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CONTENTS

1. Odette PENNERS, Janjaap SEMEIJN, Allard C.R. van RIEL, Wim LAMBRECHTS, Life Cycle Extension of Mobile Phones. An exploration with focus on the end-consumer …… 7

2. Les DUCKERS, Uswatun HASANAH, An Outline Economic Strategy for Indonesia to Sustainably Meet its Electricity and Carbon Emissions Targets ……..…. 39

3. Malgorzata ZAJĄCZKOWSKI, The European Neighborhood Policy: a perspective of the partner countries ……. 55

4. Paulina STACHURA, Measuring Energy Efficiency – structural and index decomposition analysis …… 71

5. Magdalena Maria KOZIŃSKA, Central Counterparties – risk minimizers? ……...… 87

6. Agnieszka MAREK, Adjusting Employee Management Process to Key Organisational Values …… 111

7. Luiz Fernando DE LYRA NOVAES, André Felipe FRAGA, Manoela Maria Rapuano DE LYRA NOVAES, Luiggi SENNA, Double Perspective DEA on appraising property's fair market value by Brazilian Standards …… 127

8. Janusz MYSZCZYSZYN, Usefulness of the Concept of Social Savings and Consumer Surplus in Studies on the Impact of Innovation on Economic Growth ……...… 179

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Life cycle extension of mobile phones. An exploration with focus on the end-consumer

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Abstract:

Aim: All mobile phones will eventually become obsolete and should be collected and recycled in order to recover their high content of both dangerous and valuable materials. End-consumers play a key role in these processes as the collection and recycle systems cannot work properly without their contribution. Therefore, this exploratory study investigates how Dutch end-consumers can be stimulated to return their used mobile phones.

Design / Research methods: the factors influencing consumers' propensity to return and recycle obsolete mobile phones are examined. The results are based on a survey conducted among end-consumers of mobile phones in the Netherlands.

Conclusions / findings: There is significant recycling potential as the majority of used mobile phones are simply kept at home. Keeping a used phone as a spare phone and being afraid of privacy disclosures are indicated as main reasons for not taking used phones to a recycling point.

Originality / value of the article: The findings indicate that personal satisfaction from recycling and knowledge or awareness of the potential dangers from not properly returning play a crucial role in influencing the propensity.

Keywords: end of life, e-waste, mobile phones, recycling, WEEE

JEL: Q01, Q53, Q56,

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1. Introduction

Today's production of waste from electrical and electronic equipment (WEEE) or "e-waste" amounts to 20-50 million tons every year. With an annual growth rate of 3-5%, it is the fastest growing waste stream in the world (Maragkos et al. 2013). The cell phone industry is one of its major contributors, as cell phones are the most often frequently sold appliances to households (Polák, Drápalová 2012). Worldwide cell phone sales amounted to nearly 1.9 billion units in 2014. Smart phones make up about two-thirds of these global sales (Gartner 2015).

The need for recycling "obsolete" mobile phones has greatly increased. Their usage life cycles, with replacement rates of approximately 18-24 months, are shorter than the designed service life and the highest rates so far in the history of consumer electronic devices (Bask et al. 2013). The major reasons for replacing used mobile phones are unfashionable features or damage to the phone (Yin et al. 2014; Ylä-Mella et al. 2015). According to Navazo, Méndez and Peiró (2014), several studies show that 45-48 % of used phones are simply kept at home and 23-30 % are either sold or traded in for a new phone. The number of old mobile phones ending up in recycling facilities differs between studies, ranging from 2% to 16% (Navazo et al. 2014).

However, the potential energy and material savings from recycling a larger percentage is substantial, due to the valuable materials (e.g. gold, palladium and silver) present in the mobile phones. They also contain toxic metals such as lead and cadmium, which may create a threat to human health if not properly disposed (Maragkos et al. 2013; Navazo et al. 2014; Speake, Yangke 2015).

Therefore, it is important to know which factors influence consumers' participation in mobile phone waste recycling programs (Baxter, Gram-Hanssen 2016; Borthakur, Govind 2017). According to Tanskanen (2013), a national e-waste management policy requires robust collection and recycling models, as well as awareness and changes in the behavior of the consumer. This paper investigates how end-consumers can be stimulated to return their mobile phones.

2. Literature review and hypotheses

This section provides a review of the literature and associated hypotheses, covering the life cycle extension of mobile phones, and the factors influencing consumer propensity to recycle.

2.1. Life cycle extension of mobile phones

Mobile phones can have many different users during their life span. In the literature, the term life span is not consistent, likewise, the information about the lifespan of mobile phones differs significantly, ranging from 1.5 to 7.0 years (Polák, Drápalová 2012). Other studies mention a potential life span of a mobile phone of about 10 years (Ongondo, Williams 2011a; Nnorom et al. 2009). According to Polák and Drápalová (2012), the life span is the duration of the period in which the good exists in the original form in our society, irrespective whether it still functions.

According to Ongondo and Williams (2011b), collected phones can be processed according to one of the following options: re-use, resell or refurbish. In the case of re-use, the phones are directly donated to other consumers. Reselling to other customers occurs either directly or indirectly through third parties. In the case of refurbishing, there are cleaning and reconditioning steps needed before they can be donated for re-use, resold or exported (Ongondo, Williams 2011b). Nevertheless, many phones never reach one of these options as 45-48 % of used phones are simply kept at home (Navazo et al. 2014; Wilson et al. 2017).

When a mobile phone can no longer be (re)used for its original purpose and becomes waste, it has reached the end of its life. Although legal requirements enforce proper e-waste recycling, illegal export of e-waste to developing countries often takes place and is then deposited in landfills or incinerated (Queiruga et al. 2012; Navazo et al. 2014).

Mobile phones are “up to date” products; they are often replaced before the end of their functional life, due to the rapid introduction of advanced technologies and fashionable features (Cox et al. 2013; Paiano et al. 2013). Frequently, the old phones are stored at home while they may still function. However, after this storage period they might be too old for re-use. Therefore, eliminating the storage period after a

phone's end-of-first-life can significantly increase the re-use potential (Babbitt et al. 2011).

Designing products that make use of easy-to-reuse models, recyclable materials and renewable resources, or material identifications might be a solution (Babbitt et al. 2011; Bask, Kuula 2011; Kissling et al. 2013). Phones consisting of interchangeable modules provide the convenience of repairing, upgrading and replacing defective parts. End-consumers must still return the replaced components to prevent the same storage problem as with the existing phones.

Another possibility is improving the product service systems in which manufacturers or retailers lease instead of sell mobile phones (Cox et al. 2013). The end-of-first-life management shifts from the consumer to the manufacturer and the phone is less likely to be stored at home. This facilitates the process of closing the loop since the manufacturer owns the product during the entire life cycle and the consumer only pays for the usage (Merkies 2012).

However, leasing does not ensure environmental benefits because the replacement periods for most electronics are shorter than the functional life time (Babbitt et al. 2011). In the case without lease, the consumer determines the moment of acquiring a new phone which typically results in a longer usage period before (NVMP 2016). One option might be the extension of the fixed lease periods which would lower the demand for new phones. Returned phones are older after the extended period, which reduces their resale potential.

Commonly used incentives to return obsolete phones are free envelopes, bags or boxes (Ongondo, Williams 2011b). However, the risk of damage to or loss of the phones sent by post is not guaranteed. Other incentives mentioned by Ongondo and Williams (2011a; 2011b) are charity donations, courier collection, monetary payments, discounts, prize draws, environmental incentives, free airtime/texts, or vouchers. However, large scale surveys among students (Ongondo, Williams 2011a; Li et al. 2012) showed that incentives with a monetary element such as cash payments and vouchers have the greatest influence on the willingness to return mobile phones.

Therefore, serious consideration should be given to deposit refund systems for e-waste recycling as these systems are economically more profitable than other

economic incentives such as recycling subsidies, waste disposal fees or taxes on virgin materials (Sabbaghi et al. 2016; Saphores et al. 2012; Ylä-Mella et al. 2015). These deposit refund systems, where consumers get a refund (on the deposit paid at the time of purchase) when they return the product at the end of its useful life, has already become an accepted practice for plastic bottles, glass or newspapers in many countries. According to Tanskanen (2013), similar efficient collection and recycling practices should be established for electronic waste.

However, NVMP (2016) argues that deposit refund systems are expensive and inefficient in order to change consumer behavior. It neither contributes to the responsible processing of e-waste nor to the environment. First, in contrast to for example plastic bottles, electrical devices have a low turnover rate and they are not automatically returned. In order to stimulate consumers financially, a substantial amount of deposit is required. This can have a negative impact on the sales of electronics because the amount is added to the selling price. Consequently, the risk of cross-border shopping increases. Furthermore, manufacturers have to make their products specifically identifiable for the Dutch market. This results in a loss in economies of scale related to higher costs and creates a barrier to the European free market (NVMP 2016). Moreover, practical evidence from Austria and South Korea, which implemented deposit refund systems from 1995 to 2005 and 1992 to 2002 respectively, shows that deposit refund systems on electronics have no significant effects on the return rates (Desmet, Hanquet 2013). Desmet and Hanquet (2013) argue that the monetary amount of the deposit and the collection rate determine the effectiveness of the system. The payment of deposits also requires careful management and monitoring by all the stakeholders involved.

2.2. Factors influencing return and recycling

Among the most well-known models to explain human behavior is the theory of planned behavior which is an extension of the theory of reasoned action (Fishbein, Ajzen 1975; Ajzen 1991). The theories assume that human behavior is driven by an individual's motivation to behave in a certain way. According to Ajzen (1991), these motivational factors are called intentions. These intentions are positively related to behavior and formed by the attitude towards the behavior, subjective norms as well

as (the extended variable) perceived behavioral control (Fishbein, Ajzen 1975; Ajzen 1991). In the recycling literature, behavioral intentions, actual recycling behavior and consumer attitudes towards recycling are also three dependent variables widely used (Hornik et al. 1995). Due to the fact that the differences in correlations of these three variables are not statistically significant, Hornik et al. (1995) suggests to treat them as the one-dimensional construct propensity to recycle.

Hornik et al. (1995) identifies and classifies variables affecting consumers' propensity to recycle in five categories: intrinsic incentives, extrinsic incentives, internal facilitators, external facilitators and a separate group demographic variables. Although there are multiple (as well as overlapping) variables relating to recycling behavior, developing a model including all factors might neither be feasible nor useful as it is too extensive and complex. For that reason, four empirically validated variables that most strongly predict the propensity to recycle are used as a base for this study and where necessary adapted to the situation of obsolete mobile phones (Hornik et al. 1995). These include perceived social influence, personal satisfaction, knowledge and frequency of collections. However, the collection frequency (external facilitator) will be replaced by inconvenience. The reason is that existing e-waste collection systems in the Netherlands mainly consist of central collection points, as opposed to convenient door to door curbside collection such as the waste paper collection in the Netherlands. Therefore, in the current situation of returning mobile phones, the collection frequency is less relevant and will be replaced with the inconvenience to return.

Besides this, monetary incentives will be included because this is an important determinant in order to activate a desired behavior as already became clear from section 2.2.3. It was mentioned that incentives with a monetary element such as cash payments and vouchers have the greatest influence on the willingness to return mobile phones (Ongondo, Williams 2011a; Li et al. 2012).

Moreover, used mobile phones, especially smartphones, contain sensitive personal data that is difficult to fully erase. As a result, end-consumers rather keep their used phones at their end of life instead of selling them to others or return them for recycling. Therefore, the concern about the security of personal data stored in the

phone is added to the model as it is a major barrier for returning obsolete phones nowadays (Hobson et al. 2018; Tanskanen 2013).

Furthermore, demographic variables (age, gender, education and income) are included because they are the most commonly investigated variables in the recycling literature, but their effects appear to be inconclusive (Hornik et al. 1995). The following section will shortly explain the conceptualization of the dependent and independent variables before outlining the hypotheses.

2.3. Analytical framework

Propensity to return. The dependent variable is the propensity to return. This is based on the study of Hornik et al. (1995) which investigates the critical variables influencing consumers' participation in recycling actions and could be measured by self-reports of behavior or measures of actual behavior.

Although the behavioral intention to return and recycle is an immediate antecedent of behavior and seems a proper measure, the propensity to return will be used in this study. Ajzen (1991: 181) defines intention as "how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior". However, Davies, Foxall and Pallister's (2002) study mentions that over-reliance on intentions as an indicator for a certain behavior omits the evaluation of the behavior choice being made previous to the actual decision or behavior (e.g. the choice of returning or throwing in the bin). Therefore, it might be more reasonable to try to predict a consumer's propensity to return because it reflects a general willingness to behave in a certain way, whether or not consciously intended to engage in this behavior (Pattaro 2007). In the case of a propensity, an individual is not necessarily committed to act in the suggested manner when a certain condition holds, instead it might also be an input to a further decisional phase in which he or she is likely to behave (Pattaro 2007). On the contrary, in the case of an intention, an individual has made up his or her mind about what to do if a certain situation occurs (e.g. if the phone is at the end of its life, I shall immediately return it). However, returning a mobile phone appears not to be a specific action where consumers systematically intend to engage in at a particular time. Besides this, returning is defined as giving or sending something back. Combining these

concepts, the propensity to return is defined as the tendency of a consumer to return a mobile phone with the purpose to be properly recycled.

Personal satisfaction from recycling. Carrying out an activity for its inherent satisfaction is an intrinsic factor or motivation (Ryan, Deci 2000; Hornik et al. 1995). Feeling good from pursuing a personally satisfying activity (recycling) might increase the propensity to return mobile phones for recycling. As a consequence, the self-interest to conserve resources in order to achieve personal happiness can lead to direct participation in activities and valued opportunities that make a difference in the end (De Young 2000).

Perceived social influence. While personal satisfaction from recycling relates to the individual's internal incentive to recycle, perceived social influence refers to the impact that external people have on the individual. According to Hornik et al. (1995), social influence can be defined as an individual's concern about the perceptions of others, such as family and friends, if he or she does not recycle. The individual's recycling behavior can be influenced by people in the environment. For example, a consumer might feel obliged to recycle his or her phone if recycling is seen as valuable or is common practice among friends and family.

Knowledge. In general, the more information a person has about recyclable materials or where recyclables are collected the more likely the person will recycle (Schultz et al. 1995). Several studies argue that the promotion of environmental initiatives should be increased to raise consumer awareness of current recycling practices and the importance of mobile phone waste recycling (Jang, Kim 2010; Ongondo, Williams 2011b; Tanskanen 2013; Ylä-Mella et al. 2015). It is necessary to further inform the consumers on the dangers and the potentials concerning electronic waste disposal (Speake, Yangke 2015). Therefore, in this study, knowledge refers to the consumers' awareness regarding the potential threat to the environment and human health from improper disposal.

Monetary rewards. In general, extrinsic incentives such as monetary rewards are successful in order to activate a desired behavior (Hornik et al. 1995). As mentioned before, there are many different incentives to increase the return rate of mobile phones such as free envelopes, discounts, prize draws, and cash payments. However, incentives with a monetary element such as cash payments and vouchers seem to

have the greatest influence in order to return mobile phones (Ongondo, Williams 2011a; Li et al. 2012).

Perceived inconvenience. Several studies state that convenience to return is an important factor in whether or not to participate in e-waste recycling activities (Saphores et al. 2012; Tanskanen 2013; Wang et al. 2011). Convenience refers to the consumer's belief of how much effort it takes to return their mobile phones. Existing e-waste collection systems in the Netherlands mainly consist of central collection points, as opposed to convenient door to door curbside collection. These collection points might be considered as more complicated and time consuming as compared to curbside collection. Therefore, in the situation of returning mobile phones, the perceived inconvenience will be measured.

Privacy concern. As mentioned before, the concern for privacy disclosures creates a barrier for returning mobile phones. Besides calling and sending text messages, mobile phones are increasingly used for other purposes. As a consequence, mobile phones contain sensitive personal data which is difficult to completely erase at the end of life. Therefore, end-consumers might be reluctant to sell them to others or return them for recycling.

Demographic factors. Demographic variables (age, gender, educational level and yearly income) are included in the model because they are the most commonly investigated variables in the recycling literature (Hornik et al. 1995; Saphores et al. 2012). However, their effects appear to be inconsistent. End-consumers are individuals with different characteristics and thoughts about for example the residual value or usability of the mobile phone at the end of its life. Therefore a one-size-fits-all approach is not appropriate for e-waste recycling (Speake, Yangke 2015). Hence, the demographic factors age, gender, education and income are expected to have a moderating influence on the propensity to recycle.

The following hypotheses are proposed and will be tested empirically.

Consumers who…

H1. feel highly satisfied from recycling are more likely to return and recycle their mobile phones

H2. perceive a high social influence to recycle are more likely to return and recycle mobile phones.

H3. have knowledge about mobile phone waste recycling are more likely to return and recycle mobile phones.
H4. receive a monetary incentive for returning their phones are more likely to return and recycle mobile phones.
H5. perceive returning their phone as inconvenient are less likely to return and recycle mobile phones.
H6. are concerned about their privacy are less likely to return and recycle mobile phones.

3. Method

3.1. Data collection

All variables included in this study have been presented in the literature review. Therefore, the items concerning each construct are adopted from previous studies and modified to the current context. The number of items representing a construct and the related sources are presented in the table 1. These constructs consisting of 34 items are measured on a seven-point Likert scale ranging from strongly agree to strongly disagree.

Table 1. Constructs

Construct	Items	Source
Personal satisfaction	5	De Young (1985-1986)
Social influence	5	Lee (2008), Do Valle et al. (2004)
Knowledge	7	Davies et al. (2002), Do Valle et al. (2004)
Monetary rewards	4	Shaw, Maynard (2008), De Young (1985-1986)
Inconvenience	5	McCarty, Shrum (1994), Davies et al. (2002), Do Valle et al. (2004)
Privacy	5	Smith et al. (1996), Malhotra et al. (2004)
Propensity to return	3	Gursoy et al. (2007)

The survey is distributed among end-consumers of mobile phones in the Netherlands and the unit of analysis are individuals. Convenience sampling is the non-probability sampling technique selected for this study. The primary reason is the ease of obtaining the data from the participants available at a given time (Bickman, Rog 2008). Although this technique restricts the generalization to a wider population, convenience sampling is the preferred technique given the resources available.

Due to the fact of the widespread use and ownership of mobile phones, almost everyone can contribute to this research. Therefore, the participants were kindly requested to forward the questionnaire to other respondents. However, this snowball-sampling might result in a sampling bias which increases the possibility that the participants share the same traits and only a small subgroup of the entire population will be derived (Bickman, Rog 2008). In order to reduce this sampling bias, the survey is distributed among groups with different characteristics in terms of gender and age.

3.2. Sampling

In total, 116 participants started the survey. After elimination of incomplete submissions, a total of 101 valid and complete answers could be analyzed. Of these 101 end-consumers, more than half were male (53) and the remaining 48 female. Among the 101 respondents, 60 were categorized into young adults (ages 24 or younger), 23 were middle-aged adults (ages 25-49 years), and 18 were older adults (aged 50 or older). More than two-third of the respondents had a bachelor's degree or higher (68). 45 respondents indicated to earn less than €15.000 annually, 30 people between €15.000 and €45.000, 12 people more than €45.000 and 14 preferred not to answer this question.

As shown in table 2, the respondents own on average 2.90 used mobile phones consisting of 1.61 smartphones and 1.29 standard mobile phones. The average of 2.90 mobile phones per individual in this study is lower than the average of 5 mobile phones as stated by Tanskanen (2013). However, it still represents a large recycling potential and this is confirmed by the fact that the majority of the used mobile phones are simply kept at home (69%). Keeping the used phone as a spare phone

and being afraid of privacy disclosures are indicated as the main reasons for not taking the used phones to a recycling point.

The effect of gender, age, education and income on mobile phone ownership and use among the respondents are presented in the Appendix (table A1). It is remarkable that there exists a marginally significant positive linear relationship between income and total average use of mobile phones ($p < 0.10$). This indicates that the use of mobile phones among respondents increases with the incomes earned.

Table 2. Average mobile phone use and ownership among respondents

	Average ownership	**Average use**	**Average e-waste**
Smartphones	1.61	0.97	0.64
Standard mobile phone	1.29	0.19	1.10
Total	2.90	1.16	1.74

Source: authors' own research.

Moreover, in 29% of the cases the used mobile phones are re-used: the majority gives them to others (16%) or resells them (11%), while others leave them at the store when buying a new one (1%) or bring them to a recycling point (1%). The remaining 2% dispose them with the mixed waste.

Furthermore, the replacement rate of 18-24 months mentioned in the literature is validated by this research as the majority (41%) indicated the same rate for changing to another phone, followed by 24-36 months (34%) or less often (18%). 7% of the respondents replace their phones every 12-18 months. However, the replacement rates should be interpreted with caution as they often depend on fixed contract periods as in the case of leasing or a phone via work. Therefore it is more important to consider what is done with the used phone after replacing.

3.3. Measurement model

The convergent and discriminant validity are examined in order to validate the reflective measurement model. Partial Least Squares (PLS) path modeling with the software tool Smart PLS 3.0 is used for this analysis. PLS can be used for theory

testing, but it can also be used to indicate whether relationships might or might not exist and to suggest propositions for future testing (Chin 1998). Besides this, PLS is suitable for smaller sample sizes in order to validate a model (Haenlein, Kaplan 2004).

Table 3. Factor loadings, T-values, and composite reliability

Construct (Composite Reliability)	**Cross Load.**	**t-value**	**AVE**	**α**
Inconvenience (0.948)				
I consider returning and recycling my used mobile phone as…				
… inconvenient	0.866	9.550	0.784	0.931
… too much trouble	0.934	11.938		
… too complicated	0.889	11.091		
… too time consuming	0.863	13.286		
… a difficult task	0.872	11.468		
Knowledge (0.893)				
Returning used mobile phones with the purpose to be properly recycled…				
… helps to protect the environment	0.795	6.231	0.546	0.864
… creates a better environment for future generations	0.786	6.707		
… is a major way to save energy	0.689	7.633		
… is a major way to reduce pollution	0.681	4.392		
… is a major way to reduce the wasteful use of land for dumps	0.698	7.885		
… is a major way to conserve valuable and recyclable materials such as gold, palladium or silver	0.692	5.995		
… is a major way to help the proper handling of hazardous and toxic materials, like lead and cadmium	0.818	7.169		
Monetary Rewards (0.909)				
I would take recycling my phone more seriously if I can get a benefit from it	0.870	14.693	0.715	0.871
Returning and recycling used mobile phones is worthwhile if I get cash for it	0.855	6.046		
Returning and recycling used mobile phones is worthwhile if I get a gift voucher for future purchases	0.762	5.564		
I would make more of an effort to return and recycle my phone if I get paid for it	0.889	11.176		

Table 3. Cont.

Construct (Composite Reliability)	Cross Load.	t-value	AVE	α
Privacy (0.931)				
Returning used mobile phones causes serious privacy problems	0.633	1.922	0.726	0.931
Compared to others, I am more sensitive about the way companies handle my personal information	0.885	3.713		
I am concerned that companies are collecting too much personal information about me	0.946	3.775		
I am concerned about threats to my personal privacy	0.960	3.829		
I keep my used mobile phones to guarantee my privacy	0.793	3.012		
Propensity to Return (0.842)				
I have the tendency to return and recycle my mobile phone when it is at the end of its useful life	0.795	13.500	0.641	0.718
I am probably more likely to return and recycle a mobile phone than most people I know	0.853	17.277		
I would attempt to notify others if I know they do not return and recycle their phone	0.752	11.579		
Personal Satisfaction (0.852)				
I try to find ways to avoid the creation of waste	0.738	9.229	0.537	0.783
I rather repair products than throwing them away	0.638	5.340		
I try to find ways to re-use things again	0.749	8.061		
It feels good seeing more people recycling	0.754	9.292		
I recycle because it feels right	0.776	10.002		
Social Influence (0.870)				
I discuss much about waste recycling and issues with my friends and family	0.866	16.338	0.576	0.829
I share information regarding recycling with my friends and family frequently	0.824	12.086		
I expect that my family and friends recycle	0.716	6.523		
My family expects me to recycle	0.614	4.044		
My friends expect me to recycle	0.750	6.639		

Source: authors' own research.

For the constructs (latent variables), the loadings of the reflective items are examined in order to determine the appropriateness of the items. Each loading represents the correlation between the item and the related construct (Chin 1998). Hence, items with low loadings imply that they have a weak relationship in terms of shared variance with the construct and should be deleted. In general, items with loadings of less than 0.50 should be dropped (Hulland 1999). All factor loadings resulting from the confirmatory factor analysis exceeded the recommended threshold and were statistically significant (Table 3).

The convergent validity of the measurement model is assessed by calculating the composite reliability (CR), average variance extracted (AVE), and Cronbach's alpha (α) as presented in table 3 (Hulland 1999; Fornell, Larcker 1981). The values for both the Cronbach's Alpha and composite reliability are greater than the acceptable standard of 0.70 as suggested by Nunnally (1978). As a result, the reliability or internal consistency of the items that are used to measure a latent construct are sufficient. Furthermore, the average variance extracted (AVE), the average amount of variance in the items that a construct is able to explain, is greater than 0.50. This indicates that the latent construct explains more than half of its items variances resulting in an adequate internal validity (Fornell, Larcker 1981).

In order to examine the discriminant validity, the criterion suggested by Fornell and Larcker (1981) is applied. Adequate discriminant validity means that the square root of the AVE associated with a specific construct must be greater than its correlations with other constructs. Table 4 shows the descriptive statistics and correlation matrix of the constructs. As shown in table 4, the diagonal elements representing the square root of each AVE are sufficiently greater than the off-diagonal elements in the corresponding rows and columns (Hulland 1999).

As shown in Table 4, the diagonal elements representing the square root of each AVE are sufficiently greater than the off-diagonal elements in the corresponding rows and columns (Hulland, 1999). However, Henseler, Ringle, and Sarstedt (2015) suggest to assess the heterotrait-monotrait ratio (HTMT) of the correlations, which is the average of the heterotrait-heteromethod correlations, relative to the average of the monotrait-heteromethod correlations. Hence, if the HTMT value is below 0.90,

discriminant validity can be established between two reflective constructs (Henseler et al. 2015).

Table 4. Interconstruct correlations and descriptive statistics

Construct	1	2	3	4	5	6	7	Mean	Std. Dev
Inconvenience (1)	**0.885***							3.713	1.382
Knowledge (2)	0.064	**0.739***						2.371	0.761
Monetary rewards (3)	0.310	0.103	**0.846***					2.116	0.941
Personal satisfaction (4)	-0.138	0.082	-0.072	**0.733***				3.034	0.958
Privacy (5)	0.346	0.176	0.206	0.143	**0.857***			3.428	1.450
Propensity to return (6)	-0.353	0.352	-0.266	0.377	0.132	**0.800***		4.835	0.945
Social influence (7)	-0.074	0.254	-0.045	0.560	0.161	0.431	**0.759***	4.687	1.082

Source: authors' own research.
Note: *Diagonal elements in the 'correlation of constructs' matrix are the square root of AVE

From Table 5 it is clear that all HTMT values are significantly different from 1 as all the values are below the criterion of 0.90, and even below the highest standards of 0.85, indicating sufficient discriminant validity among the constructs used in this study.

In order to test the hypotheses, hierarchical moderated regression analyses (HMRA) was done in SPSS version 22.0. Personal satisfaction, social influence, knowledge, monetary rewards, inconvenience and privacy concern were utilized as independent variables and gender, age, educational level and income as the demographic moderators.

Table 5. HTMT Results

Construct	1	2	3	4	5	6	7
Inconvenience (1)							
Knowledge (2)	0.098						
Monetary rewards (3)	0.342	0.197					
Personal satisfaction (4)	0.215	0.233	0.159				
Privacy (5)	0.481	0.190	0.324	0.212			
Propensity to return (6)	0.433	0.420	0.314	0.497	0.175		
Social influence (7)	0.213	0.300	0.169	0.680	0.256	0.507	

Source: authors' own research.

4. Results

The hypothesized relationships were tested via HMRA using SPSS 22.0. The results are shown in table 6 and in the Appendix (table A2, A3, A4). In order to test the moderating effect of the demographic variables, the first step in HMRA was to test the effects of the main variables on the propensity to return. The results show significant effects of five factors (personal satisfaction: β 0.203, $p < 0.05$, knowledge: β 0.412, $p < 0.01$, monetary rewards: β -0.219, $p < 0.05$, inconvenience: β -0.236, $p < 0.001$ and privacy concern: β 0.120, $p < 0.10$) on the propensity to return, explaining 42.1% of the variance. Hence, H1 (personal satisfaction), H3 (knowledge), and H5 (inconvenience) are supported. Although, H4 (monetary rewards) and H6 (privacy concern) are significant, they have unexpected coefficients. Therefore, H2 (social influence: β 0.123, n.s.), H4 and H6 are not supported.

The second step of the HMRA analysis included the full model by adding the moderators to the main model. In order to reduce multicollinearity, these moderators or interaction terms were first mean-centered and then multiplied with each other (Shieh, 2011). The variance inflation factors (VIFs) were calculated in order to test for multicollinearity. Except for the interaction term (> 45.000 x privacy concern), they were all below the threshold of 10.

Table 6 shows the moderating effects of gender with female as the baseline. It shows that gender purely moderates the effect of social influence and privacy concern on propensity to return (gender x social influence: β 0.373, $p < 0.05$, gender x privacy concern: β -0.353, $p < 0.01$). Therefore, H2a (the moderating effect of gender on the relationship between social influence and the propensity to return) and H6a (the moderating effect of gender on the relationship between privacy concern and the propensity to return) are supported, but H1a, H3a, H4a, H5a (the moderating effect of gender on the relationship between personal satisfaction, knowledge, monetary rewards, inconvenience and the propensity to return) are not supported.

Table 6. Moderated regression analysis of the effect of gender

Constructs	**Model 1**	**Model 2**	**Model 3**	**VIF**
Independent variables				
Personal satisfaction	0.203**	0.206**	0.229*	3.230
Social influence	0.123	0.119	-0.068	3.469
Knowledge	0.412***	0.402***	0.467***	1.960
Monetary rewards	-0.219**	-0.217**	-0.310***	2.586
Inconvenience	-0.236***	-0.241***	-0.181**	2.468
Privacy concern	0.120*	0.116*	0.242***	2.179
Moderating variable				
Gender		-0.062	-0.107	1.301
Interactions				
Personal satisfaction x Gender			0.080	3.107
Social influence x Gender			0.373**	3.370
Knowledge x Gender			-0.149	2.149
Monetary rewards x Gender			0.142	2.514
Inconvenience x Gender			-0.118	2.600
Privacy concern x Gender			-0.353***	2.796
R^2	0.421	0.422	0.543	
Adjusted R^2	0.384	0.378	0.474	
F-value	11.280***	9.598***	7.849***	
ΔR^2	-	0.001	0.121	

Source: authors' own research.
*p < 0.10, **p < 0.05, ***p < 0.01

5. Discussion

This study improves the understanding of factors stimulating end-consumers to properly return and recycle their used phones. Personal satisfaction from recycling and knowledge or awareness of the potential dangers from not properly returning and recycling have a significant positive influence. Their strength show the importance of these internal factors influencing the propensity to return. Additionally, their intrinsic nature has a relatively enduring effect on recycling because these can be sustained indefinitely (Hornik et al. 1995). Hence, more information about the toxicity and dangers of e-waste and the potential health impacts of improper disposal should be provided. It is suggested that formal, non-formal and informal learning settings should contribute to increase the mobile phone recycling knowledge and awareness. While this study considers outcome-based knowledge concentrating on global environmental issues, further research might focus on task-related knowledge because this knowledge is also necessary in order to properly recycle. Task related knowledge considers the 'what, where, and how to recycle' knowledge (Davies et al. 2002). However, it was felt that the task-related knowledge was partly captured by respondents' answers 'I do not know where to take the used cell phones' and 'I feel that recycling is troublesome' as important reasons for not taking the used phone to a recycling point.

Inconvenience showed a significant impact: Dutch consumers must bring or send the used phone to a central point. Therefore, methods need to be developed which take the existing infrastructure and resources into account while meeting the needs of end-consumers. Another recommendation is to reduce the inconvenience by decreasing the complexity and effort to return. End-consumers should be better informed about where they can bring or send their used phones as several respondents indicated that they do not know where to take them or find it troublesome to return. To be more specific, drop-off points in stores, dedicated recycling centers or door to door courier collection are suggestions to increase convenience.

Monetary or financial rewards show an unexpected negative effect on the propensity to return. However, respondents also indicated 'receiving a cash payment

or gift voucher' as the most important factor that would trigger them to return their used phone. According to Gneezy et al. (2011), monetary rewards result in two types of effects: direct price effect and indirect psychological effect. The psychological effect can sometimes adversely influence the price effect and crowd out the incentivized behaviors. The negative effect can be explained by the respondents' perception of getting not enough money in order to return their phones. In other words, the monetary rewards do not outweigh the efforts or other motivations to return used mobile phones.

Although the respondents further stated 'being afraid of privacy disclosures' as one of the main reasons for not taking used phones to a recycling point, privacy concern is positively related to the propensity to return. A reason for this unexpected positive effect of privacy concerns could be the subjectivity of this factor. Privacy concerns are not absolute concepts as consumers make choices based on trade-offs in which they give up a certain degree of personal information in exchange for benefits (Phelps et al. 2000). It can differ by individual and this is validated in this study because gender, age, education, and income have a significant effect on the relationship between privacy concerns and the propensity to return. Besides the individual characteristics, the type of information and the amount of control consumers have over subsequent distribution are important factors affecting privacy concern (Phelps et al. 2000). In the case of returning mobile phones, end-consumers have full control whether they keep their phone including the personal information or erase and return it.

The insignificance of social influence indicates that there is no overall effect of social influence on propensity to return. There is conflicting evidence whether social norms impact recycling behavior (Davies et al. 2002). Different value systems and cultures among respondents or measurement problems of this factor are possible causes. Hopper and Nielsen (1991) found no direct link between social norms and recycling behavior. Social norms are adopted on a personal level and become personal norms. Thus the direct effect of social influence might be completely mediated through personal norms. The moderated results in this study showed significant cross-over interactions i.e. the effect of social influence on the propensity to return depends on gender, age and income of the respondents. The positive effect

of social influence from friends and family on propensity to return is higher among males, middle aged and older adults and people with higher incomes. It is important to take advantage of these differences between individuals in order to design effective recycling programs. Returned phones should provide sufficient refurbishing value to make deposit refund systems economically viable.

Extant literature shows conflicting findings with respect to economic incentives. On the one hand, several researchers state that deposit refund systems for e-waste should be given serious consideration as they are economically more profitable than other economic incentives such as recycling subsidies (Saphores et al. 2012; Tanskanen 2013; Ylä-Mella et al. 2015). On the other hand, deposit refund systems for e-waste are expensive and inefficient, because mobile phones have a relatively lower turnover rate than for example plastic bottles and, due to their small size, consumers do not mind to keep them at home at the end of life. The amount of the deposit and the collection rate determine the outcome of the system. Therefore, respondents were asked what would be the amount of money that would stimulate them to return the used phones through a deposit refund system similar to one for returning plastic bottles. The amount of money ranges from €5 to €100 with an average of €30. However, this amount should be considered with caution as it depends on the type of phone and the extent of damage to the phone, but it gives an initial indication and might be useful for further considerations. Hence, this study not only contributes to earlier studies but might also serve as a starting point for future research. The findings of this research might also be of interest for the return of electronic devices other than cell phones. A similar, more recent problem is created by the booming tablet market, but also very cheap computers on-a-stick, and cameras are a growing source of concern.

Although this study has been conducted with specific attention towards methodological constraints, it has some limitations. The survey response rate leads to issues of generalizability within the Dutch and wider context. However, the results are in line with previous studies (Ylä-Mella et al. 2015; Martinho et al. 2017).

6. Conclusion

Eventually, all mobile phones become obsolete and need to be properly collected in order to recycle their dangerous as well as valuable materials. From economic, ecological and legislative perspectives, this electronic waste should be directed to proper end-of-life processes. The end-consumers have a key role in these processes as the collection and recycle systems cannot work properly without the contribution of these downstream members. They are responsible and have to decide whether to return or keep their mobile phones.

Despite the increase in mobile phone subscriptions, the high replacement rates and the presence of several mobile phone recycling programs in the Netherlands, the return rates are still low. Therefore, this study gathered information about the factors affecting consumers' propensity to participate in mobile phone waste recycling. It can be concluded that personal satisfaction from recycling, awareness and convenience can be improved by providing specific promotions and information regarding mobile phone waste recycling programs. Actions improving the internal facilitators such as educating people and enhancing the social image of mobile phone recycling activities should entice more consumers into phone recycling as well as to continue with this behavior. Recycling needs to be transparent, convenient and rewarding.

References

Ajzen I. (1991), The theory of planned behavior, „Organizational Behavior and Human Decision Processes", vol. 50 no. 2, pp. 179-211.

Babbitt C.W., Williams E., Kahhat R. (2011), Institutional disposition and management of end-of-life electronics, „Environmental Science & Technology", vol. 45 no. 12, pp. 5366-5372.

Bask A., Halme M., Kallio M., Kuula M. (2013), Consumer preferences for sustainability and their impact on supply chain management. The case of mobile phones, „International Journal of Physical Distribution & Logistics Management", vol. 43 no. 5/6, pp. 380-406.

Bask A., Kuula M. (2011), Measuring supply chain level environmental sustainability: case Nokia, „International Journal of Business Insights & Transformation", vol. 3 no. S3, pp. 16-24.

Baxter J., Gram-Hanssen I. (2016), Environmental message framing. Enhancing consumer recycling of mobile phones, „Resources, Conservation and Recycling", vol. 109, pp. 96-101.

Bickman L., Rog D.J. (eds.) (2008), The Sage handbook of applied social research methods, Sage Publications, London.

Borthakur A., Govind M. (2017), Emerging trends in consumers' E-waste disposal behaviour and awareness. A worldwide overview with special focus on India, „Resources, Conservation and Recycling", vol. 117, pp. 102-113.

Chin W.W. (1998), The partial least squares approach to structural equation modeling, „Modern Methods for Business Research", vol. 295 no. 2, pp. 295-336.

Cox J., Griffith S., Giorgi S., King G. (2013), Consumer understanding of product lifetimes, „Resources, Conservation and Recycling", vol. 79, pp. 21-29.

Davies J., Foxall G.R., Pallister J. (2002), Beyond the intention–behaviour mythology. An integrated model of recycling, „Marketing Theory", vol. 2 no. 1, pp. 29-113.

Desmet B., Hanquet G (2013), Rapport „Studie statiegeldsysteem AEEA" Möbius i.o.v. Recupel, https://www.nvmp.nl/uploads/pdf/research/2013%2005%2028%20Studie%20Statiegeldsysteem%20AEEA%20Recupel.pdf [03.11.2018].

De Young R. (1985-1986), Encouraging environmentally appropriate behavior. The role of intrinsic motivation, „Journal of Environmental Systems", vol. 15 no. 4, pp. 281-292.

De Young R. (2000), New ways to promote proenvironmental behavior. Expanding and evaluating motives for environmentally responsible behavior, „Journal of Social Issues", vol. 56 no. 3, pp. 509-526.

Do Valle P.O., Reis E., Menezes J., Rebelo E. (2004), Behavioral determinants of household recycling participation the Portuguese case, „Environment and Behavior", vol. 36 no. 4, pp. 505-540.

Fishbein M., Ajzen I. (1975), Belief, attitude, intention, and behavior. An introduction to theory and research, Addison-Wesley, Boston.

Fornell C., Larcker D. F. (1981), Evaluating structural equation models with unobservable variables and measurement error, „Journal of Marketing Research", vol. 18 no. 1, pp. 39-50.

Gartner (2015), Gartner says smartphone sales surpassed one billion units in 2014, https://www.gartner.com/newsroom/id/2996817 [03.11.2018].

Gneezy U., Meier S., Rey-Biel P. (2011), When and why incentives (don't) work to modify behavior, „The Journal of Economic Perspectives", vol. 25 no. 4, pp. 191-209.

Gursoy D., McCleary K.W., Lepsito L.R. (2007), Propensity to complain. Effects of personality and behavioral factors. „Journal of Hospitality & Tourism Research", vol. 31 no. 3, pp. 358-386.

Haenlein M., Kaplan A.M. (2004), A beginner's guide to partial least squares analysis, „Understanding Statistics", vol. 3 no. 4, pp. 283-297.

Henseler J., Ringle C.M., Sarstedt M. (2015), A new criterion for assessing discriminant validity in variance-based structural equation modeling, „Journal of the Academy of Marketing Science", vol. 43 no. 1, pp. 115-135.

Hobson K., Lynch N., Lilley D., Smalley G. (2018), Systems of practice and the Circular Economy. Transforming mobile phone product service systems, „Environmental Innovation and Societal Transitions", vol. 26, pp. 147-157.

Hopper J.R., Nielsen J.M. (1991), Recycling as altruistic behavior normative and behavioral strategies to expand participation in a community recycling program, „Environment and Behavior", vol. 23 no. 2, pp. 195-220.

Hornik J., Cherian J., Madansky M., Narayana C. (1995), Determinants of recycling behavior. A synthesis of research results, „The Journal of Socio-Economics", vol. 24 no. 1, pp. 105-127.

Hulland J., (1999), Use of partial least squares (PLS) in strategic management research. A review of four recent studies, „Strategic Management Journal", vol. 20 no. 2, pp. 195-204.

Jang Y.C., Kim M. (2010), Management of used & end-of-life mobile phones in Korea. A review, „Resources, Conservation and Recycling", vol. 55 no. 1, pp. 11-19.

Kissling R., Coughlan D., Fitzpatrick C., Boeni H., Luepschen C., Andrew S., Dickenson J. (2013), Success factors and barriers in re-use of electrical and electronic equipment, „Resources, Conservation and Recycling", vol. 80, pp. 21-31.

Lee K. (2008), Opportunities for green marketing: young consumers. „Marketing Intelligence & Planning", vol. 26 no. 6, pp. 573-586.

Li B., Yang J., Song X., Lu B. (2012), Survey on disposal behaviour and awareness of mobile phones in Chinese university students, „Procedia Environmental Sciences", vol. 16, pp. 469-476.

Malhotra N.K., Kim S.S., Agarwal J. (2004), Internet users' information privacy concerns (IUIPC). The construct, the scale, and a causal model, „Information Systems Research", vol. 15 no. 4, pp. 336-355.

Maragkos K.G., Hahladakis J.N., Gidarakos E. (2013), Qualitative and quantitative determination of heavy metals in waste cellular phones, „Waste Management", vol. 33 no. 9, pp. 1882-1889.

Martinho G., Magalhães D., Pires A. (2017), Consumer behavior with respect to the consumption and recycling of smartphones and tablets. An exploratory study in Portugal, „Journal of Cleaner Production", vol. 156, pp. 147-158.

McCarty J.A., Shrum L.J. (1994), The recycling of solid wastes. Personal values, value orientations, and attitudes about recycling as antecedents of recycling behavior, „Journal of Business Research", vol. 30 no. 1, pp. 53-62.

Merkies J. (2012), The lease society. The end of ownership, Cross Media Printing Unit, Brussel.

Navazo J.M.V., Méndez G.V., Peiró L.T. (2014), Material flow analysis and energy requirements of mobile phone material recovery processes, „The International Journal of Life Cycle Assessment", vol. 19 no. 3, pp. 567-579.

Nnorom I.C., Ohakwe J., Osibanjo O. (2009), Survey of willingness of residents to participate in electronic waste recycling in Nigeria. A case study of mobile phone recycling, „Journal of Cleaner Production", vol. 17 no. 18, pp. 1629-1637.

Nunnally J.C. (1978), Psychometric theory, 2nd ed., McGraw-Hill, New York.

NVMP (2016), http://www.nvmp.nl/ [17.05.2016].

Ongondo F.O., Williams I.D. (2011a), Greening academia. Use and disposal of mobile phones among university students, „Waste Management", vol. 31 no. 7, pp. 1617-1634.

Ongondo F.O., Williams I.D. (2011b), Mobile phone collection, reuse and recycling in the UK, „Waste Management", vol. 31 no. 6, pp. 1307-1315.

Paiano A., Lagioia G., Cataldo A. (2013), A critical analysis of the sustainability of mobile phone use, „Resources, Conservation and Recycling", vol. 73, pp. 162-171.

Pattaro E. (ed.) (2007), A treatise of legal philosophy and general jurisprudence. Vol. 1: The law and the right, Vol. 2: Foundations of law, Vol. 3: Legal institutions and the sources of law, Vol. 4: Scienta juris, legal doctrine as knowledge of law and as a source of law, Vol. 5: Legal reasoning, a cognitive approach to the law, Springer Science & Business Media, The Hague.

Phelps J., Nowak G., Ferrell E. (2000), Privacy concerns and consumer willingness to provide personal information, „Journal of Public Policy & Marketing", vol. 19 no. 1, pp. 27-41.

Polák M., Drápalová L. (2012), Estimation of end of life mobile phones generation. The case study of the Czech Republic, „Waste Management", vol. 32 no. 8, pp. 1583-1591.

Queiruga D., Benito J.G., Lannelongue G. (2012), Evolution of the electronic waste management system in Spain, „Journal of Cleaner Production", vol. 24, pp. 56-65.

Ryan R.M., Deci E.L. (2000), Intrinsic and extrinsic motivations. Classic definitions and new directions, „Contemporary Educational Psychology", vol. 25 no. 1, pp. 54-67.

Sabbaghi M., Behdad S., Zhuang J. (2016), Managing consumer behavior toward on-time return of the waste electrical and electronic equipment. A game theoretic approach, „International Journal of Production Economics", vol. 182, pp. 545-563.

Saphores J.D.M., Ogunseitan O.A., Shapiro A.A. (2012), Willingness to engage in a pro-environmental behavior. An analysis of e-waste recycling based on a national survey of US households, „Resources, Conservation and Recycling", vol. 60, pp. 49-63.

Schultz P.W., Oskamp S., Mainieri T. (1995), Who recycles and when? A review of personal and situational factors, „Journal of Environmental Psychology", vol. 15 no. 2, pp. 105-121.

Shaw P.J., Maynard S.J. (2008), The potential of financial incentives to enhance householders' kerbside recycling behavior, „Waste Management", vol. 28 no. 10, pp. 1732-1741.

Shieh G. (2011), Clarifying the role of mean centring in multicollinearity of interaction effects, „British Journal of Mathematical and Statistical Psychology", vol. 64 no. 3, pp. 462-477.

Smith H.J., Milberg S.J., Burke S.J. (1996), Information privacy. Measuring individuals' concerns about organizational practices, „MIS Quarterly", vol. 20 no. 2, pp. 167-196.

