, the estimated gross markup of the downstream firms ranges with market data and the customer preference order of the four major manufacturers is also consistent with the market shares. Manufacturers and channel intermediaries benefit greatly from warranty provision and from price discrimination by offering non-uniform warranties, and they quantify exactly these benefits. If all manufacturers offered three-month warranties (the shortest in the market), the total manufacturer and retail profits in 1999–2004 would be 82.8% and 81.1%, respectively, of the current levels. Sun benefits the most from offering warranties followed by Dell, while IBM benefits the least.

Consistent with the theoretical predictions (Tirole, 1988), the firms also benefit from price discrimination by offering a menu of warranties instead of one. If all manufacturers offered two-year uniform warranties for all their products, their profits would be 86.3% and 87.1% respectively. This price discrimination value of the warranties varies substantially across manufacturers: IBM gains the most, followed by Sun, HP and Dell. The counterfactual experiments allow the authors to evaluate the profit, maximizing the best warranty scheme for each manufacturer. The turning point in profit is one year for HP and Sun, six months for IBM and two years for Dell, although the differences in Dell's profits under one-year and two-year uniform warranties are small.

Customers also benefit from manufacturers offering a menu of bundled warranties. The total customer welfare is quantified $5,972 billion or $498 per server if all manufacturers offered uniform three-month warranties, and it would require $136 per server in the case of two-year uniform warranties. The authors also compute warranty elasticities across manufacturers and channels. Given the current warranty scheme, they find that a 1% increase in warranty duration will increase manufacturer shares by about 0.35%.

They find that server customers are heterogeneous in their preferences for manufacturers, CPU and channel, warranty preference and price sensitivity. This indicates the sorting role of warranties.

The methodology used has the limitation that only a subset of product attributes that are observed influence a customer's choice. If customers valued the unobserved product attributes and if warranties were positively correlated with these unobserved attributes, the estimated value of warranties would be overstated. This is a general problem of modelling the warranty value. Another strong limitation of their research theme is avoiding extended warranty; they only quantify the value of base warranties.

Choi and Ishii (2010) find that the conditional logit results from the simple model are mostly consistent with the results for the random coefficient logit model from the corresponding specification, except for the coefficient of the after-purchase income variable for the low- and middle-income groups. These estimation results show statistical significance, suggesting that consumers indeed have a heterogeneous preference for after-purchase income. These authors find some differences in the impact of warranties across car classes in the random coefficient logit model without brand-fixed effects; the warranty effect on different car classes decreases after including brand-fixed effects. In this full model, warranties seem to have bigger effect in the "small" and "luxury" categories, which, in the opinion of the authors, is a result consistent with the signalling theory. Another result that supports the importance of signalling motive is that the interaction between warranty and brand experience is strongly and statistically negative, indicating that consumers value warranties much less for experienced brands. In accordance with these findings, consumers heavily discount cars that have no *Consumer Reports* rating, but less so for those that come with longer warranty. This result of warranty lengths mattering more for cars with no rating further supports the signalling motive, as these cars are among those with the greatest asymmetric information between consumers and manufacturers.

The importance of insurance theory is not proved by the results. If risk aversion is a strong motive of warranty demand, the coefficients for the interaction between warranty and risk aversion proxies should be positive and increasing with quartiles. Nevertheless, none of the four models show statistical significance for any quartile of risk aversion and the signs of risk aversion coefficients are contrary to expectations. The authors tried other proxies for risk aversion, using other non-warranty insurance expenditures, but obtained no different results.

Choi and Ishii (2010) calculate the marginal effect of explanatory variables, which reflect how the probability of a consumer's observed choice changes with shifts in the values of a single explanatory variable. They use the average of each studied individual's marginal effects rather than the marginal effects of a "representative individual" with the average value for each explanatory variable. For non-binary explanatory variables, the marginal effect is the average across each individual probability derivative, and for binary explanatory variables it is the average of the difference between the actual estimated probability for the observed choice and the counterfactual estimated probability for the observed choice, assuming that the value of the binary explanatory variable of focus is zero. The analysis of marginal effects shows the strong role of brand loyalty, a result also found by Train and Winston (2007). The excluded brand of the brand dummies was Suzuki; a positive value of marginal effect indicates preference over this brand.

An interesting and novel topic in Choi and Ishii (2010) is the examination of possible trade-offs between warranty length and brand reputation, the degree to which longer warranties seem to offset differences in the estimated brand dummy. They compared a newer, lower reputation firm brand (Hyundai) to the category leader (Honda) in the small/medium car category, and the same in the luxury category (Lexus versus BMW). In both comparisons, the newer firm offers a 2 year longer powertrain warranty. The results of the three models with different levels of information asymmetry are the estimated brand dummies and the marginal effect of each additional year of powertrain warranty to the indirect utility of the consumer. Choi and Ishii quantify how many extra years of warranty a manufacturer should offer to offset the brand reputation disadvantage to the category leader. This suggests that Hyundai's two year longer warranty in 1998 was inadequate to compensate for Honda's greater reputation, and in the luxury category the longer warranty does not sufficiently address perceived quality difference for first-time luxury car buyers.

Chu and Chintagunta (2011) assess the four competing theories on the economic roles of warranties in the U.S. computer server and automobile market. Here we discuss the results in the automobile market. In the case of insurance theory, they verified the two underlying assumptions. Similar to the server market, they found indirect evidence of consumers' risk aversion through their purchases of extended automobile warranties. This, together with the *Customer Report* data regarding product reliability, indicates non-zero failure rates of automobiles.

The insurance theory predicts that the degree of consumer's risk aversion is positively correlated with the duration of the warranties purchased. The authors use proxies for household risk attitudes, relying on results by Dohmen et al. (2005). These authors find a concave relationship between age and risk attitude, which implies a convex relationship between age and warranty duration, and, similarly, a concave relationship between income and warranty duration. The results are consistent with their expectations.

The sorting theory posits that manufacturers should offer a menu of warranties, which is a fact for most manufacturers. This theory also predicts that in market equilibrium households with the same observable characteristics will buy different automobile warranties; the authors use income to illustrate this. Consistent with insurance theory, higher-income households tend to buy shorter warranties because of their lower level of risk aversion; however, households of the same income levels also buy different warranties. The authors formulate that manufacturers cannot price-discriminate their warranty policies solely on the basis of household income. To extract more consumer surplus, they choose to offer a menu of warranties and let households self-select into different warranty contracts in accordance with their risk preference.

