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Journal of Statistika | Czech Statistical Office | Na padesátém 81 | 100 82 Prague 10 | Czech Republic
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At-Risk-of-Poverty Rate or Social Exclusion in Visegrad Countries 2005–2017: Impact of Changes in Households' Structure

Jakub Fischer[1] | *Prague University of Economics and Business, Prague, Czech Republic*
Hana Flusková[2] | *Prague University of Economics and Business, Prague, Czech Republic*
Kristýna Vltavská[3] | *Prague University of Economics and Business, Prague, Czech Republic*

Abstract

The paper focuses on the poverty and social exclusion measurement. The aim of the paper is to analyse the factors influencing the differences in at-risk-of-poverty or social exclusion (AROPE) rates and their development across the Visegrad countries. As these factors, we consider the different structure of households by their social status (employed, unemployed, retired, other inactive) and the different highest attained level of education (primary, secondary, tertiary). We use data from the EU-SILC and decompose the AROPE rates as the price indices of unit value. We prove the significant impact of the structure of households by their social status in years 2005–2017 on the AROPE rate comparison for all Visegrad countries and the effect of educational composition on the AROPE rate development for all Visegrad countries except Hungary.[4]

Keywords	***JEL code***
At-risk-of-poverty, social exclusion, price index of unit value, AROPE, international comparison	*I32, C43*

INTRODUCTION

Measurement and analysis of poverty is the subject of many recent papers. Angel, Heuberger and Lamei (2018) compared differences in households' incomes based on surveys and registers. They also analysed how the methodological and empirical differences influence the number of people at risk of poverty.

[1] Prague University of Economics and Business, Faculty of Informatics and Statistics, Department of Economic Statistics, nám. W. Churchilla 4, 130 67 Prague, Czech Republic. Corresponding author: e-mail: fischerj@vse.cz.

[2] Prague University of Economics and Business, Faculty of Informatics and Statistics, nám. W. Churchilla 4, 130 67 Prague, Czech Republic.

[3] Prague University of Economics and Business, Faculty of Informatics and Statistics, Department of Economic Statistics, nám. W. Churchilla 4, 130 67 Prague, Czech Republic.

They used Austrian data from the European harmonised survey Statistics on Income and Living Conditions (EU-SILC). Angel et al. (2018) compared the data from surveys and registers using two models based on the income situation of households and the social and economic characteristics of households. The first model applied the Ordinary Least Squares (OLS) method; the second one used the multinomial regression. They utilised data from years 2008–2011 of about 6 000 households. The authors concluded a substantial increase in the at-risk-of-poverty rate between 2008 and 2011 and the difference in results when using data from the different data sources (registers and surveys).

Ayllón and Gábos (2017) analysed the relationship between indicators of poverty and social inclusion constructed in the framework of the Europe 2020 Strategy (Eurostat, 2019). This strategy sets up five main goals related to the social and economic area of the EU countries and supports the smart, sustainable and inclusive growth. The authors used three indicators: At-Risk-of-Poverty Rate (AROP), Severe Material Deprivation Rate (SMD) and Low Work Intensity Rate (LWIR). The authors compared data on eight EU countries from the years 2004–2010. For the Central European countries (Hungary and Poland), they prove the relationship between AROP, SMD and LWIR. For other countries, they did not verify a connection between these indicators.

Giarda and Moroni (2018) explored the regional differences in the at-risk-of-poverty rate. They compared the data for Italy with the data from the period 2009–2012 for France, Spain and the UK. Similarly to Ayllón and Gabos (2017), they took into account the targets of the Europe 2020 Strategy. The authors analysed the transition processes from and to the at-risk-of-poverty state. Using the econometric models, they found the main factors which influence the at-risk-of-poverty. As the factors, they considered regional differences for the explanation of the persistent-at-risk-of-poverty. According to the authors' conclusion, the economic recession affected more the Mediterranean countries compared to the Central European and Nordic countries. Using the Heckman model (Heckman, 1979), the authors proved the persistent-at-risk-of-poverty in all analysed countries; this type of poverty is stronger in Italy, France and Spain comparing to the UK. In Italy, there is a stronger impact of regional differences in the persistent-at-risk-of-poverty, comparing to other countries.

There are several ways to understand changes in poverty using index decomposition. Inchauste et al. (2014) summarised slightly different approaches, the Datt-Ravallion Method (Datt and Ravallion, 1992) and the Shapley Decomposition proposed by Shorrocks (2013). Some authors use one of these types of decomposition for analysing country data (e.g. Huppi and Ravaillon, 1991, for Indonesia; Fujii, 2017, for Philippines). We discuss these approaches in detail in the methodology section.

Our paper aims to analyse the factors of the differences in the at-risk-of-poverty rates between four Visegrad countries using the decomposition of the unit value index into the levels effect and substitution effect. We focus on the impact of changes in households' structure by the demographic characteristics of households and head of households, in particular by the status and education attained of the head of household.

We organise the paper as follows. Firstly, we describe data sources (Eurostat EU-SILC) database and methodology (index decomposition). Secondly, we present results of our analysis, divided into the effect of changes in the social structure of households and changes in their education structure, comparing the development in Visegrad countries. Finally, we discuss the results.

1 DATA AND METHODOLOGY

For the analysis of differences in at-risk-of-poverty or social exclusion (AROPE) rate between the Czech Republic, Poland, Slovakia and Hungary we use the data from the European survey Statistics on Income and Living Conditions (EU-SILC). From the Eurostat database, we extract data from four EU-SILC tables:

- *Distribution of population over 18 years by most frequent activity status, age group and sex,*
- *People at risk of poverty or social exclusion by most frequent activity status (population aged 18 and over),*

- *Distribution of population aged 18 and over by educational attainment level and age group, and*
- *People at risk of poverty or social exclusion by educational attainment level (population aged 18 and over).*

Data from these tables for all four countries are presented in Tables 1 to 4.

Table 1 Distribution of population over 18 years and at-risk-of-poverty and social exclusion rate by most frequent activity status and education attainment level, 2005–2017, Czech Republic

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Population by most frequent activity status (%)													
Employed	55.9	55.1	54.7	55.5	55.7	54.4	53.8	53.7	54.3	54.2	54.7	55.4	56.5
Unemployed	6.3	6.2	5.9	4.9	4.0	5.2	5.4	5.2	5.4	5.6	5.3	4.8	3.9
Retired	27.5	28.0	28.3	28.4	24.3	24.4	25.5	26.2	26.2	26.4	26.6	27.0	27.1
Other inactive	9.9	10.4	10.8	10.9	15.6	15.5	14.9	14.5	13.6	13.4	13.0	12.6	12.3
Population by educational attainment level (ISCED11, %)													
Levels 0–2	15.5	14.6	14.1	13.9	14.5	13.8	12.9	12.6	12.2	11.4	11.2	11.0	10.7
Levels 3–4	73.3	74.2	74.0	74.0	72.5	72.2	72.1	71.8	72.2	71.1	71.0	70.9	70.2
Levels 5–8	11.2	11.2	11.9	12.2	13.0	14.1	15.0	15.6	15.7	17.5	17.9	18.1	19.1
AROPE by most frequent activity status (%)													
Employed	9.1	8.1	6.5	7.0	6.4	6.7	7.3	7.6	7.4	6.6	6.3	5.9	5.2
Unemployed	69.1	64.9	61.0	62.9	60.5	53.5	56.8	59.6	59.3	59.0	57.0	62.3	57.5
Retired	22.2	20.7	17.8	19.2	14.3	12.3	12.5	12.8	12.3	11.7	11.8	10.8	13.2
Other inactive	24.3	22.4	18.8	18.6	23.5	24.4	26.3	27.1	26.2	26.8	25.1	25.1	23.8
AROPE by educational attainment level (ISCED11, %)													
Levels 0–2	33.8	33.0	30.2	29.7	29.0	28.7	29.8	29.7	32.4	32.0	31.6	32.8	29.5
Levels 3–4	16.9	15.5	13.0	13.1	11.6	12.1	13.4	14.0	13.3	13.3	12.3	11.4	11.2
Levels 5–8	5.5	4.9	4.0	5.7	5.0	4.6	4.7	4.7	4.1	4.2	4.1	3.8	4.1
AROPE total	**18.1**	**16.8**	**14.4**	**14.5**	**13.3**	**13.3**	**14.2**	**14.6**	**14.2**	**13.7**	**13.0**	**12.3**	**11.8**

Note: ISCED 0–2 consists of less than primary, primary and lower secondary education; ISCED 3–4 consists of upper secondary and post-secondary non-tertiary education; ISCED 5–8 consists of tertiary education.
Source: Eurostat Database, tables ilc_peps04, ilc_peps02, ilc_lvhl02, ilc_lvps04

Table 2 Distribution of population over 18 years and at-risk-of-poverty and social exclusion rate by most frequent activity status and education attainment level, 2005–2017, Hungary

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Population by most frequent activity status (%)													
Employed	52.2	48.0	50.0	48.2	48.3	46.6	46.0	46.4	46.5	47.3	51.3	52.7	54.6
Unemployed	4.1	5.7	4.4	4.9	4.4	6.0	6.6	6.9	7.2	7.5	5.3	4.5	3.4
Retired	33.1	33.6	34.0	33.8	25.2	26.8	26.2	25.9	28.3	27.8	27.3	27.0	26.7
Other inactive	10.4	12.3	11.2	12.7	21.5	19.9	20.7	20.4	17.5	17.0	15.6	15.5	14.8
Population by educational attainment level (ISCED11, %)													
Levels 0–2	35.2	28.2	26.4	26.3	26.2	25.5	24.3	23.5	23.2	22.1	20.3	20.9	22.0
Levels 3–4	50.9	56.0	57.8	57.3	56.8	57.3	58.4	58.0	57.6	58.1	57.7	57.8	57.3

Table 2 (continuation)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Population by educational attainment level (ISCED11, %)													
Levels 5–8	13.9	15.8	15.8	16.4	17.0	17.2	17.4	18.5	19.2	19.8	22.1	21.2	20.6
AROPE by most frequent activity status (%)													
Employed	23.0	18.8	18.0	16.8	19.2	18.7	19.5	20.9	23.6	20.3	18.7	18.4	19.0
Unemployed	64.5	71.5	70.1	70.3	72.7	70.8	71.3	78.3	77.8	77.4	77.5	70.4	73.1
Retired	35.6	33.9	32.7	29.8	20.4	20.5	21.3	23.8	24.8	22.5	20.3	18.0	19.0
Other inactive	38.3	41.3	40.3	40.3	44.8	44.5	47.4	48.1	50.0	45.1	42.9	41.7	38.2
AROPE by educational attainment level (ISCED11, %)													
Levels 0–2	42.1	46.7	43.1	41.2	41.5	43.1	46.3	51.7	52.8	51.2	47.7	44.2	41.9
Levels 3–4	28.3	26.6	26.6	25.4	26.9	26.4	28.0	29.3	31.0	28.4	25.0	22.8	21.4
Levels 5–8	9.2	10.7	8.9	9.4	9.4	10.1	11.3	13.1	14.0	9.7	10.5	9.9	12.0
AROPE total	**30.5**	**29.7**	**27.9**	**26.9**	**27.5**	**27.6**	**29.3**	**31.3**	**32.6**	**29.6**	**26.2**	**24.4**	**23.8**

Note: ISCED 0–2 consists of less than primary, primary and lower secondary education; ISCED 3–4 consists of upper secondary and post-secondary non-tertiary education; ISCED 5–8 consists of tertiary education.
Source: Eurostat Database, tables ilc_peps04, ilc_peps02, ilc_lvhl02, ilc_lvps04

Table 3 Distribution of population over 18 years and at-risk-of-poverty and social exclusion rate by most frequent activity status and education attainment level, 2005–2017, Poland

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Population by most frequent activity status (%)													
Employed	44.7	47.1	49.4	52.0	52.4	51.5	51.9	52.1	51.5	52.1	52.1	52.7	53.8
Unemployed	11.5	10.5	8.3	4.4	3.4	5.2	5.9	6.6	7.0	7.1	6.5	6.0	5.1
Retired	29.4	19.7	19.8	20.2	21.7	22.1	22.4	22.3	22.9	22.6	23.6	23.8	24.0
Other inactive	13.9	22.0	21.7	23.0	22.0	20.6	19.3	18.6	18.0	17.6	17.5	17.1	16.8
Population by educational attainment level (ISCED11, %)													
Levels 0–2	23.8	22.8	21.5	20.5	20.8	19.9	19.2	18.9	18.1	17.3	17.2	16.2	15.9
Levels 3–4	62.8	63.2	63.7	63.5	62.6	62.3	62.3	61.4	61.1	60.9	60.2	60.9	60.5
Levels 5–8	13.5	13.9	14.8	16.0	16.6	17.8	18.5	19.7	20.8	21.8	22.6	22.9	23.5
AROPE by most frequent activity status (%)													
Employed	32.0	27.1	23.2	20.6	17.9	17.8	17.3	17.0	16.4	15.0	14.4	13.4	12.0
Unemployed	74.1	70.0	63.6	59.3	58.4	60.1	60.3	58.7	56.3	58.0	58.3	57.2	51.5
Retired	48.5	35.0	30.3	29.6	27.9	26.7	26.2	24.5	21.0	18.8	17.4	17.0	18.1
Other inactive	52.3	53.2	48.5	45.8	44.0	41.8	41.5	41.5	40.1	40.2	40.8	40.4	37.6
AROPE by educational attainment level (ISCED11, %)													
Levels 0–2	58.5	53.2	47.1	45.5	43.7	44.1	42.2	42.0	38.3	38.5	37.5	36.8	34.7
Levels 3–4	45.5	40.1	34.5	30.3	27.2	27.3	27.2	27.0	26.1	25.1	24.0	23.1	21.3
Levels 5–8	16.8	11.9	10.3	9.1	8.2	8.2	8.5	8.4	8.8	7.8	8.0	7.2	6.4
AROPE total	**44.7**	**39.1**	**33.6**	**30.1**	**27.4**	**27.2**	**26.6**	**26.1**	**24.7**	**23.5**	**22.7**	**21.6**	**19.9**

Note: ISCED 0–2 consists of less than primary, primary and lower secondary education; ISCED 3–4 consists of upper secondary and post-secondary non-tertiary education; ISCED 5–8 consists of tertiary education.
Source: Eurostat Database, tables ilc_peps04, ilc_peps02, ilc_lvhl02, ilc_lvps04

Table 4 Distribution of population over 18 years and at-risk-of-poverty and social exclusion rate by most frequent activity status and education attainment level, 2005–2017, Slovakia

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Population by most frequent activity status (%)													
Employed	54.3	54.8	54.9	56.5	56.1	52.7	52.1	51.9	51.3	55.0	55.5	57.3	59.1
Unemployed	7.9	7.0	5.1	4.2	4.3	8.2	8.4	7.9	8.2	9.0	8.4	7.4	5.9
Retired	26.9	27.5	28.4	27.9	24.2	23.2	23.2	23.5	23.3	23.3	23.8	24.4	24.4
Other inactive	10.4	10.3	11.1	10.9	15.0	15.4	15.6	16.2	16.5	12.3	11.8	10.5	10.3
Population by educational attainment level (ISCED11, %)													
Levels 0–2	15.1	14.8	14.3	13.5	12.5	14.7	14.1	14.1	13.2	13.0	11.6	11.8	11.6
Levels 3–4	70.3	69.9	69.6	71.4	70.6	67.4	66.9	66.3	67.6	66.7	68.4	68.4	68.3
Levels 5–8	14.6	15.3	16.0	15.1	16.9	17.9	19.0	19.6	19.1	20.3	20.0	19.8	20.0
AROPE by most frequent activity status (%)													
Employed	24.6	18.3	12.1	12.4	11.3	11.1	11.3	11.0	10.5	9.7	9.9	10.1	9.0
Unemployed	61.6	59.4	60.1	56.4	63.4	57.7	58.2	55.7	54.9	58.0	59.1	59.7	58.3
Retired	34.5	30.5	27.1	26.5	21.0	18.6	16.2	17.6	15.2	14.3	13.6	13.1	12.8
Other inactive	33.8	28.2	24.7	25.5	29.4	29.6	30.9	30.2	28.7	26.7	26.6	30.0	28.4
AROPE by educational attainment level (ISCED11, %)													
Levels 0–2	41.3	36.9	38.1	34.7	35.3	34.9	34.6	35.1	32.5	33.0	33.3	35.2	33.5
Levels 3–4	31.8	26.2	19.3	19.3	18.3	19.1	19.3	18.8	18.0	17.1	16.8	16.0	14.1
Levels 5–8	17.6	12.6	9.0	8.1	7.7	8.7	9.2	9.8	10.1	7.6	8.0	7.8	6.9
AROPE total	**31.3**	**25.6**	**20.3**	**19.7**	**18.6**	**19.6**	**19.6**	**19.3**	**18.4**	**17.3**	**17.0**	**16.7**	**14.8**

Note: ISCED 0–2 consists of less than primary, primary and lower secondary education; ISCED 3–4 consists of upper secondary and post-secondary non-tertiary education; ISCED 5–8 consists of tertiary education.
Source: Eurostat Database, tables ilc_peps04, ilc_peps02, ilc_lvhl02, ilc_lvps04

Our methodological approach is inspired by the summarizing book of Inchauste et al. (2014). There are two main approaches how to decompose the total poverty rate. The Datt-Ravallion Method (Datt and Ravallion, 1992) decomposes the total poverty rate into the size effect, the redistribution effect and a residual term, which is interpreted as an interaction effect. The advantage of this approach consists in the path independency. On the other hand, the residual term could be harder to explain. The Shorrocks (2013), using the Shapley value approach, decomposes the overall poverty into just two components (within-group poverty and the contribution of population shifts). This is more understandable; but, as Inchauste et al. (2014, p. 25) note, this decomposition is path-dependent. While Datt and Ravallion (1992) have to choose the path (changes in poverty are weighted by the base-year population and changes in population shares are weighted by the end-year poverty level), Shorrock's approach is path-independent (he uses an arithmetic average of weights).

The terminology is not stable: while Datt and Ravallion (1992) use the terms "size effect" and "redistribution effect", Shorrocks uses "within-group poverty" and "contribution of population shifts" and Fujii (2017), applying the Datt-Ravallion method, proposes the terms "growth component" and "redistribution component". In our paper, we use the terminology "levels effect" and "substitution effect", according to Lippe (2007). Our paper is based on the decomposition of the price index of unit value (Hindls et al., 2007). This method combines the approaches of Datt-Ravallion and Shorrocks: the total poverty rate is decomposed into two components (similarly to Shorrocks), is path-dependent (as well as the Shorrocks method), but uses the weights from the base year and end year (similarly to Datt-Ravaillon) and not the average.

All the index decompositions were applied by the cited authors to the comparison in time (changes of poverty rates between two time periods). As the index theory allows to use the index approach for spatial comparisons, we adjusted the decomposition of unit value index for the comparison between countries.

The main objective is to compare the AROPE rates and their development in the Czech Republic with other Visegrad countries. Since the AROPE rates are very stable in time (and the most stable among all four countries), we choose the Czech Republic as the benchmark and compare the AROPE rates development in other countries to this benchmark.

The results could be influenced by the slight difference in definitions of the head of households across the compared countries. In the Czech Republic[4] and in Hungary,[5] the head of the household (family) is always the husband of a married couple, in lone-parent families mostly the parent. In non-family households the economic activity and then the income is considered. In Slovakia,[6] as the head of household is considered the person which mostly covers the basic expenditure of the household. Finally, in Poland,[7] the socio-economic groups of households are distinguished by the prevailing source of income; the term "head of household" is not used in the methodology at all.

1.1 Social-status effect

Firstly, for single spatial comparison of AROPE in Hungary, Poland and Slovakia to AROPE in the Czech Republic, we use the price index of unit value (1), according to Hindls et al. (2007):

$$\bar{I}_p = \frac{\bar{p}_c}{\bar{p}_{CZ}} = \frac{\dfrac{\sum_{i=1}^n Q_{c,i}}{\sum_{i=1}^n q_{c,i}}}{\dfrac{\sum_{i=1}^n Q_{CZ,i}}{\sum_{i=1}^n q_{CZ,i}}} = \frac{\dfrac{\sum_{i=1}^n p_{c,i} q_{c,i}}{\sum_{i=1}^n q_{c,i}}}{\dfrac{\sum_{i=1}^n p_{CZ,i} q_{CZ,i}}{\sum_{i=1}^n q_{CZ,i}}} = \frac{\dfrac{\sum_{i=1}^n Q_{c,i}}{\sum_{i=1}^n \frac{Q_{c,i}}{p_{c,i}}}}{\dfrac{\sum_{i=1}^n Q_{CZ,i}}{\sum_{i=1}^n \frac{Q_{CZ,i}}{p_{CZ,i}}}}, \tag{1}$$

where:

$\bar{p}_c$…the total AROPE rate in country c (Hungaria, Poland, Slovakia),
$\bar{p}_{CZ}$…the total AROPE rate in the Czech Republic,
$p_{c,i}$… the specific AROPE rate in social status i in country c,
$q_{c,i}$… the number of people in social status i in country c,
$Q_{c,i} = p_{c,i}\, q_{c,i}$… the number of people in at-risk-of-poverty or social exclusion in social status i in country c,
$p_{CZ,i}$… the specific AROPE rate for social status i in the Czech Republic,
$q_{CZ,i}$… the number of people with social status i in the Czech Republic,
$Q_{CZ,i} = p_{CZ,i}\, q_{CZ,i}$… the number of people in at-risk-of-poverty or social exclusion in social status i in the Czech Republic.

As the social status, we consider following statuses of the head of household:
- Employed,
- Unemployed,
- Retired,
- Other inactive.

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4 <https://www.czso.cz/csu/czso/household-income-and-living-conditions-2016>.
5 <https://www.ksh.hu/apps/meta.objektum?p_lang=EN&p_menu_id=220&p_ot_id=200&p_obj_id=4076&p_session_id=46665581>.
6 <https://www7.statistics.sk/PortalTraffic/fileServlet?Dokument=5fa25b56-41dc-4f3c-8ca8-061a3426e8a6>.
7 <https://stat.gov.pl/download/gfx/portalinformacyjny/en/defaultaktualnosci/3305/1/10/1/incomes_and_living_conditions_eu-silc_2017.pdf>.

For computing levels effect and substitution effect of the social status of the head of household, within bilateral spatial comparison, we decompose the price index of unit value (1) to the *levels effect and substitution effect*:[8]

$$I_{LE}^{(L)} = \frac{\dfrac{\sum_{i=1}^{n} p_{c,i} q_{CZ,i}}{\sum_{i=1}^{n} q_{CZ,i}}}{\dfrac{\sum_{i=1}^{n} p_{CZ,i} q_{CZ,i}}{\sum_{i=1}^{n} q_{CZ,i}}} = \frac{\sum_{i=1}^{n} p_{c,i} q_{CZ,i}}{\sum_{i=1}^{n} p_{CZ,i} q_{CZ,i}}, \tag{2}$$

and

$$I_{SE}^{(P)} = \frac{\dfrac{\sum_{i=1}^{n} p_{c,i} q_{c,i}}{\sum_{i=1}^{n} q_{c,i}}}{\dfrac{\sum_{i=1}^{n} p_{c,i} q_{CZ,i}}{\sum_{i=1}^{n} q_{CZ,i}}}, \tag{3}$$

where:

$I_{LE}^{(L)}$… the levels-effect index, describing the effect of the difference in specific AROPE rates in individual social statuses between the country c and the Czech Republic,

$I_{SE}^{(P)}$… the substitution effect index, describing the effect of the difference in the structure of households between the country c and the Czech Republic.

Letters *L*, *P* in the brackets refer to the type of index. In this type of decomposition, the levels-effect index is based on the Laspeyres index (we use the structure of households in the Czech Republic as weights), while the substitution-effect index is based on the Paasche index (we use the structure of households in country c for weighting). We can call this way as "levels effect first": we assume that we firstly analyse the impact of the difference in specific AROPE rates and secondly the impact of change in the population structure.

We can also make the decomposition in another way ("substitution effect first"):

$$I_{LE}^{(P)} = \frac{\dfrac{\sum_{i=1}^{n} p_{c,i} q_{c,i}}{\sum_{i=1}^{n} q_{c,i}}}{\dfrac{\sum_{i=1}^{n} p_{CZ,i} q_{c,i}}{\sum_{i=1}^{n} q_{c,i}}} = \frac{\sum_{i=1}^{n} p_{c,i} q_{c,i}}{\sum_{i=1}^{n} p_{CZ,i} q_{c,i}}, \tag{4}$$

and

$$I_{SE}^{(L)} = \frac{\dfrac{\sum_{i=1}^{n} p_{CZ,i} q_{c,i}}{\sum_{i=1}^{n} q_{c,i}}}{\dfrac{\sum_{i=1}^{n} p_{CZ,i} q_{CZ,i}}{\sum_{i=1}^{n} q_{CZ,i}}}, \tag{5}$$

hence:

8 The decomposition is based on the approach presented by Hindls et al. (2007).

$$\overline{I}_p = I_{LE}^{(L)} \cdot I_{SE}^{(P)} = I_{LE}^{(P)} \cdot I_{SE}^{(L)} . \tag{6}$$

We compute the price index of unit value (1) and its decomposition to the levels effect and substitution effect for years 2005, 2008, 2011, 2014 and 2017. We selected these years as we analyse the impact of structural differences shortly after the EU accession (2005), shortly before the Great Recession (2008), during the recession (2011), during the recovery period (2014) and in time of the substantial economic expansion (2017).

1.2 Education-level effect

Furthermore, we analyse the impact of educational changes. For this comparison, we adjust the price index of the unit value to the following form:

$$\overline{I}_{p,c} = \frac{\overline{p}_{c,2017}}{\overline{p}_{c,2005}} = \frac{\dfrac{\sum_{i=1}^{n} Q_{c,2017,i}}{\sum_{i=1}^{n} q_{c,2017,i}}}{\dfrac{\sum_{i=1}^{n} Q_{c,2005,i}}{\sum_{i=1}^{n} q_{c,2005,i}}} = \frac{\dfrac{\sum_{i=1}^{n} p_{c,2017,i} q_{c,2017,i}}{\sum_{i=1}^{n} q_{c,2017,i}}}{\dfrac{\sum_{i=1}^{n} p_{c,2005,i} q_{c,2005,i}}{\sum_{i=1}^{n} q_{c,2005,i}}} = \frac{\dfrac{\sum_{i=1}^{n} Q_{c,2017,i}}{\sum_{i=1}^{n} \frac{Q_{c,2017,i}}{p_{c,2017,i}}}}{\dfrac{\sum_{i=1}^{n} Q_{c,2005,i}}{\sum_{i=1}^{n} \frac{Q_{c,2005,i}}{p_{c,2005,i}}}}, \tag{7}$$

where:

$\overline{p}_{c,t}$…the total AROPE rate in country c (Czech Republic, Hungaria, Poland, Slovakia) in time t (2005, 2017),

$p_{c,t,i}$… the specific AROPE rate for educational level i in country c and time t,

$q_{c,t,i}$… the number of people with educational level i in country c and time t,

$Q_{c,t,i} = p_{c,t,i}\, q_{c,t,i}$… the number of people in at-risk-of-poverty or social exclusion with educational level i in country c and time t.

We consider the following educational levels (highest attained level of education):

- Primary education,
- Secondary education,
- Tertiary education.

Similarly to the previous decomposition, we analyse the factors of changes in the price index of unit value using the following decomposition into the *levels effect and substitution effect*:

$$I_{LE,c}^{(L)} = \frac{\dfrac{\sum_{i=1}^{n} p_{c,2017,i} q_{c,2005,i}}{\sum_{i=1}^{n} q_{c,2005,i}}}{\dfrac{\sum_{i=1}^{n} p_{c,2005,i} q_{c,2005,i}}{\sum_{i=1}^{n} q_{c,2005,i}}} = \frac{\sum_{i=1}^{n} p_{c,2017,i} q_{c,2005,i}}{\sum_{i=1}^{n} p_{c,2005,i} q_{c,2005,i}}, \tag{8}$$

and

$$I_{SE,c}^{(P)} = \frac{\dfrac{\sum_{i=1}^{n} p_{c,2017,i} q_{c,2017,i}}{\sum_{i=1}^{n} q_{c,2017,i}}}{\dfrac{\sum_{i=1}^{n} p_{c,2017,i} q_{c,2005,i}}{\sum_{i=1}^{n} q_{c,2005,i}}}, \tag{9}$$

where:

$I_{LE,c}^{(L)}$… the levels-effect index, describing the effect of the difference in specific AROPE rates in individual educational levels between the 2005 and 2017 in country c,
$I_{SE,c}^{(P)}$… the substitution-effect index, describing the effect of the difference in educational structure of households between 2005 and 2017 in country c.
For completion, we mention the second decomposition way:

$$I_{LE,c}^{(P)} = \frac{\dfrac{\sum_{i=1}^{n} p_{c,2017,i} q_{c,2017,i}}{\sum_{i=1}^{n} q_{c,2017,i}}}{\dfrac{\sum_{i=1}^{n} p_{c,2005,i} q_{c,2017,i}}{\sum_{i=1}^{n} q_{c,2017,i}}} = \frac{\sum_{i=1}^{n} p_{c,2017,i} q_{c,2017,i}}{\sum_{i=1}^{n} p_{c,2005,i} q_{c,2017,i}}, \tag{10}$$

and

$$I_{SE,c}^{(L)} = \frac{\dfrac{\sum_{i=1}^{n} p_{c,2005,i} q_{c,2017,i}}{\sum_{i=1}^{n} q_{c,2017,i}}}{\dfrac{\sum_{i=1}^{n} p_{c,2005,i} q_{c,2005,i}}{\sum_{i=1}^{n} q_{c,2005,i}}}. \tag{11}$$

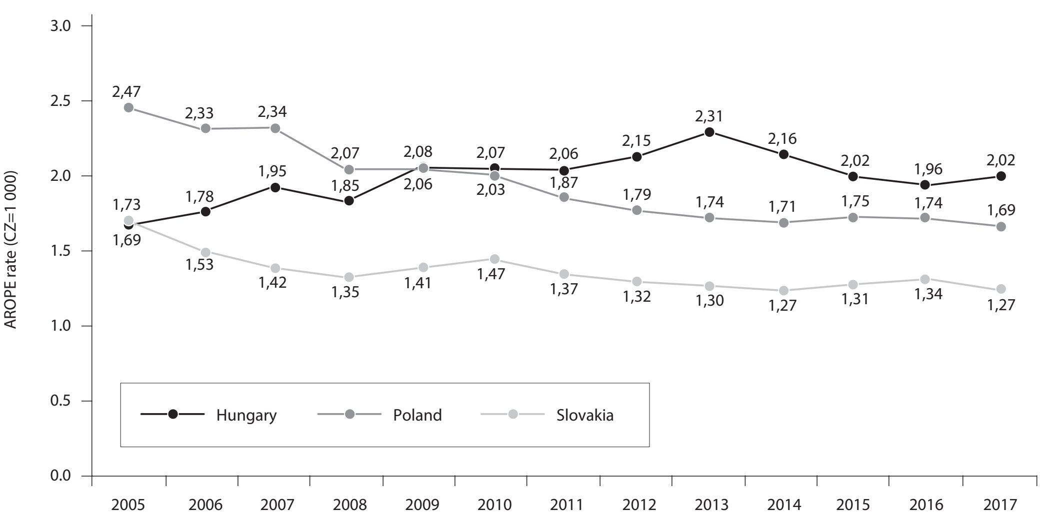
Formula (6) is also valid for this decomposition for each country c.

2 RESULTS

In Figure 1, we can compare the total AROPE rates for Hungary, Poland and Slovakia in the period 2005–2017 to the AROPE rate in the Czech Republic.

In all three countries, the share of the people at-risk-of-poverty or social inclusion is higher than the rate in the Czech Republic: index of AROPE for the countries comparing AROPE rate in CZ

Figure 1 Comparison of AROPE rates in Hungary, Poland and Slovakia to the AROPE rate in the Czech Republic



Source: EU-SILC, own computation

is higher than 1. Seeing the development in time, one can see that the difference in the share of the threatened people comparing to the Czech Republic has increased in Hungary (from 1.69 to 2.02) and continuously decreases in Poland (from 2.47 to 1.69). In Slovakia, after a slight decrease till 2011, the difference remains stable at around 1.25–1.35.

