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THEORETICAL AND METHODOLOGICAL PROBLEMS

ENVIRONMENTAL POLICY AND MANAGEMENT

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THEORETICAL AND METHODOLOGICAL PROBLEMS

PROBLEMY TEORETYCZNE I METODYCZNE

Dariusz PIEŃKOWSKI

A CONCEPTUAL FRAMEWORK TO DESIGN SUSTAINABLE PENSION POLICY

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ABSTRACT: A conceptual framework to design sustainable pension policy is offered to tackle the interplays between different determinants from the perspective of economic policy and the concept of sustainable development. The investigation of the main socio-economic determinants presented in the literature resulted in the designing of a holistic conceptual framework, which is designed to support decision-makers and researchers who need to understand the determinants of specific policy programmes and their long-term socio-economic consequences. As a result, it helps to determine and design a sustainable pension policy. The sustainable framework emphasises the ideological background for the economic debates, historical paths plotted in the path-dependence 4S framework and the key arguments for and against the funded and unfunded pension schemes. The sustainable conceptual framework emphasises the multiple objectives of pension policy, resource flows and the capital formation debate in economics, as well as the global perspective of capital flows.

KEYWORDS: path-dependence 4S framework, sustainable pension policy framework, pension schemes, global economic perspective

Today's workers will have to save more, work longer, retire later, receive less generous benefits, and perhaps pay more taxes

J. Bongaarts (2004, p. 21)

Introduction

Uhlenberg (2009) and Clark and Spengler (1980) noticed changes in the population debate since ageing problems have been reported in the 1960s. Scientists mostly agreed with the view that the unprecedented qualities and functions of the changes (Mason & Lee, 2011a; Uhlenberg, 2009) are related to the post-war generation of baby boomers in Western societies (Kang, 2013; Lee, Donehower & Miller, 2011; Liu & Spiegiel, 2011; Abel, 2003; Bakshi & Chen, 1994; Mankiw & Weil, 1989).

Consequently, there have been raised not only economic debates about the costs of their pensions, but also ethical concerns about the responsibilities of the present generations (they are called Millennials – born in the years ranging from the 1980s to the early 2000s (Howe & Strauss, 1992) for their parents. For example, Tankersley characterised baby boomers in the subtitle of his article in The Washington Post: "They chewed up resources, ran up the debt and escaped responsibility" (Tankersley, 2015). On the contrary, some findings show that the generation of baby boomers secured wealth and substantial assets for their retirement and that they are prospering well (Keister & Deeb-Sossa, 2001; Sabelhaus & Manchester, 1995; Easterlin et al., 1990); moreover, they support their families even more than their parents did (Fingerman et al., 2012; Taylor & Krishnamurthy, 2005).

Easterlin and coauthors (1990) explained that the baby boomers significantly change their behaviour to achieve wealth responding to hard situations in the labour market. The authors indicated that they preferred unmarried couple's cohabitation, singlehood and a small number of children, as well as doubling up with others or coupling the mother's work with childbearing. Samuelson (2015), like Easterlin (1961), argued that a lack of a generational conflict between Millennials, hit hard by recessions, and baby boomers result from the job optimism of the former and rising wages since the baby boomers have been retiring. Millennials feel more vulnerable but remain optimistic about their situation (Taylor et al., 2012).

However, the generation of baby boomers only accentuated the adverse trends of the present socio-economic development, leading to a heated debate among scientists. They are only a part of complex changes, which have been initiated by industrial societies and historic developments. These circumstances revealed ideological biases and the needs for broader research perspectives in economics that include socio-biological and cultural settings.

The multifaceted character of the changes reveals controversies around pension reforms, social policy measures and potential economic costs. The economic debate includes interrelated factors such as fertility and mortality, migration, altruism and family values and pension schemes. Therefore, the debate is somewhat intertwined with investigations widely undertaken by sociologists, psychologists, biologists and medical and political scientists, as well as philosophers. The trans-disciplinary character of the changes enforces a need for a holistic framework, which interrelates the body of research.

Furthermore, the intergenerational nature of the ageing issues requires long-term perspectives (Schwarz et al., 2014), and it involves the problems of just resource distribution and sustainable development. The delayed impact of various demographic policy measures impedes evaluation and mitigation of potential negative effects. Moreover, the socio-economic situation can be dissimilar in the time when the policy results eventually occur, and the outcomes can only escalate the socio-economic problems; it is also diverse based on the national and cultural contexts (Holzmann, Hinz & Gersdorff, 2005; Schwarz et al., 2014).

This paper offers a multidisciplinary framework to tackle the interplays between different factors from the perspective of economic policy and the conception of sustainable development. It supports decision-makers and researchers who need to understand the determinants of specific policy programmes and their long-term socio-economic consequences. This study particularly includes political and socio-economic effects related to pension systems. Since the ageing debate provides a wide portfolio of relatively decisive results, the study offers a framework to tackle the disparities from a sustainable development perspective. Consequently, it helps to determine and design a sustainable pension policy.

The framework combines the key dimensions of pension policy discussed from the perspective of the economic debate. The primary issue is related to ideological biases in economics that have been accompanying disputes between economic schools since the beginning of the scientific discipline. The discussion often relates demographic changes to economic interventionism and the impact of social policy on economic growth.

Next, the paper reviews the key determinants of the pension policy revealed in the economic debates. It seeks to provide the main policy areas from the perspective of sustainable development. It starts from a path dependence approach, explaining the interdependence between demographic changes, pension schemes and economic settings, and the history-specific determinants for adoption of different pension schemes. In addition, a review of the economic impact of funded and unfunded (PAYG - Pay-as-You-Go) pension schemes is offered. Following the debate on path depend-

ence, the next subsections present basic findings in economics, which include resource flows between generations and the potential economic burdens of the working-age cohort, as well as savings and their role in physical capital formation. Finally, a global perspective is accepted to explain country-specific differences, which could potentially show the portfolio of pension policy measures aimed at the goals postulated in a pension system. The last sections present the sustainable framework for pension policy, as well as conclusions and recommendations for policy-makers.

Ideological biases and the sustainability approach

Clements, Eich and Gupta (2014) defined attributes of sustainability in the context of pension policy, pointing out: *"to current and future public pension spending as a share of GDP or primary spending. Too high a share could be considered unsustainable because it crowds out more productive government spending such as education or capital expenditure, or results in an increase in taxation (including on wages) to a level that is counterproductive to growth*" (p. 7). Furthermore, they discussed their perspective in detail, emphasising two characteristics of sustainability: 1) a long-term view; and 2) intergenerational horizontal (equal treating in similar circumstances, no redistribution usually needed) and vertical equities (treating according to individuals' needs, redistribution may occur). Equity was perceived from the perspective of basic human needs and equal distribution of burdens and benefits (Clements, Eich & Gupta, 2014). The United Nations Sustainable Development Goals also emphasise the postulates of healthy lives and well-being for everyone at all ages (United Nations, 2017). The intergenerational and global perspective usually invoked in the phrase "for all" presented in the definitions of the goals is to be also applied in the pension policy, including social, ecological and economic determinants of its application and, therefore, multiple objectives.

The economic research represents a wide range of models, discussions and policy recommendations, which tend to be contradictory in terms of a particular evaluation. For example, the impact of pension systems on savings and economic growth is often discussed. However, the neoclassical approach that unfunded pension schemes should be replaced by funded ones to secure savings and incomes – suggested, for example, by Feldstein (1974) and Bailliu and Reisen (1998) – is presently challenged in ample evidence (Fanti & Gori, 2012; Barr et al., 2010; Cesaratto, 2006; Barr, 2000; Mackenzie et al., 1997); the latter research posited country-specific situations, market imperfections and multiple objectives of pension systems.

Some primary sources of the disparities are associated with priorities set by researchers and politicians, as presented in the following quotation: *"It is important to remember that pensions are not only, or even primarily, about national saving. Indeed, the primary purpose of pensions is to ensure an adequate standard of post-retirement living for individuals, consistent with the resources available to society. A reform that jeopardizes this objective cannot be considered worthwhile, whatever its impact on national saving"* (Mackenzie, Gerson & Cuevas, 1997, p. 49). Thomson (1994) and Schwarz and coauthors (2014) similarly posited a variety of contradictory social objectives, and Willmore (1999) argued that privatisation of pension funds is related to economists' view on the role of the state. According to the accepted perspective, they can emphasise different problems, such as administrative costs, investment risks or savings. Therefore, World Bank researchers suggested four general features of retirement income: 1) adequateness (able to prevent old-age poverty); 2) affordability (within the financing capacity of individuals and society); 3) sustainability (financial stability over long periods of time); and 4) robustness (demographic, economic and political shock-resistance) (Holzmann et al., 2005).

There are also suggestions that the "baby boom issue" is a political argument in favour of economic liberalisation. For example, Mullan (2002) argued that the ageing debate understates the excess capacity to generate welfare within future economies. The future economic settings should dwarf the costs of the increasing old-age dependency ratio, even with a much slower growth rate, as there is an enormous number of jobless people. Gee (2002) added that the ageing debate, particularly with the emphasis on the costs of healthcare and pension schemes, is a part of neoliberal policies, which endorse individualistic approaches and discourage commitments to risk-sharing or common goods. She recalled studies that show a lack of correlation between the paces of healthcare spending growth and population ageing. The study also pointed to an inaccurate measure of dependency ratios, which ignore unwaged labour of pensioners (such as caregiving for family members) and dependent people in the working-age cohort (such as disabled people).

Finally, the concept of capital accumulation invoked in the neoclassical perception of economic growth tends to be considered as a goal itself, not as a means to achieve social goals, which are disputable and contingent upon their contexts. The studies of the Chicago School presented by Mincer (1958), and particularly Becker (Becker, 2007; Becker et al., 1990; Becker, 1983; Becker, 1960), suggest that the accumulation of human capital is at least as important as the accumulation of physical capital. The accumulation of the former is particularly important in knowledge-based economies and social

development. The Organisation for Economic Co-Operation and Development (OECD) reports that: *"knowledge, as embodied in human beings (as "human capital") and in technology, has always been central to economic development. But only over the last few years has its relative importance been recognised, just as that importance is growing"* (OECD, 1996, p. 9). Therefore, the evaluations of the accumulation of physical capital are balanced with the different social and economic mechanisms of the accumulation of human capital in terms of quality, as well.

Despite the present well-being of baby boomers, their retirement security can be affected by many factors, such as financial market stability, government policy on the pension system and the accessibility of healthcare services (Clark et al., 2004). The ideological content and the different perspectives of socio-economic interactions explain some inconclusiveness in the findings presented in the ageing debate. Research methodology, policy recommendations and decision-making reflect the conceptual content.

The determinants of pension policy – an overview of the literature

The ideological perspective in this paper is framed by the sustainable development approach. This section presents the review of the key determinants of pension policy related to the history-specific conditions, intergenerational resource flows and the issue of capital formation, which is vigorously discussed in the economic debate. The determinants are completed with the capital flows from the perspective of the global economy, which is postulated in the concept of sustainable development.

1. A path dependence outlook and pension schemes

There is a clear assumption in most research that in a given time, a working-age cohort is crucial for economic growth, although the condition of the present cohort is determined by the behaviour of previous generations. The path dependence approach is particularly utilised to explain demographic changes and pension schemes (Lee & Mason, 2011a; Holzmann et al., 2005; Mullan, 2002; Becker et al., 1990). The research alternates the economic perspective presented in the growth models that assumed population changes to be exogenous, like in the Solow-Swam model. The works by Becker (1960), starting from the 1960s, particularly contributed to these changes, since the quality-quantity model has been proposed to explain investments in human capital. The issues so far typically abandoned in neoclassical research, such

as fertility, have been investigated in the economic models of growth as endogenous factors (Becker et al., 1990).

The seminal work of Becker and coauthors (1990) explains economic differences between the distinctive parts of the world, positing two equilibriums resulting from, inter alia, investments in human capital. The undeveloped economies ("Malthusian" equilibrium) characterise scarce human capital, large families (high fertility), low investments in human capital per child (education, healthcare and so on) and stagnation. The rates of return on human capital investments (i.e. quality) are relatively lower than those on children (i.e. quantity) because of the low stock of human capital. They assumed that the increase in the rates is positively related to the growth of the stock. The economies are trapped in a vicious circle of an undeveloped state. In turn, the economies on the path of development ("development" equilibrium) triggered by accidents and good fortune characterise the developed steady-state with a high stock of human (as well as physical) capital and lower fertility. The authors emphasise the role of accidental events in path origination.

The discourse in line with the path dependence approach also assumes that historically established PAYG pension schemes are inadequate since the baby boomers' cohorts in developed countries from the 1950s and 1960s have been entering their retirement (Bovenberg, 2008). There is a consensus on reform of the schemes and pension policy, although the dispute on the economic and social impact of funded and unfunded pension schemes is ongoing (table 1). The prevailing view is that a pillar structure of both schemes at the same time is needed, combined with some other policy measures, such as increasing the working-age period and changing retirement benefits.

PAYG schemes are widely criticised, although they exist in many countries (Pallares-Miralles et al., 2012). Kuné (2001) noticed two determinants of the schemes launching after the Second World War: the advantageous ratio of workers to pensioners and the ability to benefit regulation to adjust to price and wage changes. Additionally, it should be also remarked that in the post-war time in many countries, the retirement cohorts were deprived of funds (incomes and assets) (Schwarz et al., 2014). However, there is neither political and social commitment nor fiscal and economic support for switching PAYG schemes (unfunded) into funded ones in the near future (Bloom, Canning & Fink, 2010; Apps, Rees & Wood, 2007; Gugushvili, 2007; Sinn, 2004; Bongaarts, 2004; Barr, 2000; Samuelson, 1958), although, for example, European economies exhibit a sizable gap between pension reserve funds and their implicit pension liabilities (Schwarz et al., 2014). Instead, a mixture of the schemes has been postulated (Schwarz et al., 2014; Barr et al.,

Table 1. The advantages and disadvantages of funded and unfunded pension schemes

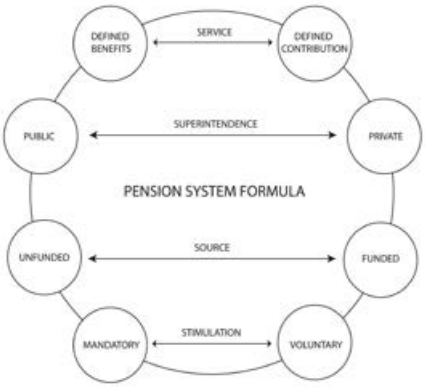
	FUNDED	UNFUNDED
dependence on demographic parameters	lower	higher distorting variables: • ineffective and closed domestic financial markets, • diminishing value of assets as pensioners will attempt to sell them to proportionally fewer workers.
rates of return	higher Aaron rule: "If the rate of growth is unaffected, the effective rate of return on premiums paid for such social insurance will exceed the marginal rate of time preference, and, consequently, people in the active labour force would willingly forego some current consumption in order to obtain such returns" (Aaron, 1966, p. 374).	lower Aaron rule: "if the sum of the rates of growth of per capita wages and of the population exceeds the rate of interest, and if the rate of interest equals the marginal rate of time preference and the marginal rate of transformation of present into future goods […] will improve the welfare position of each person" (Aaron, 1966, p. 374)
saving impact	positive in most evidence • life-cycle theory, • Solow growth model.	negative in most evidence distorting variables: • bequest and precautionary motives, rules of thumb and cognitive abilities, • the increase in pension saving can result in a decrease in non-pension savings, • opposite to Ricardian equivalence, the private sector does not fully offset the changes in public savings, • imperfect information (and a lack of financial literacy to understanding high portfolio of financial products), uncertainty about life expectancy, short-sighted contributors, • an increase in savings reduces capital gains (assets value) – this results in investments until the investments are planned (investment demand also depends upon expected rate of profit).
fiscal liabilities	higher	lower
behavioural incentives	higher impose greater discipline on pension policy formulation, although: • impose investment risks on workers, • difficulties of risk assessment: longevity, the value of pensions in each period of retirement.	lower
opportunistic behaviour	lower	higher
economic growth	higher	lower • a funded defined-contribution scheme funds invested in an expanded supply of the government paper increase public debt, just like an unfunded nonfinancial defined-contribution scheme, • the same mandatory contribution rate in a new funded scheme and payroll tax rate in an old unfunded do not affect disposable incomes.