Speake J., Yangke L.N. (2015), „What do I do with my old mobile phones? I just put them in a drawer". Attitudes and perspectives towards the disposal of mobile phones in Liverpool, UK, „Human Geographies-Journal of Studies & Research in Human Geography", vol. 9 no. 2, pp. 241-260.

Subramanian N., Gunasekaran A. (2015), Cleaner supply-chain management practices for twenty-first-century organizational competitiveness. Practice-performance framework and research propositions, „International Journal of Production Economics", vol. 164, pp. 216-233.

Tanskanen P. (2013), Management and recycling of electronic waste, „Acta Materialia", vol. 61 no. 3, pp. 1001-1011.

Wang Z., Zhang B., Yin J., Zhang X. (2011), Willingness and behavior towards e-waste recycling for residents in Beijing city, China, „Journal of Cleaner Production", vol. 19 no. 9, pp. 977-984.

Wilson, G. T., Smalley, G., Suckling, J. R., Lilley, D., Lee, J., Mawle, R. (2017), The hibernating mobile phone: Dead storage as a barrier to efficient electronic waste recovery, „Waste Management", vol. 60, pp. 521-533.

Yin J., Gao Y., Xu H. (2014), Survey and analysis of consumers' behaviour of waste mobile phone recycling in China, „Journal of Cleaner Production", vol. 65, pp. 517-525.

Ylä-Mella J., Keiski R.L., Pongrácz E. (2015), Electronic waste recovery in Finland. Consumers' perceptions towards recycling and re-use of mobile phones, „Waste Management", vol. 45, pp. 374-384.

APPENDIX

Table A1. Mobile phone ownership and use among respondents

	Average ownership			Average use			Average e-waste			Tot. resp.
	Smart-phone	Standard	Total	Smart-phone	Standard	Total	Smart-phone	Standard	Total	
Gender										
Male	1.66	1.47	3.13	0.96	0.26	1.22	0.70	1.21	1.91	53
Female	1.57	1.08	2.65	0.98	0.10	1.08	0.59	0.98	1.57	48
Age										
≤ 24	1.73	1.10	2.83	1.00	0.10	1.10	0.73	1.00	1.73	60
25-49	1.83	1.57	3.40	1.00	0.17	1.17	0.83	1.40	2.23	23
≥ 50	0.94	1.56	2.50	0.83	0.50	1.33	0.11	1.06	1.17	18
Educational level										
Sec.(voc) education	1.30	1.30	2.60	0.91	0.30	1.21	0.39	1.00	1.39	33
Higher education	1.76	1.28	3.04	1.00	0.13	1.13	0.76	1.15	1.91	68
Annual income										
< €15k	1.76	1.11	2.87	0.98	0.09	1.07	0.78	1.02	1.80	45
€15k-45k	1.70	1.40	3.10	1.00	0.20	1.20	0.70	1.20	1.90	30
> €45k	1.33	1.83	3.16	1.00	0.42	1.42	0.33	1.41	1.74	12
n.a.	1.21	1.14	2.35	0.86	0.29	1.15	0.35	0.85	1.20	14

Source: authors' own research.

Table A2. Moderated regression analysis of the effect of age

Constructs	Model 1	Model 2	Model 3	VIF
Independent variables				
Personal satisfaction	0.203**	0.162*	0.184	2.629
Social influence	0.123	0.144*	-0.054	2.734
Knowledge	0.412***	0.362***	0.346***	1.600
Monetary rewards	-0.219**	-0.224**	-0.267**	2.159
Inconvenience	-0.236***	-0.241***	-0.172**	2.068
Privacy concern	0.120*	0.113*	0.175**	2.061
Moderating variable				
25-49		-0.143	-0.168	2.281
≥ 50		-0.006	-0.087	2.243
Interactions				
Personal satisfaction x 25-49			-0.052	1.827
Social influence x 25-49			0.400*	2.054
Knowledge x 25-49			-0.190	2.127
Monetary rewards x 25-49			0.027	2.446
Inconvenience x 25-49			-0.364*	2.962
Privacy concern x 25-49			0.184	5.638
Personal satisfaction x ≥ 50			-0.003	2.490
Social influence x ≥ 50			0.565**	3.691
Knowledge x ≥ 50			0.070	2.302
Monetary rewards x ≥ 50			0.039	1.761
Inconvenience x ≥ 50			0.279	3.605
Privacy concern x ≥ 50			-0.589***	4.039
R^2	0.421	0.421	0.566	
Adjusted R^2	0.384	0.370	0.458	
F-value	11.280***	8.352***	5.220***	
ΔR^2	-	-	0.145	

Source: authors' own research.
*p < 0.10, **p < 0.05, ***p < 0.01

Table A3. Moderated regression analysis of the effect of educational level

Constructs	Model 1	Model 2	Model 3	VIF
Independent variables				
Personal satisfaction	0.203**	0.164*	0.163	4.201
Social influence	0.123	0.143*	0.037	3.742
Knowledge	0.412***	0.377***	0.283	4.224
Monetary rewards	-0.219**	-0.234***	-0.278**	3.094
Inconvenience	-0.236***	-0.228***	-0.187*	3.319
Privacy concern	0.120*	0.121*	-0.048	3.977
Moderating variable				
Higher education		0.108	0.100	1.075
Interactions				
Personal satisfaction x High edu			0.108	3.604
Social influence x High edu			0.156	3.456
Knowledge x High edu			0.153	3.983
Monetary rewards x High edu			-0.002	3.128
Inconvenience x High edu			-0.019	3.219
Privacy concern x High edu			0.238*	4.058
R^2	0.421	0.421	0.478	
Adjusted R^2	0.384	0.376	0.400	
F-value	11.280***	9.618***	6.120***	
ΔR^2	-	-	0.058	

Source: authors' own research.
*p < 0.10, **p < 0.05, ***p < 0.01

Table A4. Moderated regression analysis of the effect of annual income

Constructs	Model 1	Model 2	Model 3	VIF
Independent variables				
Personal satisfaction	0.203**	0.205**	0.363**	3.827
Social influence	0.123	0.090	-0.206*	3.726
Knowledge	0.412***	0.451***	0.480***	2.319
Monetary rewards	-0.219**	-0.215**	-0.240**	2.387
Inconvenience	-0.236***	-0.234***	-0.192**	2.561
Privacy concern	0.120*	0.113*	0.166**	2.388
Moderating variable				
€15.001- €45.000		0.183	0.059	1.532
> €45,001		-0.116	-0.374	1.870
n.a.		-0.190	-0.213	3.241
Interactions				
Personal satisfaction x 15.001-45.000			-0.157	1.965
Social influence x 15.001-45.000			0.428**	1.885
Knowledge x 15.001- 45.000			-0.349	1.778
Monetary rewards x 15.001-45.000			0.043	1.808
Inconvenience x 15.001-45.000			0.375*	3.484
Privacy concern x 15.001-45.000			-0.366**	3.414
Personal satisfaction x > 45,001			-0.117	1.875
Social influence x > 45,001			0.641**	2.313
Knowledge x > 45,001			-0.370	4.864
Monetary rewards x > 45,001			0.128	4.291
Inconvenience x > 45,001			-0.501**	2.244
Personal satisfaction x n.a.			-0.149	8.789
Social influence x n.a.			0.911**	10.09
Knowledge x n.a.			-0.193	1.884
Monetary rewards x n.a.			0.348	3.118
Inconvenience x n.a.			0.352*	3.408
Privacy concern x n.a.			-0.550**	3.344
R^2	0.421	0.438	0.615	
Adjusted R^2	0.384	0.382	0.478	
F-value	11.280***	7.785***	4.493***	
ΔR^2	-	0.017	0.178	

Source: authors' own research.

*p < 0.10, **p < 0.05, ***p < 0.01

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An outline economic strategy for Indonesia to sustainably meet its electricity and carbon emissions targets

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Abstract:

Aim: In this paper we demonstrate an outline strategy for Indonesia to move its electrical generation from fossil fuels to renewable sources in order to reduce carbon dioxide emissions whilst avoiding excessive costs. The modelling here is based on assumed present fossil fuel generating plants.

Design / Research methods: We have modelled a representative electrical generation system based on burning coal, oil and gas, and by replacing retiring stations with photovoltaic cells and wind turbines we have considered the cost and carbon dioxide implications over a 30 year period. Additionally the modelling is extended to increasing the Indonesian installed electrical capacity.

Conclusions / findings: The results show that Indonesia could meet its carbon dioxide emission reduction targets in an economic way by a phased strategy of introducing renewable energy sources. These results are preliminary and will be refined in a future article where we will include the detail of actual existing power stations, with their capacity and anticipated end of life date.

Originality / values of the article: There has been, and continues to be, a general resistance to the adoption of renewable energy. This paper shows the economic benefit that accompanies carbon dioxide reduction, and thus brings a new aspect to the consideration of carbon reduction,

Implications of the research: Indonesia faces difficulties in providing electricity whilst meeting its climate change obligations. This research points to a viable economic strategy which may not only meet those obligations, but actually increase electrical provision across the country.

Key words: *Sustainable development, climate change, carbon emissions, renewable energy*

JEL: C51, L94, Q01, Q42

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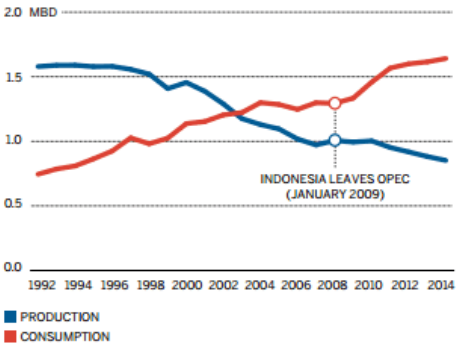
1. Introduction

The current use of conventional energy. Indonesia has a particularly difficult challenge of providing low carbon energy, particularly in the electricity sector, due to its geographical, demographical and socio-economic factors. Reserves of oil and gas, are being rapidly depleted, making Indonesia's energy security weak as she has to import both oil and gas. Because electrical power generation is dominated by coal, gas and oil and takes the substantial portion of the national oil subsidy, a strategy to shift from fossil fuels to renewable energy is necessary. With much lower green-house gas emissions, renewable energy sources will also help Indonesia to fulfil its carbon emission reduction target.

Having a population of around 264 million in 2017 spread across 17,500 islands has placed Indonesia as the 4th most populous in the world. In addition, according to the United Nations Convention on the Law of the Sea (UNCLOS) meeting on August 2017, this archipelagic country is the 7th largest country by sea and land area.

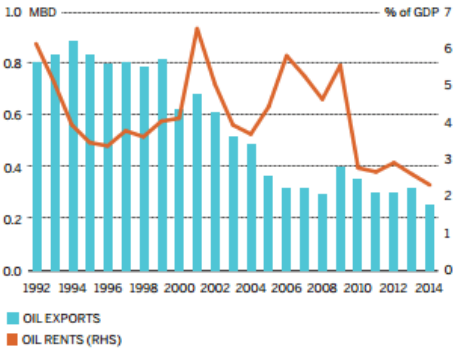
The rapidly growing oil demand coupled with the continued decrease of oil production has placed Indonesia as net oil importer country since 2004. The falling oil production might be caused by the limited investment in new oil exploration and the lack of rejuvenation of existing oil sites. Although a founding member of OPEC, the geopolitical factors and the fluctuating world oil situation forced Indonesia to make a strategic decision to suspend its OPEC membership in January 2009 (see Figure 1). However, Indonesia re-joined OPEC in 2014 although still been bearing the status of a net oil importer (BP Statistical Review of World Energy 2015).

FIGURE 1
Indonesian Oil Production and Consumption



Source: BP Statistical Review of World Energy 2015

FIGURE 2
Indonesian Oil Rents and Exports



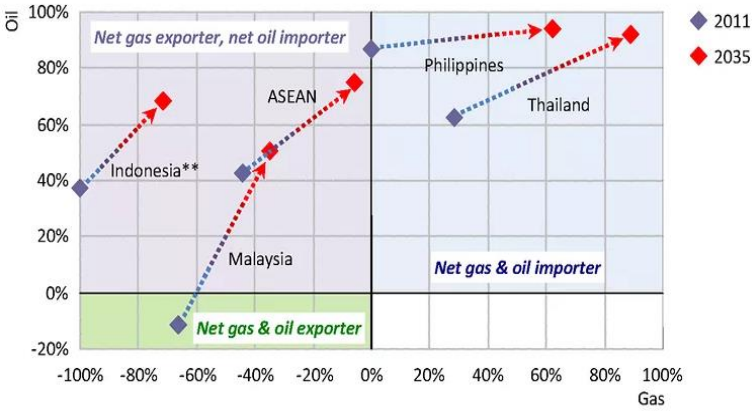
Sources: OPEC and World Bank

Less than a year after re-joining OPEC, Indonesia reconsidered its membership in OPEC due to the internal pressure to limit oil production for OPEC members. In this case, Indonesia would cut the oil production by 5,000 barrels per day (bpd) instead of 37,000 bpd required by OPEC. This disagreement forced Indonesia to leave OPEC for the second time. In regards to oil exports, the gradual decrease in oil rents[1] and exports can be seen in Figure 2.

Besides being a net oil importer, Indonesia could follow a similar story for liquefied natural gas (LNG), becoming a net LNG importer in the next ten years or less. At this time, Indonesia is still a net LNG exporter and ranks 5th highest in the world for LNG exports with 16.6 million tons/year and a market share of 6.4% (IHS Market, IGU 2017). Nonetheless, Indonesia is projected to be net LNG importer by 2022. In regards to net importer/exporter status, Figure 3 and Figure 4 shows the Indonesian position in ASEAN and in the World. The projections show Indonesia becoming more dependent on oil and gas imports and thus more vulnerable to World prices.

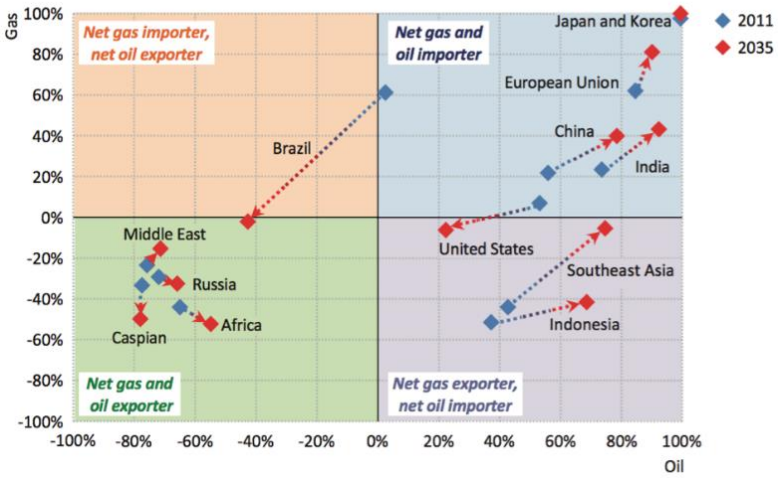
[1] By definition, oil rents reflect the difference between the world price of oil production and total costs of production. Each country in Asia has diverse oil rents value as % of its GDP. It is estimated based on sources and methods described in "The Changing Wealth of Nations: Measuring Sustainable Development in the New Millennium" (World Bank 2011).

Figure 3. Net oil and gas imports as a share of demand[2]



Source: Authors' own elaboration based on WEO (2013).

Figure 4. Net oil and gas imports/exports shares in selected regions in the New Policies Scenario



Source: Authors' own elaboration based on WEO (2013).

In regards to coal, Indonesia is the 5th highest rank in the World, after China, USA, Australia and India, with an annual production of 255.7 million tons oil equivalent (MTOE) (BP Statistics 2017). Since Indonesia has targeted greenhouse

[2] Import shares for each fuel are calculated as net imports divided by primary demand while export shares is net exports divided by production. A negative number indicates net exports. Southeast Asia covers ASEAN region, includes Indonesia.

gas emission reduction, up to now, using coal as a source of electricity generation has been highly contentious. On one hand, using coal as power generation is considered more practical because Indonesia has abundant coal coupled with low production costs. It is argued that coal in Indonesia is relatively "clean" because it is has a low (0.1 to 1 %) sulphur content and is processed using clean coal technologies. The development of coalbed methane (CBM) reservoirs at the upstream side has attracted many players recently. In addition, though renewable energy resources have been promoted to help meet emission reduction targets, there is no clear indication for the significant reduction of coal utilization in the foreseeable future. Moreover, global markets still demand a substantial amount of coal which Indonesia exports at around 70-80 % of its coal production. Indonesian coal commands a relatively high price. In regards to mid-long term national energy planning, according to the Ministry of Energy and Mineral Resources (2016) coal will contribute about 30% to the energy mix in 2025; 6% higher than in 2011. This is in contradiction with Indonesia ratifying the Paris Agreement on carbon emission reduction at the substantial level of 29% by 2030.

The commitment to climate change reduction (COP21). The Paris Accord (COP21) gained support from around 197 countries in December 2015, and these countries have ratified their commitment to the Accord and will act to restrict the increase in average surface temperature of the World to 1.5C. This is regarded as a vital target as it is a tipping point beyond which we may not be able to stabilize the World climate. Notably, US President Trump has withdrawn the US from COP21. The commitment to reduce carbon emission about 29 % by 2030 has forced Indonesia to plan for the deployment of low carbon energy. The increase of coal in Indonesia's energy mix 2025 is therefore a paradoxical policy, with unclear strategies in each Ministry and among Ministeries to achieve the emission reduction target.

Electricity provision. Indonesia has strived for more sustainable and environmentally benign energy in recent years. The commitment can be seen in Indonesia's energy mix 2025 in comparison with 2011. By setting the substantial increase in the renewable energy share to 26 % by 2025 in contrast with 6% in 2011, the government has demanded a substantial growth in renewable energy

deployment. Unfortunately, the acceleration for renewable energy deployment, particularly electricity generation, is not as fast as the "written" plan. The growing pressure over the use of clean energy has pushed Indonesia to reduce its power generation from coal, according to Ministry of Energy and Mineral Resources,

The current picture of electricity (Cornot-Gandolphe 2017): About 89% of electricity is provided by fossil fuels and the rest from hydro and geothermal. In 2010 only 68% of the population had access to electricity, by 2014 this number had risen to 84%. This means that people living on many of the islands still have no access to electricity. Meanwhile, the growth in demand (at 7.1% per year since 2010) for electricity continues to strain the existing network. Power capacity has doubled in the past decade from 27GW to 55.5GW at the end of 2015. Coal is the largest contributor at 56%, and possibly growing, whereas the government's policy to phase out the use of oil has seen a reduction in the consumption of diesel.

In this paper we demonstrate an outline strategy for Indonesia to move its electrical generation from fossil fuels to renewable sources in order to reduce carbon dioxide emissions whilst avoiding excessive costs. The modelling here is based on assumed present fossil fuel generating plants.

2. Options for replacing fossil fuels

This paper examines the options for both replacing and augmenting Indonesia's existing power stations. We look at the economics of operating each power plant to its end of life and then replacing its capacity with a renewable low carbon power plant selected from PV, wind, biomass, wave or hydro.

Nuclear. Nuclear and renewable energy technologies are "low carbon" energy sources which release much less carbon dioxide per kWh than fossil fuels. However, nuclear sources are potentially dangerous because of the radioactivity associated with their operation, decommissioning and waste management. Beyond this, the cost of new build nuclear power stations is proving to be much higher than renewable sources. Hinckley Point C in the UK is under construction by a consortium led by EDF (Electricite de France). The UK Government has guaranteed the consortium

£92.5/MWh (US$120/MWh) for 35 years. This is about twice the current cost of UK electricity, and the predictions about the cost of renewables suggest that by the time that Hinckley Point C is commissioned in 2027 this guarantee will be several times higher than the unit cost of PV or wind generated electricity.

Photovoltaic. Photovoltaic (PV) electricity is generated by converting solar energy into Direct Current (dc) electricity. This dc electricity can be stored in batteries and then converted into Alternating Current (ac) electricity by passing it through an inverter. In this case, Indonesia enjoys high solar insolation and so is an ideal candidate for exploiting PV technology. An obvious problem is the lack of output during the night and periods of low sunlight. To some extent the batteries can alleviate this difficulty.

Wind. Wind-generated electricity is produced by wind turbines of various sizes. Some wind turbines are small and can cater for a small remote community by generating a few kilo-Watts (kW) of electricity A recent development is extremely large diameter two-bladed rotors mounted on a high tower, which can produce multi Mega-Watts (MW) ac outputs. As with PV, wind turbines offer a good option for Indonesia across its numerous islands, but with the obvious difficulty of the intermittency of wind.

Others. Other renewables include tidal, hydro, wave and biomass, but in general geothermal, PV and wind are the most immediately viable technologies for Indonesia, with these others potentially contributing on some islands in the future.

3. Economic considerations

The range of cost of electricity generation from renewable and conventional energy sources can be seen in Table 1. There are some advantages by applying the model of the levelized cost of energy (LCOE) because this model provides us the net present value (NPV) of the (total) costs divided by the amount of energy generated in the whole life cycle of the project. Table 1 is taken from the 10th annual review of electricity costs (Lazard 2016), which clearly shows the lowest range of costs are

available from wind technology. These costs are based on US technology and conditions.

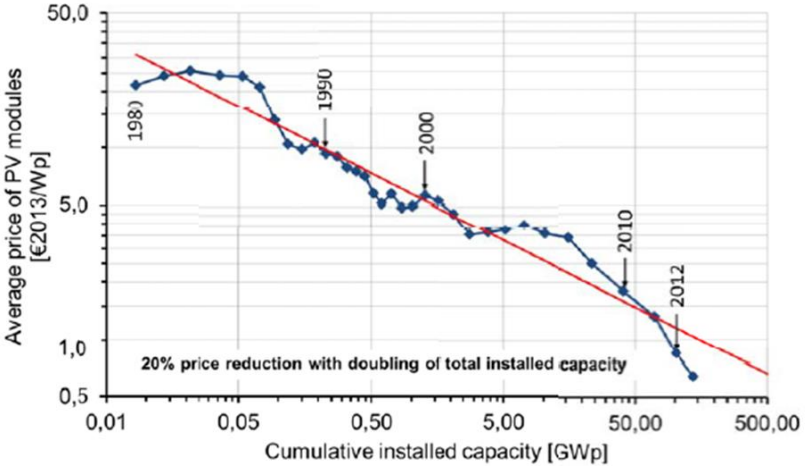
Table 1. Levelized cost of electricity generated from various sources

Renewable Energy	Cost US$/MWh		.	Conventional Energy	Cost US$/MWh	
	Min	Max			Min	Max
Solar PV residential	138	222				
Solar PV Rooftop C&I	88	193		Diesel ICE	212	281
Solar PV Community	78	135		Gas ICE	68	101
PV crystalline utility	49	61		Gas Peaking	165	217
PV thin film utility	46	56		Nuclear	97	136
Biomass	77	110		Coal	60	143
Microturbine	76	89		Gas CC	48	78
Geothermal	79	117				
Wind	32	62				

Sources: Lazard (2016).

Although PV requires substantial capital costs, resulting in high levelized costs, this source stills looks attractive. Lazard (2016) reports that the costs of PV and wind have been falling for ten years, and can be expected to continue to drop as maturing technologies become more efficient, and as mass production reduces manufacturing costs. Figure 5 shows the reduction in costs for PV falls by 20% for each doubling of installed capacity. However, the intermittency of both solar and wind resources creates problems with the grid, which Lazard states will require the continued employment of some fossil fuel power stations to meet the demand in the absence of PV or wind.

Figure 5. Historical development of the cost of PV modules

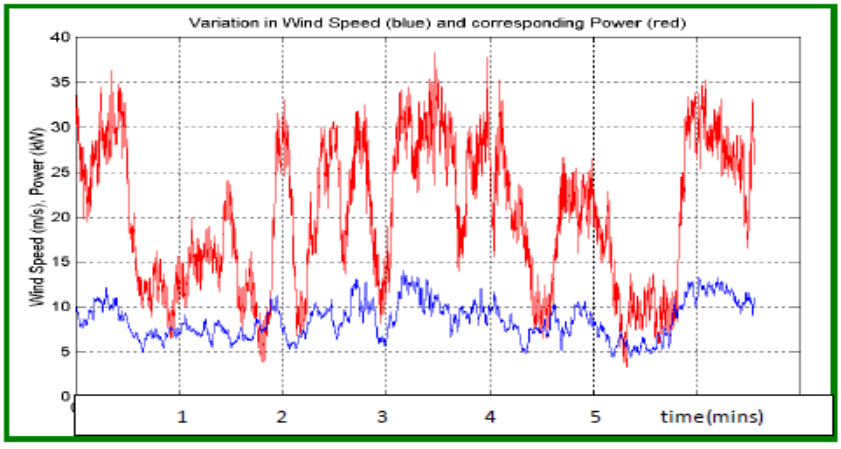


Source: Authors' own elaboration based on Fraunhofer Institute (2016).

4. Economics of intermittency

Alternatives to retaining fossil fuel power stations on the grid are to use smart grids to match supply to demand and/or to include energy storage. In fact, energy storage is essential where PV or wind are the energy providers.

Figure 6. Example of wind speed and associated instantaneous power against time



Source: Authors' own elaboration.

To illustrate this, consider Figure 6, where the wind speed varies quite extensively over a period of a few minutes. The output from a wind turbine is related to the cube of wind speed and so the power output varies by a factor of 7:1 during the few minutes of the record. Short term battery storage over minutes can help to smooth this power output. In order to meet the demand over a 24 hours period, long-term battery storage can be used. The energy storage developers in the U.S. installed 336 MWh of storage in 2016, double the amount from the previous year. This means that about 3% of the US daily electricity generated could be stored. By 2022, US energy storage installations are expected to reach 7,300 MWh, capable of storing 65% of the daily electrical generation, and generating annual revenues of $3.3 billion. The technical value of such storage is that it supports and thus permits reliance on variable inputs from renewables such as wind and PV. Lithium-ion batteries made up 98.4 percent of the U.S. energy storage market in the last quarter of 2016. Lithium-ion battery prices have fallen 73% since 2010, due to improvements in technology and scaling by manufacturers. Battery prices as a whole have declined 40 percent since 2014 (Greene, Barrow 2017). In this paper, though, we have not included additional energy storage beyond that incorporated into PV systems. In the first 15 years of the modelling this is reasonable because we will retain a major contribution from fossil fuels, which provide inherent storage. In a future paper we will model more rapid adoption of renewables and therefore will address the storage question in more detail.

5. Methodology

In this research, we assume that the present electrical generation in Indonesia comes from gas, coal and oil fueled plants in equal numbers, as this reasonably represents the cost and emissions from the power stations in Indonesia. Further, we assume that due to their different ages that they are due for decommissioning at various dates over the next 30 years. We have taken a typical installed capacity of 800MW for each of these plants to demonstrate the feasibility of a GHG reduction strategy. We will introduce more detail of generating plant capacities, costs,

emissions and scheduled end of life in subsequent modelling and a future paper. In this modeling we have used the US cost data from Lazard (2016), capacity factor, greenhouse gas emissions, as CO_2eq and cost of the energy sources are given in table 2. Note that the low capacity factors for wind and PV reflect the reliance of these sources on the intermittent availability of wind and sun, whereas the other energy sources are limited only by technical aspects of their operations such as repair and maintenance periods, and so have capacity factors close to 1 (or 100%).

Table 2. Energy source (fossil and renewable), capacity factor, greenhouse gas emissions, and cost

Energy Source	capacity factor		
		CO_2 eq T/MWh	$/MWh
gas	0.9	0.4	85
coal	0.85	1	105
oil	0.8	0.85	120
PV	0.25	0.02	55
wind	0.3	0.02	47
biomass	0.9	0.02	94
hydro	0.7	0.02	83

Source: Lazard (2016).

6. Modelling a strategy for Indonesia

We suggest a conversion strategy from fossil fuels to renewable over a period of 30 years to 2050. This relies on continuing operation of fossil fuel power stations until each one reaches its scheduled end of life, or earlier if the economics and climate change gas emissions are improved. On the other hand, gradual investment in primarily PV and wind farms replace those decommissioned fossil fuel plants. We present three scenarios.

A) Business as usual (BAU), in which only fossil fuel plants are used into the future, and are replaced by new fossil fuel plants when necessary.

B) Matching decommissioned fossil fuel plants with PV, wind farms, biomass and hydro.

C) An expansion of the Indonesian electricity provision by adding more PV and wind than in scenario B.

Results

A) Scenario Business as usual

Figure 7. (A) annual output

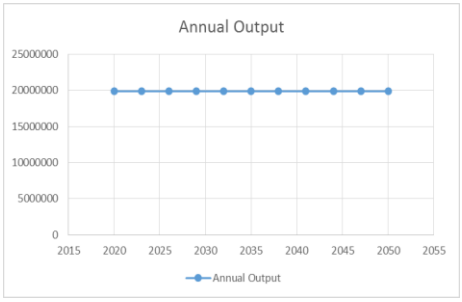
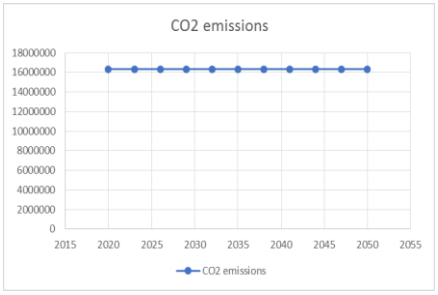


Figure 8. (A) CO_2 emissions



Source: Authors' own elaboration

The BAU scenario shows a constant annual output and CO2 emissions

B) Matching decommissioned fossil fuel plants with PV and wind farms

Figure 9. (B) Output

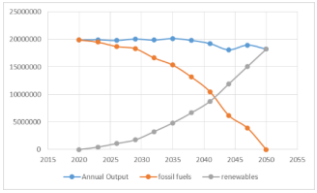


Figure 10. (B) CO_2

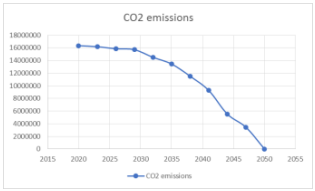


Figure 11. (B) Cost

Source: Authors' own elaboration

By introducing PV and wind to replace obsolete or retired fossil fuel plant the CO_2 emissions can be reduced to near zero by 2050, whilst the total cost of energy falls by about 30% over the same period.

C) An expansion of the Indonesian electricity provision

Figure 12. (C) Output

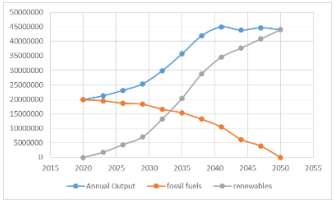


Figure 13. (C) CO_2

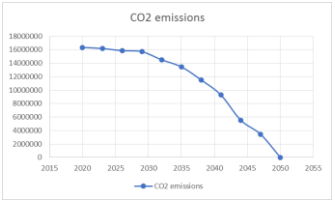


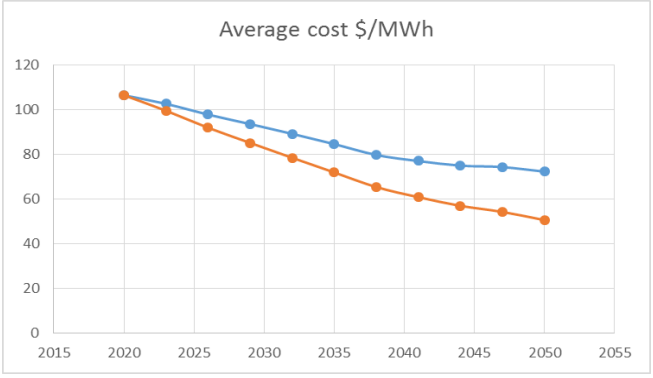
Figure 14. (C) Cost

Source: Authors' own elaboration

By more than simply replacing fossil fuel plants with renewable capacity, this scenario shows a 125% increase in electricity capacity and a near zero CO_2 emission over 30 years period. The total cost increased by only 66%.

The third scenario could be made more representative by including the falling cost of renewables. For example, there is evidence that PV costs drop by 20% each time the installed capacity doubles. Thus, the average electricity cost will approximately half by 2050. Figure 15 shows scenario C) as calculated above and with the cost of PV reducing due to improved performance efficiency and production efficiency.

Figure 15. The average cost of electricity in scenario (C)



Source: Authors' own elaboration
Note: The lower curve assumes a falling PV cost

We have not made any provision here for the cost of storage to smooth out the delivered electricity over short periods or to match output to demand. It is conceivable that individual houses fit PV panels, or have wind turbines, or have storage batteries, whilst being connected to the grid. On the other hand, renewables are extremely suitable for dispersed deployment. A community could install its own small grid together with storage. Thus, providing electricity on previously unconnected islands would not require extension of the national grid.

7. Conclusion

Indonesia can meet its commitment to COP21 by adopting a strategy of gradually replacing its fossil fuel generating power plants with PV and wind farms. This modeling suggests that the total annual cost of electricity provision will be reduced. On the other hand, by spending 66% more, the expansion scenario suggests that the electricity capacity would be increased by 125%.

References

Arshad A. (2016), Indonesia's Parliament ratifies Paris Agreement on Climate Change, The Straits Times, http://www.straitstimes.com/asia/se-asia/indonesias-parliament-ratifies-paris-agreement-on-climate-change [15.08.2017].

BP Statistical Review of World Energy 2015 (2015), https://www.bp.com/content/dam/bp-country/es_es/spain/documents/downloads/PDF/bp-statistical-review-of-world-energy-2015-full-report.pdf.

Chevron (2017), The world depends on natural gas, World LNG Report 2017 edition, International Gas Union (IGU), https://www.igu.org/sites/default/files/103419-World_IGU_Report_no%20crops.pdf [15.08.2017].

Cornot-Gandolphe S (2017), Indonesia's electricity demand and the coal sector. Export or meet domestic demand?, The Oxford Institute for Energy Studies OIES paper CL5, https://www.oxfordenergy.org/wpcms/wp-content/uploads/2017/03/Indonesias-Electricity-Demand-and-the-Coal-Sector-Export-or-meet-domestic-demand-CL-5.pdf [07.12.2018].

Fraunhofer Institute (2016), Photovoltaics Report 2016, Fraunhofer Institute for Solar Energy Systems, ISE with support of PSE AG Freiburg, www.ise.fraunhofer.de [01.03.2018].

Green B.C., Barrow D.M. (2017), Financing energy storage projects. Assessing risks – part one, http://www.renewableenergyworld.com/articles/2017/07/financing-energy-storage-projects-assessing-risks-part-one.html [21.09.2018].

Index Mundi (2017), Oil rents (% of GDP) – Asia, https://www.indexmundi.com/facts/indicators/NY.GDP.PETR.RT.ZS/map/asia [15.08.2017].

Indonesia Investments (2017a), How many islands does Indonesia have? Government to count, https://www.indonesia-investments.com/news/todays-headlines/how-many-islands-does-indonesia-have-government-to-count/item7898? [15.08.2017].

Indonesia Investments (2017b), Coal, https://www.indonesia-investments.com/business/commodities/coal/item236? [15.08.2017].

Indonesia Population (2017), Worldometers. Population, http://www.worldometers.info/world-population/indonesia-population/ [15.08.2017].

Jaquith C. (2016), Levelized cost of energy analysis 10.0, https://www.lazard.com/perspective/levelized-cost-of-energy-analysis-100/ [15.08.2017].

Jensen F., Asmarini W. (2016), Net oil importer Indonesia leaves producer club OPEC, again, https://www.reuters.com/article/us-opec-meeting-indonesia/net-oil-importer-indonesia-leaves-producer-club-opec-again-idUSKBN13Q3M7 [15.08.2017].

Lazard (2016) Levelised cost of energy 10th report, https://www.lazard.com/perspective/levelized-cost-of-energy-analysis-100/ [07.12.2018].

OPEC (2015), Welcome back, Indonesia! OPEC bulletin commentary, http://www.opec.org/opec_web/en/press_room/3403.htm [15.08.2018].

Singgih V.P. (2017), Indonesia projected to become net LNG importer by 2022, The Jakarta Post, http://www.thejakartapost.com/news/2017/05/29/indonesia-projected-to-become-net-long-importer-by-2022.html [15.08.2017].

Van Noordwijk M. et al. (2014), Reducing emissions from land use in Indonesia. Motivation, policy instruments, and expected funding streams, „Mitigation and Adoption Strategies for Global Change", vol. 19 no. 6, pp. 677-692.

WEO (2013), Special report. Southeast Asia energy outlook, International Energy Agency (IEA), https://webstore.iea.org/weo-2013-special-report-southeast-asia-energy-outlook [07.12.2018].

World Bank (2011), The changing wealth of nations. Measuring sustainable development in the New Millennium. Environment and Development, https://openknowledge.worldbank.org/handle/10986/2252 [15.08.2017].

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The European Neighborhood Policy: a perspective of the partner countries[1]

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Abstract:

Aim: The aim of the paper is an analysis and assessment of the partner-countries' various positions and interests with regard to the European Neighborhood Policy (ENP). The focus was put on expectations and reservations related to ENP in the partner countries.

Design/ research method: The analysis is based on the subject literature related to the ENP. The paper comprises three parts. The first one depicts general geopolitical overview of the ENP. Second part concentrates on partner countries different approaches towards the initiative and the third section is an attempt to examine the neighboring countries' conflicting visions towards the ENP.

Conclusions: The widespread criticism of the outcomes of the ENP is a result of grave geopolitical turbulences, i.e.: the Mediterranean partners have experienced the Arab Spring uprisings and the Eastern neighbors have again found themselves in the orbit of particular interests of Russia. The partner countries' visions and expectations towards the ENP are very diverse. Some of them seek to achieve economic benefits without closer political relations with the EU, others strive to achieve membership in the EU which is perceived as an inherent element of the process of successful reforms and systemic transformation.

Value of the article: The paper addresses the problem of declining the ENP. The reason is twofold: contradictory interests of the partner countries and second, floppy engagement of the UE's institutions in forging of the ENP policy.

Limitations of the research: The analysis is limited to general political tendencies and line of actions addressed by the ENP partner countries. It resulted both from changes in the ENP agenda as well as international relations and internal turbulences in the regions.

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1. Introduction

There is growing negative assessment among the EU's partner countries towards the outcomes of the European Neighborhood Policy (ENP). It resulted from different objectives and expectations towards the program against the provisions put by the EU. Some of the countries strive to achieve closer economic benefits with the EU without aspiring to membership, others seek to attain an accession to the EU which is to be accompanied by successful socio-economic reform and systemic transformation. Instead the EU expresses its willingness to engage with selective ENP members much more on the basis of close association than membership. Additionally the widespread criticism is a consequence of geopolitical turbulences and military crisis in the countries covered by the ENP, i.e.: the Mediterranean partners have experienced the turmoil of the Arab Spring and the Eastern neighbors have again found themselves in the orbit of particular interests of Russia, the apogee of which is the armed conflict in the Eastern Ukraine. The EU is accused of not engaging in resolution of the crisis and the lack of adequate response.

The ENP covers numerous countries from Eastern Europe, Southern Caucasus, North Africa and Middle East which are very diverse and heterogeneous. Many of the partners have never agreed with the proposed "neighborhood" formula and its scope and have failed to make substantial progress in economic, social and political modernizations. Therefore the aim of the paper is the analysis and examination of the partner-countries' various positions and interests with regard to the ENP. The key point is to find the root-causes of their divergent expectations and reservations towards the ENP. The paper comprises three parts. In the first one there was depicted general geopolitical overview of the ENP. Second part concentrates on partner countries different approaches towards the initiative and the third section is an attempt of synthetic analysis of the neighboring countries conflicting visions within the ENP.

2. ENP in a nutshell

The ENP was launched in 2004 with the aim of building new political and economic relations between the EU and its Southern and Eastern neighboring countries through supporting of introduction of reforms and systemic changes in the partner countries. In the South the initiative covered 10 countries: Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syria and Tunisia and in the East 6 states: Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine. The main objective of the ENP was to avoid the emergence of new dividing lines between the enlarged EU and its neighbors by engaging of the partner countries in negotiation of reform priorities leading to good governance, rule of law, trade liberalization and civil society representation. The ENP was to go beyond traditional financial assistance provided to the neighboring countries and was assumed to be better suited to the challenges in particular regions. The EU's offer was based on two pillars. First, it was the EU political and economic engagement pledged to increase funds within the ENP programs. Second, it was to be a platform for better economic and political cooperation between the EU as a whole and the partner countries.

The Southern dimension of the ENP was built upon the initiatives of the Barcelona Process and was reinforced by the Union for the Mediterranean (UfM). The latter was established upon the initiative of French President Nicolas Sarkozy in 2008 and has replaced the Euro-Mediterranean Partnership (EMP) which was laid down within the framework of the Barcelona Process. However the ENP and the UfM does not overlap in terms of their membership. It means that Bosnia and Herzegovina, Albania, Montenegro, Monaco, Mauritania and Turkey are members of the UfM but not part of the ENP.

Under the EMP formula there were introduced ambitious long-lasting programs on political, economic and cultural co-operation between the 15 EU Member states and 12 Mediterranean partners with much focus on democratization and sustainable socio-economic prosperity. The cooperation was enhanced by initiating a free trade area between the EU and the partners which was to be implemented by 2010 though Euro-Mediterranean Association Agreements with each of them. Because of the

mass critics and unsatisfactory results the Barcelona Process was considered a failure at its tenth anniversary in 2005 (Sarto, Schumacher 2005: 25-28).

The Union for the Mediterranean was to reinforce the Southern dimension of the ENP and put a clear distinction between the Eastern and Southern neighbors. It was also an indicator that the approach "one size fits all" applied in the ENP was inadequate to the situation and showed little added value compared to other forms of more traditional bilateral assistance (Koeth 2014: 24). The new initiative was equipped with its own intergovernmental set-up and a limited number of political and economic objectives which meant short term goals of enhancing economic relations and European security ahead of addressing local socio-economic problems (Wouters, Duquet 2013: 22). The program of ENP reinforced by the UfM was to be pursued in two ways: first by multilateral and second bilateral dimension. The multilateral perspective is related to the UfM and its predecessor – the Barcelona Process. The bilateral dimension is complemented by the Association Agreement (AAs) undertaken within the Barcelona Process and the ENP Action Plans within the ENP.

In turn, the Eastern dimension of the ENP is represented by the initiative of Eastern Partnership (EaP) which was launched in 2009. After the admission of Central European Countries to the EU in 2004 and 2007 the Union decided to launch a program which would provide the EU's Eastern neighbors with an alternative to membership a set of incentives for engaging in economic, social and political reforms. However in the view of the EaP's initiators – Poland and Sweden, the EU's membership would mean for the ENP partners the partnership (implicit) goal – contrary to the official doctrine of "sharing everything but institutions" (Hett et al. 2015: 3). The concept of "sharing everything but institutions" was issued by the European Commissioner Romano Prodi (Prodi 2002). The initiative was expected to stimulate changes in Eastern Europe by bringing forward internal reform and enhancing intra-regional cooperation. Moreover the EaP highlighted the importance of good neighborly relations, confidence-building measures and the advancement of stability.

The package of the EaP contains three major elements which if it implemented would improve economic and social situation in the partner countries and their cooperation with the EU. First it is a problem of admission and implementation of the Association Agreements (AAs.) and/or Deep and Comprehensive Free Trade Area (DCFTA). Second goal concerns a visa free regime and the third involves the issue of energy security and a membership in a Energy Community created in 2006 for the Western Balkan countries (Gromadzki 2015: 12-13). Moreover the initiative assumed to develop intraregional cooperation among the partners which would lead to formulate a stable regional block. Against this background not much has been yet achieved. However as a milestone it should be acknowledge the signing of the Association Agreement (AA) including the DCFTA by Ukraine, Georgia and Moldova. All of them expressed interest in deeper integration with the EU having in mind their future membership. In contrast the remaining partners of the EaP – Armenia, Azerbaijan and Belarus did not want to continue further integration with the EU and for the time being decided to remain out of the process.

In sum, before its enlargement in 2004 the EU had an institutional framework for closer economic and political cooperation with Mediterranean countries under the Barcelona Process. The initiative was endowed in ambitious targets of democratization, security and economic growth for the Mediterranean countries together with an unrealistic objective like making peace in the Middle East. It was clear after the years, that it was a yawning gap between the ambitions objectives of the political program and huge obstacles that stood on the way to reaching them.

The accession of Central and East European countries in 2004 and 2007 has shifted external frontiers of the EU far to the East, which intensified the interest of the EU with that area. The idea of that time was to combine two dimensions of the EU's external policy which resulted in establishing new policy framework covering both East neighbors and the Southern Mediterranean partners. On the one hand the Europeans asserted the partner countries they were going to share "everything but institutions", which meant that they were to be treated almost as members. On the other hand, number of visions and interest of each member state of the EU has almost precluded the EU from pursuing coherent policy within the ENP.

3. Different interests and visions

The ENP partner-countries diverge in almost every aspects of their political and socio-economic stance. They differentiate from the level of economic development up to historical and cultural background. This disparity can be also noted in both expectations regarding relations with Europe but also their perceptions and visions towards those relations.

The ENP was conceived to erase the impression on putting new borders between countries which found themselves "in" and "out" of the club. The EU decided to set the tone for the longstanding dialogue by deepening institutional relations and giving greater emphasis to bilateral cooperation with each neighboring country. The problem was that the partner countries had different visions and expectations against the EU's offer. Thus for some countries the EU did not match their political aspirations and economic needs, for others the program was putting too much emphasis on democratization and good governance instead of focusing on trade relations and development assistance. The Southern group of countries perceive the EU activities in the region as a bulk that hinders their maneuvers, while the Eastern partners consider the European engagement as insufficient which may not give them a guarantee for EU's accession (Bendick 2008: 4).

The 16 ENP countries have not very much in common, except several key features such as poor economic performance, poverty, lack of good governance, rule of law, violations of human rights, etc. One of this is the geographic proximity to the EU. However geographical closeness in itself is a weak argument to the importance of mutual relations (Lehne 2014: 6). Good neighboring relations with the EU are much more important factor in a strategic decision-making process taken by the partners. Most of the countries would prefer to hold individual relations with the EU than depend on cooperation with others. This is particularly visible in the Mediterranean states. Due to their long-term historical and cultural relations with Western Europe they seek to maintain individual relations with the EU based on aid programs and development assistance. The propensity of building bilateral relations is also seen in case of the Eastern neighbors.

The EU's approach to its neighborhood has been often characterized as a Eurocentric attitude where the partners interests were neglected and the needs ignored. The concept which the ENP was based on is assumed largely that the partner countries share the "same values and interests" as the EU member states. This conviction creates a belief that the neighbors should easily adhere to principles such as social cohesion, rule of law, and respect of human rights. It is very hard to accept in particular for Mediterranean countries that the driving force of their evolution and modernization might come from outside on a "carrot stick" policy basis. In their opinion the method taken in the European program clearly shows that the ENP logic was formulated with special attention to Eastern European neighbors than the Southern Mediterranean (R. A. Del Sarto, T. Schumacher 2005: 17-18).