2.1 Social-status effect

Firstly, we compute the decomposition for Hungary. In Table 5, we state the values of the price indices of unit value (which refer to the numbers quoted in Figure 1), and then we compute the levels effect and the substitution effect for each year, using Formulas (2) and (3) and assuming "levels effect first".

Table 5 Levels effect and substitution effect, AROPE rate, Hungary to the Czech Republic, social status, 2005–2017, levels effect first

Year	Total	Levels effect	Substitution effect
2005	1.694	1.699	0.997
2008	1.850	1.774	1.043
2011	2.061	1.903	1.083
2014	2.163	2.015	1.074
2017	2.018	2.005	1.007

Source: Own computation

In the whole period, there is a great difference between specific AROPE rates in Hungary and the Czech Republic within individual social groups of households (levels effect). In the period 2008–2014, we can also observe the difference in households' composition, which contributes to the difference in total AROPE rates by 4.3–8.3%.

Table 6 Levels effect and substitution effect, AROPE rate, Hungary to the Czech Republic, social status, 2005–2017, substitution effect first

Year	Total	Levels effect	Substitution effect
2005	1.694	1.742	0.973
2008	1.850	1.746	1.060
2011	2.061	1.837	1.122
2014	2.163	1.910	1.132
2017	2.018	1.992	1.013

Source: Own computation

In Table 6, we make a decomposition by Formulas (4) and (5), assuming "substitution effect first". We base this computation on the assumption that firstly we change the structure of households, and secondly, we change the AROPE rates within specific groups of households broken down by their social status. In this way of decomposition, the substitution effect (effect of the difference in households' structure) seems to be higher, at a level of 6.0–13.2% in the period 2008–2014.

The development in Poland differs compared to Hungary. The difference in the total AROPE rate between Poland and the Czech Republic continuously decrease (see Table 7). With a small exception of the "crisis" the year 2011, the effect of the different composition of households remains stable

Table 7 Levels effect and substitution effect, AROPE rate, Poland to the Czech Republic, social status, 2005–2017, levels effect first

Year	Total	Levels effect	Substitution effect
2005	2.471	2.288	1.080
2008	2.065	1.920	1.076
2011	1.873	1.803	1.039
2014	1.715	1.602	1.070
2017	1.690	1.568	1.078

Source: Own computation

in the whole period 2005–2017 – this effect contributes to the difference in total AROPE rates by 7–8%. A continuous decrease in differences in AROPE rates is primarily caused by the differences in specific AROPE rates within individual social groups.

The development in Poland differs compared to Hungary. The difference in the total AROPE rate between Poland and the Czech Republic continuously decrease (see Table 7). With a small exception of the "crisis" the year 2011, the effect of the different composition of households remains stable in the whole period 2005–2017 – this effect contributes to the difference in total AROPE rates by 7–8%. A continuous decrease in differences in AROPE rates is primarily caused by the differences in specific AROPE rates within individual social groups.

Table 8 Levels effect and substitution effect, AROPE rate, Poland to the Czech Republic, social status, 2005–2017, substitution effect first

Year	Total	Levels effect	Substitution effect
2005	2.471	2.024	1.221
2008	2.065	2.049	1.008
2011	1.873	1.759	1.065
2014	1.715	1.552	1.105
2017	1.690	1.531	1.104

Source: Own computation

Unfortunately, the results critically depend on the methodology. Using another way of decomposition, i.e. Formulas (4) and (5) assuming "substitution effect first", we obtain different results. The substitution effect is higher on average and much volatile in time. We can explain it by the primary data; in 2005, there was very high AROPE rate for people in households with "Employed" status.

For Slovakia (Table 9), we can observe the effect of the different structure of households in the years 2011–2014 (at a level of around 7–8%). On the other hand, there is a significant decrease in the impact of differences in specific AROPE rates to the total AROPE rates difference between Slovakia and the Czech Republic in years 2005–2014. While the levels effect (effect of differences in specific AROPE rates) reached 69.7% in 2005, this effect decreased to 16.9% in 2014.

We can compute the effects in the second way, "substitution level first" (Table 10). The results slightly differ in values (in 2011 and 2014 the substitution effects is stronger at a level of 10.3–10.5%), but the interpretation of results is very similar.

Table 9 Levels effect and substitution effect, AROPE rate, Slovakia to the Czech Republic, social status, 2005–2017, levels effect first

Year	Total	Levels effect	Substitution effect
2005	1.728	1.697	1.018
2008	1.353	1.381	0.980
2011	1.373	1.273	1.078
2014	1.266	1.169	1.083
2017	1.267	1.226	1.034

Source: Own computation

Table 10 Levels effect and substitution effect, AROPE rate, Slovakia to the Czech Republic, social status, 2005–2017, substitution effect first

Year	Total	Levels effect	Substitution effect
2005	1.728	1.641	1.053
2008	1.353	1.398	0.968
2011	1.373	1.243	1.105
2014	1.266	1.148	1.103
2017	1.267	1.220	1.039

Source: Own computation

2.2 Education-level effect

In this part, we compare the difference in AROPE rates in time, within all four countries, using Formulas (8) and (9).

Table 11 Levels effect and substitution effect in Visegrad countries, change in total AROPE rate, impact of education level, 2005–2017, levels effect first

Country	Total	Levels effect	Substitution effect
Czech Republic	0.647	0.726	0.891
Hungary	0.785	0.895	0.877
Poland	0.445	0.503	0.885
Slovakia	0.478	0.513	0.932

Source: Own computation

Total AROPE rate decreased in Poland by 55% (from 44.7 % to 19.9%) in years 2005–2017, by 53% in Slovakia (from 31.3% to 14.8%), by one third (from 18.1% to 11.8%) in the Czech Republic and by 22% in Hungary (from 30.5% to 23.8%). Table 11 shows the effects of changes in AROPE rates within specific groups (levels effect) and the effect of the change in educational structure. We can conclude, the change in education structure has a positive impact in all four countries. The contribution of the education structure change to decreasing AROPE rate varies from 6.8% in Slovakia to 12.3% in Hungary.

For completion, we can compute the effects by Formulas (10) and (11), assuming "substitution effect first". The difference in result is small, but not negligible. We can see the contribution of the educational

Table 12 Levels effect and substitution effect in Visegrad countries, change in total AROPE rate, impact of education level, 2005–2017, substitution effect first

Country	Total	Levels effect	Substitution effect
Czech Republic	0.647	0.714	0.906
Hungary	0.785	0.875	0.897
Poland	0.445	0.488	0.911
Slovakia	0.478	0.496	0.964

Source: Own computation

change in the Czech Republic, Poland and Slovakia again; the contribution is slightly smaller compared to the previous analysis; varies from 3.6% in Slovakia to 10.3% in Hungary.

CONCLUSION

In this article, we present the analysis of the effects of change in the structure of households in the at-risk-of-poverty and social exclusion rate. The main interpretation obstacle follows the methodology: decomposition of the price index of the unit value can be done by two independent ways, with slightly different results. However, there is an evident impact of the structure of households in the total AROPE rate in Visegrad countries and on their mutual comparison.

At-risk-of-poverty and social exclusion rates are influenced by the structure of households both by their social status and by the educational level as well. Comparing the development of AROPE rates between the Czech Republic and other Visegrad countries, we can see the impact of differences in the social structure of households to the differences in total AROPE rates in all Visegrad countries in the part of the period 2005–2017.

Furthermore, there is a positive impact of the change in the educational structure of households on the development of the total AROPE rate in all Visegrad countries except Hungary.

For further research, we recommend including the aspect of the equivalence scale into the analysis. While Jirková and Musil (2017) analysed the impact of the equivalence scale to the total and specific AROPE rates, it should be useful to extend their approach also on our structural analysis. Moreover, some methodological issues related to AROPE rates construction should be taken into account. Prokop (2019, p. 33) points out some issues consisting AROPE: using national data and national median of income; using income before executions, high non-response rate within the SILC survey.

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Working Heavier or Being Happier? Case of Slovakia

Miroslava Knapková[1] | *Matej Bel University, Banská Bystrica, Slovakia*
Miriam Martinkovičová | *Matej Bel University, Banská Bystrica, Slovakia*
Alena Kaščáková | *Matej Bel University, Banská Bystrica, Slovakia*

Abstract

The paper deals with well-being of employees who invest heavier in work. The main aim of the present study was to examine relationship between workaholism and work enjoyment as part of the work engagement. Paper focuses on workaholics and their emotional experience in performing work (affective component of well-being). The unique method based on time diary, including data on happiness, was used.

Results suggest that non-workaholics feel happier when performing paid work than workaholics. Gender and education are significant background predictors influencing heavy time investment, while parenthood and place of living do not correlate with time workaholism. Men-workaholics work longer than women-workaholics, with no significant difference in happiness. Women-workaholics feel happier when performing unpaid household work, but men-workaholics enjoy more time with children. Education in relation to income, time investment and happiness indicate that workaholism in Slovakia exists in a forced form in order to achieve the required income and forced heavy time investment must undertake deeper analysis.

Keywords

Heavy Work Investment, Heavy Time Investment, employees, happiness, well-being, allocation of time

JEL code

J22, I31, J81, K31

INTRODUCTION

For decades of cultural evolution, when human work was hard, physically strenuous, and exhausting, performed by using just simple technology and tools, it had not received as much attention as it does today. Nowadays, when human work is done with the help of machines, technical devices and intelligent technologies that man has invented and constructed to make his work easier, many researchers look at on human work from various points of view. Theoretical concepts such as Heavy Work Investment, Heavy Time Investment, Work-Life Balance, Subjective well-being, and terms as workaholism, work engagement or burnout suggest that "simplified human work" has led to unexpected problems and challenges. One of them is workaholism with all its positive and negative elements consequences. Workaholism is referred as one subtype of heavy work. Snir and Harpaz (2012) introduced a concept of heavy work investment (in the paper referred also as HWI). They designed a model of HWI, including possible predictors of HWI, types of HWI, and its outcomes. They also made a difference between situational and dispositional

[1] Faculty of Economics, Matej Bel University, Tajovského 10, 975 90 Banská Bystrica, Slovakia. Corresponding author: e-mail: miroslava.knapkova@umb.sk, phone: (+420)484462652.

types of HWI. In addition to their typology, Astakhova and Hogue (2014) distinguish between workaholic HWI, situational HWI and pseudo HWI. Rabenu and Aharoni-Goldenberg (2017) identify three types of workers who normally work long hours but vary in their work effort. They are the excessive work investors (employees who work long hours and invest excessive work effort), the low work investors (employees who work long hours, but invest relatively low level of effort in work), the moderate work investors (employees who work long hours but balance work demands with personal and physical needs).

In the paper, authors pay attention to the well-being of employees who invest heavier in the work. Paper is based on the studies that draw attention to the fact that workaholism is associated with negative emotions and unhealthy behaviour and experience, which in turn adversely affect the functioning of an individual in all other domains (household, family, children, friends, leisure) and reduce his individual well-being (Scott et al., 1997; Clark et al., 2010; Ng et al., 2007; Greenhaus and Powell, 2006). Based on primary empirical research, it demonstrates the current situation of employees in Slovakia and compares the level of affective well-being among workaholics and non-workaholics.

1 LITERATURE REVIEW

1.1 Heavy Time Investment

Most scholars begin the quest for identifying the secular trends in work hours with the onset of the industrial revolution (Golden, 2009). Maddison (1995) has shown that average hours of work in advanced OECD countries fell from around 3 000 hours a year in 1870 to between 1 500 and 2 000 hours a year by 1990. Bell and Freeman (2001) pointed out a decreasing trend in worked hours in Germany form 1985 until 1995. The same was confirmed in the United States (McGrattan, 2004), and other eighteen European countries (Bick et al., 2016). The declining trend in the number of hours worked affects, among other things, the understanding of heavy time investment.

There are various attitudes towards the time cut-off considering the time load in HWI. Brett and Stroh (2003) state that it should be more than 61 hours. According to European Directive on working time (1993), it is more than 48 hours a week. As stated by Snir and Harpaz (2012), it obviously depends on the country. In the US, almost 19% of work force works 50 or more hours per week, and almost one-third works longer than 40 hours per week (Golden, 2009). In Australia, standard full-time work is 38 hours per week. Working over 45 hours per week is considered as very extended working time and working 49 hours per week and over as extremely extended working time (Campbell, 2002). Within the Europe, usual weekly working hours of employed persons range from 31.79 h/week in Netherlands to 40.71 h/week in Greece (Alesina et al., 2005). There are also differences in considering time cut-off for different genders. According to Dex et al. (1995), it is over 60 hours per week in case of men and over 40 hours per week in case of women. According to Kato et al. (2014), working over 60 hours per week may be the cut-off to screen for high-risk groups who need preventive measures against depressive disorder. Kleppa et al. (2008) distinguish between the moderate overtime (41 to 48 hours per week) and very much overtime (49 to 100 hours a week). For Rabenu and Aharoni-Goldenberg (2017), extreme working time is 12 hours a day and more.

Long working hours are often linked with workaholism (either alone or in combination with work effort). Mosier (1983) considered workaholics as those persons who work more than 50 hours a week. Snir and Zohar (2008) defined workaholism as one standard deviation above the regional average (M = 9.6 hours/day, SD = 1.9; Snir, 1998). Thus, in their study, working 11.5 hours/day served as the cut-off criterion, with people below that criterion classified as non-workaholics. As stated by Beckers et al. (2007), in case of full-time employees, it is impossible to distinguish between the effects of long work hours and the effects of pure overtime, as for full-timers overtime work and long workhours go hand in hand. Their time cut-off for full time contractual work was 35 hours a week. Time spent in work depends also on the job position. Jacob and Gerson (1997) pointed to the fact that time investment in work is positively related to holding a professional or managerial position. The inclusion of commuting to work into working time is ambiguous (Snir and Harpaz, 2012). However, most of the studies point out that commuting to work is an inevitable burden of performing work and is not included in the working time (Bleikh, 2018; Sandow, 2019; Mazúrová and Kollár, 2017).

1.2 Workaholism versus work engagement and (potential) emotional investment

Workaholism is defined in many ways with different contexts. Most definitions include notions about long working hours (Mosier, 1983; Snir and Zohar, 2008; Kleppa, Sanne, Tell, 2008), working more than what is demanded/expected (Schaufeli et al., 2006b), prioritizing work over other activities, including neglecting of family relationships (Machlowitz, 1980), low interest in family life and work-life balance (Bonebright et al., 2000; Aziz et al., 2013), enjoyment or passion of work (Gorgievski-Duijvesteijn and Bakker, 2010; Birkeland and Buch, 2015). As workaholism is associated with a high work-related effort, some authors view workaholism in positive terms (Scott et al., 1997) whereas others emphasize its potential negative aspects (Oates, 1971; Robinson, 1998).

The workaholism is related to its interplay with work engagement, which represents a positive, fulfilling, work-related state of mind where employees bring all their cognitive and emotional energy into work (Schaufeli et al., 2006a; Trépanier et al., 2013; Fernet et al., 2013) characterized by vigour (high level of energy and mental resilience while working), dedication (strongly involved in job activities), and absorption (concentrated and happily engrossed in one's work) (Schaufeli et al., 2002; Schaufeli et al., 2006b). According to HWI perspective (Snir and Harpaz, 2012), workaholism and work engagement are two faces of the same coin. Workaholism and work engagement are subtypes of HWI: workaholism is based on an addiction to work (an internal, uncontrollable, and stable predictor), while work engagement is an expression of a passion to work (an internal, controllable, and stable predictor). Workaholics show an exaggerated need to work and it seems impossible for them to repress it, endangering health, reducing their happiness, and deteriorating their interpersonal relationships (Schaufeli et al., 2006a).

Employees characterized by a high level of work engagement work intensively for many hours, as well as workaholics do (Schaufeli et al., 2002), but with passionate involvement (Buelens and Poelmans, 2004). Workaholism and work engagement are associated with distinctive outcomes (Shimazu and Schaufeli, 2009): workaholism is associated with negative outcomes and work engagement with positive outcomes. Workaholism is associated with high levels of job strain and mental health complaints (van Beek et al., 2011), job-related negative affects (Balducci et al., 2018; Clark et al., 2014; Buelens and Poelmans, 2004) poor quality of sleep (Kubota et al., 2010; Åkerstedt et al., 2002), more interpersonal conflict at work (Mudrack, 2006), poorer social relationships (Bonebright et al., 2000), burnout (Stoeber and Damian, 2016; Falco et al., 2014) and work–family conflict (Walga, 2018; Burke, 2009). Work engagement is associated with low levels of health complaints and high levels of psychological and physical health (Seppälä et al., 2012), work motivation (Hitka et al., 2018; Demerouti et al., 2017) and well-being (Di Castro et al., 2018; Dutschke et al., 2019; Gervais and Millear, 2014).

1.3 Approaches to measure workaholism and work engagement

Recent empirical findings give reason to differentiate between 'enthusiastic' and 'non-enthusiastic' workaholics (Andreassen et al., 2010). Non-enthusiastic workaholics are characterized by high levels of work involvement, high levels of drive, and low levels of enjoyment of work, whereas enthusiastic workaholics, typically have high scores on all three workaholism components (work involvement, drive and enjoyment of work) as measured by the frequently used Workaholism Battery (WorkBAT) developed by Spence and Robbins (1992). The enjoyment of work is detected within WorkBAT methodology by item 'Sometimes I enjoy my work so much that I have a hard time stopping' and so assesses satisfaction from work. Shimazu and Schaufeli (2009) demonstrated the empirical distinctiveness of workaholism and work engagement by examining their relationships with well-being. Workaholism was measured with the Dutch Workaholism Scale (DUWAS) developed by Schaufeli and his colleagues (Schaufeli et al., 2006b). The scale consists of two subscales; Working Excessively (e.g., I stay busy and keep many irons in the fire) and Working Compulsively (e.g., I feel guilty when I take time off work). They confirmed that workaholism was positively associated with ill-health (psychological distress and physical complaints) and negatively associated with life satisfaction (job and family satisfaction) and job performance. In contrast, work engagement was negatively associated with ill-health and positively associated with life satisfaction and job performance.

Work engagement shows a negative relation with work interference (Schaufeli and Salanova, 2011; Van Wijhe et al., 2011) in the way that investment in work does not prevent the involvement in various life roles (Timms et al., 2015). This is in line with Ivy and colleagues (Ivy et al., 2010) who showed a positive relationship between work engagement and work family enrichment. The consequences on the family context of work engagement are in line with the enrichment theory (Greenhaus et al., 2006), which specifies the conditions under which work and family roles are "allies" rather than "enemies" (Friedman and Greenhaus, 2000). To summarize, according to the enrichment theory, resources generated in one life role can produce positive consequences in another role.

Scafuri Kovalchuk and colleagues (2019) used the nine-item Utrecht Work Engagement Scale (UWES) for work engagement measurement, adapted by Balducci and colleagues (Schaufeli et al., 2002; Balducci et al., 2010). Participants were asked to respond on a five-point scale ranging from "never" to "every day" with regard to how frequently they experienced the feeling. Another possibility of exploring work engagement is measurement of emotional exhaustion. Six items from Maslach Burnout Inventory were used to measure emotional exhaustion (Scafuri Kovalchuk et al., 2019). Respondents were asked to rate the frequency of effects on a five-point Likert scale from 1 (never) to 5 (every day). An item example is as follows: "I feel emotionally drained from my work". Scafuri Kovalchuk and colleagues (2019) found evidence of a protective role of work engagement against work–family conflict. These results support hypothesis regarding a possible spill over effect, which would allow a crossover of positive resources between the work and the family domains. In other words, according to the enrichment theory (Greenhaus and Powell, 2006), if, for example, one is happy and satisfied regarding his/her own work, although he/she works excessively, he/she will easily recover from working by spilling the positive emotions over from the work to family domain. Work engagement was positively and significantly correlated to gender, whereas it was negatively correlated to the discrepancy subscale of perfectionism, work–family conflict, and emotional exhaustion.

1.4 Work energy investment and affective well-being

Workaholism and work engagement are weakly and positively related with each other, but they represent two different kinds of concepts; workaholism is associated with unwell-being, whereas work engagement with well-being. Therefore, we can conclude that workaholism has adverse effects on employees' well-being, whereas work engagement has favourable effects on it (Shimazu and Schaufeli, 2009). Work engagement refers to a positive, fulfilling, work-related state of mind that is characterized by vigour, dedication, and absorption (Schaufeli et al., 2009). Thus, engaged employees work hard (vigour), are involved (dedicated) and feel engrossed (absorbed) in their work. In this sense, they seem similar to workaholics. However, in contrast to workaholics, engaged workers lack the typical compulsive drive. For them work is fun, not an addiction, they work hard because they like their job (intrinsic motivation) and not because they feel driven by an obsessive inner drive they cannot resist (Shimazu and Schaufeli, 2009).

Organizations undoubtedly appreciate, and often benefit, when their employees are fully invested in their work (May et al., 2004). However, is 'living and breathing' ones' work always a good thing? What is more meaningful: working to live or living to work? Recent research suggests the opposite, that if individuals are unable to detach from work during off-job time, they experience greater fatigue and negative affect (Sonnentag et al., 2008).

Empirical research has shown that workaholism has been associated with an increased trait negative affect (Clark et al., 2010). When individuals experience negative affect, they may be more likely to place themselves in stressful situations (i.e. differential exposure) and have more severe emotional reactions in response to stressful situations (i.e. differential reactivity). Workaholics are compulsive and perfectionistic workers, driven by feelings of guilt when they are not working, and thus they are reluctant to disengage from work (Scott et al., 1997). This guilt intensifies feelings that one is not meeting standards or obligations in either the home or work domain as determined by our cultural norms (Parrott and Harré, 1996). Thus, individuals experiencing feelings of guilt may be more likely to perceive a failure to meet expectations for performance at home and work, and hence greater perceptions of work–home conflict. Additionally, workaholics may be more likely to feel disappointment and anxiety about failing to reach an unattainable ideal level of performance because of their perfectionistic tendencies (Clark et al., 2010; Ng et al., 2007; Scott et al., 1997).

2 RESEARCH METHODOLOGY

2.1 Methodological background

When introducing HWI concept, Snir and Harpaz (2012) indicated three groups of HWI predictors. They are 1. background predictors (e.g. gender, parenthood, education level), 2. external predictors (basic financial needs, employer demand, holding a managerial or professional position, organizational culture, type of industry, labour market conditions, such as labour union policy, cross-cultural differences), and 3. internal predictors (e.g. an addiction to work, passion for work, desire to stay away from intimacy and escape from private life, low preference for leisure, materialism, work ethic, including hard work, long hours, pride in work and a job well done).

This contribution is based on the consideration of HWI according to the time spent in paid work (heavy time investment, HTI), subjective perception of the passion for paid work (perception of happiness), involvement in domestic unpaid work (as internal predictor), income (as external predictor), using the classification according to gender, parenthood, education, and place of living (background predictors), with regard to the Slovak labour market conditions.

Based on the premise of Snir and Zohar (2008), focusing only on HTI, we consider workaholism as one standard deviation above the regional average. According to Labour Force Sample Survey results in the Slovak Republic for the 4th quarter 2018, we were able to calculate average time on paid work in Slovakia for 2018 for two categories – employed persons and self-employed persons (in both categories classified also according to the gender) (see Table 1).

Table 1 Average usual hours worked per week and standard deviation in 2018 in Slovakia

	Average	Standard Deviation (SD)	Workaholism cut-off time (per week)	Workaholism cut-off time (per day)
Employees total	35.7	0.134811	35.834811	7.1669622
Employees women	34.5	0.202408	34.702408	6.9404816
Employees men	36.8	0.177256	36.977256	7.3954512
Self-employment jobs total	41.1	0.378639	41.478639	8.2957278
Self-employment jobs women	38.6	0.739178	39.339178	7.8678356
Self-employment jobs men	42.1	0.432906	42.532906	8.5065812

Source: Own construction based on the Labour Force Sample Survey results in the Slovak Republic for the 4th quarter 2018, Statistical office of the Slovak Republic

Referring to Slovak Labour code (Act No. 311/2001 Coll.), the maximum weekly working time is 40 hours. Break for lunch (usually 30 minutes), as well as commutation to work are not included in the working time (Martinkovičová et al., 2019; Mazúrová and Kollár, 2017).

To meet the aim of the paper we needed to gather data on the distribution of the time during the working day, as well as on the current feeling (emotions) at the moment of performing various activities during the day. In Slovakia, there was not any survey containing such data conducted before. To gather necessary data, we conducted original questionnaire field research (primary data collection).

Research was based on Time Use Survey (TUS) methodology. In Slovakia, there are no official time use surveys (except of two pilot surveys in 2006 (200 households were involved) and in 2018 (50 respondents were involved)). Our survey is the first survey based on TUS methodology, including time diary as recommended by Eurostat (in terms of observed variables and sample size).

To indicate the interconnection of workaholism (based on the length of working time as criteria) and the enjoyment of work, as an affective component of subjective well-being (SWB), we used the TUS methodology, as well. The TUS represents a research instrument suitable for measuring both components of subjective well-being, cognitive and affective, by linking three basic variables: time – activity – feeling (Martinkovičová et al., 2020). One of the options to measure emotions and feelings during the paid work is a question, which is used as part of a time diary. It is the so-called "column of happiness". In the 2010, within the French TUS, the French national statistical office, added the intensity of emotional experience as a separate column in the time diary (enjoyment field), asking the respondent to record "was that moment pleasant or unpleasant" on a scale from minus 3 (unpleasant) to plus 3 (pleasant) (INSEE, 2010). This method measures not only intensity but also frequency of emotional experience and we consider it suitable for measuring work enjoyment as sub-dimension of the HWI and for distinguishing between the subtypes workaholism and work engagement.

2.2 Data collection and elaboration

The survey was conducted in March and April 2019. In the survey, 517 households in Slovakia were involved, and 1 202 respondents (individuals living in the surveyed households) filled in a questionnaire and the time diary. Households were personally visited and interviewed by volunteer students (students were trained to ask questions and to collect the data). Each student interviewed three different households and had two restrictions/ criteria for contacting households. To achieve the representativeness by the area, the first contacted household was from Bratislava or Western Slovakia Region, second from Central Slovakia and the last from Eastern Slovakia Region. Next restriction concerned the household type: one contacted household was single-member household, second was a family household with children dependent on parent´s income, in which there is at least one child under 15 years of age (complete or incomplete family) and the third household was a family without dependent children in complete or incomplete family.

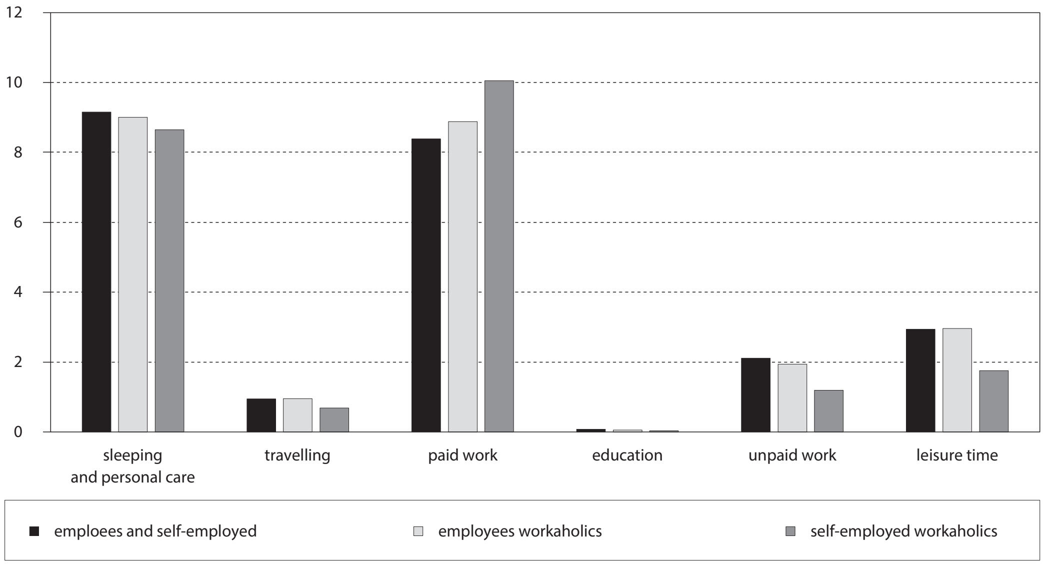
We used Computer Assisted Personal Interview method (CAPI) for recording answers from respondents. All answers were recorded, and data were prepared for further proceedings. We divided all acquired data into two databases, namely database of households´ responses and database of individuals´ responses. After weighting all data, we confirmed representativeness of the research sample by the gender, age categories, and by the education level (in the sample of individuals), and by the number of household´s members and the number of households in the regions (in the sample of households).

The questionnaire contained several modules of questions focusing on the paid work, decision making process on the allocation of time on paid work, unpaid work and leisure time, influence of the education level on the decision making process of household members, attitudes to education, financial situation in the household and socio-demographic variables of the household and its members. By completing the time diary, respondents identified the distribution of their activities during the randomly chosen working day and free day (weekend or other day when respondent usually does not perform paid work). For indicating affective SWB, respondents answered the question "How do you feel while performing the activity?". Respondents indicated level of happiness (from very unpleasant to very pleasant, we used a five-point scale) for all time diary activities, including working time, unpaid work in households, and leisure time.

For this contribution, we exported and analysed data on employees and self-employed persons.

The basic differentiation of the time allocation during the working day between various groups of activities according to the categories of employed and self-employed persons (divided on group of all employees and self-employed persons, and specifically workaholic employees and workaholic self-employed persons) is evident from Figure 1.

Figure 1 Time allocation of employees and self-employed persons, workaholic employees and workaholic self-employed (in hours per working day)



Source: Own construction

For data analysis we used SPSS software, version 25, for hypotheses testing we used the significance level 0.05.

For the identification of the correlation between the length of time devoted to paid work, unpaid work and the socio-demographic variables, we used the test of significance of Spearman´s correlation coefficient. Firstly, we identify correlations in the databases of employees and self-employed persons together. Afterwards, we focused particularly on workaholics (separately in the group of employed persons and group of self-employed persons). When insignificance was rejected, the Spearman´s correlation coefficient was computed and interpreted. In case of education and length of working time at the controlled income, we used Pearson´s partial correlation coefficient.

Because the assumptions of normal distribution of the variables (emotion at the performed activities, the length of time for paid work, number of performed activities during the day) were rejected, we used nonparametric Mann-Whitney test for testing the significance of differences by the gender, and differences between people with standard time devoted to paid work and the workaholics.

2.3 The aim of the study and hypothesis

The aim of the study is to identify the well-being of employees who invest heavier in the work (focusing on workaholics identified according to HTI). Considering various backgrounds, internal and external predictors of HWI (Snir and Harpaz, 2012), interconnection of workaholism and emotions (Scafuri Kovalchuk et al., 2019; Greenhaus and Powell, 2006) and well-being (Shimazu and Schaufeli, 2009; Clark et al., 2010; Ng et al., 2007), we set the following hypothesis:

H1 Happiness at paid work: workaholics and non-workaholics do not feel the same level of happiness while performing paid work (we assume that workaholics feel less happy at paid work than non-workaholics),

H2 Heavy time investment and happiness by gender: there is a statistically significant difference in heavy time investment and happiness by gender (we assume that men-workaholics feel happier at paid work than women-workaholics; we assume that women-workaholics feel happier at performing unpaid work than at performing paid work),

H3 Heavy time investment and education: education is a significant factor influencing HTI (we assume that employees-workaholics with higher education invest heavier in time at paid work than employees with lower education).

From total amount of 1 202 respondents, 614 were workaholics. Considering different cut-off time for workaholism for men and women, and for employed persons and self-employed persons, the sample was 577 employed workaholics, out of them 304 men-workaholics and 273 women-workaholics, and 37 self-employed workaholics (29 men and 8 women). Small differences between sample size and totals in tables are caused by not answering some questions in questionnaire.