	FUNDED	UNFUNDED
contribution costs	lower	higher
poverty reduction	lower	higher disability pensions, unemployment and low earning people support, survivors' benefits
income redistribution	lower	higher
investment strategy	hazardous private savings create supplementary retirement income for pensioners; they are related to the expected retirement age and retirement income anticipated from social security	secure public savings secure reserves to sustain social security systems; they are dependent on the anticipated availability of a state for paying pensions
administrative costs	higher (including marketing cost, transaction cost)	lower
government credibility	lower	higher
intergenerational justice	according to one's works	according to one's needs
vulnerability to inflation	higher	lower
politicisation	lower	higher
solidarity	lower	higher

Source: author's work based on Schwarz et al., 2014; Pieńkowski, 2013; Bloom et al., 2010; Holzmann et al., 2005; Orszag & Stiglitz, 2001; Hemming, 1999; Taulbee, 1999; Page, 1998; Willmore, 1998; Mackenzie et al., 1997; Aaron, 1966; Lesnoy & Leimer, 1985; Barro, 1978; Keynes, 1964; Kalecki, 1951.

2010; Holzmann et al., 2005; The World Bank, 1994). The investigations widely presented in many studies reveal the complexity of the issue and the necessity to impose concomitantly a wide variety of policy measures.

A pension system can be structured in a path-dependence framework as a combination of formulae developed in four dimensions, that is, a *4S path-dependence framework*, as follows: 1) *Service*; 2) *Superintendence*; 3) *Source*; and 4) *Stimulation.* All the combinations have been occurring worldwide, although some arrangements have been typically evolving as suggested in figure 1. For example, Pallares-Miralles and colleagues (2012) estimated that 65 percent of all national mandatory pension schemes, mostly unfunded, calculate benefits based on pensionable earnings (defined benefits), and over 70 percent of all national mandatory schemes are managed by public sectors.



- defined benefits – benefits determined by pensionable earnings,
- defined contributions – benefits determined by assets accumulated,
- funded – benefits from accumulated funds,
- unfunded – benefits from current revenue,
- public – managed by public sectors,
- private – managed by private organisations (companies),
- mandatory – obligatory participation, and
- voluntary – optional participation

Figure 1. The 4S framework for the designing of pension systems. The arrows mark only extreme formulae; however, there are achievable intermediate solutions, such as notional defined contribution in the service dimension (benefits determined by contributions in funded schemes)

Source: author's work.

The vigorous discussion among economists about funded and unfunded pension schemes led to a wide portfolio of studies addressing the problems as presented in figure 1. The analysis presents the prevailing view as well as distorting variables and theoretical assumptions. The economic view related to investment returns from pension assets, saving rates, economic growth, administrative costs and behavioural issues has additionally been completed with social goals posited in the debate. The issues presented in table 1 are reviewed in the following sections of the paper.

2. Economic stages of human activity and resource flows

Humans go through several distinct stages of economic and social activity (Clark & Spengler, 1980). The economic view recognises three main stages, distinguished due to the occupation criterion defined in terms of age. However, it should be clearly noted that the classification is for statistical purposes and does not reflect the economic reality, as has been mentioned above in the critique by Gee (2002). Moreover, it varies across different cultures and time periods. Since the industrial revolution originated in the eighteenth century, there has been a substantial change in view. For example, the latest pension reforms have legally increased the working-age period, such as the reform in 2013 in Poland to the age of 67 from the age of 60 for women and 65 for men (Góra, 2013), although the new regulation brought back in the previous limits (i.e. 60 and 65).

In turn, the social reforms and economic policy since the industrial revolution have significantly changed the labour force structure because of the

participation of young people and women in the labour market. For example, the Parliament of the United Kingdom passed the Factory Act in 1819 in the cotton industry that set the minimum working age at 9 (Harrison & Hutchins, 2013). The share of cotton mill workers under the age of 18 had been estimated at 75 percent in 1788, and it was reduced by over 30 percent in the fifteen years following the Factory Act (Galbi, 1997). However, the participation of children under the age of 15 in labour markets even today occurs in some developing economies (Ray, 2000).

Table 2. The basic view of the economic stages of human development (ranks: 1 – highest, 3 – lowest)

	Pre-working age	Working-age	Retirement age
Occupation	education	work	leisure
Dependency	+	-	+/-
Income	-	+	-/+
Saving rate	-	+	-
Political power	-	+	+
Total net transfer ranks	1 (+)	3 (-)	2 (+)
Private net transfer ranks	1 (+)	3 (-)	2 (-)
Consumption ranks	3	1	2

Source: author's work.

The present economic approaches indicate three stages, which can be characterised as follows (table 2):

- pre-working age (up to 14, 17 or 19 years old),
- working age (15, 18 or 20 to 65-67 years old), and
- retirement age (over 65-67 years old).

Table 2 shows the main characteristics of the cohorts. It is clear that the members of the youngest cohort assigned to education engage in consumption behaviours despite a lack of income and savings. The findings based on statistical estimations indicate that in most countries, they are the largest beneficiaries of public transfers, although private net transfers vary in different countries. These people are notable economically and politically dependent.

In contrast, retirement turns into leisure time – but pensioners hold political power, although their economic dependency is affected by several factors, such as pension schemes or saving behaviour. It is assumed that they can obtain incomes from assets; however, they can be highly dependent on

public or private transfers, as shown in abundant evidence also presented in this study. The longest stage is characterised by productive work and savings in the working-age cohort.

The life cycle model originally proposed by Modigliani (1966) assumes that the savings of a household result from the preferences of its members to smooth lifetime consumption regardless of their income fluctuations. The idealised reality presented in the model is then considerably modified with the findings of behavioural economics and challenged by market imperfections. In light of a wealth of evidence, consumers can be divided into the following groups: 1) forward-looking or wealth-constrained; 2) backwards-looking or liquidity-constrained. The former as stated in the life cycle model, while the latter are mostly sensitive to current income (McMorrow & Roeger, 2004). There is a variety of factors supporting the contrary behaviour to that presented in the life cycle model, such as precautionary or bequest motives, cognitive qualities (myopia, inertia, loss aversion) or liquidity constraints resulting from market imperfections (Beznoska & Ochmann, 2012). All the variables can considerably change the ideal picture presented in the model, and the socio-economic policy should take into account all the factors.

Lee and Mason (2011a) pointed to country-specific trends and dissimilarities. They analysed the dependency settings in different types of societies. A few contemporary hunter-gatherer societies, which prevailed during the most extensive period of human social evolution, were compared with both poor and well-developed societies, which predominate in the modern world; the poor societies, such as Nigeria or India, were usually placed between the extremes of hunter-gatherer societies and well-developed societies. The study reveals that together with economic progress, consumption rises with age (generally because of publicly provided healthcare); incomes start later and decline to nearly zero among the elderly, and the incomes increase domination of public over private transfers. Private transfers in almost all the societies were downward (from old to young), as well as total (private and public) net transfers, although the projected changes in the population structures of some rich countries for 2050 can reverse the direction of the transfers (i.e. more resources will flow upward from young to old). Nevertheless, there were notable variations, which suggest a multifactorial phenomenon reflecting the distinctive variability of policy measures, culture-specific values and demographic profiles. Willmore (1998), supporting the above study on downward patterns in many societies, argued that economic development is secondary to cultural patterns which influence the direction and amount of transfer flows (i.e. whether children are economic liabilities for downward flows or economic assets for upward ones).

According to the role of the working-age cohort in economic performance, Macunovich (2012), referring to Keynes's work (1937), argues that economic slowdowns partially resulted from demographic changes. A decrease in demand is related to the shrinking cohort of young people aged 15-24, which generates a demand for goods and services associated with the formation of new households. This cohort's demand significantly influences total consumption expenditure and consequently producers' investment. The expanded production capacity in response to the rising demand for new households exceeds the demand brought about by the shrinking cohorts of successive generations, leading to bankruptcies and economic slowdowns. It results in fluctuations in GDP per capita, current account balance and gross capital formation.

3. Capital formation

The role of working-age cohort consumption sparks a much more vigorous and inconclusive debate on economic growth. The research can be classified into three main strands: 1) the effect of pension schemes (or more generally social security) on savings and economic growth (physical capital formation), which predominantly began with the considerable work by Feldstein (1974); 2) the role of human capital and its alterations on economic growth, mostly developed in the work of Becker (Becker et al., 1990; Becker, 1960); and 3) the behavioural determinants of economic performance linked to discounting, savings' motivations and cognitive qualities, mostly developed by behavioural scientists such as Thaler and Sunstein (2009) and Kahneman and Tversky (2000).

The most indecisive debate centres around the effect of social security on savings and economic growth. The prominent time series data research conducted in the 1970s with the US data by Feldstein (1974), and with contrary evidence by Munnell (1974), Barro (1978), Darby (1979) and Esposito (1978) concluded with two possible suppositions: 1) a methodological problem of the effect of isolation, or 2) a lack of influence on savings. Similarly, Lesnoy and Leimer (1985) concluded their review of later research at the beginning of the 1980s, emphasising the methodological problem with the time series data. An interesting review presented by the US Congressional Budget Office in 1998 showed that one dollar of social security wealth decreases other assets up to 50 cents, although the estimation ranged from 0 to 50 cents (Page, 1998). In addition, Pfau's (2005) investigation with extended data series and a new approach to time series methodology confirmed a decline in savings by 50 percent, as posited in Feldstein's (1974) study.

The only partial private savings offset to a public sector deficit, contrary to Ricardian equivalence theory, is presented in numerous studies (McMorrow & Roeger, 2004). Masson and colleagues (1998) posited in their review that an increase in government expenditures may limit resource accessibility for private sectors and subsequently may reduce private savings, irrespective of whether the expenditures affect the government's deficit. They also estimated an offset averaging 75 percent, especially if related to the deficit resulting from an increase of public expenditures, not lower taxation. However, the study indicated a variety of factors which influenced savings, such as age structure and GDP growth or, with less robust effects, interest rate and terms of trade; it also suggested some persistent country-specific traits.

The non-equivalence is usually explained by various distorting variables, such as bequest and precautionary motives, behavioural proficiencies, information asymmetry and other market conditions (Schwarz et al., 2014; McConnell, 2013; Holzmann et al., 2005; McMorrow and Roeger, 2004; Willmore, 1998). For example, World Bank researchers, as well as International Monetary Fund scientists, suggested that increased pension savings may have a negative effect on non-pension savings and may eventually limit capital formation following the replacement of unfunded pension systems with funded ones (Schwarz et al., 2014; Mackenzie et al., 1997). Mackenzie and colleagues (1997) theorised that the same mandatory contribution rate in a new funded scheme and payroll tax rate in an old, unfunded scheme does not affect disposable incomes. The pension savings of the new scheme offset the government deficit, leaving the national savings rate unaffected.

The World Bank's study by Schwarz and coauthors (2014) presented evidence in European economies on relatively independent savings behaviour, regardless of the introduction of mandatory funded schemes. The results have been explained by the debt financing of the transitional deficit in the successive periods of the reforms. The research also suggested that the positive responsiveness of the capital markets to the new assets can only be established with proactive public policy; similar problems with ineffective and closed domestic financial markets were reported Holzmann and colleagues (2005) and Bebczuk and Musalem (2009). Moreover, Holzmann and colleagues (2005), taking into account the condition of financial markets, argued that if the pension savings from funded defined-contribution schemes lent to a government (for example, invested in the government paper) increased fiscal deficit and hence public debt, they may be treated as unfunded, non-financial, defined-contribution schemes. Therefore, the impact on public debt should be the criterion for the funded (if they do not affect the debt) and unfunded sources of pension financing.

Finally, the potential increase in savings resulting, for example, from pension system reforms, would have varying impact on economic growth. For example, the increase may lead to capital depreciation because of a lower interest rate and consequently affect the asset gains of pensioners (Mason & Lee, 2011a; Hemming, 1999). Because investments are not driven exclusively by interest rate variances, it would not contribute to economic growth. Works by Keynes (1964) and Kalecki (1951) posited other determinants of investment, such as past investment decisions, expected profitability and uncertainty. However, the interest rate changes, savings and capital flows should also be discussed from the perspective of the global market and relationships between countries, which vary in economic and demographic conditions.

4. The global economy perspective

The potential increase in savings resulting from the pension reforms has to be also interrelated to the economic impact of demographic changes. The hypothesis originally stipulated in the asset meltdown debate since 1989 by Mankiw and Weil (1989) has been challenged in many simulations and studies, although the issue has not been clearly resolved. The general idea in line with the original study implies that a positive shift in the supply of assets generated by the dis-savings of the growing cohort of pensioners (e.g. baby boomers) with proportionally fewer workers will lead to a substantial drop of their prices. New research has presented new models and evidence since the original study (Huynh et al., 2006; Brooks, 2000; Schieber & Shoven, 1996; Bakshi & Chen, 1994).

Such research includes the seminal work of Poterba (2001), Börsch-Supan and colleagues (2006) and Schich (2009). For example, Börsch-Supan and colleagues, taking into account international disparities, argued that it should be analysed in relation to direct and indirect effects, as well as levels and trends. The direct effect assumes unrestricted capital mobility between countries with different demographic conditions, equalising the rates of return to capital worldwide. The processes are indirectly accentuated by the dissimilar pension systems in varying countries and their impact on private savings (funded or unfunded). The dimension of levels and trends describes initial settings and a time path in an economy, respectively. The simulation in the study suggests that the open-world economy will stimulate capital flows and alleviate the ageing population problems, such as asset-price meltdown resulting from dis-saving. However, the unfunded pension systems and a lack of pension reforms can substantially hamper the positive effects.

A schematic model of the global economy showing the above concept is presented in figure 2. This is a simple presentation that additionally includes human capital flows and the mitigation of population ageing examined in

migration research. The model lacks ample behavioural, economic, social, political and cultural variables discussed in numerous research studies. However, it explains the economic assumptions and some findings presented in the ageing debate, such as those presented by Börsch-Supan and coauthors (2006).

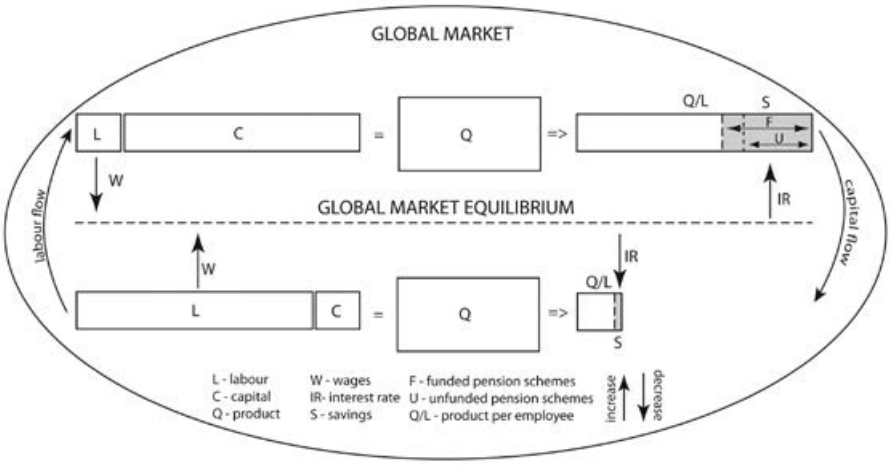


Figure 2. A schematic model of capital flows in the global economy

Source: author's work.