Additionally there are growing disparities even among the countries with geographical proximity such as the Eastern neighbors. Most of them strive to build closer and substantive relationship with the EU, however the ENP does not match the most ambitious interests of these countries (i.e. Ukraine or Georgia) (Lehne 2014: 7). In return the EU has not sent a clear message about eventual accession of these countries, what make them feel uncertain and confused. Georgia clearly considers the ENP as a path towards European integration from the very beginning while Moldova and Ukraine have changed slightly their political positions in the course of time. Armenia has developed a rather pragmatic approach with a clear focus on economic cooperation and Azerbaijan has also limited expectations towards the ENP as the country attached greater importance to cooperation with Russia and Central Asian neighbors (Delcour 2011: 11).

However countries with perspective of future membership perceive the EU's promises as too little. An incentive of accession would be much more powerful force to reform than a blurred perspective on EU's enlargement dispensed in symbolic doses (Delcour 2011). While certain member states, namely from Central Europe deem that Ukraine, Georgia and Moldova should be given a perspective for future membership, a number of other states, mainly from the "old" Europe are skeptical and reserved. For instance country like Moldova is very much interested in closer cooperation with the Union as it is very much dependent on its financial assistance as well as trade relations and considers the EU as a main destination of its job

seekers. Other states from the Eastern Partnership do not share the same attitude as Moldova. For Azerbaijan the EU is one of its many trading partner and Armenia has recently opted for Euro-Asian customs union with Russian.

The ENP partner countries have been very much influenced by complex and floating situation in neighboring area. The engagement of other state actors such as the US, Turkey, Russia, China, Saudi Arabia or Qatar reduces relative power of the EU by offering financial and material commitments without strict conditionality. The EU is perceived as a institution which put tough requirements in terms of reforms and modernizations and offers too little in return (Youngs 2014: 89-99). Therefore the EU's offer involves burdensome costs for the recipient and long-term procedures of disbursement which make the EU's assistance less attractive.

4. Southern Mediterranean perspective

Southern Mediterranean partners perceive the ENP initiative with undisguised reserve. They accused the Europeans of not arranging consultations with the Southern partners before launching the initiative. They felt overlooked because the project was designed especially for Central and Eastern Europe and then it had been extended to the South Mediterranean countries at the last minute (Boumghar 2013: 1-3). First of all they object the ENP instrument which speaks of sharing European values and express the approach based on the European hegemony. The conditionality underpinning the ENP appears to Southern partners as a mechanism which make the impolite pupil set back on the right bank. The post-colonial stigma influences the current South-North relations and makes the Southern partners very much responsive to relations with European counterparts. It correlates strictly to their sensitivity in relation to sovereignty and interference. Despite the critics Mediterranean partners have accepted an argument of conditionality, which means that in case of human rights violation the AAs with a partner country can be suspended.

Although the initiative seems to be needed and fills some gap in mutual relations, the Southern partners expressed serious reservation concerning the merit of the ENP, which assumes European financial assistance and deepening economic cooperation to be proportional to the progress made in areas such as human rights, rule of law and civil societies development. Instead, the partners would prefer the EU to consider the problems like management of migration or a signature of readmission agreement that to deal with domestic issues related to democratization processes. In the view of Southern partners democratic changes are the results of internal demand that should be handled domestically without any international pressure (Boumghar 2013).

Reservation towards the ENP is reflected by the long-lasting process of establishing free trade area (FTA) between the EU and the Mediterranean countries. The launching of FTA with the EU by 2010 was a key objective within the Barcelona Process. Bilateral FTAs. were included in each Association Agreements and negotiation position of the partners depended on economic development of a country and its profile. The Mediterranean saw the initiative as a imbalanced due to their inferior economic position and the mono-export oriented markets. The asymmetry stems from the fact that the EU is the main commercial partner for most southern Mediterranean countries, whilst the importance of partners covered by the FTA is much smaller for the Europeans. After the years of implementation there has arisen many concerns around the FTA which related to misallocation of resources and trade diversion, fiscal unsustainability of tariff cuts, rising unemployment associated with eventual deindustrialization in the short run (Lorca, Escribano 2015: 9). Final results did not meet the initial goals. First, the coverage of the FTA was restricted to the trade in goods and second only limited number or countries engaged in development of their FTAs both with the EU and with other partner countries in the region (Wouters, Duquet 2013: 37).

After the years of implementation the most advanced Mediterranean partners have been offered a new formula of a free trade agreement. Though the scale and the content of the reforms taken under the AAs were poor, the EU acknowledged to be sufficient for launching a new set of negotiations. The offer of launching negotiations on Deep Comprehensive Free Trade Agreement (DCFTA) was

addressed to Jordan, Egypt, Tunisia and Morocco. The DCFTA was assumed to be an instrument enabling the countries (both from the Eastern and Southern dimension of the ENP) to create better integration of their economies into the EU single market. The DCFTAs consist of two parts: first – tariff reduction which is built on WTO commitments and second – adoption of EU trade acquis going beyond tariff reductions to cover more extensively the dimensions of investment protection, public procurement and competition policy. They cover all trade-related areas such as services, intellectual property rights, customs, public procurement, energy-related issues, competition, etc.

Most of the Mediterranean partner countries have concluded AAs with the EU which cover trade in industrial goods with some additional protocols on liberalization in agriculture commodities (the AAs were entered into force with Algeria in 2005, Egypt in 2004, Israel in 2000, Jordan in 2002, Lebanon in 2006, Morocco in 2000, Palestine Interim Agreement in 1997 and Tunisia in 1998). However for the time being there has been little chance to implement the provisions of the DCFTA even in the most advanced Southern partners such as Morocco, Jordan or Tunisia.

5. The Eastern dimension perspective

The Eastern partners perceive the ENP as a program which did not meet their expectations concerning both economic relations and accession's aspirations. Taking into account deteriorating economic conditions they are not very much willing to bear significant costs of transformations and integrations with the EU, particularly when the ultimate goal of such relationship has not been clearly defied (Sadowski 2013: 9). Despite declarations about "co-ownership" of the ENP initiative, the partner countries do not perceive the EU's model of mutual relations as their own project. Therefore they consider the actions taken by the EU under the ENP as not to be agreed jointly with the partner countries. Their general position towards the initiative depends mostly on current political and economic situation in the regions

as well as the short-term interest of governments and local politicians (Sadowski 2013: 28).

There are two groups of EaP countries for which cooperation with the EU means something else. The first one with participation of Ukraine, Moldova and Georgia have accelerated negotiations with the EU by signing Association (AA) and the DCFTA in June 2014, and a visa-free regime with Moldova in April 2014. The three other EaP states, Belarus, Armenia and Azerbaijan, have signed up to a Russian-led Eurasian Economic Union (EEU), which has automatically excluded them from joining the DCFTA (Knott 2015). In turn they select and focus these elements of economic cooperation with the EU, which would provide them with better access to European market and transfer of technology. Accordingly they treat their relations with the EU instrumentally by balancing between the EU and Russia. They count on substantial benefits but they have done no progress in economic and political liberalization instead. Belarus is engaged in issues that can not endanger the power of the ruling regime, such as border security, while avoiding cooperation in potentially dangerous areas, such as closer political relations or economic integration. In Azerbaijan current political establishment is much more committed in relation with Russia than with the EU. Relations with the EU are based mainly on energy cooperation, which is seen as a priority for European market. Belarus and Azerbaijan are engaged in economic integration with Russian within the framework of custom union.

The second group of the countries consists of Moldova, Georgia, Ukraine. Their priority in relations with the UE is accession. The problem is that the EU does not guarantee them membership in the nearest future, which consequently leads to weakening of the partner's engagement in the process of integration. Therefore, due to the changing circumstances some of them lose their pro-European enthusiasm. Additionally financial crisis in the Eurozone has shown the ENP partners that the European model of development is not the only option available for them. A competitive project has arisen under the leadership of Russia who offers deeper economic and political cooperation under the Euro-Asian union. As a result Armenia has changed over the time its course of actions towards the EU. Currently the

country may be positioned somewhere between these two groups, though closer to Belarus and Azerbaijan than to Ukraine or Georgia (Gromadzki 2015: 13).

Despite the fact that Russia was not a formal partner country within the ENP framework, its foreign policy has very much influenced Eastern partners interests and their political position. Russia's attitude towards the ENP and its Eastern dimension has appeared very quickly very hostile and aggressive. All partner countries with the most advances institutional relationships with the EU have became a subject to Russian threats, political and economic sanctions. Russia has asserted pressure on the countries to withdraw from cooperation with the EU and to choose Euro-Asian customs union under its leadership. When the EU completed the DFCTA with Ukraine, Russia decided to react and convinced Kiev to shift the course of its policy. These steps have led to mass proceedings in the Ukrainian Eastern territory and military accession of Crimea. It seems that the Russian intention is destabilization of the Ukrainian's East regions, not to mention about the intimidation of the other states in Eastern European and the Southern Caucasus.

The dilemma of having good relations with Russian together with extending or deepening cooperation with the EU is one of the biggest challenge the Eastern partners are facing. The vast majority of countries are seeking to develop good relations with Western Europe but at the same time trying not to pressing Russian's buttons. They attempt to gain benefits both from the EU and Moscow. Due to their close economic and political ties with Russia they are afraid of deterioration their mutual relations which may result in economic and political sanctions or military rehearsal. The exception is Georgia and Moldova whose politicians have expressed occasionally their independence from Russian influences. Nevertheless they are also forced to pursue cautious policy towards Russia.

The lack of clear defined policy objectives under the ENP has led to the situation in which the politicians from the partner countries treat the EU instrumentally and nearsightedly. Political leaders have often used their relations with the EU to strengthen their political position and to get short-term economic gains. According to R. Sadowski the widening discrepancy between the objective of integration and the timeframes of possible accession makes the politicians from the partner countries less interested in achieving the final goal of the EU' integration

(Sadowski 213: 32). Additional costs associated with introducing of economic and social reforms would not prevail them on taking the agenda.

6. Conclusions

The ENP is weakening. The reason is twofold: different visions and expectations from the partner countries and second a floppy engagement of the UE's institutions in the forging of the ENP coherent policy.

First, different visions and perception of the partner countries towards the ENP come from their divergent interest and concerns. However it can be found a general feature of their approaches which is based on common criticism against the provisions of the program. In consequence each of the partner-country both from the Southern and Eastern dimension of the ENP prefers developing its individual relations with the EU than jointly with others. Second, a weakened political commitment from the EU may result in a departure from the policy objectives such as support for democratic transition and bringing the partner countries closer to the EU (Kaca 2014). In light of the EU's current "post-Arab spring" relations with Mediterranean partners and fragile relations with Russia the EU might take the course to reduce its ambitions in terms of deepening political integration with both regions and limit the EMP and the EaP to technical cooperation.

Most of the partners have so far made little progress in reforms, modernizations and integration with the EU. Since the inception of the ENP in 2004 their internal situation related to democratization, free market transformation or civil society has not very much improved, except some countries from the Eastern Partnership which aspire to EU's membership. Moreover the other countries have not been prepared to bear additional costs for modernization especially when they faced deteriorating economic and social conditions. Moreover the EU is seen as it has been losing interest in the neighborhood policy owing to its internal Euro crisis.

The ENP partners differ in almost every aspect, from their level of social and economic development to security and political situations. In this respect they differ also in approach to outcomes of the ENP and the matter it is pursued. General line

runs between the partner countries which are very keen on future membership and these who do not aspire to become a member of the EU. The first ones have fulfilled the essential commitments by signing the AAs and DCFTAs. The problem is that the (pro-EU) political class of Georgia, Ukraine and Moldova view the membership option as a panacea, both to shore up uncertain domestic support for EU integration and as a buffer to Russian leverage (Knott 2015). The second group did not expect the enlargement of the EU but they relied on closer but selective economic and political relationships with European members based on greater financial assistance and open access to the European market. They expect from the Europeans to open up their common market for goods and services and a greater admission of labor forces.

The way the ENP is seen by the partner countries varies considerably. In the Mediterranean countries, except Israel, accession to the UE is not taken into account, while the EU's involvement in domestic affairs is perceived negatively. In most cases (i.e. Egypt, Tunisia, Morocco, Algeria, Jordan and Syria) European concern of domestic affairs is highly critical not only by the governments, but also by the representatives of civil society. By contrast partners from the Eastern Partnership initiative criticize the EU for deficient engagement within the ENP and the lack of a key message about the EU's Eastward enlargement. These attitude prevailed specially in Ukraine, Moldova and Georgia. The most difficult partner-countries to qualify are the Palestinian Authority and Belarus. Israel is an another exception. It has good long-standing political and economic relations with the EU, however for the reason of security and geopolitical situation its rapprochement to the EU is quite difficult.

Both the Southern and Eastern partners perceive each other as a rivals in their strive to meet the ENP requirements, particularly in receiving financial assistance. Mediterranean partners would prefer to be in different initiative than together with their counterparts from the Eastern Europe. Accustomed to traditional closer economic relations with the EU they did not like to share the same cooperation platform with Eastern neighbors. In their view a single inclusive approach to both of them may not be applied simultaneously.

References

Bendick A. (2008), The ENP. Visibility and perception in the partner countries, „Working Paper", Research Unit EU External Relations, Stiftung Wissenschaft und Politik, German Institute for International and Security Affairs, Berlin.

Boumghar L. (2013), The Algierian position on the European Neighborhood Policy, „Geographical Overview", Institut National d'Études de StratégieGlobale (INESG), Algiers, IEMed Mediterranean Yearbook, http://www.iemed.org/observatori-en/arees-danalisi/arxius-adjunts/anuari/iemed-2013/Boumghar%20Algeria%20ENP%20EN.pdf [24.03.2017].

Delcour L. (2011), Bringing South Caucasus closer to Europe. Achievements and challenges in ENP implementation, „College of Europe Natolin Research Papers", no. 03.

Gromadzki G. (2015), Eastern partnership revisited. Associated countries in focus, Stefan Batory Foundation, Friedrich Ebert Stiftung, Warsaw, http://www.batory.org.pl/upload/files/Programy%20operacyjne/Otwarta%20Europa/Eastern_Partnership_Revisited.pdf [28.03.2017].

Hett F., Kikić S., Meuser S. (eds.) (2015), Reassessing the European Neighborhood Policy. The Eastern dimension, Friedrich Ebert Stiftung, http://library.fes.de/pdf-files/id-moe/11483.pdf [24.03.2017].

Kaca E. (2014), Is the Eastern partnership weakening? The consequences of the EU institutions' power shift to neighborhood policy, „PISM Bulletin", no. 133, 25 November.

Knott E. (2015), Following the Riga summit, more realism is required over what the EU can offer its eastern partners, London School of Economics, http://blogs.lse.ac.uk/europpblog/2015/06/01/following-the-riga-summit-more-realism-is-required-over-what-the-eu-can-offer-its-eastern-partners/ [22.03.2017].

Koeth W. (2014), The „Deep and Comprehensive Free Trade Agreements". An appropriate response by the EU to the challenges in its neighborhood?, European Institute of Public Administration, http://www.eipa.eu/files/repository/eipascope/20141120085243_EIPASCOPE_2014_WKO.pdf [22.032017].

Lehne S. (2014), Time to reset the European Neighborhood Policy, Carnegie Europe, http://carnegieeurope.eu/2014/02/04/time-to-reset-european-neighborhood-policy-pub-54420 [01.11.2018].

Lorca A., Escribano G. (2015), The Euro-Mediterranean Free Trade Area. From competition to integration, http://unpan1.un.org/intradoc/groups/public/documents/CAFRAD/UNPAN013747.pdf [24.03.2017].

Prodi R. (2002), A wider Europe. A proximity policy as the key to stability, Brussels, 5-6 December, http://europa.eu/rapid/press-release_SPEECH-02-619_en.htm [22.03.2017].

Sadowski R. (2013), Partnership in times of crisis. Challenges for the Eastern European countries' integration with Europe, Centre for Eastern Studies, Warsaw.

Sarto R.A., Schumacher T. (2005), From EMP to ENP. What's at stake with the European Neighbourhood Policy towards the Southern Mediterranean?, „European Foreign Affairs Review", no. 10, pp. 17-38.

Wouters J., Duquet S. (2013), The Arab uprisings and the European Union. In search of a comprehensive strategy, „Leuven Centre for Global Governance Studies Working Paper", no. 98, Leuven.

Youngs R. (2014), Europe in the new Middle East. Opportunity or exclusion?, Oxford University Press, Oxford.

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Measuring energy efficiency – structural and index decomposition analysis

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Aim: The aim is to recognize the main determinants of the energy efficiency improvement in transport in Poland in the years 2000-2014 using structural and index decomposition analysis, and to identify areas where there is still potential for further reduction of energy consumption.

Design / Research methods: Techniques used to analyse changes in energy use are: structural decomposition analysis and index decomposition analysis. Each of these two methods is characterized by distinctive, unique techniques and approaches, as they have developed quite independently. Index decomposition analysis measures the impact of energy efficiency gains on the level of energy consumption, at the most detailed sector disaggregation level allowed by the available data. Whereas structural decomposition analysis allows to analyse the impact of the external factors, such as technological, demand, and demographic effects, on the fluctuations of the total energy consumption. The similarities and differences between the two approaches are summarized and illustrated with a numerical example of Polish transport.

Conclusions / findings: The article recognizes the main determinants of the energy efficiency improvement in transport sector in Poland in the years 2000-2014. In case of Poland ODEX shows an overall progress of energy efficiency in transport by 24.3%. Results obtained with decomposition analysis indicate large divergences in energy efficiency improvements between modes of transport and vehicle types and identify areas where there is still potential for further reduction of energy consumption. Results from decomposing structure of energy use, show activity effect to be main reason for energy use growth. The distribution of each mode in total traffic of passengers and goods changes toward less energy efficient modes. The only factor driving down the energy use is energy savings.

Originality / value of the article: Using two methods of decomposition analysis and comparing obtained outcomes allows to get a broader view on energy use trends. Results presented in this article are a good starting point for further detailed analysis of changes in energy use of transport.

Keywords: energy efficiency, index decomposition analysis, structural decomposition analysis, indicators, energy

JEL: O13, Q40, Q56

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1. Introduction

European environmental policy has evolved since the 1990s, due to energy security and climate change concerns, and now focuses on five dimensions: energy security, the internal energy market, energy efficiency, decarbonisation of the economy, as well as research, innovation, and competitiveness. In order to advance energy efficiency improvement, changes in law and new regulations were introduced at the international and national levels. While also putting obligation on the governments to report on the progress. The current 2030 target on 27% energy efficiency improvement (from 1990 levels) is accompanied by a 40% greenhouse gas emissions (GHG) reductions target and a 27% target for renewable energy in each Member State. Implementation of the new energy policy and the increasing number of energy targets induces an urgent need to understand the trends in energy use and select appropriate tools for monitoring progress. The purpose of the indicators is to assess the results achieved, the extent to which the objectives have been met, while enabling international benchmarking.

One of the main focuses of the vast literature has been on identifying drivers for changes in total energy use (Ang, Zhang 2000; Liu, Ang 2007). Decomposition analysis has become useful tool for comparing the driving forces of change in energy use of the whole economy and main sectors (Weber 2009). In general, there are many reasons why country's energy demand changes over time, e.g. growth in economic output, investment in infrastructure, efficiency improvements or changes in the production and consumption patterns. Decomposition analysis attempts to divide changes in energy consumption over time into various driving forces for change. It aims to distinct between energy efficiency increases representing energy savings or "technical changes" and other factors like changes in the structure of an economy, demographic or behavioural changes etc. (Metcalf 2008).

There are two well-developed schools of decomposition studies, the methods of index decomposition analysis and structural decomposition analysis (Hoekstra, van der Bergh 2003; Ang, Zhang 2000). Each of these two methods is characterized by distinctive, unique techniques and approaches, as they have developed quite independently. An index decomposition analysis measures the impact of energy

efficiency gains on the level of energy consumption at very detailed sector disaggregation level (by sub-sector or end-use). While structural decomposition analysis allows to analyse the impact of the external factors, such as technological, demand, structural and demographic effects, on the fluctuations of the total energy use.

In this article, the energy usage indicators are compared and analysed for transport sector in Poland in the years 2000-2014. The aim is to identify factors determining changes in energy consumption in this sector using structural and index decomposition analysis. The similarities and differences between the two approaches are also summarized and illustrated. The study was conducted on the basis of data provided for this purpose by Enerdata, the data controller of the EU ODYSSEE-MURE program in which engages 28 EU Member States and Norway. The program has been developed to monitor indicative energy policy targets introduced in European Union by Directive 2006/32/EC. It aims at continuous monitoring of changes in energy consumption. It employs two complementary ODYSSEE databases: one for energy efficiency and second for CO_2 emissions, as well as MURE database for policy enforcement measures to reduce energy consumption.

2. Index decomposition analysis

The term index decomposition analysis was first used in Ang and Zhang (2000) to differentiate the technique from structural decomposition analysis. Index decomposition analysis is methodologically based on tools used for analysing energy-related trends since the 1970s[1], first used to study the impact of changes in product mix on industrial energy demand. It has since been expanded to include other areas including CO_2 emission analysis, environmental management, and sustainable use of natural resources. An aggregated component, for example the energy consumption of one sector, is broken down into several determining factors

[1] The use of index decomposition analysis in order to describe and analyse trends in energy consumption started in the 2nd half of the 1970s in the U.S. (Weber 2009).

to analyse their influence on the aggregate. In this section index decomposition analysis of the energy demand variation is carried out for transport sector in Poland to show the drivers behind the changes observed. The analysis was based on unit consumption data used to calculate the energy efficiency index of Polish economy in the ODYSSEE-MURE program.

The Odyssee energy efficiency index (ODEX) is the leading indicator used in the ODYSSEE-MURE program and published by the European Environmental Agency (EEA) to verify progress on energy efficiency in Europe. ODEX measures energy efficiency progress of the whole economy (all final consumers) as well as by the main sectors (industry, transport, households) in 28 EU Member States and Norway. ODEX is a bottom-up index, because it is constructed from specific energy consumptions or unit consumptions at the most detailed sector disaggregation level allowed by the available data and re-aggregated at the level of final energy consumption. An aggregated bottom-up energy efficiency indicator is very useful tool for detailed diagnosis by sub-sector or end-use and to evaluate the impact of particular policy measures on energy efficiency improvement (Bosseboeuf et al. 2005).

The ODEX is calculated for three main sectors, i.e. industry, transport and households, as a weighted average of sub-sectoral indices, where the weight is the share in the final energy consumption of each sub-sector. The sub-sectoral indices are calculated from changes observed in unit energy consumption measured in physical units (for instance tons of steel, m² for dwellings, etc.) and are afterwards aggregated and weighted. Undoubtedly, the value of the energy efficiency index will depend on the degree of sector disaggregation. The greater the disaggregation, the more structural effects will be removed from the indicator. Using indices enables different units to be combined for a given sector. Moreover, since the ODEX is calculated at the sectoral level and mostly based on physical instead of monetary activities, it seems to be a more adequate indicator to estimate energy efficiency trends than energy intensities. In the ODEX methodology the impact of energy efficiency improvement is analytically separated from other factors, like economic growth, structural changes within a sector or weather conditions (Enerdata 2016).

In the ODYSSEE-MURE database the ODEX index is represented by

percentage change compared to 1990 levels, so it does not focus on absolute values, but shows only the change comparing to the state at the reference year (value of ODEX equal to 99 means a 1% energy efficiency gain). However, the calculation is based on a sliding base year, which means that energy efficiency gains are measured in relation to the previous year. ODEX cumulates the incremental energy savings from one year to the other (for a detailed description of the methodology see ODYSSEE 2016; Lapillonne, Pollier 2011).

In fact, ODEX is equal to a rate of energy savings, i.e. the ratio between the actual energy consumption of the sector or economy in year *t* and actual energy consumption without energy savings (Enerdata 2016). In the formula below I_t is a value of index for year *t*, then the ratio I_t/I_{t-1} is described as the energy consumption of year *t* divided by the energy consumption that would have taken place in year *t* had the unit consumptions been those of year *t-1* (ODYSSEE 2016):

$$\frac{I_t}{I_{t-1}} = \frac{\sum_i EC_{i,t}}{\sum_i A_{i,t} \cdot UC_{i,t-1}}$$

where:

i – sector;

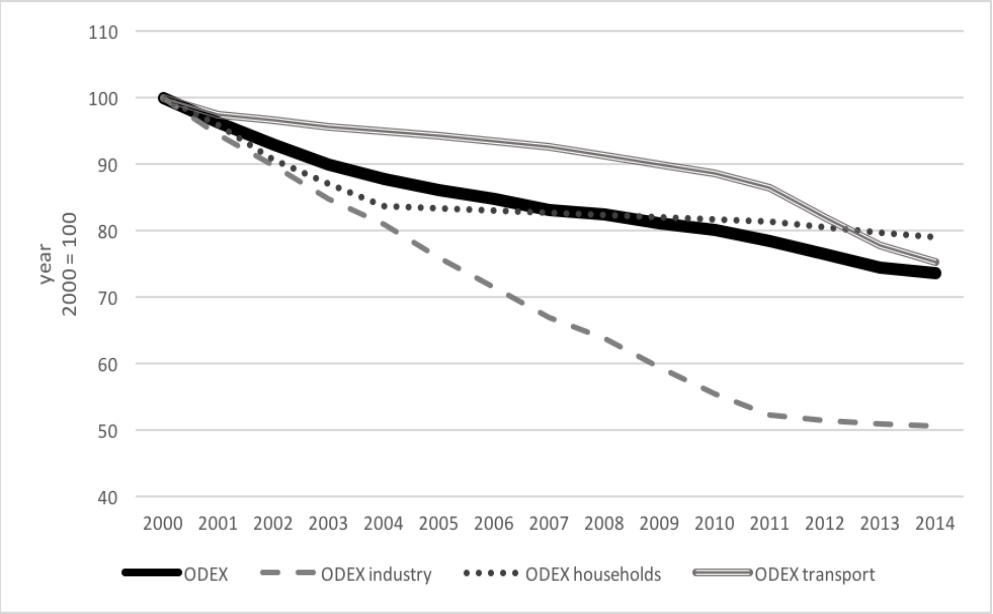
$EC_{i,t}$ – energy consumption of sector *i* in year *t*;

$A_{i,t}$ – activity variable of sector *i* in year *t*;

$UC_{i,t-1}$ – unit consumption of sector *i* in year *t-1*.

For the purpose of presented analysis, the ODEX index has been recalculated and represented by percentage change compared to 2000 levels. According to the ODEX indicator (Figure 1) energy efficiency of Polish economy improved by 26.4% between 2000 and 2014, at an annual average rate of 1.9% per year. All sectors contributed to the improvement, with the largest gains registered in the industry sector. ODEX for transport until 2011 has been falling very slowly and only in recent years has shown a higher rate of decline. Finally, the index decreasing by an average of 1.7% per year, reached a value of 75.7 in year 2014.

Figure 1. Energy efficiency index ODEX for Poland (2000-2014)



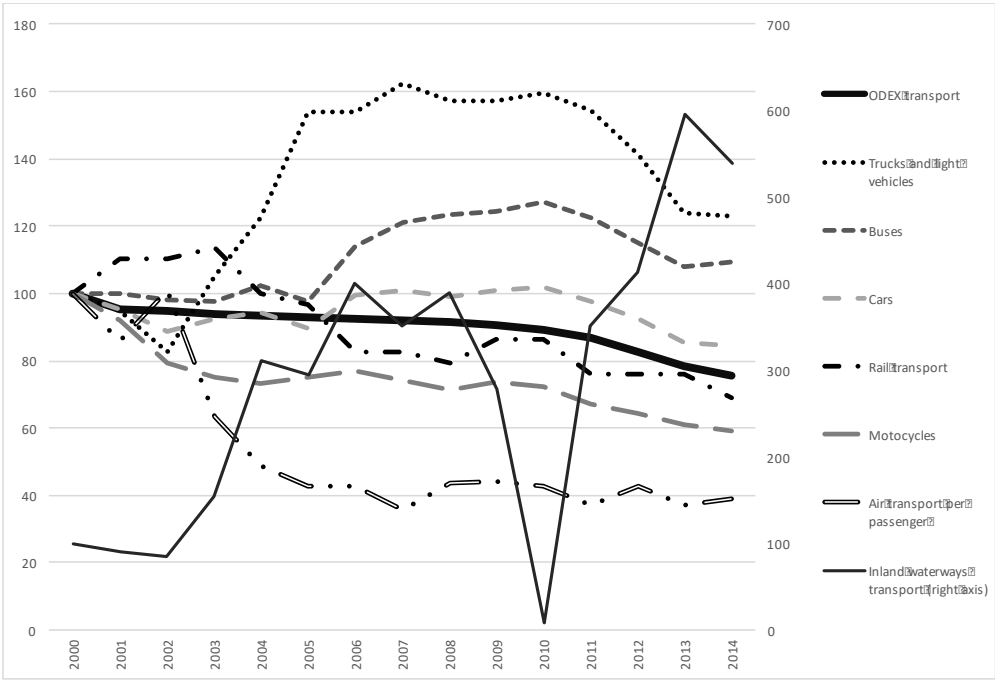
Source: Author's own elaboration based on ODYSSEE databases, ENERA (2000=100).

Methodology of the ODEX allows to calculate the aggregated energy efficiency index in several steps, each with a different level of aggregation. Therefore, it is possible to calculate separate indexes for industry, transport and households, and afterwards, based on these indexes, a general index for all these sectors combined. Also, it is possible to conduct a decomposition analysis of the sector indicator and examine at very detailed level the reasons behind the change.

The results of the decomposition analysis of the ODEX index for transport sector are presented on Figure 2 below. For transport sector, the evaluation is carried out at the level of 3 modes and 4 vehicle types: cars, trucks and light vehicles, motorcycles, buses, air transport, rail, and water transport. For cars and motorcycles, energy efficiency is measured by the specific energy consumption per vehicle. For the transport of goods, the unit consumption per ton-kilometre is used (equal to the transportation of one metric ton of freight one kilometre). Similarly, for the transport of passengers, the unit consumption per passenger-kilometre is used (ODYSSEE 2016). On the basis of the unit consumption data for the individual subsectors,

included in the sectoral ODEX, trends in energy consumption were computed using the year 2000 as the baseline.

Figure 2. Decomposition of energy use in transport in Poland (2000-2014)



Source: Author's own elaboration based on ODYSSEE databases, ENERA (2000=100).

As shown on Figure 3, energy efficiency of the whole sector increased by 24.3% between year 2000 and 2014, with an annual average rate of 1.73%. The biggest drop in energy use exceeding 60% was recorded in air transport. The biggest increase observed was in case of water transport – by 438.5% (relative to base year). The very large fluctuations in energy consumption in water transport are difficult to understand and may suggest imperfection of statistics, as energy efficiency progress should change smoothly.

Energy efficiency of passenger cars improved by nearly 16% and motorcycles by over 40%. The trend for trucks and buses was different. After the decline in efficiency, small decrease can be observed after year 2012, but both indexes are still by 22.9% (trucks) and 9.2% (buses) above the base year.

Figure 3. Energy savings in transport in Poland (2000-2014)

Transport mode	2000	2014	Change	Change/year
ODEX transport	**100**	**75,7**	**-24,3%**	**-1,73%**
Inland waterways transport	100	538,5	438,5%	31,32%
Trucks and light vehicles	100	122,9	22,9%	1,63%
Passenger transport	100	109,2	9,2%	0,66%
Cars	100	84,3	-15,7%	-1,12%
Rail transport	100	69,0	-31,0%	-2,22%
Motocycles	100	59,2	-40,8%	-2,92%
Air transport per passenger	100	39,0	-61,0%	-4,35%

Source: Author's own elaboration based on ODYSSEE databases, ENERA.

As already mentioned, there are many factors which cause changes in the energy use in transport or any sector, but have no connection with the efficiency with which energy is used. These changes may be structural, behavioural or they may result from factors, such as weather or demographic changes. The ODEX indicator described above measures only the impact of energy efficiency gains on the level of total energy consumption, while other factors which influence final energy consumption are omitted. In order to include impact of external factors on the fluctuations of the total energy consumption another tool was created based on the ODYSSEE databases which allows for structural decomposition analysis.

3. Structural decomposition analysis

Structural decomposition analysis allows to understand why country's energy demand changes over time, e.g. due to the growth in economic output, investments in infrastructure, efficiency improvements or changes in the production and consumption patterns, as well as estimating the relative share of each of these effects. This tool is based on the environmental input–output analysis and has become a standard method in energy analysis (Hoekstra, van der Bergh 2003).

The objective of the analysis is to decompose the variation of total final energy consumption over a given period of time into various components (e.g. economic growth, lifestyle changes, energy savings) to analyse their influence on the aggregate. In particular, it allows to explain how the variation of the final energy consumption by sector is linked to the energy savings calculated with top-down

methods. In ODYSSEE structural decomposition methodology energy savings are derived from:

- Energy efficiency index ODEX presented above or;
- The method proposed by the European Commission for Energy Service Directive (ESD)[2].

This two approaches are in fact very similar. In case of transport sector the definition of energy savings is the same as proposed by ESD calculations. Despite the importance of the measurement of energy savings, there is also a need to monitor the total amount of energy consumed by sector as it will be the main driver of CO_2 emissions.

The variation of the energy consumption of transport is decomposed into three main factors (Bosseboeuf et al. 2015):

- Activity effect – change in passenger traffic;
- Energy savings – variation of the energy consumption per passenger kilometre or tonne-km for each mode of transport;
- Modal shift effect – change in the share of each transport modes in the total traffic.

The activity effect is present in the transport sector due to more traffic for passengers and goods. It captures the changes in the value added and measures the impact of the economic activity on the energy consumption. It is calculated for the different modes of transport separately and then summarized. For passengers, it is calculated by multiplying the variation of the traffic measured in passenger-kilometre for each mode by the energy consumption per passenger-kilometre at base year. For goods, it is calculated by multiplying the traffic in tonne-kilometre of each mode by the specific energy consumption per tonne-kilometre at base year. As described in Enerdata (2015) the activity effect is calculated as follows:

Activity effect (passenger): $\mathrm{EQT}_{\frac{t}{t-1}} = \sum_{i=0}^{n} \left(\Delta \mathrm{pkm}_{n,\frac{t}{t-1}} \times \mathrm{CU}_{n,t-1}\right)$

Activity effect (goods): $\mathrm{EQT}_{\frac{t}{t-1}} = \sum_{i=0}^{m} \left(\Delta \mathrm{tkm}_{m,\frac{t}{t-1}} \times \mathrm{CU}_{m,t-1}\right)$

[2] The Energy Service Directive 2006/32/EC.

where:
EQT – activity effect;
CU – energy consumption per passenger or good kilometre by mode;
n = cars, bus, rail for passengers;
m = trucks and light vehicles, rail for goods, inland waterways;
pkm – number of passenger kilometre by mode;
tkm – number of ton kilometre for goods by mode.

Energy savings effect is measured by multiplying the variation of the energy consumption per passenger-km or tonne-kilometre of each mode of transport by the number of passenger/goods kilometre[3] (Enerdata 2015):

Energy savings (passenger): $\mathrm{EST}_{\frac{t}{t-1}} = \sum_{i=0}^{n} (\Delta \mathrm{CU}_{n,\frac{t}{t-1}} \times \mathrm{pkm}_{n,t})$

Energy savings (goods): $\mathrm{EST}_{\frac{t}{t-1}} = \sum_{i=0}^{m} (\Delta \mathrm{CU}_{m,\frac{t}{t-1}} \times \mathrm{tkm}_{m,t})$

where:
EST – savings effect;
CU – energy consumption per passenger or good kilometre for all transport mode;
n = cars, bus, rail for passengers;
m = trucks and light vehicles, rail for goods, inland waterways;
pkm – number of passenger kilometre by mode;
tkm – number of ton kilometre for goods by mode.

The weighting method has been defined in such a way that the calculation of energy savings is strictly equal to the sum of energy savings by end-use, with energy savings obtained by multiplying the variation in unit energy consumption by an indicator of activity. For instance, energy savings for cars is equal to the variation in l/100km per car multiplied by the number of cars.

For cars, energy savings can be split into four effects (Enerdata 2015):

- Change in the efficiency of cars measured in litre/100km ("technical

[3] The methodology proposed by the Commission to calculate energy savings for the monitoring of the ESD in the top-down approach. It differs from the calculation used for the ODEX as the indicator used for cars is litre/100km instead of goe/pkm.

efficiency effect");

- Change in traffic in passenger-km and distance travelled ("activity effect");
- Change in the average car occupancy rate ("occupancy rate effect");
- Change in fuel mix: from gasoline to diesel and from oil products to biofuel, both leading to an increase of the average heat content in toe/litre ("substitution effect").

Modal shift effect measures the impact of changes in the distribution of each mode in total traffic of passengers and goods. It is calculated as a difference between the sum of savings of each mode for passenger and goods respectively and the aggregate savings calculated for passenger or goods as a whole (Enerdata 2015):

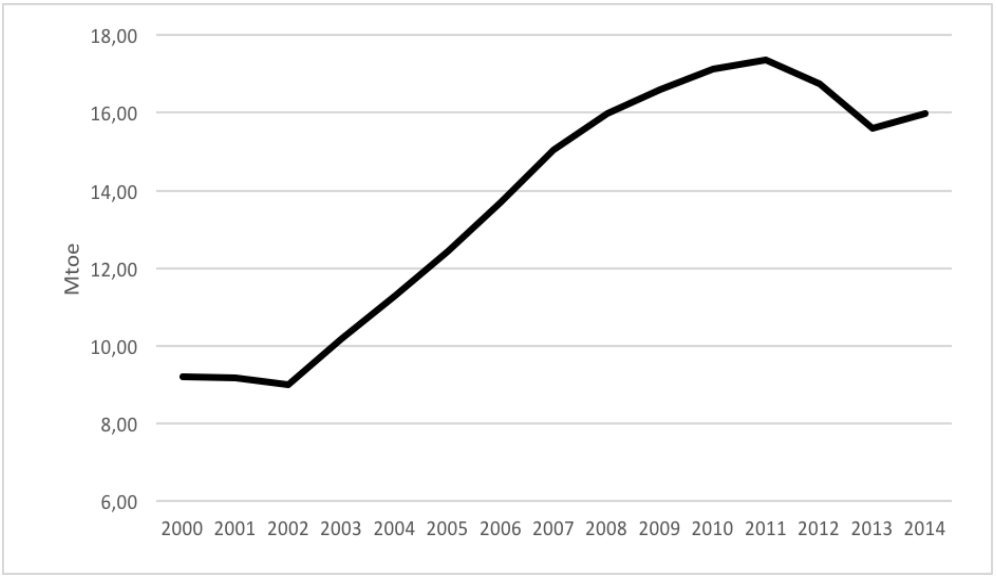
Modal shift for passenger as a whole: $MST_{\frac{t}{t-1}} = EST - (\Delta CU_{\frac{t}{t-1}} \times pkm_t)$

Modal shift for goods as a whole: $MST_{\frac{t}{t-1}} = EST - (\Delta CU_{\frac{t}{t-1}} \times tkm_t)$

where:
MST – modal shift effect;
EST – savings effect;
CU – energy consumption per passenger or good kilometre by mode;
pkm – number of passenger kilometre by mode;
tkm – number of ton kilometre for goods by mode.

Total energy consumption of transport in Poland has almost doubled between year 2000 and 2014, rising from 9.18 to 15.98 Mtoe (Figure 4). The biggest increase by 93.35% occurred in years 2002-2011.

Figure 4. Total consumption of transport in Poland (2000-2014)

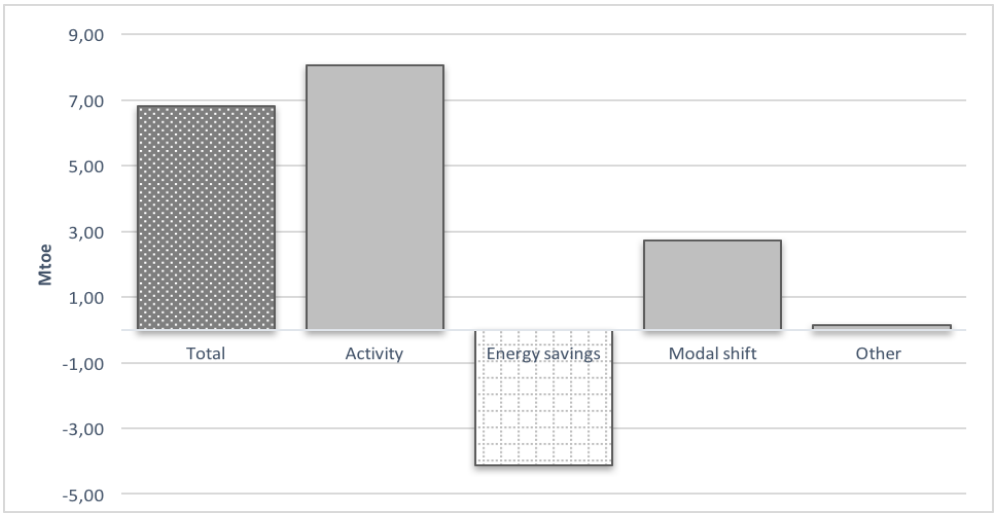


Source: Author's own elaboration based on ODYSSEE databases, ENERA.

The variation of the energy consumption of transport in Poland between year 2000 and 2014 has been decomposed into main factors, as shown on Figure 5. The other effects represent "negative" savings due to inefficient operations in transport. This deterioration of energy efficiency is mainly taking place in freight transport due to low capacity utilization.

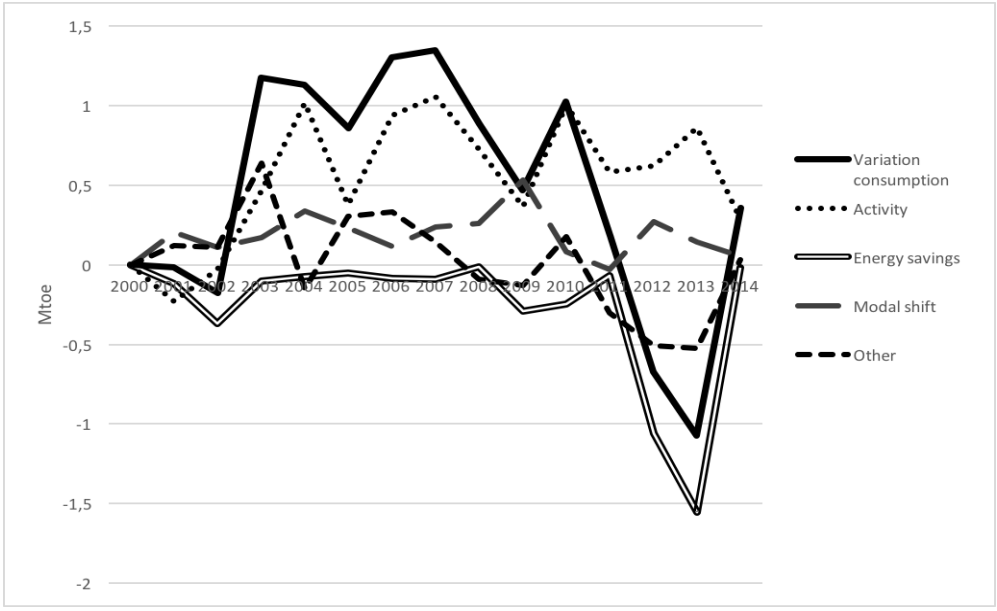
As presented on Figure 5, energy consumption of transport has increased by 6.81 Mtoe over the 2000-2014 period mainly due to increase in passenger and goods traffic (activity effect) which contributed to increase of the energy consumption by 8.06 Mtoe. Another positive effect can be noted in modal shift, with increase of 2.73 Mtoe. Whereas, only energy savings decreased the energy consumption by 4.13 Mtoe over the 2000-2014 period. It would be interesting to see, if this structure was more or less constant through analysed period of time and if there are any trends that can be observed and analysed. Figure 6 shows structural decomposition of the annual changes in energy use in transport in Poland in years 2000-2014.

Figure 5. Structural decomposition of the energy use in transport in Poland (2000-2014)



Source: Author's own elaboration based on ODYSSEE databases, ENERA.

Figure 6. Structural decomposition of the annual changes in energy use in transport in Poland (2000-2014)



Source: Author's own elaboration based on ODYSSEE databases, ENERA.

Annual growth of energy use in transport was caused mainly by activity effect, which increased the energy consumption between 0.5 and 1 Mtoe every year. Also, modal shift effect constantly contributed to increase of total energy use in years 2000-2014. The most significant fluctuation concerns energy savings. This effect was almost insignificant through many years and that changed substantially since 2011. Energy savings caused a significant decrease in total energy consumption at the end of analysed period, interrupting the upward trend, what can be observed in Figure 4.

4. Concluding remarks

There is a strong political need and demand for monitoring energy efficiency trends, mainly through the use of a limited number of simple, understandable and "saleable" indicators. ODEX is a new type of aggregated energy efficiency index, which is considered to be a very relevant alternative to the popular, but too simplistic energy intensity ratio. ODEX is not only relatively easy to understand by non-specialists, but as an aggregated bottom-up indicator it serves the need of the European Commission for the aggregated indicator to monitor the energy efficiency target fulfilment. On the other hand, it also matches the need for a good proxy of a pure bottom-up evaluation. Moreover, ODEX eliminates structural effects and lifestyle effects as far as possible; and in that sense, it can be concluded that this indicator is closer to an engineering based evaluation of energy efficiency.

This paper recognizes the main determinants of the energy efficiency improvement in transport sector in Poland in the years 2000-2014. This sector includes road, air, rail and water transport. ODEX as an overall energy efficiency index aggregates the trends for each transport mode in a single indicator for the whole sector. Index decomposition analysis consists in breaking down an aggregated component, for example the energy consumption of one sector, into several determining factors to analyse their influence on the aggregate. In case of Poland ODEX shows an overall progress of energy efficiency in transport by 24.3% between years 2000 and 2014, with an annual average rate of 1.73%. Results

obtained with decomposition analysis indicate large divergences in energy efficiency improvements between modes of transport and vehicle types and identify areas where there is still potential for further reduction of energy consumption. The biggest drop in energy use exceeding 60% (relative to base year) was recorded in air transport and the biggest increase by 438.5% was observed in water transport.