3 RESULTS AND DISCUSSIONS

The different feelings of happiness during the paid work of workaholics and non-workaholics are related to the different ways of investing energy and emotional commitment. An interesting access to work engagement offered self-determination theory. On its basis work engagement may be a protective factor from the undesirable outcomes of workaholism (Ryan and Deci, 2017; McMillan and O'Driscoll, 2004). This theory focuses on the autonomous motivation that is characterized by people being engaged in an activity with a full sense of willingness, will, and choice; furthermore, often, autonomously regulated activities are intrinsically motivated. When the work's motivation is externally regulated, individuals perceive their behaviour as being directly controlled by others, often through contingent rewards and threats; in this case, they talk about "motivation control" that can have negative spillover effects on subsequent performance and work engagement (Scafuri Kovalchuk et al., 2019). This approach shows that workaholism is associated with controlled motivation and work engagement with autonomous motivation generating high levels of positive affect (Van Beek et al., 2011; Gillet et al., 2017). Engaged workers lack the typical compulsive drive, which is typical for workaholics. For them work is fun, not an addiction, they work hard because they like their job (intrinsic motivation) and not because they feel driven by an obsessive inner drive they cannot resist. So, even though workaholics and engaged employees may work similarly hard, their motivation to do so differs fundamentally. It is interesting to note that workaholism shows a positive relationship with excess working time whereas this relationship is absent for work engagement (Shimazu and Schaufeli, 2009). Based on this concept, we tried to identify if the level of happiness at paid work is the same in the group of workaholics and non-workaholics. Comparing the level of happiness of workaholics and non-workaholics, using Mann-Whitney U test, we found out that employees non-workaholics feel happier at performing paid work than employees workaholics (p-value = 0.003). In the group of self-employed people this assumption was not confirmed (p-value = 0.11).

In case of second hypothesis we assume, that men-workaholics feel happier at paid work than women-workaholics and that women-workaholics feel happier at performing unpaid work than at performing paid work. International surveys as well as our original research on unpaid work in Slovakia (Antonopoulos and Hirway 2009; Martinkovičová et al., 2020) have shown long-term unequal distribution of participation of men and women on unpaid work and draw attention to the ongoing trend of greater participation of women in unpaid work activities. We analysed correlations of workaholism and several background predictors (gender, age, parentship, place of living, education). We found out statistically insignificant correlation between the workaholism and parentship, age category and place of living (Table 2). On the other side, there is weak correlation between the paid work time investment and gender, men-workaholics spend more time in paid work than women-workaholics (see Table 3); differences are statistically significant for both groups workaholics.

Table 2 Correlation matrix – heavy time investment (HTI) and background variables (Spearman´s correlation coefficients)

			HTI	Gender	Age	Education level	Parentship	Place of living
Employees	HTI	Correlation Coefficient	1.000	–0.231	–0.014	–0.128	0.028	0.078
		Sig. (2-tailed)		0.000	0.732	0.002	0.497	0.061
		N	577	577	577	577	577	572
Self-employed	HTI	Correlation Coefficient	1.000	–0.382	0.018	0.105	–0.076	–0.153
		Sig. (2-tailed)		0.020	0.915	0.537	0.649	0.372
		N	37	37	37	37	37	36

Source: Own construction

Table 3 Time investment of workaholics by the activity status – descriptive statistics (hours per week)

	Employees			Self-employed		
Gender	N	Mean	Std. Deviation	N	Mean	Std. Deviation
Men	304	43.0265	7.35607	29	51.2062	8.25076
Women	273	40.7972	6.37898	8	45.3582	6.32454

Source: Own construction

In the case of happiness feeling, on the basis of surveyed data, there was not statistically significant difference between the level of happiness in paid work of employed workaholic men and women. We used Mann-Whitney test (p-value = 0.456). When comparing happiness at performing paid work and unpaid household work, both men-workaholics and women-workaholics feel happier at performing unpaid work (used Wilcoxon test, men: N = 265, p-value = 0; women: N = 251, p-value = 0). The results show that women-workaholics feel even happier and emotional when performing unpaid work than men-workaholics do. Our research shows that although the time burden of paid work increases for women-workaholics, it does not affect the persistently higher affective well-being from unpaid work (Wilcoxon test, p-value = 0.023). We assume that it is linked with the fact, that unpaid work has an economic but also a significant social value. Most of these activities, family actions, regular cycles (such as cooking, washing, ironing, learning with children, helping in the garden and others) have significant reinforcing nature and importance. These activities positively influence the social and family relationships of people, both in terms of creating educational patterns, understanding their place in the family as traditional work, or in the context of meaningful leisure time in own family environment.

However, unexpected result of the analysis was that men-workaholics feel happier at taking care of children than women-workaholics (p-value = 0.018; children care is a part of unpaid work activities).

After deeper analysis, we found out that women-workaholics performed significantly more types of activities during the day than men-workaholics. It seems that women-workaholics, facing the double burden (heavy investment in paid work as well as heavy investment in unpaid household activities) divide the happiness between many various activities, while men-workaholics feel happy while enjoying moments with their children. The hypothesis H2 was statistically tested and confirmed.

It is important in many respects to consider education when researching HWI. It is natural to assume that effort, energy, costs, as well as time invested in higher education should be reflected (manifested) in the form of career stimulation, higher responsibility and undoubtedly increasing income (Želinský et al., 2018). All these factors should affect the subjective well-being of employees. On the other hand, meeting these expectations requires spending more time in paid work. In Table 4, there is data on distribution of time in paid work of workaholics by the education level.

Table 4 Distribution of time in paid work of workaholics by the education level

	Hours in paid work per week				Total
	Up to 38	From 38 up to 42	From 42 up to 50	More than 50	
1 Primary school	0	0	3	1	4
2 Secondary vocational school, vocational school (less than 4 years)	37	16	19	25	97
3 Grammar school, secondary vocational school, vocational school (at least 4 years)	78	72	53	36	239
4 Postgraduate studies, post-secondary education	4	5	3	10	22
5 Higher education, university	101	79	58	14	252
Total	220	172	136	86	614

Source: Own construction

However, our analysis showed unexpected results. We confirmed negative correlation between the education and time investment (higher the education, lower the time investment of workaholic employees – see Table 2). This result is inconsistent with the premises (Želinský et al., 2018; Snir and Harpaz, 2012). That is why we focused deeper on this phenomenon. Using the Pearson Correlation, we identified significant positive correlation of education and income ($r = 0.327$, p-value = 0.000). Using the partial correlations, we found a significant negative correlation between the education and time in paid work, at the controlled level of income ($r = -0.254$, p-value = 0). Thus, employees-workaholics with lower education must invest heavier in time than employees-workaholics with higher education, to reach the same level of income. At the same time, there is an indirect support for the flexibility of the labour market in the form of parallel employment relationships (part-time work, teleworking, home office, etc.). Considering the level of happiness (as discussed at hypothesis H1), workaholic employees in Slovakia invest heavily in time to reach desired income, however, without feeling happiness during the heavily invested worked hours. This phenomenon of "forced workaholism" or "forced HTI" requires deeper analysis in the future. Based on the analysis, hypothesis H3 was not confirmed.

CONCLUSION

The concept of HWI reveals several interesting contexts and many unexpected correlations. The paper examines workaholics in Slovakia (considering a workaholic as an employee who works longer than a standard deviation above the national average), in relation to their experienced affective well-being. In the paper, authors present unique data collected in Slovakia, based on the Time Use Survey methodology with added information on the happiness (self-reported feeling of happiness on the five-point scale). The paper provides not only theoretical framework, but also empirical data on several predictors and outcomes of HWI. In addition to employees, as standardly understood subjects of HWI, the article also points to self-employed persons and their heavy workload.

In paid work, level of positive emotional experience of workaholics is lower than level of positive emotions of non-workaholics. The standard length of working time is linked with the same job enjoyment of both workaholics and non-workaholics. A negative change of affective well-being in the form of growing tension, discomfort or stress occurs when workaholics work beyond this time limit.

In case of the relationship between workaholism and gender, the research confirmed a more heterogeneous portfolio of emotional commitment for women-workaholics. It is related to the ability to diversify the experience of positive emotions in different phases of the working day in favour to an increased feeling of happiness in performing activities outside working hours (unpaid work and leisure). However, men-workaholics enjoy time spent with children more than women-workaholics.

An examination of the relationship between HTI and the level of education revealed the so-called forced workaholism. This finding can be a stimulus for professional discussion on this issue in the future in the form of a comparison of international research in this area. It would be interesting to find an answer to the question of whether we can generalize this phenomenon or if it is a typical accompanying feature of less developed economies, or former post-socialist countries.

Research was based on a static data collected in a specific period. It is necessary to continue with the research, compare data in time. Because of general lack of empirical data, it was not possible to compare the situation in Slovakia with other countries. The research was not conducted specially for the purpose of collecting all possible data on HWI. That is why we were able to analyse only limited features of HWI in Slovakia. The main characteristic we analyse is the time, it means only one component of HWI (heavy time investment). In the research, we did not focus on the effort in work. To get a general overview about the HWI in Slovakia, it would be necessary to also include analysis of the effort and perception of subjective feeling of workaholism.

In the research, we focused on the standard population in Slovakia. We assume that our results, although generalized for the entire Slovakia, relate to the average employed persons, and do not take into account the specific corporate culture in multinational companies (where it is possible to assume an overtime culture, it means workaholism forced by working environment).

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Time-Varying Elasticities of Import Demand: the Cases of Czech Republic and Hungary

Mile Bošnjak[1] | *University of Zagreb, Zagreb, Croatia*
Vlatka Bilas[2] | *University of Zagreb, Zagreb, Croatia*
Ivan Novak[3] | *University of Zagreb, Zagreb, Croatia*

Abstract

This paper aims to examine price and income elasticity of import demand in Czech Republic and Hungary while allowing parameters of import demand to vary over time. Research sample consists of quarterly time series data the first quarter of 1996 to the third quarter of 2018. The results were obtained following state space model with time-varying parameters approach. The results revealed import demand elastic to changes in income in both countries while the elasticity was found to be higher in Hungary comparing to Czech Republic. Elasticity of import demand to changes relative prices were found in Hungary while in case of Czech Republic the price elasticity estimates indicated convergence of prices. Based on the empirical results from this research, the paper brings country-specific policy implications.

Keywords	***JEL code***
Import demand, income, relative prices, Kalman filter	*C13, C51, F17, F2*

INTRODUCTION

Understanding elasticity of substitution between domestic and foreign goods is one of the most important issues for any economy. Underlying literature assumes imperfect substitutes between domestic and foreign goods and empirical findings mostly imply higher income elasticity comparing to price elasticity of import demand. Following Crucini and Davis (2016) due to capital reallocation, the demand would be shifted towards lower prices only in a long run. Crucini and Davis (2016) pointed out that domestic and foreign goods are poor substitutes in a short run, while in the long run the substitutability increases. Hungary and Czech Republic are selected due to dynamic path from centrally planned economies to European Union (EU) member countries. Following Gagyi (2016), Hungary restructured its economy from import substitution to export-led specialization in Hungarian economy through reforms directed

[1] Assistant professor of International economics and senior research associate, University of Zagreb, Faculty of Economics and Business, Zagreb, Croatia. E-mail: mile.bosnjak76@gmail.com.
[2] Professor of International economics, University of Zagreb, Faculty of economics and business, Zagreb, Croatia. E-mail: vbilas@efzg.hr.
[3] Assistant professor of International economics and senior research associate, University of Zagreb, Faculty of economics and business, Zagreb, Croatia. E-mail: inovak@efzg.hr.

to attract foreign direct investment. Konopczak (2013) examined Balassa-Samuelson effect in the Czech Republic, Slovakia, Poland and Hungary and pointed out that the catching-up driven inflationary pressure is a non-negligible issue in the context of the CEE countries. Therefore, the goal of the paper is to estimate long-term import demand elasticity for these two countries. The aim of the paper is to illustrate role of prices in import demand and its potential variation over the last two decades while taking into account effect out of joining EU. Consequently, the research hypothesis of the paper assumes convergence of prices in Hungary and Czech Republic towards prices in members of European Monetary Union (EMU).

The rests of this paper is organized as follows: Section 1 briefly summarizes theoretical foundation and existing literature related to the topic under consideration. Section 2 presents the research data and methodology, while Section 3 provides research results and discussion and final section provides an overview of the main findings of the research.

1 THEORETICAL FOUNDATION AND BRIEF LITERATURE OVERVIEW

Following baseline theory of imperfect substitutes, function of a country's import demand is illustrated in Formula (1):

$$M = f(Y_d,\ P_d, P_M). \tag{1}$$

Import demand of country (M) is expected to be elastic domestic income (Y_d), domestic prices of imperfect substitutes at home market (P_d) and price of imported goods (P_M). The elasticity of import demand to increase in domestic income and domestic prices of imperfect substitutes are expected to be positive while the effect of increase in price of imported goods is expected to be negative. Grounded on theory of imperfect substitutes and a form of baseline model in Formula (1), on-going empirical literature brings various evidences from all over the globe. As introductory stated, the literature was directed towards long-term or towards short-term elasticity of substitution. This paper directs its attention towards long-term effects to capture long-run effects of prices and contributes with robust and accurate estimates regarding convergence of prices in two considered cases towards the prices in EMU countries.

Bayat et al. (2015) examined causality and dynamics between crude oil prices and exchange rates in Czech Republic, Poland and Hungary, the results indicated that oil price fluctuations affected real exchange rates in the long run in Poland and Czech Republic while oil price fluctuations did not affect exchange rate in any period in Hungary. Martinez-Zarzoso and Ramos (2008) pointed out that with the higher integration of economies, the volume of trade between them was increasing and role of exchange rates as one of the determinants was decreasing. Stanislava et al. (2017) used time series data from 1994 to 2014 and found the price of substitutes and past consumption as significant determinants of beer consumption while income elasticity was insignificant. Gürtler (2019) examined J-curve pattern in the Czech economy using quarterly data for the period 2000–2014. The results point out that the real effective exchange rate has a strongly negative effect on trade balance in the short run while in the long run the effects were positive and in line with the J-curve. Mirdala et al. (2018) followed panel data approach on a sample of 21 EU member countries and quarterly time series over the period 1999Q1–2016Q4 to examine determinants of imports and exports demand. The results pointed out a dominant role of domestic demand in determining import dynamics. Leško and Muchová (2019) followed convergence quadrants diagram and analysed different phases of non-price convergence within Central and Eastern Europe (CEE). The results indicated that most of the countries from CEE region grew at a higher rate than the one consistent with the BOP equilibrium. Furthermore, the research results pointed out that the convergence of the countries in CEE region was unsustainable considering the lower ratio of income elasticities and increasing external debt. Bilas et al. (2018) found similar development pattern in net exports of Czech Republic, Slovakia, Slovenia, Hungary. Halpern et al. (2015) pointed out that importing all input varieties in Hungary would increase a firm's revenue productivity by 22% and main reason was imperfect substitution between foreign and domestic inputs. Imbs and Mejean (2017) followed multi-sector model developed from Arkolakis et al. (2012) and estimated aggregate elasticity of trade for 28 countries. The lowest values of trade elasticity were found for small open specialized economies and the difference in trade elasticity was explained with specialization of consumption, specialization of production or with international differences in sector-level trade elasticity. Erdey and Pöstényi (2017) between examined International trade of Hungary over the period 1993–2014 and found that International trade of Hungary was in line with Linder hypothesis. International trade of Hungary was more prominent with countries having similar factor endowments differentiated products are used as key drivers of international trade in Hungary. Recent paper from Leibovici et al. (2019) points out that trade is time-intensive and variation in the rate of import substitution across time affects how trade volumes respond to changes in output and prices. Hałka and Leszczyńska-Paczesna (2019) analysed price convergence in in European Union countries over the period 1999–2016 and reported lower dispersion of prices in 2016 comparing to 1999. Furthermore, the research revealed catching-up of countries with price level below the average that is more prominent up until 2008. As illustrated earlier within this section, contemporary literature struggle to explain convergence of prices within EU and recent paper from Çulha et al. (2019) and Leibovici et al. (2019) indicated time-varying nature of import demand substitution. Therefore, the baseline model in Formula (1) and state space model with time-varying parameters make an appropriate analytical framework to examine elasticity of import substitution and price convergence. Mirdala (2016) pointed out increased responsiveness of real exchange rates in EMU non-member states to demand and supply shocks due to the effects of the crisis period. Furthermore, real exchange rates in EMU member states from EU-11 group became more responsive to nominal shocks. This paper contributes to the debate while bringing time-varying estimates of import substitution for Hungary and Czech Republic.

2 RESEARCH DATA AND METHODOLOGY

The research data sample consists of quarterly time series data over the period 1996Q1–2018Q3. The data on imports and gross domestic product at constant prices were retrieved from National Bureaus of statistics of Hungary and Czech Republic, respectively. The data on real effective exchange rate against 19 European Monetary Union (EMU) countries were retrieved from Eurostat database – all of the variables under consideration were X-13 ARIMA seasonally adjusted and are transformed to (natural) logarithm so as to the estimated coefficients can be interpreted as elasticities. The observed series are illustrated in the Appendix in Figure A1 and Figure A2 while descriptive statistics of the series are provided in Table A1 and Table A2. As already stated, the methodological approach in this paper employs a state space model with time-varying parameters instead of the commonly used time series approaches. Modelling the import demand elasticity within TVP framework allows us the insights into evolution of the relationship with the time. Bošnjak (2019) used state space model with time-varying parameters to examine current account determinants in cases of Serbia and Romania. Recent paper from Çulha et al. (2019) employed state space model with time varying parameters to examine the case of import demand in Turkey. Following Harvey (1991), a general form of the state space model is presented in Formula (2) and transition Formula (3):

$$Y_t = X_t' \beta_t + \varepsilon t, \qquad \varepsilon_t \sim IIDN(0, \sigma^2), \tag{2}$$

$$\beta_t = \theta + \Gamma\beta_{t-1} + \nu_t, \qquad \nu_t \sim IIDN(0, Q), E(\varepsilon_t \nu_t) = 0, \tag{3}$$

where:

Y_t – 1 × 1 vector presenting observed dependent variable,

X_t – k × 1 vector presenting observed explanatory variables,
β_t – k × 1 vector presenting unobserved variables,
Γ – k × k matrix of constant parameters,
ε_t – error term in observation Formula (2),
ν_t – error term in transition Formula (2) and
Q – the diagonal variance-covariance matrix.

Kalman (1960) provided the algorithm to obtain filtered and smoothed estimates of unobserved time-varying coefficients (β_t) recursively. The prediction equation is given in the Formula (4) and the covariance matrix is given in Formula (5):

$$\hat{\beta}_{t|t-1} = \Gamma \hat{\beta}_{t-1}, \tag{4}$$

$$P_{t|t-1} = \Gamma P_{t-1} \Gamma' + Q_t . \tag{5}$$

Eventually, the estimates were updated recursively following Formulas (6) and (7):

$$\hat{\beta}_t = \beta_{t|t-1} + P_{t|t-1} X(Y_t - X^{'\hat{\beta}_{t|t-1}})(XP_{t|t-1} X + H_t), \tag{6}$$

$$P_t = P_{t|t-1} - P_{t|t-1} X' XP'_{t|t-1} / X'P_{t|t-1} X + H_t . \tag{7}$$

A time-varying parameters (TVP) model within state-space model consists of an observation or measurement equation and a transition or state equation. Thus, the import demand equation in cases of Hungary and of Czech Republic can be specified in logarithmic form given by Formulas (7) to (11):

$$\ln(M_t) = \alpha_t + \beta_{1,t} \ln(Y_t) + \beta_{2,t} \ln(\mathrm{REER}_t) + \beta_{3,t}\, \mathrm{EU} + \varepsilon_t, \quad \varepsilon_t \sim IIDN(0, \sigma^2), \tag{8}$$

$$\alpha_t = \alpha_{t-1} + \nu_{0,t}, \quad \nu_{0,t} \sim IIDN(0, \sigma_{\nu 0}^2), \tag{9}$$

$$\beta_{1,t} = \beta_{1,t-1} + \nu_{1,t}, \quad \nu_{1,t} \sim IIDN(0,\sigma_{\nu 1}^2), \tag{10}$$

$$\beta_{2,t} = \beta_{2,t-1} + \nu_{2,t}, \quad \nu_{2,t} \sim IIDN(0,\sigma_{\nu 2}^2), \tag{11}$$

$$\beta_{3,t} = \beta_{3,t-1} + \nu_{3,t}, \quad \nu_{3,t} \sim IIDN(0,\sigma_{\nu 3}^2), \tag{12}$$

where the observation equation is given by Formula (7) and state equations by Formulas (8), (9), (10) and (11). State equations illustrate that the new state value is modelled as a linear combination of the former state value and an error process. The observation equation presents the relationship between observed variables and unobserved transition or state variables. Dependent variable $\ln(M_t)$ is observed and presents imports (M_t) in (natural) logarithmic form, while explanatory variables are GDP (Y_t) in (natural) logarithmic form, real effective exchange rate (REER_t) in (natural) logarithmic form and dummy variable (EU) that indicate EU membership. The explanatory variables establish the relationship between the observable dependent variable and the unobservable time-varying coefficients. The terms α_t, $\beta_{1,t}$, $\beta_{2,t}$ and $\beta_{3,t}$ are unobserved time-varying coefficients to be estimated. ε_t and $\nu_{0,t}$ represent the error term in the measurement and state equations, respectively. The model in Formulas (7), (8), (9), (10) and (11) presents state space form with initial conditions. The estimates of the state-space were obtained using the Kalman filter while the estimates of the parameters in the equations were obtained by maximizing the Likelihood-function. Kalman filter is a recursive procedure that needs to set plausible initial values.

To do so, the parameters of the model was first estimated by means of OLS and these parameters and fitted values of the state variables obtained from the OLS estimation was specified as initial values. Eventually, the paper follows methodology presented in this section and brings the results for Hungary and Czech Republic. These two countries are EU member countries. TVP approach allows the insight into time variation. Therefore, it is expected to illustrate potential convergence of prices within EU and effects of EU membership.

3 RESEARCH RESULTS AND DISCUSSIONS

Following presented methodology and research data, the results for case of Hungary are summarized in Table 1.

Table 1 Time varying determinants of import demand: the case of Hungary

	Final state	Root MSE	z-statistic	p-value
α (Constant)	–6.902	1.522	–4.534	<0.010
ln(*Y*) (Income)	1.347	0.100	13.452	<0.010
ln(*REER*) (Real effective exchange rate)	0.240	0.101	2.369	<0.010
EU (EU membership – dummy variable)	0.063	0.028	2.213	0.013
Log likelihood: –224.793		AIC: –449.568		
Diagnostic tests:				
Ljung- Box Test statistic: 23.049		p-value: 0.027		
Jarque Bera Test statistic: 0.683		p-value: 0.710		
ARCH Test statistic: 21.285		p-value: 0.046		

Source: Own estimates

The results in Table 1 point significant and relatively income elasticity of import demand or marginal propensity to importing Hungary. Furthermore, income elasticity of demand in Hungary have not varied of time as illustrated in Figure A4 in the Appendix. Depreciation of real effective exchange rate were found to positively affect imports in Hungary. The reasonable explanation can be that real depreciation of real effective exchange rate in Hungary did not redirected demand in Hungary towards home products. Furthermore, an increase in prices of imported goods increase in volume of import demand while the quantities of imports holding constant. The time variation of the effects are illustrated in Figure A5. Eventually, the effects of joining European Union on imports in Hungary were positive. Therefore, after joining EU imports in Hungary has increased significantly and time variation of the effect is illustrated in Figure A6. The estimates for the case of Czech Republic is summarized in Table 2.

Following the estimates in Table 2, imports in Czech Republic has been elastic to changes in income and time invariant as illustrated in Figure 8. However, the import elasticity of demand is lower in Czech Republic comparing to Hungary. The effects of prices in Czech Republic was insignificant at the final state. Figure A9 illustrates that there was negative elasticity in the past that has approached to zero over time. Therefore, In case of Czech Republic, the depreciation in real exchange rate was negatively correlated with imports demand and by the time, the effect out of real exchange rate has vanished. Eventually,

Table 2 Time varying determinants of import demand: the case of Czech Republic

	Final state	Root MSE	z-statistic	p-value
α (Constant)	0.297	2.212	0.134	0.446
ln(Y) (Income)	0.963	0.172	5.597	<0.010
ln($REER$) (Real effective exchange rate)	–0.066	0.142	–0.463	0.321
EU (EU membership – dummy variable)	0.210	0.030	6.940	<0.010
Log likelihood: –242.221		AIC: –466.443		
Diagnostic tests:				
Ljung- Box Test statistic: 23.265		p-value: 0.025		
Jarque Bera Test statistic: 0.000		p-value: 0.999		
ARCH Test statistic: 12.926		p-value: 0.374		

Source: Own estimates

due to price convergence the effect of exchange rate at the end of the observed period was not distinguishable from zero. With joining EU imports in Czech Republic has increased significantly and more than in case of Hungary. Time varying effects of joining EU is illustrated in Figure A10.

Conclusively, the obtained estimates illustrate long-run elasticity of import demand in two considered cases. There was higher income elasticity of import demand in case of Hungary comparing to Czech Republic. Following Kolozsi et al. (2018) there was highly expansionary fiscal policy in Hungary what might explain high import elasticity of demand at least partially. Furthermore, there was a higher long run increase of import in Czech Republic comparing to Hungary as a results of EU membership. However, the effects from real effective exchanger rate on imports were different in these two cases. Exchange rate of national currency against euro has been a nominal anchor of monetary policy in both of the considered countries. At the beginning of transition process, Hungary had adopted crawling peg regime and Czech Republic had adopted a pegged regime with horizontal bands. In case of Hungary, we found positive and significant long-term effects from real exchange rate depreciation to increase in imports. This finding is not in line with theoretical assumptions since the depreciation of real exchange rate should redirect import demand towards domestic substitutes. Therefore, the domestic goods in Hungary might not be substitutes for the imported goods. Furthermore, Hungarian industry is import dependent industry. In case of Czech Republic, the results indicate long-term convergence of prices. At the beginning of the observation period, there was a negative effect from real exchange rate depreciation to imports in Czech Republic. By the time, the long run effect has disappeared and eventually at final state, the effect from real effective exchange rate on imports in Czech Republic was not distinguishable from zero. Hence, there was convergence of prices in Czech Republic towards EMU member countries. Lízal and Schwarz (2017) presented the evidence of the functioning of foreign exchange interventions and the exchange rate pass-through to consumer prices in Czech Republic. Nucu and Anton (2018) pointed out monetary policy in the EMU have prominent effects on monetary conditions in CEE countries.

CONCLUDING REMARKS

There are several conclusions that can be drawn out of the research presented in this paper. Firstly, Robust and accurate estimates from state space model with time varying parameters contributes to the existing body of literature and policy makers in Hungary and Czech Republic while considering the effects of joining EMU. Secondly, long-term import demand in case of Hungary was elastic to change in income and prices while joining the EU increased the level of imports. The elasticity from real effective exchange rate to imports in Case of Hungary was positive. The positive price elasticity indicates that domestic goods were poor substitute of imported goods in Hungary. In case of Czech Republic, there was income elasticity of import demand as well but lower comparing to Hungary. The positive effect from joining EU on import in Czech Republic was more prominent comparing to Hungary. Furthermore, price elasticity of demand in Czech Republic was theoretically consistent. At the beginning of the observation period, there was negative elasticity from real effective exchange rate to imports. Hence, the foreign goods were substituted with domestic good with lower prices. By the time the effects from real effective exchange rate to import has vanished and eventually cannot be distinguished from zero. The results indicate long-term convergence of prices in Czech Republic towards the prices in EMU countries. Eventually, the main research hypothesis that assumes convergence of prices towards EMU countries is supported in case of Czech Republic while not in case of Hungary. Despite many similarities between two considered countries, there were evident differences in import demand and elasticity of substitution between domestic and foreign goods. Further research need to be directed towards structure of imports and its consumption.