This scheme pictures capital flows (physical capital and human capital) between two economies with different capital-to-labour ratios. The savings rate is smaller in the economy with the lower capital intensity, and consequently, lower labour productivity (in terms of product per employee). The lower supply in physical capital in the economy induces a higher interest rate than in the economy with greater savings. The differences between saving rates and relative interest rates induce physical capital outflows from the latter economy, eventually equalising both interest rates. At the same time, the lower supply in labour in the highly capital-intensive economy generates higher wages, and the labour (human capital) inflow from the economy with higher labour supply eventually equalises wages. The outflow of the physical capital from the above economy is also balanced by the inflow of human capital. Funded pension schemes induce higher savings rates than unfunded ones in both economies.

The findings prevailing in the asset-price meltdown debate, such as those presented in the OECD review (Schich, 2009), predict a decline in the price of assets, although it will be mitigated by many factors, and the rapid decline in the financial asset prices is particularly questionable. However, at the same time, the author suggests that the volatile global financial markets can trigger

unpredictable effects due to the demographic changes, as the recent financial crises shows. The study partially confirmed findings presented by Mankiw and Weil (1989) due to non-financial assets, which are exposed to a higher risk. The author posited that the extended demographic changes and forward-looking financial markets are the key mitigation factors for the demographic changes in the financial markets.

A sustainable pension system framework

A pension budget, similarly to the concept of generational economy developed by Mason and Lee (2011b), remains in the mutual dependencies of four main economic processes: produce; consume; share, and save resources. Pension systems, regardless of the way of financing their savings, are understood as deferred consumption. In the unfunded schemes, the taxes paid for the present generation entitle the taxpayers to future consumption as pensioners; and private pension savings (in funded schemes) lent to a government can have similar macroeconomic effects as the unfunded schemes. Public spending (share), from the macroeconomic point of view, is consumption, which similarly to private consumption can be deferred or spent on different areas according to the government's political priorities (table 1).

Private consumption decreases according to the growth in both public consumption and the rate of savings. Pension funds can be financed from private savings or/and public expenditures. Due to the fact that the socio-economic systems are imperfect and, for example, opportunistic behaviour as well as unemployment, the systems need to secure socio-economic development according to the political priorities (including such priorities as equality in the distribution of wealth). The political priorities shape public expenditure patterns.

The pension measures can be classified into four interrelated groups in accordance with the way in which they affect socio-economic systems. The measures are aimed at the following issues: 1) private consumption and savings of working groups; 2) consumption of pensioners; 3) public consumption, and 4) social values (figure 3). The measures in the first group determine the disposable income of households. Pension savings, such as private funds or public funds based on taxes, are determined by a number of socio-economic factors, presented in table 3. However, the increase in the consumption level and savings rate according to technological advances and economic growth corresponds with the development of human capital quality and the "development" equilibrium.

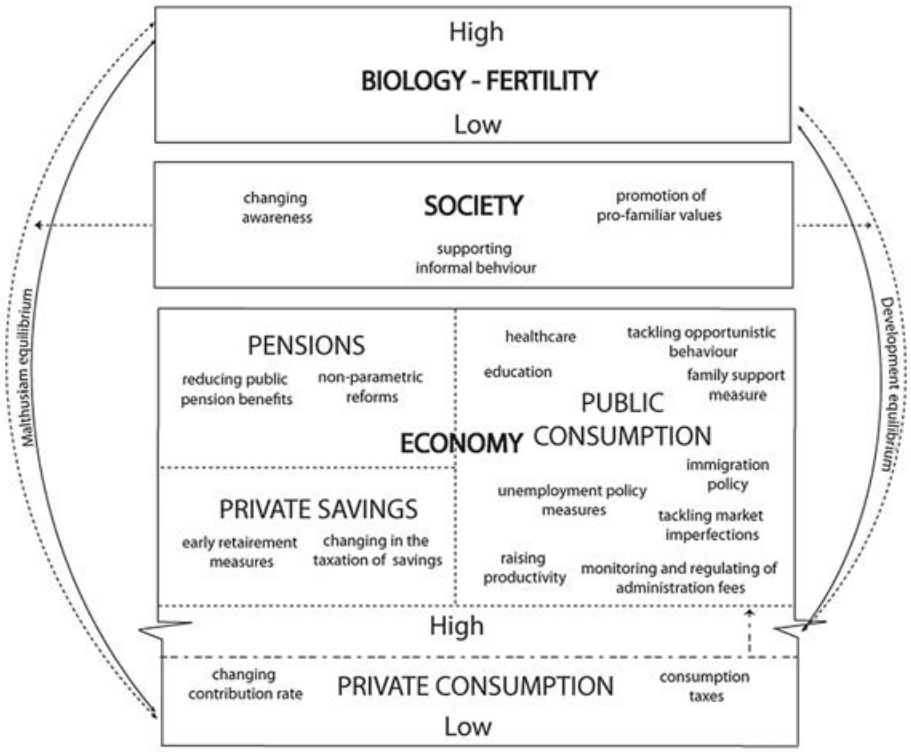


Figure 3. A sustainable pension policy framework from a macroeconomic perspective
Source: author's work.

The lower fertility resulting from these changes can be modified by the social system values (e.g. pro-family values) and – relatedly – priorities in public expenditures (e.g. pro-family support measures). Healthcare programmes increase fertility, although they are also costly investments in quality; moreover, technological progress increases the cost of healthcare, extending the range of possible diseases that can be treated (Apps, Rees & Wood, 2007). Social values are related to the directions and quantity of private transfers, substantially modifying informal support for pensioners and children. The forms of the informal support dominate in the societies with a "Malthusian" equilibrium; in the developed countries, public transfers dominate.

Table 3. Pension reform measures

POLICY MEASURES
SOCIAL SYSTEM
Changing awareness toward: • older workers, • health practices that increase health spending (e.g. poor nutrition, sedentary life style, risky behaviour promoted such as those presented in many internet footages, rely on medical treatment at the cost of preventing behaviour, which requires behavioural changes, etc.), • pension systems funds. Cons: *"individual attitudes toward retirement are less influential than societal norms of the 'right time to retire"* (Schwarz et al., 2014, p. 255).
Promotion of pro-family values.
Support informal behaviour toward intra-family or intergenerational financial and non-financial helping practices.
PUBLIC CONSUMPTION
Higher fertility policy: • family-support measures (subsidised childcare, reduced taxes for families with children and paid parental leave); Cons: • *"when the birth rate falls, there are fewer young workers to support old pensioners but they also need less income"* (Fanti and Gori, 2012, p. 960), • difficulties for women in labour markets, increase social care spending.
Unemployment policy: • re-design workplaces for elderly and disabled people, • creation of job places, • tackling an informal economy, • creating job opportunities for people with disabilities. *"Workers of different generations are not substitutes for each other, and there is evidence that increasing the employment of older workers does not increase youth unemployment […] When mixed-age teams work together, older workers are able to mentor younger workers, increasing the productivity of the whole work team"* (Schwarz et al., 2014, p. 260-261); *"older workers can remain productive throughout long working lives and are not necessarily less productive than younger workers. While certain physical abilities do decline, other capacities are enhanced by experience"* (Schwarz et al., 2014, p. 261). Cons: • increases completion of labour markets and reduces wages.
Tackling market imperfections • financial markets, inflation, • behavioural obstacles (e.g. myopia), • monopoly, etc.
Tackling opportunistic behaviour – monitoring and controlling benefit distribution.
Monitoring and regulating of administration fees • restricting fee levels, • restricting choices of changing funds, • clearinghouse, • blind accounts.

Raising productivity
Immigration policy including return migrants and their benefits based on the work abroad. Cons: • problematic for social, economic and cultural reasons.
PENSIONS
Non-parametric reforms – systemic changes in pension schemes (e.g. defined benefits vs. defined contributions).
Self-adjusting mechanisms (indexation rules tied with economic and demographic parameters such as inflation, growth etc.), **Reducing public pension benefits:** Reducing indexation of benefits (f. e. increasing the number of years used to calculation benefits), lowering accrual rate (the rate of benefit per year of service), Reducing post-retirement indexation of pensions (relative to inflation), Changing the formula to the calculation of retirement benefits, Reducing replacement rate (the level of pensions in retirement relative to earnings when working), Reducing inheritability provisions (i.e. widows' and widowers' pensions), Reducing indexation of earnings, Increasing taxes on benefits, Increasing tax receipts, Decreasing minimum pension.
PRIVATE SAVINGS
Early retirement measures: Reducing the penalty on continued work at older ages, Removing incentives to early retirement, Increasing working-age period, Rising pension tax rate, Means testing (reducing the number of people eligible to benefits).
Changing in the taxation of savings – the double taxation on savings (pension benefits and savings) should be avoided, as should the lack of taxation, as higher-income individuals profit excessively in the latter case.
PRIVATE CONSUMPTION
Changing contribution rate Cons: *"while reducing contribution rates did improve the functioning of the labour markets and improve labour competitiveness, the increases in formalisation were not sufficient to offset the decline in revenue from existing contributors"* (Schwarz et al., 2014, p. 254).
Consumption taxes *"consumption taxes allow for better intergenerational burden-sharing as they affect all cohorts, while labour taxes again affect only younger cohorts"* (Schwarz et al., 2014, p. 261).

Source: author's work based on Schwarz et al., 2014; Bloom et al., 2010; Hirschman, 2007; Schwarz, 2006; Holzmann et al., 2005; Bongaarts, 2004; Jackson, 2003; Fanti & Gori, 2012; Gruber & Wise, 2002; Hemming, 1999.

The third group is related to direct regulations of pension schemes within a given budget. For example, changes in the indexation of earning or a replacement rate affect public spending budgets and pensioners' consump-

tion levels. A fully funded pension system can be treated as private savings; however, it is vulnerable to both socio-economic (such as inflation or changes in the taxation of benefits and savings) and behavioural (e.g. difficulties in risk assessments) settings (figure 3). The latter requires a form of paternalism to secure pensioners regardless of a socio-economic system (Thaler & Sunstein, 2009).

Finally, the last group of measures shape public spending patterns. They are responsible for the way in which goods and services are provided (e.g. social programs as well as education and healthcare, which can be financed from public expenditures). They also provide services to tackle market imperfections and shape social behaviour.

Conclusions and recommendations

The problem of sustainable pension policy is multifaceted and related to both socio-cultural and economic transformations, as well as related to the transformations historically determined pension systems. The contemporary information society and the knowledge-based economy characterise the computerisation of production and the increase of investments in the quality of human capital. This is associated with the development of secular rational values that are less related to religion, traditional family values and authority (World Values Survey, 05-01-2016). These changes are unprecedented phenomena, such as the ageing population related to such changes.

Certain socio-economic conditions facilitated the PAYG schemes in the past, although their effectiveness is limited to certain strictly designed socio-economic settings, same as their opposite extreme so (i.e. funded schemes). The contemporary pace of socio-economic changes requires more reliable and resistant schemes to various changes in the long term. Nevertheless, the development level determines them and the system of values dominated in particular countries. For example, societies with individualistic ethics and liberal economies favour voluntary and funded systems.

However, the claims that funded schemes solely solve all the problems related to population ageing are unjustified in light of the many socio-economic and behavioural analyses. Their efficiency is hampered by market imperfections (including financial speculations identified in the global crisis in 2008 and behavioural obstacles) and the cyclical character of economic growth. The schemes are a part of social policy goals related to such issues as poverty-combating programmes and the level of social security, which are also the key postulates of the sustainable development goals.

The debate on pension systems revealed the inadequacy of socio-economic institutions to react to the challenges of a changing world. Moreover, the inconclusiveness of much research suggests a multifactor phenomenon and requires policy specifically fitted to a particular country which takes into account the following parameters: the level of economic growth; human capital and savings rates; the efficiency and stability of financial markets; socio-economic policy patterns and the level of market interventionism; and the demographic structure and trends, including migration policy, the system of cultural values, and socio-economic settings such as unemployment, labour law and possibilities to employ people with disabilities and old-age workers. The framework offered in this paper shows the holistic sustainable development approach from the perspective of global economic relationships between production factors, multiple socio-economic objectives and the fairness criteria postulated in the UN Sustainable Development Goals. The specific socio-economic conditions of particular countries should be balanced with the postulates offering a sustainable and long-term intergenerational pension system that is resilient to both cyclical fluctuations and sudden shocks; and it should meet the postulates of intergenerational horizontal and vertical equities referred to in the debates on justice and sustainable development.

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ENVIRONMENTAL POLICY AND MANAGEMENT

POLITYKA EKOLOGICZNA I ZARZĄDZANIE ŚRODOWISKIEM

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THE ASSESSMENT OF DEVELOPMENT CONVERGENCE AMONG POST-SOCIALIST COUNTRIES BASED ON SELECTED INDICES

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ABSTRACT: The aim of the paper was to determine development convergence between post-socialist countries and changes taking place in this respect. The research covered the period of 2000-2018 and focused on 25 post-socialist countries (11 EU, 7 East European and 7 Asian states). Statistical methods and econometric models were employed to analyze the HDI, EPI and EFW indices. The research revealed that there is very little convergence among post-socialist countries on social development (ca. 5%), environmental performance (ca. 2%) and economic freedom (ca. 1%). All of the study countries were classified as highly developed (HDI>0.79), and "mostly free" in terms of economic freedom (EFW>0.6). Higher variation was observed for environmental performance, with only 16 countries out of 25 with an EPI>60. The post-socialist EU countries scored higher on the three indices than the other post-socialist nations, though Asian countries registered higher growth rates.

KEYWORDS: convergence, HDI index, EPI index, EFW index, post-socialist countries

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Introduction

The analysis of convergence allows researchers to answer the question of whether the countries that differ significantly in terms of macroeconomic variables will converge in these respects or diverge over time. Real convergence is the process whereby lower-income economies catch up with those of higher-income economies, whereas the distancing of more developed economies from the less developed is understood as the process of divergence (Sulima, Woźna, https://mfilep.pl/pl/index.php/Konwergencja).

Convergence occurs when two or more economies reach a similar level of development and wealth over time (absolute convergence σ) or when low-income countries catch up with higher-income countries (absolute convergence β). Divergence is the opposite of convergence (Próchniak, Rapacki, 2007).

To assess the overall development of European regions, the researcher has to select methods of analysis that are adequate to address the research objective. Ultimately, the choice of methods, indicators or indices depends on the study area and questions posed.

The aim of this paper is to determine the level of convergence between post-socialist countries and the changes occurring in this respect. To achieve that aim, the following questions have been posed:

- Do the study countries converge in terms of socioeconomic welfare (HDI) and environmental performance (EPI)?
- Do economically highly developed countries score high also on social development?
- To what extent do economic freedom foster social welfare and environmental performance of the study countries?
- Is the growth rate determined by the trend function similar to Asian and European countries?

For the purposes of this paper, convergence is understood as closing the gap between the countries not only with regard to their economic, social and environmental welfare levels, but also their economic freedom as measured by selected indicators.

25 countries out of all post-socialist countries were selected for a detailed analysis due to, in particular, data availability.

An overview of the literature

The main goal of sustainable development is to improve the quality of life and ensure a good living environment for present and future generation. This can be achieved by building sustainable societies which are able to use resources efficiently and to tap the ecological and social innovation potential of the economy. Such societies and communities will indeed ensure economic welfare, environmental protection and social cohesion. It is necessary for people to understand that without environmental sustainability, no human welfare is possible. And in turn, the prerequisite for building a sustainable welfare society is economic welfare, which is not a goal in itself (Karmowska, 2017).