Structural decomposition analysis conducted for transport sector allows to identify driving forces in energy demand over analysed period. Results from decomposing energy usage at the most detailed level possible, show activity effect to be main reason for energy use growth. Energy consumption of transport has increased by 6.81 Mtoe in total and activity effect contributed to the increase of the energy consumption by 8.06 Mtoe in years 2000-2014. The only important factor in driving down the energy use of the transport is energy savings, which decreased the energy consumption by 4.13 Mtoe over the 2000-2014 period. Modal shift effect, with increased by 2.73 Mtoe, proves that the distribution of each mode in total traffic of passengers and goods in Poland changes for worse (i.e. toward less energy efficient modes) and does not support energy use reduction.

To summarize, multiple approaches can be applied to analyse energy use in order to generate a variety of perspectives on determinants of changes. There are two schools of decomposition methods, index and structural decomposition analysis, that can be used to analyse the determinant effects using sector level data, which seem to be complementary. Using these two methods and comparing obtained outcomes allows to get a broader view on energy use trends. Results presented in this paper are a good starting point for further detailed analysis of changes in energy use of transport.

References

Ang B.W., Liu N. (2007), Energy decomposition analysis. IEA model versus other methods, „Energy Policy", vol. 35 no. 3, pp. 1426-1432.

Ang B.W., Zhang F.Q. (2000), A survey of index decomposition analysis in energy and environmental studies, „Energy", vol. 25 no. 12, pp. 1149-1176.

Bosseboeuf D., Lapillonne B., Eichhammer W. (2005), Measuring energy efficiency progress in the EU. The energy efficiency index ODEX, „ECEEE 2005 Summer Study Proceedings – What works & who delivers", https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2005/ [02.11.2018].

Bosseboeuf D., Lapillonne B., Pollier K. (2015), Decomposition analysis of the energy demand methodology and ODYSSEE tool, ADEME, Riga.

Enerdata (2015), Understanding variation in energy consumption. Methodological report, http://www.indicators.odyssee-mure.eu/php/odyssee-decomposition/documents/interpretation-of-the-energy-consumption-variation-glossary.pdf [20.05.2018].

Enerdata (2016), Definition of data and energy efficiency indicators in ODYSSEE data base, http://www.odyssee-mure.eu/publications/other/ [20.05.2018].

European Union (2006), Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC.

Hoekstra R., van den Bergh J. (2003), Comparing structural decomposition analysis and index, „Energy Economics", vol. 25 no. 1, pp. 39-64.

Lapillonne B., Pollier K. (2011), Decomposition of final and primary energy consumption, Enerdata, Grenoble.

Metcalf G.E. (2008), An empirical analysis of energy intensity and its determinants at the state level, „The Energy Journal", vol. 29 no. 3, pp. 1-26.

ODYSSEE (2016), Definition of ODEX indicators in ODYSSEE data base, http://www.indicators.odyssee-mure.eu/odex-indicators-database-definition.pdf [20.05.2018].

Weber C. (2009), Measuring structural change and energy use. Decomposition of the US economy from 1997 to 2002, „Energy Policy", vol. 37 no. 4, pp. 1561-1570.

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Central counterparties – risk minimizers?

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Aim: Recently, central counterparties (CCPs) have gained on popularity due to their positive impact on the financial markets during crisis (limiting contagion on cleared instruments). The post-crisis reforms favored CCPs as risk minimizers. The aim of the article is to critically assess the functioning of the CCPs and their role in the financial system.

Design / Research methods: In order to attain the article's goal, the critical analysis of the CCPs' activity was performed. For that purpose, the regulations and mechanisms for CCPs' functioning were considered. The next step was the analysis of the scale of CCPs' activity and dependencies between CCPs and various market participants based on the accessible data. Based on the desk research and content analysis, the risks of CCPs were derived.

Conclusions / findings: CCPs are not risk minimizers, but they are risk managers (redistributors). Moreover, due to the significant increase in the their importance for the stable functioning of the financial markets, they should be treated as too big to fail institutions. Another recommendation that could be derived from analysis of CCPs' activity is to reframe their role in terms of running macroprudential policy. Last but not least, as the importance of proper functioning of CCPs for financial markets has increased, financial safety net mechanisms should also be properly reshaped in order to accommodate expanded role of CCPs.

Originality / value of the article: The literature, especially polish, regarding the assessment of the CCPs' roles and functions is relatively scarce, especially concerning the potential dangers connected with them. The article contains the unbiased assessment of CCPs' impact on the financial markets and proposes inventive treatment of CCPs as risk redistributors, which are too big to fail.

Keywords: central counterparties, central clearing obligation, systemic risk, risk management, crisis, too big to fail

JEL: G01, G18, G20, G28

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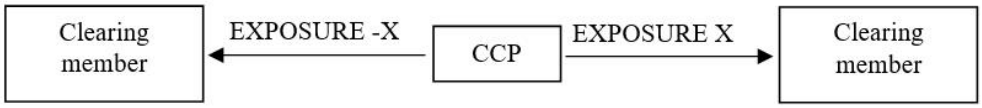
1. Introduction

Central counterparty (CCP) is a clearing house which business involves the settlement and clearing of transactions in different classes of financial instruments. Its activity consists in entering between the original parties of the transaction – when settling and clearing a trade, CCP becomes the buyer to every seller and the seller to every buyer (taking over the entire counterparty credit risk). Simultaneously, the clearing house, theoretically, does not run any financial risks, as for every open transaction (e.g. with the original seller) it automatically enters into the opposite deal (with the original buyer), thus making CCP's position always netted and closed[1].

Figure 1. Exposures in the CCP clearing



Source: own elaboration.

Experiences resulting from the Lehman Brothers (LB) bankruptcy showed that CCPs, due to their specific mechanism of functioning, are also skillful crisis managers. The system of charging margins from clearing members for every cleared transaction proved to be a tool limiting potential losses (resulting from transactions settled through the CCP) and, at the same time, containing the further spread of the crisis to the customers of the failed bank – most of the bank derivative transactions settled by CCPs (nominal value: over $500 billion) after the collapse of LB were cleared without loss to its customers (Fleming, Sarkar 2014: 197). After this emergency situation (successful for CCPs), world leaders decided to implement reforms that would require institutions to settle and clear standard OTC derivatives through central counterparties. This led to an increase in the importance of CCPs. But is the current state-of-play appropriate from the point of view of the safety of financial markets?

[1] There are two possible mechanism of clearing the transaction: novation and open offer (Sobczyński 2013: 111).

The aim of the article is to critically evaluate the benefits and risks associated with CCPs' activities and the growing scale of their business. Based on the assessment of CCPs' functioning model, policy recommendations has been proposed.

The first part of the article summarizes the legal framework for functioning of CCPs. Second one deals with the advantages of the CCPs' functioning in the financial markets. The third chapter presents data related to the recent scope and scale of central counterparties' activity. The fourth paragraph comprises a critical assessment of CCPs' business – the emphasis was put on the risks they generate under current market and regulatory framework. The last part of the article provides a summary of the benefits and potential costs of the CCPs' activity, conclusions and recommendations for further policy actions.

2. Legal framework for CCP's functioning

The functioning of CCPs is subject to the increasing number of legal provisions, which were initiated by the G-20 policy statement favoring CCPs as fundamental financial infrastructures (G20 2009). This declaration of the financial market reform was then implemented by countries in the form of national legal acts. The most crucial are Dodd-Frank Act in the USA and EMIR in the European Union (with executives acts elaborated by the respectively U.S. Securities and Exchange Commission and U.S. Commodity Futures Trading Commission, as well as European Securities and Market Authority), as these are the most essential jurisdictions for clearing financial contracts (mentioned markets clear the biggest volume of transactions).

The legal provisions implemented with reference to the functioning of CCPs can be principally divided into two groups:

a) Provisions regarding the conduct of core CCPs' business – clearing,
b) Provisions regarding the organization and functioning of CCPs' entity.

The first group of laws introduced the so-called central clearing obligation. This embraces the requirement to clear standard OTC derivatives (the market of which

was deemed to have significant impact on the burst-out of the financial crisis) through CCPs and report on them to central (authorized) repositories. The list of the centrally cleared transactions is set both by the CCPs (which decide what kind of transactions they want to clear and for which they apply for authorization) and regulators (which set the list of transactions that should be centrally cleared).

The second group of legal provisions envisages the rules of licensing CCPs, their minimal capital requirements, general organization and the functioning of the default waterfall. The latter seems to have the most significant contribution to the perception of CCPs as potential crisis managers, as it embraces the mechanism of sharing losses when one or a few clearing members default on their obligations towards a CCP (and they are not able to further serve their financial liabilities). As a general rule, clearing participants are obliged to provide CCP with appropriate margins (collateral) and contributions to the default funds (there can be a few default funds within one CCP – each for different class of cleared instruments). In general, the mechanism foresees that in the case of the CCP's member failure the collateral is taken over by the clearing house to cover losses or the auction is being organized to close the CCP's open position and its costs are covered by the collateral. If margins are insufficient, defaulter's default fund contribution is used to cover losses. In the next step (if margins and contribution to the default fund are scarce) the CCP's own capital is utilized (so called "skin-in-the-game" calculated basing on the capital requirements rules). The last line of defense consists in the remaining part of default fund.

The provisions implemented in the USA and EU are similar (they represent the same idea and pursue common goals), but not identical. The most important divergences lay in the subjective scope of the regulations (lower number of entities excluded from central clearing obligation in the USA), different treatment of the intra-group transactions (excluded from central clearing in the EU) and lack of push-out rules (forcing banks to transfer their swap transactions in which they are swap dealers or security-based dealers to special purpose vehicles, as a result of the impossibility to embrace such transactions with FDIC's guarantees) in the EU (Świderski 2013: 127).

Legal binding provisions regarding the activity of CCPs is also supplemented by the whole set of guidelines and codes of good practices prepared by e.g. International Organization of Securities Commissions (IOSCO) or Committee on Payments and Market Infrastructures (CPMI).

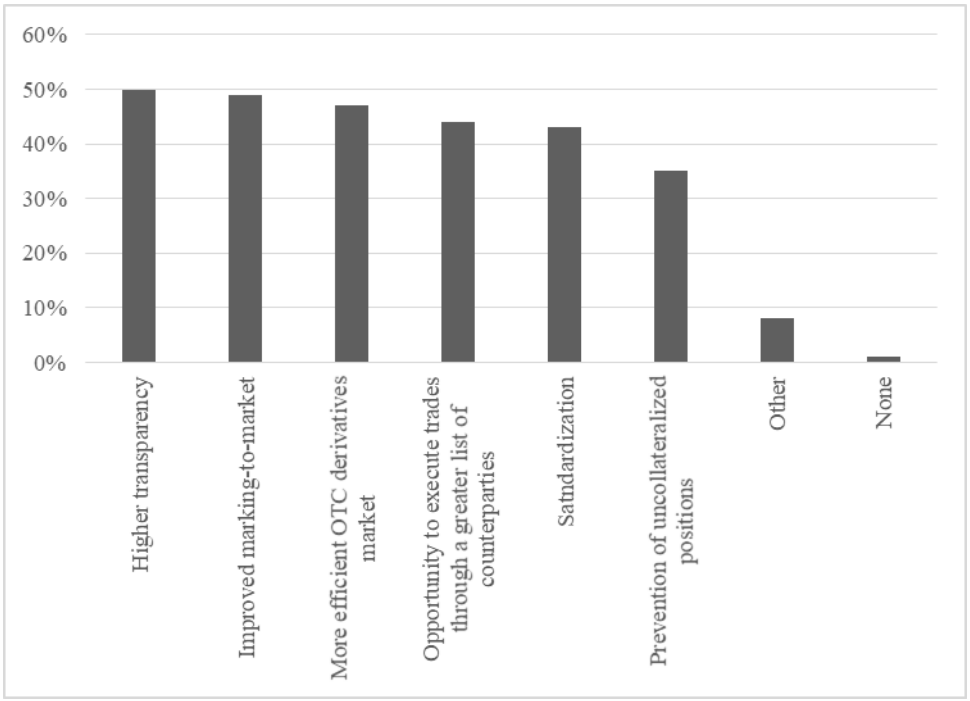
The above-mentioned legal framework for central clearing and CCPs' functioning is assessed as wide, detailed and even casuistic. Nevertheless, the provisions are further being changed and expanded (e.g. by the rules regarding recovery and resolution of CCPs). Therefore, taking into consideration the enhanced legal status of CCPs and visible growth of their importance to the functioning of the financial markets, it is of the utmost importance to critically assess their role for the economy and capital markets.

3. CCPs as risk minimizers

Although CCPs are not the originators of financial transactions and, in this sense, they do not create trends in the financial markets (they only serve an auxiliary role in transactions), they do perform a number of essential functions from the point of view of the whole financial system.

To start with, it is important to stress that CCPs are governed by laws and internal regulations (similar in all clearing houses) that clearly define uniform access rules for the participation in CCPs and the clearing rules for handled assets classes. This results in the increased standardization and transparency of the settlements – transaction parameters that were previously agreed individually (bilaterally) for every trade are fixed and imposed by CCP. This is particularly important for the functioning of the OTC derivatives markets. In the studies conducted by Greenwich Associates, issues related to the greater market transparency, better marking-to-market and standardization were identified as key benefits of the CCPs' functioning in addition to the reduction of systemic risk (Greenwich Associates 2014: 4).

Figure 2. Benefits of central clearing through CCPs (apart from systemic risk reduction)



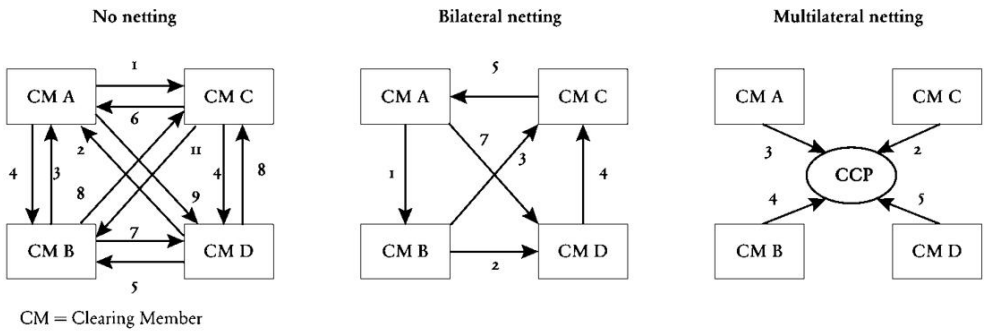
Source: Greenwich Associates (2015: 4).

However, most important advantages of CCPs' activity are related to the potential reduction of the financial risks. First of all, CCPs guarantee the settlement and clearing of the transactions (from both parties' point of view – initial seller and buyer) even if the original contractor fails to meet its obligations. The counterparty's credit risk is therefore taken over by the clearing house that acts as a backstop. This hinders the risk for financial institutions operating in the market (CCP as a counterparty credit risk neutralizer), for which the only party in the transactions might be the regulated clearing house (instead of the whole range of contractors with diversified creditworthiness). In such a way, coordination problems are also limited. This minimization is of the utmost importance in a crisis situation. By guaranteeing settlement of transactions and managing the posted collateral, CCPs turn into crisis managers (entities specialized in the crisis management) because the rules they set

and apply to distribute losses resulting from the clearing member's collapse enable the smooth burden sharing. Consequently, CCPs stabilize the markets and contribute to the reduction of their volatility (Pirrong 2011: 11).

It should also be emphasized that CCP's activity simplifies to some extent the relationships between various market players, as bilateral transactions with multiple counterparties are displaced by the transactions with CCP. This, in turn, implies the use of multilateral netting for all cleared transactions, which reduces the net exposure of the given market participant (and hence its capital / liquidity needs to hedge taken risks) (Rehlon, Nixon 2013: 4). Consequently, it automatically entails the cost reduction of the CCP participant (multilateral netting implies that fewer securities are required as collateral, as the number of cleared transactions is reduced by as much as 90%; fewer number of transactions reduces also transaction costs). In this way, the clearing members' management costs can also be curtailed as they may limit the resources that previously were devoted to monitor the financial condition of numerous contractors – instead of one clearing house (DnB 2013: 15). Therefore, the overall benefit of clearing transactions in CCPs is the increased market efficiency resulting from the improved counterparty credit risk management.

Figure 3. Benefits of netting



Source: DnB (2013: 13).

As a result of listed benefits, the clearing of transactions through CCP may result in the increase of the clearing member's capacity to enter into further deals (e.g. due to savings on collateral achieved through netting of exposures). This, in

turn, boosts liquidity in the financial markets and reduces spreads between buying and selling prices of financial instruments (DnB 2013: 15).

Possible reduction in operational risk of CCPs could also be pointed out. It can be attained as a result of multilateral netting, as the number of settled and cleared transactions is lower than the number of traded transactions. Combined with the standardization effects, this reduces the risk of errors during servicing traded securities (DnB 2013: 14).

The above-mentioned benefits of CCPs' activity suggest that, at the level of the whole financial system, systemic risk is reduced, at least in relation to these financial market segments, which are engaged in trading of derivative instruments through CCPs. This phenomenon is indicated by 40% of respondents in the study carried out by Greenwitch Associates (Greenwitch Assiciates 2014: 3). Moreover, DnB points out that markets using CCPs are generally safer. However, the condition for that is safe and prudent management of the CCP (DnB 2013: 14).

All in all, the arguments and researches cited above suggest that CCPs are engaged in providing financial market not only with enhanced effectiveness, but also with a public good – financial stability. However, the model of delivering this good is unusual, as CCPs are usually private entities but not public authorities (these typically ensure the provision of public goods). This, however, may imply that due to these features, the activity of CCPs may be associated also with threats.

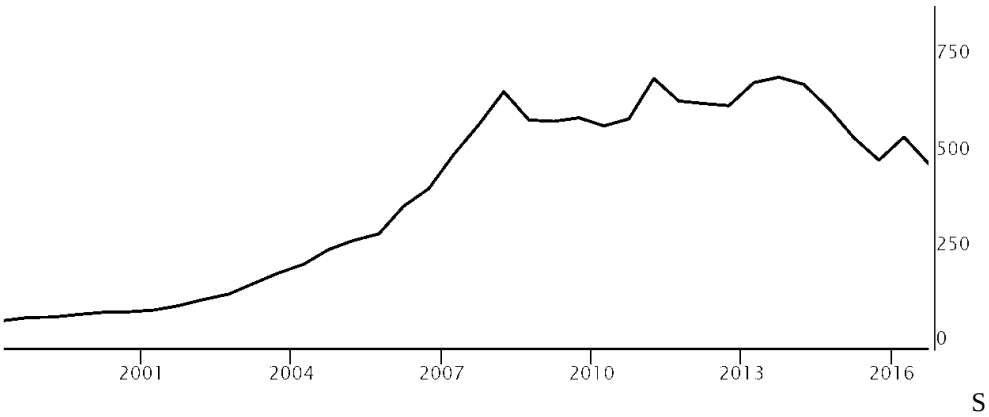
4. Scale of CCPs' activity in the world

As a consequence of the enumerated benefits of the functioning of CCPs, their relevance for the financial markets has been increasing for several years. As mentioned earlier, the experiences of the global financial crisis played pivotal role in the growing popularity of CCPs[2]. These lessons prompted the leaders of the world largest economies (G-20) to initiate the financial market reform consisting in

[2] In particular, the considerable bearing had the turbulences triggered by the involvement of financial institutions in trading OTC derivatives, as well as the collapse of LB and the effective management of its derivatives positions by the central counterparty in the United Kingdom and United States, thereby reducing the negative impact of its bankruptcy on the markets (Norman 2011: 3-6).

obliging institutions to centrally clear all standard OTC derivatives (G-20 2009). In the EU, this reform was implemented by constituting the so-called "central clearing obligation" in the EMIR Regulation, which is applicable towards financial institutions (e.g. banks, insurers, asset managers) and non-financial institutions, whose exposure to OTC derivatives exceeds certain thresholds different for various instruments[3].

Figure 4. Nominal value of OTC derivatives traded globally (trillion US $)



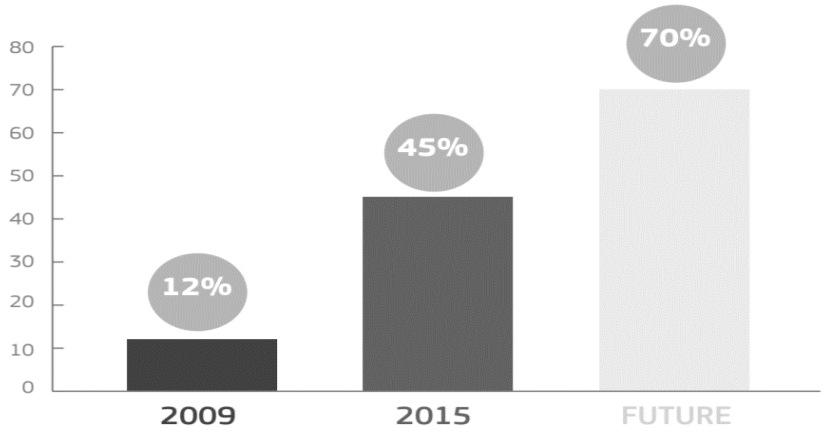
Source: own elaboration based on the data from BIS Statistics Explorer (accessed on 25.10.2017).

Although the nominal value of traded OTC derivatives has been falling slowly since the crisis, the volume of transactions cleared by CCPs and their share in all cleared derivatives has increased. Since 2009, the scale of CCPs operations has almost doubled (European Commission 2017: 2). According to the European Commission's estimates, the value of transactions cleared by CCPs in Europe has already exceeded the equivalent of 15 times EU GDP (European Commission 2016: 1). According to the Bank for International Settlements, the value of OTC derivatives cleared by CCPs in the world amounted to approximately $337 trillion at

[3] For credit derivatives – EUR 1 billion, equity derivatives – EUR 1 billion, interest rate derivatives – EUR 3 billion, currency derivatives – EUR 3 billion and commodity derivatives – EUR 3 billion. These limits apply to speculative transactions. Risk hedging transactions are not subject to central clearing (www 1).

the end of June 2016 ($328 trillion in interest-rate derivatives) and accounted for about 62% of all derivatives (European Commission 2017: 2). From the EU perspective, CCP in the UK accounts for about 75% of the euro-denominated interest rate derivatives (European Commission 2017: 2) and is crucial clearing house for most EU institutions which clear there their derivative transactions directly or indirectly.

Figure 5. Share of the CCP cleared transactions in the overall number of cleared derivatives transactions

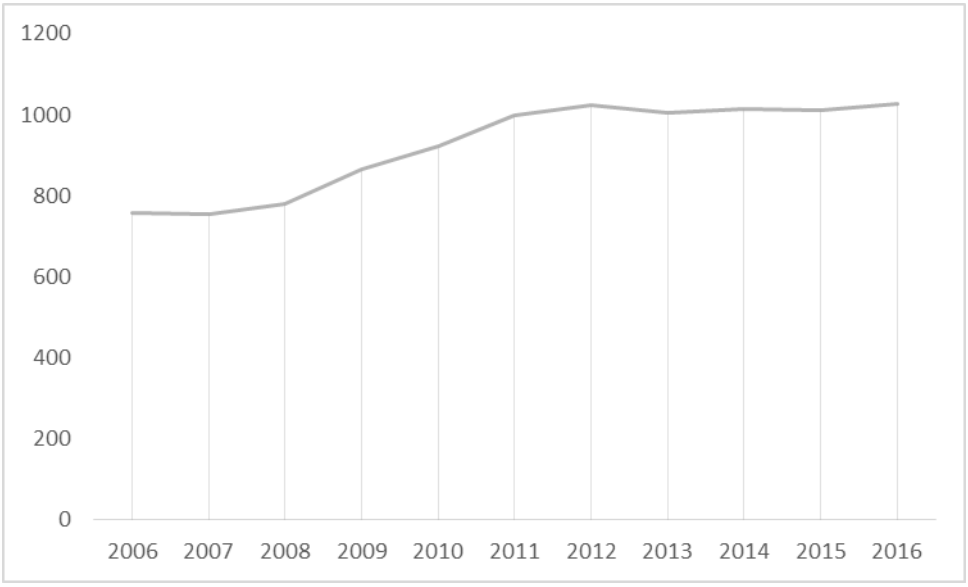


Source: European Commission (2016: 5).

Meanwhile, the number of clearing members in the CCPs is growing slowly – their main clients remain the largest financial institutions. Therefore, exposures to CCPs are concentrated in a narrow group of around 20 large institutions, which contribute to around 75% of all CCPs' financial resources (i.e. initial margin and default fund) (BIS, FSB, OICU-IOSCO 2017: 2). The analysis of interconnections between CCPs and clearing members indicates that a few "major" CCPs are being formed (in which the largest financial institutions clear their transactions). The rest of CCPs creates a group of "peripheral" clearing houses with a greater number of less-connected members. At the same time, the largest financial institutions are usually also providers of various services to CCPs (such as credit lines, custody

services, cash management) (BIS, FSB, OICU-IOSCO 2017: 2) or even their owners. This results in the creation of a negative feedback loop between (in particular) "major" CCPs and the largest financial institutions in the world, which increases the risk that during market turbulences the problems of CCPs or their clients will require public bailout.

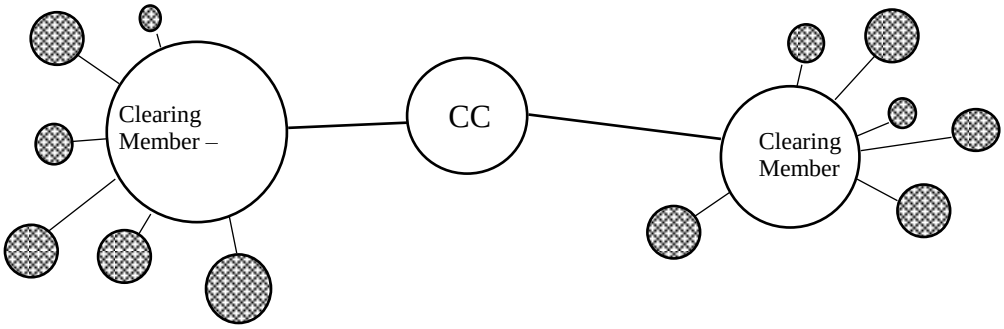
Figure 6. Number of clearing members in European CCPs



Source: own elaboration based on the data from ECB Statistical Data Warehouse (CCP – Central Counterparty Clearing Statistics).

Beyond growing number of CCPs' clearing members, it is also expected that the number of entities that will clear their transactions indirectly through CCPs (being clients of CCP clearing members) will gradually inflate. On the one hand, it results from the introduction of a central clearing obligation. On the other hand, it is an implication of the necessity to meet a dozen of requirements to become a direct member of CCP. The accession procedure is also quite time-consuming (www 3).

Figure 7. Stylized structure of CCPs' interconnectedness



Source: own elaboration.

The above-mentioned figures confirm the growing importance of CCPs in the stable functioning of financial markets. Due to the introduction of central clearing obligation, CCPs are becoming increasingly popular not only among the largest players in the financial markets, but also among smaller ones (indirectly). However, forced regulation and freely structured use of central clearing services (directly or indirectly) may lead to unexpected consequences (e.g. a real shift of CCPs' functions to their clearing members – who are not subject to regulations regarding the conduct of CCP business – due to the lack of direct access to CCPs' services by smaller entities).

5. Critical evaluation of the CCP's activity – areas of potential risks

The launch of the central clearing obligation was accompanied by the endorsement of the benefits that financial markets can derive from the activities of CCPs. As a result of the actions taken and the regulations implemented, the importance of such entities has increased, as evidenced by the data cited above. Nevertheless, the activity of CCPs is also associated with multiple risks.

Firstly, the regulatory reform associated with CCPs' business changes the structure of financial market, as growing standardization in all segments (especially OTC market) is observed. In such an environment, the diversity of instruments is

being reduced. This is limiting the institutions opportunities to manage their risk and is tunneling them to one of standardized areas of financial markets. Increasing number of institutions being assigned to one of such areas makes the whole system vulnerable to shocks, as the diversification benefits disappear.

Secondly, by performing the functions enumerated in the preceding paragraphs, CCPs take over the credit risk of entities that clear transactions in the clearing house. As a consequence, although from the individual market participants' perspective credit risk is reduced, it is nevertheless concentrated in CCPs. As a result, their activity does not diminish the credit risk in the system, but only shifts it to them contributing to the rise in their systemic risk. Consequently, CCPs set of tasks should be enlarged with systemic risk management. However, they currently do not have any appropriate instruments and expertise in this field. Moreover, CCPs do currently seem to be itself perceived as macroprudential quasi-tool. Thus, visible conflict of tasks and roles arises.

Additionally, it should be emphasized that the participation of clearing members in a given CCP is not automatic. Entities must be accepted by CCP as clearing participants based on the assessment criteria elaborated by CCPs themselves. However, the latter are not professionals (unlike banks) in the management of credit risk, so there is a danger that they will not be able to properly assess the credit risk of potential clients and diversify them. In such a way an asymmetry arises – clearing participants reduce their exposure to credit risk when clearing in CCPs but the latter not necessarily. It should also be added that the participation requirements are similar in all CCPs. This leads to the situation that direct clients of CCPs are institutions with analogues risk profiles, which favors further concentration of risk (lack of diversification effects). This effect is escalated by the increased interest of market participants in CCP services and makes the crisis management mechanisms of the CCP increasingly important.

Furthermore, as a consequence of introduction of central clearing obligation and limited possibilities for some obliged entities to clear in CCPs (participation requirements), the concentration of risk increases not only in CCPs, but also in the largest financial institutions through which the transactions of non-direct CCP customers are settled (DnB 2013: 23). Thus, although there is a break in the

interdependence resulting from the bilateral settlement of transactions between institutions, new relationships arise because of the implementation of the central clearing obligation making CCPs "single points of failure". These dependencies, however, are the next channels through which the losses can spread during the crisis. These losses may result not only from the bankruptcy of the clearing member but also from the financial problems of the CCP itself. Although some existing studies indicate on the low risk of contagion (Heath et al. 2015: 35-42), it is worth noting that due to legislative changes, the scale of CCP activity has increased dramatically and in practice their resistance in the new regulatory environment has not been tested. Therefore, it is difficult to assess the actual level of risk.

It is worth adding that many CCP's participants are also providers of services necessary for its continuous operation (BIS, FSB, OICU-IOSCO 2017: 2). The reason for that is that CCPs often do not have (due to legal restrictions) accounts in such financial safety net institutions such as central banks. Consequently, in order to be able to provide their services they are forced to utilize such facilities through other institutions (usually their clients). This creates a dangerous risk of feedback loop between CCP and its customer-service providers, as the problems (also technical, operational) of the latter can easily spread to the former. The paralysis of the functioning of CCP, however, implies the dysfunction of whole segments of the financial markets. Therefore, it seems that the institutional architecture for central clearing obligation should be expanded. The increased role of CCPs on financial markets should be associated with the enhanced safety mechanisms dedicated for CCPs. As an example, the provision of liquidity could be pointed.

By settling and clearing transactions on a daily basis, CCPs take over also a valuation risk since they determine the current value of the instruments, the amount of margins and credit exposures of the clearing members according to the market prices and their own valuation models. It is worth pointing out, at the same time, that most transactions are settled by a limited number of CCPs that have similar valuation and margin calculation models, which exposes the financial markets to the intensified effects of risk materialization (in case of the certain risk materialization, the effects appear simultaneously in several clearing houses, as almost all of them are exposed to the similar customer profiles and models). It should be stressed that

the risk lies also in the dependence on the historical data. Additionally, it should be pointed out that due to regulatory favoring of CCPs, their popularity may grow also in those classes of instruments that are currently not subject to mandatory clearing. This will probably be highly-complicated financial contracts (also higly-risky), in valuation of which CCPs will not have appropriate expertise. The asymmetry of information may be crucial here, as contract originators may be the only parties that are aware of genuine risk profile of the transaction. This exposes CCPs to the financial risk that may have to be borne by other clearing members in case of CCPs' financial problems (contagion effect).

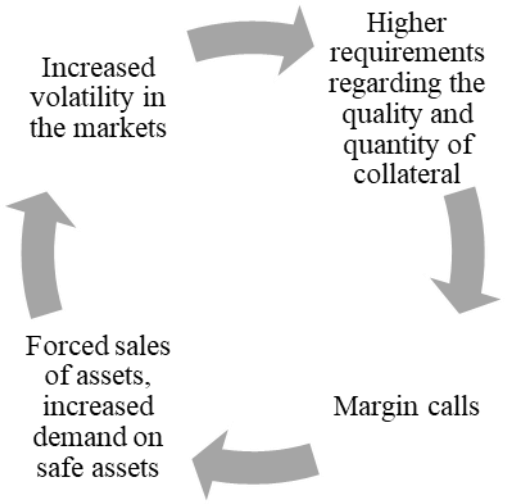
The mechanism that partially secures the materialization of financial risk is system of collecting margins and contributions to the default fund. However, the financial means received by the CCP must be managed safely. Therefore, they are frequently invested in "safe and liquid assets". It should be noted that due to the whole range of regulatory reforms, many institutions (in order to fulfill new requirements) are forced to maintain its funds in the form of "safe and liquid assets" (e.g. deposit guarantee funds, *resolution* funds, banks and their liquid reserve to fulfill LCR requirements). As a result, the demand for such assets is increasing. Two consequences of such a trend may be indicated. First, the growing demand for "safe and liquid assets" will influence their pricing mechanism (probably inflating their prices which will no longer represent their real value; potential for bubble creation may also be indicated). Second, when searching for appropriate assets (and in the face of the lack of real "safe and liquid assets"), CCPs may purchase new more risky instruments, which will be evaluated as safe and liquid.

Moreover, the system of collecting margins may be a further mechanism that exacerbates the problems of CCPs' participants during a crisis, as it has pro-cyclical character and may entail the so-called cliff effect (Hermans et al. 2013: 10). CCPs increase the amount of margins charged (and increase the amount of haircuts used in relation to pledged securities) precisely at the time of increased market volatility (in particular, margins are increased during the falls in the market)[4]. This means that

[4] As an example, the actions of LCH RepoClear could be pointed out. They consisted in raising margins on Irish bonds during the Irish crisis and thus causing difficulties for its participants (Pirrong 2011: 12). Another example is the increase in deposits resulting from increased market volatility

clearing members need to provide additional collateral in the situation of probably reduced liquidity in the markets (this implies problems with raising funds and, for the whole market, deepens the liquidity problems). As a result, the credit exposure of the counterparty to the CCP increases when its creditworthiness deteriorates, which is referred to in the literature as a "wrong-way risk" problem (Hermans et al. 2013: 11).

Figure 8. Procyclicality of margin calls



Source: own elaboration.

In case of large clearing members' bankruptcies, the need to sell the securities accepted as a margin from the liquidated institution may contribute to further price decrease. In view of the above-mentioned facts, the most important type of risk for CCPs seems to be the liquidity risk (when the CCP needs to restore the balanced accounts) and the counterparty credit risk (materializing when the participants are unable to fulfill their obligations). Additionally, CCPs must face a number of other specific risks, such as legal, business, investment, money settlement and operational one. The materialization of the identified dangers (in case of both default and non-default events) may be particularly dangerous if the financial resources of the CCP

following the announcement of the results of the referendum in the United Kingdom, which favored the exit from the European Union (www 2).

are exhausted and will need to be replenished by the participants or shareholders. This will contribute to the enhanced tensions on the market.

One should also emphasize that, as a result of CCPs' credit risk takeover, central clearing obligation can exacerbate the problem of moral hazard. This may occur by running the increased risk (e.g. through higher exposure to risky derivatives) by CCP's participants that are aware that the counterparty's credit risk is taken over by the clearing house. In case of the collapse of the opposite side of the original transaction, its consequences will be borne by CCP or all its members (and not only by the entity that entered into a transaction with failing institution). In addition, if a CCP participant bankrupts, its losses are limited to the posted collateral (Greenwich Associates 2014: 5). Furthermore, CCPs may also be prone to the risk of negative selection as they may not have full information about the level of risk associated with the cleared complex financial instruments (as opposed to the originator). This may incentivize participants to conclude more transactions of this kind, as the potential risk is transferred to the CCP.

6. Conclusion

In the financial markets, CCP's business is treated as an innovation that aims to reduce the risk on the OTC derivatives market. Although such entities have been operating in the economy for a long time, only the lessons from the recent financial crisis and the regulations introduced afterwards have led to a significant increase in their importance for the markets.

It is noteworthy that as a result of post-crisis regulatory changes, the dependence of financial markets on CCPs is rising steadily (share of transactions cleared by CCPs is constantly growing). At the same time, the group of such entities is not wide (only 17 authorized CCPs in EU), and their activity is quite specific. This poses a threat that, in case of CCPs' crisis, its services in a given area may be difficult to substitute (no alternative entities, relatively long period of joining the new CCP). This may result in a sudden termination of the transactions (for a longer

period of time), which in turn will cause paralysis of the financial institutions that have used the services of a problematic CCP.

At the same time, the activity of CCPs, while providing many benefits, also entails many other risks. They are summarized in the table below.

Table 1. Benefits and costs of clearing in CCP

Benefits of clearing in CCPs	Costs of clearing in CCPs
Risk reduction due to: - Multilateral netting - Improved risk management practices - Firewall function (results from the default waterfall)	Risk concentration as: - Counterparty risk of each clearing member is shifted towards CCP As a result systemic risk increases. Default of CCP may result in credit and liquidity shortages of clearing participants and linked CCP and causing contagion to other markets.
Operational efficiencies because of: - Reduced amount of settlement instructions, - Straightforward processing	Costs of participation consisting of: - Costs of collateral for margins and default funds - Membership fee - Operational costs
Trading benefits resulting from: - Anonymity - Increased liquidity and reduced spreads	Economic costs of potential freeze of the market if CCP fails Procyclicality of margins
Transparency	

Source: own elaboration based on Wendt (2015: 5).

Weighing up the pros and cons of CCPs, one can talk about the existence of a CCP paradox[5]. On the one hand, they reduce the risk associated with the clearing of the transactions, especially derivatives, because they guarantee their settlement. On the other hand, the takeover of the counterparty credit risk and the increase in the scale of cleared transactions mean that CCPs are becoming systemically important institutions. Given that the main players in CCPs are also systemically important institutions, these entities are both exposed and vulnerable to systemic risk. The main channels that strengthen the systemic risk of CCPs are connections with both

[5] It is also indicated by P. Norman (Norman 2011: 5).

participants (by providing central clearing services) and other contractors (who technically support CCPs). In addition, all CCPs operate according to similar strategies and based on very similar operating rules (e.g. regarding the permission to centrally clear in a given CCP, default waterfall etc.) and exposures to comparable asset classes. Therefore, the materialization of risks in one CCP is highly likely to spur the problem of another CCP.

Therefore, the analysis leads to the conclusion that CCPs are not risk minimizers. They are rather risk redistributors or risk managers, and that is the issue that constitutes the positive aspect of CCPs' provision of services on the financial markets.

Policy recommendations

CCPs have certainly become systemically important institutions. The stability of the entire financial system depends on their proper functioning, as due to the scale of the handled transactions and the linkages between CCPs and other entities, their problems can easily spread to clearing participants (who are usually also systemically important). As a result, the "too big to fail" (or "too important to fail") doctrine should be extended also on central counterparties. This is justified by their following features:

– The volume of cleared transactions is usually high, sometimes exceeding the GDP of the country in which they are registered.
– Their activities are international.
– Their bankruptcy exposes financial stability to the negative consequences.
– There is a risk of necessity to use public funds to save the institution in case of any problems.

For the reasons elaborated above, CCPs should be embraced by the legal framework analogous to the one applicable towards "too big to fail" institutions (adjusted to their specificities). It is therefore important to provide reliable mechanisms to stabilize the situation of CCPs in the event of failure. The basic example of this are the CCPs' default waterfalls using the CCP's "defense lines". Nevertheless, capital requirements as one of them should be enhanced, so that

CCP's shareholders provide real backstop for CCP's turmoil. Furthermore, the resolution framework should also be considered.

Another recommendation that could be derived from analysis of CCPs' activity is to reframe their role in terms of running macroprudential policy. CCPs are seen as entities that reduce systemic risk, as they reduce the interdependencies between financial market participants. Nevertheless, the analysis provided in the article indicates that CCPs are accumulating systemic risk, therefore the interest of macroprudential policy should be shifted from banks to CCPs. Also, the set of macroprudential tools should be appropriately remodeled in order to include more CCPs specific tools (currently, macroprudential tools are concentrated on bank capital requirements and other parameters characteristic for bank business).

Last but not least, as the importance of proper functioning of CCPs for financial markets has increased, financial safety net mechanisms should also be properly reshaped in order to accommodate expanded role of CCPs. As an example, the provision of liquidity instruments for CCPs should be considered.

References

BIS, OICU-IOSCO (2012), Principles for financial market infrastructures, https://www.bis.org/cpmi/publ/d101a.pdf [22.02.2018].

BIS, FSB, OICU-IOSCO (2017) Analysis of central clearing interdependencies, https://www.iosco.org/library/pubdocs/pdf/IOSCOPD570.pdf [25.10.2017].

Bliss R., Steigerwald R. (2006), Derivatives clearing and settlement. A comparison of central counterparties and alternative structures, „Economic Perspectives", vol. 30 no. 4, pp. 22-29.

Braithwaite J.P. (2015), Legal perspectives on client clearing, LSE Legal Studies Working Paper No. 14/2015.

Campbell S.D., Ivanov I. (2016), Empirically evaluating systemic risks in CCPs. The case of two CDS CCPs, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2841076 [25.02.2018].

Chande N., Labelle N., Tuer E. (2011), Central counterparties and systemic risk, Bank Of Canada Financial System Review, https://www.bankofcanada.ca/wp-content/uploads/2011/12/fsr-1210-chande.pdf [02.11.2018].

Czapiewski P. (2010) Wybrane uproszczenia w modelach oceny poziomu ryzyka instrumentów finansowych prowadzące do niedoszacowania stopnia tego ryzyka, in: Nauki ekonomiczne w świetle nowych wyzwań gospodarczych, Bartkowiak R., Ostaszewski J. (eds.), Oficyna Wydawnicza SGH, Warszawa.

Cont R. (2017), Central clearing and risk transformation, Norges Bank Working Paper 3/2017, https://static.norges-bank.no/contentassets/432aa1c401a243f9b08a3f3aecd4c71d/working_paper_3_17.pdf?v=03/31/20170 93420&ft=.pdf [02.11.2018].

Cont R., Kokholm T. (2013), Central clearing of OTC derivatives. Bilateral vs multilateral netting, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2233665 [23.02.2018].

DnB (2013), All the ins & outs of CCPs, https://www.dnb.nl/en/binaries/711869_All_Ins_Outs_CCPs_EN_web_v3_tcm47-288116.pdf [25.10.2017].

Duffie J.D. (2015), Resolution of failing central counterparties, Stanford University Graduate School of Business Research Paper No. 15-12.

Duffie J.D., Zhu H. (2011), Does a central clearing counterparty reduce counterparty risk?, Rock Center for Corporate Governance at Stanford University Working Paper No. 46, Stanford University Graduate School of Business Research Paper No. 2022.

European Commission (2016), Safe financial infrastructure, https://ec.europa.eu/info/system/files/ccp-proposal-factsheet-28112016_en.pdf [25.10.2017].

European Commission (2017), Communication from the Commission to the European Parliament, the Council and the European Central Bank responding to challenges for critical financial market infrastructures and further developing the Capital Markets Union, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52017DC0225 [25.10.2017].

Fleming M., Sarkar A. (2014), The failure resolution of Lehman Brothers, „FRBNY Economic Policy Review", vol. 20 no. 2, pp. 175-206.

G-20 (2009), G-20 leaders statement. The Pittsburgh Summit, http://www.g20.utoronto.ca/2009/2009communique0925.html [25.10.2017].

Greenwich Associates (2015), Systemic risk and the impacts of central clearing, Greenwich Report, https://www.lch.com/system/files?file=media_root/Systemic%20Risk.pdf [02.11.2018].

Haene P., Sturm A. (2009), Optimal central counterparty risk management, Swiss National Bank Working Papers 2009-7, https://www.snb.ch/n/mmr/reference/working_paper_2009_07/source/working_paper_2009_07.n.pdf [02.11.2018].

Heath A., Gerard K., Manning M. (2015), Central counterparty loss allocation and transmission of financial stress, Reserve Bank of Australia Research Discussion Paper 2015-02, https://www.rba.gov.au/publications/rdp/2015/pdf/rdp2015-02.pdf [02.11.2018].

Hermans L., McGoldrick P., Schmiedel H. (2013), Central counterparties and systemic risk, „ESRB Macro-prudential Commentaries", no. 6, https://www.esrb.europa.eu/pub/pdf/commentaries/ESRB_commentary_1311.pdf?304b50ae2f9e397af2 7790a19ba31ea1 [02.11.2018].

Huang J. (2010), The law and regulation of central counterparties, Hart Publishing, Oxford–Portland.

Koleśnik J. (2014), Role of public institutions and their strategies in crises events in 2008-2010, „Finanse. Czasopismo Komitetu Nauk o Finansach PAN", vol. 7 no. 1, pp. 37-51.

Gregory J. (2014), Central counterparties. Deleveraging after Lehman: evidence from reduced rehypothecation, John Wiley & Sons, Chichester.

Lopez J.C., Manning M. (2017), Who pays? CCP resource provision in the post-Pittsburgh world, Bank of Canada Staff Discussion Paper 2017-17, https://www.bankofcanada.ca/2017/12/staff-discussion-paper-2017-17/ [02.11.2018].

Minca A., Amini H., Filipovic D. (2017), Systemic risk and central clearing counterparty design, Swiss Finance Institute Research Paper no. 13-34, http://www.systemicrisk.ac.uk/sites/default/files/images/6.Andreea%20Minca.pdf [02.11.2018].

Niedziółka P. (2009), Kredytowe instrumenty pochodne a stabilność finansowa, Oficyna Wydawnicza SGH, Warszawa.

Norman P. (2011), The risk controllers, John Wiley & Sons, Hoboken NJ.

Padoa-Schioppa T. (2006), Central counterparties. The role of multilateralism and monopoly, „Economic Perspectives", vol. 30 no. 4, pp. 42-45.

Pirrong C. (2011), The economics of central clearing. Theory and practice, ISDA Discussion Papers Series, May 23, https://www.isda.org/a/yiEDE/isdadiscussion-ccp-pirrong.pdf [02.11.2018].

Pruchnicka-Grabias I. (2011), Pochodne instrumenty kredytowe. Systematyka, wycena, zastosowanie, Wydawnictwo CeDeWu, Warszawa.

Rehlon A., Nixon D. (2013), Central counterparties. What are they, why do they matter and how does the Bank supervise them?, http://www.bankofengland.co.uk/publications/Documents/quarterlybulletin/2013/qb1302ccpsbs.pdf [25.10.2017].