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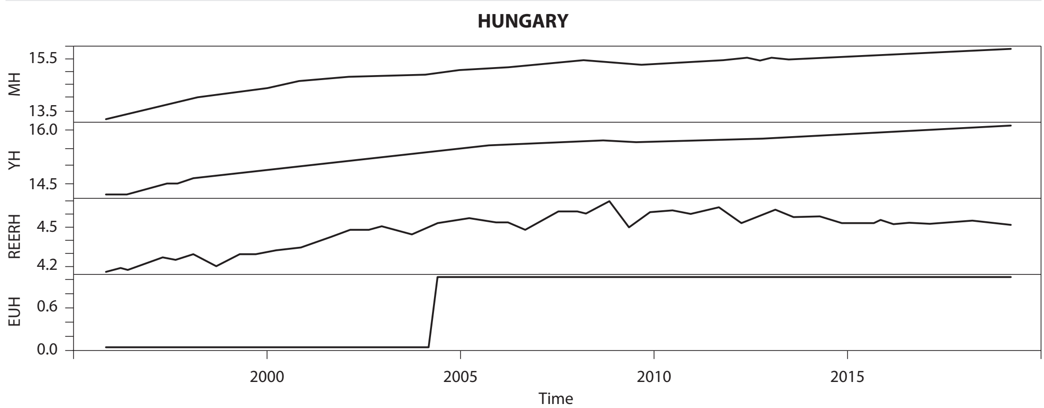
APPENDIX

Table A1 Descriptive statistics of the variables: the case of Hungary

	MH	YH	REERH
Min.	13.18	14.15	4.154
1^{st} Q	14.74	15.09	4.422
Median	15.33	15.62	4.520
Mean	15.08	15.43	4.476
3^{rd} Q	15.55	15.77	4.570
Max.	15.94	16.14	4.690

Source: Own estimates

Figure A1 Development of the observed series: the case of Hungary



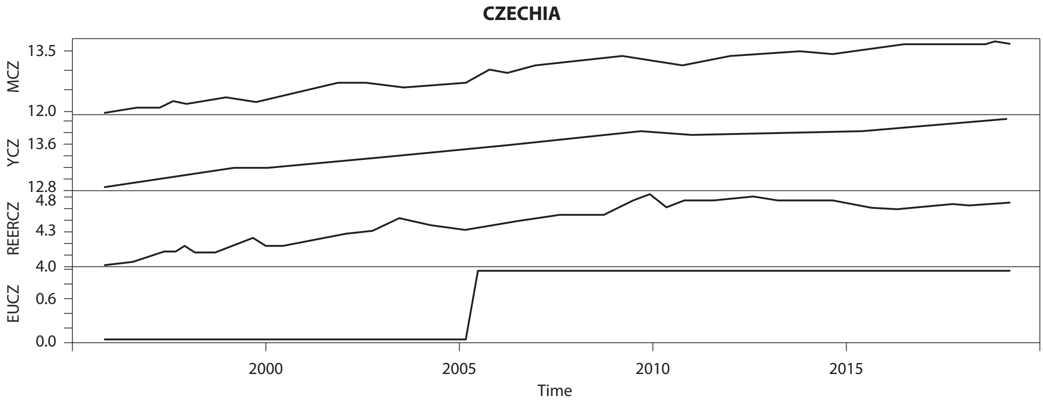
Source: Own estimates

Table A2 Descriptive statistics of the variables: the case of Czech Republic

	MCZ	YCZ	REERCZ
Min.	11.98	12.84	4.024
1st Q	12.63	13.32	4.270
Median	13.17	13.67	4.463
Mean	13.01	13.58	4.413
3rd Q	13.45	13.83	4.566
Max.	13.74	14.06	4.647

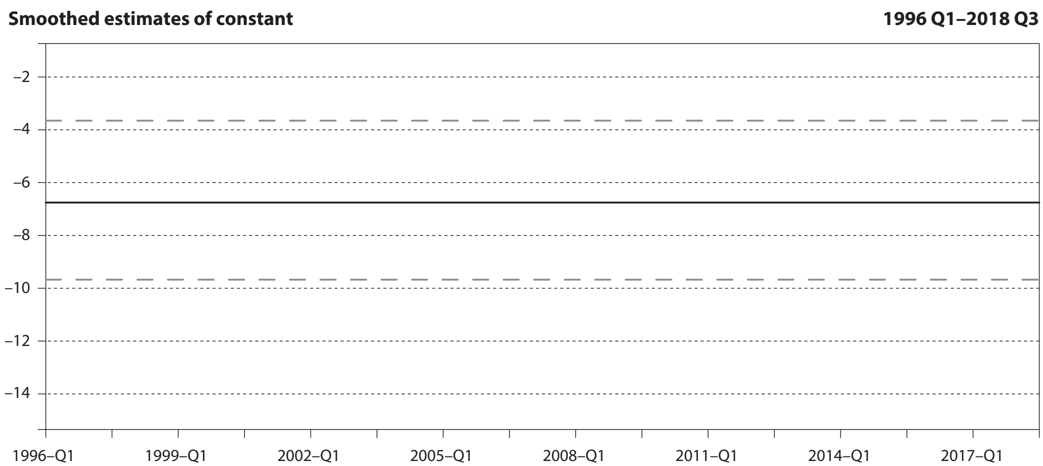
Source: Own estimates

Figure A2 Development of the observed series: the case of Czech Republic



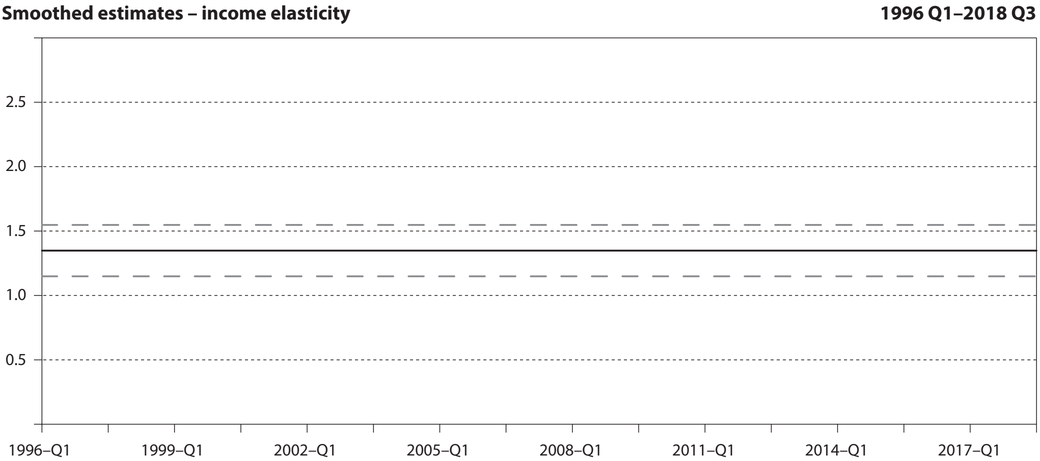
Source: Own estimates

Figure A3 TV estimates of constant term: the case of Hungary



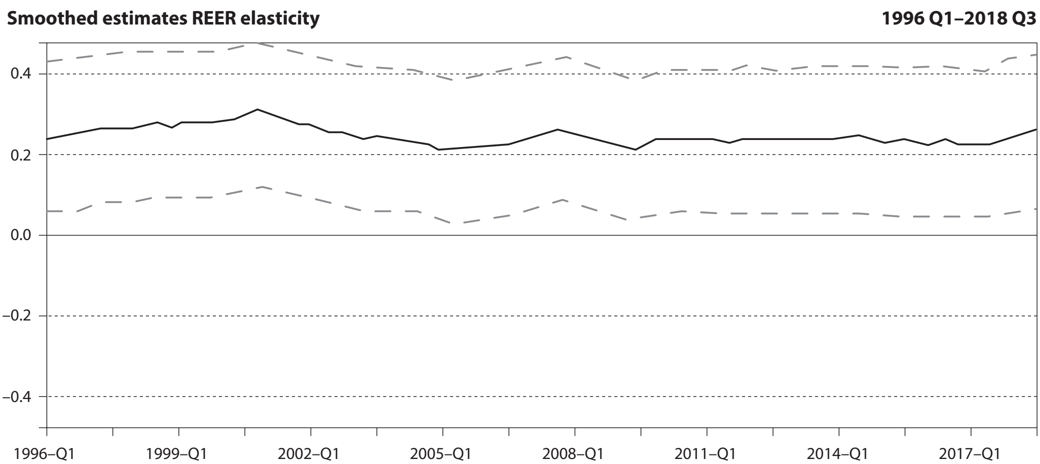
Source: Own estimates

Figure A4 TV estimates of income elasticity: the case of Hungary



Source: Own estimates

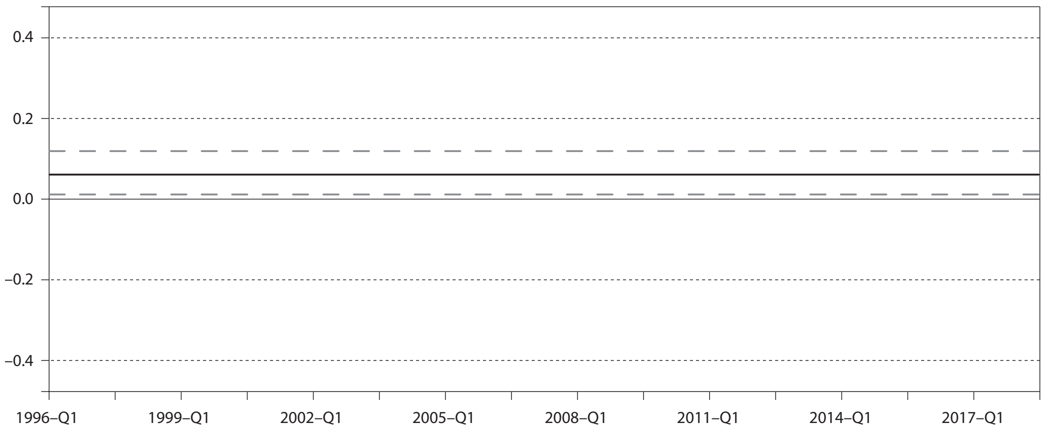
Figure A5 TV estimates of price elasticity: the case of Hungary



Source: Own estimates

Figure A6 TV estimates of EU membership effects: the case of Hungary

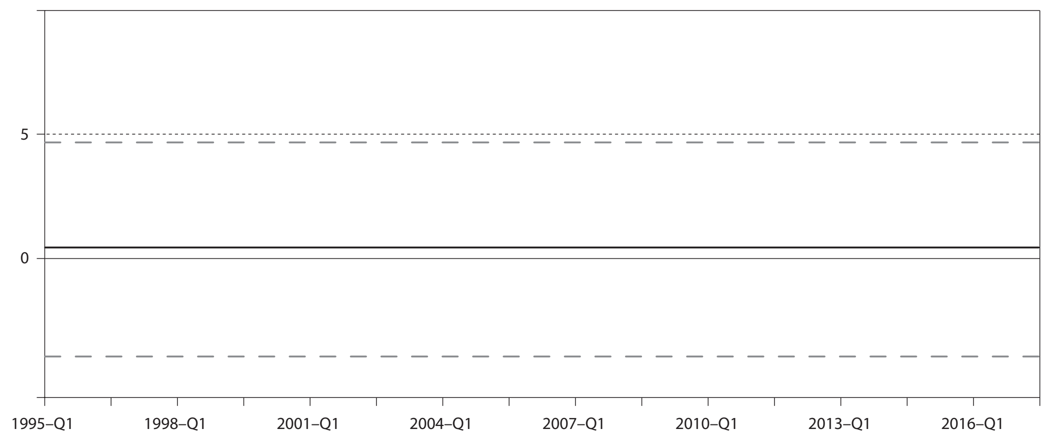
Smoothed estimates EU membership **1996 Q1–2018 Q3**



Source: Own estimates

Figure A7 TV estimates of constant term: the case of Czech Republic

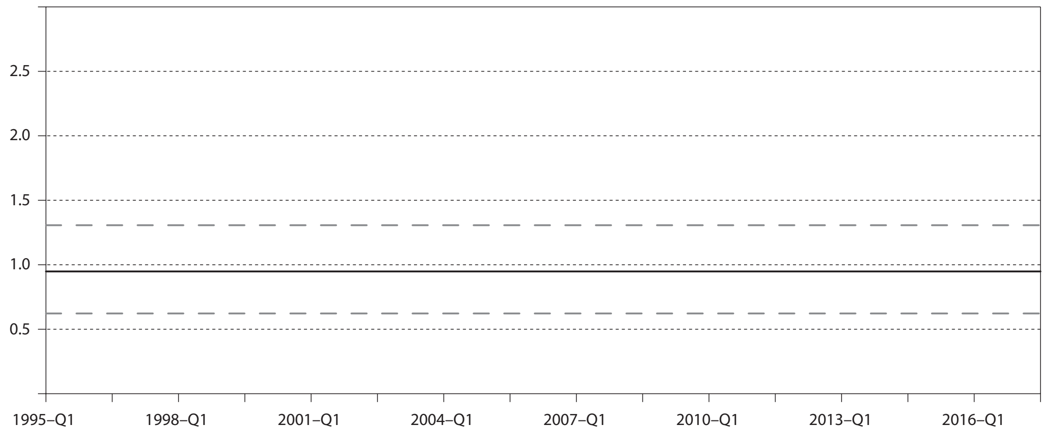
Smoothed estimates of constant **1995 Q1–2018 Q3**



Source: Own estimates

Figure A8 TV estimates of income elasticity: the case of Czech Republic

Smoothed estimates – income elasticity **1995 Q1–2018 Q3**



Source: Own estimates

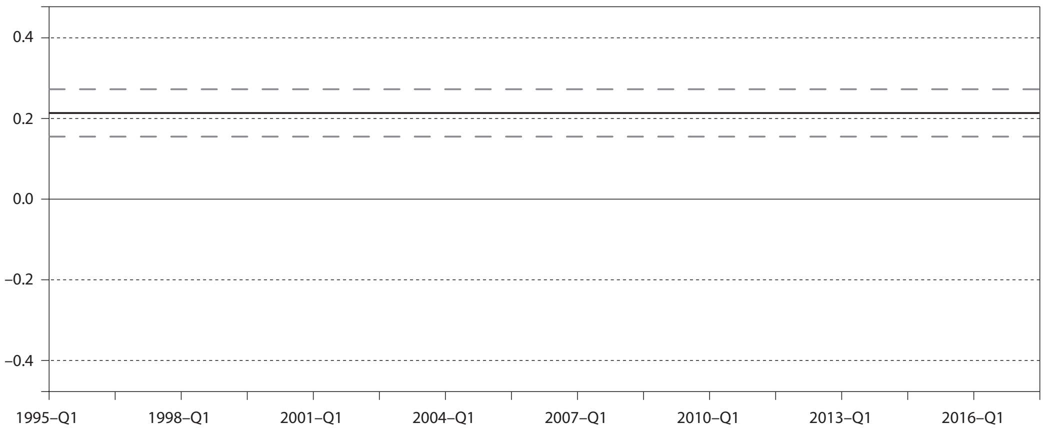
Figure A9 TV estimates of price: the case of Czech Republic

Smoothed estimates REER elasticity **1995 Q1–2018 Q3**

Source: Own estimates

Figure A10 TV estimates of EU membership effects: the case of Czech Republic

Smoothed estimates EU membership **1995 Q1–2018 Q3**



Source: Own estimates

Skill and Wage-Earning Potential: Evidence from Indian Labour Market

Sonu Madan[1] | *Indira Gandhi University, Meerpur, Rewari, India*
Surender Mor | *B. P. S. Women University, Khanpur Kalan, Sonipat, India*

Abstract

The focus of paper is on explaining variations in wage earning potential of regular wage earners caused by varying skill levels. Further, the paper attempts to analyse the conditional causal effect for a broad range of occupational groups to infuse external validity during estimation process which helps to explore how universal is the causal effect. The study brought out the fact that skill level of workers affects the wage-earning potential of workers significantly. However, different skill requirements to perform a range of tasks & operations, along with associated complexity, moderates the strength of causal linear relationship and the resultant slope indicating relationship between skill level of workers and their wage-earning potential varies significantly across occupational groups. Thus, conceptualization of task-content based approach of occupations determines wage-earning potential of workers and hereby is a promising boulevard for future research. The study recommends in job training courses along with introduction of intra-occupational diversified range of tasks & operations to secure incremental wage.

Keywords	***JEL code***
Skill, regular wage earners, wage-earning potential, occupational groups, conditional effect	*J01, J21, J31*

INTRODUCTION

Globalization has contributed towards integration of labor markets and has enhanced the mobility of labour leading to reduced wage-gap, among workers in both developed and developing countries due to technological development and transmission. Developing countries has experienced increased efficiency owing to more openness, especially in trade. Increasing economic activities across the globe has given rise to the relative demand for unskilled workers resulted in narrowing the gap in wages between unskilled and skilled workers (Wood, 1995).The reduction in wage inequality due to increasing liberalization and globalization in developing countries rests on the fact that the supply of unskilled labor, relative to the skilled labor, is larger in developing in compared to developed countries (Wood, 1994). Simultaneous, technological advancements have raised the demand for skilled workers to meet specific industrial requirements giving way to wage inequality substantially (Vashisht and Dubey, 2018). The wage differentials of skilled and non-skilled workershave enhanced intra-country higher wage differentials

[1] Assistant Professor, Department of Economics, Indira Gandhi University, Meerpur, Rewari, Haryana, 123035, India. Corresponding author: e-mail: sonumadan15@gmail.com, phone: (+91)8685911117.

besides exhibiting a strong tendency for alternative work for higher wages besides willingness to travel more miles to find alternative employment with higher wages (Mor and Mor, 2011).

Wage earning potential depends on skill of a person, which indicates the ability of a person to perform his/her duties, is associated with a given job. Skill is a measure of workers' expertise, specialization, and supervisory capacity and skilled workers are considered more trained than unskilled workers and are paid higher for more responsible position at workplace. Wage earned by workers has its demand side linkages with the economy and hereby serve as control phenomenon for the economy in broader sense (Madan, 2019a). An occupation is a set of tasks & duties performed in a job, which are characterized by high degree of similar work types. A set of tasks to be performed requires specific type of skill for operational efficiency (Annex 1). Tasks performed by workers at their work place can be divided into two categories i.e. routine tasks, which can be easily performed using machines & can be codified, and non-routine tasks, which cannot be mechanized easily and require cognitive skills or non-routine manual tasks (Vashisht and Dubey, 2018).

Digitization of technology and de-routinised the nature of work in various occupations has substantially affected the wage-earning potential of workers. The occupational diversity has contributed a lot in this phenomenon of wage differential because different occupations require different set of skills (Annex 1), depending upon the range& complexity of tasks to be performed. Occupations are central to the economic diversification and are accounted for the growth of long run wage inequality (Madan, 2019b). Task dimension of occupations is one of the key reasons for variance in occupational mean wage because of differentiated risk & skill requirements in accordance with occupational structure (Liu and Grusky, 2013; Williams and Bol, 2018). Skill requirements, job content, occupational descriptions, among others, are considerations for wage differential among workers (Madan and Goyal, 2019).

The Indian labour market, with 500 million adults, is the second largest economy in terms of labour force, where around 90 percent of workforce is employed in the informal economy (Mor et al., 2020). Recently, Government of India (2020) has tasked numerous steps for employment generation coupled with improving employability such as Prime Minister's Employment Generation Programme (PMEGP), Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS), Pt. Deen Dayal Upadhyaya Grameen Kaushalya Yojana (DDU-GKY) and Deendayal Antodaya Yojana-National Urban Livelihoods Mission (DAY-NULM) etc. Moreover, owing to various initiative to formalize the economy like introduction of GST, digitization of payments, direct benefit transfer of subsidies/scholarships/wages & salaries to bank accounts, opening of Jan-Dhan accounts, extending social security coverage to more workers. The measures also have increased the demand for skilled labourers to be placed at different positions in accordance with their capabilities leading to wage differentials. Moreover, formal employment in the economy increased from 8 per cent in 2011–12 to 9.98 per cent in 2017–18 and number of workers who receive predetermined wages/salary on regular basis increased from 88 million in 2011–12 to 115 million in 2017–18 (Government of India, 2020).

Surely, a significant part of variation in wage differential is explained by the differences in educational attainments, occupational differences and work experience gained with age, among others. The interaction between technology and tasks, at various levels of educational attainments of workers, to be performed has categorized the employment structure as low and high wage occupational structure. This paper is an attempt to overcome the challenges that have emerged from changing demand of work force leading to diversified wage-earning potential of workers. Considering the polarization of work opportunities in the light of skill oriented de-routinization, years spent to acquire formal education may be considered as a proxy for skill level of workers, which in turn may be an enabling factor to make a choice of occupation as different occupations require different skill levels. In this backdrop, education can be considered not only a factor responsible for wage differentials as there is remarkable difference in the wage earning of workers with same educational attainments.

1 LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

1.1 Skill and wages

The human capital revolution and increased availability of information on earnings and individual skills have shifted the weight of education, age, and experience towards differences in earnings. The difference in wages is determined by competitive factors like costs of training, probability of success, steadiness of work, workplace amenities, differences in individual inborn abilities, institutional factors such as regulation of wages, restricted labor mobility, and barriers to entry. Human capital in terms of schooling and training explains the differences in the structure of wage earnings across the globe resembling higher earnings for more educated/skilled workers (Willis, 1986; Becker, 1993). Labor market integration, coupled with migration in response to wage differentials, changes the wage structures and per capita GDP provide stimulus to skilled formation in both host and home countries (Behrens and Sato, 2006). Skill dynamics may result in a sub-optimal situation of an under-education trap due to a lack of human capital at stationary state. The public sector can play an important role in the skills development process by incentivizing parents and employers in early level of schooling (Cunningham and Villasenor, 2016). Contrary to this, Mason (2008) pointed in his study that enhancing workforce skills may not enhance the relative productivity of a worker. Expansions of educational institutions have accelerated the growth in the supply of qualified workers to outstrip the growth in demand resulting in a substantial decline in the wage premium to white collar jobs. These educational attainments need to fulfill the requirement of employer to be utilised effectively within firms and other organisations. Employers value all skill sets including socio-emotional skills, cognitive skills and technical skills and are valued differently in the labor market across region, industry, occupation, and education level.

Horvath (2014) highlighted that skill-biased technological change lead to increasing inequality in wages and employment opportunities between high school and college graduates. The output per capita as well as wage equality can be enhanced effectively by a minimum wage or a redistribution policy. Wage policies of organisations and individual skill differences are the key noted pattern of inter-industry wage differentials. Linkages between technological development and access to education lead towards an increase in the demand for more educated labour which is responsible for different wage structures. The increased participation between secondary and tertiary sector, routed through secondary & technically education, is crucial for improved skilled development (Onsomu et al., 2010). Further, skills equipment reduces the fear of failing (Mor, Madan, Chhikara, 2020). There may be a positive relationship between skill level and wage earnings. Higher the skill, a worker/employee possess, more the chances of fetching higher wages/salaries. Hence, testing of the following hypothesis is of immense importance:

H_{01}: Skill, education and experience do not affect the wage earnings.

1.2 Wage income and occupational structure

The wage rates/salaries differ in accordance with different structure of occupation's as some highly technical or risky occupation may offer higher wages/salaries as compared less risky and non-technical types of jobs/activities. Autor and Dron (2013) in their pioneering work have attributed towards exploring changes in the task content of works associated with different occupation structure in the light of changes in technology. The study reported a negative association between the use of information and communications technologies (ICT) and task contents which are routine manual & routine cognitive, while it was positively associated with non-routine cognitive task contents in USA during 1960 and 1980. These results are in line with for selected OECD countries (Michaels, Natraj, Van Reenen, 2014; De La Rica and Gortaazar, 2016). De-routinisation of jobs, has also been confirmed by Salvatori (2015) while examining the employment structure in the United Kingdom between 1979 and 2012 due to a sharp decline in supply of non-graduate workers rather than technology. These results coincide with the research findings of Hardy, Keister, Lewandowski (2015, 2016) for central and East European countries. However, structural changes have been found an important reason for divergence of work opportunities in US started in the early 1950s (Barany and Siegel, 2018).

Wage inequality began to rise in the early 1980s, just a few years after the invention of microcomputers and this burst of new technology caused a rise in the demand for highly skilled workers, which in turn led to a rise in earnings inequality (Card and Dinaro, 2002). The relative demand for highly skilled workers increased in the 1980s, causing earnings inequality to increase (Johnson, 1997). The demand for skilled labour increases as the pool of skills increased in OECD countries but innovation has been found threatening the interests of workers with demand for high skills. In view of this, the following hypothesis will be tested:

H_{02}: Wage earnings are independent of occupation structure.

1.3 Occupation and skills

Different occupations require different kind of skills to perform the tasks of different level of activities. Skills play an important role in labour market disparities because labor mobility reduces differences in regional unemployment rates while migration of high-skilled labourers tends to reinforce disparities in labour market (Granato et al., 2014). Skill requirements vary across occupations and certain job-specific tools (skills), specifically required for an occupation, and are associated with higher pay whereas non-specific tools correlate to lower-paying sales, service, and administrative occupations (Cunningham and Mohr, 2019). Moreover, occupations that require high skills need costly investment in human capital (Conley, Onder, Torgler, 2012). The quality of employment and the technological knowledge base have different impact on the location of knowledge-intensive and on low-cost labour-intensive manufacturing sectors (Amoroso et al., 2015). The access and use of ICT has not been equal for the different groups of our societies, and Europe witnessed an emergence of social cleavages due to skills and occupational differences. Skilled immigrants and natives are imperfect substitutes in some occupations but are complements in others which resemble that even large inflows of foreign skilled workers have limited impacts on domestic workers (Ma, 2020). There exist wage differentials in public and private sectors occupations where public sector premiums at the bottom of the wage distribution reflecting that low skill workers are overpaid (Siminski, 2012) and degrees holder workers possess more substantial advantages than certificates in the labor market (Bailey and Belfield, 2019). Hence, the under-mentioned hypothesis intends to be tested.

H_{03}: Occupation and skills are independent of each other.

2 METHODOLOGY

2.1 Database and sampling

Periodic Labour Force Survey (PLFS) provides statistics on labour force specific indicators in cross classification of education, industry, occupation, wages and various demographic characteristics such as age, marital status, region based on the data collected during July 2017 to June 2018. PLFS covered 102 113 households and have enumerated 433 339 persons in numbers. A sample of 42 417 regular wage earners engaged in various occupational groups to perform economic activities are considered purposefully to analyze thewage-earning potential of workers at various skill levelsmoderated for classified occupational groups. For the purpose, regular wage earners from nine broad group of occupations, corresponding to their skill level, as per International Standard Classification of Occupations-08, (ILO, 2012) are selected. The details on occupational groups along with number of workers selected thereof is given in the Annex 2.

2.2 Specification of variables, moderator, and covariate

Wage earning is a randomized continuous variable. To meet the assumption of normality in the distribution of residuals, natural log (Ln) of wage is considered. Years of formal education has been considered as a proxy to capture skill level of workers and hereby is a continuous variable. Occupational category of workers influences, significantly, the nature of relationship between skill level of workers and their wage-earning potential. Hereby, seven dummies (number of occupational groupsless one) are used to compute the individual interaction lines (Annex 2). The age of employees, a continuous variable, has been used as a covariate to neutralize the effect of experience gained with age on the stated relationship. The interaction effect of skill and occupation on wage reveals that age has been an important factor to affect the relationship. Research on labour forces in Israel confirm that unemployment rate of young people can be attributed more towards characteristics of the labour market, whereas for elder employment aspirants it is more a function of their age (Axelrad, Malul, Luski, 2018). Though, gender of workforce is also an important factor of concern, but the present study is confined in exploration of varying earning potential of all workers in different occupation and hereby occupational diversity has been considered as moderator instead of gender.

2.3 Model specification and estimation techniques

2.3.1 Main effect and interaction effects

A linear causal relationship between *skill level of workers (X) and their wage earning (Y)* is presumed to measure the main/direct effect of variations in *X* on *Y*. The main effect is measured by regression coefficient *bi* (Formula (1)). However, the strength of this relationship alters with *occupations* wherein a worker is employed. Different occupations require different skill level depending upon the range of tasks & operations to be performed along with their complexity, and so we would say that *occupation (M)* moderates the causal linear relationship between *X* and *Y*. Though, regression coefficients measure the strength of relationship persisting between variables, but at the same time the relationship may not be same for all categories of moderated variable (Bauer and Curran, 2005; Preacher et al., 2006; Hayes and Matthes, 2009). A moderator can reverse or intensify a relationship (Judd and Kenny, 2010). The slope of relationship between response variable and predictor varies across groups represented by categorical moderator variable. A moderation analysis infuses external validity during estimation process which helps to explore how universal is the causal effect. It's is customary to indicate the effect of moderator by the *interaction* of *X* and *M (XM)* while explaining *Y*. Interaction term is to estimate the expected difference in the effect of an additional year of formal education for workers engaged in different occupational structure (Figure 1). However, experience gained with age *(A)* is in question to affect the stated relationship and hereby need to be controlled to neutralize its effect while measuring the impact of *X* on *Y*. At this backdrop, the following multiple regression equation is estimated:

$$Ln\ (Y_i) = \alpha + b_1 X_i + \sum_{j=2}^{k} bjMi + \sum_{\lambda=k+1}^{2k-1} b\lambda XiMi + C_1 A_i + e_{Yi}. \tag{1}$$

Re-arranging terms in Formula (1), such that:

$$Ln\ (Y_i) = (\alpha + \sum_{j=2}^{k} bjMi) + (b_1 + \sum_{\lambda=k+1}^{2k-1} b\lambda Mi)Xi + C_1 A_i + e_{Yi}, \tag{2}$$

here:

Ln (Yi) is the natural logarithm of monthly wage/salary of i^{th} regular worker employed in any broad occupational group,

X_i (I = 0,1, ……N) is years of formal education to acquire skill level required for any occupation;

M_i (I = 0, 1) is the dummy assigned to i^{th} worker belong to a specified occupational group (1) or not (0)

to indicate its effect over reference category occupation,
b_j is the vector of coefficients associated with occupational categories dummies (b_j = 2… k). Herein,
b_λ is the vector of coefficients associated with interaction of years of education & occupational (b_λ = k + 1… 2k – 1). The corresponding values obtained from $b_1 + \sum_{\lambda=k+1}^{2k-1} b\lambda Mi$ is the conditional effect of X (workers' skill) on Y (wage earning potential), given specified M (specified occupational group) and may be referred to as simple slope; and
C_1 (C_1 = 1,…N) is the covariate for age measured in years to adjust moderated causal relationship between X & Y for age.

The sign and magnitude of regression coefficients will be estimated by econometric methods. As all the variables are non-arbitrary, the *b's* are fixed unstandardized model parameters to be estimated. The coefficients b_1 measures the direct effect of X on Y (b_1 = 0,…N) in the absence of any moderator (M_i) (Figure 1).

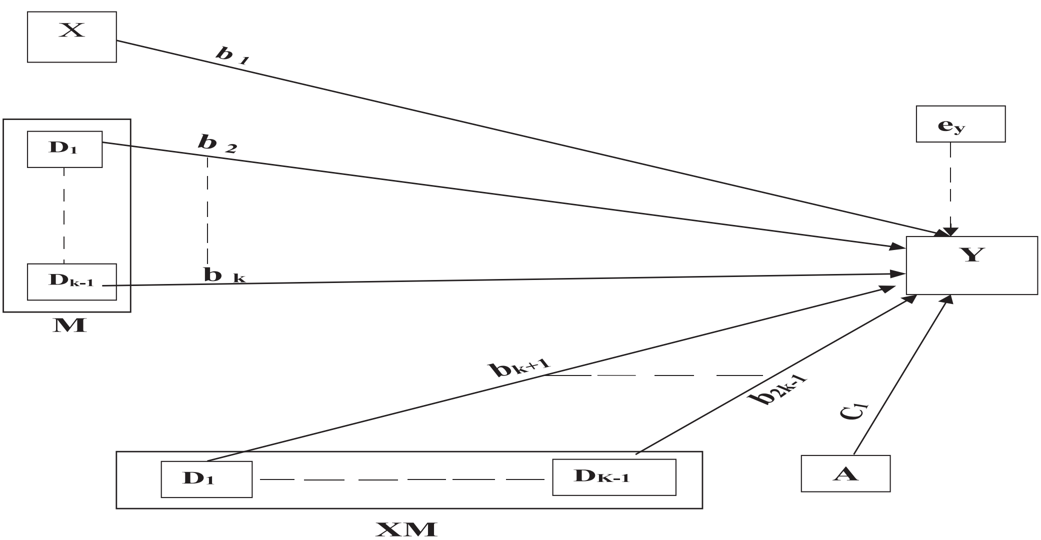
In this study, a log-linear regression model with dummy variables is applied. In the case of dummy variables, the following formula is used to estimate variation in monthly wages:

$$[100(e^b - 1)]. \tag{3}$$

In this model, b_λ is the primary parameter of interest, if non-zero, implies that the linear relationship between workers' skill and wage varies linearly with occupation structure wherein the worker is employed (Aiken and West, 1991; Cohen et al., 2003; Dawson, 2014; Hayes, 2013; Bodner, 2016). The model attempts to capture *conditional effect of X on Y* in the under mentioned form:

$$Ln\ (Y_i) = \alpha + b_{k+1}\, D_1 + \ldots + b_{2k-1}\, D_{k-1}\,. \tag{4}$$

Figure 1 Model estimation



Source: Graphical presentation of model estimation technique explained in Section 2.3.1

2.3.2 Interaction lines, significance of slope, effect size and power analysis

To capture the causal relationship between the dependent and independent variables for each category of moderator controlled for covariate, separate regressions equations are estimated to provide interaction effect in accordance. Significance of slope of each interaction line is measured at 5 percent levels of significance. Effect size of moderators' effects is measured using f square (f2) to estimate the magnitude of the combined impact of independent variable on the dependent variable. By convention, effect sizes of 0.02, 0.15, and 0.35 are considered small, medium, and large, respectively following Aguinis et al. (2005).

2.3.3 Compilation of output

The output is compiled using Windows software programme namely "Interaction" version 1.7.2211, designed by Danial, S. Soper, especially to analyze and draw statistical interactions.[2] The elementary occupation (group 8) has been considered as reference category.

3 RESULTS

The study utilizes statistics on educational attainments, occupational structure, age, and wage level of 42 417 regular workers obtained from Periodic Labour Force Survey (PLFS) conducted during July 2017 to June 2018. Workers' working in other's farm or non-farm enterprises (both household and non-household) and receiving salary or wages on regular basis (and not based on daily or periodic renewal of work contract) in return are regular wage/salaried workers. This category not only includes persons getting time wage but also persons receiving piece wage or salary and paid apprentices, both full time and part-time. Table 1 shows that the mean monthly Ln wage of regular workers is Ln 9.383 (INR 11 884). The minimum and maximum Ln wage for all workers, irrespective of their occupational group, is witnessed to be Ln 4.605 i.e. INR 100 and Ln 13.459 i.e. INR 700 115. The mean education of regular workers is found to be 11 years of formal education with variation of illiterate, with no formal education, to 21 years of formal education. On an average, the age of workers is 37 years. The statutory working age of India is 15–64 years, but a meager proportion of workforce is found to be working in all ages. Though, the minimum and maximum age of workers is found to be 10 years and 78 years (Table 1), but only a meager percentage is found to be working in the age group below 15 years (0.08 percent) and above 65 years of age (0.51 percent) for their livelihood, so far as PLFS, 2017–18 is concerned. The persons working beyond statutory working age are mainly engaged in informal sector.