1. The basic and most commonly used measure of socio-economic growth of a region, and thus the convergence/divergence, is the GDP *per capita*. However, since this standard measure does not exhaustively answer the research questions posed, other economic, environmental and social measures of development will be considered in the study. Since some of the study characteristics are not directly comparable, they are used to build synthetic variables – indices that allow for comparisons between different states.
2. One of the most popular composite measures of development is the *Human Development Index* (HDI) (http://hdr.undp.org/en/composite/trends). It was created in 1990 as an acknowledgement that economic development alone cannot capture human development, and that people and their potential must be considered as well. HDI is composed of three principal areas of interest: GNI *per capita*, life expectancy at birth and education (Karmowska, Marciniak, 2015, 2016). The HDI is a single index measure and a geometric mean of the three key dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living. HDI utilizes four key metrics. The key metrics for assessing population's health is life expectancy at birth, the metrics of education is the average years of schooling received by people aged 25 and older, and the years of schooling that children of school entrance age can expect. The standard of living is assessed by Gross National Income (GNI) *per capita*. The HDI uses the logarithm of income to reflect the diminishing importance of income with increasing GNI *per capita*. The stores for the three HDI dimensions are aggregated into a single composite index using geometric mean. HDI simplifies and captures only part of what human development entails (http://hdr.undp.org/en/content/human-development-index-hdi).

The environmentally sustainable economic development of post-socialist countries is rarely a subject of academic publication. Undoubtedly, most of the research focuses on the EU states and for the purposes thereof, indices are built that include, i.a., environmental welfare (Sustainable Society Index, SSI), environmental efficiency (Environmental Performance Index, EPI) or efficiency of natural resource management (ECO-Innovation Scoreboard) (Karmowska, Czaja, Jach-Chrząszcz, 2018).

The Environmental Performance Index was constructed in 2012 as a continuation of the Environmental Sustainability Index (published over the years 1999-2005). EPI provides a data-driven summary of the state of environmental health and ecosystem vitality for countries around the world identifies targets for environmental performance and measures how close each country comes to these objectives. EPI goals encompass key environmental topics such as clean air, water quality, greenhouse gas emission, use and preservation of natural resources and environment protection (www.epi.yale.edu). The EPI is based on 2 fixed policy objectives and 32 performance indicators across 11 issue categories. It uses a scoreboard from 0 to 100. A score above 65 (highs score) is achieved by strong performers across most issues, leaders in environmental sustainability, a score of 60-65 (average score) shows average environmental performance, and a score below 60 (low score) indicates that much more attention must be paid by these countries to environmental sustainability requirement.

The backdrop for our analysis is the assessment of economic freedom in individual countries, which is often equated with the free market. Economic freedom, from the liberal free-market perspective, is defined as the freedom to conduct business activity, produce, trade and consume any goods and services acquired without the use of force, fraud or theft. On the one hand, it gives entrepreneurs equal economic opportunity, and on the other, ensures consumers' freedom of choice. The Index of Economic Freedom (IEF) or Economic Freedom of the World (EFW) are the two indices that measure economic freedom. The index captures and measures the performance of main market institutions, such as money, property rights and trade in individual countries. The score allows us to compare the level of economic freedom between countries and also, track the changes over time (Karmowska, 2017a, 2017b).

The Economic Freedom of the World *(EFW)*, a survey published annually since 1995 by a Canadian think-tank, Fraser Institute, seeks to measure the degree of economic freedom in most of the world's nation. EFW incorporates 42 distinct economic variables, grouped in 24 components, to create an index. It measures the degree of economic freedom in five major areas: Size

of Government, Legal System and Security of Property Rights, Sound Money, Freedom to Trade Internationally, Regulation of credit, loans, and business.

Each component is placed on a scale from 0 to 10, reflecting the distribution of underlying data, where 10 stands for greatest economic freedom. Averaged component ratings within each area are then averaged to derive ratings for each of the five areas, and then the five area ratings are averaged to derive a final score – summary rating for each country. A lower summary EFW rating demonstrates more state's interference in the economy and relatively little economic freedom.

Data and research methods

The paper employed statistical data from the World Bank, Eurostat and the Sustainable Society Foundation. Performance of 25 post-socialist countries was researched over the period of 2000-2018. Research problems were examined from the static and dynamic point of view.

To measure variation in regional development the following statistical measures were used, i.a,: area of feature variation, maximum value, minimum value, standard deviation, coefficient of variation. According to Kukuła (2010, p. 27), the values of these measures provide information on the degree of variation in development between the spatial objects studied.

The HDI, EPI and EFW were the main indices analyzed.

Moreover, trend models of the study indicators were calculated for their means, medians and maximum and minimum values (Nowak, 2002, Kukuła, 2003).

Range R was adopted as one of the convergence measures, R being the difference between the maximum (x_{max}) and minimum values (x_{min}) of the indicator:

$$R = x_{max} - x_{min}. \tag{1}$$

Another measure employed was the coefficient of variation

$$V = \frac{x_{mean}}{S} \cdot 100, \tag{2}$$

where:
x_{mean} – indicator's mean value,
S – standard deviation.

And the annual average rate of convergence/ divergence coefficient K which is based on the coefficient of variation and captures the annual average increase in convergence/ divergence expressed in % (Williamson, Fleming, 1996).

$$K = \frac{V_{t_1} - V_{t_2}}{V_{t_1}(t_2 - t_1)} \cdot 100 \quad , \tag{3}$$

where:
K – average annual rate of convergence/ divergence,
V_{t_1} – coefficient of variation at the start year,
V_{t_2} – coefficient of variation at the last year.

Convergence occurs when the value of the K indicator is above zero (K > 0), whereas when it is below zero (K < 0) divergence occurs in the study group of countries.

Based on the HDI and EPI, that is on the level of socioeconomic development and environmental performance, the countries analyzed were put into three groups (table 1).

Table 1. Socioeconomic development and environmental performance by country groups

Group	HDI range	EPI range	level of socioeconomic development/ environmental performance
1	0.80 – 1.00	66 – 100	high
2	0.50 – 0.79	60 – 65.9	average
3	0.00 – 0.49	0 – 59.9	low

Source: author's work.

Based on the Summary Economic Freedom Ratings (EFW), countries are put in 5 groups:
1. *Free* 8.0 – 10,
2. *Mostly free* 7.0 – 7.9,
3. *Moderately free* 6.0 – 6.9,
4. *Mostly unfree* 5.0 – 5.9,
5. *Repressed* 0 – 4.9.

Changes occurring in individual countries should be viewed in the spatial context of a region as no state operates in isolation from the neighbouring countries and region. The issue of inequality and economic, social and environmental convergence is the subject of vast research efforts in the EU and worldwide (Baumol, 1986; Barro, Sala-i-Martin, 1992; Mankiw, Romer, Weil, 1992; Gawlikowska-Huckel, 2002; Malaga, Kliber, 2007; Malaga, 2004, among many others).

Results of the research

Spatial variation in economic development is a fundamental challenge for the present day economy. The balancing of regional economic disparities is the primary goal of regional policies (Todl, 2001). Classification of countries according to their socioeconomic development (HDI) and environmental performance (EPI) provides a basic insight into the level of development and variation in the development of the study countries.

A classification of the study countries according to HDI and EPI in 3 years: 2000, 2010 and 2018 is provided in table 2.

Table 2. Country classification by HDI and EPI

Class	HDI	EPI
2000		
1	Slovenia	
2	Armenia, Azerbaijan, Bulgaria, Bośnia and Herzegovina, Belarus, Croatia, Czechia, Estonia, Georgia, Hungary, Kazahstan, Kyrgyzstan, Latvia, Lithuana, Moldova, Macedonia, Poland, Romania, Russia, Serbia, Slovenia, Tajikistan, Ukraine, Uzbekistan	Czechia, Croatia, Latvia, Lithuana, Poland, Slovakia
3		Armenia, Azerbaijan, Bulgaria, Bośnia and Herzegovina, Belarus, Estonia, Georgia, Hungary, Kazahstan, Kyrgyzstan, Moldova, Macedonia, Romania, Russia, Serbia, Slovenia, Tajikistan, Ukraine, Uzbekistan
2010		
1	Croatia, Czechia, Estonia, Hungary, Latvia, Lithuana, Poland, Slovakia, Slovenia,	Latvia, Slovakia
2	Armenia, Azerbaijan, Belarus, Bulgaria, Bośnia and Herzegovina, Bulgaria, Georgia, Kazahstan, Kyrgyzstan, Moldova, Macedonia, Romania, Russia, Serbia, Tajikistan, Ukraine, Uzbekistan	Croatia, Czechia, Lithuania, Poland, Slovenia
3	-	Armenia, Azerbaijan, Bulgaria, Bośnia and Herzegovina, Belarus, Estonia, Georgia, Hungary, Kazahstan, Kyrgyzstan, Macedonia, Moldova, Romania, Russia, Serbia, Tajikistan, Ukraine, Uzbekistan
2018		
1	Belarus, Bulgaria, Croatia, Czechia, Estonia, Hungary, Kazahstan, Latvia, Lithuana, Poland, Romania, Russia, Slovakia, Slovenia	Bulgaria, Czechia, Latvia, Lithuana, Slovakia, Slovenia

2	Armenia, Azerbaijan, Bośnia and Herzegovina, Georgia, Moldova, Macedonia, Serbia, Slovenia, Tajikistan, Ukraine, Uzbekistan	Armenia, Azerbaijan, Belarus, Estonia, Croatia, Hungary, Poland, Macedonia, Romania, Russia,
3	-	Bosnia and Herzegovina, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Serbia, Tajikistan, Ukraine, Uzbekistan

Source: author's work.

A cross-country comparison of HDI shows that the study countries successfully maintained their high socioeconomic development and welfare over the years (>0.79 HDI). In 2000 only one country, namely Slovenia, showed very high human development, while all other countries ranked as highly developed (> 0.5 HDI). A decade later, the top-ranking group expanded totalling as many as 9 countries, including Poland. In 2018 it expanded even further, with 14 countries ranked as very highly developed in socioeconomic terms.

Environmental performance of the study countries, measured by EPI, presents a different picture. In 2000, none of the subject countries ranked in the highest-ranking class, with only 6 countries classified in the second top clasp. In 2010, two countries, Latvia and Slovakia, moved to the top-ranking class, whereas only one country, Slovenia, was upgraded from the 3rd to 2nd class. By 2018, a significant improvement had been made and 6 countries scored above 66 on environmental performance. 16 out of the 25 study countries received an average and above-average score. It is definitely a positive change, especially in view of high social development observed in these countries.

The classification of countries by EPI and HDI allows to identify the leader. As illustrated by figure 1, 13 countries ranked in the top grouping with best results in environmental performance and socio-economic development.

As mentioned above, the analysis was extended to include an additional factor, that is economic freedom of the study countries measured by EFW index. Since economic freedom is, among other things, the unfettered opportunity to engage in business activities whilst ensuring equal opportunity to all entrepreneurs who are able to satisfy consumer demands better than their competitors, it can be assumed that it has a significant impact on both socioeconomic and environmental welfare.

In view of the fact that not all of the study countries had their economic freedom assessed in the first study year, the research had to be narrowed down to 2010 and 2018. The list is not exhaustive, with Uzbekistan missing, and Belarus included in the economic freedom ranking for the first time in 2016 (table 3).

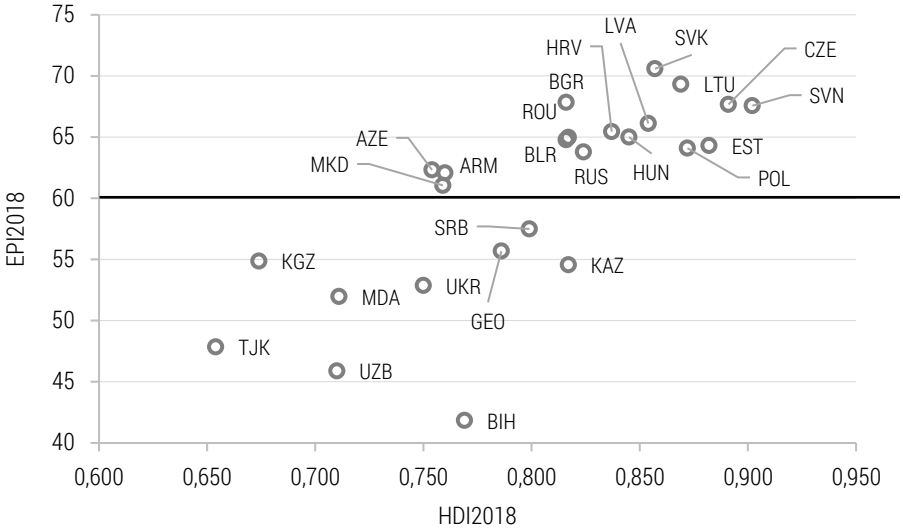

Figure 1. EPI and HDI in 2018

Source: author's work based on https://ec.europa.eu/eurostat/data/database [11-11-2018].

Table 3. Country classification by EFW index

classes/year	2010	2018
Free	Estonia	Georgia, Lithuania
Mostly free	Armenia, Bulgaria, Czechia, Georgia, Hungary, Latvia, Lithuania, North Macedonia, Poland, Romania, Slovakia, Slovenia	Armenia, Bulgaria, Croatia, Czechia, Estonia, Hungary, Kazakhstan, Latvia, North Macedonia, Poland, Romania, Serbia, Slovakia, Slovenia
Moderately free	Bosnia and Herzegovina, Croatia, Kazakhstan, Kyrgyz, Moldova, Russian Federation, Serbia, Tajikistan	Azerbaijan, Belarus, Bosnia and Herzegovina, Kyrgyz, Moldova, Russian Federation, Tajikistan, Ukraine
Mostly unfree	Azerbaijan, Belarus, Ukraine	
Repressed		

Source: author's work.

The average score on economic freedom in the 24 post-socialist nations was 7.05 in 2010, and 7.25 in 2018.

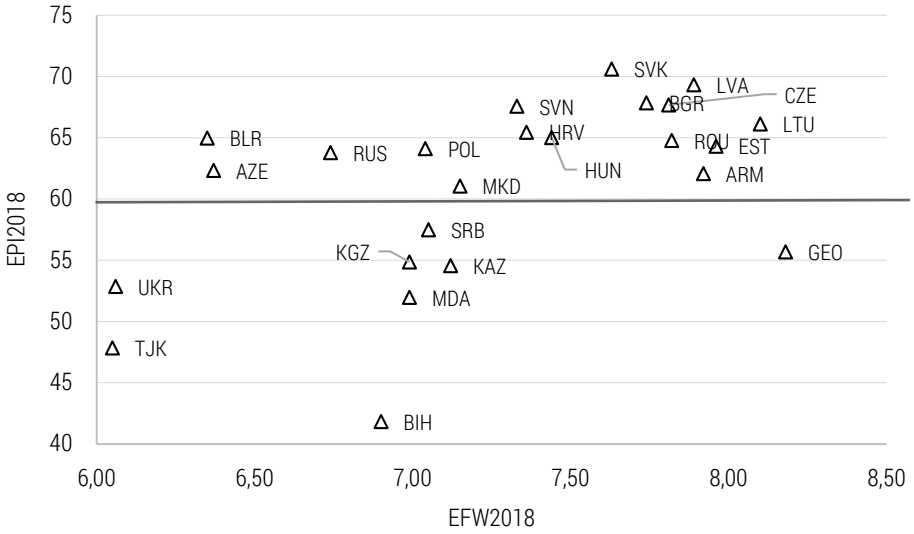

Figure 2. EFW and EPI in 2018

Source: author's work.

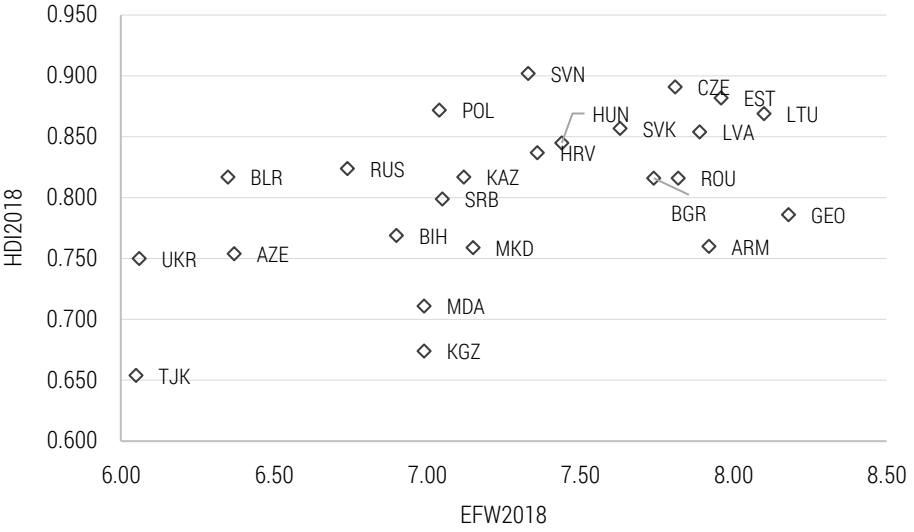

Figure 3. EFW and HDI in 2018

Source: author's work.