The information asymmetry assumption of the signalling theory is verified by running two sets of regressions of automobile quality indicators (overall quality score and accident avoidance score) on warranty duration, product price and major product attributes. One set of regressions includes manufacturer dummies as regressors, while the other set does not. The powertrain warranty years are positively correlated with the quality score only when the manufacturer dummies are not included in the model. This implies that when other quality signals, that is manufacturer reputation and brand, are present, warranty length is no more a signal of product quality.

According to the authors, the insignificant warranty coefficient in these regression models also implies that automobile warranties do not play an incentive role for manufacturers to reveal product quality to consumers. The incentive theory posits a positive correlation between new product reliability and warranty duration. The results show that powertrain warranty has a significant effect on the predicted reliability of new vehicles only if the manufacturers' fixed effect is not included in the model. Therefore, the authors conclude that there is no evidence to support the incentive theory of warranties in the automobile market.

6. Further Research Topics

Chu and Chintagunta (2009) suggest as a further research topic the question how base and extended warranties interact with each other. The market for extended warranties is growing rapidly, and it would be profitable for the firms to know what type of customers are more likely to buy extended warranties and why. Other further research topics refer to the indirect channels; to the interactions between manufacturer and retailer warranty provisions whether they are complements or substitutes; whether warranties are overprovided and consumers are overprotected, and whether these two are mutually profit-enhancing. In addition, future research could try to use firm-level warranty data instead of aggregate data and firm characteristics, and examine their relationship.

Choi and Ishii's (2010) main finding is that signalling should be a more important motive for warranties in the automobile industry than risk aversion. In terms of future research, specifications with more direct measures of risk aversion and product information need to be developed to understand the consumer perception of warranties as signals. The analysis should be extended from the consumer behaviour to the supply side. According to these authors' hypothesis, automobile manufacturers may view exceptionally long warranties only as a transitional strategy until their brand reputation "catches up" with the category leaders.

As a direction for further research, Chu and Chintagunta (2011) determine decomposing the four warranty theories in markets different from the U.S. automobile market. Markets differ in their degree of information asymmetry – as we have observed in the case of server market in Chu and Chintagunta (2009) –, availability of other quality cues, consumer risk aversion and moral hazard. It is likely that warranties assume different roles in different markets.

Acknowledgements

This work was supported by a grant of the Romanian Ministry of National Education, CNCS – UEFISCDI, project number PN-II-ID-PCE-2012-4-0066.

References

Akerlof, G. A. (1970). The market for ‘lemons’: qualitative uncertainty and the market mechanism. *Quarterly Journal of Economics* 84 (3): 488–500.

Berry, S.; J. Levinsohn; A. Pakes (1995). Automobile prices in market equilibrium. *Econometrica* 63 (4): 841–890.

Berry, S.; J. Levinsohn; A. Pakes (1999). Voluntary export restraints on automobiles: evaluating a strategic trade policy. *American Economic Review* 89 (3): 400–430.

Chatterjee S.; Y. S. Kang; D. P. Mishra (2005). Market signals and relative preference: the moderating effects of conflicting information, decision focus, and need for cognition. *Journal of Business Research* 58: 1362–1370.

Choi, B.; J. Ishii (2010). Consumer perception of warranty as signal of quality. Working paper.

Chu, J.; P. K. Chintagunta (2009). Quantifying the economic value of warranties in the U.S. Server Market. *Marketing Science* 28 (1): 99–121.

Chu, J.; P. K. Chintagunta (2011). An empirical test of warranty theories in the U.S. computer server and automobile markets. *Journal of Marketing* 75: 75–92.

Crawford, G. S. (2012). Endogenous product choice: a progress report. *International Journal of Industrial Organization* 30 (3): 315–320.

Dohmen, T.; A. Falk; D. Huffman; U. Sunde; J. Schupp; G. G. Wagner (2005). Individual risk attitudes: new evidence from a large, representative, experimentally-validated survey. *Discussion Paper Series* No. 1730, Institute for the Study of Labor.

Emons, W. (1989). The theory of warranty contracts. *Journal of Economic Surveys* 3: 43–56.

Gal-Or, E. (1989). Warranties as a signal of quality. *Canadian Journal of Economics*. 22 (1): 50–61.

Goldberg, P. K. (1995). Product differentiation and oligopoly in international markets: the case of the U.S. automobile industry. *Econometrica* 63 (4): 891–951.

Grossman, S.J. (1981). The informational role of warranties and private disclosure about product quality. *Journal of Law and Economics* 24 (3): 461–83.

Guajardo, J. A.; M. A. Cohen; S. Netessine (2012). Service competition and product quality in the U.S. automobile industry. Working paper.

Heal, G. (1977). Guarantees and risk-sharing. *The Review of Economic Studies* 44 (3): 549–560.

Jaeger, A. F.; A. Falk; H. Bonin; D. Huffman; T. Dohmen; U. Sunde (2007). Direct evidence on risk attitudes and migration. *Discussion Paper Series* No. 2655, Institute for the Study of Labor.

Kubo, Y. (1986). Quality uncertainty and guarantee – a case of strategic market segmentation by a monopolist. *European Economic Review* 30 (5): 1063–1079.

Matthews, S.; J. Moore (1987). Monopoly provision of quality and warranties: an exploration in the theory of multidimensional screening. *Econometrica* 55 (2): 441–467.

Menezes, M. A. J.; I. S. Currim (1992). An approach for determination of warranty length. *International Journal of Research in Marketing* 9 (2): 177–195.

Moore, H. L. (1914). Economic cycles: their lLaw and cause. New York: Macmillan.

Nelson, P. (1974). Advertising as information. *Journal of Political Economy* 82 (4): 729–754.

Nevo, A. (2000). A practitioner's guide to estimation of random-coefficients logit models of demand. *Journal of Economics & Management Strategy* 9 (4): 513–548.

Nevo, A. (2011). Empirical Models of Consumer Behavior. *Annual Review of Economics* 3: 51–75.