Table 1 Descriptive statistics of Indian labour market

Variables	Mean	SD	Minimum	Maximum	N
Ln (Wage)	9.383	0.816	4.605	13.459	42 417
Formal Education (in Years)	11.023	4.626	0.000	21.000	
Age	37.113	11.274	10.000	78.000	

Source: Author's calculations based on data extracted from PLFS, NSO (2019)

It is clear from Table 2 and 3 that the model is a good fit as it has been able to explain a major portion of variation in the wage level of regular workers as indicated from R^2 = 34.5 (Table 3), $F_{16,\,42\,400}$ = 1 394.92, p < .001 (Table 2). The predictive power of model is good enough as it can explain 35 percent variations in the wage level. The value of f square (f^2) effect size (0.526) indicates large effect size, revealing that the magnitude of the combined impact of the skill levelsof workers in various occupations. The value of Beta (type II error rate) is too small (0.0001) indicated negligible probability of committing type II error while making decision on rejection of null hypothesis. Similarly, the

[2] <*https://www.danielsoper.com/Interaction/free.aspx*>.

observed power of the model is greater than 0.80 indicating that the probability of rejecting null hypothesis when it false, is high enough for making a right decision in this regard. The predictive power of the model is estimated to be 34 percent.

Table 2 Model summary: fitting of regression model for Indian labour market

	Sum of square	D.O.F	Mean square	F	Sig
Regression	9 757.798	16	609.862	1 394.924	0.001
Residual	18 537.329	42 400	0.437		
Total	28 295.128	42 416			

Source: Author's calculations based on data extracted from PLFS, NSO (2019)

Table 3 Model summary and power analysis for Indian labour market

Effect size (f^2)	Noncentrality parameter (Lambda)	Critical F	Noncentral F	Beta (Type II error rate)	Observed power	R^2
0.526	22 327.733	4.732	140.736	0.000	1.000	0.345

Source: Author's calculations based on data extracted from PLFS, NSO (2019)

3.1 Main effect

So far as the effect of skill level of worker is concerned (X), workers with higher education can get higher wage. An additional year spent on education leads to raise 7 percent increase inwage as indicated from value of regression coefficient associated with X_1. It indicates that the prompt return for an additional year of education is 6.9 percent and the compounded return is 7.1 percent $[100(e^{0.069} - 1 = 0.071)]$, controlling the effect of age which is found to be a significant positive factor effecting mean wage level due to experience gained with age (Table4, Figure 2). In the light of significant value of parameter estimate, our 1st upheld hypothesis of no effect of skill level obtained from educational attainments on wage earning of workers has been rejected.

Table 4 Parameter estimates of main effect, moderation and interaction

Variables/Interactions	B	Std error	T	Sig
Constant	7.60*	0.02	368.638	0.001
X	0.069*[7.1]	0.001	34.685	0.001
D1	–0.206* [–18.62]	0.073	–2.837	0.004
D2	–0.276* [–24.11]	0.048	–5.729	0.001
D3	–0.184* [-16.81]	0.041	–4.484	0.001
D4	0.551*[73.50]	0.048	11.390	0.001
D5	0.006 [0.60]	0.025	0.230	0.817
D6	0.373* [45.20]	0.027	13.627	0.001
D7	0.510* [66.53]	0.029	17.437	0.001
ID1 (D1X)	0.060*	0.005	11.522	0.001
ID2 (D2X)	0.046*	0.003	12.957	0.001
ID3 (D3X)	0.030*	0.003	9.305	0.001

Table 4 (continuation)

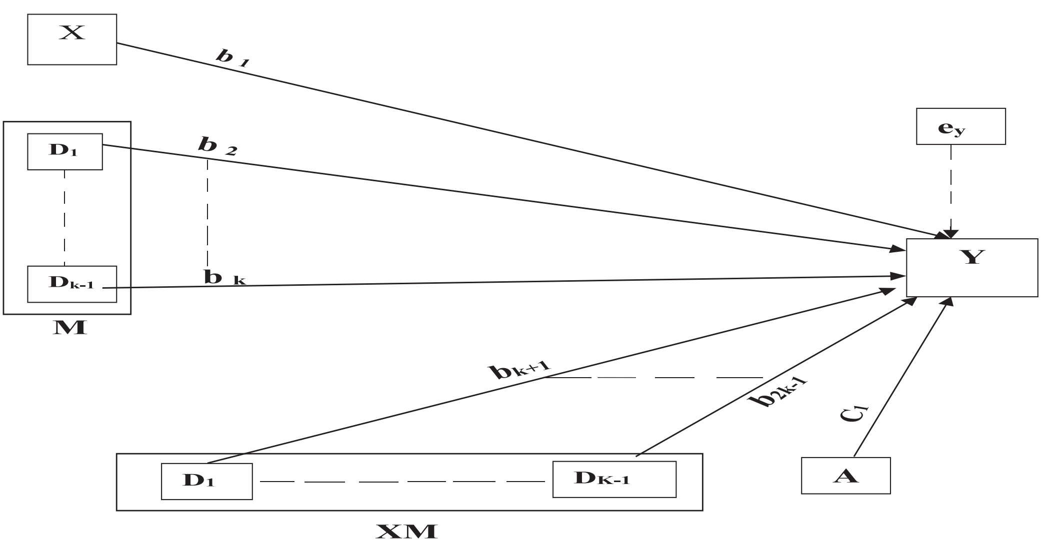
Variables/Interactions	B	Std error	T	Sig
ID4 (D4X)	–0.013*	0.004	–3.518	0.001
ID5 (D5X)	0.013*	0.003	5.0423	0.001
ID6 (D6X)	–0.017*	0.003	–5.913	0.001
ID7 (D7X)	–0.024*	0.003	–7.660	0.001
C1 (Age)	0.021*	0.001	71.183	0.001

Notes: (a) The model is estimated in log-linear form. (b) Response variable = Ln (monthly wage). (c) * indicates that the unstandardised coefficient is significant at 1% level of significance. (d) Value of [$100(e^b – 1)$] is given in square brackets [ ]. (e) D1: Dummy for managers; D2: Dummy for professionals; D3: Dummy for technicians and associate professionals; D4: Dummy for clerical support workers; D5: Dummy for service and sales workers; D6: Dummy for workers skilled in agricultural, forestry, fishery, craft and related trade activities; D7: Dummy for plant & machine operators and assemblers. (f) Reference group: elementary occupation.
Source: Author's calculations based on data extracted from PLFS, NSO (2019)

3.2 Wage earning and occupational structure

Different occupations correspond to different nature of work profiles. Task dimension of occupations is one of the key reasons for variance in occupational mean wage because of differentiated risk & skill requirements in accordance with occupational structure (Liu and Grusky, 2013; Bol and Weeden, 2015; Williams and Bol, 2018). Skill requirement, job content, occupational descriptions, among others, is considerations for wage differential among workers. Table 4 comes out with interesting revealing fact about the differential wage structure for different occupations. So far as mean wage level in different occupations is concerned, it is clear from the value of regression coefficients (Table 4, Figure 1) associated with different occupations that in case of managers (–18.62 percent), professionals (–24.11 percent), technicians and associate professionals (–16.81 percent) the base level mean wage is witnessed to be less than elementary occupations, whereas it begins somehow at high level for other professions. For clerical support workers, the base level mean wage is 73 percent higher than those

Figure 2 Estimation of regression coefficients



Source: Graphical presentation of Table 4 working in elementary occupations. Similarly, for workers skilled in agricultural, forestry, fishery, craft, and related trade activities and for plant & machine operators and assemblers, the base mean wage is higher by 45 percent and 66 percent than elementary occupations. These findings drive out an interesting fact that managers, professionals & technicians & associate professionals have only required qualification at entry levels which can be replaced easily by other aspirants for work as they lack specified operational skills. At the same time, workers skilled in agricultural, forestry, fishery, craft and related trade activities and for plant & machine operators, assemblers and clerical support workers possess technical expertise to accomplish specified tasks which compels recruiters to offer higher mean wages at the entry level. Hereby, it is evident that wage level of workers at entry levels varies with occupation structure, which provide reason to reject the 2nd maintained hypothesis of independence of wage earning and occupation structure.

3.3 Interaction effect

The presence of a significant interaction of years of formal education and occupation (XM) indicates that the effect of increase in additional one year of education on natural log of mean wage is different for different occupations. It is interesting to note that though the base level mean wage of managers, professionals & technicians & associate professionals is less than elementary workers but the interaction effect is strong enough to give raise to their wage-earning potentials with upgradation in their skill levels. Every one-year increase in formal education, leads to wage hike of managers, professionals & technicians & associate professionals by 6 percentage points, 4.6 percentage points & 3 percentage points respectively over & above to those in elementary occupations. This reveals out the fact that with increased years of education, the workers in these occupations acquire non manual cognitive skills with professional efficiency and cannot be replaced easily given the scarcity of workers with similar skill, efficiency level & managerial capabilities. Though, the base line mean wage in clerical support workers, ignoring the effect of workers' skill level, is witnessed to be 75 percentage points higher than elementary occupations, but skill enhancement provides less monetary benefits by 1.3 percentage points than elementary workers. Similarly, in comparison to elementary workers, workers in occupational group 6 & 7 also get less monetary rewards towards upgraded skill levels (Table 3). Workers belonging to these occupations mostly continue to perform similar type of tasks even after spending more years on skill upgradation making recruiters to provide less increment for additional skill upgradation. This indicates that monetary reward for work is not same for all workers even in same occupation. This correspond to the study of Ma (2019) in United States, which point out that the rewards for skilled labourers from science and engineering background are 2 percent higher as compared to other.

Table 5 brought up the base line mean wage and incremental effect of skill upgradation in different occupations. The base line mean wage is observed to be lowest for professionals (Ln 7.323, i.e. INR 1 515) preceding to managers (Ln 7.393, i.e. INR 1 625), elementary workers (Ln 7.600, i.e. INR 1 999), service and sales workers (Ln 7.606, i.e. INR 2 010), and workers skilled in agricultural, forestry, fishery, craft and related trade activities respectively (Ln 7.974, i.e. INR 2 905). It is found to be highest for clerical support workers (Ln 8.152, i.e. INR 3 470) followed by plant & machine operators and assemblers (Ln 8.110, i.e. INR 3 228). The less base wage for managers and professionals at entry levels indicates that in the initial years of their work, they possess only required qualification and lack cognitive & specialized operational skills in the relevant areas. Moreover, their work profile in the early years can be replaced easily by other aspirants for work.

So far as the incremental effect of skill upgradation on wage earning potential of workers corresponding to different occupations is concerned, it is observed to be highest for managers (12.9 percent) followed by professionals (11.5 percent), technicians and associate professionals (9.9 percent), service and sales workers (8.2 percent), elementary workers (6.8 percent), clerical support workers (5.5 percent), workers

Table 5 Conditional effect of formal education on Ln wage for each group of occupation

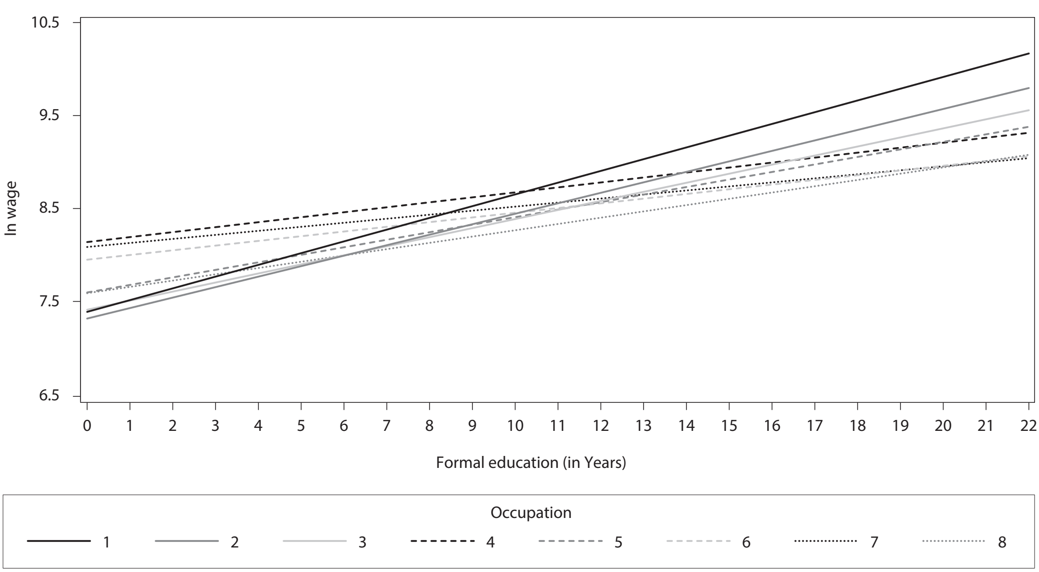
Occupation	Intercept	Coefficient	SE	T	P
1	7.393	0.129*	0.005	26.653	0.001
2	7.323	0.115*	0.003	38.781	0.001
3	7.416	0.099*	0.002	37.393	0.001
4	8.152	0.055*	0.003	16.038	0.001
5	7.606	0.082*	0.002	44.756	0.001
6	7.974	0.051*	0.002	22.597	0.001
7	8.110	0.044*	0.002	17.540	0.001
8	7.600	0.068*	0.002	34.685	0.001

Notes: (a) The model is estimated in log-linear form. (b) Response variable = Ln (monthly wage). (c) * indicates that the unstandardized coefficient is significant at 1% level of significance. (d) Occupational group-1 denotes managers; Occupational group-2 is for professionals; Occupational group-3 denotes technicians and associate professionals; Occupational group-4 denotes clerical support workers; Occupational group-5 denotes service and sales workers; Occupational group-6 is for workers skilled in agricultural, forestry, fishery, craft and related trade activities; Occupational group-7 denotes plant & machine operators and assemblers and Occupational group-8 refers to Elementary occupation.
Source: Author's calculations based on data extracted from PLFS, NSO (2019)

skilled in agricultural, forestry, fishery, craft and related trade activities (5.1 percent) and is minimum for machine operators and assemblers (4.4 percent) in response to increase in every one year of formal education.

This indicates that increase in wage not only requires work experience but also scope of expertise services within the job profile of a worker. The scope of operational activities performed by managers, professionals, technicians & associate professionals, service & sales workers become wider enabling them

Figure 3 Conditional interaction effect of education on Ln wage with covariate age



Note: Group-8 (elementary occupation) is reference category.
Source: Graphical presentation of Table 5

to perform complex nature of work with expertise. This enables them to earn more from their work/profession with time. Therefore, our 3rd hypothesis stating that occupation and skills are independent of each other has also been rejected.

4 DISCUSSION

Occupations are central to the economic diversification and are accounted for the growth of long-run wage inequality. The study highlights the impact of skill on wage, in different occupations and justifies the consideration of task dimension of occupations as one of the key reasons for variance in occupational mean wage. The study established that wage earnings depend on the skill of a person. It is interesting to note that the base level mean wage of managers, professionals and technicians & associate professionals is less than elementary workers. The observed reason for the same is the lack of specified operational skills for better outcomes in the absence of professional training. Similar inferences have been drawn by Cunningham and Mohr (2019) wherein the numbers of job-specific tools are found highly relevant to perform a range of tasks at different occupation levels. American Community Survey (2010) also observed that the ability to utilize tools is associated with higher wages. The verdicts further suggest that the base mean wage of clerical support workers, workers skilled in agricultural, forestry, fishery, craft and related trade activities, plant & machine operators and assemblers is much higher than elementary occupations as workers in these occupations possess the technical expertise to accomplish specified tasks which compels recruiters to offer higher mean wages at the entry-level.

The addition of the study in the existing research is the minuscule examination of interaction effect of occupational structure and skill up gradation of sampled occupations, which depicts that every one-year increase in formal education, leads to give more rise to workers associated with some specified occupations than in others. The scope of operational activities performed by managers, professionals, technicians & associate professionals, service & sales workers with increasing years of training become wider. At the same time possession of non-manual cognitive & analytical skills enable them to perform complex nature of work with expertise. This indicates that an increase in wage not only requires years of experience but also the scope of expert services within the job profile of a worker enabling them to earn more from their work/profession with time. These findings correspond to the study of Ma (2019) in the United States, which point out that the rewards for skilled labourers from science and engineering background are 2 percent higher as compared to other.

The study further reveals that the task contents of occupations requiring moderate skill- such as elementary workers, clerical support workers are structured, exact, and repetitive in nature to perform routine tasks. Workers employed in agricultural, forestry, fishery, craft and related trade activities, plant & machine operators and assemblers do not depend on computers and are mostly manual in nature and continue to work in the same line and thereby experience less increment in their mean wage structure in spite of high comparative wage-earning without any skill than workers in other occupations. This finding is consistent with the research study of Mason (2008) pointing on the fact that enhancing workforce skills may not enhance the relative productivity performance of a worker as the expansion of educational institutions have accelerated the growth in the supply of qualified workers to outstrip the growth in demand resulting in a substantial decline in the wage premium to white-collar jobs. The similar research undertaken by Shi et al. (2018), for analysis of recruitment process in the German-speaking part of Switzerland, brought out the fact that it is the skill acquired vide academic standard matters to provide employment at the entry-level, not the personal characteristics of employment aspirant.

The findings of the study seem relevant in a larger perspective when compared with research undertaken across the globe. For instance, the study pinpoints that though wage-earning potential of workers and skill acquired by education are associated but the resultant wage premium for every additional year of education is not the same across different occupation. Some occupations require complex operational

& cognitive skills and have diverse job profiles accordingly and have resulted in differentiated wage-earning potential. Similar researches in this line also have shown that wage premium of the tertiary education is found to be slightly lower across EU-15 countries (Obiols-Homs and Sánchez-Marcos, 2015), skill up-gradation of workers results in polarization of workers against mid-skilled jobs taken by graduates (Brekelmans and Petropoulos, 2020) and labour earning penalty is not same for all workers rather differ significantly with their occupation in Brazil (Reis, 2018). The study on skilled labour mobility on ASEAN member economies establishes the advantages of the mobility of skilled labour force in reducing the wage differentials (Corong and Aguiar, 2019).

CONCLUSION

The study measured the impact of workers' skill on their wage-earning potential in consideration of the occupational structure of the workplace, adjusted for age of workers and revealed out skill requirements in different occupations while considering age as a covariate so that the effect of age on the stated relationship can be neutralized. The verdict infers that every additional year of formal schooling is associated with an increase of 7 percent in wages on an average. These dividends of an additional year of education vary across occupations, i.e. managers (6 percent), professionals (4.6 percent), & technicians & associate professionals (4.3 percent), over & above to those in elementary occupations. Furthermore, that managerial, professionals, technical and associate professionals' occupation, without relevant education, lack specified operational skills and can be replaced easily by other aspirants for work resulted in low wage. So far as other occupations are concerned, though their mean wage at the beginning year of education, is found to be higher than workers elementary occupations, the wage increments with due course of time are less as the nature of work performed remains more or less the same.

The present research contributes to the existing body of knowledge by underlying the interaction effect of skill on wage-earning potential of workers in accordance with their job profile in various occupations. So far as other occupations are concerned, though their mean wage at the beginning year of education, is found to be higher than workers elementary occupations, the wage increments with due course of time is less as the nature of work performed remains more or less the same. In the course, the study reported the incremental effect of education (skill) on wage in different occupations besides reporting that the incremental effect of skill up-gradation on wage-earning potential of workers in stated occupations is observed to be highest as they develop complex operational & cognitive skills leading to change in their job profile. Incremental wage differential among occupational structure closely linked to a shift in employment from one occupation to another. Hereby, it is a need of time to mandate in job training courses to increase the labour productivity over time and reduce job polarization caused by intra-occupation migration of workforce.

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ANNEX 1

Table A1 Measurement of skill level in related occupations

Skill Level	Nature of work and skill required
I	The ability to perform simple and routine manual or physical tasks, require primary education for basic numeracy, or physical fitness as per the requirement of job.
II	The operational efficiency for operating, maintenance & repair of electrical and mechanical equipment and generally require completion of secondary education for competitive performance.
III	To perform complex technical & practical tasks with technical or procedural knowledge in specialized area.
IV	The creative ability to perform complex problem-solving & decision making and require extended level of literacy and numeric ability along with excellent communication skills. This level involves completion of secondary level of territory education leading to advanced research qualifications. This level of skill level involves on job extensive experience, which in some cases may be replaced for some years of formal education.

Source: ILO (2012)

ANNEX 2

Table A2 The occupational categorization of workers corresponds to their skill level

Group	Occupational group	Occupational functionaries of the group	Sampled observations[#]	Mean wage (Ln)
1	Managers	Chief executives, senior officials, legislators, administrative & commercial managers, production & specialized services managers, hospitality, retail and other services managers.	2 155 (5.08 percent)	10.087
2	Professionals	Science & engineering professionals, health professionals, Teaching professionals, business & administration professionals, Information & communications technology professionals, legal, social & cultural professionals.	5 631 (13.27 percent)	9.845
3	Technicians and associate professionals	Science & engineering associate professionals; health associate professionals; business and administration associate professionals; legal, social, cultural and related associate professionals; Information and communications technicians.	6 433 (15.17 percent)	9.571
4	Clerical support workers	Occupation as general & keyboard clerks; customer services clerks; numerical & material recording clerks and other clerical support workers.	4 081 (9.62 percent)	9.670
5	Service and sales workers	Personal service workers; sales workers; personal care workers and protective services workers.	8 045 (18.97 percent)	9.150
6	Skilled agricultural, forestry and fishery workers	Market-oriented skilled agricultural workers; market-oriented skilled forestry, fishery and hunting workers; subsistence farmers, fishers, hunters & gatherers.	5 371* (12.66 percent)	9.170
7	Craft and related trade workers	Building and related trades workers, excluding electricians; metal, machinery and related trades workers; handicraft & printing workers; electrical & electronic trades workers; electronics and telecommunications installers and repairers; food processing, wood working, garment and other craft and related trades workers.		
8	Plant & machine operators and assemblers	Stationary plant & machine operators; assemblers; drivers and mobile plant operators.	5 247 (12.37 percent)	9.258
9	Elementary occupations	Cleaners & helpers; agricultural, forestry and fishery labourer; labourer in mining, construction, manufacturing, and transport; food preparation assistants; preparation assistants; street and related sales and service workers; refuse workers and other elementary workers.	5 454 (12.86 percent)	8.870
10	Armed forces occupations	Commissioned armed forces officers; non-commissioned armed forces officers; armed forces occupations, other ranks.	0000 (NA)	NA
Total number of observations			42 417 (100 Percent)	9.383

Notes: # Sampled observations used in the study. * Total from Group 6 and Group 7 together. Figure in parenthesis.
Source: ILO (2012) International Standard Classification on Occupations-08

Application of Quantile Regression of Used Vehicle Purchasers in Turkey

Funda Bayrakdaroglu[1] | *Muğla Sıtkı Koçman University, Muğla, Turkey*
Hatice Hicret Ozkoc[2] | *Muğla Sıtkı Koçman University, Muğla, Turkey*

Abstract

The automotive sector is one of the leading industries in Turkey, and therefore worthy of examination, both in terms of its size and its economic impact. The Turkish automotive sector can be divided into the sale of new vehicles and their resale as used vehicles. It is notable that the used vehicle market in Turkey is economically more significant, hence the current study's focus is on Turkey's used vehicle market. According to the study's findings, which aims to analyze the used vehicle market in the context of consumer demographics through ordinary least squares and quantile regression method and data obtained from the Turkish Statistics Institution (TURKSTAT), meaningful segments related to demographic characteristics such as income and education level were reached.

Keywords

Used vehicle market, consumer demographics, linear regression, quantile regression, Turkey

JEL code

M30, C21

INTRODUCTION

Vehicles, which were initially only used to meet transportation needs, now go far beyond this basic function in meeting many of the emotional needs of today's consumers such as self-realization, social status gain, or living a "flashy" lifestyle whereby a vehicle is commonly seen as a status symbol. With the increased production of automobiles following the end of the Second World War through to the current era, having a vehicle has become amongst the most essential needs for many of today's consumers.

The used vehicle market has become one of the most important areas of modern consumerism, and represents an economic phenomenon that needs to be considered and analyzed economically, both in terms of Turkey's domestic market economy as well as internationally. The used vehicle market has become one of the leading commercial sectors, and, according to Asilkan and Irmak (2009), used vehicle sales in many countries now outnumber new vehicle sales. Although this rate varies from country to country, Duvan and Ozturkcan (2009) stated that the rate of used vehicle sales is now two or three times higher than for new vehicles. For example, in the United States, three out of four vehicle sales

[1] Muğla Sıtkı Koçman University, Faculty of Economics and Administrative Sciences, Kötekli Campus, 48000 Kötekli, Muğla, Turkey.
[2] Muğla Sıtkı Koçman University, Faculty of Economics and Administrative Sciences, Kötekli Campus, 48000 Kötekli, Muğla, Turkey. Corresponding author: e-mail: hatice.ozkoc@mu.edu.tr, phone: (+90)2522115103.

correspond to transactions involving used vehicles (Used Car Market Report, 2017). In addition to its economic potential, there exists a notable gap in the literature when it comes to studies based on the used vehicle market. In other words, whilst there is a significant level of research and statistics published in the literature on new vehicle sales, there is little information on the used vehicle market (Akci, 2016). In addition, Turkey gives the appearance of an unsaturated market when compared to many other countries in terms of car ownership, with 189 out of every 1 000 individuals in Turkey owning a car. However, this rate increases to 569 in Europe and 808 in the United States (Piskin, 2017). Moreover, the structure and maturity of the used vehicle market varies dramatically from country to country, and even for countries located geographically close to each other (CIRP II, 2007). The current Turkish used vehicle market is therefore significant both in terms of its academic standing and its economic potential for the country.

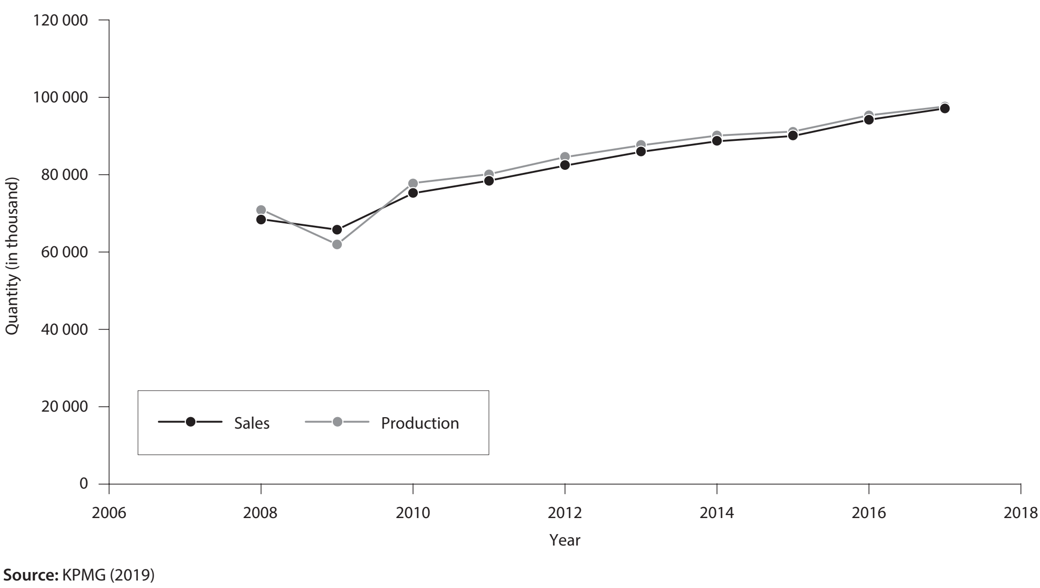
From this perspective, the current study aims to examine the demographic segmentation of used vehicle purchasers based on actual purchasing data for 2018 obtained from the Turkish Statistics Institution (TURKSTAT). As a result of this actual market data analysis, it will be possible to evaluate how consumers who bought used cars are grouped in the context of various demographic perspectives.

1 LITERATURE REVIEW

Inspired initially by the invention of the wheel, the practitioners first invented commercial transportation and farming vehicles for the purposes of trading. Later on, the automotive sector market started to transform personal travel with the aim to improve the comfort of human travel, resulting in a transformed automotive sector that today supplies one of the most widely used commodities and the most heavily invested sectors in human history (Yayar and Yilmaz, 2018). Production and vehicular sales worldwide have increased massively over the years, and run almost in parallel (Figure 1).

As seen in Figure 1, the number of sales and production in automotive industry in the world has increased year by year. However, both sales and production have decreased from 2008 to 2009. This may has been caused by 2008 global financial crisis.

Figure 1 Worldwide production and sales numbers (2008–2017)



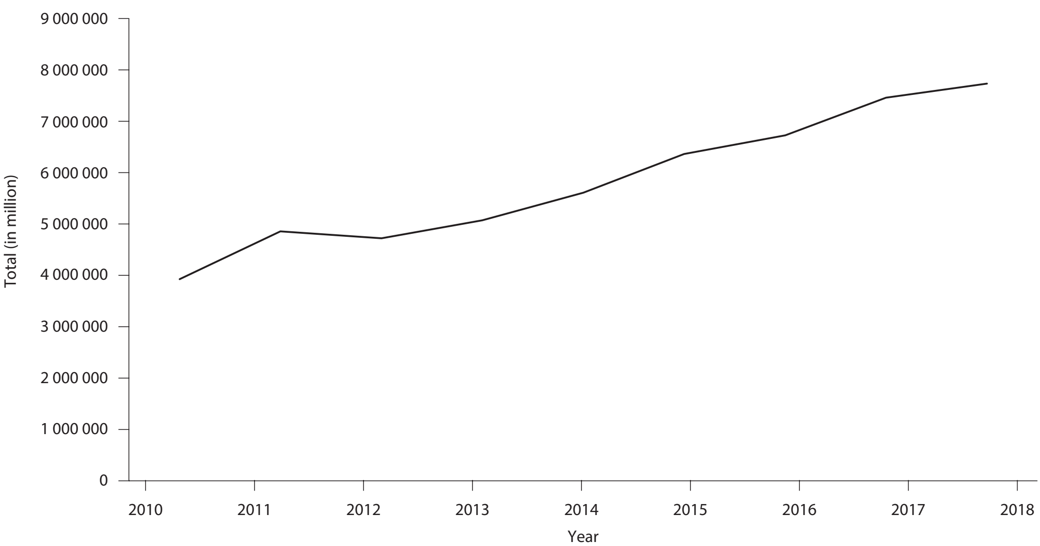
Source: KPMG (2019)

The automotive sector is often seen as an indicator of industrialization, with the sector closely related to other industries also increasing in importance (Karaatli et al., 2012). In addition to the contribution of vehicle taxation (from sales, annual road-use levies, and fuel taxes) and fuel expenditures to the national economy, vehicle owners can now independently travel with relative ease for the purposes of retail shopping, showing the potential increased economic impact of vehicle ownership compared to non-vehicle owners in both economic terms and as a social phenomenon (Balce, 2016).

The used vehicle market, which has become an important part of the automotive sector, includes private transactions (where both the buyers and sellers are individuals) and resale (where vehicles are remarketed by vehicle dealers for commercial gain) (Duvan and Ozturkcan, 2009). Dealers sell vehicles in two ways: as vehicles registered to them; or as an authorized seller on behalf of the vehicle's owner. As private sellers, individual vehicle owners have more alternatives available to them; from authorizing commercial vendors to present their vehicle at regularly held vehicle markets or auctions which are located in most cities on certain days of the week, promoted for private sale via the Internet (known as the "used vehicle e-market"), or by placing a sales advertisement on the vehicle itself (Balce, 2016).

The United States, United Kingdom, and also France present what are probably the best examples of used vehicle markets (Duvan and Ozturkcan, 2009). After an intensive period of growth of China's national economy and the corresponding increase in living standards, the sales of used vehicles in China increased 19-fold from just 2000 to 2012. In fact, China's used vehicle market is expected to exceed 10 million vehicles annually by 2020 (Xujiao et al., 2014). In Turkey, the number of used vehicles sold in 2015 exceeded 6.4 million, which equates to approximately five times the number of new vehicle registrations (Piskin, 2017). Figure 2 illustrates the number of used vehicle registration changes in Turkey between 2010 and 2018.