Most countries fell into the *Mostly free* and *Moderately free* category. This is in stark contrast to 2010 when only Estonia was deemed *Free* and 3 countries were classified as *Mostly unfree*. Surprisingly, in 2018 five nations – Estonia, Hungary, Poland, Slovakia and Tajikistan – scored lower on economic freedom than in 2010. Two countries, Georgia and Lithuania, showed big change in economic freedom and went up in the ranking.

Most study countries (16) score well on both indicators, that is environmental performance and economic freedom (figure 2).

The outcome is even more positive when one looks at the countries' economic freedom and socioeconomic welfare (figure 3).

In view of the research scope and aims set, a more thorough analysis has not been conducted. However, the author believes that such kind of analyses, from the general to the particular, is most interesting and deserve a separate, dedicated paper.

Convergence

As proven by statistical data (table 4), changes in socioeconomic welfare and environmental performance resulted in the gradual closing of the gap between the study countries. Over the 2000-2018 period, the highest average annual rate of convergence was observed in the area of socio-economic development, with K_{HDI}=4.21%. By contrast, from 2010 onwards, the environmental performance of the study countries showed divergence (average annual of 0.17%) even though convergence at an average annual rate of K_{EPI}=1.95% was noted. Similarly, the analysis of the variance of the EFW index also indicates that economic freedom levels are slowly converging, with the coefficient of convergence of K_{EFW}=0.9%.

Besides the statistics for HDI, EPI and EFW indices, GDP *per capita* was incorporated to give an idea of what the changes in economy looked like as captured by this particular measure. Cross-country variation in GDP *per capita* (measured by the coefficient of variation) is very high with 60% in 2000 and 47% in 2018. It means that disparities between the study countries become smaller, although the range in GDP *per capita* widened two times over the research period (from ca. USD 17 thousand to 37 thousand). This was partly caused by a higher growth rate of GDP *per capita* of the richest countries (by an average annual of USD 1152), with the poorest countries recording an average annual growth rate of USD 132 over the same period of time. After GDP *per capita* was added in the calculations, the annual average speed of convergence of the study countries was merely K_{GDP}=1.12% (figure 3).

Table 4. HDI, GPD, EPI and EFW

Statistics	2000	2010	2018
HDI			
Variation	9.76%	8.77%	8.28%
Range	0.286	0.251	0.248
The average annual rate of convergence/divergence		0.76%	4.21%
GDP			
Variation	60.42%	48.68%	47.55%
Range	16 960	25 517	37 078
The average annual rate of convergence/divergence		1.02%	1.12%
EPI			
Variation	21.24%	21.90%	12.44%
Range	34.7	38,6	28.8
The average annual rate of convergence/divergence		-0.17%	1.95%
EFW			
Variation		9.24	8.49
Range		2.20	2.13
The average annual rate of convergence/divergence			0.90%

Source: author's work based on data published by the World Bank.

Trends

The next stage of research was to determine trend functions for the study indices and their values. Because of the completeness and continuity of data, it was possible to determine a growth trend only for GDP per capita and HDI (figures 4 and 5).

All trend functions were linear, with a very high coefficient of determination. They meet all of the standard significance criteria, which is why the coefficients of regression can be treated as a measure of the average annual growth of a given indicator.

In the study period, the lowest HDI was recorded for Tajikistan (0.538 in 2000 and 0.654 in 2018). Similar HDI values were observed for Kirgizstan (HDI=0.594 in 2000 and HDI=0.674 in 2018), and Uzbekistan (HDI=0.596 in 2000), however in the latter case socioeconomic improvement was much slower (HDI=0.710 in 2018). The average annual rate of growth was 0.0064 for Tajikistan, 0.0045 for Kirgizstan and 0.0066 for Uzbekistan.

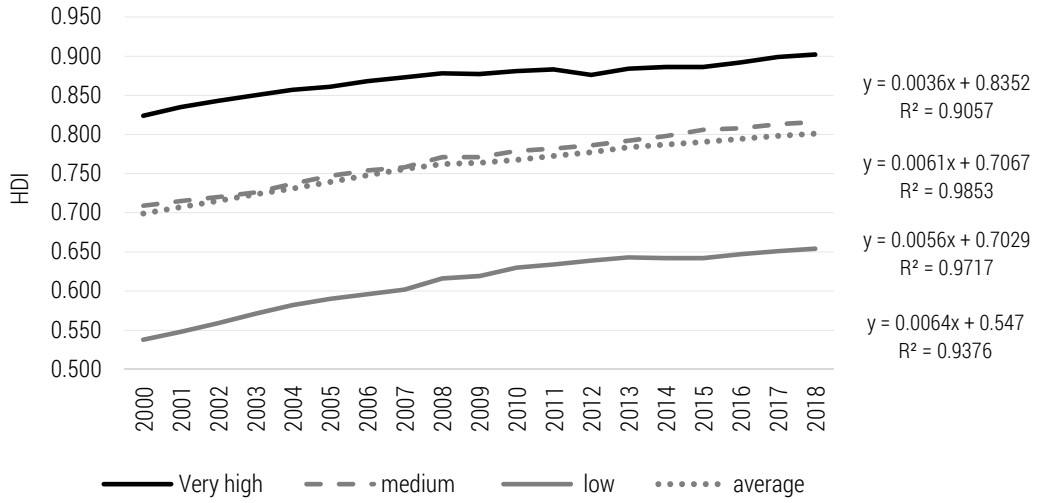

Figure 4. HDI trends of the study countries over the years 2000-2018

Source: author's work based on data published by the World Bank.

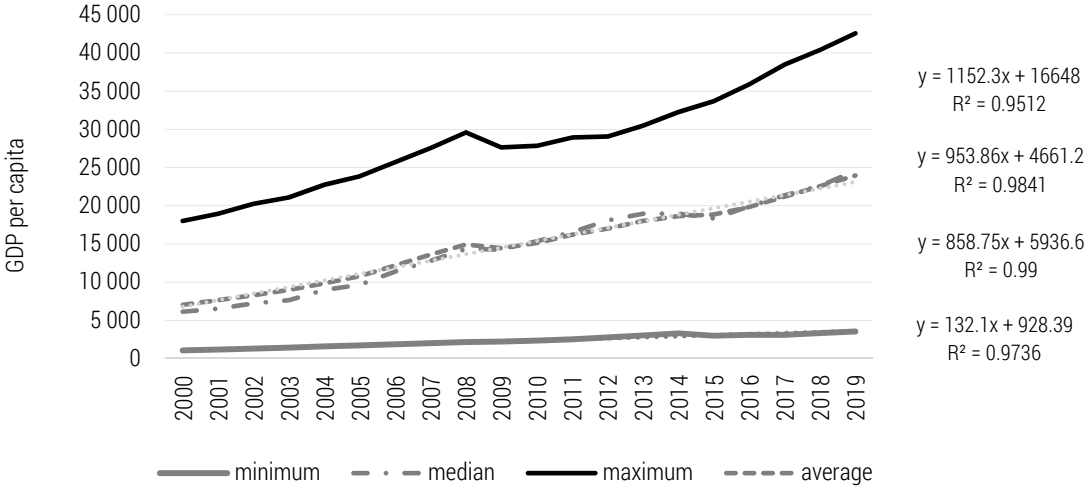

Figure 5. GDP *per capita* of the study countries

Source: author's work based on data published by the World Bank.

Slovenia was the indisputable leader of development over the entire study period (HDI=0.843 in 2000, and HDI=0.902 in 2018). The country's relatively low average annual growth rate of only 0.0036 can be explained by the fact that already in 2000 Slovenia was an advanced, high-income economy with a very high HDI.

Since GDP *per capita* is a component of HDI, the least developed countries also have the lowest GDP *per capita* (figure 5).

Conclusions

The analysis conducted has cognitive and applicative value as it allowed to answer the research questions posed in the introductory part of the paper.

1. Definitely, the study countries converge with regard to socioeconomic welfare, environmental performance and economic freedom. The speed of convergence varies across regions.
2. In 2018 the EPI and HDI indices showed relatively high correlation (R=0.7334), which confirms the top-ranking countries on the Environmental Performance Index also score high on social welfare.
3. The answer to the question of the extent to which economic freedom facilitates and support social welfare and environmental performance in the study post-socialist countries is not unequivocal. The indices are positively correlated with an average of R=0.5045 for the EFW and EPI, and R=0.5482 for EFW and HDI. Such correlation means that as economic freedom became stronger, environmental performance and social welfare improved.
4. In an attempt to answer the question: "Is the growth rate determined by the trend function similar for Asian and European countries?", the study countries were classified into 3 groups: 1) the EU member states (11); 2) East European states (7) and 3) Asian states (7). The estimated linear trends with high significance and good fit quality, indicate an average annual HDI growth rate of 0,0062 for the countries from 1) group, 0.0051 for 3) group and 0.0035 for group 2). The HDI score was high in 2000 for the group of Asian countries (ca. 0.7), yet in 2004 it dropped to 0.565 and since then it went up continually.
5. As it comes to environmental performance, the EU states scored higher than the other countries (with an average EPI=66.6 in 2018), however since 2000, the EPI index grew by a mere average of 5.3. Environmental performance of the other post-socialist, non-EU states was at a similar level, ca. 55, but their EPI score increased significantly – by ca. 12 points for Eastern European countries and by 10.5 points for Asian countries.

The research conducted, aside from its theoretical value, may be seen as valuable input to inform decisions of policymakers regarding regional development on the global scale.

The contribution of the authors

Grażyna Karmowska – 50%
Nino Mikiashvili – 50%

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METHODOLOGICAL APPROACH OF INVESTMENT AND INNOVATION REGIONAL ENVIRONMENTAL POLICY USING THE SMART SPECIALIZATION AND QUINTUPLE HELIX MODELS

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ABSTRACT: The purpose of the study, therefore, is to form a methodological approach concerning the determination of dominants of investment and innovation regional environmental policy. The methodology bases on Smart Specialization and Quintuple Helix models. This research formulates the authorial vision for the combination of Quintuple Helix and Smart Specialization methodologies in order to determine the strategic priorities of investment and innovation policy of the national economy. It allows not only to define the dominants in nature but also to determine the uniqueness of regions based on scientific and technological potential, taking into account the priorities of individual Sustainable Development Goals. The presented research is an additional argument to existing official developments, as Guide on Research and Innovation Strategies for Smart Specialisation. A methodological approach has been developed, taking into account the methodology of "Smart Specialization" and in the context of existing European experience.

KEYWORDS: Quintuple Helix, Smart Specialization, Sustainable Development Goals, investment and innovation policy, natural resource potential

Introduction

In today's globalized and constantly changing world, is a prerequisite for resources and opportunities creation, on the basis of unique industrial and sectoral structures as well as a corresponding knowledge base. Effective use of public environmental investments and innovations, support of regions in the development of their innovation and investment potential, focusing limited human and financial resources on several competitive areas in order to promote the economic growth. This approach is the main direction of Quintuple Helix implementation (5 helix) methodology which adapted to modern needs of regional nature policy. It should be noted that modern researchers in the world consider innovation and investment policy at the macro, meso and micro levels through the prism of modern management models. One of the basic models of innovation and investment policy is the Triple Helix model (3 helix). The concept of interaction between the "University-Industry-Government" and "Triple Helix" was proposed in the 1990s by Professor Etzkowitz and his colleague Leydesdorff, which included the work of Lowe's predecessors and Sabato and Mackenzie. It describes the transition against the predominant industry-government dyad in industrial society to a more relevant triple interaction between universities, industry and government towards knowledge societies. Although at works of these and other researchers are used such names of the participants of this triad, in our opinion, more accurate to say about interactions "higher education institutions (HEIs) – business – government bodies t", and it's exactly what we'll use in the future.

Knowing that the Triple Helix can be considered as a heart, built into the Quadruple Helix (4 helix). Model 4 helix is conducive for successful implementation of the business process, stimulates intensive experimentation and invention, simultaneously intensifying the innovation activity. It can be used as an innovative architecture, an environment that allows you to simultaneously integrate four sectoral spaces based on dynamically balanced "from the top-down" and "from bottom to top" approaches: from the top-down – government, science, industry; from bottom to top – civil society. Inter- and intra-sectoral (as well as inter- and intra-regional) interfaces of knowledge and learning, built into the architecture of the quadro-spiral, determine its efficiency and stability. Campbell D.F.J. and others (2015) developed an innovative model into a five-pointed spiral, where the fifth constitutes the natural environment of society. Let's note that this methodology in combination with the ideologeme of Smart Specialization is actively considering in world science. This is the methodology with which the European Union has reviewed the rationale of the country's economic development. The Intelligent / Smart Specialization Platform (S3) was established by the European Commission in

June 2011 at the IPTS2 Joint Research Center in Seville, Spain. "Intelligent Specialization" (S3) is designed to assist EU Member States and regions in developing, implementing research and innovation strategies for Smart Specialization (RIS3). The Smart Specialization concept focuses on the development and implementation of innovative strategies that take into account regional characteristics, namely: economic structure, existing areas of excellence, clusters, research, research institutions, expansion of interregional and international networks of scientific and technical cooperation (Foray et al., 2012). Smart Specialization defines the interaction of economic sectors through the innovation and natural resource component, which creates sustainability between local economic entities. It is a combination of policy concepts, sectoral and cross-sectoral use of innovation and technology. Smart Specialization focused on 1) searching for dominant clusters of economic growth, areas with a small number of owners for simplified cooperation, 2) searching and reorganization of various specializations, 3) understanding the distribution of risks (Richardson, 2014).

This proposed methodology concerns not only developing new specializations in regions that have the potential to grow through local opportunities. It (so-called "Smart Specialization") is also the development of new specializations in regions that are unique in the world, more complex, that improve the local economy, in particular in the field of environmental management. The complexity of knowledge means the degree of sophistication and the number of opportunities required to develop new technology. Today, the regional policy of European countries is implemented together with the state innovation policy and policy to promote entrepreneurship, which creates conditions for the economic development of regions, effective use of existing potential (on approval of the State Strategy for Regional Development until 2020: Resolution of the Cabinet of Ministers of Ukraine of August 6, 2014 № 385. Official Gazette of Ukraine of 09.09.2014, № 70, p. 23, Article 1966, act code 73740/2014).

Analysis of recent studies and publications

Modern approaches to the management of innovation and investment systems in the world are gradually becoming transformed today. Note that at one time, leading international scientists (Carayannis, Campbell, 2012) formed the concept of the Quadruple Helix as a way to expand the triple spiral and open relatively closed processes of policymaking and innovation systems, thus making them more democratic. Early innovation systems, formed on the basis of the methodology of the so-called "Triple Helix", were based on

cooperation between universities, government and industry (Leydesdorff, Etzkowitz, 1996, 2000; Rubel, Zhykhareva, 2018). These systems were also to include the fourth spiral – the public and thus created the ideology of the quadruple model. The social capital and authorities of the regions are the glue that holds them together in the Quadruple Helix (4 helix spiral). The use of 4 helix for the intellectual interaction of regions implies a focus on the process of transforming the potential of business and communities for innovative and social learning (figure 1).