Padmanabhan, V.; R. C. Rao (1993). Warranty policy and extended service contracts: theory and an application to automobiles. *Marketing Science* 12 (3): 230–247.

Petrin, A. (2002). Quantifying the benefits of new products: the case of the minivan. *Journal of Political Economy* 110 (4): 705–729.

Purohit, D.; J. Srivastava (2001). Effect of manufacturer reputation, retailer reputation, and product warranty on consumer judgments of product quality: a cue diagnosticity framework. *Journal of Consumer Psychology* 10 (3): 123–134.

Riley, J. G. (1979). Informational Equilibrium. *Econometrica* 47 (2): 331–360.

Spence, M. (1977). Consumer misperceptions, product failure and producer liability. *Review of Economic Studies* 44 (3): 561–572.

Stone, J. (1954). The measurement of consumer expenditure and behavior in the United Kingdom, 1920-1938. vol 1., Cambridge University Press.

Tirole, J. (1988). The theory of industrial organization. MIT Press, Cambridge, MA.

Train, K. E.; C. Winston (2007). Vehicle choice behavior and the declining market Share of U.S. Automakers. *International Economic Review* 48 (4): 1469–1496.

Acta Univ. Sapientiae, Economics and Business, **2**, (2014) 95–108

A Comparison of Algorithms for Conjoint Choice Designs

László ILLYÉS
Sapientia Hungarian University of Transylvania, Faculty of Economic and Human Sciences, Department of Economic Sciences, Miercurea Ciuc
E-mail: illyeslaszlo@sapientia.siculorum.ro

Zsolt SÁNDOR
Sapientia Hungarian University of Transylvania, Faculty of Economic and Human Sciences, Department of Business Sciences, Miercurea Ciuc
E-mail: sandorzsolt@sapientia.siculorum.ro

Abstract. We study the performance of some widely-used design construction algorithms like the coordinate exchange and swapping-cycling as well as some of their versions. We measure performance in two ways, namely, first, by measuring jointly both running time and the efficiency achieved, and, second, by fixing the running time of the algorithms and measuring the efficiency achieved while allowing the number of choice situations to vary. In addition, we also analyse the performance in terms of heterogeneous designs. A somewhat surprising outcome of our analyses is that a simplified version of the joint swapping-cycling algorithm outperforms the coordinate-exchange algorithm irrespective of the performance measure.

Keywords and phrases: survey, logit model, greedy approach.
JEL classification: C15, C83

1. Introduction

Choice experiments are widely used to study consumer preferences for various products in different areas like marketing, transportation, environmental and health economics. Their popularity stems from the fact that they can be used to elicit preferences for hypothetical products. An important question in designing a choice experiment is what hypothetical products to present to the respondents who participate in the experiment. One approach in the literature was to design choice experiments based on statistical efficiency.

Conjoint choice designs based on statistical efficiency are typically constructed by optimizing an objective function that is a scalar function of the information matrix of the model considered (Huber & Zwerina, 1996; Sándor & Wedel, 2001). The variables in this optimization are the attributes of the hypothetical products, which are taken to be discrete. This implies a discrete optimization problem, whose complexity depends on the number of choice situations involved in the experiment and on the complexity of the underlying model.

The need for considering complex models stems from the need for modelling consumer preferences more realistically. Examples from this line of literature are Sándor and Wedel (2002) and Bliemer and Rose (2010), who use the random coefficient logit to model consumer heterogeneity in preferences for attributes. While the design construction problem is already rather complex in the former, the latter paper considers the panel version of the random coefficient logit, which allows for correlation between the choices made by a given consumer in different choice situations. The computational complexity of evaluating the objective function for this model is much more severe than in previously considered models. Moreover, if, for this model, we allow for a much larger number of choice situations, like in the heterogeneous design considered by Sándor and Wedel (2005), then the computational complexity becomes even more severe.

Therefore, we believe that the performance of the design construction algorithms in terms of speed is crucial. In the literature, several different algorithms have been proposed. Meyer and Nachtsheim (1995) proposed the coordinate-exchange algorithm, which has the appealing feature of being the simplest algorithm for the problem. Huber and Zwerina (1996) proposed the relabeling and swapping algorithms, while Sándor and Wedel (2001) proposed the cycling algorithm. The three latter algorithms have been used jointly or in pairs (relabeling-swapping or swapping-cycling) in order to attain higher efficiency.

In this paper, we study the performance of these algorithms and some of their versions. We measure performance in two ways, namely, first, by measuring jointly both running time and the efficiency achieved and, second, by fixing the running time of the algorithms and measuring the efficiency achieved while allowing the number of choice situations to vary. In addition, we also analyse the performance in terms of heterogeneous designs. A somewhat surprising outcome of our analyses is that a simplified version of the joint swapping-cycling algorithm outperforms the coordinate-exchange algorithm irrespective of the performance measure.

The remainder of the paper is organized as follows. In Section 2, we present the conjoint choice design problem in the context of the logit model. Section 3 explains the algorithms used. Section 4 presents results from comparing the algorithms for homogeneous and heterogeneous designs. In the last section, we conclude and outline further directions of research.

2. Conjoint Choice Designs for the Logit Model

In a choice experiment, a respondent is presented a conjoint choice design that consists of several choice sets of hypothetical products characterized by their attributes. The respondent is supposed to choose the best alternative in each choice set. The choice data collected in this way can be used to estimate the parameters of the underlying model. Pioneering work in conjoint choice design (e.g., Huber & Zwerina, 1996) assumed the logit model. In this paper, we use this model for two reasons. First, we provide a comparison of the different algorithms for the most commonly used model in the literature. Second, we provide a set of results that can be used as reference for studying the performance of different algorithms applied for more complicated models.