Figure 2 Used vehicle registration changes in Turkey (2010–2018)



Source: TURKSTAT, Road Motor Vehicle Statistics

The number of road motor vehicles – including car, minibus, bus, small truck, truck, motorcycle and special purpose vehicles – handed over has increased as shown in Figure 2. These increase shown in Figure 2 also is parallel with the increase illustrated in Figure 1. Akci (2016) proposed a number of reasons for the increases seen in used vehicle sales in Turkey:

- *Price:* used vehicles can be purchased at significantly lower cost when compared to equivalent new vehicles;
- *Initial purchase tax:* an initial purchase tax is levied for new vehicles, whereas this does not apply for the resale of used vehicles; therefore, some consumers opt for "almost new" used vehicles as a means to avoiding this tax charge;
- *Resale value:* new vehicles face a dramatic fall in resale value immediately after the initial purchase, whereas there is no major price gap between subsequent resales of used vehicles;
- *Taxation:* the amount of annual road tax levy decreases in Turkey as the vehicle ages, with older used vehicles taxed less annually compared to new or recently new vehicles;
- *Overall economic climate:* changes seen in the general welfare level of Turkish consumers such as due to changes in domestic interest rates, currency exchange rates, or other monetary fluctuations can lead to increased or decreased demand in the Turkish used vehicle market.

From the reasons stated, it can be seen why a clear increase has been identified in the importance of the Turkish used vehicles market. However, academic research on used vehicles in Turkey has mostly focused on the price variable (see Asilkan and Irmak, 2009; Balce, 2016; Yayar and Yilmaz, 2018). In addition, the Turkish used vehicle market has also seen research conducted using artificial neural networks (see Karaatli et al., 2012) as well as through factor analysis in the Turkish literature (see Ozcalici and Ayricay, 2018).

The demographic profile of the vehicle purchaser plays a key role in the decision-making process of buyers. A research study conducted by Deloitte (2016) showed that 67% of used car buyers were aged between 26 and 35 years old, that 66% had 2–4 members in their family, and approximately 88% of used car buyers had 4-year college degree or above. Aritan and Akyuz (2015) stated that demographic segmentation is commonly used in the automotive industry, and brand preference is mainly led according to buyer demographics.

2 METHODS

The current study used household data in order to examine the consumer segmentation of used vehicle purchasers in Turkey in the context of demographic variables. The study was based on a micro dataset related to Household Budget Research that was formed from a study undertaken by TURKSTAT in 2018. The 2018 research revealed that 1 058 household heads purchased second hand vehicles. TURKSTAT conducted their survey nationwide with a significantly large sample size. However, since there was no distinction as to new or used vehicles having been purchased in the survey, it was not possible for the data to directly identify used vehicle purchases, which represented the most significant limitation of the TURKSTAT study.

In the current study, two approaches were used to describe the purchaser relationships. First, the Ordinary Least Squares (OLS) model was employed as a criterion for the purposes of evaluation, and second, quantile regression was used in order to provide a finer level of fragmentation or data granularity based on relationships within various quantiles.

In a study by Mosteller and Tukey (1977), the researchers' stated the following explanation concerning the ordinary least squares method: "What the regression curve does is give a grand summary for the averages of the distributions corresponding to the set of x's. We could go further and compute several regression curves corresponding to the various percentage points of the distributions and thus get a more complete picture of the set. Ordinarily this is not done, and so regression often gives a rather incomplete picture. Just as the mean gives an incomplete picture of a single distribution, so the regression curve gives a correspondingly incomplete picture for a set of distributions" (p. 266). Therefore, quantile regression techniques may be considered more successful in revealing relationships when the varying percentage values of the dependent variable are considered.

For this reason, the quantile regression approach offers several advantages. First, standard regression estimators are quite sensitive, despite the assumption of normality. Another advantage is that whilst ordinary least squares focus on the mean, quantile regressions define the entire conditional distribution of the dependent variable. Finally, a quantile regression approach avoids the restrictive assumption that error terms are distributed equally to all points of the conditional distribution (Coad and Rao, 2008).

The quantile regression, as developed by Koenker and Bassett (1978), is presented as follows:

$$y = x'\beta_q + u_q \text{ with } Quant_q\,(y|x) = x'\beta_q,$$

where y is the dependent variable, β_q is an unknown parameter vector association with the q^{th} quantile, u_q is an unknown error term, $Quant_q\,(y|x)$ denotes the q^{th} conditional quantile of y given x. In order to obtain the estimators of β_q, based on a particular value for the q^{th} quantile, the following loss function (Koenker, 2005) is applied:

$$\hat{\beta}_q = \arg\, min_{\beta_q}\left(\sum_{y\geq x'\beta} q|y - x'\beta| + \sum_{y<x'\beta}(1-q)\,|y - x'\beta|\right).$$

3 RESULTS

In the current study, in order to understand the behavior of consumers in Turkey who purchased used vehicles, their level of expenditure on the vehicle was considered as the dependent variable. As independent variables, the total income of the household and household size were then taken into consideration.

At the same time, the age, marital status, education level, gender, and employment status of the head of the household, which was assumed to be the decision-maker, were added to the model as independent variables. In addition, both the expenditure and income variables were included in the model using logarithms.

The status of completed education was categorically evaluated by TURKSTAT to form six categories: "primary school," "middle school," "high school," "vocational school," "university," and "postgraduate." Descriptive statistics and frequencies related to each of the variables used in the current study are presented in Table 1 and Table 2.

Table 1 Descriptive statistics of variables

Variable	Mean	Std. dev.	Min	Max
Dependent variable				
Price (log)	7.802	0.756	4.982	10.161
Independent variables				
Age	44.848	12.086	22	93
Income (log)	10.950	0.558	7.539	13.840
Household size	3.804	1.610	1	15
***N* = 1 058**				

Source: Created by the authors

Table 2 Frequencies of dummy variables

Variable	*n*	%
Primary school	449	42.45
Middle school	189	17.86
High school	220	20.79
Vocational school	61	5.77
University	125	11.81
Postgraduate	14	1.32
Male	989	93.48
Married	978	92.44
Employment status	867	81.95

Source: Created by the authors

The results of linear regression models and various levels of quantile regression are presented in Table 3. Accordingly, Table 3 first presents computations for regression models, each with only one independent variable. When these models (OLS1-OLS7) were analyzed, it can be seen that age, income, household size, and education variables all had a statistically significant effect on the vehicle purchase expenditure (i.e., the price paid), as the dependent variable. In contrast, gender, marital status, and employment status had an insignificant effect on the dependent variable. In the OLS8 model, a linear regression model was created using all of the independent variables together. For the OLS8 model, gender, disposable annual income, household size, education level, and employment status had a combined significant effect on the dependent variable. Finally, the OLS9 model was obtained as a result of excluding the independent variables that were found to be insignificant from the OLS8 model. Therefore, OLS9 is the final linear regression model, and was obtained by removing statistically insignificant independent variables from the OLS8 model on a one by one basis. According to this model, while other variables remained constant, the price (log) decreases by 0.005 when the age increases by one unit, while the increase in household size by one unit decreases the dependent variable by 0.03. However, while other independents variables remained constant, an increase of 1% in income rises spending by 0.51%. As can be seen in the OLS9 model's results, while the other independent variables remained constant, employed consumers spent less on buying used vehicles than consumers who were not employed. At the same time, spending increased in accordance with increases in the consumers' level of completed education. According to the results of the OLS9 model, education level was found to be the variable having the largest numerical effect among the independent variables, followed by working status. When other independent variables are kept constant, compared to primary school graduates, the value of the dependent variable is 0.232 units higher for secondary school graduates, 0.331 units for high school graduates, 0.329 units for university graduates, and 0.390 units for graduate graduates.

Table 3 also presents the coefficient estimates for the nine most relevant quantiles (0.05, 0.20, 0.25, 0.40, 0.50, 0.60, 0.75, 0.80, 0.99). As can be seen in Table 3, the results indicate that income has a significant and positive impact on all quantiles. Besides, Table 3 shows that educational status as well as income also have a positive effect, and that the dependent variable tends to increase due to the increase in education level in general. Finally, there were insignificant effects seen for the independent variables of gender, marital status, and household size in used vehicle expenditures.

Table 3 OLS and quantile regressions

Price (log)	***OLS1***	***OLS2***	***OLS3***	***OLS4***	***OLS5***	***OLS6***	***OLS7***	***OLS8***	***OLS9***
Age	***–0.004***							***–0.004***	***–0.005***
Income (log)		***0.570***						***0.507***	***0.510***
Household size			***–0.032***					***–0.029***	***–0.030***
Middle school				0.089				0.082	
High school				***0.354***				***0.263***	***0.232***
Vocational school				***0.548***				***0.365***	***0.331***
University				***0.701***				***0.364***	***0.329***
Postgraduate				***0.887***				***0.419***	***0.390***
Male					–0.138			–0.084	
Married						–0.069		0.075	
Employment status							0.028	***–0.138***	***–0.145***
Constant	***8.002***	***1.560***	***7.922***	***7.586***	***7.931***	***7.865***	***7.779***	***2.515***	***2.546***
R^2	0.005	0.177	0.005	0.117	0.002	0.001	0.001	0.230	0.228

Breusch-Pagan/Cook-Weisberg test for heteroscedasticity

Chi2(7) = 17.51 [Prob > chi2 = 0.014]

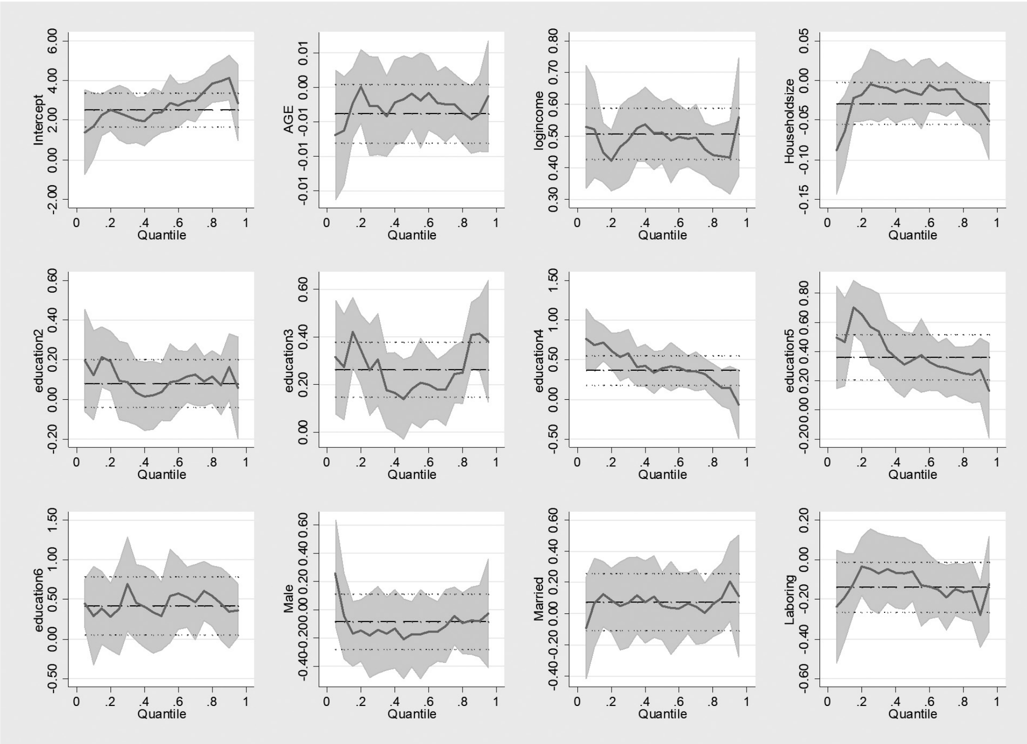
N = 1058 Jarque Bera = 9.445 [0.009]

Price (log)	**5%**	**20%**	**25%**	**40%**	**50%**	**60%**	**75%**	**80%**	**99%**
Age	–0.001	0.0001	–0.003	–0.002	–0.001	0.0004	–0.002	–0.004	0.0004
Income (log)	***0.510***	***0.423***	***0.466***	***0.537***	***0.511***	***0.531***	***0.457***	***0.440***	***0.531***
Household size	–0.015	–0.018	–0.005	–0.015	–0.015	–0.069	–0.011	–0.023	–0.069
Middle school	0.037	0.192	0.094	0.015	0.037	0.027	0.091	0.115	0.027
High school	***0.181***	***0.346***	***0.261***	***0.168***	***0.181***	0.260	***0.239***	***0.252***	0.260
Vocational school	***0.390***	***0.611***	***0.535***	***0.425***	***0.390***	–0.411	***0.321***	***0.234***	–0.411
University	***0.340***	***0.656***	***0.569***	***0.357***	***0.340***	–0.091	***0.269***	***0.252***	–0.091
Postgraduate	0.292	0.282	0.384	0.406	0.292	–0.123	***0.606***	***0.541***	–0.123
Male	–0.174	–0.145	–0.182	–0.133	–0.174	0.320	–0.042	–0.094	0.320
Married	0.050	0.085	0.048	0.075	0.050	–0.070	0.005	0.062	–0.070
Employment status	–0.060	–0.033	–0.048	–0.066	–0.060	0.043	***–0.149***	***–0.162***	0.043
Constant	***2.396***	***2.507***	***2.365***	***1.943***	***2.397***	3.368	***3.429***	***3.831***	3.368
Psd R^2	0.121	0.142	0.139	0.128	0.121	0.122	0.126	0.127	0.184

Note: Base category: primary degree, female, not married, unemployment. Emboldened and italicized numerals denote statistically significant to .05 level.
Source: Created by the authors

The Breusch Pagan/Cook-Weisberg heteroscedastic test was performed on the error terms of the OLS9 model. As can be seen in Table 3, the test statistic was 17.51 (0.014) with heteroscedasticity in the error terms of the model. The normal distribution of error terms was analyzed by way of the Jarque-Bera test and the null hypothesis was rejected (test result: 9.445 [0.009]). Therefore, using quantile regression estimators provides more meaningful results than OLS.

Figure 3 Effect of independent variables



Note: Dashed lines represent OLS estimates with 95% confidence level. Dotted lines represent 95% confidence intervals for quantile regression estimates. Solid lines represent quantile estimates with 95% confidence level. Shaded areas represent 95% confidence intervals for quantile regression estimates.
Source: Created by the authors on Stata Package Program

Figure 3 illustrates the effects of the independent variables on the dependent variable (vehicle price). In Figure 3, household size, education, gender, and quantile estimation results are shown to be outside the confidence intervals, hence using quantile estimates yields more meaningful results. It can therefore be observed that household size, age, and income level of the head of the household had significant but varying effects on the expenditure amount (vehicle price) in different tranches. On the other hand, it can be seen that the amount of expenditure was negatively affected at various levels of education (e.g., vocational school).

CONCLUSION AND DISCUSSION

The current study utilized raw data obtained from a national household budget survey that was conducted by TURKSTAT in 2018. In the study, used vehicle expenditure was employed as the dependent variable using logarithms. A series of 18 different models were calculated based on this single dependent variable. The first nine of the independent variables are least squares, whilst the other nine are quantile regressions according to different percentages. Demographic characteristics of the household head, as in total annual income and household size were used as explanatory variables in the models. In all of the models, a meaningful and positive effect of income on expenditure emerged in accordance with the economic expectation, whilst all coefficients of income met the expectations in economic terms. While it was observed that the educational status of the household head had a positive effect on the purchase of used vehicles, the expenditures of employed consumers were lower in the OLS8, OLS9, 0.75, and 0.80 quantile regression models compared to those who were unemployed. One of the surprising results of the current study was that gender and marital status were not found to be statistically significant across all of the models. When the models' results were analyzed, while age showed a significant and adverse effect in the OLS models, there was no statistically significant effect found to exist for this variable in the quantile regression models.

For developing economies like Turkey in particular, the significant role of the consumers' income and education level in the used vehicle market, as in other industries, is considered to be the most salient finding of the study. This finding correlates with the finding of Akci's (2016) study, in which the economic reasons were seen as leading factors in consumers' purchasing decisions related to used vehicles. Yayar and Yilmaz (2018) also found a relation between income level and the price of used vehicles in their study, which compared four cities within the TR83 region of Turkey (which encompasses Amasya, Çorum, Samsun, and Tokat).

The Internet has also emerged as a marketplace especially pertinent to the sale of used vehicles and for prospective buyers to gather product and market-related information (CIRP II, 2007). Online marketplaces and vehicle websites have played an effective role in matching the current market to the available consumers (Deloitte, 2016). Therefore, the used vehicle market must also be considered within the realm of general e-commerce.

In future studies, the researchers aim to discuss consumer insights and the confidence conditions of consumers within the used vehicle e-market within economies such as Turkey, where e-trade is still somewhat limited in comparison to more developed economies.

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Economical and Practical Aspects of the AOQL Single Sampling Plans

Jindřich Klufa[1] | *Prague University of Economics and Business, Prague, Czech Republic*

Abstract

Single sampling inspection plans when the remainder of rejected lots is inspected with given Average Outgoing Quality Limit (denoted AOQL) minimizing mean inspection cost per lot of process average quality are presented in this paper. These plans were introduced by Dodge and Romig for inspection by attributes (each inspected item is classified as either good or defective). The corresponding plans for inspection by variables were created by the author of this paper. The comparison of these two types single sampling inspection plans from the economic point of view and the comparison of their operating characteristics (producer's risk, consumer's risk) is performed in present paper. We shall also show how the decision problem (inspection by variables or inspection by attributes) can be solved in practice using software Mathematica.

Keywords

Acceptance sampling, cost of inspection, inspection by attributes, inspection by variables, operating characteristics

JEL code

C40, L15, C83

INTRODUCTION

The paper deals with some methods of acceptance sampling. Acceptance sampling is one of the techniques used in quality control, either in vendor-buyer relationships or for management of within-company processes. The aim is to meet desired levels of protection against risk while keeping an eye on economic characteristics of the process. Inference is made based on inspection of a sample of items taken from a lot. Depending on quality of the sample, the whole lot may be either accepted or rejected, or inspection of another sample may follow in case of double, multiple or sequential sampling plans.[2] Acceptance sampling plans, specified by sample size and critical value (or acceptance number), determine the rules for this decision process.

There are many ways of classifying acceptance sampling. One such classification is according to whether an item is inspected by attributes (see e.g. Hald, 1981), i.e. just classified as either good or defective (nonconforming) or by variables. Sampling plans for inspection by variables allow obtaining same level

[1] Department of Mathematics, Faculty of Informatics and Statistics, Prague University of Economics and Business, Prague, Nám. W. Churchilla 4, 130 67 Prague 3, Czech Republic. E-mail: klufa@vse.cz.

[2] For sequential sampling see e.g. KLŮFA, J. Užitečné přejímky srovnáváním neobsažené v ČSN 01 0254. *Magazín ČSN*, 1993, 3(4), pp. 83–89.

of protection as the corresponding sampling plans for inspection by attributes while using lower sample size. The basic notions of variables sampling plans are addressed in Jennett and Welch (1939).

Another important classification of sampling plans is according to type of quality levels which are considered. One possibility is that two quality levels (producer and consumer quality level) are specified, together with the corresponding probability of acceptance. Solution for finding such plans and its software implementation is discussed in Kiermeier (2008). Another problem is solved in Dodge and Romig (1998, 2nd Ed.), where AOQL sampling plans for inspection by attributes when remainder of rejected lots is inspected, minimizing the mean number of items inspected per lot of process average quality are introduced. Acceptance sampling when the remainder of rejected lots is inspected and AOQL sampling plans of Dodge-Romig type for inspection by variables is addressed in Klůfa (1997). The Dodge-Romig single sampling plans for inspection by variables and attributes (all items from the sample are inspected by variables, remainder of rejected lots is inspected only by attributes) we can find in Kaspříková and Klůfa (2015). Rectifying AOQL acceptance sampling plans that minimize the mean inspection cost per lot of the process average quality based on the usage of the exponentially weighted moving average statistic (EWMA statistics), and the economic comparison of these plans with the existing plans with respect to savings in the cost of the inspection are in Kaspříková (2019). Other sampling inspection plans based on EWMA statics are in Wang (2016), Aslam, Azam, Jun (2015), and Balamurali, Azam, Aslam (2014). The sampling system based on the concept of count of cumulative conforming control is compared with Dodge–Romig single sampling plans based on average outgoing quality limit in Yazdi and Nezhad (2017). The Dodge-Romig plans for inspection by variables are also studied in Chen and Chou (2001).

1 AVERAGE OUTGOING QUALITY

Acceptance sampling plans when the remainder of rejected lots is inspected are considered in present paper. For these plans we define the average outgoing quality (denoted AOQ). The average outgoing quality is the mean fraction defective after inspection when the fraction defective before inspection was p. The average outgoing quality naturally depends on input quality p, i.e. AOQ is the function of p (denoted AOQ(p)). Let us denote the number of items in the lot N (the lot size), the number of items in the sample n (the sample size, $n < N$) and $L(p)$ the probability of accepting a submitted lot with fraction defective p (the operating characteristic, we shall also write the abbreviation OC). Under the notation Np is the number of defective in the lot, np is expected number of defective in the sample (all defective items found are replaced by good ones) and difference $Np - np = (N - n)p$ is the number of defective in the lot after inspection when the lot is accepted. Therefore, the fraction defective after inspection when the lot is accepted is:

$$(1 - \frac{n}{N}) \cdot p \quad \text{with probability} \quad L(p),$$

and the number of defective in the lot after inspection when the lot is rejected is:

$$0 \quad \text{with probability} \quad 1 - L(p),$$

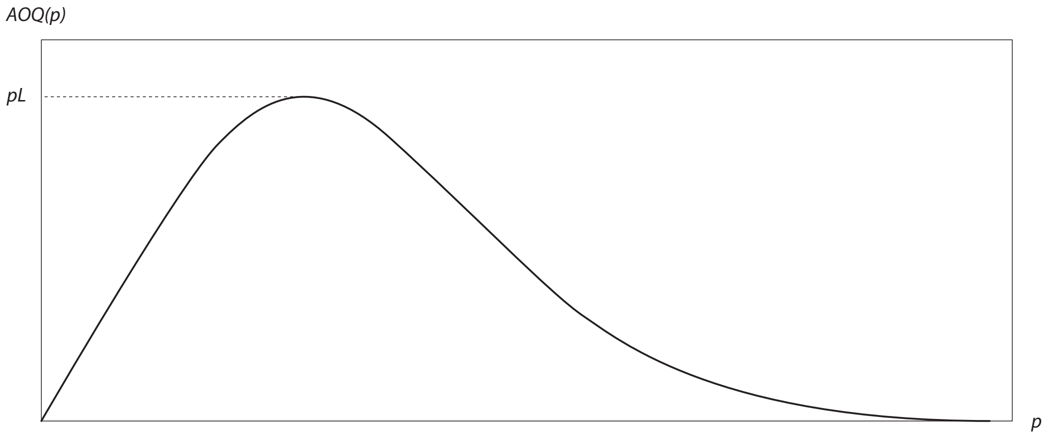
(all defective items found are replaced by good ones). Therefore, the mean fraction defective after inspection when the fraction defective before inspection was p is approximately:

$$AOQ(p) = (1 - \frac{n}{N})\, p\, L(p).$$

A typical graph of this function is shown in Figure 1. It is evident that $AOQ(0) = AOQ(1) = 0$ and $AOQ(p) > 0$ for p in interval (0,1). When fraction defective p increases, the function $AOQ(p)$

a first increases. Then the lots are increasingly rejected, so $AOQ(p)$ begins to decline. For just one p in interval (0,1) the function $AOQ(p)$ has maximum (the function $AOQ(p)$ is continuous in interval [0,1]).

Figure 1 Typical graph of the average outgoing quality $AOQ(p)$



Source: Own construction

2 AOQL PLANS FOR INSPECTION BY ATTRIBUTES

The number of inspected items when the lot with fraction defective p is accepted (the remainder of rejected lots is inspected) is:

n with probability $L(p)$,

and the number of inspected items when the lot with fraction defective p is rejected is:

N with probability $1 - L(p)$.

Let us denote $\bar{p}$ the process average fraction defective (the given parameter). Therefore, the mean number of items inspected per lot of process average quality is:

$$I_s = n \cdot L(\bar{p}) + N \cdot (1 - L(\bar{p})) = N - (N - n) \cdot L(\bar{p}).$$

Let us consider the inspection by attributes. The inspection procedure is as follows (see e.g. Hald, 1981): The lot is accepted when the number of defective items in the sample is less or equal to c. We must find the sample size n and the acceptance number c, i.e. the acceptance sampling plan (n, c).

One way to find the acceptance sampling plan (n, c) is to minimize the mean number of items inspected per lot of process average quality:

$$I_s = N - (N - n)\, L(\bar{p}; n, c), \qquad (1)$$

(the probability of accepting a submitted lot with fraction defective p depends on the sampling plan (n, c), therefore instead $L(p)$ we write $L(p; n, c)$) and for protection of the consumer against the acceptance of a bad lots to use the condition:

$$\max_{0<p<1} AOQ(p) = p_L, \tag{2}$$

where p_L is the average outgoing quality limit (the given parameter, denoted AOQL). Formula (2) guarantees that average outgoing quality is less or equal to p_L (the chosen value) for each fraction defective p before inspection – see Figure 1.

Since the operating characteristic for inspection by attributes using hypergeometric distribution (see e.g. Hald, 1981) is:

$$L(p; n, c) = \sum_{i=0}^{c} \frac{\binom{Np}{i} \cdot \binom{N-Np}{n-i}}{\binom{N}{n}}, \tag{3}$$

we must find for chosen value p_L and given parameters N and $\bar{p}$ single sampling inspection plan (n, c) which minimize:

$$I_s = N - (N-n) \cdot \sum_{i=0}^{c} \frac{\binom{N\bar{p}}{i} \cdot \binom{N-N\bar{p}}{n-i}}{\binom{N}{n}},$$

under the condition:

$$\max_{0<p<1} \left(1 - \frac{n}{N}\right) \cdot p \cdot \sum_{i=0}^{c} \frac{\binom{Np}{i} \cdot \binom{N-Np}{n-i}}{\binom{N}{n}} = p_L.$$

This problem has been solved in Dodge and Romig (1998). Corresponding AOQL single sampling plans for inspection by variables (all items from the sample and from the remainder of rejected lots are inspected by variables) are calculated in Klůfa (2008). The AOQL plans for inspection by variables are described in the following section.

3 AOQL PLANS FOR INSPECTION BY VARIABLES

Now we shall assume that measurements of a single quality characteristic X are independent, identically distributed normal random variables with unknown parameters μ and σ^2. For the quality characteristic X is given either an upper specification limit U (the item is defective if its measurement exceeds U), or a lower specification limit L (the item is defective if its measurement is smaller than L). The unknown parameter σ is estimated from the sample standard deviation s. Under these assumptions the lot is accepted (see e.g. Klůfa, 2018) if:

$$\frac{U - \bar{x}}{s} \geq k, \quad \text{or} \quad \frac{\bar{x} - L}{s} \geq k,$$

where k is the critical value (the search parameter), $\bar{x}$ is the sample average and s is the sample standard deviation:

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2}.$$

We must find the sample size n and the critical value k, i.e. the acceptance sampling plan (n, k).

One way to find the acceptance sampling plan (n, k) for inspection by variables (similarly as Dodge and Romig) is to minimize the mean number of items inspected per lot of process average quality:

$$I_m = N - (N - n)\, L(\overline{p}; n, k), \tag{4}$$

under the Formula (2). Since the operating characteristic for inspection by variables using noncentral t distribution (see e.g. Kaspříková and Klůfa, 2011) is:

$$L(p; n, k) = \int_{k\sqrt{n}}^{\infty} g(t; n-1, u_{1-p}\sqrt{n})\, dt, \tag{5}$$

where $g(t; n-1, u_{1-p}\sqrt{n})$ is probability density function of noncentral Student t-distribution with $(n-1)$ degrees of freedom and noncentrality parameter $\lambda = u_{1-p}\sqrt{n}$ (u_{1-p} is quantile of standard normal distribution of order $1-p$), we must find for chosen value p_L and given parameters N and $\overline{p}$ single sampling inspection plan (n, k) which minimize:

$$I_m = N - (N - n) \cdot \int_{k\sqrt{n}}^{\infty} g(t; n-1, u_{1-\overline{p}}\sqrt{n})\, dt,$$

under the condition:

$$\max_{0<p<1} \left(1 - \frac{n}{N}\right) \cdot p \cdot \int_{k\sqrt{n}}^{\infty} g(t; n-1, u_{1-p}\sqrt{n})\, dt = p_L .$$

This problem has been solved in Klůfa (1997). This paper contains only approximate solution. Exact solution of this problem is very complicated. We can find it in Klůfa (2008) (software Mathematica) and in Klůfa (2014) (software R). Similar problems concerning of acceptance sampling are solved in Chen and Chou (2013), Yazdi et al. (2016), Yen et al. (2014), Wang and Lo (2016), Chen (2016), Aslam et al. (2018), Gogah and Nasser (2018), Nezhad and Nesaee (2019), Aslam et al. (2019), and Kaspříková (2017). Comparison of the AOQL single sampling plans for inspection by variables and the AOQL single sampling plans for inspection by attributes is in the following section.

4 ECONOMICAL AND PRACTICAL ASPECTS OF AOQL PLANS

The sample size for AOQL single sampling plans for inspection by variables is always less than the sample size for AOQL single sampling plans for inspection by attributes, i.e. using the acceptance sampling plans for inspection by variables we check a smaller number of items – see e.g. Table 1.

Table 1 AOQL plans by variables (upper row) and AOQL plans by attributes (lower row) for $p_L = 0.005$

$\overline{p}/N$	100	1 000	10 000	50 000
0.001	$n = 16, k = 2.315$ $n = 42, c = 0$	$n = 34, k = 2.315$ $n = 70, c = 0$	$n = 59, k = 2.328$ $n = 165, c = 1$	$n = 80, k = 2.339$ $n = 275, c = 2$
0.002	$n = 19, k = 2.276$ $n = 42, c = 0$	$n = 49, k = 2.309$ $n = 70, c = 0$	$n = 101, k = 2.345$ $n = 265, c = 2$	$n = 149, k = 2.366$ $n = 390, c = 3$
0.003	$n = 21, k = 2.256$ $n = 42, c = 0$	$n = 65, k = 2.309$ $n = 145, c = 1$	$n = 163, k = 2.366$ $n = 375, c = 3$	$n = 269, k = 2.395$ $n = 625, c = 5$
0.004	$n = 23, k = 2.239$ $n = 42, c = 0$	$n = 82, k = 2.310$ $n = 145, c = 1$	$n = 261, k = 2.386$ $n = 485, c = 4$	$n = 519, k = 2.425$ $n = 875, c = 7$
0.005	$n = 24, k = 2.231$ $n = 42, c = 0$	$n = 101, k = 2.231$ $n = 145, c = 1$	$n = 422, k = 2.404$ $n = 595, c = 5$	$n = 1\,181, k = 2.457$ $n = 1\,410, c = 11$

Source: Own calculation – upper row, Dodge and Romig (1998) – lower row

On the other hand, the cost of inspection of one item by variables (we shall denote c_m^*) is usually greater than the cost of inspection of the same item by attributes (we shall denote c_s^*), i.e. usually $c_m^* > c_s^*$. Under the notatation $I_m c_m^*$ is the mean cost of inspection by variables per lot of process average quality and $I_s c_s^*$ is the mean cost of inspection by attributes per lot of process average quality. Therefore, if:

$$I_m c_m^* < I_s c_s^*,$$

then the AOQL plan for inspection by variables is more economical than the corresponding Dodge-Romig AOQL plan for inspection by attributes, if:

$$I_m c_m^* > I_s c_s^*,$$

then acceptance by attributes is preferable. For the comparison of the AOQL single sampling plans for inspection by variables with the corresponding Dodge-Romig AOQL plans for inspection by attributes from economical point of view we shall define the parameter S by formula:

$$S = (1 - \frac{I_m c_m^*}{I_s c_s^*}) \cdot 100.$$

When $I_m c_m^* < I_s c_s^*$ (acceptance by variables is preferable) then $S > 0$, when $I_m c_m^* > I_s c_s^*$ (acceptance by attributes is preferable) then $S < 0$. The parameter S represents *the percentage of savings of inspection cost* when AOQL plan for inspection by variables is used instead of the corresponding AOQL plan for inspection by attributes. Let us denote c_m the fraction of the cost of inspection of one item by variables and the cost of inspection of the same item by attributes, i.e. $c_m = \frac{c_m^*}{c_s^*}$. Usually $c_m > 1$ (when $c_m \leq 1$, the AOQL plans for inspection by variables are always more economical than the corresponding Dodge-Romig AOQL attribute sampling plans). Using this cost parameter c_m the percentage of savings of inspection cost is:

$$S = (1 - \frac{I_m}{I_s} c_m) \cdot 100. \tag{6}$$

The percentage of savings of inspection cost when sampling plan for inspection by variables is used instead of the corresponding plan for inspection by attributes S depends on input characteristics of the acceptance sampling p_L (the average outgoing quality limit), N (the lot size), $\overline{p}$ (the process average fraction defective) and on the cost parameter c_m (the fraction of the cost of inspection of one item by variables and the cost of inspection of the same item by attributes). Some values of the percentage of savings of inspection cost S for chosen parameters p_L, N, $\overline{p}$ and c_m are in Table 2.