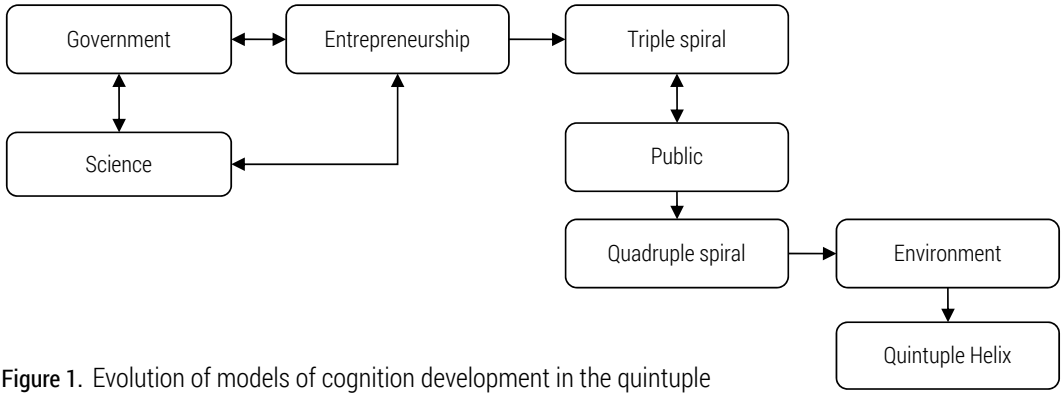

Figure 1. Evolution of models of cognition development in the quintuple spiral

Source: author's work based on Carayannis, Campbell, 2012.

Modern world researchers (Carayannis, Campbell, 2012) point to the importance of broadening the existing definition of democracy through the inclusion of not only political and civil law, but also the ideology of sustainable development. In this context, they have refined the concept of the triple innovation spiral from a regional point of view, considering it not only through the quadruple system of spirals, but also the quadruple, where the fifth spiral is a natural feature of a particular region. Thus, the expansion of the former innovation system includes the prospects of both democracy and environmental issues. Carayannis, E. G. etc. considered the model of the pentagonal spiral as a way of emphasizing the transformation of society and the modern economic system into an international paradigm of sustainable development. According to Carayannis, E. G., the quadruple spiral model consists of five spirals: the economic system, the environment, the media and culture, the public and the political system (Grundel, Dahlström, 2016) (figure 2).

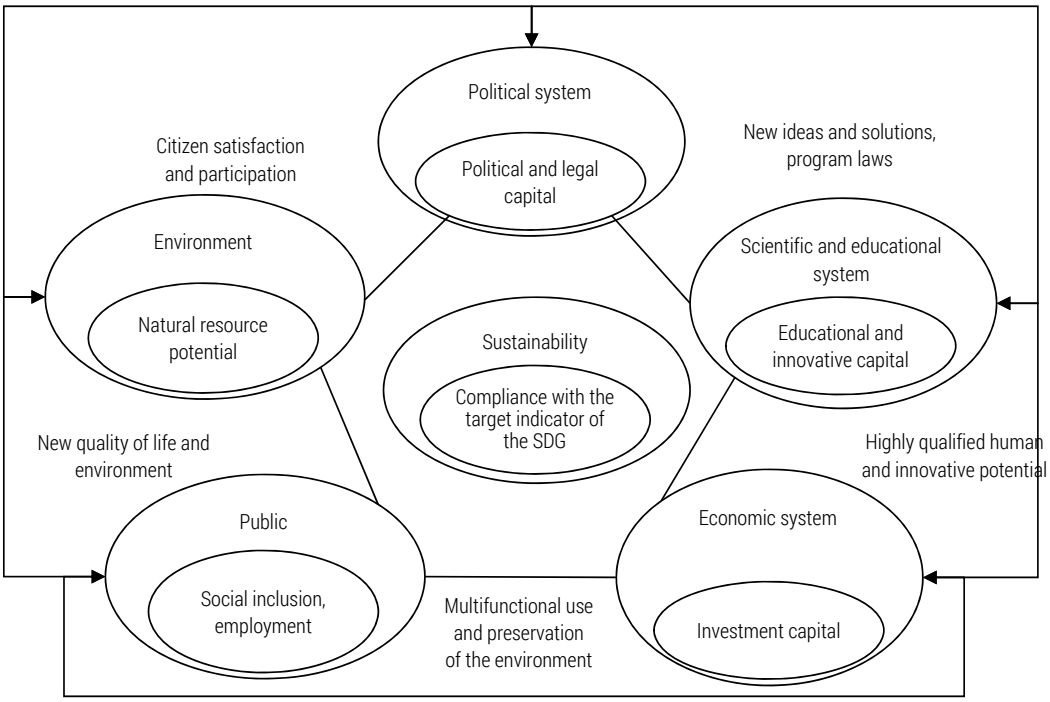

Figure 2. Effects of investment and innovation Quintuple Helix policy development
Source: author's work based on Carayannis, Campbell, 2012.

Note that the modern view of Quintuple Helix (5 helix) involves a combination of different approaches to implementation, including the use of Smart approach. In regional science, the result of the innovation process is closely related to the geographical (in this case, spatial or regional) context and institutional features (Doloreux, Parto, 2005). Different data sources require comprehensive use, but Smart-assessment does not always use complete and correct global and domestic scientific approaches to determine the nature of this process (table 1).

In 2018, the Resolution of the Cabinet of Ministers of November 14, 2018, № 959 came into force in Ukraine, according to which all regions within the regional development strategy must determine at least one strategic goal based on the European methodology of Smart Specialization. The Ministry of Economic Development, Trade and Agriculture planned to allocate UAH 6.75 billion in 2021-2023 for Smart Specialization of Regions. Strategic guidelines for regional development for 2021-2027 aimed at solving the tasks of the previous period, which was characterized by the financing of projects aimed at the development of funds, ignoring the creation of new jobs and increasing

budget revenues (Regional Development Strategies 2021-2027). Requirements for Smart Specialization are approved at the state level by the relevant resolutions of the Cabinet of Ministers of Ukraine "On approval of the Procedure for developing the State Strategy for Regional Development of Ukraine and action plan for its implementation, as well as monitoring and evaluating the implementation of this Strategy and Action Plan."

Table 1. Review of the literature on the disclosure of the essence of the methodology used in the coverage of Smart Specialization

Author	The essence of the methodology
(Ortega A.R., McCann, P., Perianez-Forte, I., Cervantes, M., Larosse, J., & Sanchez, L., 2013)	The use of methods for forecasting and diagnosing regional features to identify new activities, possible synergies and complementarities that may arise in the regional context.
(Sugimoto, C.R., Robinson-Garcia, N. and Costas, R., 2016)	Use of scientific publications on conducting diachronic network analysis to identify patterns of mobility among the location of the region.
(Bakhshi, H. and Mateos-Garcia, J., 2016)	Use of unstructured data to identify areas of technological and economic activity in a more accurate way by methods of information analysis.
Internet resources, public interactions	Use public feedback and increase the accountability of all stakeholders in the RIS3 process. Use of data and technologies of social media, online tools.
(Delaney, K. and Osborne, L., 2013)	Involvement of RIS3 beneficiaries and users, public consultations, expert recommendations, submission through web tools.

Source: aurhor's work.

In the process of Smart Specialization, zoning takes place by combining areas in science and education, areas of industrial production and areas not focused on science and technology, within which there are different subcategories. These categories reflect the main activities and interactions of knowledge, innovation and regional specificities in the EU. Today Ukraine is an industrial-agrarian country, but some experts emphasize the return of our state to the agrarian-industrial model. In this context, the provision of rational nature management in the regional policy will be of special importance. Ukrainian agricultural exports – grain, oil, livestock and poultry products, goods of processing industries – are almost international. Accordingly, for further effective development and taking into account the rich natural resource potential of our country, it is necessary to identify areas with a specific focus on nature management.

Research methods

A number of methods were used to analyze the regional context of innovation-investment and natural resource potential: comparison, tabular and graphical methods, rating evaluation methods, expert method, modelling method (figure 3).

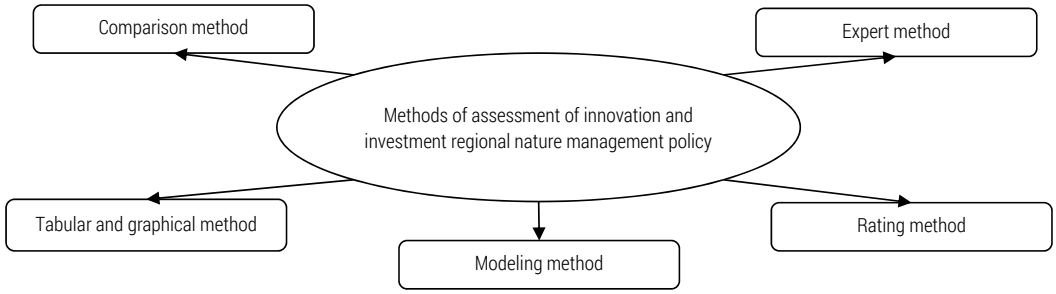

Figure 3. Methods of evaluation of investment and innovation regional nature management policy taking into account Smart Specialization

Source: author's work based on Рябоволик, Т.Ф., 2017, p. 71.

Using the comparison method, the evaluation was performed in comparison with the best analogues. Design issues for a method-comparison study include the selection of the measurement methods, number of measurements and the range of conditions over which the measurements are made (Hanneman, 2008). Expert methods provided an opportunity to assess phenomena and processes for which there are no statistics. The method by means of which obtained results are based on the opinions and assessments of competent experts is called expertise, an expert's opinion or the method of expert assessment (Iriste, Katane, 2018). This is an advantage of the methodological provisions in terms of transforming the structure of existing Ministries and Offices, as well as reducing the sources of primary information in the state. As a result of the reform of the Ministry of Ecology and Natural Resources to the Ministry of Energy and Environmental Protection, and then to the Ministry of Environmental Protection and Natural Resources of Ukraine, there is no single standard for regions on statistical reporting, as well as the latest data on some objects. In this regard, the methodological provisions use the rating method of research, the order of items by making judgements of absolute value, using a numerical scale (McGraw-Hill Dictionary of Scientific & Technical Terms, 6E., 2003). It reflects the ranking of the region by a group of indicators rating method of assessment. The method of comparison allowed

not only to determine the dominants of investment and innovation policy of nature management but also to present a comprehensive economic and environmental assessment of regional development. Note that when making management decisions in the field of environmental management is an essential and necessary tool of the analytical stage is the involvement of external experts.

Modelling method used in creating a comprehensive assessment of the priority of implementation of Smart-projects in the field of nature management. With the modelling method, every problem is solved by creating a model or, more often, adapting a known model to the specifications of the problem. The modelling method may facilitate the solution of textbook problems by providing deeper physical insight. But it also supports a deemphasis on textbook problems (Hestenes et al., 1995). With tabular and graphical method have designed all calculations and research schemes. Tabular method a set of qualitative data can be summarized by constructing a frequency distribution. The graphical method used to visually describe data from a sample (Descriptive Stats: Tabular & Graphical Methods, 2020).

Results of the research

The study proposes a methodological approach to a comprehensive assessment of the dominants of investment and innovation regional environmental policy, taking into account European practices, based on the philosophy of the Quintuple Helix (5 helix) model of the international paradigm of sustainable development, the methodology for assessing innovation and investment and resource potential. smart specialization of regions taking into account their resource-ecological base.

Under the *investment and innovation policy of nature management of the regions*, the authors understand the activities of state and regional bodies aimed at creating favourable institutional and economic conditions to stimulate the implementation of environmentally oriented investments and innovations in economic activities of regional regions, taking into account the available natural resource potential. *Assessment of innovation and investment regional nature management policy* is a process of the systematic study of the results of economic and environmental interactions and environmental consequences of management at the regional level, which is based on a comprehensive analysis of relevant areas of planned investment and innovation activities. *Natural resource potential* is a set of identified and usable natural resources at a given level of production (in the world, country, region, local level). It is the most important part of the national wealth of the country

(region) and ensures their raw materials and fuel independence and security. *Dominant positioning of the region* is an economic concept used in investment and innovation policy in determining the fact of the dominant regional market position.

The key role in maintaining the competitiveness of economic systems belongs to the innovative specialization of economic activity, which diversifies economic activity. The lack of a clear innovation-oriented specialization of production and the trend towards the concentration of innovation-oriented services indicates the necessary development of relevant clusters (Бакушевич, Гощинська, Мартиняк, 2019, p. 240). Unlike traditional ones, they should include so-called institutions of knowledge and attracting talents to the place of concentration of resources and financing of their efficient and rational use. In Ukraine, systemic obstacles that hinder the formation of "Smart Specialization" are associated with the centralized and universal nature of strategic planning of economic development, which does not take into account the conditions and needs of specific regions. Regions (table 2).

Table 2. Dynamics of the rating of some countries according to the Innovation Efficiency Index for 2010-2018

Country	2010	2012	2014	2015	2016	2017	2018
Ukraine	54	14	14	15	12	11	5
Kazakhstan	77	131	118	124	108	116	111
China	14	1	2	6	7	3	3
USA	63	70	57	33	25	21	22
Germany	56	11	19	13	9	7	9
Poland	85	80	76	93	66	48	42
India	101	2	31	31	63	53	49
Japan	18	88	88	78	65	49	44
Switzerland	15	5	6	2	5	2	1
Luxembourg	5	8	9	3	1	1	2

Source: author's work based on The Global Innovation Index 2010-2018.

Analysis of the financing of existing priority areas of innovation is carried out in Ukraine on the basis of the Law of Ukraine "On Priority Areas of Innovation in Ukraine", which defines seven strategic priority areas of innovation, and the Cabinet of Ministers of Ukraine dated 28.12.2016 №1056, which strategic priorities identified 41 medium-term priority areas of innovation at the national level (On priority areas of innovation in Ukraine № 3715-VI).

The number of enterprises that have implemented environmental innovations is characterized by uniformity between regions, but the highest level is occupied by the Rivne region, Vinnytsia and Poltava.

Smart Specialization (S3) focuses on the role of universities and university research as a key driver of innovation and regional development. This is seen as providing the necessary cohort of skilled knowledgeable professionals who can conduct research, commercialize intellectual property and catalyze the adoption of research.

The business process will be different in each region according to the density of innovators and entrepreneurs in some regions and low population, a small number of sectors and large dominant organizations, but with few external links – in others. In accordance with the Procedure for evaluation of regional development projects that can be implemented at the expense of the state budget received from the European Union (On amendments to the Procedure for evaluation of regional development projects that can be implemented at the expense of the state budget received from the European Union On 165), the expected result is to increase the competitiveness of regions through the development of regional and local economies based on the effective use of existing potential, existing competitive advantages, creating a favourable investment environment, modernization of the real sector of the economy, growth of export potential, creating conditions for innovation processes taking into account the principles of Smart Specialization. Preservation and restoration of natural areas have found their place in the areas of rural and tourist development of the regions.

The territory of Ukraine is rich in natural resources that need to preserve and improve their ecological condition, overcome the consequences of irrational use of nature and take measures to prevent further depletion of natural resources. Carrying out appropriate measures and solving environmental problems by greening enterprises and institutions require increased investment in environmental protection.

Given the existing trends in world science on the active implementation of the Quintuple Helix (5 helix) model in the domestic economy, which is adapted to modern needs of sustainable development and regional environmental policy, it is important to define methods, formulations, procedures and indicators of its implementation in practice. Note that the modern vision of this approach in the regional dimension is just being formed. This scientific direction in the world community is primarily associated with the combination of the methodology of Smart Specialization and individual Sustainable Development Goals.

Monitoring and evaluation of the effectiveness of the implementation of investment and innovation regional policy are carried out in order to moni-

tor the process of its implementation, identify problems of regional development and the reasons for their occurrence, increase the effectiveness of management decisions. It provides for periodic monitoring of relevant indicators on the basis of available official statistics and information.