In the logit model, the utility of respondent $i = 1,...,N$ for hypothetical product $j = 1,...,J$ in choice set $s = 1,...S$ is specified as:

(1) $$U_{ijs} = x'_{ijs}\beta + \varepsilon_{ijs},$$

x_{ijs} is a k x1-vector of attributes of alternative j, β is a k x1-vector of parameters weighting these attributes, and ε_{ijs} is an error term having an i.i.d. type I extreme value distribution. The probability that profile j is chosen from the choice set s has the closed form

(2) $$p_{ijs} = \frac{\exp(x'_{ijs}\beta)}{\sum_{r=1}^{J}\exp(x'_{irs}\beta)}.$$

The information matrix can be computed as the variance of the first-order derivatives of the log-likelihood function, and it is equal to the sum of the choice-set specific information matrices:

(3) $$I(\beta) = \sum_{i=1}^{N}\sum_{s=1}^{S} X'_{is}(P_{is} - p_{is}p'_{is})X_{is},$$

where $X_{is} = [x_{i1s},...,x_{iJs}]'$ is the matrix of the attributes in choice set s, $p_{is} = [p_{i1s},...,p_{iJs}]'$ and $P_{is} = diag(p_{i1s},...,p_{iJs})$. In order to study the algorithms with different objective functions, we consider two scalar transformations of the information matrix, namely the $D-error = \det[I(\beta)]^{-1/k}$, which uses the determinant, and the $A-error = tr(I^{-1}(X,\beta))$, which uses the trace of the inverse of the information matrix (Kessels et al., 2006). Both design criteria should be minimized with respect to the elements of X_{is} for all consumers i and choice sets s. This approach corresponds to the so-called heterogeneous design approach; when the designs presented to respondents are the same, that is $X_{is}=X_s$ for all i and s, and then we talk about the homogeneous design approach. We note that the design criteria depend on the parameters that need to be estimated; in order to deal with this issue, we follow the locally optimal design approach by assuming a certain value for these parameters when constructing the design.

In this paper, we consider designs with 15 choice sets with 2 alternatives in each. The alternatives are assumed to be hypothetical products having 4 attributes with 3 levels denoted by 1, 2 and 3. The attributes are qualitative variables coded as [1 0], [0 1] and [-1 -1]. The assumed value of the parameter-vector is the transposed of [-1, 0, -1, 0, -1, 0, -1, 0].

3. Algorithms Used

First, we present the core algorithms, and then we specify the versions and combinations that we use. We illustrate each algorithm by means of the choice set example from *Table 1*.

Table 1. *Example of a choice set*

	Attribute 1	Attribute 2	Attribute 3	Attribute 4
Alternative 1	3	2	3	2
Alternative 2	2	1	2	1

Swapping (Huber & Zwerina, 1996) changes the level values between the two alternatives for the same attribute. In the example (see *Table 2*) values, 3 from the first alternative is changed with value 2 from the second alternative. It starts with the first attribute of the first choice set and continues with the second, third and fourth attributes, and then it proceeds in a similar way with the second choice set until the last choice set.

Table 2. *Swapping the 1st attribute*

	Attribute 1	Attribute 2	Attribute 3	Attribute 4
Alternative 1	2	2	3	2
Alternative 2	3	1	2	1

Cycling (Sándor & Wedel, 2001) changes both levels of the two alternatives corresponding to the same attribute in the following manner: 1→2, 2→3 and 3→1. In the example (Table 3), cycling is applied to the levels of the first attribute; so, 3 becomes 1 and 2 becomes 3. It starts with the first attribute of the first choice set and continues with the second, third and fourth attributes, and then it continues with the second, third etc. choice sets in a similar fashion.

Table 3. *Cycling the original levels for the 1st attribute*

	Attribute 1	Attribute 2	Attribute 3	Attribute 4
Alternative 1	1	2	3	2
Alternative 2	3	1	2	1

The coordinate-exchange algorithm (Meyer & Nachtsheim, 1995) changes one attribute level at a time to the other values. In the example (Table 4), the level of the first attribute of the first alternative is changed from 3 to 1 and then to 2. It starts with the first attribute of the first alternative in the first choice set; then, it continues with the levels of the second, third and fourth attributes, and then it proceeds in a similar way with the attributes of the second alternative and the other choice sets.

Table 4. *Coordinate exchange for the 1st alternative in the 1st attribute*

	Attribute 1	**Attribute 2**	**Attribute 3**	**Attribute 4**
Alternative 1	1	2	3	2
Alternative 2	2	1	2	1
Alternative 1	2	2	3	2
Alternative 2	2	1	2	1

For each algorithm, those changes that improve on the design criterion are preserved and those that do not improve are discarded. The original swapping (henceforth sw) and cycling (henceforth cy) algorithms restart from the beginning after each improving change. We have found that this feature slows down the algorithms considerably; so, we have introduced versions of these algorithms that do not restart after improving changes, but only after reaching the last attribute of the last choice set. We refer to these versions as the *no restart* versions, and we denote it by *nr*. The original coordinate-exchange algorithm does not restart from the beginning after improving changes; so, it is of *nr*-type by default; we now consider a version that restarts from the beginning after each improving change. We denote the latter algorithm by *kx* and the former by *kxnj*. Our proposed algorithms for evaluation are presented in *Table 5*.

Table 5. *The algorithms*

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
sw_cy	*swnj_cynj*	*swnj_cy*	*sw_c.nr*	*cynj*	*swnj*	*kxnj*	*kx*

The first algorithm (*sw_cy*) is the one used by Sándor and Wedel (2001) without the relabeling algorithm. Swapping is applied first and, when this does not give any improvement, then the algorithm proceeds further by cycling. The second algorithm uses swapping first without restart, and then cycling without restart. The third algorithm uses swapping without restart and the original cycling. The fourth algorithm first runs the original swapping, and then the no restart cycling. The 5th and 6th algorithms are pure cycling and swapping with no restart, while the 7th is the original coordinate exchange and the 8th is the coordinate exchange with restart. The original coordinate-exchange algorithm is remarkable in that it can be regarded as the simplest algorithm conceptually.

4. Results

We present two sets of results: one for homogeneous and one for heterogeneous designs.

Homogeneous designs

For each algorithm mentioned in *Table 5*, we construct 20 designs using the same 20 (level-balanced) starting designs. We measure the average running time of each algorithm and we represent the results in scatter plots of points, where the vertical axis shows the average running time in seconds for each algorithm. In one set of results, we analyse the average of the design criterion values, while in another set of results we look at the minimum of the design criterion values. The latter results aim at capturing the performance of the algorithms for finding a design that is closer to the globally optimal design.