Sikorzewski W. (2013), Partnerzy centralni w świecie EMIR'a, in: Wyzwania regulacji rynków finansowych. Unia bankowa, kontrahenci centralni, parabanki, Rogowski W. (ed.), Oficyna Allerhanda, Kraków.

Singh M., Aitken J. (2009), Counterparty risk, impact on collateral flows, and role for central counterparties, International Monetary Fund Working paper, WP/09/173.

Sobczyński D. (2013), Centralny kontrpartner CCP – novum na polskim rynku finansowym, in: Wyzwania regulacji rynków finansowych. Unia bankowa, kontrahenci centralni, parabanki, Rogowski W. (ed.), Oficyna Allerhanda, Kraków.

Sroka I. (2013), Zarządzanie ryzykiem w izbie rozliczeniowej KDPW_CCP, „Problemy Zarządzania", vol. 42 no. 2, pp. 124-139.

Szpringer M., Szpringer W. (2016), Law and economics of Central Counterparties (CCP). Selected issues of regulation and competition concerning financial market infrastructure, „European Business Law Review", vol. 27 no. 5, pp. 587-603.

Ślązak E. (2012), Theoretical grounds for the use of the public policies, in: Development per public policy support in the food economy – the example of Poland, Wieger M. (ed.), Instytut Ekonomiki Rolnictwa i Gospodarki Żywnościowej, Warsaw.

Świderski A. (2013), Kontrahenci centralni (central counterparties, CCPs) – przepisy unijne a polskie regulacje, in: Wyzwania regulacji rynków finansowych. Unia bankowa, kontrahenci centralni, parabanki, Rogowski W. (ed.), Oficyna Allerhanda, Kraków.

Wendt F. (2015) Central counterparties. Addressing their too important to fail nature, IMF Working Paper WP/15/21.

World Federation of Exchanges (2015), CCP risk management recovery and resolution – aligning CCP and member incentives, https://www.world-exchanges.org/home/images/easyblog_articles/60/WFE-CCP-Paper-FINAL-2015102_20151021-110126_1.pdf [22.02.2018].

Widz E. (2017), Rola centralnego kontrahenta w rozliczeniach transakcji na rynku nieregulowanym OTC na przykładzie działalności KDPW_CCP, „Annales Universitatis Mariae Curie-Skłodowska Lublin – Polonia", vol. LI, 1 Sectio H.

Zaleska M. (2015), Refleksje na temat unii rynków kapitałowych, in: Janc A., Mikołajczak P., Waliszewski K., Europejska unia rynków kapitałowych. Perspektywa finansowania przedsiębiorstw w Polsce, Wydawnictwo CeDeWu, Warszawa.

Legal acts

Regulation (EU) No. 648/2012 of the European Parliament and of the Council of 4 July 2012 on OTC derivatives, central counterparties and trade repositories (EMIR Regulation).

Internet sources

(www 1) https://www.esma.europa.eu/regulation/post-trading/non-financial-counterparties-nfcs [03.11.2017].

(www 2) https://www.opengamma.com/2016/07/05/25-increase-in-cleared-swaps-initial-margin-in-the-5-days-since-brexit/ [03.11.2017].

(www 3) http://www.theotcspace.com/2015/10/02/clear-or-not-clear-directly-question [03.11.2017].

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Adjusting the employee management process to key organisational values

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Abstract:

Aim: The paper is aimed at highlighting the growing importance of values in both management theory and practice with a focus on aligning employee management practices with the key values in organisations which practise Management by Values (MBV).

Design / Research methods: Critical literature review and analysis of results of accessible empirical research.

Conclusions / findings: Management by Values can only yield effects if it is applied in all sections of the firm with employees taking up actions in line with the shared organizational values. That is why it is crucial to reflect the core values in recruitment and selection of employees, as well as training, motivation or work productivity assessment. The analysis of the literature revealed the need for more in-depth research on the links between staff policy and management by values, especially in management practices.

Originality / value of the paper: The paper is aimed at managers who implement MBV in their organisations as well as scholars focusing on the subject of values in management. What is more, it synthesizes different outlooks on MBV and embeds this concept in realities of Polish companies.

Limitations of the research: The literature review and analysis of the results of empirical research conducted in Polish companies indicate the growing importance of values in management practice and the necessity of constructing specific tools that would enable leaders to operationalize key values and use some indicators to assess present and potential employees in the terms of their respect for the organization's shared values.

Keywords: key organizational values, employee management, management by values

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1. Introduction

In considering the factors which enable today's organizations to survive on the market and win competitive advantage in a turbulent business environment, it is hard not to notice that in vast majority these are non-material factors. The cornerstone of an organization are its employees who, through their knowledge, skills and ongoing improvement, as well as their engagement in performing their duties, contribute to the greatest extent to the firm's growth, building its success and competitive advantage in the broad sense of these terms. Nowadays, it is increasingly more often that one talks about an employee's market, in particular when individuals are sought whose competences match precisely the needs of a firm. This is why the concepts are becoming ever more popular which foster the development of employees' potential, take into account the needs of knowledge employees, talent management, employer branding or personnel marketing.

In a rapidly changing world, organizations must adjust their operations very quickly to advancing technologies and ever more individualized preferences of consumers, which is why they look for enduring values ensuring stability while helping make decisions in accordance with the organization's philosophy of operations and strategy. Values are predominantly present in organizational culture; in the relationships among people; in the systems of values and systems of ethics generally accepted by the members of an organization (Bugdol 2006:10). In the context of this paper, what appears necessary is to define the concept of key values more precisely and to place them among other values which operate in organizations. While a vision is a particular image of what the firm should be like in the future, with its mission and goals indicating the reason for the firm's existence, organizational values, and in particular those of key importance, are valuable pointers towards success. It is through these values that executive staff and employees know how to go about things, how to run business and how to shape the organization in order to move it a step closer towards accomplishment of its mission (Hill, Jones 2012: 32).

The aim of this paper is to indicate the ways of adjusting employee management process to core organizational values. The analysis was conducted based on the

literature review, and taking into account the results of the research carried out in Polish organizations by a team of researchers from Warsaw and Cracow over the period of 2012-2104 (Herman et al. 2016: 9).

2. Organizational values

For many years now organizational values have been the focus of scholars from a variety of fields such as psychology, sociology or management science. While placing the discussion in management sciences one should mention the two major mutually complementary strands of research which take into account the role of values in organization: the studies on organizational culture, where values operate as one of its elements, and the concept of management by values which concentrates around the management process determined by a set of core values recognized in organization as the most important ones.

According to Hofstede, values, understood as tendencies to make a specific choice, are the core of culture. As they begin to shape already in the early childhood, changing them is very difficult and requires a long lasting process. People are often not conscious of these values with the only way of reading them being an analysis of how employees behave in specific situations (Hofstede 2000: 44; Adedeji et al. 2017:86). It should, however, be noted that Hoftstede talks here about national culture, because for the organizational culture its core lies in "shared perceptions of daily practices" (Hofstede 2000: 268-270). E. Schein, on the other hand, draws attention to the fact that not all values that operate in organization can be perceived as corporate values. They only gain in importance when employees begin to see them as being helpful in solving problems encountered in the organization and so they are commonly applied in employees' operations, since employees recognized the values as effective based on the positive experiences which they have shared in their own common reality (Schein 2009: 28). In this sense, not all the values circulating in the organization are equally valuable for the organization's functioning. Every person employed in the firm brings with himself his individual hierarchy of values, yet not every such value is important from the perspective of the operations of the entire

organization. In order for the values to be recognized as organizational values they need to meet the following conditions: they have to exert impact on all the cells of the organization, and not merely on certain departments or branch offices; they must be linked to the organization's success; they must be controlled by somebody or something (specific indicators); they have to be measurable; and all entities engaged in the organization must aspire to those values (Alas et al. 2006: 271). Only such values can form a foundation on which to build organization's strong culture and to implement management by values.

3. The concept of management by values

Considering the diversity of values present in an organization and their key relevance for the firm's stability, one should stress the importance of managing appropriately this extraordinary factor which exerts impact on whether or not one is successful on the market. Employing the concept of management by values requires a holistic approach to the organization and the processes unfolding within it. For in combining management philosophy with practice, this concept contributes to humanizing management in that it incorporates shared values in all aspects of the organization's operations, while, on the other hand, it focuses on practicing these values and aligning them with the mission and vision of a particular enterprise (Lachowski 2012: 230). According to K. Blanchard and M. O'Connor, this is a business practice which motivates clients to keep on returning to the organization and inspires employees to strive for improvement on a daily basis. Management by values makes it possible for the owners to be proud of their organization and still make money, while also encouraging important stakeholders to foster business relationships with a specific firm (Blanchard, O'Connor 2003: 25).

Agata Stachowicz-Stanusch emphasizes the process-like nature of this concept and defines management by values as a "process of transferring core values of organization from the generation of those managing the organization onto the next generation by taking over the responsibilities arising from these values and by protecting them in the name and to the benefit of the organization and its

participants through institutionalization of these core values" (Stachowicz-Stanusch 2007: 38). This definition suggests that there are so called core values which underlie the functioning of the organization. They are conceived of as a specific group of "publicly expressed values or concepts which are believed in by the majority of members of a particular organization and which are regarded as the most central and important for the organization's permanence and growth" (Stachowicz-Stanusch 2004: 40). As a part of national heritage, which the organization's members transfer from generation to generation, the core values shape the firm's identity and determine the way it operates (Stachowicz-Stanusch 2007: 14). It should, however, be stressed that there is not a single ideal set of core values that could ensure market success of every organization. This set, which is some sort of organizational canon of values, must be tightly fitted to the firm's needs, must be shared and accepted by all employees and reflected in their daily practices (Lachowski 2012: 233-234).

The sets illustrating key values in contemporary organizations are presented in Table 1. In comparing them one begins to realize the fact that firms define their fundamental principles completely differently. Some organizations give single nouns to depict their values, while others present them using a more descriptive way. It should be further highlighted that even the name itself can harbor different definitions and ways of understanding organizational values, and they will ultimately determine completely different decisions and behaviors. Taking a closer look at the value "integrity" shows that the Kellog company defines it as follows: "We Act With Integrity and Show Respect." For the Coca-Cola Company, on the other hand, "integrity" implies simply "be real," while in the company Mosty Łódź S.A. "integrity and reliability" means nothing more but task implementation, fulfilling one's responsibilities and avoidance of purposeful faults. This example demonstrates that it is not possible to create a universal list of actions across different elements of the personnel function, for they will result directly from the definition of a specific value and the firm-specific way in which this value is realized through organizational practices.

Table 1. Illustrations of the key value sets

Company	Key values
Kellogg	integrity, accountability, passion, humility, simplicity, results
The Coca-Cola company	leadership, collaboration, integrity, accountability, passion, diversity, quality
Wolters Kluwer	*Focus on customer success; Make it better; Aim high and deliver; Win as a team*
The Adecco Group	passion, entrepreneurship, responsibility, team spirit, customer focus
BP	Safety, respect, excellence, courage, one team,
Mariott	We put people first; we pursue excellence; we embrace change; we act with integrity; we serve our world
Ceresit	Innovation; Quality; Technical knowledge; Sustainable development
Mosty Łódź S.A.	Honesty; integrity and reliability; safety; compliance with the law; compliance with social standards; compliance with environmental standards.
KGHM Polska Miedź	Zero harm, teamwork, results-driven, accountability, courage
PKN Orlen	**Responsibility, Progress, People, Energy, and Dependability**

Source: http://www.kelloggcompany.com/en_US/our-values.html; http://www.coca-colacompany.com/our-company/mission-vision-values; http://wolterskluwer.com/company/about-us/company-values.html; http://www.adeccogroup.com/our-company/core-values/; http://www.bp.com/en/global/corporate/about-bp/people-and-values/our-values.html; http://www.marriott.com/culture-and-values/core-values.mi; http://www.ceresit.pl/pl/about-ceresit/our-key-values.html; http://www.mosty-lodz.pl/pl/kluczowe-wartosci.html; http://www.orleneko.pl/PL/ofirmie/KulturaKorporacyjna/Documents/Kodeks_Etyczny_Eko.pdf; http://kghm.com/en/sustainable-development/strategic-approach/values;

In moving on to the process itself of managing by values, one ought to assert that scholars identify different stages of its implementation. Table 2 includes the comparison of how management by values unfolds according to the approaches presented in literature. Stachowicz-Stanusch distinguishes four stages of the process of management by values starting with the discovery of the core values, their development, institutionalization to their redefinition (Stachowicz-Stanusch 2007: 39-41). Within the institutionalization stage, the author identifies the protection of the core values, which consists in taking actions supporting their development at every stage of the process involving employee management. Blanchard and

O'Connor, on the other hand, propose to start the MBV by explaining the mission and values, then by proceeding to communicating the mission and values to employees, and then to adjusting organizational practices to the mission and key values (Blanchard, O'Connor 2003: 39). In light of the subject of this paper, one should cite the stages of value development in organization according to A. Argandoñy, as they make the process slightly more specific. Argandoñy believes that the process should begin by identifying the already existing values, and only then one should move on to identify the preferred values. The third stage involves communication, institutionalization of values and employees' commitment, which is then followed by adjusting organizational practices to the values. Argandoñy notes that during the subsequent phase it is necessary to align the human resources policy to the core values, while the final stage is comprised of the revision of the management by values process (Argandoña 2003: 21).

Table 2. Management by values

Stachowicz-Stanusch A.	**Blanchard, O'Connor**	**Argandoña A.**
1. discovering core vales 2. development of core values -description of core values - definitions of behaviors -formulating the declaration of core values -communicating core values 3. institutionalization of core values -core value implementation -core value protection - core value control 4. redefinition of core values	1. explaining mission and values communicating mission and values to employees 2. adjusting organizational practices to mission and key values	1. identification of existing values 2. identification of desired values 3. communicating and institutionalizing values and employees' engagement 4. adjusting organizational practices to core values 5. revision of the process of management by values

Source: Stachowicz-Stanusch 2007: 39-41; Blanchard, O'Connor 2003: 39; Argandoña 2003: 21.

Blanchard and O'Connor emphasize that what is crucial for successful management by values are organization's employees (Blanchard, O'Connor 2003: 32). This assertion is reflected in each approach to the MBV outlined above, since it is people who are carriers, promoters and propagators of values. If the management staff does not evince specific behaviors, the implementation of the key values is not possible, while lacking the employees' acceptance, the organization has no chances of sustaining and transferring these values to next generations, which is what makes them endure.

4. Aligning HR policy with core organizational values

Employees of an organization play a crucial role at each stage of the management by values process. Every employee can and should make his own contribution to the identification of the most important values by indicating what he believes is crucial for the firm. Naturally, not all the principles mentioned can find their way to the list with key values underpinning operations of a firm, and yet without this preliminary gathering of information given by different employees, discovering those values would be difficult. After all, this is the employees who talk to one another about what is the most important for their firm, being the link between the organization and the environment, and by inference, potential clients, partner or the local community. This is why it is so important that employees understand the definitions of the key values precisely, accept them along with their consequences in terms of making decisions and taking up actions in specific situations. To this end, tools are created aimed at supporting the MBV in organization with the core values taken into account when constructing the individual elements of the HR policy.

Each of the approaches to the MBV process presented above has the stage of aligning organizational practices with core values, with Stachowicz-Stanusch mentioning this aspect while discussing the stage of institutionalization of those values, while Argandoña emphasizes the need of adjusting them to the HR policy. For Blanchard and O'Connor, on the other hand, the stage which ensures coherence

of daily practices with key values is one that is most expanded, since it distinguishes individual, team and organizational practices (Blanchard, O'Connor 2003: 134).

While looking for ways of aligning HR policy with key organizational values the conclusion to be made is that the values are here an independent variable, being something primal in relation to the form of the individual elements of employee management. The shape of the individual processes making up the personnel function is, on the one hand, determined by the conditions on the labor market, and, on the other hand, by organizational internal regulations. Thus, adjusting this process requires, on the one hand, general arrangements which would define how the key values can impact the HR elements, while on the other hand, once a specific set of values has been established, it is possible to develop the individual elements of the personnel function in such a way as to allow their implementation to foster the application of core organizational values.

The further section of the paper presents selected issues pertaining to the process of adjusting employee management practices to key organizational values. Stachowicz-Stanusch refers to the components of personnel function at the stage involving the institutionalization of the core values, which encompasses, among other things, aligning every operation of an organization with these values. The author stresses that what is needed is to hire employees displaying "the necessary personal characteristics and basic abilities allowing for the implementation of the core values," in other words, the candidate's cultural compliance with the organization's core values (Stachowicz-Stanusch 2007: 125). Devising recruitment procedures that would be coherent with the key values is undeniably a task that is time consuming and demanding, but it will pay dividends in the future, since an effective employee recruitment leads to savings in time and money which would otherwise be needed to carry out new recruitments following the departure of an employee who turned out to be a wrong hire. Ineffective recruitment may be particularly costly for small and medium-sized businesses, where "resources are limited, with every recruitment mistake affecting the productivity of the entire firm". Moreover, considering the fact that shaping attitudes among employees which are consistent with the values espoused in the firm is a long process, it is better to hire, if possible, persons who respect values which are consistent with the organizational

values (Lachowski 2012: 290). Not only will this allow an employee to adapt more quickly, but it will also reduce the training costs. While designing a recruitment system what is crucial is to ensure that all candidates have a comparable opportunity of presenting their abilities, thereby allowing one to really see whether a particular candidate is suitable in terms of the firm's key values. It should be emphasized that the role of the recruitment system that is based on values grows in direct proportion to a sought-after employee's participation in the implementation of the organization's strategy (Dolan et al. 2006: 188).

The research conducted by Herman et al. showed that "most people who are involved in staff recruitment and selection focus on values, but only 23% of them believe that their organization has an adequate methodology" (Herman et al. 2016: 101). That values are taken into account in the recruitment and selection process was confirmed by 94% of respondents, with 40.6% being those who reported having neither suitable tools nor procedures which could allow them to diagnose and compare candidates in terms of values on a routine basis. For 29.9% or respondents, satisfactory operationalization of values became a fact with respect to certain job positions and occupational groups (Herman et al. 2016: 102-103). The findings of the empirical studies confirm that in the recruitment process the values of candidates applying for individual jobs are of importance, while showing the need for developing adequate tools to be used in firms for comparing candidates as regards values.

For the implementation of the core values, what makes one of the most important stages in the employee management process is training, including initial training, just after starting the job, and the training that comes at a later stage of one's employment. Creating a training program designed to support management by values should be preceded by answering two basic questions: what new beliefs employees should learn and what beliefs they should abandon in order to foster and develop each of the organization's key values? What abilities and knowledge should employees have so as to be able to develop in themselves patterns of behaviors which are consistent with the organizational values? (Dolan et al. 2006: 190).

If an organization is just beginning to implement management by values, it has to devise a definition for each core value, and then a particular value-related

standards which employees have to learn to respect. In this case training is aimed at teaching employees in such a way as to make them understand those values, and further on, to equip them with possibilities that would allow them to realize those values in practice (Stanusch 2007: 125). Merely communicating the values and the standards which define them may prove to be insufficient for those values to be realized in firm's everyday practices.

While offering employees a cohesive training system one should also bear in mind the attractiveness and effectiveness of the different forms aimed at one's improvement. Instead of lectures, it might be better to suggest meetings with other employees with a view to share experiences, to create a good practice data base, where proven solutions to problems from the past would be described, or also to organize meetings once a project has been completed in order to discuss mistakes encountered at different stages of the project. It is quite often that employees emphasize that what counts the most for them in the context of learning are meetings aimed at sharing experience with people who encounter on a daily basis problems which are similar to those emerging at work. It is therefore worth making sure that employees have adequate conditions for sharing knowledge, and that such elements as on the job training, cooperation and coaching, as well as mentoring programs are supported.

Motivation is yet another element of employee management in an organization. People take up work to satisfy their diverse needs, from the need for living conditions, relationships with other people to self-actualization and growth. Considering that academic literature differentiates between external and internal motivation, the motivations behind taking up a job cannot be reduced merely to the expectations in terms of financial gain, since what should also be noticed are the dignity-based motivations which are related to employee's subjectivity and the importance of the employee's individual values being consistent with the organizational values. What is also highlighted in literature is the need to create a motivating work environment adjusted to the individual needs of employees (Barrett 2014: 35-36). Referring to Herzberg's two-factor theory of motivation, remuneration for work is placed in the group of hygiene factors which do not make job satisfaction grow, although when those factors are not present the employee's

productivity falls and he gets dissatisfied with his work conditions. One should therefore keep in mind that non-material motivating factors can fulfill their role if the employee is decently rewarded. One comes across the fundamental principle of rewarding one for a gainful employment in the Holy Scripture which says, "Worthy is the laborer of his pay" (Vol. 5, 18). The specific terms and conditions of employees' remuneration are governed by the relevant provisions of law, and first and foremost, by the contract of employment concluded with an employer.

While the financial terms are often what determines whether or not people take up a specific job, over the course of doing this job the motivators which gain in importance are those associated with receiving recognition from other fellow workers, with a sense of co-owning the firm or with the possibilities in terms of professional growth. With financial incentives being adequately secured, people search for something else that could provide them with the basis for their actions, something that would afford them joy and satisfaction engendered by accomplishing their goals. Key organizational values are just this element, as they are a benchmark by which one makes decisions, resolves conflicts and creates value for clients.

According to A. Blikle, working for values brings about inner satisfaction with people wishing to repeat the action they embarked on, whereas being driven by financial gain comes in a situation when this aspect is clearly absent, yet once it has been satisfied, it no longer works as a motivator. Blikle also draws attention to dignity-based discord which emerges with abandoning one's values for financial gain. When this occurs, people are reluctant to repeat their actions, for it involves an inner sense of punishment and dissatisfaction (Blikle 2016: 73). In a situation when this discord between employer's demands and employee's values and moral principles keeps on recurring, it happens that the employee no longer condones using unethical solutions and resigns.

The management by values process should be supported by adequately constructed motivational systems which foster the behaviors which respect key values, while containing actions that contradict those principles. The questions that remain open are those concerned with the extent to which the traditional motivational schemes linked to work results are suitable to the needs of today's employees, how these schemes work in organizations driven by values and how

strong, in such organizations, is the influence of values on employees' motivation and actions. The findings of the research mentioned earlier show that among the managers and specialists from the firms examined the prevalent belief is that when rewarding employees values are taken into account only sporadically and in exceptional cases (34.6% of respondents). It should, however, be stressed that 24.8% of respondents confirmed that values were considered when rewarding employees through a reward and punishment scheme. Sometimes, an increase in a basic salary was attributed to behaving in accordance with organizational values. Respondents also reported quite frequent (19.1%) and sporadic links (45.9%) between promoting values and non-material distinctions. The scheme-based relationship between values and non-material motivation was reported by 5.9 respondents, while 29.1% of the surveyed did not see such relationships in their organization (Herman et al. 2016: 110-115).

A tool supporting the implementation of management by values as well as allowing for its monitoring may be periodic employee appraisal scheme, provided it takes into account the criteria related to the key values being respected at every work position. On the one hand, a superior will receive information about the extent to which these values have been implemented by his employees, and on the other hand, during the appraisal meeting, he will be able to pay attention to behaviors aligned with the principles governing the firm and to indicate those ways of behavior which are against the philosophy adopted. Thus, the scheme of periodic appraisal will allow for the achievement of the corrective objective (discovering errors so as to be able to avoid them in the future), the stabilizing objective (encourage an employee to repeat the desired behaviors) and the development objective (to show the employee the superior's expectations that are to be met as they determine the employee's development) (Ludwiczyński 2006: 279-280).

In the practice of the firms examined, 52.7% of respondents declared taking into account values while appraising employees; however, only 11.1% of responses pertains to the majority of professional groups or the majority of employees. In the employee appraisal, 13.3% of respondents applies the value criterion in relation to selected professional groups, with 28.3% of respondents applying this practice in individual and exceptional cases. A large number of managers and specialists from

the organizations participating in the study (41.8%) said that they did not consider values while appraising employees, focusing only on their skills and work performance (Herman et al. 2016: 104-105).

5. Conclusion

In summing up the above discussion, the conclusion to be made is that given their functioning in a constantly changing environment, employees need a solid foundation in their organization which will assist them in making specific decisions and taking specific actions. What makes such a pillar are the key values. One of the elements of their institutionalization is aligning them with organizational practices in every aspect of the operations of the firm. Since people come to an organization already with their own values, and then realize organizational values, the employees' values should be considered while constructing the HR policy. As the analysis of the literature shows, the issue surrounding the adjustment of individual components of employee management process to organizational values is not an area that has been extensively explored. The research conducted by a team from Warsaw Universities and the Jagiellonian University of Cracow allows one to conclude that this phenomenon exists in Polish firms, with many managers seeing the need of taking into account values, predominantly during the process of employee selection. They argue that it is necessary to introduce tools which will allow for operationalization of different values and for comparing people applying for a specific job in terms of how well they match organizational values. The subject of organizational values also comes up in the process of motivating and rewarding employees; however, considering values in those aspects has not been a common development yet, just like the management by values itself. Whether this concept has been gaining in importance or whether it was just a passing trend in management can only be revealed by similar research conducted in a few years' time. The changes unfolding in the modern world, however, suggest that there is a need to build firms which are based on strong foundations, and organizational values are certainly that.

References

Adedeji B.S., Rahman M.M., Khairuddin I., Uddin M.J., Rahaman M.S. (2017), A synthesised literature review on organisational culture and corporate performance, "Journal of Advanced Research in Social and Behavioural Sciences" vol. 7 no. 1 (2017), pp. 83-95.

Alas R., Ennulo J., Türnpuu L. (2006), Managerial values in the institutional Context, "Journal of Business Ethics", vol. 65 no. 3, pp. 269–278.

Argandoña A. (2003), Fostering values in organizations, "Journal of Business Ethics", vol. 45, nos. 1/2, pp. 15–28.

Barrett R. (2014), The values-driven organisation. Unleashing human potential for performance and profit, Routlege, Oxon.

Blanchard K., O'Connor M. (2003), Managing by values, Berrett-Koehler Publishers, Inc., San Francisco.

Blikle A. (2016), Doktryna jakości, https://www.moznainaczej.com.pl/Download/DoktrynaJakosci/DoktrynaJako%C5%9Bci_wydanie_II.pdf [15.10.2016].

Bugdol M. (2006), Wartości organizacyjne. Szkice z teorii organizacji i zarządzania, Wydawnictwo Uniwersytetu Jagiellońskiego, Kraków.

Dolan S.L., Garcia S., Richley B. (2006), Managing by values, Palgrave Macmillan, New York.

Herman A., Oleksyn T., Stańczyk I. (2016), Zarządzanie respektujące wartości. Raport z badań, Difin, Warszawa.

Hill C.W.L., Jones G.R. (2012), Essentials of strategic management, Cengage Learnind, Mason.

Hofstede G. (2000), Kultury i organizacje, Zaprogramowanie umysłu, PWE, Warszawa.

Jaakson K., Management by values: are some values better than others?, "Journal of Management Development", vol. 29 no. 9, pp. 795–806.

Lachowski S. (2012), Droga ważniejsza niż cel, Wydawnictwo Studio Emka, Warszawa.

Lencioni P.M. (2002), Make your values something, "Harvard Business Review", vol. 80 no. 7, pp. 113-117.

Ludwiczyński A. (2006), Ocenianie pracowników, in: Zarządzanie zasobami ludzkimi, eds. Król H., Ludwiczyński A., PWN, Warszawa.

Schein E. (2009), The corporate culture. Survival guide, Jossey-Bass, San Francisco.

Stachowicz-Stanusch A. (2007), Potęga wartości. Jak zbudować nieśmiertelną firmę, Helion, Gliwice.

Stachowicz-Stanusch A. (2004), Zarządzanie poprzez wartości. Perspektywa rozwoju współczesnego przedsiębiorstwa, Wydawnictwo Politechniki Śląskiej, Gliwice.

Internet sources:

http://kghm.com/en/sustainable-development/strategic-approach/values [02.07.2017].

http://wolterskluwer.com/company/about-us/company-values.html [02.07.2017].

http://www.adeccogroup.com/our-company/core-values/ [02.07.2017].

http://www.bp.com/en/global/corporate/about-bp/people-and-values/our-values.html [02.07.2017].

http://www.ceresit.pl/pl/about-ceresit/our-key-values.html [02.07.2017].

http://www.coca-colacompany.com/our-company/mission-vision-values [02.07.2017].

http://www.kelloggcompany.com/en_US/our-values.html [02.07.2017].

http://www.marriott.com/culture-and-values/core-values.mi [02.07.2017].

http://www.mosty-lodz.pl/pl/kluczowe-wartosci.html [02.07.2017].

http://www.orleneko.pl/PL/ofirmie/KulturaKorporacyjna/Documents/Kodeks_Etyczny_Eko.pdf [02.07.2017].

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Double Perspective DEA on appraising property's fair market value by Brazilian Standards

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Abstract:

Objective: This article innovates when we incorporate the statistical analysis to the method of Double-Perspective Data Envelopment Analysis (DP-DEA), with the objective of obtaining an estimate of greater accuracy and reliability according to the assumptions of the Best Unbiased Estimator (BUE).

Design / Research Method: Double Perspective Data Envelopment Analysis (DP-DEA) is an extension to Classical Data Envelopment Analysis (DEA) for estimating efficiency, asset values, indicators, and other attributes from two perspectives, achieving a common result is the main objective. This article innovates in DEA methodology, in two aspects: 1. To demonstrate the ability of the DP-DEA to perform at intervals the estimation of values from a random sample; 2. Through the statistical analysis, making estimates of central tendency according to the assumptions of the Best Unbiased Estimator (BUE – Best Unbiased Estimator).

Conclusions / findings: The practical procedures performed step by step through DP-DEA according to the assumptions of the BUE, presented in its main findings and conclusions are: 1. Incorporation of statistical analysis to the DP-DEA method, which assumes assumptions of properties of the Best Estimator Non-biased; 2. Within the scope of the DEA, it presents an innovative capacity to make estimates from random samples, and; 3. At the end of the article, by simulation, able to validate modeling through the variation of property characteristics, demonstrating that the estimation of the corresponding values is consistent according to the market's expectations.

Originality / value of the method: This article opens new avenues to be explored by the DEA community. Firstly, as a tool for valuing assets, according to the Comparative Market Data Method. In

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Brazil, DP-DEA has been approved by the Brazilian Association of Technical Standards for this purpose. Another innovation is to evaluate performance which results from common gain according to two perspectives, which interact in the process or procedure under analysis.

Key words: Double Perspective Data Envelopment Analysis; Real Estate Appraisal; Best Unbiased Estimator

JEL: C61, D12

1. Introduction

This article presents the evolution of a new field of application and research for Data Envelopment Analysis (DEA) through an approach in valuing assets.

The methodology of Double-Perspective Data Envelopment (DP-DEA) (Novaes 2002; Lins et al. 2005) was developed according to the classical theory of Data Envelopment Analysis (Charnes et al. 1978; Banker et al. 1984), which is ground breaking in the area of DEA methodology due to the ability to make estimates from a set of data (Sampaio 2010). Thesis reports an applying of Double Perspective Data Envelopment Analysis to the Benchmarking Process of Public Utilities.

This article applies the DP-DEA to estimate the fair market value of property under the Direct Comparative Method of Market Data (Lewis 1999). Similarly, to regression analysis, DP-DEA studies the dependence of one or more variables explained by one or more explanatory and / or independent variables, to estimate a range of viable values from two different perspectives and to find common satisfactory results.

The case in question, the objective is to estimate the fair market value in which a property can be traded, that is, the central tendency value where the supply and demand of the commodity – property – serves the interests of the buyer and the seller. The plausibility of this assertion is best understood according to the law of supply and demand (Whelan, 1996), according to where there is a region of central tendency, where the supply and demand curves meet, and the fair market value is established (Misra, 2013).

The main innovation presented in this article is to demonstrate the use of statistical fundamentals, applied to the DP-DEA, has the property of establishing the best unbiased estimator.

In section 5, we verify, instead of establishing a single value estimate, a range of admissible values delimited by the enclosures that encapsulate the analyzed data set is defined. The hypothesis formulated is that the envelopes delimit the viable region of occurrence, which satisfy the laws of supply and demand (Shephard 1975) applied to the real estate market, according to the buyer and seller's views.

To summarize, we contextualize the main contributions of DP-DEA in the research and the application which is to be portrayed in this article, through the following themes:

- Contextualization of the theoretical innovation of the DP-DEA approach in relation to the DEA methodology.
- Origin, history and motivation of the DP-DEA (Double Perspective DEA) methodology (Novaes, 2002).
- Fundamentals and mathematical formulation of the DP-DEA method.
- Criteria and assumptions adopted to establish the best DP-DEA estimator.
- Formulation and characterization of the equation of the central tendency estimator.
- History and relevance of Real Estate Evaluation Standards in Brazil
- Regulatory and Market Context for applying the methodology in Brazil.
- Application of DP-DEA according based on the real estate market data.

2. Contextualization of the theoretical innovation of the DP-DEA approach in relation to the DEA methodology

The theoretical context of the scope of the DEA methodology is portrayed in an article by Ali Emrouznejad and Guo-liang Yang (2017), when researching the diversity of its application in various areas of human knowledge in the last four decades. We verify that among approximately fifty related keywords like the mostly used, they are not cited in the focus of this article: Real Estate Appraisal; Direct Market Data Method, and; Best Unbiased Estimator.

The originality and innovation introduced by DP-DEA corresponds to its ability to estimate values for one or more dependent variables through one or more

explanatory and / or independent variables, introducing a new area of research and application for the DEA methodology.

According to the most recent bibliographies, one of the main obstacles to the greater diffusion of the DEA is the analysis of productivity and efficiency which lies in the fact that it has no statistical basis (Ray 2004). The same authors assume that two different samples, which use the same input packages and produce sets of different quantities of products, would lead to different measures of the production frontier.

Bayraktar et al. (2008) also note that the sources of uncertainty are in the process of matching demand with supply. In this application, by encapsulating observed market data, uncertainty translates into the variability of occurrences which can satisfy each perspective of demand and supply, a condition that will be better explained in the 5 and 6 section.

It is important to verify what the DEA community reaction, has been when introducing the use of a more statistical basis, as we can verify in the following publications:

- Wanke et al. (2017) describe several new parametric models to deal with input/output uncertainty in DEA;
- Banker's (1993) interpretation of the DEA as MLK – Maximum Likelihood Estimation, uses the F statistic to establish greater reliability to the adopted model;
- Land et al. (1993) proposed a DEA approach with probability restrictions;
- Varian (1985) proposed a statistical test of data consistency with the WACM – Wax Costs Minimization Axiom and WAPM – Weak Axium and maximum profit;
- Simar and Wilson (1998) use consistent bootstrap techniques to generate empirical distributions of efficiency outcomes;
- Subhash (2004) notes that a new way to deal with input/output uncertainty in DEA depends on the randomness of probability distributions;
- Morita and Seiford (1999), Brázdik (2004) and El-Demerdash et al. (2013) observe that a restriction limits the use of the stochastic DEA model in cases where the event is unique or deterministic, a priori or posteriori of

probability distributions needs to be addressed. However, the uncertainty of input/output may be related to the inaccuracy and not to the randomness. Where, some Fuzzy DEA methodologies are compared.

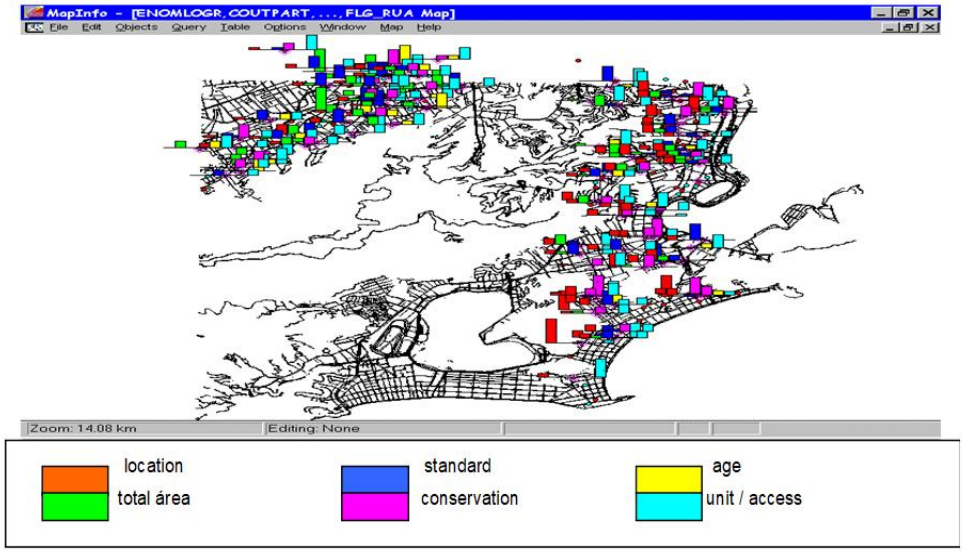
- Bayraktar et al. (2008) investigate the impact of value range of practices on retailer performance and makes the economic premise that uncertainty is generally defined as unknown future events which cannot be predicted quantitatively within useful limits, thus making the occurrence of uncertainty unpredictable.

3. Origin, history and motivation of the Double Perspective DEA

The Double Perspective DEA technique was developed within the doctorate thesis of Luiz Fernando de Lyra Novaes (Novaes L.F., 2002), under the guidance of professor Marcos Pereira Estellita Lins. The introductory international publication of this method on a paper of Lins et al. (2005) "Real Estate Appraisal. A Double Perspective Data Envelopment Analysis Approach".

A first important result was the presentation of a conference paper, awarded first prize in the III Symposium of Appraisal Engineering – Avaliar 2002 (see Novaes et al., 2002), promoted by the Brazilian Association of Institutions for Financing Development (ABDE). One relevant approach presented in that occasion, was the capacity of the parameters forming of frontier hyper plane defined by DP-DEA Multipliers Model (Novaes 2002) on interpreting the real estate buyer's behavior, similar with the price-elasticity, verified on lower surface. Each real estate price-elasticity graph bar is geocoded, e.g., see Figure 1.

Figure 1. GIS representation of physical features on apartments assessment



Source: Novaes (2002).

Over the map of Rio de Janeiro municipal district was geocoded factors graph bars that represents the main factors trade-off, that explain the buyer interest for each apartment analyzed, on response of what are the relative importance of real estate valuation factors, based on sales data compiled by a real estate market.

When you are looking for a property, new home or starting a home renovation, it is important that you understand the factors influencing the property valuation.

Location: The axiom “location, location, location” emphasize the importance of this factor on chose a property, and the reason it is such a prevalent cliché is because there is truth behind it. Proximity to beaches, laser places, employment centers, medical facilities, shops, and schools is a determining factor for many families and young couples when buying a home. Proximity to a wide array of local amenities and good transport links increases the value of your potential property.

Age and Conservation: The age of a property doesn’t automatically reduce its value. However, the condition of conservation of a property makes a huge difference. An old but well-maintained property can achieve a valuation that is the same as that of a new build of equivalent specifications; sometimes, even higher.

Area and number of rooms: The size of an apartment on combination with the number of rooms affects the value of the property. For example, increasing the number of bedrooms and bathrooms is a good move to increase the value of your home, whereas removing facilities or reducing the number of bedrooms is not.

Standard: Represents the quality of accessories and materials on wall-covering, floorcovering, facades, common area and apartment. A building class distinguished by a quality rating of the building construction, varying from luxury until minimum recovering. The standard reflects directly on value real estate variation.

Unit/access: The condition of apartment access distinguished mobility and how is increased on exclusivity on the use of the building amenities, service and social hall and lift usage. These conditions are correlated with the investment made on the construction of the building, representing what is offered on comfort to residents.

The influence of each real estate factor price elasticity is distinguished by the graph bar geocoded exactly on the location of each apartment. The red bar represents the location, the blue represents more privacy, yellow is apartment age, dark blue the building standard, purple is conservation and green are apartment dimension. Observing the map, we can see a buyer behavior varying with its location. Some factor is more important as if formed by a location cluster, permitting interprets the buyer's behavior changing in function of the apartment localization into the map. On the cluster formed by coastal apartments, we can conclude that the location is prevalence. However, for the cluster formed by suburban region apartments other factors, total area, conservation and units/access are preponderant and they do not account with none influence of location.

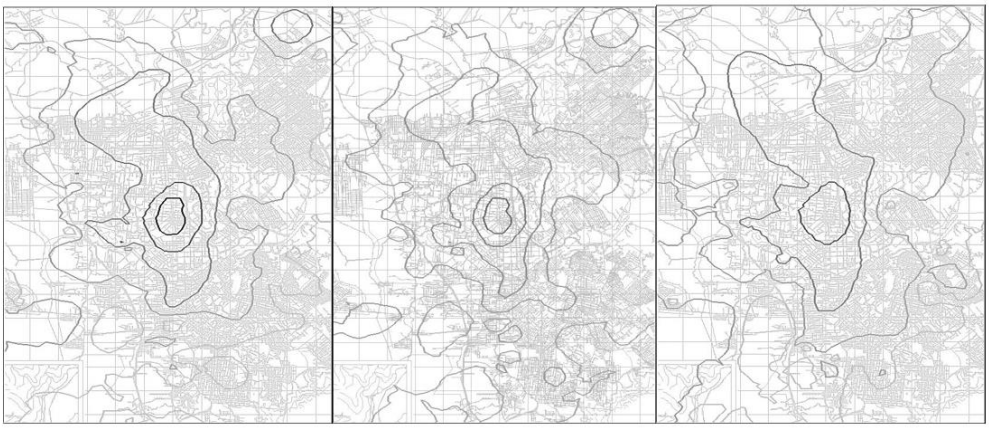
In 2009/2011 it was performed NBR 14.653 review – Brazilian National Uniform Standards of Professional Appraisal Practice (ABNT 2011). The DP-DEA – Double Perspective Data Envelopment Analysis method (Novaes 2002) was included within the scope of quantitative methods recommended for appraisal.

On page 17 the Standard recommends: "Other analytical tools for induction of market behavior, considered of interest by the appraisal engineer, such as space regression, data envelopment analysis and artificial neural networks, may be applied, given that theoretical and practical point of view where duly justified, with

the inclusion of validation, where relevant. In the case of the use of data envelopment analysis (Double Perspective-DEA), Appendix D must be observed".

Novaes and Paiva (2010 lining up with Appendix D ABNT 2011), established an approach to solve the LOOP – Law of One Price arbitrage (Eckard 2004). A general equilibrium model of real estate values developed to analyze property price per square meters variation over a digital map of the urban area of the city of Joinville compared with MRA – Multiple Regression Analysis. All computational results were geocoded on a GIS – Geographic Information System generating scales of price isolines over the Map, enabling compare accuracy between DP-DEA and MRA. Comparing Figure 2 with Figure 3 and Figure 4 with Figure 3, is perceptively the fitness adjustments of DP-DEA value isolines, e.g., Figure 2, with the value observed isolines than MRA isolines.

Figure 2. DP-DEA Figure 3. Observed data Figure 4. MRA



Source: Novaes, Paiva (2010: 4-6).

4. Fundamentals and mathematical formulation of the DP-DEA method

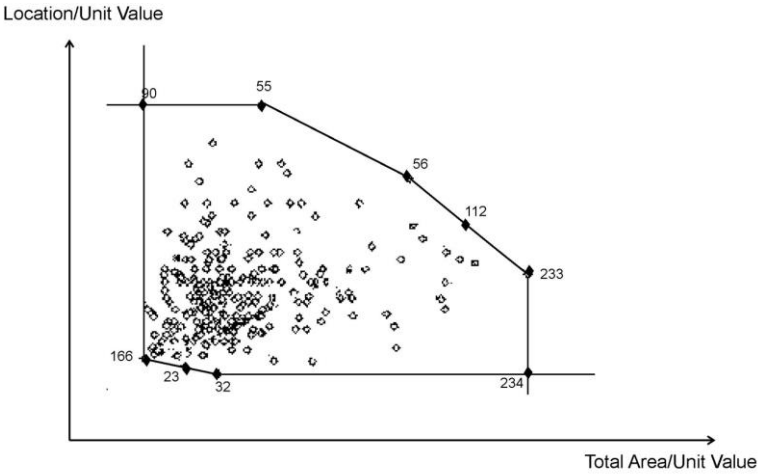
DP-DEA Seller Perspective Surface is stablished by the efficient price on seller behavior, that wishes to maximize the output (selling value), given the input (property attributes). Symmetrically opposite, DP-DEA Buyer Perspective Surface is established by the efficient price on buyer behavior, that wishes to minimize its

input (purchase value), given the outputs (property attributes). The problem is treated through DEA linear programming problems, which provide two DEA frontiers: the seller and the buyer, therefore the name DP-DEA is given to represent the behavior interaction by seller and buyer on realizing a market transaction.

In this paper, the DP-DEA method is applied to a dataset consisting of properties market value of real estate transactions which occurred in some specific region. A panel data, representing the scope of an observed real estate market, contains the possible transaction values influenced by the supply or demand as a function of properties characteristics. Modeling starts by selecting" observed real estate data, with "m" independent variables, considering the usual main factors that report the characteristics property attributions and "s" dependent variable, mainly considering the property value and/or sale velocity, real estate build quality and/or other output of interest. The DP-DEA model determines a subset composed of "k" data which belongs to each perspective's enveloping surface. This data is considered that the best attends either one or the other perspective and defines the segments of the enveloping surface, thus motivating the envelope form of DEA CCR or BCC models (see Lins, Meza 2006). The contained subset, not belonging to this surface, is formed by the remaining "n – k" inefficient data for each perspective. The computation of the normalized distance of each observed unit requires the solution of a linear programming problem (Lins et al. 2005: 5-14).

Figure 5 shows the area contained under the enveloping surfaces, which correspond to a panel data of real estate market. It results from the intersection of the set of supply possibilities and the set of demand possibilities (see Färe et al. 1996; Shephard 1970). The buyer's perspective frontier defined by units 166, 23, 32 and 234; and from the seller's perspective frontier defined by units 90, 55, 56, 112 and 233. Regression literature exposes that the desirable statistical properties fall into two categories: small-sample or large-sample. Under DP-DEA assessment approach, fundamentally, we observe the assumptions described and the following considerations.

Figure 5. DP-DEA Envelopment Surfaces – Seller and Buyer Perspectives



4.1 For large-sample

Normal Approximation Rule states, as when dataset increase, the distribution of the sample mean $\bar{X}$ concentrates more and more around its target the population μ (Wonnacott, Wonnacott, 1990). This rule known how Central Limit Theorem can be achieved to any PDF Probability Density Function (Davidson, 2008).