Monitoring the implementation of regional policy is carried out by determining the list of relevant indicators, tracking their dynamics, preparation and publication of the results of such monitoring and includes: monitoring the implementation of indicators of the objectives of documents defining regional policy (in this scientific work – determination of optimal values of indicators of resource and ecological productivity according to SDG by regions of Ukraine); monitoring of socio-economic development (in this scientific work – innovation and investment regional nature management). The synergy of investment and innovation is an integral part of the country's economic development. To succeed in an innovative project, there is a need for a ratio between the initial investment and financial return. After all, any innovative project is an investment, as a result of the fact that companies face the most important financial goal – to maximize profits. One of the main features of the Smart Specialization approach is that the region must make strategic decisions taking into account its position in interaction with other regions. The region must determine its competitive advantages by systematically comparing with other regions, comparing national and international contexts for effective benchmarking. The region should be able to identify relevant links in trade, services and knowledge, thus identifying possible integration models and schemes with partner regions. This is especially important for less developed regions. The position of the regional business sector in the framework of international industrial interactions (value chain), in this regard, is the most important element (A Guide to Research and Innovation Strategy for Smart Specializations).

Implementation of the Smart Specialization Strategy, which will provide a combination of the above components will provide an opportunity to determine the approach to the formation and implementation of state regional policy. The search for a dominant position of the regions is aimed at preventing the growth of disparities that hinder the development of regions and should be ensured through a coherent policy to stimulate the development of "growth points" and support economically less developed and depressed areas.

In Ukraine, the largest number of higher education institutions is concentrated in Kharkiv, Dnipropetrovsk, Lviv and Odesa regions. Most higher education institutions are subordinated to the Ministry of Education and Science of Ukraine. The Ministry of Agrarian Policy and Food of Ukraine and the State Agency of Forest Resources of Ukraine, which primarily train specialists in

natural sciences, occupy the middle link in the ranking of universities by number in the country. The training of nature specialists in universities and colleges is more common in the agricultural sciences. Innovative literature tends to exaggerate the role and effectiveness of university-based research and development, emphasizes the creation of knowledge rather than the dissemination and exploitation of knowledge, and prioritizes research universities over other types of educational institutions and opportunities.

There is a lack of good strategic intelligence or forecasting models, and often a commitment within education, especially higher education, that it should not be too closely aligned with business and economics. Despite the average level of provision of the country with higher education institutions with the predominance of environmental sciences, employment in this area is characterized by negative dynamics in recent years. Priorities are usually set by the institution based on the competencies of teachers/academics, interests and priorities, which are not always well aligned with the (changing) socio-economic context and do not change easily due to contractual issues. There are also no mechanisms through which the vision of the region can be discussed, agreed and implemented. In this context, it is very important to strengthen the environmental component in the scientific and educational spheres in order to further implement the borrowed knowledge in the formation of investment and innovation policy of nature in certain regions.

A comprehensive assessment of investment and innovation policy of the region in the proposed methodological approach is carried out on four groups of factors, namely:

- economic activity and investment potential of environmental protection of the regions of Ukraine (factor 1: GRP, UAH million; capital investments for environmental protection, UAH million; capital investments for environmental protection at the expense of own funds of enterprises, UAH million),
- the scientific and innovative potential in the field of nature management of the regions of Ukraine (factor 2: scientific and innovative activity of Ukraine; employment in the field of nature management; universities of I-IV levels of accreditation; the number of students),
- resource and environmental productivity according to the SDG by regions of Ukraine (factor 3: carbon productivity of GRP; GRP energy consumption; water capacity of GRP; waste productivity GRP),
- natural resource status of regions (factor 4: provision with average long-term river runoff; drinking and technical groundwater reserves; underground mineral water reserves; area of nature reserve fund; forests and other wooded areas; afforestation area; agricultural land; combustible natural gas; oil, brown, coal, peat; metallic minerals).

Table 3. Analysis of the group of indicators of economic activity and investment potential of the environmental orientation of the regions of Ukraine

Region	GRP, UAH million	Cap. invest. for environmental protection, UAH million	Cap.invest. for environmental protection at the expense of own funds of enterprises, UAH million	The sum of points for assessing strengths and weaknesses
Vinnytsia region	++	+	+	4
Volyn region	+	+	+	3
Dnepropetrovsk region	++++	++++	++++	12
Zhytomyr region	+	+	+	3
Transcarpathian region	+	+	+	3
Zaporozhzhia region	++	++	++	6
Ivano-Frankivsk region	+	+	+	3
Kyiv region	++	+++	+	6
Kirovograd region	+	+	+	3
Lviv region	++	+	+	4
Mykolayivska region	+	+	+	3
Odesa region	+	+	+	3
Poltava region	++	+	+	4
Rivne region	+	+	+	3
Sumy region	+	+	+	3
Ternopil region	+	+	+	3
Kharkiv region	+++	+	+	5
Kherson region	+	+	+	3
Khmelnytsky region	+	+	+	3
Cherkasy region	+	+	+	3
Chernivtsi region	+	+	+	3
Chernihiv region	+	+	+	3

Source: author's work.

The first stage is the analysis of the first group of indicators of economic activity and investment potential of environmental orientation *(factor 1)*, which was formed from indicators (table 3): gross regional product; state capital investments in environmental protection; capital investments in environmental protection at the expense of own means of the enterprise, the

organizations, establishments. For the analysis of *factor 1,* the maximum values on each indicator of the group with equal to 10 points are defined. In this case: the calculated score for all regions according to the highest score; the expert assessment (by highly qualified experts – scientists of the Institute of Market Problems and Economic&Ecological Research of the National Academy of Sciences of Ukraine, dealing with Smart Specialization and environmental economics) was evaluated according to the formula: (where B – score according to the value of each indicator in the group, K – the weighting factor of each indicator in the group); identified strong 9-10 (++++), moderate 6-8 (+++), neutral 3-5 (++) and weak 0-2 (+) sides; calculated the number of points for determining the dominants and a comprehensive assessment of the priority of implementation of Smart-projects in the field of nature management.

At the second stage, the *second factor* of assessment of scientific and innovative potential in the field of nature management *(factor 2)* (table 4) was determined by indicators:

- scientific and innovative activity of Ukraine,
- employment of the population in the field of nature management,
- number of higher bulk institutions of I-IV levels of accreditation by regions,
- number of students.

Table 4. Analysis of the group of indicators of economic activity and investment potential of the environmental orientation of the regions of Ukraine

Region	Scientific and innovative activity of Ukraine	Employment in the field of nature management	Universities of I-IV levels of accreditation	Number of students	The sum of points for assessing strengths and weaknesses
Vinnytsia region	+++	++++	++	+	10
Volyn region	++	++	+	+	6
Dnepropetrovsk region	+++	++	+++	+++	11
Zhytomyr region	++	++	++	+	7
Transcarpathian region	++	+++	+	+	7
Zaporozhzhia region	++	+++	++	++	9
Ivano-Frankivsk region	++	+++	+	+	7
Kyiv region	+++	+	++	++	8
Kirovograd region	++	++	+	+	6
Lviv region	++	++++	+++	+++	12

Region	Scientific and innovative activity of Ukraine	Employment in the field of nature management	Universities of I-IV levels of accredita-tion	Number of students	The sum of points for assessing strengths and weaknesses
Mykolayivska region	++	+++	+	+	7
Odesa region	++	+++	+++	+++	11
Poltava region	+++	+++	++	++	10
Rivne region	++++	++++	+	+	10
Sumy region	++	++	+	+	6
Ternopil region	++	+++	++	+	8
Kharkiv region	++	+++	++++	++++	13
Kherson region	+++	+++	++	+	9
Khmelnytsky region	++	+++	++	+	8
Cherkasy region	+	+++	+	+	6
Chernivtsi region	++	++	+	+	6
Chernihiv region	+++	++	+	+	7

Source: author's work.

The third stage was calculated resource and environmental productivity according to the SDG by region *(factor 3)* (table 5), by indicators:

- carbon productivity (environmental productivity),
- GRP energy intensity (resource productivity),
- GRP water capacity (resource productivity),
- waste GRP (environmental productivity).

Table 5. Analysis of the group of indicators of resource and environmental productivity according to the SDG by regions of Ukraine

Region	Carbon product GRP	Energy intensity of GRP	Water capacity GRP	Waste product GRP	The sum of points for assessing strengths and weaknesses
Vinnytsia region	+	++	+++	+	7
Volyn region	++	+	++	+	6
Dnepropetrovsk region	+	+++	+	++++	9
Zhytomyr region	++	++	+++	+	8
Transcarpathian region	++	+	+++	+	7
Zaporizhzhia region	+	+++	+	+	6
Ivano-Frankivsk region	+	++++	++	+	8
Kyiv region	++	++	++	+	7
Kirovograd region	++	+	+++	+	7
Lviv region	+	++	+++	+	7
Mykolayivska region	+	++	+	+	5
Odesa region	+	++	+	+	5
Poltava region	+	++	++++	+	8
Rivne region	+	+++	++	+	7
Sumy region	+	++	++	+	6
Ternopil region	++	+	+++	+	7
Kharkiv region	+	++	++	+	6
Kherson region	+++	++	+	+	7
Khmelnytsky region	+	++	++	+	6
Cherkasy region	+	++	++	+	6
Chernivtsi region	++++	++	++	+	9
Chernihiv region	+	++	++	+	6

Source: author's work.

The fourth stage is the assessment of the natural resource status of the regions *(factor 4)* (table 6) by indicators:

- provision of average long-term river runoff,
- drinking and technical groundwater reserves,
- underground mineral water reserves,
- area of the nature reserve fund,

- forests and other wooded areas,
- afforestation areas,
- areas of agricultural land,
- combustible minerals (combustible natural gas, oil, lignite and peat, peat),
- metallic minerals.

Table 6. Analysis of the group of indicators of natural resource status of the regions of Ukraine

Region	1	2	3	The sum of points for assessing strengths and weaknesses
Vinnytsia region	++	+++	+	6
Volyn region	+	++++	+	6
Dnepropetrovsk region	+++	+++	+	7
Zhytomyr region	+	++++	++	7
Transcarpathian region	++	+++	+	6
Zaporozhzhia region	+++	++++	+	7
Ivano-Frankivsk region	++	+++	++	7
Kyiv region	++	+++	+	6
Kirovograd region	++	+++	+	6
Lviv region	++++	+++	+	8
Mykolayivska region	+	++	+	4
Odesa region	++	+++	+	6
Poltava region	++	++++	++	8
Rivne region	+	+++	+	5
Sumy region	++	++++	+	7
Ternopil region	++	+++	+	6
Kharkiv region	+++	+++	+++	9
Kherson region	+	++++	+	6
Khmelnytsky region	++	++++	+	7
Cherkasy region	++	++	+	5
Chernivtsi region	+	+++	+	5
Chernihiv region	++	++++	+	7

Source: author's work.

At the fifth stage, the sum of points on four factors was calculated to determine the dominants of investment and innovation policy of the regions and to form a priority rating for the implementation of Smart-projects in the field of nature management (figures 4, 5).

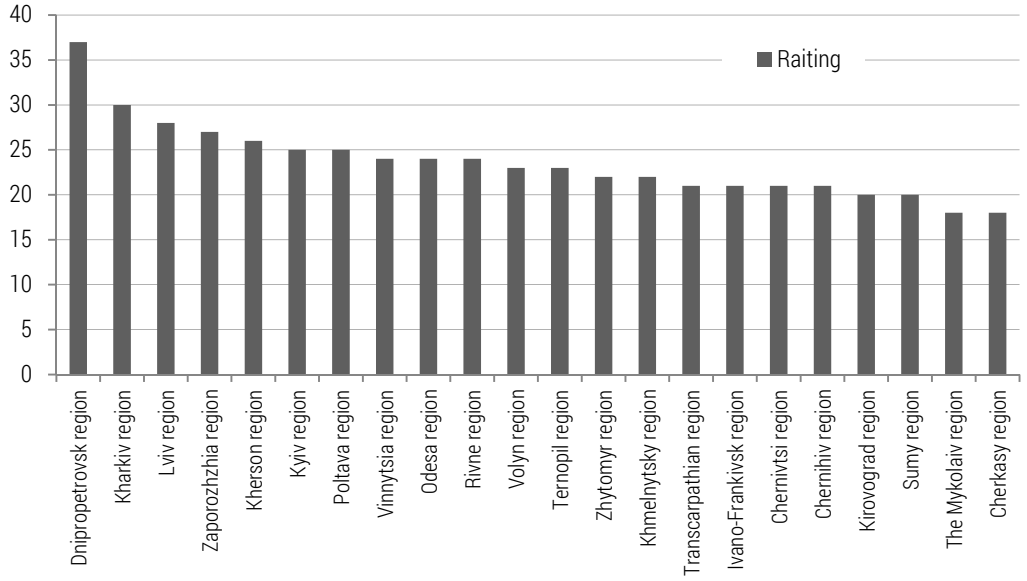

Figure 4. Rating of development of investment and innovation regional policy of nature management of regions by groups of indicators of Smart Specialization

Source: author's work.

To substantiate the group of indicators of natural resource status of the regions of Ukraine, three subgroups of indicators were outlined and systematized.

The first (1) included: provision of average long-term river runoff; drinking and technical groundwater reserves; underground mineral water reserves.

To the second (2) group: Nature reserve fund areas; forests and other wooded areas; afforestation areas; agricultural land.

To the third (3) group: combustible natural gas; oil, brown, coal, peat; metallic minerals.

Strengths and weaknesses were determined by calculating the sum of the scores of the subgroup, namely: strong 20-18 (++++), moderate 17-12 (+++), neutral 11-6 (++) and weak 0-5 (+) sides.

The analysis of economic activity and investment potential of the environmental orientation of the regions of Ukraine allowed us to determine that

in most regions the production of the gross regional product is a strong point of development. The volumes of investments actually disbursed in the reporting period at the expense of the state budget of Ukraine and local budgets for environmental protection are characterized by growing dynamics but are generally not a strong point of regional development.

The EU's Smart Specialization platform provides both information and expert and financial support using the resources of the European Structural and Investment Funds. The pilot regions will receive individual support from the European Union to quickly remove investment barriers and innovate. In addition, we are talking about the automation of production, the transition to alternative energy sources – depending on the Smart Specialization of a particular region. Today, only three regions of Ukraine have been selected as participants in the EU's Smart Specialization platform: Odesa, Kharkiv and Zaporizhzhia (Odesa region was chosen to participate in the EU project "SMART-specialization").

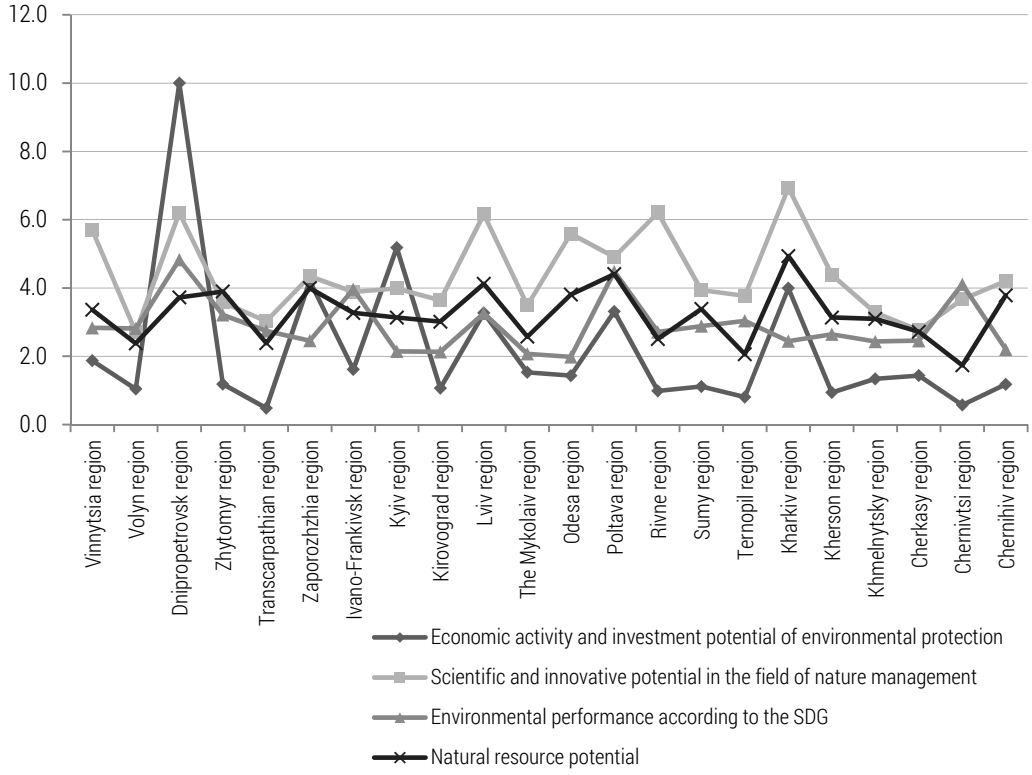

Figure 5. Comprehensive assessment of the priority of implementation of Smart-projects in the field of nature management

Source: author's work.