Illustration 1

The AOQL was chosen 0.1%, i.e. $p_L = 0.001$. The process average fraction defective is $\overline{p} = 0.0003$ and $c_m = 2.1$ (the cost of inspection of one item by variables is more than twice the cost of inspection of one item by attributes). For inspection a lot with 4 000 items we shall look for the AOQL plan for inspection by attributes and the AOQL plan for inspection by variables. In the second step we shall compare their operating characteristics. Finally we shall compare these plans from economical point of view.

Under input parameters of acceptance sampling $p_L = 0.001$, $N = 4\ 000$, $\overline{p} = 0.0003$ we can compute the AOQL plan for inspection by variables (see Klůfa, 2008):

$$n = 98, k = 2.8715.$$

Table 2 Percentage of savings of inspection cost S (%) for $p_L = 0.001$, $c_m = 2.1$

$\overline{p}/N$	100	1 000	4 000	10 000	50 000	100 000
0.00010	43	62	69	75	79	79
0.00020	35	54	64	75	77	83
0.00030	27	45	62	66	73	77
0.00040	20	39	58	62	71	77
0.00050	16	31	52	58	66	71
0.00060	12	24	43	52	64	66
0.00070	8	18	35	48	58	62
0.00080	3	10	27	39	50	56
0.00090	–1	3	16	24	37	41
0.00100	–5	–5	6	10	16	18

Source: Own calculation

The corresponding AOQL plan for inspection by attributes is (see Dodge and Romig, 1998):

$n = 340$, $c = 0$.

Moreover, in Dodge and Romig tables we can find for this AOQL attribute sampling plan (340, 0) the lot tolerance fraction defective:[3]

$p_t = 0.0064$.

Now we shall compare the operating characteristics of these plans. From results of the calculation (see the Appendix) it is seen that the operating characteristic of the AOQL plan for inspection by variables (98, 2.8715) is much better than the operating characteristic of the AOQL plan for inspection by attributes (340, 0). For example, from Figure 2 and Table 3 we can see that the AOQL plan for inspection by variables (98, 2.8715) gives better protection of the producer (for p near to 0 the probability of accepting a submitted lot is greater than for the AOQL plan for inspection by attributes). Producer's risk (the probability of rejecting a lot of process average quality) for the AOQL plan for inspection by variables $\alpha = 0.0075$ is much smaller than producer's risk for the AOQL plan for inspection by attributes $\alpha = 0.1011$ (see Out[16] and Out[17] in the Appendix). Moreover, the lot tolerance fraction defective for the AOQL plan for inspection by variables (98, 2.8715) is (see Out[18]):

$p_t = 0.0051$.

[3] The lot tolerance fraction defective p_t is such value of the fraction defective p for which is $L(p_t) = 0.10$, i.e. the probability of accepting a submitted lot with fraction defective p_t is 0.10 (consumer's risk) – see Klůfa (2015). This condition protects the consumer against the acceptance of a bad lot: the probability of accepting a submitted lot with fraction defective $p \geq p_t$ shall be less or equal to 0.10 – see e.g. Figure 2 and Table 3.

Table 3 Some values of OC of the AOQL plan by variables (98, 2.8715) – see $L_1(p)$ and some values of OC of the AOQL plan by attributes (340, 0) – see $L_2(p)$

p	$L_1(p)$	$L_2(p)$
0.0001	0.9999	0.9651
0.0005	0.9670	0.8372
0.0009	0.8685	0.7262
0.0013	0.7413	0.6299
0.0017	0.6145	0.5463
0.0021	0.5011	0.4738
0.0025	0.4049	0.4109
0.0029	0.3257	0.3563
0.0033	0.2615	0.3090
0.0037	0.2098	0.2679
0.0041	0.1685	0.2323
0.0045	0.1355	0.2014
0.0049	0.1092	0.1746
0.0053	0.0882	0.1513
0.0057	0.0713	0.1312
0.0061	0.0579	0.1137
0.0069	0.0383	0.0854
0.0077	0.0257	0.0641
0.0085	0.0173	0.0482

Source: Own calculation

It means that the AOQL plan for inspection by variables (98, 2.8715) gives also better protection of the consumer for control of separate lots.

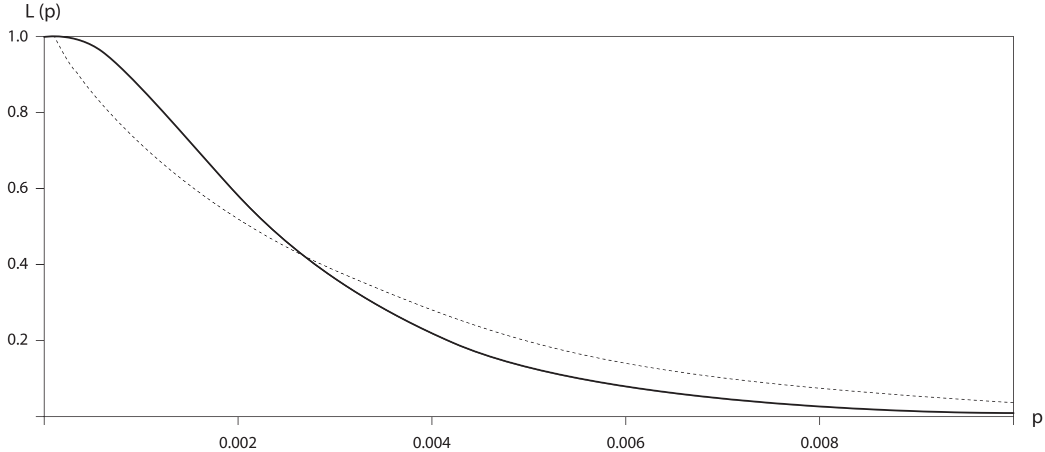
Finally, we shall study economical aspects of the AOQL plan for inspection by variables (98, 2.8715) and the AOQL plan for inspection by attributes (340, 0).

For the cost parameter $c_m = 2.1$ the percentage of savings in inspection cost when sampling plan for inspection by variables is used instead of the corresponding plan for inspection by attributes (see Table 4 and Out[20]) is approximately:[4]

$$S = 62.$$

[4] From Table 4, we can get a good idea of saving control costs, although we don't know the exact c_m value.

Figure 2 The OC of the AOQL plan for inspection by variables (98, 2.8715) and the OC of the AOQL plan for inspection by attributes (340, 0) – dotted



Source: Own construction

Table 4 Dependence of the percentage of savings ***S*** on c_m

c_m	Percentage of savings *S* (%)	c_m	Percentage of savings *S* (%)	c_m	Percentage of savings *S* (%)
1.1	80.2913	2.6	53.4157	4.1	26.5402
1.2	78.4996	2.7	51.6240	4.2	24.7485
1.3	76.7079	2.8	49.8323	4.3	22.9568
1.4	74.9162	2.9	48.0406	4.4	21.1651
1.5	73.1245	3.0	46.2489	4.5	19.3734
1.6	71.3328	3.1	44.4572	4.6	17.5817
1.7	69.5411	3.2	42.6655	4.7	15.7900
1.8	67.7494	3.3	40.8738	4.8	13.9983
1.9	65.9577	3.4	39.0821	4.9	12.2066
2.0	64.1660	3.5	37.2904	5.0	10.4149
2.1	62.3742	3.6	35.4987	5.1	8.62317
2.2	60.5825	3.7	33.7070	5.2	6.83147
2.3	58.7908	3.8	31.9153	5.3	5.03977
2.4	56.9991	3.9	30.1236	5.4	3.24807
2.5	55.2074	4.0	28.3319	5.5	1.45637

Source: Own calculation

It means that under the same protection of consumer the AOQL plan for inspection by variables (98, 2.8715) is more economical than the corresponding Dodge-Romig AOQL attribute sampling plan (340, 0). Since $S = 62$, it can be expected approximately 62% saving of the inspection cost (despite the fact that the cost of inspection of one item by variables is more than twice the cost of inspection of one item by attributes).

Now we shall solve the decision problem (inspection by variables or inspection by attributes) in the case when the cost parameter c_m is unknown.

For given input parameters of acceptance sampling p_L (the average outgoing quality limit, the AOQL), N (the lot size), $\overline{p}$ (the process average fraction defective) the percentage of savings of inspection cost S is a function of the cost parameter c_m – see (6). Naturally, when c_m increases then the percentage of savings of inspection cost S decreases, i.e. $S = S(c_m)$ is decreasing function of c_m ($S = S(c_m)$ is a linear function of one variable c_m). For one value of the parameter c_m (we shall denote c_m^L) the percentage of savings of inspection cost S will be zero. According to (6) from equation $S = 0$ we have:

$$c_m^L = \frac{I_s}{I_m}. \tag{7}$$

This new parameter c_m^L (a limit value of the cost parameter c_m) we can use for deciding if inspection by variables should be considered in place of inspection by attributes. If the cost parameter c_m is less than this parameter, i.e. $c_m < c_m^L$, then $S > 0$ (see Formula (6)) and the AOQL plan for inspection by variables is more economical than the corresponding Dodge-Romig AOQL attribute sampling plan. On the other hand, if $c_m > c_m^L$, then $S < 0$, i.e. inspection by attributes is better than inspection by variables.

The limit value of the cost parameter c_m^L depends for given AOQL on the lot size N and the process average fraction defective $\overline{p}$ i.e. $c_m^L = c_m^L(N, \overline{p})$. Some values of the function are in Table 5. From numerical calculations (see also Table 5) it follows that value of the deciding point c_m^L increases when the lot size N increases and when the process average fraction defective $\overline{p}$ decreases.

Table 5 The deciding points c_m^L for $p_L = 0.0025$

$\overline{p}/N$	**500**	**1 000**	**4 000**	**10 000**	**100 000**
0.00025	3.7	4.0	5.3	5.9	7.1
0.00050	3.1	3.4	5.3	5.0	6.3
0.00075	2.8	3.1	4.0	4.5	5.9
0.00100	2.5	2.9	3.6	4.5	5.9
0.00125	2.3	2.7	3.3	3.7	5.0
0.00150	2.1	2.5	3.0	3.4	4.8
0.00175	2.0	2.3	2.8	3.0	4.2
0.00200	1.9	2.2	2.6	2.7	3.8
0.00225	1.8	1.9	2.2	2.3	2.9
0.00250	1.7	1.8	1.9	2.0	2.1

Source: Own calculation

Illustration 2

The AOQL was chosen 0.1%, i.e. $p_L = 0.001$. The process average fraction defective is $\overline{p} = 0.0003$ and the lot size is $N = 4\ 000$. We shall decide if the AOQL plan for inspection by variables should be considered in place of the AOQL plan for inspection by attributes.

Under input parameters of acceptance sampling $p_L = 0.001$, $N = 4\ 000$, $\overline{p} = 0.0003$ we can compute the deciding point c_m^L (a limit value of the cost parameter c_m). The deciding point (see Out[21]) is approximately:

$$c_m^L = 5.6.$$

If we can assume that $c_m < 5.6$, i.e. $c_m^* < 5.6\ c_s^*$, we use the inspection by variables (c_m^* is the cost of inspection of one item by variables, c_s^* is the cost of inspection of the same item by attributes). On the other hand, if we can assume that $c_m > 5.6$, we use the inspection by attributes.

CONCLUSION

The cost parameter c_m defined as the fraction of the cost of inspection of one item by variables and the cost of inspection of the same item by attributes is not known in practice. For determination the AOQL plan for inspection by variables and the AOQL plan for inspection by attributes we don't need to know value of the parameter c_m. We need to estimate the parameter c_m if we want to determine the percentage of savings of inspection cost S (see *Illustration 1*). When we only need to decide whether the AOQL plan for inspection by variables is more economical than the corresponding AOQL plan for inspection by attributes, we do not need to know the exact value of the parameter c_m. In this situation it is sufficient to calculate the parameter c_m^L defined by Formula (7). According to c_m^L we can easily decide whether the inspection by variables is better than the inspection by attributes (*Illustration 2*). If the deciding point c_m^L is high, then inspection by variables is usually better than inspection by attributes and using the AOQL plan for inspection by variables can bring significant savings of the inspection cost. From numerical calculations (see also Table 5) it follows that value of the deciding point c_m^L increases when the lot size N increases and when the process average fraction defective $\overline{p}$ decreases. For chosen value of AOQL, when the lot size N is large and the process average fraction defective $\overline{p}$ is small, using the AOQL plan for inspection by variables instead of the corresponding Dodge-Romig AOQL attribute sampling plan, we can achieve significant savings of the inspection cost under the same protection of consumer. In very many practical situations we can save more than half of the control costs.

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APPENDIX

The solution of the *Illustration 1* and the *Illustration 2* using software Mathematica:

In[1]: = ndist = NormalDistribution [0,1]
Out[1] = NormalDistribution [0,1]
In[2]: = nbig = 4 000 *(the lot size N = 4 000)*
Out[2] = 4 000
In[3]: = pbar = 0.0003 *(the process average fraction defective* $\overline{p}$*)*
Out[3] = 0.0003
In[4]: = n = 98 *(the sample size for inspection by variables)*

Out[4] = 98
In[5]: = k = 2.8715 *(the critical value for inspection by variables)*
Out[5] = 2.8715
In[5]: = n2 = 340 *(the sample size for inspection by attributes)*
Out[5] = 340
In[6]: = c = 0 *(the acceptance number for inspection by attributes)*
Out[6] = 0
In[7]: = lambda[p_]: = Quantile[ndist, 1 – *p*] * Sqrt[*n*]
In[8]: = nonctdist[p_]: = NoncentralStudentTDistribution[*n* – 1, lambda[*p*]]
In[9]: = L1[p_]: = 1 – CDF[nonctdist[*p*], *k* * Sqrt[*n*]]
(the OC for inspection by variables – see Formula (5))
In[10]: = L2[p_]: = Sum[Binomial[nbig * *p*, *i*] * Binomial[nbig-nbig * p, n2 – *i*] / Binomial[nbig, n2], {*i*, 0, *c*}]
(the OC for inspection by attributes – see Formula (3))
In[11] = Table[{p, L1[p], L2[p]}, {p, 0.0001, 0.008)5, 0.0004}]
Out[11] = {{0.0001,0.999857,0.965094},{0.0005,0.967028,0.837206},{0.0009,0.868518,0.72, 6221}, {0.0013,0.741294,0.629911},{0.0017,0.614491,0.546342},{0.0021,0.501092, 0.473831},{0.0025,0.404948, 0.410919},{0.0029,0.325728,0.356339},{0.0033,0.261482, 0.30899},{0.0037,0.209837,0.267917}, {0.0041,0.168514,0.232289},{0.0045,0.135518, 0.201387},{0.0049,0.109183,0.174586},{0.0053,0.0881509, 0.151342},{0.0057,0.0713322 ,0.131185},{0.0061,0.057859,0.113706},{0.0065,0.0470436,0.0985498}, {0.0069,0.0383423,0.0854087},{0.0073,0.0313253,0.0740155},{0.0077,0.0256531, 0.0641381},{0.0081, 0.0210568,0.0555756},{0.0085,0.0173233,0.0481533}}
In[12]: = TableForm (%)
Out[12]/TableForm = *see Table 3*

Graphical comparison of the operating characteristics of the AOQL plan for inspection by variables (98, 2.8715) and the AOQL plan for inspection by attributes (340, 0) is as follows:

In[13]: = oc1: = Plot[L1[*p*],{*p*, 0, 0.009},AspectRatio → 0.9,AxesLabel → {"p", "L(p)"},PlotStyle → Thickness[0.0055]]
In[14]: = oc2: = ListPlot[Table[{*p*, L2[*p*]},{p, 0, 0.009, 0.0003}]]
In[15]: = Show[oc1, oc2]
Out[15] = *see Figure 2*

Producer's risk of the plans (98, 2.8715) and (340, 0) is:

In[16]: = alpha1 = 1 – L1[pbar]
Out[16] = 0.00748985
In[17]: = alpha2 = 1 – L2[pbar]
Out[17] = 0.101115

The lot tolerance fraction defective for the AOQL plan for inspection by variables (98, 2.8715) is:

In[18]: = FindRoot[L1[p] = 0.10, {p, 0.001}]
Out[18] = {p–>0.00506374}

Economical aspects:

In[19]: = S[cm_]: = (1 – cm * (nbig – (nbig – n) * L1[pbar])/(nbig – (nbig – n2) * L2[pbar])) * 100
(the percentage of savings of inspection cost S – see (6), (4) and (1))
In[20]: = Table[{cm, s[cm]}, {cm, 1.1, 5.6, 0.1}]
Out[20] = {{1.1,80.2913},{1.2,78.4996},{1.3,76.7079},{1.4,74.9162},{1.5,73.1245},{1.6,71.3328}, {1.7, 69.5411},{1.8,67.7494},{1.9,65.9577},{2.,64.166},{2.1,62.3742},{2.2,60.5825},{2.3, 58.7908},{2.4,56.999 1},{2.5,55.2074},{2.6,53.4157},{2.7,51.624},{2.8,49.8323},{2.9,48.0406},{3.,46.2489},{3.1,44.4572},{3.2, 42.6655},{3.3,40.8738},{3.4,39.0821},{3.5,37.2904}, {3.6,35.4987},{3.7,33.707},{3.8,31.9153},{3.9,30.123 6},{4.,28.3319},{4.1,26.5402},{4.2, 24.7485},{4.3,22.9568},{4.4,21.1651},{4.5,19.3734},{4.6,17.5817},{4.7, 15.79},{4.8, 13.9983},{4.9,12.2066},{5.,10.4149},{5.1,8.62317},{5.2,6.83147},{5.3,5.03977},{5.4, 3.24807}, {5.5, 1.45637},{5.6,–0.335337}}
In[20]: = TableForm (%)
Out[20]/TableForm = *see Table 4*

The deciding point:

In[21]: = cmL = (nbig – (nbig – n2) * L2[pbar])/(nbig – (nbig – n) * L1[pbar])
Out[21] = 5.58128 *(the deciding point c_m^L – see (7))*

Lessons from the Crisis in Foreign Aid Statistics

Simon Scott[1] | *Paris, France*

Abstract

The OECD's Development Assistance Committee (DAC) has compiled foreign aid statistics since the 1960s, and it invented the concept of Official Development Assistance (ODA) in 1969. For decades, ODA data were on actual flows, the DAC having rejected suggestions commencing in 1963 to instead focus on flows' "grant equivalents". But in 2014 the DAC decided, from 2018, to switch ODA loan reporting to "grant equivalents" using unrealistic parameters that exaggerated donors' fiscal effort. In 2016 it decided to abandon the requirement that all ODA transactions be concessional. By 2018, having failed to agree grant equivalent methodology for equity investments, loans to the private sector, and debt relief, it decided to maintain reporting of these on a flow basis. ODA therefore now mixes flows and grant equivalents, which are incommensurable statistical quantities, and embodies other contradictions and anomalies. This paper examines the degradation of the ODA measure and identifies general lessons for statistical development exercises and quality control efforts.

Keywords	***JEL code***
Foreign aid, official development assistance, statistical quality, grant elements, grant equivalents, discount rates	*C46, F53*

INTRODUCTION – FOREIGN AID STATISTICS

Institutional framework

Since 1961, the Organisation for Economic Co-operation and Development (OECD) has compiled statistics on foreign aid and other resource flows to developing countries, based on information supplied on a questionnaire completed by the members of its Development Assistance Committee (DAC), and some other aid providers (OECD, 2011). Of the 37 OECD member countries, 30 are also DAC Members. The EU is a full member of the DAC, although it is not a member of the OECD. In 1968, the DAC created an Ad Hoc Group on Statistical Problems, which after several changes of name and status is now known as the DAC Working Party on Development Finance Statistics (WP-STAT).

The WP-STAT consists mainly of the senior statisticians in each DAC member country who compile and submit statistics to the DAC. It is the main forum for discussing changes to statistical rules and procedures, although on all important matters it can only make recommendations for decision by the DAC itself. The DAC consists mainly of diplomats posted to the OECD for two to four years, who may also have to represent their countries' positions on several other OECD committees dealing

[1] Former Head, Statistics and Monitoring Division, Development Co-operation Directorate, OECD, Paris, France. The views are those of the author and no institutional endorsement is implied. E-mail: simondscott56@gmail.com.

with other domains of economic, social or environmental policy. These diplomats are occasionally joined by interested staff from DAC members' administrations at home.

Roughly once a year, the DAC meets at "High" or "Senior" level. High Level Meetings (HLMs) are nominally for the ministers of DAC countries responsible for foreign aid, and Senior Level Meetings for top level officials. In practice many members are represented at below Ministerial level at HLMs and by senior staff at various levels from capitals or even by the country's regular DAC representative at SLMs. In recent years, numerous contentious issues concerned with the rules for compiling aid statistics have not been the subject of agreed recommendations by the WP-STAT, have not been resolved by regular DAC meetings, and have ended up being decided by High or Senior Level meetings on the basis of "political compromises".

Conceptual framework

Financial inflows to developing countries can be separated into four categories, since they can be from either official or private sources, and, in each case, can be either on market terms or concessional, i.e. given away, or at least subsidised so as to give something of value away.

These useful distinctions have their origin in balance of payments (BoP) statistics, and until 1961, statistics on foreign aid closely followed BoP categories. As the DAC developed its own statistical collections, however, divergences of treatment started to emerge between them and the BoP. These were, at least in the early years, carefully documented in DAC statistical reporting directives to facilitate reconciliation with BoP data.

Numerous divergences from the BoP emerged after the DAC introduced the concept of official development assistance (ODA) in 1969.

The invention of ODA was somewhat accidental. The DAC had been created by the USA in 1960–61 mainly to encourage other Western countries to share the financial burden of aid. The USA supplied the Chair of the group, and during the 1960s successive chairs worked to encourage larger flows at softer terms.[2] US efforts led to a DAC Recommendation on Financial Terms and Conditions in 1965, but monitoring DAC members' performance against this Recommendation proved difficult. This was because the Recommendation applied to all official flows, including export credits at "hard" financial terms, which primarily aimed to promote donors' exports rather than recipient countries' development. So in February 1969 the DAC agreed a Supplement to the Recommendation which from then on applied only to "official development assistance, which is intended to be concessional in character" (Scott, 2015, p. 11).

ODA thus came to represent the official, concessional category of international financial flows, and it became the "official name" for foreign aid. It was defined as "those flows" to developing countries that were "concessional in character" and had "the economic development and welfare of developing countries" as their "main objective". Over the succeeding decades, the WP-STAT and the DAC held many discussions about ODA eligibility, but these questions were always judged against this definition, which remained unchanged after 1972.

What did not remain unchanged was the list of activities that qualified as ODA, which steadily lengthened as donors searched for expenditures that would help them meet the ODA target of 0.7% of donors' national income which the UN had set in 1970. During the 1970s, the DAC added aid to NGOs and administrative costs to the ODA measure; in the 80s it added donors' imputed domestic spending on students and refugees from developing countries; and in the 90s and early 2000s came various peace and security expenditures (OECD, 2011, p. 6).

Many of these expenditures were internal to donor countries, infringing the balance-of-payments principle of measuring cross-border flows. Their inclusion gradually made ODA more a measure of budgetary efforts for development than of international transactions.[3]

[2] Softer terms means lengthening the maturities or reducing the interest rates on loans, or replacing them with grants.
[3] The developmental relevance of several of the items remained a matter of debate (Raffer, 1998; OECD, 2005).

Even so, the DAC clung to balance-of-payments conventions in one area where they yielded higher figures than budgetary expenditures. When donors forgave commercial debt, mainly export credits, they counted the full nominal value of this debt, including late charges and penalty interest, although they typically acquired the debt for far lower sums, and may even have insured it in return for premia, which were never deducted from ODA as a receipt. CSOs and academics frequently charged that rules on debt relief inflated DAC members' ODA totals, and in 2006 the retiring chair of the WP-STAT told DAC Chair Richard Manning that "fundamental questions are increasingly being raised, including by you, on the amount of ODA that can be claimed". He advised that "[f]rom a statistical standpoint, it would be possible to come up with rules [that reflected] the true effort of the official sector [but that] the obstacles are political, not least tensions between ministries of finance and aid agencies on how much the former can charge to the budgets of the latter" (Meijndert, 2006, p. 3).

1 MEASUREMENT CONCEPTS: FLOWS AND GRANT EQUIVALENTS

Especially before the invention of ODA, total flow figures were often presented in terms of commitments, i.e. the full amount of new financing agreements, with no deduction for loan repayments. This correctly showed the value of fresh capital being allocated for development, but it overstated donors' financial effort. To remedy this, in 1963 John Pincus of the RAND Corporation proposed that: *In order to arrive at a method that will allow us to measure the resources cost of aid to the donor, we must reformulate the definition of aid…expressing the value of aid as the combined nominal (or market) value of aid less the discounted present value of loan repayments…By this definition, all forms of aid are reduced to their value as grant or subsidy* (Pincus, 1963, pp. 4–5).

He then worked out this grant-equivalent value for DAC countries in 1961 and 1962. But he could not identify a single, most appropriate rate at which to discount loan repayment obligations because the "[d]onor's sacrifices and recipient's benefits may be different". So he produced three alternative estimates based on discount rates of 5%, to approximate the cost of capital in donor countries; 5.75%, the World Bank lending rate at the time; and 10%, a "rough approximation of the free market rate – the long-term private lending market to underdeveloped countries". Pincus only used 10% because, in the early 1960s, "the long-term private lending market is too thin to allow a precise estimate", but he already saw that "If there were a large free market in long-term loans to underdeveloped countries, its long-term rate would represent both the lender's and borrower's alternatives" (Pincus, 1963, pp. 6–7).

Having too thin a capital market to identify the appropriate discount rate for a given loan was a major drawback, for without it, grant equivalent figures became arbitrary. One could literally arrive at any "grant equivalent" number, from the full value of the loan down to zero or even a negative amount, by varying the discount rate applied to the repayments.[4]

Moreover, the premise of Pincus' article was somewhat questionable. His focus on commitments allowed him to claim that: *Clearly whatever its merits, a method that weights equally grants, loans of any term and condition, contributions in kind, etc., fails to establish an economic measure of resource sacrifice, which should presumably be one element of a formal foreign aid burden-sharing system* (Pincus, 1963, pp. 3–4).

This was true as far as it went, but it ignored the fact that DAC reports used commitments data mainly as an indicator of the latest trends in aid allocation, and not as a measure of economic sacrifice.

[4] More formally, the bounds of a loan's possible "grant equivalent" (for positive interest and discount rates) are its gross disbursement and its net transfer. This follows necessarily from the fact that the grant equivalent is the gross disbursement minus the discounted repayment obligations. If the discount rate is set to infinity, it reduces the repayments to nothing and the loan's grant equivalent is its gross disbursement. If the discount rate is set to zero, then the planned principal and interest payments are deducted in full and the loan's grant equivalent is its expected net transfer over its lifetime – a negative amount equal to its total interest payments. For further information on the operation, history and applications of grant equivalents – see Scott (2017).

Only one of the four statistical tables in the 1963 DAC report used by Pincus presents commitments; the other three all present net disbursements (OECD, 1963, pp. 79–82), and most of the discussion of resource flows also focuses on net disbursement figures (ibid., p. 13f.).

The DAC's "net disbursements" basis also started from total outflows, but instead of discounting the total repayment stream upfront, it subtracted actual repayments of loan principal as they occurred, ignoring interest. This method derived from the balance-of-payments concept of capital flows. It had the feature that, over the life of a loan, the net flow would sum to zero, as repayments of principal exactly cancelled the original amount lent. If one also deducted interest, one arrived at the loan's "net transfer" – a negative amount equal to the interest bill, and thus not a measure that appealed to DAC members eager to showcase their efforts (Scott, 2015, pp. 5–6, 9, 10, 18).

The DAC explored Pincus' suggestion in the mid-60s, at one stage publishing the grant equivalents of its members' flows using two alternative discount rates: 10%, and the long-term official borrowing rates in each lending country prevailing in the year of the loans (all of which were less than 10%). But it was not convinced. Apparently picking up on Pincus' admission that the market was then too thin to establish long-term lending rates to developing countries, the DAC's 1966 annual report noted that "the choice of the appropriate rate for discounting presents some difficulty" (OECD, 1966, p. 54). Its 1967 report went further, stressing that the grant equivalent of a loan was "an entirely notional figure. It does not correspond to an actual flow of funds or of goods and services […and] cannot be applied to private capital flows. For equity investment, future rates of return are not known" (OECD, 1967, p. 78).

When the ODA concept arrived in 1969, there was thus no thought of casting it in terms of grant equivalents. ODA simply became a subset of official flows, usually presented on a net disbursements basis – i.e., deducting actual principal repayments each year, not the present value of the total repayment burden. Nevertheless, the grant element of loans (i.e. their grant equivalent as a percentage of their face value) was from then on used to calculate the overall concessionality of donors' aid programmes, a target for which was set in the DAC Recommendation. Later, in 1972, a minimum grant element of 25%, calculated using a 10% discount rate, became a test for a loan's flows to count as ODA (Scott, 2017, pp. 14–15).

The core net-flow basis for ODA appeared to be settled once and for all after the UN agreed in 1970 that donors should allocate "a minimum net amount" of 0.7% of their national income within an existing total flow target "in terms of actual disbursements". When in later decades Pincus' idea of a grant equivalent measure of aid resurfaced, proponents generally accepted that it could not be called ODA, but must have some new name that reflected its different nature, such as Effective Development Assistance (Chang et al., 1998) or Official Development Effort (Hynes and Scott, 2013).

2 THE CRISIS

2.1 Origins and development

As mentioned earlier, the DAC from the 1970s to the 1990s gradually expanded the scope of expenditures that could be scored as ODA, while maintaining the original definition of the concept. By the early 2000s the limits of this approach appeared to have been reached. In fact, under the chairmanship of Richard Manning of the UK (2003–7), several attempts to further dilate ODA coverage were checked. During this period the DAC agreed that transfers under the Clean Development Mechanism could be scored as ODA only if the donor did not benefit from the associated carbon credits or if any such benefit was deducted from the ODA flow (Manning, 2008). Attempts by Greece to score expenditures on the 2004 Olympics and, later, tuition costs of Greek Albanian schoolchildren were rejected. Proposals to count multilateral contributions to UN peacekeeping were examined, but it was agreed in 2006 that only 6% of these would qualify as ODA.[5] In 2007, the DAC agreed that, where a developing country was allowed to buy back its debt at a discount, the discount would not count as ODA (OECD, 2011, p. 6).

The DAC's cautious approach during this period may have been influenced by increased scrutiny of aid figures by the CSO community. In 2005 David Roodman, then at the Center for Global Development in Washington, started an alternative statistical series, Net Aid Transfers, which removed debt relief from ODA, and also subtracted interest receipts on ODA loans. In the same year and with follow-up in 2008 and later, Romilly Greenhill and Patrick Watt of ActionAid published a study of what they termed Real Aid. This concept, which became widely used by CSOs, identified over half of ODA as "phantom aid" that "never materialises for poor countries, but is instead diverted for other purposes within the aid system" (ActionAid, 2005, p. 17).