4.2 For small-samples

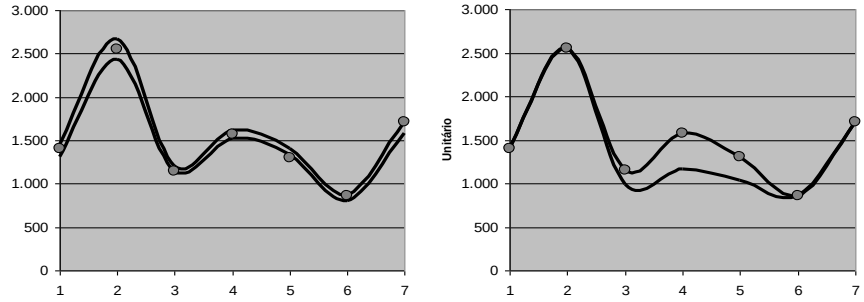
Comparing the envelopes DP-DEA results with confidence interval of multiple linear regression, we can examine the differences of these two techniques. First applying (Souza 2009: 5-15) compared the L.R. – Linear Regression Confidence Interval at 80% with the Frontiers defined by DP-DEA with database extracts of different sources and observes these results. At a data set formed with 2 variables and 7 data (Zeni 1990), e.g. see Table 1 and Figure 6. The second applying, with 2 variables and 35 data (Lins et al. 2003). Although the surfaces of the envelopes confidence interval data are best fit, it is found 22 observed data are outside, see Table 2. However, all data observed are contained by the envelopes DP-DEA, see Figure 7 and Table 2.

Table 1. Sample composed by 2 variables and 7 data comparing L.R. with DP-DEA estimate

	Data		Regression 80% Results				
Unit (R$/m2)			Infered				
Observed	Dts.(m)	Area(m^2)	($/$m^2$)	Lower	Uper	Buyer Pp	Seller Pp
1,400.00	1,800.00	2,500.00	1,381.04	1,316.52	1,448.72	1,400.00	1,400.00
2,550.00	450.00	2,800.00	2,547.29	2,427.91	2,672.54	2,550.00	2,550.00
1,150.00	1,350.00	7,700.00	1,176.80	1,145.14	1,209.34	985.61	1,150.00
1,575.00	500.00	11,000.00	1,572.55	1,528.07	1,618.33	1,163.53	1,575.00
1,300.00	720.00	12,000.00	1,373.84	1,337.69	1,410.97	1,034.06	1,300.00
860.00	1,600.00	14,700.00	840.16	804.25	877.68	860.00	860.00
1,710.00	200.06	14,800.00	1,645.10	1,583.20	1,709.41	1,710.00	1,710.00

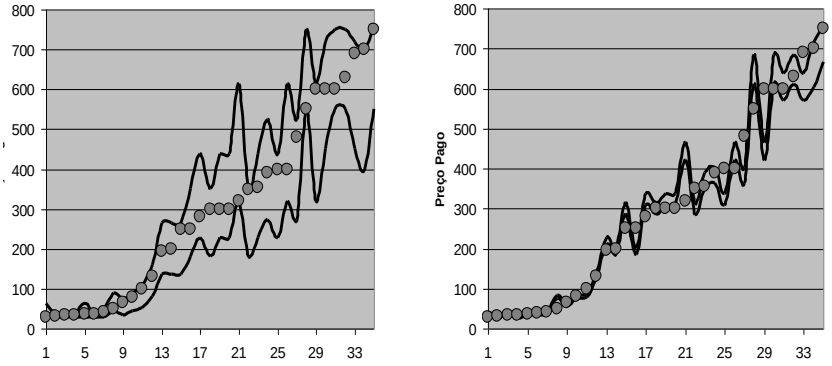
Source: Zeni (1990: 9-16).

Figure 6. Comparing L.R. Confidence Interval (80%) fitness with DP-DEA Buyer and Seller Surfaces



Source: Zeni (1990: 9-16).

Figure 7. Comparing DP-DEA Buyer and Seller Surfaces fitness with L.R. Confidence Interval (80%)



Source: Souza (2009).

Table 2. Sample composed by 3 variables and 35 data comparing L.R. with DP-DEA estimate

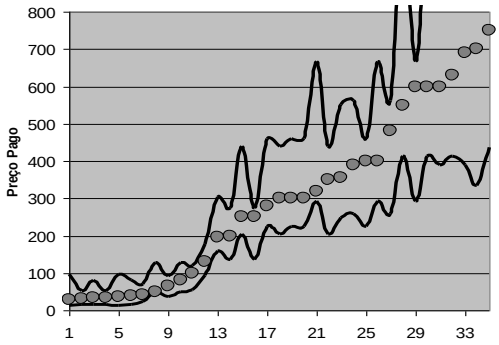
Data set			Regression 80% Results			DP-DEA Results	
Price Observ. (U$ millions)	Return(%)	Risk (%)	Inferred (U$/m²)	Inferior	Superior	Inferior	Superior
30.00	70.00	50.00	37.07	32.79	41.91	30.00	64.13
32.00	40.00	10.00	29.45	27.30	31.76	30.00	38.00
33.00	40.00	5.00	36.69	33.18	40.57	30.00	38.00
35.00	40.00	10.00	29.45	27.30	31.76	30.00	38.00
36.00	70.00	50.00	37.07	32.79	41.91	30.00	64.13
38.00	40.00	5.00	36.69	33.18	40.57	30.00	38.00
42.00	50.00	10.00	39.57	36.82	42.52	30.00	46.71
50.00	100.00	20.00	79.50	74.90	84.39	43.81	90.26
65.00	80.00	20.00	59.17	55.92	62.60	34.60	72.84
80.00	100.00	20.00	79.50	74.90	84.39	43.81	90.26
100.00	120.00	40.00	81.23	77.21	85.45	53.02	107.68
130.00	180.00	50.00	129.45	124.33	134.79	80.63	159.95
195.00	300.00	80.00	219.32	210.47	228.54	135.87	264.47
200.00	300.00	120.00	192.84	184.42	201.66	135.87	264.47
250.00	400.00	100.00	299.05	284.92	313.89	181.90	351.58
250.00	300.00	120.00	192.84	184.42	201.66	135.87	264.47
280.00	500.00	200.00	322.51	308.22	337.47	227.94	438.68
300.00	400.00	100.00	299.05	284.92	313.89	181.90	351.58
300.00	500.00	200.00	322.51	308.22	337.47	227.94	438.68
300.00	500.00	200.00	322.51	308.22	337.47	227.94	438.68
320.00	700.00	300.00	442.74	420.30	466.38	320.00	612.89
350.00	400.00	100.00	299.05	284.92	313.89	181.90	351.58
355.00	500.00	130.00	369.75	351.58	388.86	227.94	438.68
390.00	600.00	250.00	382.50	364.26	401.66	273.97	525.79
400.00	500.00	200.00	322.51	308.22	337.47	227.94	438.68
400.00	700.00	300.00	442.74	420.30	466.38	320.00	612.89
480.00	600.00	250.00	382.50	364.26	401.66	273.97	525.79
550.00	1,000.00	400.00	648.04	612.03	686.16	550.00	750.00
600.00	700.00	300.00	442.74	420.30	466.38	320.00	612.89
600.00	1,000.00	400.00	648.04	612.03	686.16	550.00	750.00
600.00	870.00	280.00	603.49	571.15	637.67	450.33	717.50
630.00	1,000.00	400.00	648.04	612.03	686.16	550.00	750.00
690.00	870.00	280.00	603.49	571.15	637.67	450.33	717.50
700.00	800.00	150.00	658.33	604.05	717.48	396.67	700.00
750.00	1,000.00	300.00	709.97	667.71	754.90	550.00	750.00

Source: Lins et al. (2003: 1413-1424).

The graphs are classified by the observation value (graph plotted points) rather than the inferred value (since this is not necessarily within the confidence), e.g. see Table 2.

At first glance RL takes "advantage". However, 22 of the 35 RL points are outside the 80% confidence interval, see Table 2. To place them within the range, we change the significance successively until their total inclusion. The new chart, indicating the significance used, see Figure 8. The RL has its significance close to 0.0%, which in statistical terms corresponds to a deterministic interval. The RL range is broader than DP-DEA.

Figure 8. L.R. Confidence Interval ~100%

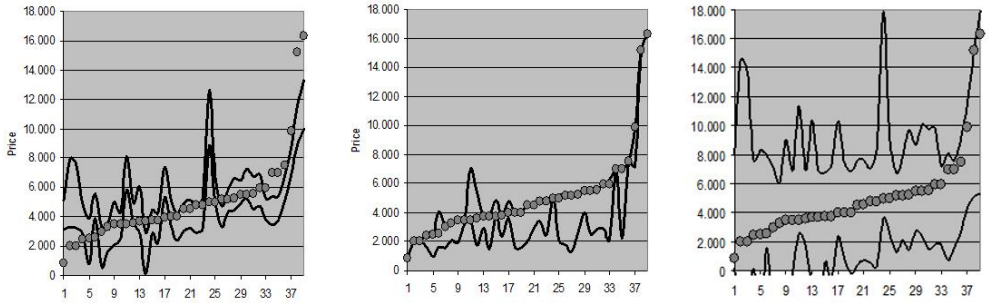


Source: Souza (2009).

The third base is taken from Maddala (2001). Table 4.7 – Price of Rural Property Land, 5 (five) independent variables in 39 observations. They refer to rural land prices near Saratoga, Florida with the following variables: Price (dependent US $,acre), WL (bare ground), DA (distance to airport miles), D75 (distance to highway miles), A (acreage), MO (month of actual transaction).

It is observed that the regression does not contain all the points observed in its 80% CI graph, especially in the extremes. By changing the significance successively until their total inclusion, we have the new graphic profile with C.I. approximately equal 100%, which in a quick examination gives more fitness to DP-DEA, see Figure 9.

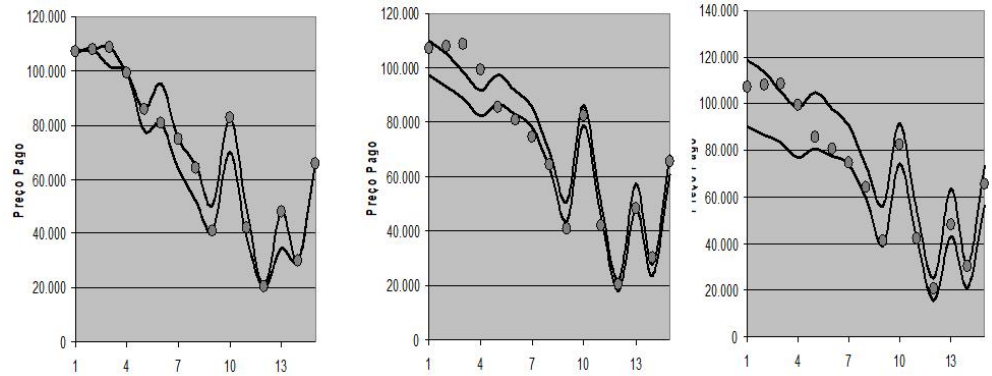
Figure 9. Comparing L.R. C.I. 80% with DP-DEA Envelopment and L.R. C.I. 100%



Source: Souza (2009).

The fourth example is provided by the "Manual of Econometrics" (Vasconcellos (1999)), e.g., see Figure 10. This is an exercise in section 6 of the section of "Multicollinearity". Visual comparison of the graphs shows that the shape of the curves is quite similar, however the regression does not contain several points observed within the confidence limits. For this to occur we must return to the CI of the model data and make its uncertainty equal to 1%. The new chart comparative is as above, with a slight visual disadvantage for the regression that still has a point outside (only included if the significance is 0.20%).

Figure 10. Comparing DP-DEA. with L.R. C.I 80% and 100%

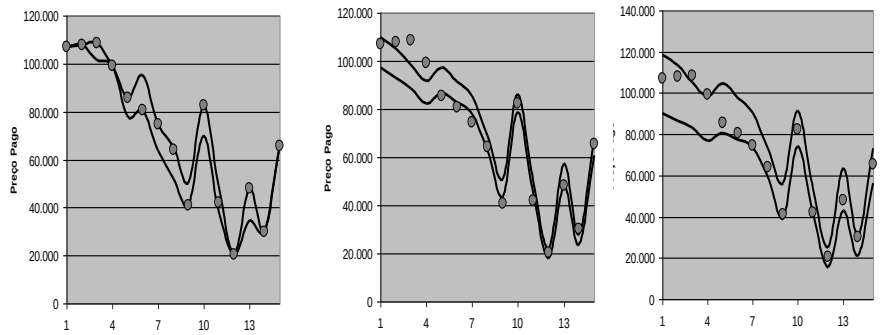


Source: Souza (2009).

The fifth and final example comes from the National Institute of Standards and Technology (NIST) data collection of the Department of Commerce, Technology Administration of the United States. This body provides certified results for regression analysis of varied series, with an increasing degree of difficulty.

The goal is to report these results to companies and developers to compare with those produced by commercial software. The series we will use as an example is Longley. This classic statistical series of work in America was one of the first used to test the computational precision of the minimum square. The response variable (y) is the total derivative employment and the prediction variables are implicit GNP deflator with 1954 = 100 (x1), gross national product (x2), unemployment (x3), size of armed forces (x4), the illegal population above the age of 14 (x5) and the year (x6). Three points are not contained in IC = 80.0% of RL. For this to occur we must have CI = 97.5%, see Figure 11.

Figure 11. Example 5 Data Base 6x16



Source: Souza (2009).

The DP-DEA is an iterative non-linear process, e.g. see a practical demonstration on section 9. It seems to be an advantage of the DEA to provide an immediate critique of data: if a given point extends the boundaries too much, it can be removed from the sample and the process restarted. New frontiers are generated, thus successive frontier modeling. The examples presented here indicate that highly collinear models are better explained by RL, whereas in small samples with almost no data, DEA is a very valid alternative.

5. Criteria and assumptions adopted to establish the best DP-DEA estimator.

Instead of obtaining only a single estimate of $\widehat{\boldsymbol{\theta}_j}$, $j = 1, \ldots, n$, DP-DEA obtain three estimates of $\widehat{\boldsymbol{\theta}_j}$. Two estimators are the buyer efficient value and the seller efficient value, i.e., the independents variables "xij", with i = 1 to m , explained by dependents variables "yrj", with r = 1 to s, representing respectively by projections $\widehat{\boldsymbol{\theta}}_{\boldsymbol{j\ Buyer}} = \left(\widehat{\boldsymbol{x}}_{\boldsymbol{ij}}, \widehat{\boldsymbol{y}}_{\boldsymbol{rj}}\right)_{\boldsymbol{Buyer}} and\ \widehat{\boldsymbol{\theta}}_{\boldsymbol{j\ Seller}} = \left(\widehat{\boldsymbol{x}}_{\boldsymbol{ij}}, \widehat{\boldsymbol{y}}_{\boldsymbol{rj}}\right)_{\boldsymbol{Seller}}$. The key concept underlying interval estimation is formal defined by DP-DEA approach (see Novaes 2002; Lins et al. 2005).

The interval between $\widehat{\boldsymbol{\theta}}_{\boldsymbol{j\ Buyer}}$ and $\widehat{\boldsymbol{\theta}}_{\boldsymbol{j\ Seller}}$ are established by buyer and seller envelope surfaces, e.g. see Figure 12. Thus, interval estimation, in contrast with point estimation, provides a range of possible values within the third estimator $\widehat{\boldsymbol{\theta}_j}$ lies, the central tendency value (Novaes, Paiva 2011).

According to which:

See respectively notation on next Table 3.

Observed data $\theta_{j\ (\ j=1,\ldots,n)} = \left(x_{ij}, y_{rj}\right)_{(i=1,\ldots,m\ ;\ r=1,\ldots,s)} \exists\ A\ |A$ is a dataset of a population observed.

The buyer and seller envelopes surfaces are performed respectively when $\theta_j = \widehat{\boldsymbol{\theta}}_{\boldsymbol{jBuyer}}$ and $\theta_j = \widehat{\boldsymbol{\theta}}_{\boldsymbol{jSeller}}$, j =1,…,n, respectively.

When θ_j matches the buyer or the seller envelopes surfaces, it has efficiency equal a 1 under each perspective, as like in Figure 12, respectively h_{Bj} =1 and 1,h_{Sj} = 1.

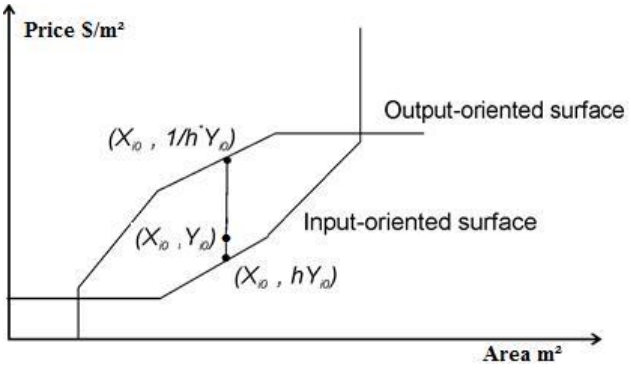
h_B and h_S are the decision variable estimated under DP-DEA approach (Novaes, Paiva 2011: 2-14).

$\widehat{\boldsymbol{y}}_{\boldsymbol{rjBuyer}} = \boldsymbol{y_{rj}} \times \boldsymbol{h_{Bj}}$ and $\widehat{\boldsymbol{y}}_{\boldsymbol{rj\ Seller}} = \boldsymbol{y_{rj}} \times \boldsymbol{h_{Sj}}$ (Novaes 2002; Lins et al. 2005).

Figure 12 shows the interval between $\widehat{\boldsymbol{\theta}}_{\boldsymbol{j\ Buyer}}$ and $\widehat{\boldsymbol{\theta}}_{\boldsymbol{j\ Seller}}$,the projections of $\theta_{j\ (\ j=1,\ldots,n)} = \left(x_{ij}, y_{rj}\right)$ on DP-DEA envelopes surfaces, i. e., the hyper-planes formed by maximization of outputs and the minimization of input on envelopment PPL form. The variable h and 1,h' correspond to efficiency determinate by DP-DEA

approach, in such a way, which input under a buyer's perspective is the output under the seller's perspective and vice-versa (see Novaes 2002; Lins et al. 2005).

Figure 12. DP-DEA Buyer and Seller Perspective Surfaces



DP-DEA Buyer and Seller Perspective Surfaces are defined to Real States Appraisal application, in observing the Law of Supply and Demand. The law of supply and demand theory explains the interaction between the supply of a resource and the demand for that resource. The theory defines the effect that the availability of a particular product and the desire (or demand) for that product has on its price (Sholarin, Awange 2015).

6. Formulation and characterization of the equation of the central tendency estimator

The LOOP – Law of One Price (Eckard 2004) main principle states that when assets are identical in all aspects of value or characteristics, they must have the same price under market equilibrium. If two identical assets have different prices, there will exist an arbitrage opportunity and exploring this opportunity will help ensure that prices of the two assets converge.

An asset's fundamental value is the price that well-informed investors are willing to pay in a free and competitive market. By the Law of One Price, investors would assess values such that equivalent assets have the same price. There can be a

temporary difference between the market price of an asset and its fundamental value. Likewise, security analysts make their living by researching the prospects of various firms and recommending which stocks to buy, because their price appears relatively low to the fundamental value, and which to sell, because their price seems relatively high to the fundamental value.

Table 3. Notation DP-DEA Central Tendency Estimator

$\hat{\theta}_j = (\hat{x}_{i\theta j}, \hat{y}_{i\theta j})$ – *Central Tendency Estimate*

$$\sum_{j=1}^{n} (\hat{y}_{i\theta j} - y_{ij}) = 0 \qquad (1)$$

/ $$\hat{y}_{i\theta j} = Z(y_{iSj} - y_{iBj}) + y_{iBj} \qquad (2)$$

$$\hat{y}_{i\theta j} \geq 0 \qquad Z \geq 0 \qquad (3)$$

By Seller's Perspective $$y_{iSj} = y_{ij} \Big/ h_{Sj} \qquad (4)$$

By Buyer's Perspective $$y_{iBj} = y_{ij} \times h_{Bj} \qquad (5)$$

$$Z = \frac{\sum_{j=1}^{n} y_{ij} - \sum_{j-1}^{n} h_{Bj} \times y_{ij}}{\sum_{j=1}^{n} \left(\frac{1}{h_{Sj}} - h_{Bj} \right) \times y_{ij}} \qquad (6)$$

$$and \qquad \hat{x}_{i\theta j} = x_{ij} \qquad (7)$$

Notation

$\hat{y}_{i\theta j}$ – j Central Tendency Estimate

y_{iSj} – Projectedvalue of data j on the enveloping surface on seller's perspective

y_{iBj} – Projectedvalue of data j on the enveloping surface on buyer's perspective

y_{ij} – Real estate j price observed

Z – escalate

h_{Sj} – Real estate assessed j deviations to the enveloping surface on seller's perspective

h_{Bj} – Real estate assessed j deviations to the enveloping surface on buyer's perspective

$\hat{x}_{i\theta j}$ – j Factors or Characteristics Estimate

x_{ij} – j Observed Data Factors or Characteristics

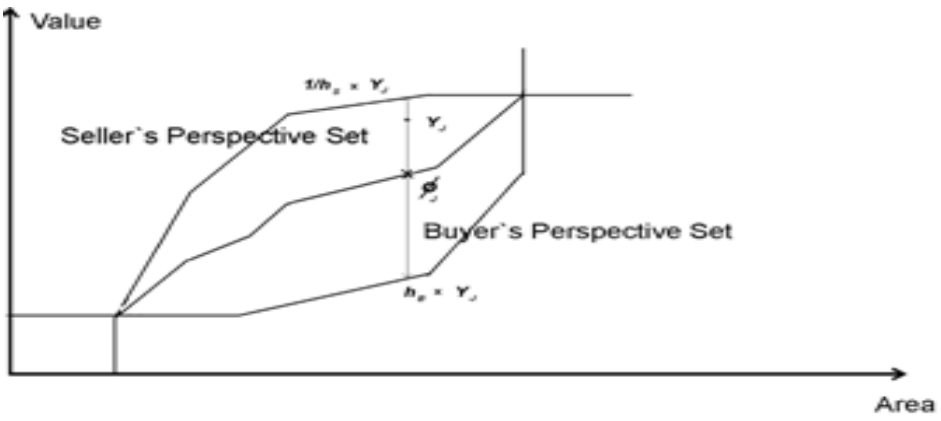
The real estate market assumptions states that no two distinct assets are identical in all aspects. There are always some differences of characteristics, maybe the localization, configuration or the size of the lot and the house or something else. The process of valuation requires that we find assets comparable to the one whose value we want to estimate and make judgments about which differences are important on their value to investors. This specific market equilibrium point is achievable when buyer and seller engage in a dispute and have attended their own interests of all kinds on the value of a specific real estate.

A strategy is introduced to determine central tendency estimates. The DP-DEA central tendency estimator between the two encapsulating surfaces (Novaes, Paiva 2010), is the dependent variables $\widehat{\theta_j}$ estimated by the minimization of the median absolute deviation of the whole distribution determined by the escalate Z (minimum-distance between the mass of dataset).

6.1. Central tendency estimates piece-wise line

In section 9, DP-DEA software estimates the dependent variables Φj by the minimization of the median absolute deviation of the whole distribution determined by one estimated escalate Z. (Novaes, Paiva 2010). The LOOP,DP-DEA piece-wise line on R2, e.g. Figure 13, applying all possible variations of Φj (Novaes, Paiva 2010).

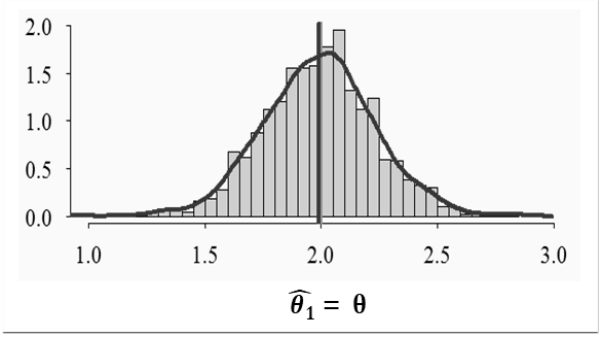
Figure 13. Central tendency piece-wise estimator line and the interval between Seller and Buyer Perspective Surfaces



6.2. Best Unbiased Estimator (BUE) Assumptions applied for DP-DEA modeling

In this section we describe how we deal with the DEA community's dilemma, already mentioned in item 2, when performing the DP-DEA model incorporating the statistical analysis with the objective of defining the best estimator of the central tendency value of the data evaluated.

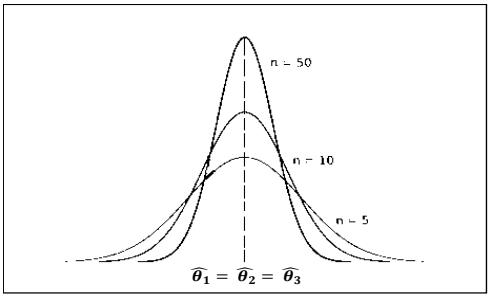
Figure 14. No tendency



In the practical modeling presented in section 9 of this article, the statistics used was to observe the three fundamental properties desirable for estimators, namely: non-bias, efficiency and consistency. The following summarizes the main aspects of each of these properties:

No Tendency: An estimator is said to be non-biased when its sample distribution has mean equal to the parameter to be estimated $\theta = \Theta$, e.g. Figure 14.

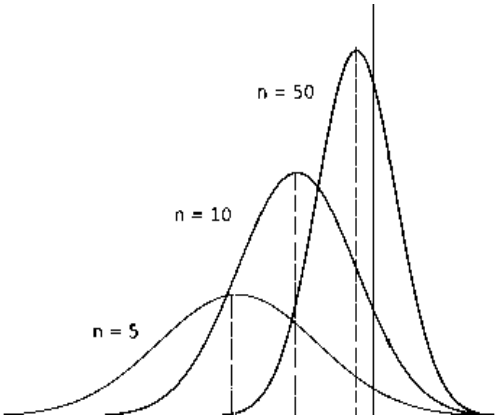
Figure 15. Efficiency



Efficiency: It is considered that between two non-biased estimators, the one with the smallest variance is called an efficient estimator.

That is, if Variance ((θ_1)) <Variance ((θ_2)) then (θ_1) is efficient, since (θ_1) and (θ_2) are non-biased estimators for Θ, e.g. Figure 15.

Figure 16. Consistency



Consistency: If the estimator approaches the true value of the parameter, as the sample grows, then it can be said that it is consistent. That is, if the amount of data tends to infinity then (θ_1) tends to Θ, e.g. Figure 16.

In accordance with the proposal to promote more confidence to DEP-DEA assessment modeling approach, incorporating some statistical treatment to perform goodness-of-fit test "R2" – the coefficient of determination – that be able to tell us how well the DP-DEA assessment line fit the data.

More generally, our interest is to predict the current values of dependents variables representative of a population, then the nature of the distribution of the errors $e_{ij} = (y_{ij} - \hat{y}_{i\theta j})$ needs to be assumed on behalf best fitted result to dataset extracted of some population.

The BUE achievement requires that each $e_{ij} = (y_{ij} - \hat{y}_{i\theta j})$ is distributed normally with: Mean: $E(e_{ij}) = 0$; Variance $E(e_{ij}^2) = \sigma^2$ and $\text{cov}(e_{ij}, e_{kj})$: $E(e_{ij}, e_{kj}) = 0 \ \ when \ i \neq k$

i.e.: $e_{ij} \sim N(0, \sigma^2)$ means that e_{ij} and e_{kj} are not only uncorrelated but normally and independently distributed (Gujarati 1995: 51-77, 191-237).

DP-DEA assessment modeling approach, in the same way of the confidence interval generated by ordinary least squares, instead of relying on a line estimator, an interval is defined around the estimator piece-wise line, e.g. see Figure 13. This interval "involves" the data with smaller or larger dispersion. On the other hand, the DP-DEA may also be shaped with the same goal: to adjust the upper and lower curves in the response variable (Gujarati 1995: 777-784).

7. History and relevance of Real Estate Evaluation Standards in Brazil

Brazilian Association of Technical Standards is a nonprofit organization that develops and publishes standards on a wide variety of topics, by the National Standardization Forum, composed of Committees (ABNT,CB) and Sectorial Standardization Organisms (ONS), which are in charge of the Brazilian Standards. Research reports are elaborated by delegates of the Study Commissions (ABNT,CE), composed of producers, consumers, users and other involved agents, such as universities and laboratories. The Committees (CB) and Organisms (ONS) thus develop a Project for the Standard, which circulates for Public Consultation amongst the ABNT's associates and other interested parties.

Appraisal Engineering has one of the most main activity on the real estate valuation, prerogative for preserving the integrity of the mortgage lending process for the benefit of the general public and the parties involved (e.g. Banks, Promotion Agencies, Pension Funds) and the buyer (see Shapiro et al. 2013).

The real estate's value estimation is drawn up by a civil engineer or architect, through the use of methodologies for the valuation of tangible (property, land holdings), intangible (commercial capital, industrial capital, brands, patents, etc.), and financial (shares, corporate rights) assets, established and regulated by the Brazilian National Uniform Standards of Professional Appraisal Practice – NBR – 14653 (ABNT 2011).

The first draft for real estate's appraisal standards organized by public entities and institutes directed to Appraisal Engineering date 1957. This was followed by others, of huge relevance, elaborated by institutes that operate in the field, but the subject acquired relevance during 60's great boom of expropriations, with the studies developed by commissions of professionals dedicated to specialized inspections and juridical assessments.

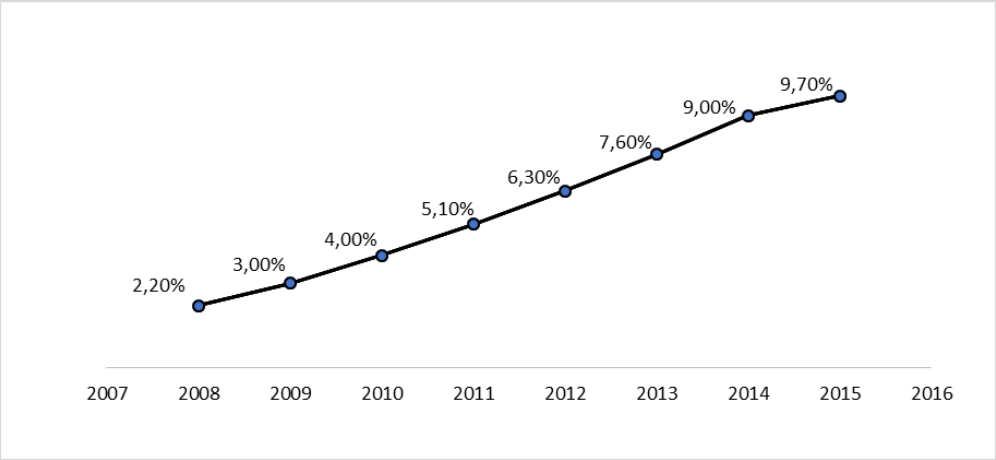
In 1977, emerges the first Brazilian Appraisal Norm of Urban Real Estate the ABNT's NBR 5676 (NB-502), whose major innovation is the establishment of accuracy levels for the evaluations. At the time, the ABNT started to produce other standards for evaluations, with the following typology: Rural Estates; Standardized Units; Industrial machines, equipment and Industrial complexes, and; Urban Glebes.

Revised in 1989, the Brazilian Appraisal Standards for Urban Real Estate is registered by the National Institute for Metrology (INMETRO) with # 5676. In this opportunity, the accuracy levels are transformed into stringency levels. The evaluation capacity of real estates was amplified and improved, along with its professionals, with modern statistical techniques in conjunction with information technologies. The important role given to the application of multiple linear regression in NBR 5676 of ABNT represented the initial stimulus for the appreciation of the use of data treatments based on scientific instrumental.

The basic assumptions of the use of statistical inference with the use of multiple linear regression started to stand out in the ABNT (2011) norm, drawn up in 2004, as a way of warning the evaluators of the damaging consequences of the non-observation of the adopted models and the consequent estimates. Fundamentally, the ABNT (2011) approaches the principles and methods that the appraisers shall attend, to ensure the necessary quality concerned in appraisal practices.

The Brazilian real estate market is in constant expansion, in view of public policies directed to increase the supply of real estates. There is a housing deficit in Brazil estimated in 10 million homes and a latent demand for more than 1.5 million homes per year, due to the insertion of young people in the labor market and related family formation. The increase of Mortgage Credit was launched year by year, that can be seen in Figure 17.

Figure 17. Mortgage Credit X GDP Brasil



Source: BACEN.

According to the specialized media, the Federal Saving Bank – CAIXA ECONÔMICA FEDERAL – is the major economic agent in the segment of mortgage credit, with a market-share of 67.2%, launching R$ 384,2 billion in 2015.

CAIXA is the biggest entity directly interested in incorporating the best practices and techniques in the daily real estate assessment's activities, a subcontracted service and contracts more than one million assessment reports Appraisers per year. The Department of Standards Management (GEPAD) has acted strongly, aiming to promote the research and incorporation of new technological advances in the Appraisal Engineering field and, when proved effective, the consolidation through ABNT standards.

The Assessment Engineering professionals are engineers and architects who become experts in this area through the implementation of specialized courses. The diffusion of the technique's improvement is disseminated via forums and congresses carried out in national and international levels. The SOBREA – Brazilian Appraisal Engineering Society of and the IBAPE – Brazilian Appraisal and Proficiency Institute of, with national representation in 21 federation units are the main entities bringing together the expertise of about 49,000 civil engineers and architects.

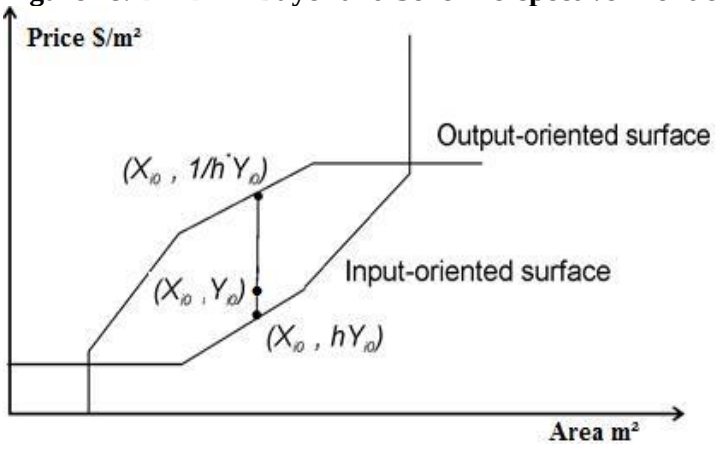
8. Regulatory and market context for applying the methodology in Brazil

The current fair market value is the objective of professional appraisal work, based on sample data collected into a local real estate market observed. A sample is fitted by similar sales with similar home's factors or features: style; dimensions, age, date, localization, influent sites and others. An appraiser has to observe a CMA (Comparative Market Analysis) (AI 2006,2013) that is analogues to the Direct Capital Comparison Method (DCCM) (ABNT 2011; Shapiro et al. 2013).

In Brazil, the NBR 14.653 – Brazilian Appraisal Norm of Urban Real Estate Appraisal relates the procedures to be observed by the professional appraisers in the activities regarded in works dealing by the stakeholders. One of the most important stakeholder that induce and foment the real estate market is the Federal Savings Bank – Caixa Economica Federal. Caixa has a great interest on configure the quality of appraisals works. With this proposal foment the diffusion of the knowledge into their contracted professionals and credential enterprises dialed to for fit appraisal works in 5,500 cities distributed in all Brazilian states.

Homogenizing the properties heterogeneity is done by the proceedings observed on ABNT (2011). NBR establish the procedure to translate observed factors and features properties into quality variables by allocated code, dummy variables or proxy variables. The quantitative variables like dimensions, age, distance and other factors observes its actual value. The more usual scientific method observed to appraisers is the MRA – Multiple Regression Analysis. Appraisers inferring observed prices of real estate market to assess market value of a specific property usually utilize several MRA software specifically designed. Complementary, the econometric model selected is the most properly fitted according to statistical criteria defined by the NBR and the MRA methodology available on Real Estate appraisal software tools.

Figure 18. DP-DEA Buyer and Seller Perspective Frontiers



At the same way, the extreme envelopment surfaces of DP-DEA method establish an interval for a property's value as a function of its physical features or factors and location proposed by Novaes (2002), see Figure 18. Lins et al. (2005: 3-8) describe the DP-DEA proceedings that makes use of two encapsulating surfaces that enfold, in an n-dimensional space, all the observed data, see Figure 5. Real estate units which, either from the point of view of the seller or the buyer, present an "efficient" price, will define those surfaces. The remaining units can have their value assessed by taking the envelopments as frameworks, under an output-oriented or an input-oriented DEA model.

The value of central tendency or "the fair market value" is describe by the surface performed by the combination of the attractive value estimated between the two encapsulating surfaces, which minimize the absolute deviation established by the center of mass or gravity of the whole distribution (see Novaes, Paiva 2010) and Figure 13.

9. Application of DP-DEA according based on the real estate market data.

Double Perspective DEA (DP-DEA) uses as an objective measure of the observed units' normalized distance to the two simultaneous perspectives: the hyper-

plane by maximization of outputs and the minimization of inputs. In such a way that inputs under a buyer's perspective are the outputs under the seller's perspective and vice-versa, the dependent variable – apartment unit value ($,m²) (Lins et al. 2005: 3-14), see Figure 19.

DP-DEA proposes that, just as the seller wishes to maximize the output (selling value), given the inputs (property attributes), the buyer wishes to minimize its input (purchase value), given the outputs (property attributes). The problem is treated through two mathematical programming, which provides two DEA frontiers: the seller and the buyer, therefore the name DP-DEA given to the present method.

The DP-DEA method is usually applied to a database consisting of market values to the properties, which were established in scriptures of real estate transactions and that occurred in several regions of a city or on offerings. DEA production possibilities represent the scope for negotiation, containing the possible transaction values influenced by the supply or demand (see Shapiro et al. 2013), as a function of properties factors. Modeling starts by selecting" observed real estate data, with "m" independents variables, considering the usual main factors that report the characteristics property attributions and "s" dependent variable, mainly considering the property value and,or sale velocity, real estate build quality and others outputs of interest. DP-DEA model determines a subset composed of "k" data that belongs to the perspective's enveloping surface. These data are considered that the best attend one or other perspective and define the segments of the enveloping surface, thus motivating the envelope form of DEA CCR or BCC models (see Lins, Meza 2006). The contained subset, not belonging to this surface, is formed by the remaining "n – k" inefficient data to each perspective. The computation of the normalized distance of each observed unit requires the solution of a linear programming problem (Lins et al. 2005).

The LOOP,DP-DEA function (Novaes, Paiva 2010) appraisal the market value estimator between the two encapsulating surfaces, which minimize the median absolute deviation of the whole distribution.

DP-DEA establish a central tendency hyper-plane surface see section 6, see Figure 13. DP-DEA software estimates the dependent variables Φj by the minimization of the median absolute deviation of the whole distribution determined

by one estimated escalate Z (Novaes, Paiva 2010). The LOOP,DP-DEA piece-wise line on R2 is illustrated in Figure 13, section 6, applying all possible variation of Φj (Novaes, Paiva 2010).

9.1. Practical example with a single Independent Variable.

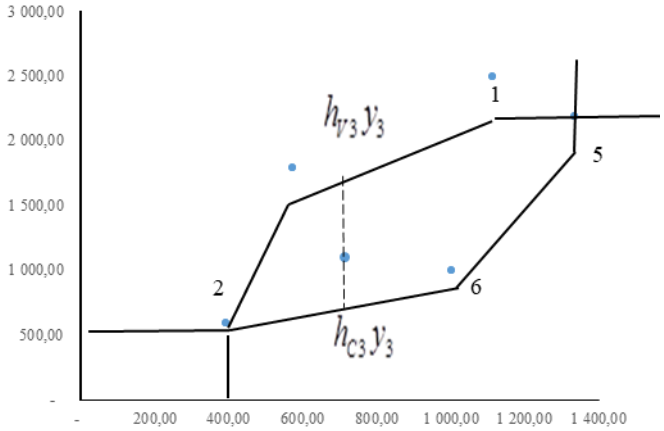
A practical approach of real estate appraisal based on urban lots sample with two variables. Data sample collected are defined in Table 4.

Table 4. Urban lots sample with two variables

				Transformed
Data	*Total Area*	*Unit Value*	*Total Value*	*1/ Total Area*
1	90.00	2,500.00	225,000.00	**1,111.11**
2	255.00	600.00	153,000.00	**392.16**
3	140.00	1,100.00	154,000.00	**714.29**
4	175.00	1,800.00	315,000.00	**571.43**
5	75.00	2,200.00	165,000.00	**1,333.33**
6	100.00	1,000.00	100,000.00	**1,000.00**

On Figure 19, R2 data graph allows visualizing double envelopment surfaces. The upper frontier is the locus of data highest value, the Seller's perspective frontier. According to the basic assumptions, item D.2.1 of Annex D of ABNT (2011), the transformation of the independent variable – Total Area – must be performed to present a positive correlation with the independent variable – Unit Value. In Table 4, the last column corresponds to the inverse function of the variable Total Area.

Figure 19. Total Area x Unit Value



The data set corresponds to the 2 x 6 matrix, where each column represents a lot. The 1st row corresponds to the independent variables and the 2nd row corresponds to the dependent variables:

$$\begin{bmatrix} 1111.11 & 392.16 & 714.29 & 571.43 & 1333.33 & 1000.00 \\ 2500.00 & 600.00 & 1100.00 & 1800.00 & 2200.00 & 1000.00 \end{bmatrix}$$

Decision variables are

h_{V0} and $\lambda = [\lambda_1 \quad \lambda_2 \quad \lambda_3 \quad \lambda_4 \quad \lambda_5 \quad \lambda_6]$

The value projected of each optic is estimated according to the projection of the data observed value through each envelope. According seller's viewpoint, the data "3" estimated value is equal:

$$y_{v3} = h_{V3} \times y_3$$

To estimate decision variable h_{V3} is used the Output-Oriented Model PPL VRS Envelopment as follows:

Envelopment (Dual) for BCC

$MaxH_{V0} = h_{V0}$

$$Subjecttoh_{v0}y_{r0} - \sum_{j=1}^{n} \lambda_j y_{rj} \leq 0, r = 1, \ldots\ldots, s$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0}, i = 1, \ldots\ldots, m$$

$$\lambda_j \geq 0, \forall k, j, i$$

A Linear Problem Programming to estimate the lot value "3" projected at the frontier of the seller's perspective can be represented matricially as:

Envelopment (Dual) for BCC

$$Max[1 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0] \begin{bmatrix} h_{vo} \\ \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \\ \lambda_6 \end{bmatrix}$$

Such that

$$\begin{bmatrix} 1100.00 & -2500.00 & -600.00 & -1100.00 & -1800.00 & -2200.00 & -1000.00 \\ 0 & 1111.11 & 392.16 & 714.29 & 571.43 & 1333.33 & 1000.00 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} h_{vo} \\ \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \\ \lambda_6 \end{bmatrix} \begin{matrix} \leq \\ \leq \\ = \end{matrix} \begin{bmatrix} 0 \\ 714.29 \\ 1 \end{bmatrix}$$

$\lambda_j \geq 0, \forall k, j, i \; e \; h_v$ *irrestricted signal.*

The solution can be realized through the Simplex Method – Minimization Problem (Boldrini et al. 1980) or by Excel Solver. Through Performer DEA software (2016), we obtain the following results for the decision variables:

$$\begin{bmatrix} h_{vo} \\ \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \\ \lambda_6 \end{bmatrix} = \begin{bmatrix} 0.5541 \\ 0.265 \\ 0 \\ 0 \\ 0.735 \\ 0 \\ 0 \end{bmatrix}$$

Seller's perspective, value estimated for data "3" is:

$$y_{v3} = 1/h_{v3} \times y_3 = 1/0.5541 \times 1100.00 = 1985.30^{1}$$

The decision variable h_{C3} is estimated by Input-Oriented Model PPL VRS Envelopment (Lins et al. 2005), as follows:

Envelopment Problem (Dual)

$$MinH_{C0} = h_{C0}$$

$$Subject\ to\ \ h_{C0} y_{r0} - \sum_{j=1}^{n} \lambda_j y_{rj} \geq 0, \quad r = 1,....., s$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{i0}, \quad i = 1,....., m$$

$$\lambda_j \geq 0, \forall k, j, i$$

$$For VRS : \sum_{j=1}^{n} \lambda_j = 1$$

[1] *See Data "3" Table 5 – Maximum Value.*

From the data of the related Sample in Table 5, we obtain the following formulation:
Envelopment Problem (Dual)

$$Min\,[1 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0]\begin{bmatrix} h_{co} \\ \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \\ \lambda_6 \end{bmatrix}$$

Such that

$$\begin{bmatrix} 1100.00 & -2500.00 & -600.00 & -1100.00 & -1800.00 & -2200.00 & -1000.00 \\ 0 & 1111.11 & 392.16 & 714.29 & 571.43 & 1333.33 & 1000.00 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix}\begin{bmatrix} h_{co} \\ \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \\ \lambda_6 \end{bmatrix}\begin{matrix} \geq \\ \leq \\ = \end{matrix}\begin{bmatrix} 0 \\ 714.29 \\ 1 \end{bmatrix}$$

$\lambda_j \geq 0,\ \forall\, k, j, i$

The solution can be realized through the Simplex Method – Minimization Problem (Boldrini et al. 1980) or by Excel Solver. Through Performer DEA software (2016), we obtain the following results for the decision variables:

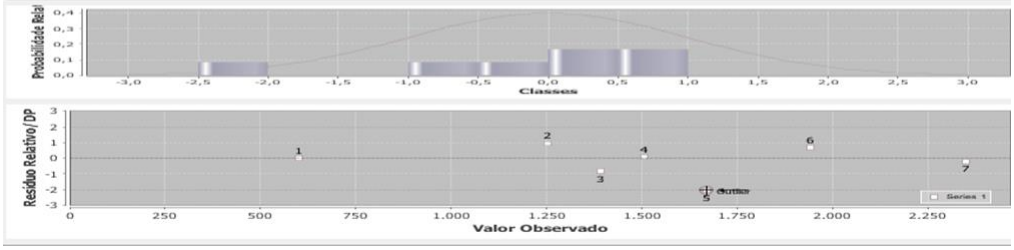
$$\begin{bmatrix} h_{co} \\ \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \\ \lambda_6 \end{bmatrix} = \begin{bmatrix} 0.7382 \\ 0 \\ 0.43 \\ 0 \\ 0 \\ 0 \\ 0.57 \end{bmatrix}$$

According buyer's viewpoint, the data "3" estimated value is equal to: $y_{C3} = h_{C3} \times y_3 = 0.7382 \times 1100.00 = R\$812.00$ [2]

Data "3" estimated the fair market value, according equations (24) and (28) (Novaes, Paiva 2010) is R$1,390.313.