Figure 1 presents the scatter plot in the case of the D-error criterion. We can observe that *sw_cy* and *swnj_cy* are the best algorithms on average in terms of the D-error, while *swnj* and *kxnj* are the best on average in terms of running time. By considering both measures jointly, we can notice that both *kx* and *sw_cynj* are worse than *swnj_cy* with respect to both measures, that is they produce less efficient designs and run longer on average.

Figure 2, which presents the scatter plot in the case of the A-error criterion, leads to qualitatively similar findings. Again, *sw_cy* and *swnj_cy* are the best algorithms on average in terms of the design criterion, while *swnj* and *kxnj* are the best on average in terms of running time. By considering both measures jointly, *kx* is worse again than *swnj_cynj* with respect to both measures. Similarly, *cynj* is worse than *swnj_cynj* with respect to both measures.

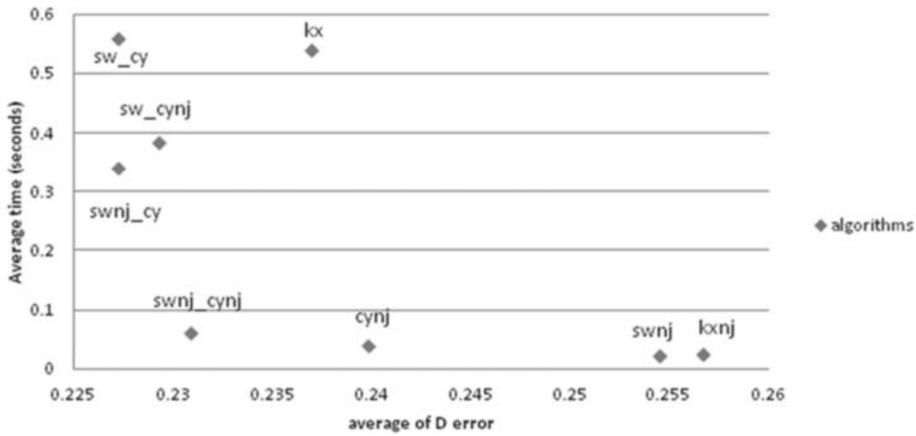


Figure 1. *Average running time and average D-error for homogeneous design*

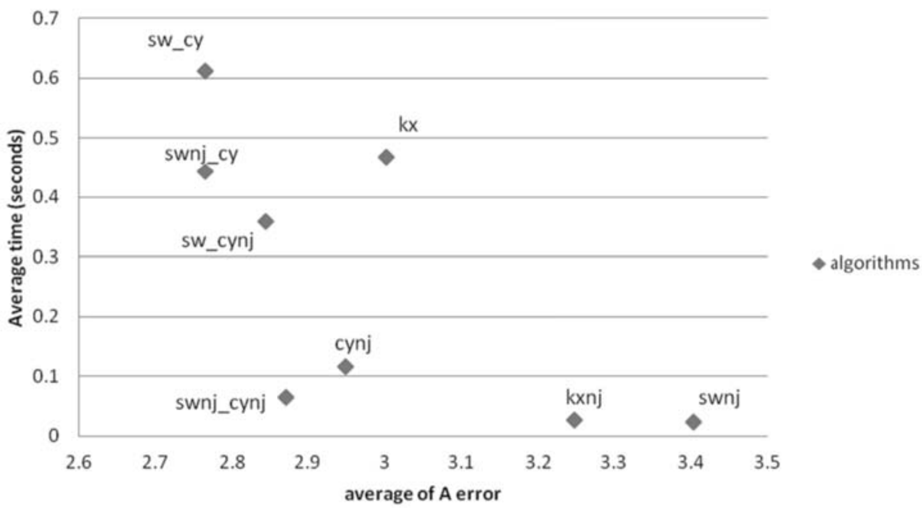


Figure 2. *Average running time and average A-error for homogeneous design*

Figures 3 and 4 present the scatter plots when instead of the average D-errors the minima of these are plotted on the horizontal axis. Qualitatively, *Figure 3* is very similar to *Figure 1* and *Figure 2* is very similar to *Figure 4*, and in fact similar conclusions can be drawn regarding the relative performance of the algorithms.