Yet just as it was becoming politically almost impossible to stretch the ODA definition further, donors had promised huge increases in aid. The Gleneagles G8 Summit in 2005 recorded that the EU had promised to nearly double its ODA between 2004 and 2010 from €34.5 billion to €67 billion, or 0.56% of its collective national incomes, and that it would meet the UN target of 0.7% by 2015. The UK pledged to reach the UN target by 2013, Germany pledged to reach 0.51% by 2010 "supported by innovative instruments", and several other countries also pledged substantial ODA increases (G8, 2005).

These promises looked ambitious even at the time, but after the 2008 global financial crisis they became unrealistic. Pressure therefore increased to boost ODA totals with as little financial sacrifice as possible. The "soft underbelly" of the ODA definition was its lax definition of ODA loan concessionality. As Richard Manning lamented in 2008: *I do, however, leave [the DAC chairmanship] with one item of business that I feel that the Committee has been far too slow in addressing. This is the continued use of a discount rate of 10 % in calculating the 25% minimum grant element required for a loan to count as ODA. This convention, adopted in 1972 as a proxy for the opportunity cost of public investments foregone to make funds available for lending, is out of line with the measures used either by OECD for its export credit work or by the IMF and the World Bank for considering lending to be of a concessional character. In my view the grant element formula is simply indefensible, since in present market conditions it is incompatible with the requirement, explicitly stated in the ODA definition, that loans must be "concessional in character"* (Manning, 2008).

Quietly at first, and then with increasing assurance, France, Germany and the EU ramped up their lending programmes to developing countries. Many of the new loans were unsubsidised, but as long-term euro interest rates had declined to 2 or 3 per cent, they easily met the grant element test.

This led to disputes between these members and the DAC's "Secretariat": the permanent OECD officials who collected and curated the statistics (OECD, 2012a). By 2011, the EU became so incensed at the Secretariat's rejection of its ODA loan reporting that it cut off its funding. Highly political negotiations ensued, culminating in an interim settlement reached at Marlborough House, London, in December 2012. This provided for "Transparency regarding the terms of individual ODA loans" and to "Establish, as soon as possible, and at the latest by 2015, a clear, quantitative definition of 'concessional in character', in line with prevailing financial market conditions". This would "Maintain the definition of ODA, and only attempt to clarify the interpretation of loans that qualify as ODA" (OECD, 2012b). In practice the agreement meant that, while the DAC worked out the meaning of "concessional in character", the EU, France and Germany could continue to report unsubsidised loans as ODA provided they identified and justified these.

The next two years saw even more intensive negotiations, including work by an "expert reference group" outside the DAC, and a top-level panel of eight DAC members convened by the then Permanent

[5] Successive revisions raised this to 15% by 2017.

Secretary of the UK's Department for International Development, Mark Lowcock.[6] The result, ratified at the December 2014 DAC High Level Meeting (OECD, 2014), was something of a surprise, in that it did not "maintain the definition of ODA", as promised only two years earlier. Instead, it decided to "modernise" ODA by turning it from a measure of actual flows into a measure of the "grant equivalent" of those flows, as Pincus had proposed 51 years earlier – and as the DAC had previously rejected. This would "incentivise lending on highly concessional terms", "incentivise innovation" and "encourage the use of ODA to mobilise additional private sector resources for development" (OECD, 2014, pp. 3, 7).

At the same time, the DAC replaced the 10% discount rate used to determine whether a loan's flows would score as ODA with a sliding scale. It selected a "base rate" of 5%, adding politically-negotiated risk margins of 1, 2, or 4%. The base rate was borrowed from an IMF/World Bank formula which itself had been based on average prime lending rates in US dollars over the previous decade. The choice of risk margin depended on the country income group of the recipient, not on actual, observed country risk. As neither was based on currency-specific market rates in the various OECD currencies, the final discount rates of 6, 7 or 9% were essentially arbitrary. The DAC also set new thresholds: grant equivalents would only be recorded if they represented at least 10%, 15% or 45% of the loan value respectively. The whole new "grant equivalent" system would only come into effect with 2019 reporting on 2018 flows, after which the DAC would still also publish figures on a flow basis, but using the new discount rates and thresholds (OECD, 2014; 2018).

The decision to shift to grant equivalents was remarkable. There was no precedent for such a radical change in the nature of a widely-used international statistical measure. Grant equivalents were a completely different quantity from flows, which were the basis for the UN's 0.7% ODA/GNI target – and GNI itself was also a flow (United Nations, 1970, p. 43).

Moreover, from an economic standpoint, fixed, arbitrary, politically negotiated discount rates, invariant by loans' duration and currency, or borrowers' actual credit risk, could not claim to produce realistic grant equivalents. The results would hardly provide an "economic measure of resource sacrifice" or estimate loans' "value as grant or subsidy", to use Pincus' terms. Nor was there any excuse for using arbitrary rates. What had been missing in 1963 – a "large free market in long-term loans to underdeveloped countries" – now existed, and "long-term rate[s that] would represent both the lender's and borrower's alternatives" were readily available, as several DAC members had already noticed (Canada et al., 2012).

Nevertheless, the 2014 decisions did have two potentially saving graces. First, they stated that "The discount rates and the grant element thresholds to be applied under the changes we are agreeing today will need to be regularly reviewed". Secondly, they acknowledged that "Changing the measurement system from net flows to risk-adjusted grant equivalents will therefore also […require] that the rules on reporting ODA debt relief will need to be updated to rule out double counting...the existing regulations for reporting debt relief should expire with the reporting of 2017 flows, and be replaced by new regulations reflecting our agreement today" (OECD, 2014, p. 7).

The DAC, however, was soon distracted from these tasks by pressures from some its members to make the rules even more generous. By February 2016 these led to a further DAC HLM agreement (OECD, 2016) that flows to the private sector could be included in ODA "based on the system of risk-adjusted grant equivalents" even if they were "non-concessional in nature". This was a contradiction in terms, since grant equivalents were nothing but a measure of concessionality, and it also involved a fundamental weakening of ODA's concessional nature. The same meeting further agreed that since "financing the private sector is generally riskier than the official sector",

[6] The Chair of the WP-STAT at this time, Ms Hedwig Riegler of Austria, has pointed out to the author that her group also had a "concessionality task team" working on this issue, which came very close to proposing the OECD's Differentiated Discount Rates (DDRs) as the new discount rate, but which failed to agree on it due to the political influences being exerted on this technical body. In her view, the process demonstrated that by this time, the WP-STAT had "practically no role in ensuring the technical/statistical integrity of proposals for statistical development" (Riegler, personal communication, 7.1.2020). The DDRs – official OECD benchmark rates used to monitor compliance with an international Arrangement to avoid subsidies on export credits – were also the discount rates proposed for ODA grant equivalents in Roodman (2014) and Roodman (2015).

there would need to be a "risk premium in the discount rate additional to the already agreed sovereign risk premia". The resulting higher discount rates would inevitably generate higher grant equivalents. The meeting further agreed to develop grant equivalent methods for equity investments in private sector entities, "reimbursable grants" and guarantees, on the ground that this would "remove the disincentives for using these instruments…ensuring efficient use of scarce public funds and targeting projects with high expected social returns" (OECD, 2016, p. 5).

In the end, however, all these discussions proved fruitless, and by late 2018 the DAC found itself with no agreed methodology for grant equivalent reporting of debt relief, loans to the private sector, equity investments, or guarantees. The project to convert ODA to a consistent grant equivalent measure by 2019 reporting on 2018 flows had failed.

The logical conclusion would have been to retain the old flow-based measure until a credible grant-equivalent system had been worked out. This would also have been the sensible way of interpreting the OECD convention of remaining with the *status quo ante* until members reached consensus on something new. But, after four years of touting the benefits of grant equivalents, and having reached further agreements that would boost reportable ODA, the DAC was reluctant to abandon "ODA modernisation". It therefore adopted a suite of "provisional" arrangements (OECD, 2018) which, subject to a compulsory review in 2021, provided that its members should report as ODA:

- The notional "grant equivalents" of loans to governments produced by applying the discount rates and thresholds agreed in 2014.
- The net flow, not the grant equivalent, of loans to the private sector, applying the old 10% discount rate and 25% grant element test discarded in 2014.
- The net flow, not the grant equivalent, of equities and reimbursable grants.
- For equities sold at a profit, not the actual proceeds but the amount initially invested.
- All debt relief, whether the loans were to the private or public sectors, or had been reported as flows or grant equivalents, applying the rules the 2014 HLM had promised to abolish.
- For all flows to private sector entities in developing countries, *either* the net flows of their financing institutions to developing countries, as above, *or* the net flow of their subsidies to those investing institutions, *ad libitum*.

This tangled settlement largely ignored a "letter of warning" from two former DAC chairs and a WP-STAT chair (Atwood et al., 2018), and was sharply criticised by CSOs (Oxfam, 2018). It was applied for 2019 reporting of 2018 flows, and again for 2020 reporting of 2019 flows (OECD, 2020a, pp. 4–7; 2020b, pp. 1, 2, 6).

2.2 The present state of ODA

The 2018 decisions meant that 2019 and 2020 ODA reporting would be based on rules that contained substantial contradictions and anomalies. Perhaps the most serious flaw remained the fictitious "grant equivalents", which, by ignoring easily observable market rates, would produce just what the DAC itself had criticised in 1967: "entirely notional figure[s]" which did "not correspond to an actual flow of funds or of goods and services".[7]

[7] By 2017–19, the disconnect between actual market rates and the arbitrary DAC discount rates was even more pronounced than it had been in 2014. China's 10-year bond was typically yielding around 3.5%, but if a donor made a loan to China at the same terms, it would discount the reflows at 6%, and report a "grant equivalent" of around 20% of the amount lent. The gap was even wider for financing to southeast Asian countries. Malaysia, Indonesia and the Philippines were floating 10-year yen bonds yielding only 0.6% to 1.3%, but if Japan lent directly to these countries at these rates, large ODA grant equivalents would be reportable, since the DAC discount rate was 6% for Malaysia, and 7% for Indonesia and the Philippines. It is, of course, true that such loans would also have met the "old" test of a 25% grant element using a 10% discount rate. But had they then been reported as ODA – which the DAC Secretariat may have opposed on the ground that they were not "concessional in character" – then the repayments would also have been reportable, eventually nullifying the ODA credit received. By contrast, the new system reported grant equivalents on official loans upfront, with no subsequent deduction for repayments. Thus, misreporting a non-concessional loan under the old system left ODA *temporarily* too high; doing it under the new system leaves it *permanently* too high.

But this error was now compounded by its interactions with subsequent, largely inconsistent, decisions. The result was a new system that did not even measure an identifiable quantity, since it was a mixture of flows and grant equivalents. Nor did it have a coherent point of measurement, since flows to the private sector could be measured either domestically as net contributions to development finance institutions (the "institutional" approach), or internationally as net payments to developing countries (the "instrument-specific" approach). These two approaches, furthermore, did not relate to the same funds, since the former were typically subscriptions to the capital base of the institutions, whereas the latter came from working capital that the institutions raised on markets.

Continuing to report loans to the private sector as flows instead of grant equivalents, using the "old" grant element test, represented failure to convert ODA to a grant equivalent basis, and also undermined the claims made since 2014 that grant equivalents provided a fairer measure of effort (OECD, 2014, p. 6). Requiring that these loans still meet the classical ODA test of being "concessional in character" contradicted the DAC's 2016 finding that they were "non-concessional in nature" (OECD, 2016, p. 6). In practice, donors might well take the 2016 decision as licence to ignore the fundamental ODA requirement of concessionality, as long as loans met the outmoded grant element test.

Continuing to report debt relief while reporting the "risk-adjusted grant equivalents" of loans to the official sector double-counted loan risk, violating DAC's 2014 undertakings (Meeks, 2018). If risk was built into the ODA amount reported when loans were extended, there was no case for reporting any relief later granted on them. On the other hand, if debt relief was still reportable as ODA, then loans' grant equivalents would have to be worked out using risk-free discount rates, and the case for the risk premia included in the DAC's 2014 discount rates collapsed. Yet while this article was in press, the DAC announced changes to debt relief reporting which only exacerbated the double-counting. Its new approach will use risk-adjusted rates to inflate both the grant equivalent of the original loan, and the grant equivalent of any relief eventually provided. In many cases, the ODA amount reportable for debt forgiveness will exceed the debt forgiven – see Ritchie (2020).

The situation with "old" loans – extended before 2018 – was similarly contradictory. Where these had been to governments, their repayments, still coming in, were now ignored, even though their full outflows had originally been reported. But if they had been to the private sector, then under the 2018 decisions their repayments were still reportable.

The new rule to cap reporting of the proceeds of equity sales meant that only sales that resulted in a loss would be reported correctly. If the equity were sold at a profit, donors would not report their actual receipts but only their original investment. Since receipts give rise to negative entries, understating them overstates financial effort. It also contradicts the DAC's "joint understanding" that its alternative "institutional" and "instrument-specific" methods of recording flows to the private sector "should generate, over time, comparable ODA figures for comparable donor efforts" (OECD, 2016, p. 6). For if an equity *fund* made profits returned to a donor government, the institutional approach would capture them, whereas the underlying profits on *individual* equity investments would not be reportable using the instrument-specific approach.

These and other problems with the "new ODA" were drawn to the attention of the DAC Chair in late 2019 (Scott and Moorehead, 2019). The Chair conceded that the DAC had reached "political compromises" which were "always and inevitably a bit messy" and that "there is of course unfinished business…but this too will need to find a middle path between technical and political considerations". The Chair stated her belief that the "new system has many benefits, including a fairer measure of the degree of concessionality". She also pointed out that "we publish data using both the new grant equivalent and the old flow-based methodologies" – without, however, explaining that the new measure still counted several forms of aid on a flow basis, or that the old measure now included the new discount rates and the new rule to ignore profits on equity investments.

The Chair also claimed in relation to 2018 figures that "the new grant equivalent methodology has not led to inflation of the amount of ODA. For some members, their ODA figure is lower under the new system." Yet this was only a temporary timing effect. As explained above, in the long run, ODA reporting on every loan sums to zero on a net flow basis; whereas only positive grant equivalents are reportable. By 2020 reporting on 2019 flows, the "new ODA" figure was already more than \$5 billion, or 3.7%, higher than the net flow figure. ODA had officially risen 1.4% from the previous year, whereas the rise was only 0.1% on the traditional, net flow basis (OECD, 2020a, pp. 1, 4, 6).

2.3 Causes and possibilities for recovery

Taking the long view, one can observe several aspects of the DAC's nature that contributed to the present "train wreck" of the ODA rules. First, the Committee acts in isolation from the international statistical community: its decisions are not open to review by any statistical authority, or subject to any co ordination with related statistics, such as on the balance of payments or national accounts. Second, the DAC is a political body, whose prime interest in statistics is to develop rules that will help it present the efforts of its members in the best possible light.[8] Third, while it does have a specialised statistical subgroup, the WP-STAT, this body has no power to change the rules on its own, and in practice has had all significant decisions in recent years taken above its head. Fourth, in recent years the DAC's broad aid policy remit has led it to try to achieve policy objectives through *incentives built into statistical rules*,[9] rather than through its earlier approach of agreeing Recommendations to be monitored through *neutral statistical rules*.

As of early 2020, there were some tentative signs of progress towards greater DAC openness. Since 2017 its Secretariat had been publishing all records of the meetings of a broad-based task force it convened to develop a new measure of Total Official Support for Sustainable Development (TOSSD).[10] It had also agreed a framework for co-operation with civil society organisations, and in late 2019 the statistics working party approved a proposal to issue records of its meetings (though not the background documents) as "unclassified" (OECD, 2019; OECD, 2020c, pp. 5–6). These moves offer some hope that the DAC may in future be more open to informed criticism. Yet its essential institutional set-up remains unchanged, and the scale of the task of re-establishing a credible measure of foreign aid is daunting.

3 LESSONS FOR CODES OF PRACTICE AND STATISTICAL QUALITY FRAMEWORKS

Given the deterioration of the ODA rules in recent years, it may be thought that existing structures for ensuring statistical quality have here proven inadequate. On closer examination, however, it appears that the fault lies not so much with the structures as with a failure to apply them.

Two broad families of documents aim to ensure the quality of international statistics. First are general guidelines and principles such as the UN Principles Governing International Statistical Activities (United Nations, 2005), to which the OECD has subscribed, and the Recommendation of the OECD Council on Good Statistical Practice (OECD, 2015). These deal mainly with procedural and institutional matters, and are designed to ensure sound statistical processes. The second type of discipline is provided by so-called "quality frameworks", which spell out the characteristics of good statistics, and provide mechanisms for managing the quality of statistical outputs and processes. These two types of disciplines are complementary:

[8] As the DAC Chair puts it, "Committee work needs to strike a functional balance between the space for members to deliberate, negotiate and reach a compromise – and then to publicise its work as appropriate" (Scott and Moorehead, 2019).

[9] "It is expected that the modernised system would create incentives for increasing the use of these instruments – and by extension boost efforts to scale up engagement by the private sector in development finance" (OECD, 2016, p. 5). Cf. also the references in Section 2.1 to DAC statements of the need for statistical rules to encourage, incentivise, or remove disincentives to particular actions.

[10] For the latest information on the development of TOSSD, see the Task Force's website (OECD, 2020d). For a penetrating analysis of developments up to 2019 – see Riegler (2020).

principles usually include conformity with quality frameworks, and quality frameworks may borrow criteria from lists of principles (Scott, 2019).

Upon inspection, it is apparent that recent discussions of ODA rule changes violated both sets of guidelines.

For example, the Principles Governing International Statistical Activities urge adherents to "make documents for, and decisions of, statistical meetings publicly available" (United Nations, 2005, p. 1). Until recently this has not been standard practice, although as noted above, records but not documents will now be issued unclassified.

Nor did the DAC's *modus operandi* conform to the OECD Recommendation's requirement that statistical authorities with "professional independence" from policy departments should have "exclusive authority…to decide on statistical methods" and be "protected…from political and other interference in developing…official statistics". The DAC also failed to observe the Recommendation's demand for "impartiality, objectivity and transparency of official statistics" based on "sound methodology" that respects "scientific independence…in an objective, professional and transparent manner" (OECD, 2015, pp. 10, 11).

The Recommendation includes reference to the OECD's own quality framework for statistical activities. Among the quality dimensions of this framework which DAC decisions clearly flouted are "accuracy (statistics accurately and reliably portray reality)" and "coherence and comparability (statistics are consistent internally, over time and in space and it is possible to combine and make joint use of related data from different sources)".

However, both the OECD's quality framework (OECD, 2012c) and more detailed guidelines available for national statistics, such as the United Nations' National Quality Assurance Frameworks Manual for Official Statistics (United Nations, 2019) have a strong procedural orientation. As a rule, they explain how to develop good statistics, rather than providing specific tests of whether an existing statistical product, or changes introduced to a product, are sound. The incoherencies introduced into the ODA measure since 2019 reporting on 2018 flows suggest that these guidelines may need to provide greater specificity if they are to ward off similar problems in future.

For example, the UN Manual requires (United Nations, 2019, p. 105) that "when statistical modelling is used in the statistical production process (e.g., for seasonal adjustment), the validity of model assumptions is carefully considered and the impact on final estimates is evaluated". The grant equivalent calculation for an ODA loan is itself a model. Its assumptions, including the discount rates and thresholds, were politically negotiated, which may or may not meet the UN Manual's injunction that they be "carefully considered". But in any case, as demonstrated above, the DAC model produces clearly unrealistic estimates of loans' true "grant equivalents". There is also the issue of whether and under what circumstances a model result should be *preferred* to an observed value, in the way that the "new ODA" prefers grant equivalents to actual, measured flows. Quality frameworks might benefit by providing more guidance on the appropriate uses of model-generated "data".

Another example is data coherence. Here the OECD framework (OECD, 2012c, p. 48) states, correctly, that "verification mainly involves the coherence of the information received over time, across datasets and across countries". The provision in the "new ODA" for countries to report as ODA either inflows to, or outflows from, development finance institutions, clearly violates this principle. But the framework could perhaps make the point more forcefully by stressing the need to respect a single point of measurement wherever possible. "Point of measurement" is not mentioned anywhere in either the UN or the OECD document. Those documents might also usefully warn against statistical rules that would sum different statistical quantities, such as flows and grant equivalents, within the same aggregate.

In line with the OECD's Recommendation on political independence mentioned above, its quality framework (OECD, 2012c, p. 8) states that it is important that data "are not manipulated, nor their release timed in response to political pressure", and that they "cannot be withdrawn in response to political pressure". However, neither it nor the UN document specifically warns against developing statistical rules with the policy aim of encouraging or rewarding particular behaviours by the agents whose actions the statistics will measure – which has been a recurring theme in the "ODA modernisation" process.

There are also some basic rules of logic which quality frameworks may have omitted because they seemed self-evident, but which the ODA experience suggests may be worth spelling out explicitly. For example, the frameworks could recommend that if changes to statistical instructions alter the quantity being measured, then consideration should be given to starting a new series with a new name, rather than splicing the new measurements onto the old ones under the same name. This might have avoided the present situation where the OECD has reported ODA/GNI ratios for 2018 and 2019 in which the numerator no longer corresponds to the "net flow" concept used in the United Nations' target for this ratio.

Finally, while quality frameworks address issues concerned with the use of provisional *data*, they do not address the issue of when it is appropriate to use provisional rules. As of mid-2020 the OECD has used, for two successive years, a definition of ODA containing no fewer than six footnotes flagging items or issues that have "not been agreed yet", "will be reviewed", "remain to be clarified", or are "pending finalisation of the overall reform of the DAC statistical framework" (OECD, 2020b, p. 6). Quality frameworks might usefully include guidance about the use of data based on unfinished rules, especially in cases where a previous set of rules has been used successfully over a long period.

Overall, it is clear that the DAC's "ODA modernisation" process infringed key statistical principles, practices, and quality dimensions to which the OECD has subscribed. This suggests that the Organisation may need to tighten its institutional mechanisms to ensure that its quality assurance framework is more rigorously applied in future. But the experience may also suggest several useful amplifications and clarifications of its and other organisations' frameworks.

CONCLUDING REMARKS – WAS CORRUPTION INEVITABLE?

Granted that the "ODA modernisation" project violated numerous existing guidelines for statistical work, can one therefore conclude that better enforcement of these guidelines, or more rigorous guidelines, would have avoided all problems? Unfortunately, this may not be the whole story.

For it is a proverbial truth that policy-relevant indicators are subject to corruption. "Goodhart's Law"[11] states that: *When a measure becomes a target, it ceases to be a good measure.* And "Campbell's Law" gives a hint of the processes involved: *The more any quantitative social indicator is used for social decision-making, the more subject it will be to corruption pressures and the more apt it will be to distort and corrupt the social processes it is intended to monitor.*

ODA has now been both a target and a tool for decision-making about aid allocations for 50 years. So the wonder may be not that it has become corrupt, but rather that the process took so long. In particular, why did the decline accelerate so markedly from 2014?

One answer may be the DAC's increasing disregard of outside advice. In the 60s it had given detailed and sustained consideration to Pincus' suggestion of a grant equivalent measure, and as recently as the early 2000s it had seemed sensitive to CSO critiques of the breadth of ODA coverage. By contrast, after Roodman (2014) diagnosed a "crisis in ODA statistics" and proposed a suite of recommended remedies, both his and numerous other sensible external suggestions fell on deaf ears (cf. CSOS, 2018).

Yet the real key to the timing and the inevitability of the recent corruption of ODA may be a more fundamental shift in the attitude of the DAC. Up to 2012, the Committee was always careful to present rule changes as objectively justifiable within ODA's core concept. From then on, "modernisation" gradually mutated into

[11] For information and references on Goodhart's Law and Campbell's Law (see Rodamar, 2018).

an effort to encourage particular aid allocation behaviours. ODA rules no longer aimed to reflect reality, but rather to shape reality. And one can no longer expect to find the truth once one is focusing on another task.

It may therefore be of interest to students of Goodhart's and Campbell's Laws to examine whether in other cases the crucial turn towards corruption also came when those tending the statistical apparatus started to show more interest in pursuing policy objectives than in faithfully portraying reality.

The ODA measure under exclusive DAC tutelage may by now be beyond redemption. The present "provisional" rules give ODA credit for loans with zero fiscal cost, double-count default risk, and hide profits on equities. And as donors increasingly resort to these dodges to boost their figures, they will progressively lose interest in restoring rigour to the ODA rules.

Rehabilitating ODA, or developing a new and more credible measure of foreign aid, will almost certainly require a new institutional set-up, which insulates statistical development work from political interference. This is bound to require more input from national statistical offices, and from international agencies such as the UN, World Bank and IMF that have an interest in accurate measurement of international flows. Even so, the DAC's recent moves towards greater transparency, as well its involvement of outside actors in the development of TOSSD, gives some hope that it might yet play a positive role in these developments.

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Mathematical Methods in Economics (MME 2020) International Conference

Petra Zýková[1] | *Prague University of Economics and Business, Prague, Czech Republic*
Josef Jablonský[2] | *Prague University of Economics and Business, Prague, Czech Republic*

The *Mathematical Methods in Economics* (MME) conference has a very long history and tradition. It is one of the most important scientific events organized in the Czech Republic in the field of operational research, econometrics, mathematical economics, and related research areas. In 2020, the 38th International Conference on Mathematical Methods in Economics was organized in the city of Brno from 9–11 September.[3] In addition to the local organizer (the Faculty of Business and Economics, Mendel University in Brno), leading organizers of the MME conference are the Czech Society for Operations Research (CSOR) and the Czech Econometric Society.

The total number of participants in this year's MME conference was almost 100. Due to the Covid-19 pandemic, several participants chose virtual attendance. Participants came from the Czech Republic, China, Austria, Poland, the Netherlands, Norway, and Slovakia. The programme started with an opening ceremony, where the Chair of the Organising Committee, Svatopluk Kapounek, introduced the main programme and all of the facilities. After that, the first plenary session started with two exciting lectures. The first one, titled *Model Uncertainty in Econometrics: What to Do When You Don't Know What to Do?*, was presented by Professor Jesus Crespo Cuaresma from the Vienna University of Economics and Business. Professor Petr Molnár from the University of Stavanger Business School in Norway delivered the second plenary talk about *Online Attention and Financial Markets.* After the plenary session, the conference was divided into four parallel sessions. The total number of presentations was more than 80. All accepted papers are published in the *Proceedings of the MME 2020*. They have been submitted, as in previous years, for indexing in the Web of Science CPCI database.

It has been a long tradition for PhD students to compete for the best paper during MME conferences. The competition is organized and honoured by the CSOR. All submitted papers were peer-reviewed, and the programme committee further evaluated the papers with positive referee reports. Six best-selected papers were presented at the conference in a special session, and the evaluation committee decided on the winners. The six best papers were awarded after a conference dinner at the university campus. Petra Tomanová (University of Economics, Prague, Czech Republic), with her paper 'Robustness of Dynamic Score-Driven Models Utilizing the Generalized Gamma Distribution', was the winner of the competition. Karel Kozmík (Charles University, Prague, Czech Republic), with his paper 'Using Machine Learning to Predict Optimal Parameters in Portfolio Optimization Problems', ranked second. Petr Vejmělka (Charles

1 Prague University of Economics and Business, Faculty of Informatics and Statistics, Department of Econometrics, W. Churchill Sq. 4, 130 67 Prague 3, Czech Republic. E-mail: petra.zykova@vse.cz.
2 Prague University of Economics and Business, Faculty of Informatics and Statistics, Department of Econometrics, W. Churchill Sq. 4, 130 67 Prague 3, Czech Republic. E-mail: jablon@vse.cz.
3 More at: <*https://mme2020.mendelu.cz*>.

University, Prague, Czech Republic) ranked third, with his paper 'Recursive Estimation of IGARCH Model'. David Neděla (Technical University of Ostrava, Czech Republic), Anna Selivanova (Czech University of Life Sciences Prague, Czech Republic), and Petra Zýková (Prague University of Economics and Business, Prague, Czech Republic) won the remaining three awards. The farewell ceremony closed the conference.

The conference was organized with great expertise. All sessions took place in the Faculty of Business and Economics. The welcome evening took place in the VIDA! Science Centre in Brno, where all the conference participants had the science centre all to themselves. The science centre consists of more than 6 200 square metres of fun. This unique exhibition is divided into five thematic sections: the Planet, Civilization, Man, and the Microworld. There are many interesting science attractions, most of which are physical (e.g., 3G flight simulation).

An essential part of all conferences is a social programme that offers many opportunities to discuss various problems in an informal environment. The organizers have prepared two possible trips. A trip to the Sloup-Šošůvka Caves, which are situated in the northern part of the Moravian Karst near the town Sloup in the Sloup-Šošůvka Caves natural reservation area, and the trip to the Labyrinth underneath Zelný trh in the Brno city centre, where there is a large maze of undergrounds tunnels, corridors, and rooms. The tour in the Labyrinth was followed by a guided tour of the city centre of Brno. The conference dinner took place at the university campus in Building X, with accompanying music (traditional South Moravian sounds).

This year's annual meeting of the CSOR decided that the 39th MME conference will be organized in the city of Prague by the Faculty of Economics and Management, Czech University of Life Sciences Prague, from 8–10 September 2021.

14th Year of the *International Days of Statistics and Economics* (MSED 2020)

Tomáš Löster[1] | *Prague University of Economics and Business, Prague, Czech Republic*
Jakub Danko[2] | *Prague University of Economics and Business, Prague, Czech Republic*

From 10th to 12th September 2020, a worldwide conference of the *International Days of Statistics and Economics* (MSED) took place at the Prague University of Economics and Business.[3] The conference belongs to traditional professional events; this year, the fourteenth year of this event was held. Prague University of Economics and Business (the Department of Statistics and Probability and the Department of Managerial Economics) was the main organizer, as usual; and was helped by the Faculty of Economics, the Technical University of Košice, and Ton Duc Thang University, as co-organizers. The conference ranks among important statistical and economic conferences, which can be proved by the fact that Online Conference Proceedings were included in the Conference Proceedings Citation Index (CPCI), which has been integrated within the Web of Science, Clarivate Analytics since 2011.

Despite the unfavourable development in the spring of this year, when the epidemiological situation caused ambiguity in the possibility of the simultaneous presence of a larger number of doctoral students and academics and practitioners in one place, the conference was prepared as planned. The received papers were first evaluated in terms of scientific content and suitability of the topic concerning the focus of the conference. After the exclusion of unsatisfactory abstracts, a double independent anonymous review procedure took place in the spring of this year, as a result of which a total of 141 scientific articles were accepted after all modifications and exclusions of rejected articles.

In August of this year, concerning the worsening epidemiological situation, it was decided on a hybrid form of the conference, i.e. part of the papers took place in person, for those conference participants who were allowed to participate at the Prague University of Economics and Business and for some participants, for example, who was not granted a visa, an online presentation took place. None of the conference participants was deprived of any presentation because discussions and presentations from the Prague University of Economics and Business were also broadcast via MS Teams.

A total of 231 conference participants from various countries were registered this year. Traditionally, the most numerous group of foreign participants who were registered includes researchers and doctoral students from Russia (89), then from Slovakia, Vietnam, Austria, Bulgaria, Japan, etc.

We would also like to invite researchers, doctoral students, and the wide professional public to the fifteenth International Days of Statistics and Economics, which will take place at the Prague University of Economics and Business traditionally in early September and, depending on the current epidemiological situation, will take place online if necessary.

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1 Faculty of Informatics and Statistics, W. Churchill Sq. 4, 130 67 Prague 3, Czech Republic. E-mail: tomas.loster@vse.cz.
2 Faculty of Informatics and Statistics, W. Churchill Sq. 4, 130 67 Prague 3, Czech Republic. E-mail: jakub.danko@vse.cz.
3 More at: <*http://msed.vse.cz*>.

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Authors and Contacts
Rudolf Novak*, Institution Name, Street, City, Country
Jonathan Davis, Institution Name, Street, City, Country
* Corresponding author: e-mail: rudolf.novak@domain-name.cz, phone: (+420) 111 222 333

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