Table 5. Minimum, Maximum and Estimated Values – DP-DEA

Data	Observed Value	Minimum Value	Estimate Value	Maximum Value	Residuals	Relative Residuals	Relative
1	2.500	1.400	1.942,193	2.500	557,807	22,31%	0,69
2	600	600	600	600	0	0,00%	0,00
3	1.100	811,982	1.390,311	1.985,294	-290,311	-26,39%	-0,81
4	1.800	717,972	1.251,307	1.800	548,693	30,48%	0,94
5	2.200	2.200	2.347,871	2.500	-147,871	-6,72%	-0,21
6	1.000	1.000	1.668,318	2.355,882	-668,318	-66,83%	-2,05
7	1.545,292	890,323	1.506,147	2.139,706	39,145	2,53%	0,08



9.2. DP-DEA software graph analysis

Table 5 reports a simulating of real estate appraisal data. Data "7" is characterized on Table 6.

Figure 20 reports observed, central tendency, minimum and maximum estimate values. The data on abscissa axis and unit value on ordinate axis.

[2] *See Data "3" Table 5 – Minimum Value.*
[3] *See Data "3" Table 5 – Estimated Value.*

Table 6. Urban Lots Sample – Area x Unit Value – Appraising Data "7"

	A	E	Address	Complement	Privative Area	Unit price	Total Price
1	☑	☐	R. Ipê	15	90,00	2500,00	225000,00
2	☑	☐	R. Azaleia	223	255,00	600,00	153000,00
3	☑	☐	R. Bromelia	165	140,00	1100,00	154000,00
4	☑	☐	R. Jasmim	33	175,00	1800,00	315000,00
5	☑	☐	R. Camelia	29	75,00	2200,00	165000,00
6	☑	☐	R. Margarida	68	100,00	1000,00	100000,00
7	☑	☑	Dado Novo	a estimar	120,00		

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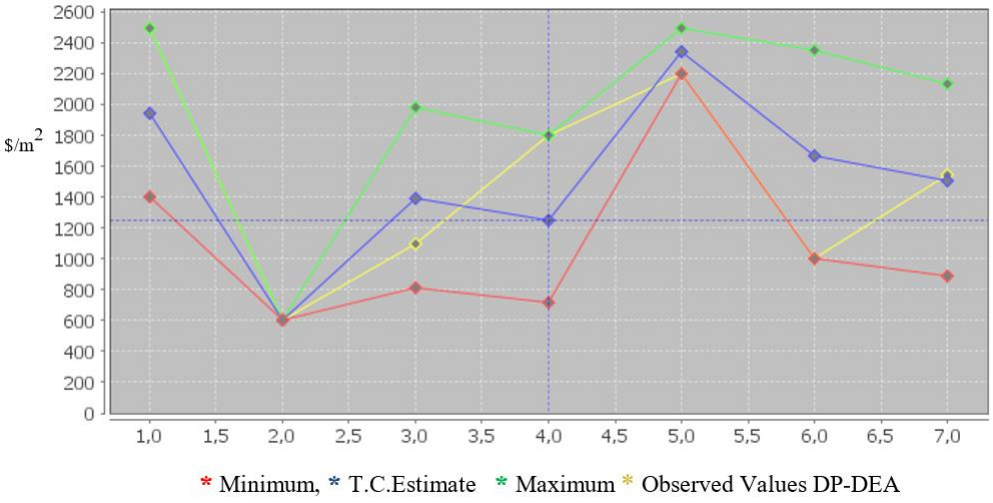
Data "7" estimate Value with area of 120.00 m2:

Tendency Central	R$		
Minimum Value	R$	Maximum	R$

Figure 20. Minimum, estimated, maximum and observed Values DP-DEA



9.3. DP-DEA software modeling and application on real estate appraisal

DP-DEA software incorporates some statistical and graphs analysis: Dependent variables x Independent variables; coefficient of determination (R^2); multiple correlation (R); correlation analysis; Table of Residual Standard Deviation and Graph Analysis; Graph of appraisal values and observed, buyer and seller's

perspective values variations; Graph of adherence between observed and assessed variables. The DP-DEA software is an innovator product that observes the Double Perspective Data Envelopment Analysis Methodology.

Real estate appraisal is the action of judging the market value of properties – lands and its improvements. The market value improves an important role in land management involving public administration, institutions of landing regulations, properties financial institutions and so, a broad range of stakeholders, until meet the personal interest of be a property owner. Then the market value would be comprehensive and reliable enough to attend all these actors. At the end of a sale process, we can represent all these actors by the two involved negotiator the buyer and the seller.

The DP-DEA approach by the Direct Capital Comparison (DCC) (Mackmin 1994) method was applied to a database consisting of the market values of apartments that were established in transactions, and which have occurred in several neighborhoods of the Niteroi's municipal district of Rio de Janeiro's state.

In the predictive modeling procedures, we need to establish a sample using information extract of some Real Estate agent's data. Nowadays, the internet enables to get complementary information on Real Estate's sites. Websites allows one to either send a lead inquiry or search through property type categories: eventual sale price, location, styling, sale condition, size, amenities, features, improvements and upgrades, attractive or economic sites, the current real estate market and mortgage interest rates, among others.

The parameterization consists in depict subjective amenities or property characteristics in quantitative or qualitative variables. This phase is one of the most important that involves the modeling process, is essential to adequate properly the scales and variations of each qualitative variable. It can be configured by allocate code, dummy variable and proxy variable.

The database used in DP-DEA computations consists of 14 variables (features) for each one of the 76 residential units (apartments). These variables include: buy and sell transaction price; property privative area; Effective age; number of rooms, baths, bedrooms; building amenities; parking places; Quality of Construction; neighborhood index and unit's conservation; date of collecting data, corresponding

event. For the description and comments of each one sees U.S. Department of Housing and Urban Development (Housing Department, 2015), Appraisal Institute Commercial Data Standards (2004) or Brazilian National Uniform Standards of Professional Appraisal Practice (ABNT, 2011).

First, we proceed an exam to understand the variables behavior and correlation, see Table 7 and Figure 21.

Table 7. Variables Correlation Analysis

Variable	Event	Month	Age	Conserve	Pattern	Equipment	Private Ar	Parking Sp	Bedroom	Bath	Serv room	Location	Panor View	Unit value
Event	100,00%	42,79%	35,28%	-11,98%	35,83%	7,87%	51,12%	32,58%	38,18%	39,42%	-4,20%	37,72%	39,49%	37,95%
Month	42,79%	100,00%	3,42%	-11,94%	34,78%	28,52%	60,96%	59,50%	48,35%	51,35%	-5,81%	29,33%	46,93%	31,67%
Age	35,28%	3,42%	100,00%	-59,32%	-16,90%	-47,99%	18,12%	-10,37%	-1,24%	-3,59%	-4,41%	11,60%	14,51%	-6,96%
Conservation	-11,98%	-11,94%	-59,32%	100,00%	21,11%	23,19%	-10,88%	4,02%	-1,04%	2,02%	-4,03%	-9,71%	-12,72%	23,42%
Pattern	35,83%	34,78%	-16,90%	21,11%	100,00%	29,60%	47,87%	59,08%	44,47%	51,85%	38,05%	40,57%	36,53%	55,28%
Equipment	7,87%	28,52%	-47,99%	23,19%	29,60%	100,00%	30,70%	39,23%	28,62%	36,35%	5,55%	18,32%	5,12%	15,66%
Private Area	51,12%	60,96%	18,12%	-10,88%	47,87%	30,70%	100,00%	73,58%	75,12%	76,13%	21,91%	43,19%	62,96%	34,49%
Parking Space	32,58%	59,50%	-10,37%	4,02%	59,08%	39,23%	73,58%	100,00%	76,06%	76,06%	34,36%	41,91%	49,56%	48,43%
Bedroom	38,18%	48,35%	-1,24%	-1,04%	44,47%	28,62%	75,12%	76,06%	100,00%	70,94%	20,66%	45,39%	42,75%	29,91%
Bath	39,42%	51,35%	-3,59%	2,02%	51,85%	36,35%	76,13%	76,06%	70,94%	100,00%	22,64%	37,64%	46,13%	46,76%
Service room	-4,20%	-5,81%	-4,41%	-4,03%	38,05%	5,55%	21,91%	34,36%	20,66%	22,64%	100,00%	16,52%	17,36%	24,63%
Location	37,72%	29,33%	11,60%	-9,71%	40,57%	18,32%	43,19%	41,91%	45,39%	37,64%	16,52%	100,00%	30,59%	32,35%
Panoramic View	39,49%	46,93%	14,51%	-12,72%	36,53%	5,12%	62,96%	49,56%	42,75%	46,13%	17,36%	30,59%	100,00%	53,64%
Unit value	37,95%	31,67%	-6,96%	23,42%	55,28%	15,66%	34,49%	48,43%	29,91%	46,76%	24,63%	32,35%	53,64%	100,00%

The variables of the apartments collected have the following configuration:

Event – if sold or sale pending – dummy variable;

Month – first is 20th January;

Actual Age;

Conservation – allocated code – scale 1 to 6 representing the first the necessary recuperation to new (first use);

Building Class – allocated code – minimum class is one and high class = 6;

Building Amenities – allocated code – without amenities is zero; playground = 2, and swimming pool = 3;

Parking Space – quantitative variable;

Private area – square meters – number of parking places;

Location – proxy variable by familiar income on Census Tract geocode map;

Bedrooms – quantitative variable;

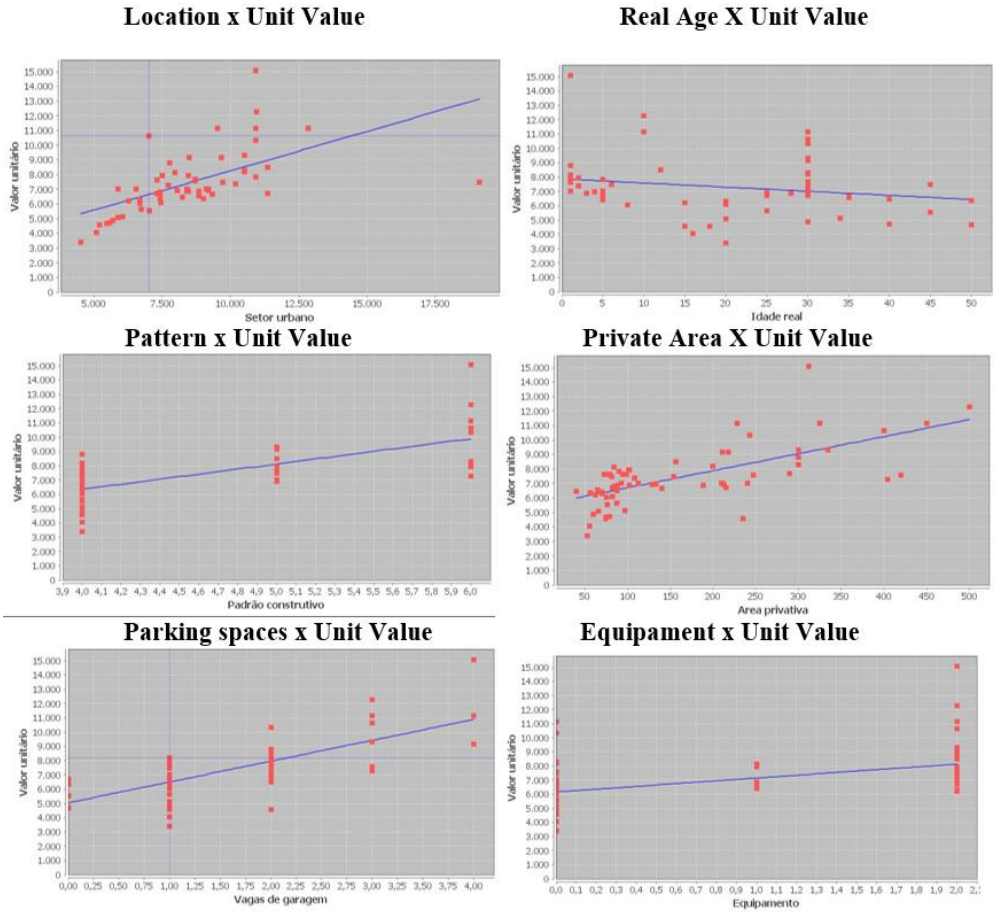
Bathrooms – quantitative variable;

Service rooms – quantitative variable;

Panoramic view – yes or no – dummy variable;

Unit value – R$,m².

Figure 21. Relation between dependent and independent variables

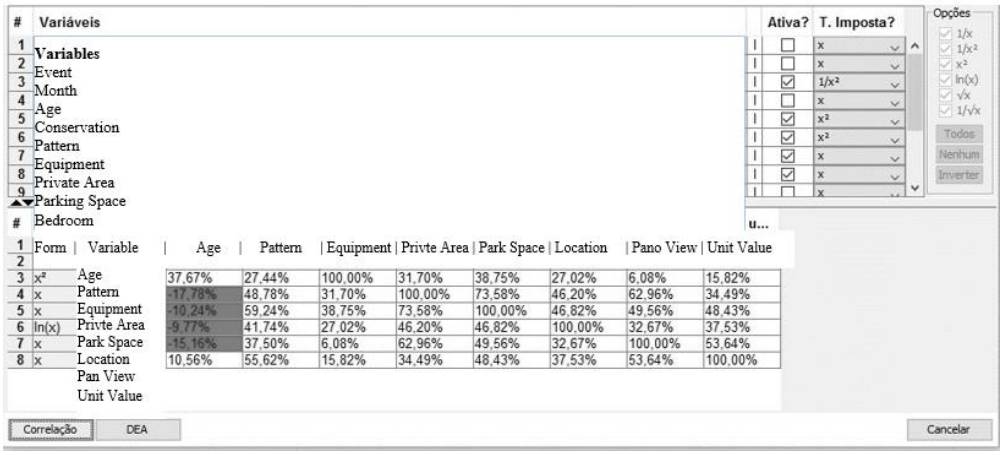


Relationship view between dependent variable e each on independent variable of the six selection, e.g., see Figure 21. Will permit see each data adherence with the data set tendency line. Putting on suspicion the data not adequate.

First model graph analysis simulation

The correlation analysis presented in Table 8 is the result of an optimization procedure, to obtain a best relation sheep by transforming the independent variables.

Table 8. Transformed Variables Correlation Analysis – 1 step



Form	Variable	Age	Pattern	Equipment	Privte Area	Park Space	Location	Pano View	Unit Value
x²	Age	37,67%	27,44%	100,00%	31,70%	38,75%	27,02%	6,08%	15,82%
x	Pattern	-17,78%	48,78%	31,70%	100,00%	73,58%	46,20%	62,96%	34,49%
x	Equipment	-10,24%	59,24%	38,75%	73,58%	100,00%	46,82%	49,56%	48,43%
ln(x)	Privte Area	-9,77%	41,74%	27,02%	46,20%	46,82%	100,00%	32,67%	37,53%
x	Park Space	-15,16%	37,50%	6,08%	62,96%	49,56%	32,67%	100,00%	53,64%
x	Location	10,56%	55,62%	15,82%	34,49%	48,43%	37,53%	53,64%	100,00%
	Pan View								
	Unit Value								

The modeling process are implemented by graph analysis, it permits understanding the relationship between variables, its correlation, see Table 8. By DP-DEA software simulating with all variables and dataset, we concluded that is necessary to extract 6 outliers' data or with Relative Residuals more than 35%. Correlation analysis enable selecting the variable with highest explanation with the dependent variable Transformed independent variables to be more adjusted with market behavior.

Figure 22. Relative probability distribution of residuals comparing fitness adherence with normal distribution

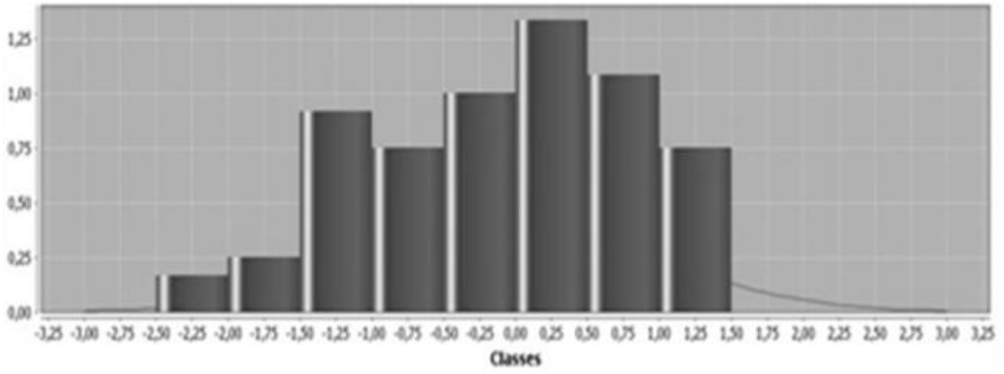


Figure 23. Relative Residuals , Pattern Deviation Outliers Analysis and Homoscedasticity

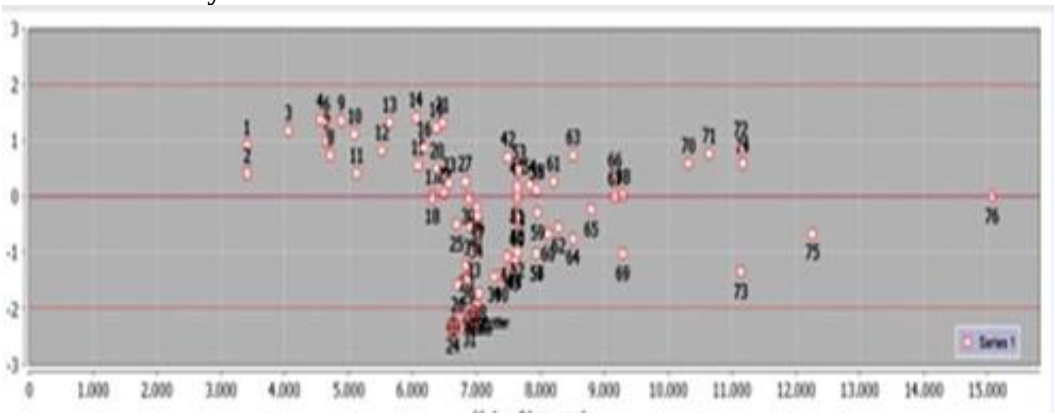
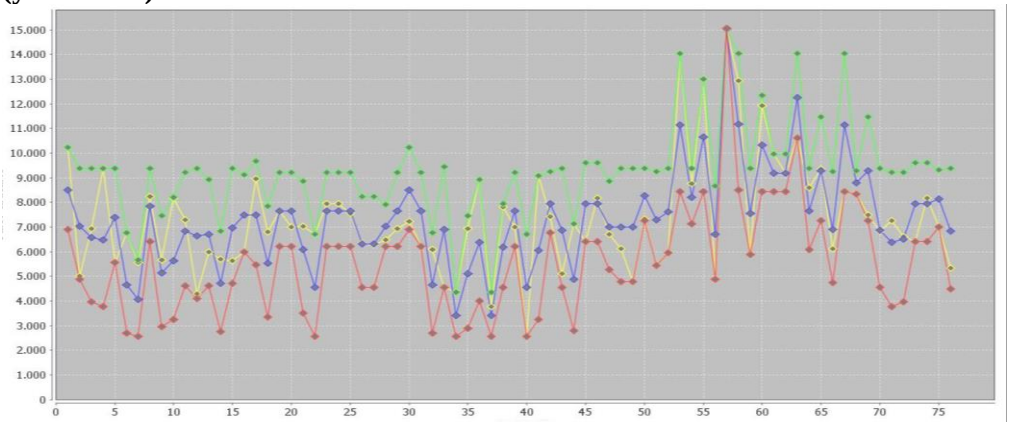


Figure 24. Appraisals of unit value (blue line) of central tendency (loop DEA), buyer's (red line) and seller's value (green line) and observed value data (yellow line)



* Minimum, * T.C.Estimate * Maximum * Observed Values DP-DEA

Figure 25. Adherence between Unit Value Observed and Appraisal Values

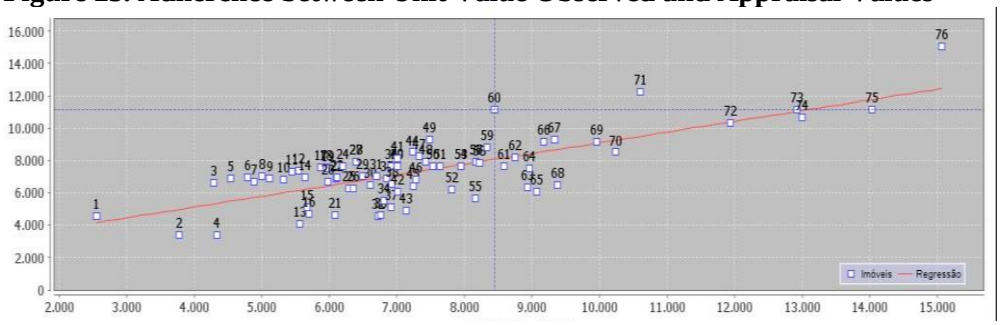
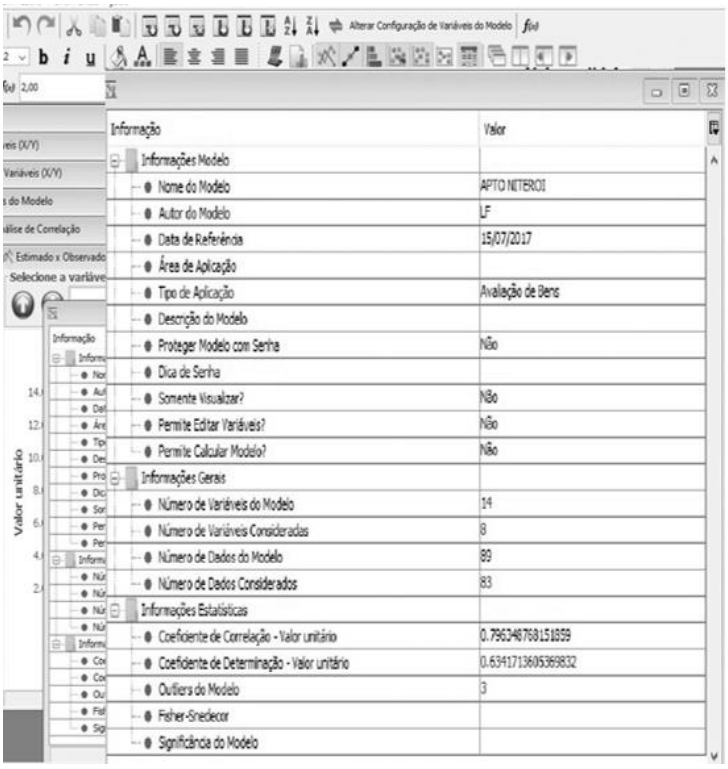


Figure 26. Model analysis R²



R^2 model analysis, see Figure 26. Results: R^2 = 63.42%; R = 79.63%; Outliers = 3; Data = 83; Variable = 8.

Analyzing if the DP-DEA appraiser model is adequate. Steps:

Graph in Figure 22 – Verifying Fitness adherence with Normal distribution.
Graph in Figure 23 – Examining the residuals distribution to verify homoscedasticity.
Graph in Figure 24 – The adjust of distance between seller's and buyer's frontiers.
Graph in Figure 25 – Verifying the adherence between observed and appraisal values.
Table in Figure 26 – The first model analyzed has $R^2 = 0.6341$
Conclusion of this first model simulation: We conclude that some analysis criteria doesn't corresponding with expected results. We decide to continue the process to find a better model.

9.4. Real Estate appraisal DP-DEA model selected

After testing and simulating some models, we stopped when the model achieved the following results: Verifying the correlation between the variables selected if presented the expected behavior with the predicted in real estate market

Table 9. Relation between dependent and independent selected variables

Análise de Correlação

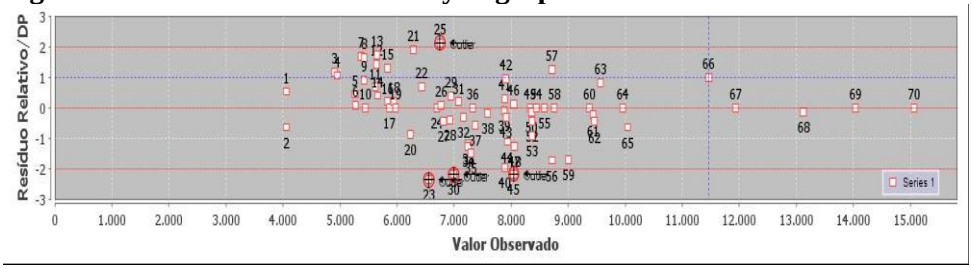
Selecione a variável que deseja-se analisar

Variável: Idade real

#	Forma	Variável	Idade real	Padrão cons...	Equipa...	Area pri...	Vagas de g...	Setor Cen...	Vista pano...	Valor u...
1	$1/x^2$	Actual Age	100,00%	9,63%	40,64%	8,97%	-11,13%	-10,83%	-17,09%	7,30%
2	x^2	Quality Building	9,63%	100,00%	28,48%	-50,85%	61,68%	42,86%	40,21%	48,90%
3	x^2	Equipments	40,64%	28,48%	100,00%	-35,98%	40,61%	25,33%	2,74%	18,31%
4	1/x	Privative Area	8,97%	-50,85%	-35,98%	100,00%	-71,74%	-61,21%	-57,80%	-31,68%
5	x	Parking Space	-11,13%	61,68%	40,61%	-71,74%	100,00%	50,09%	53,43%	46,89%
6	ln(x)	Location	-10,83%	42,86%	25,33%	-61,21%	50,09%	100,00%	36,99%	32,80%
7	x	Panoramic View	-17,09%	40,21%	2,74%	-57,80%	53,43%	36,99%	100,00%	43,63%
8	x	Unit Value	7,30%	48,90%	18,31%	-31,68%	46,89%	32,80%	43,63%	100,00%

Verifying Data Residuals Outliers and Homoscedasticity, see Figure 27.

Figure 27. Outliers and errors analysis graph



Verifying fitness adherence of Residuals with Normal Distribution (Figure 28); adherence between observed and appraisal values (Figure 29); interval amplitude between the buyer and seller frontiers (Figure 30).

Figure 28. Fitness adherence with normal distribution

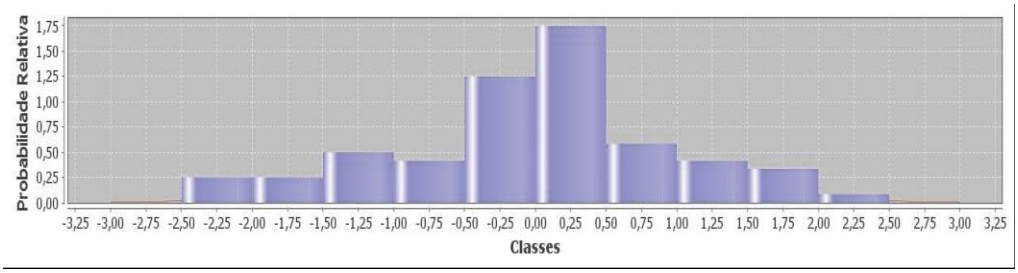


Figure 29. Adherence between observed and appraisal values

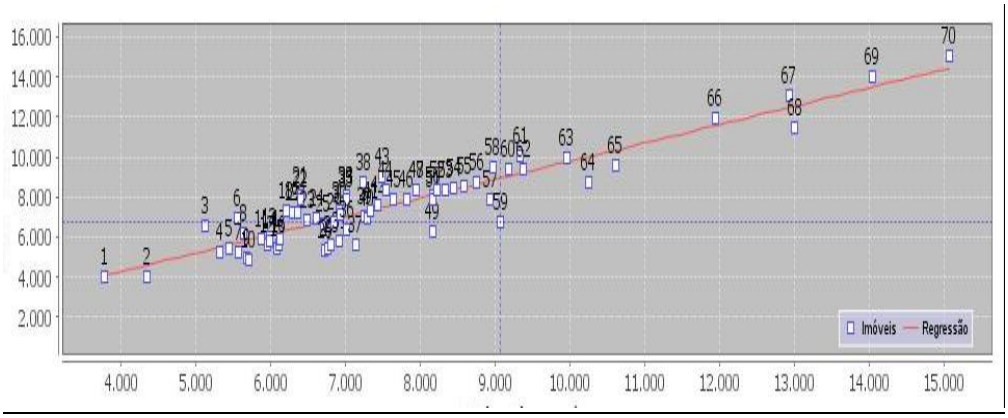
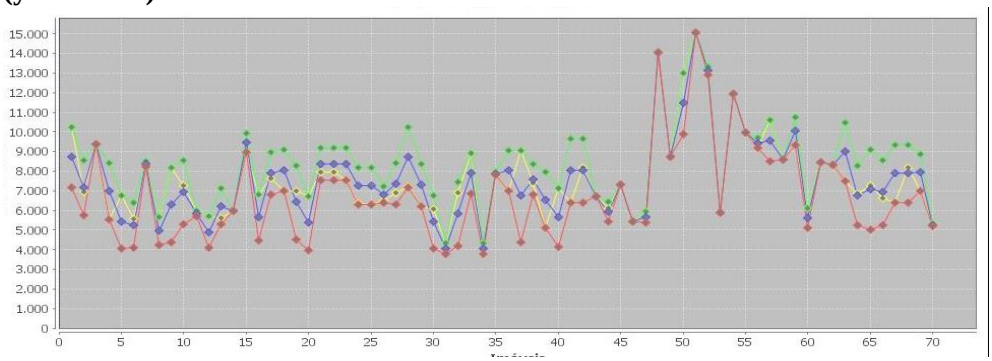
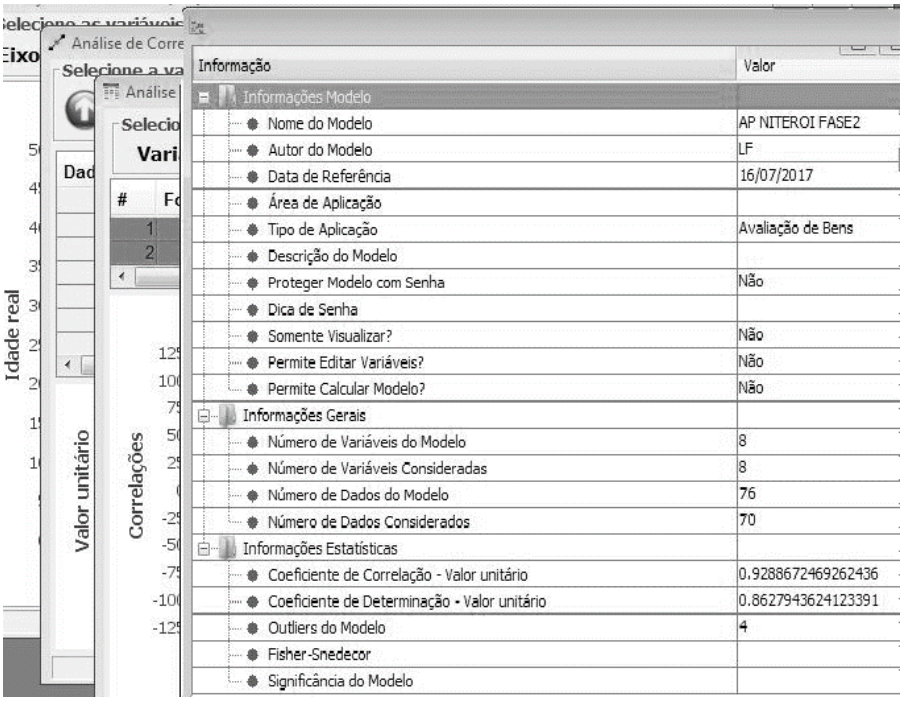


Figure 30. Appraisal values (blue line) of Central Tendency (Loop DEA), Buyer's (red line) and Seller's values (green line) and Observed data values (yellow line)



* Minimum, * T.C.Estimate * Maximum * Observed Values DP-DEA

Figure 31. R^2



Verifying R^2 Model Analysis.

9.5.The Selected model

This last model selected achieves the appraised values, in tables 10 and 11, were, fundamentally, validated by the statistical analysis, it was achieved by model that best observes the BUE assumptions. This last model is constituted by transforming some of independent variables defined in Table 7. It shows best statistical parameters obtained comparatively with others simulated models: expected influence of independent variables with dependent variable; best R^2 = 0.86279; residuals fitness adherence; errors with normal distribution and outliers' results; smaller amplitude between buyer and seller frontier; better adherence between assessed and observed values of dataset, see figures 27, 28, 29, 30 and 31.

Real estate appraisal of central tendency, buyers and sellers' perspectives valuation and residuals statistical results for observed and appraisal data are related in tables 10 and 11.

Table 10. Results of DP-DEA software – Assessed and Projected Values and Residuals

Data	Value Observed	Buyer Perspective Value	Assess Value	Seller Perspective Value	Residuals	Relative Residuals	Relative Residual,Standard Desviation
1	10,239.34	7,164.54	8,716.55	10,239.34	1,522.79	14.87%	1.25
3	6,923.08	5,740.41	7,167.09	8,566.90	- 244.01	-3.52%	-0.3
4	9,375.00	9,375.00	9,375.00	9,375.00	-	0.00%	0
5	5,546.31	5,546.31	6,992.29	8,411.04	- 1,445.98	-26.07%	-2.2
6	6,756.76	4,068.94	5,425.62	6,756.76	1,331.14	19.70%	1.66
7	5,563.64	4,102.25	5,264.22	6,404.30	299.42	5.38%	0.45
8	8,222.22	8,222.22	8,358.68	8,492.57	- 136.46	-1.66%	-0.14
9	5,670.10	4,219.15	4,951.52	5,670.10	718.58	12.67%	1.07
10	8,160.92	4,384.78	6,290.79	8,160.92	1,870.13	22.92%	1.93
11	7,282.98	5,307.73	6,944.39	8,550.23	338.59	4.65%	0.39
13	5,975.61	5,694.73	5,836.50	5,975.61	139.11	2.33%	0.2
14	5,696.20	4,095.20	4,903.31	5,696.20	792.89	13.92%	1.17
15	5,639.10	5,313.18	6,230.39	7,130.34	- 591.29	-10.49%	-0.88
16	5,974.03	5,974.03	5,974.03	5,974.03	-	0.00%	0
17	8,964.76	8,964.76	9,455.01	9,936.03	- 490.25	-5.47%	-0.46

Table 10. Cont …

Data	Value Observed	Buyer Perspective Value	Assess Value	Seller Perspective Value	Residuals	Relative Residuals	Relative Residual,Standard Desviation
18	6,806.66	4,449.77	5,639.41	6,806.66	1,167.25	17.15%	1.45
19	7,640.39	6,824.30	7,908.00	8,971.29	- 267.61	-3.50%	-0.3
20	7,003.69	7,003.69	8,056.72	9,089.93	- 1,053.03	-15.04%	-1.27
21	7,012.20	4,534.76	6,432.54	8,294.59	579.66	8.27%	0.7
22	6,717.72	3,985.22	5,364.45	6,717.72	1,353.27	20.14%	1.7
23	7,945.21	7,534.25	8,366.09	9,182.26	- 420.88	-5.30%	-0.45
24	7,945.21	7,534.25	8,366.09	9,182.26	- 420.88	-5.30%	-0.45
25	7,534.25	7,534.25	8,366.09	9,182.26	- 831.84	-11.04%	-0.93
26	6,357.14	6,285.71	7,244.94	8,186.11	- 887.80	-13.97%	-1.18
27	6,285.71	6,285.71	7,244.94	8,186.11	- 959.23	-15.26%	-1.29
28	6,487.19	6,397.48	6,812.86	7,220.42	- 325.67	-5.02%	-0.42
29	6,914.89	6,310.23	7,370.61	8,411.04	- 455.72	-6.59%	-0.56
30	7,231.54	7,164.54	8,716.55	10,239.34	- 1,485.01	-20.54%	-1.73
31	6,196.58	6,196.58	7,291.02	8,364.86	- 1,094.44	-17.66%	-1.49
32	6,081.08	4,068.94	5,425.62	6,756.76	655.46	10.78%	0.91
34	4,339.62	3,773.58	4,059.29	4,339.62	280.33	6.46%	0.54
35	6,914.89	4,179.66	5,828.69	7,446.68	1,086.20	15.71%	1.32

Table 11. Results of DP-DEA software – Appraisal and Projected Values and Residuals

Data	Value Observed +-	Buyer Perspecti-ve Value	Appraisal Value	Seller Perspective Value	Residuals	Relative Residuals	Relative Residual, Standard Deviation
36	8,928.57	6,863.40	7,905.80	8,928.57	1.022.77	11.46%	0.97
37	3,773.58	3,773.58	4,059.29	4,339.62	- 285.71	-7.57%	-0.64
38	7,808.76	7,808.76	7,880.48	7,950.84	- 71.72	-0.92%	-0.08
39	7,005.25	7,005.25	8,047.60	9,070.33	- 1.042.35	-14.88%	-1.25
41	9,066.67	4,393.54	6,752.31	9,066.67	2.314.36	25.53%	2.15
42	7,425.74	6,805.44	7,585.35	8,350.57	- 159.61	-2.15%	-0.18
43	5,113.64	5,113.64	6,555.28	7,969.77	- 1.441.64	-28.19%	-2.38
44	7,133.33	4,128.33	5,645.11	7,133.33	1.488.22	20.86%	1.76
45	6,395.12	6,395.12	8,044.83	9,663.47	- 1.649.71	-25.80%	-2.17

Table 11. Cont. …

Data	Value Observed +-	Buyer Perspecti-ve Value	Appraisal Value	Seller Perspective Value	Residuals	Relative Residuals	Relative Residual, Standard Deviation
46	8,166.08	6,395.12	8,044.83	9,663.47	121.25	1.48%	0.13
47	6,696.43	6,696.43	6,696.43	6,696.43	- 0.00	0.00%	0
48	6,113.74	5,420.47	5,945.35	6,460.36	168.39	2.75%	0.23
50	7,333.33	7,319.35	7,326.41	7,333.33	6.92	0.09%	0.01
51	5,445.54	5,445.54	5,445.54	5,445.54	0.00	0.00%	0
52	5,952.38	5,365.68	5,661.82	5,952.38	290.56	4.88%	0.41
53	14,035.08	14,035.08	14,035.08	14,035.08	-	0.00%	0
54	8,750.00	8,750.00	8,750.00	8,750.00	0.00	0.00%	0
55	13,000.00	9,899.99	11,464.73	13,000.00	1.535.27	11.81%	1
57	15,064.10	15,064.10	15,064.10	15,064.10	-	0.00%	0
58	12,923.07	12,923.07	13,121.72	13,316.63	- 198.65	-1.54%	-0.13
59	5,870.44	5,870.44	5,870.44	5,870.44	- 0.00	0.00%	0
60	11,934.15	11,934.15	11,934.15	11,934.15	0.00	0.00%	0
61	9,952.60	9,952.60	9,952.60	9,952.60	0.00	0.00%	0
62	9,174.31	9,174.31	9,436.87	9,694.48	- 262.56	-2.86%	-0.24
63	10,600.00	8,503.35	9,561.64	10,600.00	1.038.36	9.80%	0.83
64	8,581.31	8,581.31	8,581.31	8,581.31	- 0.00	0.00%	0
65	9,333.33	9,333.33	10,041.95	10,737.23	- 708.62	-7.59%	-0.64
66	6,103.28	5,113.64	5,613.16	6,103.28	490.12	8.03%	0.68
67	8,444.44	8,444.44	8,444.44	8,444.44	-	0.00%	0
68	8,333.33	8,333.33	8,333.33	8,333.33	-	0.00%	0
69	7,485.02	7,485.02	9,000.10	10,486.65	- 1.515.08	-20.24%	-1.71
70	6,847.84	5,232.64	6,769.21	8,276.85	78.63	1.15%	0.1
71	7,246.38	5,016.05	7,076.08	9,097.31	170.30	2.35%	0.2
72	6,606.68	5,243.27	6,923.11	8,571.32	- 316.43	-4.79%	-0.4
73	6,395.12	6,395.12	7,887.45	9,351.67	- 1.492.33	- 3.34%	-1.97
74	8,166.08	6,395.12	7,887.45	9,351.67	278.63	3.41%	0.29
75	7,005.99	7,005.99	7,937.10	8,850.68	- 931.11	-13.29%	-1.12
76	5,319.15	5,224.15	5,272.10	5,319.15	47.05	0.88%	0.07

10. Conclusion

With this paper we expect to open new paths that can be explored by DEA community. DP-DEA method is a useful tool to assess either performance or asset value when we need to consider two divergent interests but that needs to fulfill a common result. The statistical analysis incorporated on this appraisal application demonstrates its accuracy, achieving best-fit results and fulfilling a legal rule established on the Brazilian Professional Appraisal Practice Standards.

We would like also to emphasize that DP-DEA software appraisal capacity has innovated DEA study area, as an appraisal tool. In Table 12 – Simulation Results of DP-DEA Appraisal software, we present a simulation that considers the value appraisal of six different apartments. Modifying the two elected factors that influence the apartment valuation (Privative Area (m²) and Actual Age) and keeping the others factors constant (Building Quality, Equipment, Parking Space and Panoramic View), DP-DEA software could find the three important values: buyer perspective valuation, seller perspective valuation and central tendency, according to real market behavior.

Table 12. Simulation Results of DP-DEA software – Appraisal

	Actual Age Year	Quality Building	Equip a-ment	Privative Area m²	Parking Space	Location $, m²	Pano rami c View	Buyer Perspective $, m²	Value Assessed $, m²	Perspective Value $, m²
Apartment 01	1	5	1	150	2	9719.85	1	11,389.00	**13,209.09**	15.064.10
Apartment 02	15	5	1	80	2	9719.85	1	8,198.78	**9,836.50**	11.384.76
Apartment 03	15	5	1	150	2	9719.85	1	8,198.78	**9,714.63**	11.201.93
Apartment 04	15	5	1	300	2	9719.85	1	7,.062.96	**7,746.05**	8.391.83
Apartment 05	15	5	1	160	2	9719.85	1	8,.198.78	**9,707.10**	11.187.01
Apartment 06	30	5	1	150	2	9719.85	1	8,198.78	**9,705.53**	11.183.90

Other important analytic capacity of DP-DEA software goes far beyond, DP-DEA (Novaes 2002; Lins et al. 2005) making it possible to understand each perspective behavior (buyer , seller) through the mathematical Multiplier DEA Model frontier formulation. A practical approach inferring the buyer behavior, was

presented on section 9. On the related example, it was considered the combination of factors that motivate the decision to buy a real estate in a specific location. The capacity of the parameters to create the frontier hyper plane, defined by the constraints of DP-DEA Input-oriented Model (Novaes 2002), illustrates the real estate buyer's behavior, like price-elasticity, verified on lower DP-DEA frontier. Each real estate price-elasticity graph bar is geocoded on Figure 1 – GIS representation of physical features of apartments appraisal of competitive buyer's perspective. Secondly, we used Loop-DP-DEA (Novaes, Paiva 2010) to find the central tendency, considering a sample of the market data set. Complementary, in section 9, we have demonstrated the fair market value appraisal incorporating statistical analysis to search the best unbiased estimator DP-DEA model.

The main contribution of this paper, considering estimation techniques assumptions, is demonstrated in section 9.4 and 9.5, concluding that DP-DEA modeling approach attends the assumption of Best Unbiased Estimator, Koch (2013). Thus, through the successive iterations of DP-DEA, we could obtain the minimization of estimation's mean square errors and the expected value of the error tending to zero.

The most usual technique used for appraisals is MLRA, which adopters resist to switch to other techniques, because it is already a consolidated methodology. Considering this scenario, we are making a huge effort to spread this new technique and to incorporate consistent statistical analysis to improve the estimation accuracy, when compared to the real dimension prospected.

References

Appraisal Institute Commercial Data Standards (2004), Marshall and Swift - Version 2.0 Commercial Data Standards, http:www.redi-net.com,adn_db,AI _standards.pdf .

U.S. Department of Housing and Urban Development (2015), Appraisal Report and Data Delivery Guide, FHA Single Family Housing, B. Uniform Residential Appraisal Report Form for One Family Residential Properties. http://valuationmanagementgroup. com/ wp-content/uploads/2015/10/Appraisal-Report-and-Data-Delivery-Guide_ver-June-15-2015.pdf.

ABNT (Associacão Brasileira de Normas Técnicas) (2011), Avaliação de bens. Parte 2: Imóveis urbanos, Anexo D, ABNT NBR 14.653-2, https:,,www.ebah.com.br,content,ABAAAg6hAAI,nbr-14653-2-2011 [24.11.2018].

Banker R.D. (1993), Maximum likelihood, consistency, and Data Envelopment Analysis: a statistical foundation, "Management Science", vol. 39 no. 10, pp 1265-73.

Banker R.D., Charnes A.W., Cooper W.W. (1984), Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis, „Management Science", vol. 30 no. 9, pp 1078-1092.

Bayraktar E., Tatoglu E., Sari K. (2008), Investigating the impact of value chain practices on retailer's performance: a casual approach, Icovacs, Izmir, Turkey.

Boldrini J.L., Costa R.S., Figueiredo V.L., Wetzler H.G. (1980), Álgebra linear, 3rd. ed., Harbra , São Paulo.

Brázdik, F. (2004), Stochastic data envelopment analysis: oriented and linearized models, CERGE-EI Discussion papers # 116, http://home.cerge-ei.cz/brazdik/research.html [11.02.15].

Charnes A.W., Cooper W.W., Rhodes E.L. (1978), Measuring the efficiency of decision-making units, „European Journal of Operational Research", vol. 2 no. 6, pp. 429-444.

Davidson M. (2008), The Normal Distribution and the Central Limit Theorem https:// www. maplesoft.com/applications/view.aspx?sid=6879and view=html.

Eckard E.W. (2004), The law of one price in 1901, „Economic Inquiry", vol. 42 no. 1, pp. 101-110.

El-Demerdash, B.E., El-Khodary, I.A., Tharwat, A.A. (2013), Developing a stochastic input-oriented data envelopment analysis (SIODEA) model, "International Journal of Advanced Computer Science and Applications", vol. 4 no. 4, pp. 40–44.

Emrouznejad A., Yang G. (2017), A survey and analysis of the first 40 years of scholarly literature in DEA: 1978-2016, „Socio-Economic Planning Sciences", vol. in press.

Färe R., Grosskopf G., Lovell C.A.K. (1996), Production frontiers, Cambridge University Press, Cambridge.

Gujarati D.N. (2003), Basic econometrics, 4th ed., McGraw-Hill, New York.