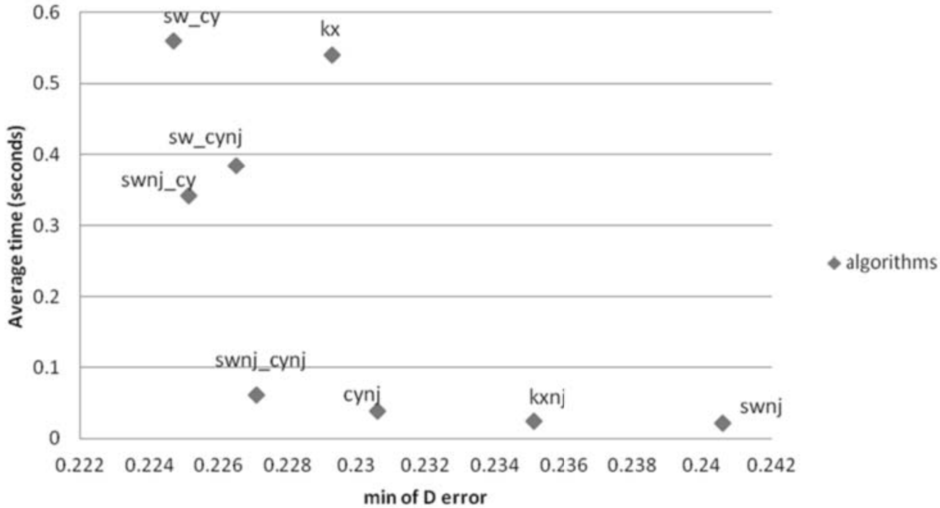


Figure 3. *Average running time and min of D-error for homogeneous design*

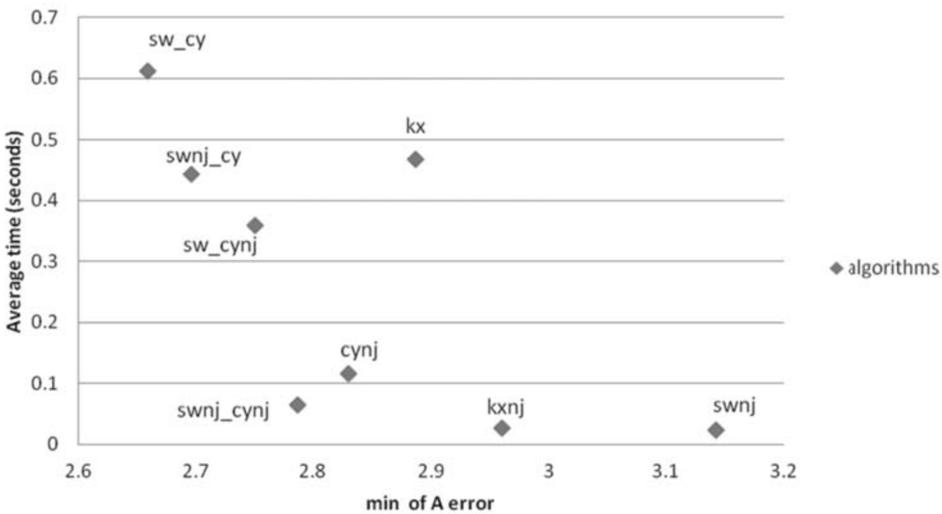


Figure 4. *Average running time and min of A-error for homogeneous design*

We intend to determine the algorithm(s) that has (have) the best performance taking into account figures 1–4. First, we note that since *kx*, *sw_cynj* and *cynj* are dominated in terms of both measures either in the case of the D-error or in the case of the A-error, they cannot have the best performance, so they can be discarded. Further, figures 1 and 3 suggest that *sw_cy*, *swnj_cy* and *swnj_cynj* are similar in terms of the D-error because the percentage difference between the worst and the best is less than about 2.2%, and it is known that this means that a percentage increase of at most 2.2 % in the number of consumers used for the worst design is sufficient to match the performance of the best design. Out of these three algorithms, *swnj_cynj* needs the least running time; so, we discard the other two algorithms. Therefore, the best algorithm is one of the following: *swnj_cynj*, *kxnj* and *swnj*.

Since the running times of these algorithms are slightly different and they yield designs with different D-errors and A-errors, we compare them by fixing the running time to 120 seconds and running the algorithms in this time with different starting designs as many times as possible. The minima of the design criteria obtained are presented in *Table 6*. For example, for the fastest algorithm in the case of the D-error (*swnj*), we obtained 5,792 designs and the minimum of their D-errors is 0.24978. Also, the slowest algorithm (*sw_cy*), which is not presented in *Table 6*, in this case, produced 228 designs. For both design criteria, the best algorithm turns out to be *swnj_cynj*: its lowest value in the D-error case is 0.23063 and in the A-error case is 2.862. This is followed by *swnj* and *kxnj* in the case of the D-error criterion, while in the case of the A-error criterion by *kxnj* and *swnj*.

Table 6. *Minimum D- and A-errors for three selected algorithms with a running time of 120 seconds*

	swnj	**kxnj**	**swnj_cynj**
D1design	0.24978	0.25944	0.23063
D10des	0.02242	0.02262	0.02217
A1design	3.44375	3.30272	2.86219
A10des	0.27879	0.27320	0.26043

It is important to mention that the percentage difference in D-error between the designs obtained by the *kxnj* and *swnj_cynj* algorithms is 11.1%. On the one hand, this means that one needs by 11.1% more respondents when using the *kxnj* algorithm than when using the *swnj_cynj* algorithm. On the other hand, this difference means that the *kxnj* algorithm is more likely to get stuck at local optima than the *swnj_cynj* algorithm.

Heterogeneous Designs

A heterogeneous design is a design in which different respondents are given different designs. So, the main distinction with respect to homogeneous design is that in the latter respondents get the same design. The main motivation for using heterogeneous design, as shown by Sándor and Wedel (2005), is that it offers higher statistical efficiency with the same number of respondents since the design is optimized with fewer constraints. These authors also show that it is not necessary that every respondent get a design different from the others; it is sufficient to use six different designs for all respondents.

First, we present an analysis of heterogeneous designs that is analogous to that presented in figures 1 and 2. *Figure 5* shows that *sw_cy* and *swnj_cy* are again the best algorithms on average in terms of the D-error and *swnj* and *kxnj* are the best on average in terms of running time. By considering both measures jointly, we can again notice that both *kx* and *sw_cynj* are worse than *swnj_cy* with respect to both measures.