Hitchner J.R. (2017), Financial valuation. Applications and models, John Wiley and Sons, Hoboken NJ.

Koch R.K. (2013), Parameter estimation and hypothesis testing in linear models, 3rd ed., Springer, Berlin.

Kuosmanen T.K., Cherchye L., Sipiläinen T. (2006), Law of one price in data envelopment analysis. Restricting weight flexibility across firms, „European Journal of Operational Research", vol. 170 no. 3, pp. 735-757.

Land K.C., Lovell C.A.K., Thore S. (1993), Chance-constrained Data Envelopment Analysis, "Managerial and Decision Economics", vol. 14 no. 6, pp. 541-554.

Lins M.E., Meza L.A. (2006), Data Envelopment Analysis and integration perspectives, Decision Support Theory, Coppe,UFRJ, pp. 7-53.

Lins M.E., Novaes L.F.L., Legey L.F.L. (2005), Real estate appraisal. A Double Perspective Data Envelopment Analysis approach, „Journal of Operational Research", vol. 138 no. 1, pp. 79-96.

Lins M.P.E., Sollero M.K.V, Calôba G.M., Silva A.C.M (2007), Integrating the regulatory and utility firm perspectives, when measuring the efficiency of electricity distribution, European Journal of Operational Research", vol. 181 no. 3, pp. 1413-1424.

Mackmim D. (1994), The valuation and sale of residential property, Cengage Learning EMEA, Andover.

Maddala G.S. (2001), Introduction to econometrics, 3th edition, Wiley, New York.

Misra M., Katiyar G., Dey A.K. (2013), Consumer perception and buyer behaviour for purchase of residential apartments in NCR, „International Journal of Indian Culture and Business Management", vol. 6 no. 1, pp. 56-66.

Morita H., Seiford L.M. (1999). Characteristics on stochastic DEA efficiency – reliability and probability being efficient, "Journal of the Operations Research Society of Japan", vol. 42 no. 4, pp. 389–404.

Novaes L.F.L. (2002), Double Perspective DEA in real estate appraisal with GIS, doctoral thesis, Coppe,UFRJ, Rio de Janeiro, http:,,www.pellisistemas.com.br,downloads,Tese_EDO_DEA.pdf [24.11.2018].

Novaes L.F.L., Fraga A.F., Novaes M.M.R.L. (2016), www.avalsoft.com.br software, LOOP-DP-DEA.

Novaes L.F.L., Lins M.E., Paiva S.A., Pinheiro Jr. L.F. (2002), Avaliação Imobiliária pelo Método da Envoltória sob Dupla Ótica, 3º Simpósio Brasileiro de Engenharia de Avaliações, Curitiba.

Novaes L.F.L., Paiva S.A. (2010), Double Perspective Data Envelopment Analysis. One approach to estimate the „LOOP" arbitrage, „iBusiness", vol. 2 no. 4, pp 354-362.

Plagnet M.A. (2006), Use of benchmarking methods in Europe in the electricity distribution sector, Conference on Applied Infrastructure Research, https:,,www.infraday.tu-berlin.de,fileadmin,fg280,veranstaltungen,infraday,conference_2006,papers_presentations,paper---plagnet.pdf [24.11.2018].

Ray S.C. (2004), Data Envelopment Analysis. Theory and techniques for economics and operations research, Cambridge University Press, New York.

Sampaio L.P.C.B. (2011), Applying Double Perspective Data Envelopment Analysis to the benchmarking process of public utilities, doctoral thesis on electric engineering, Electrical Engineering Department, University of Brasília, Brazil.

Shephard R.W. (1970), The theory of cost and production functions, Princeton University Press, New Jersey.

Simar L., Wilson P. (1998), Sensitivity analysis of efficiency scores: how to bootstrap in nonparametric frontier models, "Management Sciences" vol 44 no. 11, pp. 49-61.

Souza R.M.S. (2009), Análise comparativa do intervalo de confiança dos mínimos quadrados versus envoltórias da envoltória – III Simpósio SOBREA, http:,,www.scielo.br,scielo.php?script=sci_arttextandpid=S0006-87052002000200013 [24.11.2018].

Subhash C. Ray (2004), Data Envelopment Analysis – theory and techniques for economics and operations research, Cambridge University Press, Cambridge, USA.

Vasconcellos M.A.S., Alves D. (1999), 1TH Edition, Code – 040555111.

Varian, H.R. (1985), Nonparametric analysis of optimizing behavior with measurement error, "Journal of Econometrics", vol. 30, pp. 445-458.

Wanke P., Barros C.P., Emrouznejad A. (2017), Assessing productive efficiency of banks using fuzzy-DEA and bootstrapping: a case of Mozambican banks, "European Journal of Operational Research", vol. 249, pp. 378-389.

Whelan J., Msefer K. (1994), Economic supply and demand, MIT System Dynamics in Education Project Under the Supervision of Professor Jay W. Forrester, https:,,ocw.mit.edu,courses,sloan-school-of-management,15-988-system-dynamics-self-study-fall-1998-spring-1999,readings,economics.pdf [24.11.2018].

Wonnacott T.H., Wonnacott R.J. (1990), Introduction statistics for business and economics, 4th ed., John Wiley and Sons, Hoboken NJ.

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Usefulness of the concept of social savings and consumer surplus in studies on the impact of innovation on economic growth

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Abstract:

Aim: The main objective of the paper was to calculate social savings (and consumer surplus) of innovation on the example of railroads in Germany for 1985. The railways were among the most important innovations in the nineteenth century. Being aware of the limits of the social savings technique, the author included the concept of consumer surplus in his calculation

Design / Research methods: For the purpose of the research, the author used the concept of social savings proposed by Robert Fogel and consumer surplus.

Conclusions / findings: For the year 1895, social savings amounted to 2.82% (first equation) of GDP and 5.04% of GDP (second equation), taking into account elasticity of demand (-1,38), social savings amounted to 1.27% of GDP and 2.18% of GDP for Germany. The result thus elicited the author referred to the social savings from railroads as made available in literature and the author's previous research. The author demonstrated that the social savings from the innovation were relatively small.

Originality / value of the article: The results of research are useful for examining the impact of innovation, such as railroads, on the level of social savings. The paper fills the gap in the Polish economic thinking on the use of counterfactual methods.

Implications of the research: The concept of social savings which takes into account demand elasticity can be applied successfully in evaluating the impact of (various) innovations on economic growth.

Limitations of the research: The weakness of the method may be the lack of knowledge about the real level of elasticity of demand for innovation, as well as determining the level of prices of an alternative good, especially if the use of innovation at the initial stage of bringing it to the market involves a relatively high price.

Keywords: Social savings, consumer surplus, elasticity of demand, innovation, rail transport.

JEL: N73, O30, R11

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1. Introduction

The role of technological innovations in creating economic growth can hardly be overestimated. Numerous examples of technological changes can be cited, depending on the period studied, which affected both the growth rate and rising standards of living.

The development of transport, including that of railroads, was certainly crucial to building the capitalist order of the nineteenth century given that transport was what, on the one hand, determined the rapid growth of other industries of the national economy, with this rapid growth, on the other hand, calling for more efficient modes of communication.

The railroad, being one of the most important innovations during the technological revolution, has frequently been the subject of research. In this respect, the studies launched in the 1960s proved to be critical as they contributed to the emergence and development of a new paradigm, New Economic History[1]. In seeking to verify the long established theorems and commonly accepted truths, scholars associated with this research stream use historical statistical data in order to investigate them in-depth by employing econometric methods.

The belief that railroads, as a novel means of communication, played one of the most crucial roles in the economic development of Europe and the USA was just such commonly accepted truth (Fishlow 1965; Fremdling 1985; Voss 1960; Myszczyszyn 2013). This view was, however, altered by Fogel's work *Railroads and American economic growth. Essays in econometric history* (Fogel 1964).

Hence the main aims set by the present author are as follows:

- to show the usefulness or usability of the social saving measure, including consumer surplus, in the assessment of the impact of the rail sector on economic growth of the German Reich;
- to determine the level of savings in relation to the gross domestic product (GDP) for the period set by the author. Considering that two studies, those by Sympher and

[1] It was initiated in the 1950s by two young scholars J. Meyer and A. Conrad, and further expanded by, among others, Fogel (1962), and Fishlow (1965).

Heubach, concerned with the rivalry between rail and waterway transport were available, the author analyzed the year of 1985;
- to compare the results produced (for the year 1985) with the author's previous findings presented in his work *Wpływ kolei żelaznych na wzrost gospodarczy Niemiec (1840−1913)* [*The impact of railroads on German economic growth (1840−1913)*] (Myszczyszyn 2013a) and with the results calculated by other authors.

Another important aim is to promote the work of new economic historians considering the fact that the achievements in the field of the paradigm mentioned earlier have been rather limited in Poland (Pomorski 1986; Matera 2015; Guzowski, Poniat 2015).

2. Take-off and Germany's economic growth (1850-1913). Railroad development

Germany was the last European country to embark on a path to rapid economic development (take-off) in the mid-nineteenth century. Politically divided, impoverished and backward, German nations founded, under the aegis of Prussia, German Custom Union, which manifested their economic integration. With the war against France won, they created the German Empire (1871) which competed effectively with France, England and the USA on an economic level (Myszczyszyn 2011).

The gross domestic product (GDP) expressed in constant 1913 prices grew from M 11.4 billion (1850) to 56,8 billion (1913) thus producing an average growth rate at 2.53% over 1850-1870, while the years following Germany's unification (1873-1913) saw this rate at 2.75%. Moreover, the GDP per capita expressed in constant 1913 prices grew from M 338 (1850) to M 874 (1913), with an average annual growth rate between the years 1850-1870 being at 1.76%, and at 1.5% throughout the years 1873-1913. Germany was at the forefront of the economic change faced by the European continent.

To return to the development of railroads, the German nations (including Prussia) were initially (in the 1830s) reluctant to involve public funds in the

development of this mode of transport – railroads were therefore built through the private sector and local communities. It was only in the mid-nineteenth century that the government authorities began to initiate and finance new railroads on a greater scale, with the 1870s seeing the commencement of the process to nationalize the then private railroad.

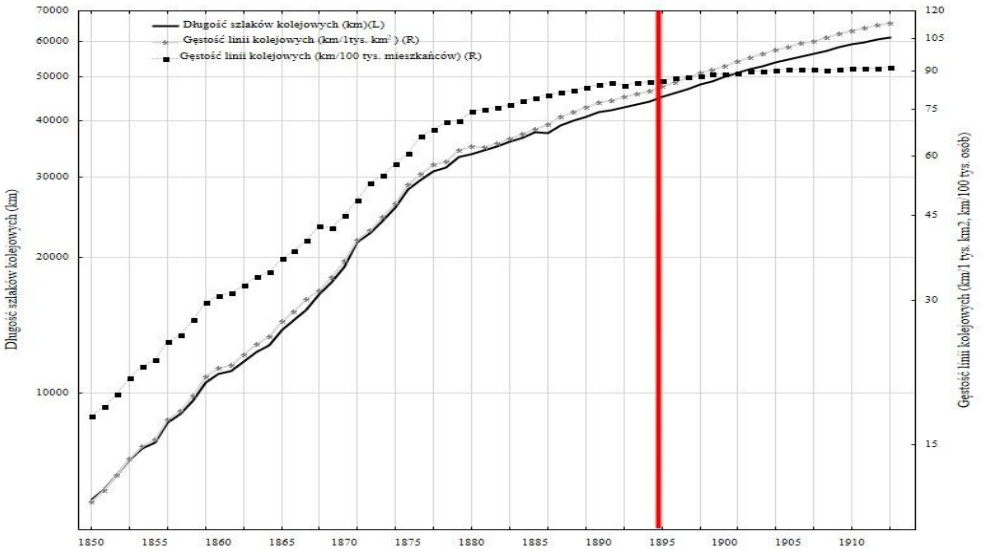
Despite the low profitability of some of the railroads (areas scarcely populated and under-developed), the annual rate of increase of new railroads across the German nations over the years 1850-1875 was at 5.8%, falling to the level of 1.83% after 1880 (Statistisches Jahrbuch für das Deutsche Reich 1880-1914). The year 1913 saw the length of the railroads at 61 159 km. What also grew quickly was the rail network coverage– in the year 1895 which the author analyzed it was 83.6 km railroads per thousand square kilometers, whereas in the wake of the German unification it was only 40.1 (1871) (Figure 1).

Equally interesting and further attesting to the rapid growth of the rail sector is the comparative analysis of the volume of rail freight (in million tkm) and passenger (million pkm) transport against the GDP index per capita (1913=100) (Figure 2), as well as the comparison of the GDP index per capita against the indices of rail freight and passenger transport (Figure 3). In the year 1895, the railroads had the following capacity: 26.6 billion tkm (cargo); 19.9 billion pkm (persons).

The conclusion that can be drawn easily is that one ought to contribute the greatest growth dynamics to the rail freight transport although during the initial stage of the rail network development (up to 1870) it was the passenger transport index that grew visibly faster.

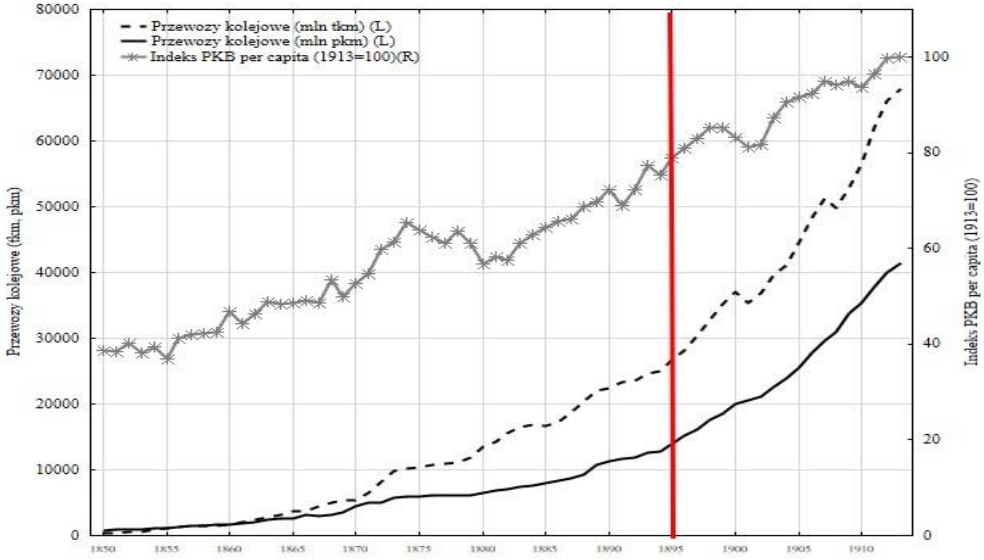
The analysis cited can be seen as evidence for recognizing the rail sector as the leading one in Germany although the rate of increase as regards new railroads from the 1880s to the outbreak of World War One was relatively low (1.1-2.3% annually). What, however, proved to be important for the development of local railroads was the expansion of the railroad of the third order (*Kleinbahn-narrow-gauge railroad*). Those railroads were critical for the local transport growth, while additionally the legal regulations in place made it possible to build them at a substantially low cost, although their vast majority failed to make any profit (Myszczyszyn 2015).

Figure 1. The development of railroads in Germany in 1850-1913



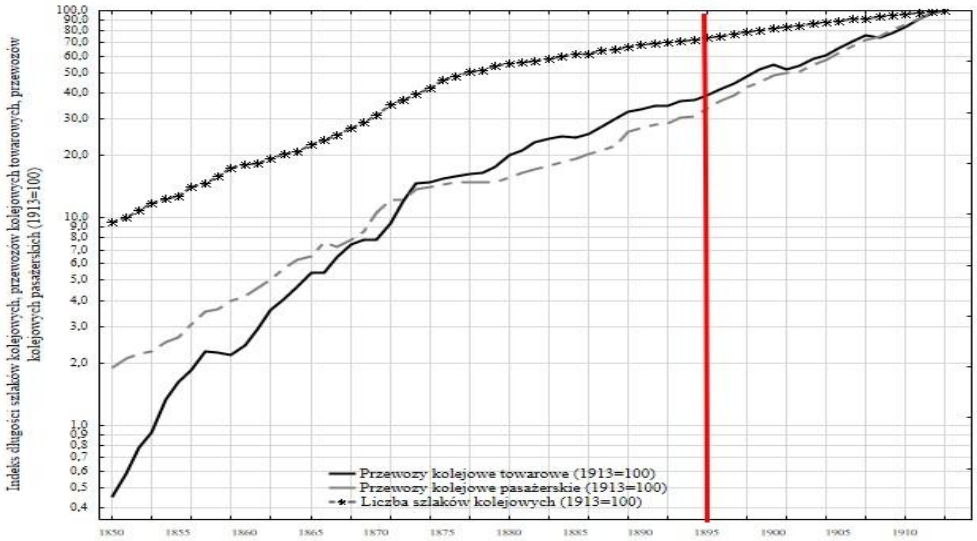
Source: author's own calculations based on: Statistisches Jahrbuch fűr das Deutsche Reich, 1885-1913; Hoffmann (1965).

Figure 2. German GDP index per capita (1913=100) against the volume of rail passenger (million pkm) and freight (million tkm) transport



Source: author's own calculations based on: Statistisches Jahrbuch fűr das Deutsche Reich, 1885-1913; Hoffmann (1965); Fremdling (1985: 17-19); Myszczyszyn (2013b: 179-191).

Figure 3. The index of the railroad length, rail passenger and freight transport (1913=100)



Source: author's own calculations based on: Statistisches Jahrbuch fűr das Deutsche Reich, 1885-1913; Hoffmann (1965); Fremdling (1985: 17-19); Myszczyszyn (2013b: 179-191).

The analysis of the above statistical data and the analysis which the author conducted at an earlier time confirm that at the end of the nineteenth century Germany was, in Europe and globally, at the forefront in railroads expansion, and consequently, in their length and coverage (Myszczyszyn 2013b).

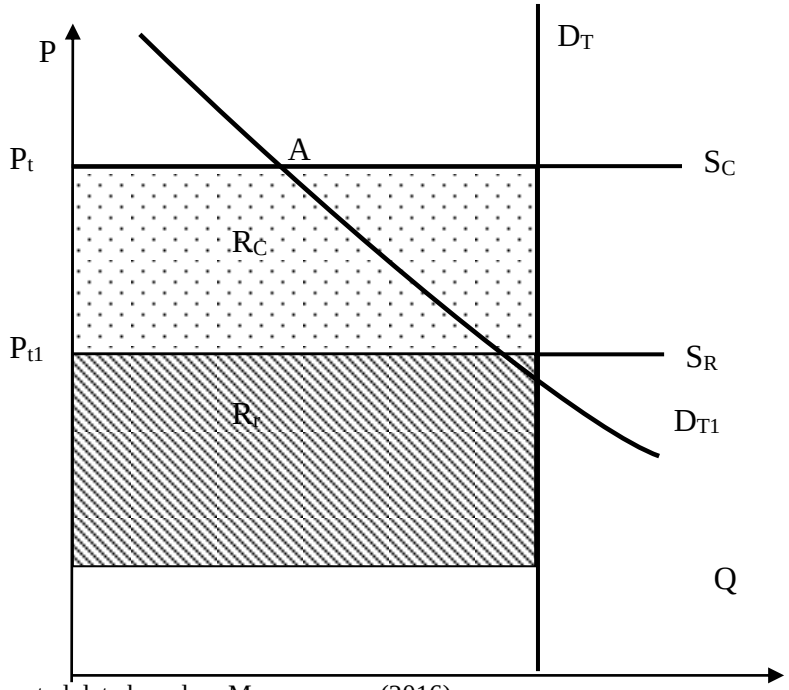
3. Emergence and development of the concept of social savings

A leading representative of new economic historians, Fogel presented the concept of social savings in 1962 in a scientific paper *A quantitative approach to the study of railroads in American economic growth. A report of some preliminary findings* (Fogel 1962: 163-197). He elaborated on the issue of social savings in his book from 1964 *Railroads and American economic growth. Essays in econometric history* (Fogel 1962). In 1979 in his paper *Notes on the social saving controversy*, Fogel wrote "I defined the social savings of railroads in any given year as the

difference between the actual cost of shipping goods in that year and the alternative cost of shipping exactly the same bundle of goods between exactly the same points without the railroad." (Fogel 1979: 2-3).

The social savings methodology is based on estimating the savings produced by a new technology compared to another (traditional) technology. The savings on resources is compared to the gain in real national income. Social savings tend to be expressed as a percentage of the gross domestic product (GDP), gross national product (GNP), net national product (NNP).

Figure 4. A hypothetical demand for new transport services and traditional transport as exemplified by the rail sector, taking into account rigid (D_T) and elastic demand curve(D_{T1})



Source: self-reported data based on Myszczyszyn (2016).

The method used to calculate social savings is illustrated below, assuming that the demand curve D_T is perfectly inelastic (rigid demand) and also when the demand curve is elastic D_{T1} (Figure 4).

where:

D_T – rigid demand for services, e.g. transport service,
D_{T1} – (elastic) demand for services, e.g. transport service,
S_C – supply of alternative transport services (without railroads),
S_R – supply of alternative transport services (including railroads),
R_C – social savings from innovation,
R_r – resources spent on transport (with railroads).

As O'Brien notes, counterfactual reasoning "can be used if reliable alternatives are available and which in addition have to be adequately defined" (O'Brien 1977: 23). This is why the premise of the social saving concept proposed by R. Fogel was that social savings brought about by the expansion of railroads were most frequently confronted by having them compared to waterways networks.

As Fogel assumed, the capital necessary for the rail network to expand was equal to normal profits (normal profits were equal to alternative costs). Moreover, Crafts notes that the social saving approach is also a practical method to calculate total factor productivity (Myszczyszyn 2013b: 161, 179-191).

In the social saving accounting, one defines what costs society would incur if there was no innovation, with the post-innovation demand. Hence, it can be given as:

$$\textit{Social savings} = (C_{t-1} - C_t)\, Q_t$$

where:
C – marginal cost (assuming that costs are proportional to production, the marginal cost is the same as the average cost),
Q – total quantity,
t-1 – pre-innovation time,
t – post-innovation time.
Assuming that the market is fully competitive, market prices can be viewed as the cost measure, then social savings are defined as:

$$\textit{Social savings} = (P_{t-1} - P_t)\, Q_t$$

where:
P_{t-1}= price of an alternative transport mode, e.g. inland waterways transport,
P_t= price of rail transport,
Q_t= the quantity of goods transported by rail (e.g. tkm – ton-kilometer)

The assumption referring to the market competitiveness is deliberate since the data on costs, unlike on prices, are usually unavailable or very difficult to acquire. The only thing that needs to be recalled is that according to the microeconomic premises, prices, over a long period of time and with perfect competition, equal costs (companies make only normal profit). For rail transport, this is a very strong premise that is hardly justified in practice.

Fogel also created an upper bound estimate of social savings assuming that transport demand was perfectly inelastic.

Fogel's calculations showed that social savings of the rail sector in the USA (1890) were only at 1.8% of GDP. This finding and Fogel's theses came as a considerable surprise to the scientific community. Fogel's methodology, as a counterfactual methodology, has been used in some countries with a view to estimating the influence of railroad on economic growth. Those calculations are presented in the present author's work (Myszczyszyn 2013b). For instance, social savings from the rail sector (including freight transport) were at 4.1% of GDP in England and Wales (1859), 11% (1890); Brazil 19-38% (1913); France 5.8% GDP (1872); Spain 7.5% (1978).

However, the data cited above as regards social savings cannot be seen as clear indicators for the involvement of railroads in generating economic growth in any given country considering the following:

- the social savings calculations that are available in the literature refer to different countries, different years, and were conducted using a variety of methodologies, and, in the light of the fact that some data were unavailable, those estimates may be unreliable and so drawing clear conclusions may be flawed,
- the value of social savings may be substantially smaller if we assume that price elasticity of demand is high. In such case the falling prices, in line with the elasticity concept, lead to increased demand (and vice-versa), which is why Leunig advocates using consumer surplus for the analysis of the impact exerted by the development of technology.

According to Fogel, the social saving methodology entails calculating savings in any period investigated while determining the difference between the actual cost of e.g. freight, passenger transport in this year and the alternative cost, e.g. using inland waterways for transporting exactly the same amount of goods, number of people. Thus, the railroads are theoretically eliminated.

The figure illustrates the demand for transport while assuming that it is either rail transport that is taken into consideration (S_R) or only an alternative mode of transport (S_C). In the case that is typical for the social saving concept one should determine total expenditures (revenue), that is an R_C area, which would denote possible savings in the economy as a result of the rail sector development, and then to refer those savings to the GDP level.

In summing up, one should emphasize that, notwithstanding the criticism directed at the calculation of social savings, in the case of the rail sector this indicator has become a valid element in defining the effects of an innovation which in the nineteenth century the railroad expansion embodied.

4. The consumer surplus concept

Fogel's social saving concept faced considerable criticism. This comes as no surprise given that in the USA one of the major innovations of the nineteenth century, that is railroad, was characterized by a relatively low rate of social savings.

In the wake of Fogel's publication, Boyd and Walton (1972) questioned the advisability of calculating social savings based on the assumption that the elasticity demand coefficient was equal 0. This implies that demand is rigid, failing to respond to price changes. In principle, one can recognize that social savings estimated in this way determine, in line with Fogel's reasoning, an upper bound estimate of savings.

The research on econometric estimates of price elasticity of demand for passenger transport which Boyd and Walton conducted after the Second World War brought them to the conclusion that this indicator was equal |1| (unit demand). Hence, consumer surplus could be called the total financial gain of all consumers who would be willing to purchase one unit of a given good at a price that is higher

than the price of market equilibrium P_R. The exact size of this measure depends on the shape of the demand curve, which as a rule is characterized by a negative slope (Greasley, Olexey 2011; Myszczyszyn 2013b: 175-179).

This can be illustrated algebraically as follows:

$$\Delta CS = (P_{t-1} - P_t)Q_{t-1} + \alpha(P_{t-1} - P_t)(Q_t - Q_{t-1})$$

where:

ΔCS – change in consumer surplus,

α – a parameter determining the demand curve slope,

Q – quantity,

t – post-innovation time, t-1 – pre-innovation time.

In order to determine the relationship between the social saving, and consumer surplus and the assumption that $Q_t = 1$, we obtain:

$$\frac{\Delta CS}{SS} = \alpha + (1 - \alpha)Q_{t-1}$$

With such construction of the equation there are, depending on parameter α, three different categories, namely with the parameter assuming the following values: $\alpha > 1$, $\alpha = 1$, $\alpha < 1$.

If $\alpha > 1$, then we consider Giffen goods for which the demand curve has a positive slope (which is rather exceptional) and then the quotient $\frac{\Delta CS}{SS} > 1$. This would mean that the fall in the price of a product is accompanied by the fall in its consumption – the income effect outweighs the substitution effect. Then the quantity Q_t multiplied by the price would be smaller than Q_{t-1} multiplied by the price before launching the innovation. For Giffen goods, the social saving SS would be smaller than consumer surplus CS.

If $\alpha = 1$, then the demand would be perfectly inelastic. This means that the social saving SS would equal the consumer surplus CS.

The third possibility, if $\alpha < 1$, then $\frac{\Delta CS}{SS} < 1$, which means that the social saving SS is higher than the consumer surplus CS, and this can be the most probable alternative.

If the demand and price are normalized, in other words, $Q_t = P_t = 1$, then we can assume that

$$Q = P^e$$

where:

e – demand elasticity.

Seeking to determine consumer surplus, one can use the following equation (an increase in consumer surplus is related to Q, while taking into account P):

$$\Delta CS = \int_{P_t}^{P_{t-1}} P^e dp = \frac{1}{e+1}(P_{t-1}^{e+1} - P_t^{e+1})$$

In order to determine the relationship between the change in the value of consumer surplus and social saving estimation for a fixed demand elasticity, one should present the above equation as a price and demand elasticity function, and then divide it by equation $SS=(P_{t-1}-P_t)Q_t$. Then we will receive:

$$\frac{\Delta CS}{SS} = \frac{P_r^{e+1} - 1}{(e+1)(P_r - 1)}$$

where:

$P_r = \frac{P_{t-1}}{P_t}$ – the price ratio before and after innovation.

The above equations show that the size of deviation $\frac{\Delta CS}{SS}$ depends not only on the degree of elasticity of the demand straight-line curve but also on factor P_r.

As Fogel argued, even for a very inelastic demand curve for freight and passenger transport (e = -0,4), the calculations based on the assumption that elasticity equals 0 may imply that $\frac{\Delta CS}{SS}$ will change by even 46% (Fogel 1979: 11-12; Myszczyszyn 2013b).

Seeking to achieve the research objective, the present author used various degrees of demand elasticity against elasticity e=-1,38, estimated by W. Hoffmann for transport expenditures. In the case of Germany, the elasticity degree of demand for transport expenditures changed considerably over the years 1850-1913, just like the total of expenditures which households allocated for this kind of purchases. As

Hoffmann notes, in the mid-nineteenth century, a person would spend on average 40 pf (1913 prices) on transport with those expenditures growing very fast to reach 18 M per person in 1913.

5. Results

Using the above assumptions, the author estimated social savings for rail freight, omitting passenger rail transport and the railroad of the third order.

Two alternatives were assumed for the rail freight – the equations 1) and 2) shown below.

In order to calculate the social savings from the first equation, the author used the source data derived from Sympher's work *Die wirthschaftliche Bedeutung des Rhein-Elbe-Kanals* (Sympher 1899) formulating the following equation:

1) $P_t=0.6P_W+0.3P_K+0.1P_P$

where:

Pw – the rate for inland waterway transport determined based on the rate of average inland freight (applying the different rates for the four major waterways (river basins such as the Rhine, the Elbe, the Oder and the Vistula) which were at 1.65pf/tkm (Sympher 1899: 38-39); [2]

P_K – the rate for inland waterway transport (canals), the rate of freight water transport was assumed to increase by 0.5 pf/tkm (Myszczyszyn 2013b);

P_P – the rate for horse drawn transport (wagons) was set at 40pf/tkm.

It was assumed that the value of rail transport in 1895 was at 483 million M (Hoffman 1965).[3]

The results published at an earlier date referring to the first equation induced the author to formulate equation 2). To this end, the author used Heubach's study – *Die Verkehrsentwicklung auf den Wasserstrassen und Eisenbahnen des Elbe=Odergebietes in dem Zeitraum von 1882-1895* (Heubach 1898).

[2] Author's own calculations in which the author included the estimates for the four major rivers of the Reich such as the Rhine, the Elbe, the Oder and the Vistula, as well as additional costs for water freight.

[3] The results from the first equation were published in Myszczyszyn (2016).

Across the Oder-Elbe waterways, including the so called March route (1895), 9.2 million Mt (9 271 million tkm) were transported by rail and waterways in total, which accounted for 34.85% of the overall inland transport of the German Reich. The average length of the rail route was 117km, while for waterways it was 335km (Heubach 1898: 24-25). The assumption was that 50% of transport would be by using natural waterways, 30% by artificial waterways (e.g. canals), and 20% by roads using horse drawn transport (wagons).

2) $P_t=0.5P_W+0.3P_K+0.2P_P$

where:

Pw – the rate for inland waterways transport, determined based on the rate of average inland freight (applying the different rates for two waterways (the Oder-Elbe river basins) at 1.5pf/tkm as the highest rate (the highest cost of brown coal freight on the Aussig-Magdeburg route), and having taken into account the fact that the waterways transport was on average 25% longer for the same distance as compared to the rail transport, it was assumed that the average cost of freight would be at 1.9pf/tkm) (Heubach 1899: 56-57, Tafel V).[4]

P_K – the rate for inland waterways transport – artificial sections (e.g. canals), it was assumed that the freight accounted for 75% of rail freight, that is (3.06 pf), that is, 2.0 pf/tkm (Heubach 1899: Tafel V),

P_P – the rate for horse drawn transport (wagons) was set at 40 pf/tkm.

Table 1. Social savings of the rail sector in Germany in 1895

Description	Equation 1)	Equation 2)
Rail transport (mln tkm)	26 600,00	26 600.00
Alternative rate for 1 tkm (M.)	0.055	0.0964
Value of rail transport (mln M.)	483.00	813.96
Value of transport as an alternative for railroads (million M)	1 463.00	2564.24
Social savings (million M.)	980.00	1 751.24
Savings rate (% GDP)	**2.82**	**5.04**

Source: self-reported data.

[4] The author's own calculations; the author took into account the estimates made for the Oder river and the Elbe, and additional costs for water freight.

The value of rail transport in 1895 was calculated by multiplying the average price for rail freight 3.6 pf by rail transport, which resulted in 813.96 million M. The calculation results are illustrated in Table 1.

The social savings from the rail sector (freight) were at the following level:

- 2.82% of GDP according to the first equation;
- 5.04% according to the second equation.

Such results confirm that the role of railroads seen through the prism of the social savings ratio to the GDP level was relatively minor. This finding also justifies the cause and the reason prompting German researchers (Fremdling, Tilly, Pierenkemper and others) to focus rather on defining the importance of railroad as a key sector through the effects that go forwards and backwards (*Vorwärtskopplungseffekte, Rückwärtskopplungseffekte*), disregarding the level of investment outlays on railroad expansion at a time when waterways transport was definitely less expensive (Fremdling 1985; Pierenkemper, Tilly 2004). It should be noted that the social savings calculated by the author amounted to 2.08-2.32% of GDP in 1909 (Myszczyszyn 2013b: 175). Indeed, the rail transport had economic effects which would go "backwards" and "forwards" stimulating the development of other German industries. The development of railroads itself together with the German Custom Union, in Germany's conditions, also exerted a substantial impact on the integration and unification of the nations divided politically. Still, the success and economic development of Germany was also influenced by plenty of other factors, such as increased industrial production, chemical industry development, agricultural progress, reduced illiteracy, etc., as well as the state's involvement in the economic processes.

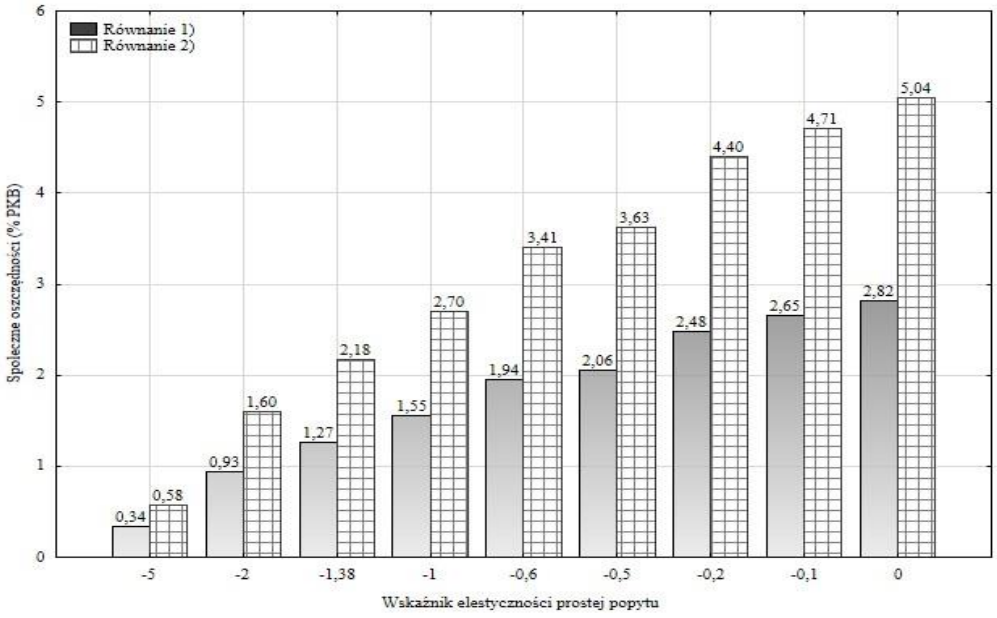
In the subsequent step, the author showed, using different degrees of elasticity of demand, the quantity of social savings while taking into account consumer surplus for the rail sector (Figure 5).

The savings demonstrated by the author in relation to the GDP level (1895) were only at 1.27% of GDP (assuming that the demand elasticity ratio was at the level e= -1.381) for the first equation and 2.18% of GDP for the second equation. It should be noted that the social savings which the author calculated for 1909 were at 1.53-1.58% of GDP (Myszczyszyn 2013b: 179).

These calculations (and the previous ones for the year 1909) further confirm how important the elasticity of demand is for the innovation under study. Assuming that demand is inelastic, social savings may prove to be relatively high, while for elastic demand they may be considerably lower.

Assuming that demand for transport was relatively elastic, that is, the demand curve was not rigid, then consumer surplus would automatically become much lower than the social savings calculated, and for the year 1895, assuming that the demand was rigid, the surplus oscillated within the 1.27%-2.18% range in relation to the GDP.

Figure 5. Social savings of the rail sector in Germany taking into account consumer surplus and using different levels of demand elasticity (1895)



Source: self-reported data.

6. Summary

The analysis of the social savings from Germany's rail sector for the year 1895 allows for drawing the following conclusions:

- the growth pace of rail transport in German nations and (later on) in the German Reich was very impressive although the waterways transport was not pushed to the sidelines of those changes. The emergence of a new transport mode coupled by a fast increase in production potential allowed for the development of trade, also stimulating the development of other industries (e.g. machine industry, iron industry). Moreover, railroads revolutionized the market of mass passenger transport and postal transport;
- the rail transport was not cheap compared to alternative modes of transport (e.g. inland waterways transport). For instance, in the case of Prussia the average fee for rail freight transport should not be lower than 2.2 pf/tkm. This level assured viability of the rail transport. Sadly, the state would often bring lower fees which it justified by the higher need (cf. Grotewold 1914: 17-19, 305, 393). Still, this also yielded positive effects as the difference in the transport costs allowed for the inland transport to further develop. As Voss suggests, the development of railroads itself did not imply the reduction of transport costs. The rail transport cannot therefore be viewed as a substitute for the inland transport at the time in question. Despite the rapid development of the rail network coverage, the share of the waterways transport (1880-1913) in relation to the rail transport grew from 21.1% to 24% (Voss 1960: 62-63). However, this rapid economic growth (including the development of industry) allowed for using the (innovative) rail transport on a large scale.
- for the expansion of railroads substantial investment had to be incurred which could otherwise have been allocated for other economic activities, including the expansion of canals, river regulation, development of areas with low economic activity, and, first and foremost, constructing new road and improving the condition of the already existing hard paved roads (Myszczyszyn 2015). The most telling fact (among other things, in the context of the lack of financial resources) is the planning for over fifty years of the construction of the Rhine-

Elbe canal. Despite Karl von Thielen's statement, who was then the Prussian minister for public construction works, that the inland waterways transport was to be seen as a partner of equal importance to railroads, the rail transport had in fact been considerably privileged (Heubach 1898: 42);

- the fee policy in rail transport was often unstable and lacking uniformity ultimately leading to the use of other alternative (cheaper) modes of transport, which inland waterways frequently represented;
- the subsequent development of wheeled transport confirmed the thesis that some portion of the railway network, even though being profitable, had to be removed in the wake of such new technology as vehicle transport which made railroads unviable. Nevertheless, the new rail sections unviable for the eastern provinces, which tended to be under-developed, brought about a new wave of economic recovery. Neither should one forget the importance of the third order railroads for the development of local markets (e.g. the Prussian province of Pomerania);
- the expansion of some of rail routes was dictated by military and political considerations, being questionable, to say the least, from an economic point of view;
- owing to economic effects (forwards and backwards), rail transport influenced the demand and development of numerous areas of national economy, delivering a transport that was more secure, on time and less dependent on the forces of nature;
- the railroad development allowed for transport in regions where waterways were developed poorly, watercourses were not navigable or their condition was such as to render bulk transport impossible. On top of that, given that the common course of rivers was in south-north, there were no transport links in east-west, and considering the shape of the German Reich border, that proved to be of particular relevance;
- in addition, rail sections between industrial centers tended to be shorter than the natural river courses, which ultimately led to having to pay more (even at a lower fee for 1Mt) for the same volume of goods using the inland waterways transport.

The analysis of social savings of railroads in Germany illustrates the relatively law value of this indicator. The results elicited confirm that alternative modes of freight transport (in this case water transport) were in many instances less expensive, which, however, does not yet mean that the emergence and expansion of railroads had no impact on economic growth and its pace, which is further corroborated by the econometric model built by the author (Myszczyszyn 2013b).

Moreover, despite its limitations, the social saving concept, (the ratio of price elasticity of demand equals 0) together with consumer surplus can be employed successfully in estimating the effectiveness of technological novelties supplanting previous solutions. At this point, what proves crucial is to estimate not only savings as a fraction of GDP, but also to define the degree of elasticity of the demand curve.

As the author showed, social savings can be relatively high assuming that the demand is rigid, as then it is only the upper bound estimate of the savings produced. As a result, by taking into account the level of elasticity of demand, the impact of technological novelties on economic growth may be quite radically reduced. If it turns out that demand is elastic, then consumers will respond strongly to the change in price (ceteris paribus), which can lead to a lower demand for new good and substantially reduce social savings from launching a novelty over a specific period of time.

References

Das Deutsche Eisenbahnwesen der Gegenwart (1911), vol. 1-2, Verlag von Reimar Hobbing, Berlin.

Boyd J., Walton G.M. (1972), The social savings from nineteenth century rail passenger services, „Explorations in Economic History", vol. 9, pp. 233-254.

Crafts N. (2004), Social savings as a measure of the contribution of a new technology to economic growth, Department of Economic History London School of Economics Working Paper, no. 6, London.

Fishlow A. (1965), American railroads and the transformation of the antebellum economy, Harvard University Press, Cambridge MA.

Fishlow A. (1966), Productivity and technological change in the railroad sector, 1840-1910, in: Output, employment, and productivity in the United States after 1800, „Studies in Income and Wealth", National Bureau of Economic Research, New York, London, pp. 583-646.

Fogel R. (1962), A quantitative approach to the study of railroads in American economic growth. A report of some preliminary findings, „Journal of Economic History", vol. XXII no. 2, pp. 163-197.

Fogel R. (1964), Railroads and American economic growth. Essays in econometric history, Johns Hopkins Press, Baltimore.

Fogel R. (1979), Notes on the social saving controversy, „Journal of Economic History", vol. XXXIX no. 1, pp. 1-54.

Foreman-Peck J. (1991), Railways and the late Victorian economic growth, in: New perspectives on the late Victorian economy. Essays in quantitative economic history, 1860-1914, Foreman-Peck J. (ed.), Cambridge University Press, Cambridge.

Fremdling R. (1985), Eisenbahnen und deutsches Wirtschaftswachstum 1840-1879. Ein Beitrag zur Entwicklungstheorie und zur Theorie der Infrastruktur, Gesellschaft für Westfälische Wirtschaftsgeschichte E.V., Dortmund.

Grotewold Ch. (1914), Die deutsche Schiffahrt in Wirtschaft und Recht, Verlag von Ferdinand Enke, Stuttgart.

Guzowski P., Poniat R. (2015), Że zaś w wieku cyfr cyframi tylko poprzeć można twierdzenie... – raz jeszcze o kondycji polskich badań nad historią gospodarczą, „Roczniki Dziejów Społecznych i Gospodarczych", vol. LXXV, pp. 289-305.

Heubach E. (1898), Die Verkehrsentwicklung auf den Wasserstraβen und Eisenbahnen des Elbe. Odergebietes in dem Zeitraum von 1882-1895, Siemenroth & Troschel, Berlin.

Hoffmann W.G. (1965), Das Wachstum der deutschen Wirtschaft seit der Mitte des 19. Jahrhunderts, Springer-Verlag, Berlin.

Laffut M., O'Brien P.O. (ed.) (1983), Railways and the economic development of Western Europe, 1830-1914, St Martin's Press, New York.

Leunig T. (2011), Social saving, in: Economics and history. Surveys in cliometrics, Greasley D., Olexey L. (ed.), Willey-Blackwell, London.

Matera R. (2015), Kilka uwag na temat miejsca badań ilościowych w polskiej historii gospodarczej. Stan i perspektywy, „Roczniki Dziejów Społecznych i Gospodarczych", vol. LXXV, pp. 277-288.

Myszczyszyn J. (2010), Koleje żelazne jako istotny element procesu wstępnej industrializacji państw niemieckich, „Kultura i Historia", no. 17, http://www.kulturaihistoria.umcs.lublin.pl/archives/1757 [09.12.2018].

Myszczyszyn J. (2011), Niemiecki Związek Celny (Deutscher Zollverein) i koleje żelazne a rozwój gospodarczy Niemiec w XIX w. Próba oceny, „Kultura – Historia – Globalizacja", no. 9, pp. 77-91.

Myszczyszyn J. (2013a), Wpływ kolei żelaznych na wzrost gospodarczy Niemiec (1840-1913), Wydawnictwo Uniwersytetu Łódzkiego, Łódź.

Myszczyszyn J. (2013b), Wykorzystanie koncepcji social savings w określeniu wpływu sektora kolejowego na wzrost gospodarczy Niemiec w początkach XX w., „Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu", no. 305, Wydawnictwo Uniwersytetu Ekonomicznego, Wrocław.

Myszczyszyn J. (2015), Rozbudowa infrastruktury komunikacyjnej (drogowej i kolejowej) w XIX i początkach XX wieku na przykładzie prowincji Pomorze, in: Kresy Zachodnie. Gospodarcze i społeczne znaczenie polskich kresów, Głowiński T. (ed.), Wydawnictwo Gajt, Wrocław, pp. 227-243.

Myszczyszyn J. (2016), Wykorzystanie koncepcji społecznych oszczędności i nadwyżki konsumenta w badaniach wpływu innowacji na wzrost gospodarczy na przykładzie transportu kolejowego w Niemczech, „Studia i Materiały, Miscellanea Oeconomicae", vol. 20, no. 1.

O'Brien P. (1977), The new economic history of the railways, Billing & Sons Ltd., Guilford, London, Worcester.

Pierenkemper T., Tilly R. (2004), The German economy during the nineteenth century, Berghahn Books, New York.

Pomorski J. (1986), Paradygmat New Economic History. Studium z teorii rozwoju nauki, Wydawnictwo UMCS, Lublin.

Statistisches Jahrbuch für das Deutsche Reich (1880-1917), Herausgegeben vom Kaiserlichen Statistischen Amt, Berlin.

Sympher L. (1899), Die wirthschaftliche Bedeutung des Rhein-Elbe-Kanals, vol. 1, Siemenroth & Troschel, Berlin.

Voss W. (1960), Die langfristige Entwicklung des Eisenbahngüterverkehrs in Deutschland von 1880 bis 1957 in ihrer Abhängigkeit von Wachstum und Strukturwandlungen der Wirtschaft, Hamburg.