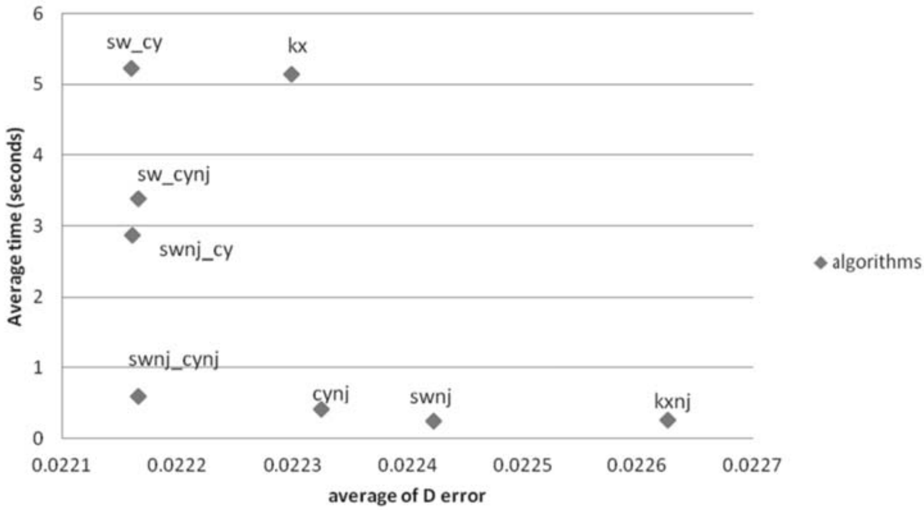


Figure 5. *Average running time and D-error for heterogeneous design*

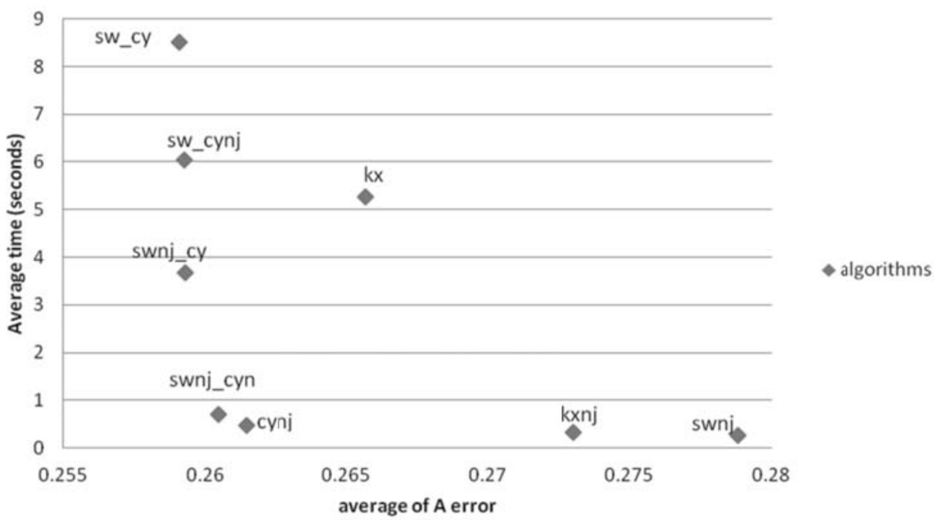


Figure 6. *Average running time and A-error for heterogeneous design*

Figure 6 shows that *sw_cy*, *swnj_cy* and *swnj_cy* are the best algorithms on average in terms of the A-error criterion, while *swnj* and *kxnj*, as in *Figure 2*, are again the best on average in terms of running time. By considering both measures jointly, *kx* is worse again than *swnj_cynj* with respect to both measures.

Figures 5 and 6 yield a conclusion that is qualitatively similar to the homogeneous design case. We intend to determine the algorithm(s) that has (have) the best performance taking into account figures 5-6. First we note that since *kx* and *sw_cynj* are dominated in terms of both measures either in the case of the D-error or in the case of the A-error, they cannot have the best performance, so we discard them. Further, figures 5 and 6 suggest that *sw_cy*, *swnj_cy* and *swnj_cynj* are rather similar in terms of both the D- and A-error. Out of these three algorithms, *swnj_cynj* needs the least running time; so, we discard the other two algorithms. Therefore, the best algorithm is one of the following: *swnj_cynj*, *cynj*, *kxnj* and *swnj*.

Similar to the homogeneous case, since the running times of these algorithms are slightly different and they yield designs with different D-errors and A-errors, we compare them by fixing the running time to 120 seconds and running the algorithms in this time with different starting designs as many times as possible. The minima of the design criteria obtained are presented in *Table 6*. For both design criteria, the best algorithm turns out to be again *swnj_cynj*: its lowest value in the D-error case is 0.02217 and in the A-error case is 0.26043.

The percentage difference in D-error between the designs obtained by the *kxnj* and *swnj_cynj* algorithms is 2%, which is clearly lower than in the homogeneous design case. This means that the difference between the *kxnj* and the *swnj_cynj* algorithms in terms of local versus global optimality is less pronounced in the heterogeneous design case.

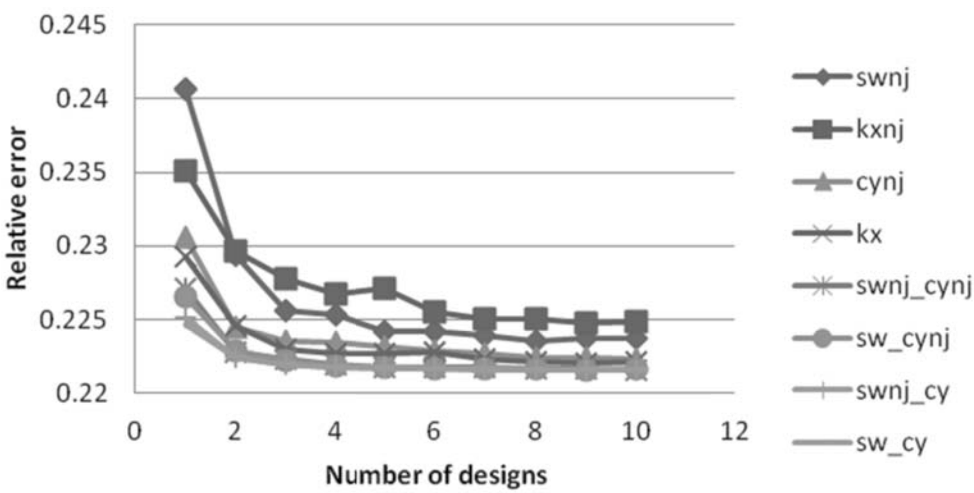


Figure 7. *D-errors relative to the number of different designs*

In order to present further insights regarding the algorithms in the heterogeneous design case, we present their performance based on 1, 2,… 10 different designs (figures 7 and 8). We refer to the design criteria as relative D- and A-error because we multiply these by the number of different designs used. This way, the relative design errors measure the marginal effect of using an additional different design.

The first impression from *Figure 7* is that for all the algorithms the marginal improvement in relative D-error diminishes as the number of designs increases. Further, for the algorithms *sw_cy*, *swnj_cy*, *sw_cynj* and *swnj_cynj*, the relative D-error becomes constant for 4-5 designs or more (a similar finding is reported in Sándor and Wedel, 2005). The algorithms *kx* and *cynj* come close to this constant, but only for 9-10 designs. The algorithms *swnj* and *kxnj* reach constant relative D-error values that are higher. This kind of behaviour of *swnj* is not surprising because swapping preserves the level balance property; so, this algorithm searches in a design space that is smaller than that searched by the other algorithms. The fact that *kxnj* reaches an even higher relative D-error constant is somewhat unexpected. We believe that it is related to the finding mentioned above that the coordinate-exchange algorithm seems to be more likely to get stuck in local optima than the other algorithms.

Figure 8 is in essence similar to *Figure 7*. We can, however, notice that the two coordinate-exchange algorithms and, to a lesser extent, the *swnj* algorithm do not display a monotonically decreasing trend. Again, we believe that this is related to the fact that the coordinate-exchange algorithm seems to be more likely to get stuck in local optima than the other algorithms.

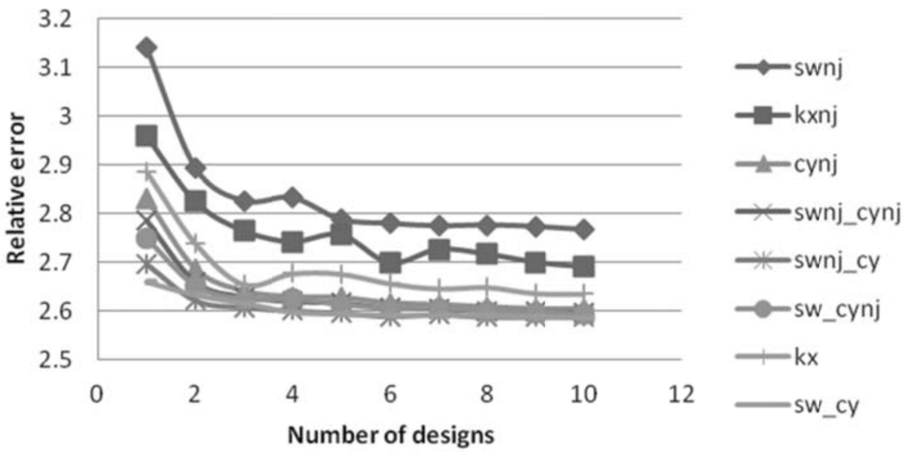


Figure 8. *A-errors relative to the number of different designs*

Finally, we mention that we implemented all the algorithms for heterogeneous designs as so-called greedy algorithms. That is, instead of optimizing all the designs jointly, we have first optimized one design, then the second design only while keeping the first one fixed, then the third design while keeping the first and second designs fixed, and so on. For more details, we refer to Sándor and Wedel (2005).

5. Conclusions

This paper compares the swapping-cycling (Huber & Zwerina, 1996; Sándor & Wedel, 2001) and the coordinate-exchange (Meyer & Nachtsheim, 1995) algorithms regarding their speed and relative optimality. The comparisons include versions of the swapping and cycling algorithms that do not restart from the beginning of the design after each successful modification as well as a version of the coordinate-exchange algorithm that restarts after each successful modification. The comparisons are done for both homogeneous and heterogeneous designs.

The main outcome of our results is that the joint swapping-cycling algorithm without restart outperforms the other algorithms – thus, the coordinate-exchange algorithm as well – both in the homogeneous and heterogeneous design cases. An interesting implication of this finding is that the simplicity of the coordinate-exchange algorithm that is viewed as an appealing feature does not necessarily imply that the algorithm performs well with respect to speed and optimality. Our final conclusion is that researchers should use the joint swapping-cycling algorithm without restart when they adopt the logit for modelling consumer choice.

It would be interesting to know if the same conclusion can be reached in the case of more realistic models like random coefficient logit. Besides locally optimal design, Bayesian design, which – instead of assuming some values for the model parameters – assumes that their distribution is known, is another important design problem that may not lead to the same conclusion. The performance of some global optimization procedures (e.g. Genetic Algorithms, Tabu Search, Simulated Annealing) in conjunction with the design algorithms discussed in this paper may also change the conclusion of this paper. We intend to study these problems in the future.

Acknowledgements

This work was supported by a grant of the Romanian Ministry of National Education, CNCS – UEFISCDI, project number PN-II-ID-PCE-2012-4-0066.

References

Bliemer, Michiel C. J.; Rose, John M. (2010). Construction of experimental designs for mixed logit models allowing for correlation across choice observations, *Transportation Research B* 44: 720–734.

Huber, J.; Zwerina, K. (1996). The importance of utility balance in efficient choice designs, *Journal of Marketing Research* 33: 307–317.

Kessels, R.; Goos, P.; Vandebroek, M. (2006). A comparison of criteria to design efficient choice experiments, *Journal of Marketing Research* 43: 409–419.

Meyer, R. K.; Nachtsheim, C. J. (1995). The coordinate-exchange algorithm for constructing exact optimal experimental designs, *Technometrics* 37: 60–69.

Sándor, Z.; Wedel M. (2001). Designing conjoint choice experiments using managers' prior beliefs. *Journal of. Marketing Res.* 38(November): 430–444.

Sándor, Z.; Wedel M. (2002). Profile construction in experimental choice designs for mixed logit models, *Marketing Science* 21 (4): 55–75.

Sándor, Z.; Wedel, M. (2005). Heterogeneous conjoint choice designs, *Journal of Marketing Research* 42: 210–218.

The list of our occasional referees in 2013-2014:

Béla Baranyi
Sándor Elek
Gergely Fejér Király
Zoltán Gál
Katalin Vér
Mónika Józon
Árpád Szabó
Attila Szőcs

Acta Universitatis Sapientiae

The scientific journal of Sapientia Hungarian University of Transylvania publishes
original papers and surveys in several areas of sciences written in English.
Information about each series can be found at
http://www.acta.sapientia.ro.

Acta Universitatis Sapientiae
Economics and Business

This volume contains one issue.

Sapientia University **Scientia Publishing House**

ISSN 2343-8894 (printed version)
ISSN-L 2343-8894

Information for authors

As a broad-based professional and international journal, the Acta Universitatis Sapientiae, Economics and Business welcomes submissions of applied and theoretical research papers in all fields of Economics and Business. The journal especially encourages submissions on research from management, marketing, quantitative methods and their applications, regional economics, regional development, agricultural economics, and finance. However, the journal is open to research coming from other areas of Economics and Business as well. The primary interest is to publish academic research, but the journal also welcomes good quality research coming from practitioners.

One issue is offered each author free of charge. No reprints will be available.

Contact address and subscription:
Acta Universitatis Sapientiae, Economics and Business
RO 400112 Cluj-Napoca
Str. Matei Corvin nr. 4.
Email: acta-econ@acta.sapientia.ro

Printed by Gloria Printing House
Director: Péter Nagy

ISSN 2343-8894 (printed version)
ISSN-L 2343-8894
http://www.acta.sapientia.ro