The scientific and innovative potential of the regions of Ukraine is the strongest component of the development of Smart Specialization. Only in a few areas does it need significant support and cooperation. Employment in the field of nature management is characterized by an almost equal distribution among the regions. The location of higher education institutions is the weakest component of the group, as is the concentration of students (talents). Achieving the Sustainable Development Goals is presented by the best results in fulfilling the task of increasing water capacity. The field of waste productivity is characterized by a low level of development among almost all areas. Energy intensity productivity is in second place among the goals achieved by the regions, carbon productivity – the penultimate. The natural resource potential of the regions is determined by the highest indicators of development of forest and nature reserves. Provision of supplies of drinking, technical, groundwater and river runoff as well as rational and efficient use of agricultural land is the primary tasks at the present stage of development of Ukraine's economy. Gaps in the use of natural resource potential are minerals, combustible and metallic. However, this is more about their natural occurrence than organizational and economic issues.

Conclusions

Modern approaches to the management of innovation and investment systems in the world are gradually being transformed today. The presented scientific article substantiates the methodological approach for determining the dominants of investment and innovation policy at the regional level through a comprehensive combination of concepts Quintuple helix, Smart Specialization and Sustainable Development Goals. The institutional essence of investment and innovation policy of nature management at the regional level as a modern model of Quintuple helix is determined. The study analyzes the compliance of the priorities of investment and innovation policy of the region with the Sustainable Development Goals.

The Quintuple Helix model is a way of emphasizing the transformation of society and the modern economic system into an international paradigm of sustainable development. Note that the modern view of Quintuple helix involves a combination of different approaches to implementation, including the use of Smart approach. The expansion of the former innovation system should include the prospects for both democracy and environmental issues.

The authors formed a categorical-conceptual apparatus and proposed a methodological approach to determine the dominants of investment and innovation policy, which is based on a step-by-step study: monitoring the

implementation of indicators (indicators) of documents that determine regional policy (determining optimal values of resource and environmental productivity of regions of Ukraine); monitoring of the innovation and investment regional sphere of nature management.

The proposed methodological approach allows not only to outline the dominants in the field of nature management but also to determine the uniqueness of the regions, based on scientific and technical potential, taking into account the priorities of the Sustainable Development Goals. Note that the proposed research is an additional argument to existing official developments, as Guide on Research and Innovation Strategies for Smart Specialisation. The study found that the number of enterprises that have implemented environmental innovations is characterized by uniformity between regions, but the highest level is occupied by the Rivne region, Vinnytsia and Poltava. The concentration of higher education institutions in Ukraine is concentrated in Kharkiv, Dnipropetrovsk, Lviv and Odesa regions. The training of specialists in nature management among universities and colleges is more numerous in the agricultural sciences. The Ministry of Agrarian Policy and Food of Ukraine and the State Agency of Forest Resources of Ukraine, which primarily train specialists in natural sciences, occupy the middle link in the ranking of universities by number in the country. Employment in the field of nature management is characterized by negative dynamics in recent years.

The authors assess the investment potential of the regions, which justifies the prospects of such regions as Dnipropetrovsk, Kharkiv and Kyiv. The indicators of Zaporizhia, Lviv and Poltava regions are quite close. The dynamics of capital investment in environmental protection by type of environmental protection measures over the years is defined as positive. According to the analysis of capital investments developed by enterprises and organizations for environmental protection measures, the largest share of developed investments was in Kyiv region, now the first places are taken by Odesa, Dnipropetrovsk and Zaporizhia regions. The dynamics of implementation of environmental measures and solving environmental problems represents that in Rivne, Vinnytsia and Odesa regions the indicators of financing the implementation of environmental measures have reached the greatest importance, in Kyiv – large-scale financing of greening and solving environmental problems.

The authors prove that the dynamics of reducing the total amount of emissions of pollutants into the atmosphere from stationary sources is characterized in Volyn, Zhytomyr, Ternopil, Kherson, Chernivtsi regions as positive. The assessment of energy deviation indicates the presence of a significant number of regions that do not increase energy intensity in accordance with the Sustainable Development Goals, namely Vinnytsia, Dnipropetrovsk,

Zaporizhia, Ivano-Frankivsk, Odesa, Poltava, Rivne, Cherkasy, Chernivtsi, Chernihiv regions. The water content in two oblasts, Zaporizhia and Kherson regions, significantly exceeds the target. The goal of reducing the volume of waste generation and increasing the volume of their processing and reuse on the basis of innovative technologies and industries in Zakarpattia, Kyiv, Kharkiv and Kherson regions has been practically fulfilled.

The authors, when studying the natural resource state of the country in terms of regions according to the statistical database, found that the dynamics of growth of areas of nature reserves is characterized by relative stability. Forest lands are mainly located in Zhytomyr, Rivne, Chernihiv and Zakarpattia regions. Afforestation is characterized by unstable dynamics, the largest areas were in the Kherson region those are now the Vinnytsia region. The highest share of arable land is in steppe areas and forest-steppe zone. The increase in Ukraine's energy potential is also associated with the possibility of using minerals in the Dnipropetrovsk region. The leading place among the territories of groups of combustible minerals was taken by the Volyn region, in the second place – Kharkiv, Lviv. Dnipropetrovsk, Zaporizhia and Poltava regions predominate among the reserves of metallic minerals.

According to the results of the research, the principles of Smart-specialization of regional development of Ukraine are determined. In particular, today only three regions of Ukraine have been selected as participants in the EU's Smart-Specialization platform: Odesa, Kharkiv and Zaporizhia.

In most regions, the production of the gross regional product is a strong point of development. Investment volumes are characterized by growing dynamics but are generally not a strong point of regional development. Volumes of investments mastered at the expense of own funds of enterprises are positively reflected in Dnipropetrovsk and Zaporizhia regions. The scientific and innovative potential of the regions of Ukraine is the strongest component of the development of smart specialization.

Achieving the Sustainable Development Goals is represented by the best results in fulfilling the task of increasing energy intensity. The field of waste productivity is characterized by a low level of development among almost all areas. Carbon productivity is in second place among the achieved goals by the regions, water capacity – the penultimate. The natural resource potential of the regions is determined by the highest indicators of development of forest areas and nature reserves.

Involvement in innovation processes of educational institutions, companies, government agencies and users of innovations will be a driver of talent mobilization to meet the capabilities and needs of strong regions. The development of environmental investments and innovations requires the delineation of priorities based on strengths, avoidance of duplication and fragmen-

tation of the concentration of funding sources. The use and preservation of natural resource potential require the development of specialized clusters and the provision of space for intersectoral relations within the region and abroad, which contributes to technological diversification.

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The contribution of the authors

Natalya Andryeyeva – 38% (substantiated methodical provisions on the combination of Quintuple helix methodology, Smart-specialization and Sustainable Development Goals; defined the institutional essence of investment and innovation policy of nature management at the regional level as a modern model Quintuple helix).

Hanna Tiutiunnyk – 38% (conducted an assessment of the innovation potential of the regions as a component of investment and innovation policy of nature management; analyzed the dynamics of implementation of environmental innovations by enterprises of Ukraine, the concentration of higher education institutions of I-IV levels of accreditation in terms of regions, in particular, subordinate government agencies; determine the number of students, specialists in higher education institutions majoring in natural sciences, employment in the field of nature management).

Borys Burkynskyi – 12% (comparative characteristics of statistical data Ukraine – EU countries).

Nina Khumarova – 6% (studied the natural resource potential of the country in terms of regions according to the statistical database).

Larysa Kupinets – 6% (established that it is very important to strengthen the environmental component in the scientific and educational spheres in order to further implement the borrowed knowledge in the formation of investment and innovation policy of nature management of individual regions).

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STUDIES AND MATERIALS

STUDIA I MATERIAŁY

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USE OF WASTE MATERIALS IN ALKALINE-ACTIVATED LIGHTWEIGHT CONCRETE

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ABSTRACT: The article presents the concept of using energy waste as an alternative material to natural aggregate and cement, which is one of the elements of sustainable construction. Because the amount of ash produced annually by power plants is very high, its use in the construction sector would allow for its significant elimination from the landfills of polluting components. The use of ash as a substitute for cement, as well as the replacement of natural aggregate by ash sintering process for the production of light concretes would be a big step towards sustainable construction, whose integral point is the implementation of technologies allowing for the integration of construction with the environment. Current knowledge allows for the development of technologies for the production of lightweight concretes based on energy waste materials using alkalis with properties similar to or better than those of traditional lightweight concretes. This is extremely important from environmental protection, and at the same time is an alternative technology for the production of lightweight concretes when natural resources are exhausted.

KEYWORDS: waste raw materials, ash aggregate, concrete, lightweight concrete, sustainable construction

Introduction

The main idea of sustainable construction is to design, build and use buildings and structures that interact with the surrounding environment and do not pollute it with various types of waste, thus making the use of the facilities friendly for both users and the environment. The main assumption of this idea is primarily the durability and quality of design, construction and material solutions, but also the availability and comfort of the designed buildings and structures, taking into account the aspects protecting the environment against pollution. In the modern world, more and more importance is being attached to the preservation of green areas and resting places that blend in with built-up areas.

Taking into account the priorities of sustainable construction principles, the aim is to reduce energy consumption and ensure that future generations can benefit from depleting natural resources. This is particularly important in the housing sector, where its visible development has increased demand for natural resources in the form of aggregates or water, used for the production of concrete, which is the main material used in modern construction. The decreasing number of plants extracting natural aggregates, destroying the environment and the amount of research carried out on the use of alternative raw materials for the production of concrete, testify to the growing awareness of the society and less consent to the use of natural resources. Therefore, it is particularly important to replace natural aggregate with secondary aggregate in the production of construction products, with increasing demand for it.

Production of geopolymers can be a viable alternative to the management of certain waste from the energy, mining and metallurgical sectors, especially fly ash. This makes it possible to use significant amounts of energy waste and to produce new products, and thus partially minimize the negative impact of these factors on the environment. Many years of research have allowed the use of fly ash for the production of concrete and showed its positive impact on the physical and mechanical properties of the final product. Fly ash showing the pozzolanic properties improves the properties of concrete, accelerating the hydration of cement at an early stage, increasing the amount of water bound in the C-S-H phase, resulting in an increase in the final strength of concrete or increasing its durability.

This article focuses in particular on the properties of lightweight concrete based on alkaline activated waste materials. This is important, not only because of the replacement of cement with ash, thus causing the disposal of an excessive amount of building or industrial waste, but also the use in the mix of ash-bearing aggregate resulting from the sintering of the energy

resource in place of natural aggregate. Therefore, in addition to the problem of a decreasing amount of aggregates, there is also a problem related to greenhouse gas emissions from cement production processes. The use of fly-ash and aggregate formed from fly-ash is aimed at the complete elimination of Portland cement from the concrete composition, the production of which results in the emission of greenhouse gases in the range of 7-8% on a global scale, including the emission of CO_2 constituting almost a half of the emitted gases and minimizing the consumption of natural aggregates, which are nowadays a valuable raw material. The production of geopolymers may therefore lead to a significant reduction of the environmental burden.

Related research

The research carried out on geopolymeric composites produced by alkaline activation of waste materials has led to the development and development of technologies for their obtaining. One of the first people in the world to receive a binder based on fly ash by its activation with sodium hydroxide were Anna Derdacka-Grzymek and Andrzej Stok (Rajczyk, Giergiczny, Szota, 2015). They carried out a number of studies which allowed to establish that the binding and hardening of geopolymeric binders based on fly ash is caused by dissolving the active components of ashes in sodium hydroxide solution (Derdacka-Grzymek, Stok, 1980).

In 1999, Palomo A., Grutzeck M.W. and Blanco M.T. described the mechanism of fly ash activation with strong alkaline solutions. The product of the reaction was amorphous aluminosilicate gel with a structure similar to that of zeolites. It was shown that temperature and curing time significantly increase the mechanical strength of the final product.

Van Jaarsveld J.G.S. Van Deventer J.S.J. published a study in the same year which showed the effects of Na+ and K+ on the physical and chemical properties of fly ash geopolymers, both before and after bonding. It was found that alkaline metal cation controls and influences almost all stages of geopolymerization, from ordering of ions and soluble compounds during the dissolution process to the role of structure guiding during gel curing and final crystal formation.

In 2002, Swanepoel J.C. and Strydom C.A. investigated fly ash, a waste product from the energy and petrochemical industries, as a basic component of a new geopolymeric material. Many analyses showed that the optimum firing temperature is 60°C for 48 hours.

Hardjito D., Wallah S.E., Sumajouw D.M.J. and Rangan B.V. published a scientific paper in 2004, presenting the development of fly-ash based geopolymer concrete. The results of the research showed the influence of various

parameters on the properties of geopolymer concrete. The application of geopolymer concrete was also identified and the scope of future research needs was determined.

Hardjito D., Wallah S.E. and others at the same time presented the influence of the mixture composition on the compressive strength of fly ash-based geopolymer concrete. The results showed that the molar ratio of water to sodium oxide and the ratio of water to geopolymer by mass affect the compressive strength of fly ash-based geopolymer concrete. The compressive strength decreases as these coefficients increase. They have also published further studies in which they attempted to investigate the properties of fresh geopolymer concrete. The compressive strength of geopolymer concrete increased with an increase in NaOH concentration, as well as with an increase in alkaline solution concentration. The compressive strength was even higher than that of conventional concrete at 14M concentration. Subsequent tests were carried out for changes in compressive strength of geopolymer concrete taking into account age, curing of concrete samples at a higher temperature and longer curing period.

In 2005, Song X.J., Marosszeky M. and others presented experimental data on the durability of volatile ash-based geopolymer concretes treated with 10% sulphuric acid solutions for up to 8 weeks. The results confirmed that geopolymer concretes are highly resistant to sulphuric acid in terms of very low weight loss, below 3%. Moreover, the geopolymer cubes were structurally intact and still had a significant load-bearing capacity, although the whole section was neutralised with sulphuric acid.

In 2009, Wallah S E. prepared four series of samples of different compression strength to test the shrinkage of drying geopolymer concrete. He then compared the test results with the calculated dry shrinkage results, according to the Gilbert method, which is usually applied to ordinary Portland cement. The tests showed that geopolymer concrete based on heat-cured fly ash is subject to very small shrinkage during drying.

Studies by Lloyd L.A. and Rangan B. V. were described in an article published in 2010 and presented the stages of the experiment carried out on geopolymer concrete based on fly ash. The test data were used to identify the influence of significant factors that affect the properties of the geopolymer mixture as well as the hardened geopolymer.

In the simultaneous analysis of Diaz E. I., Allouche E. N. and Eklund S. examined the suitability of fly ash piles for geopolymer production. They presented the results of chemical analyses, X-ray diffraction (XRD) and particle size distribution (PSD) of five sources of fly ash obtained from coal-fired power plants in the USA. Geopolymer paste and concrete samples were prepared from each stack. The samples were subjected to a number of chemical

and mechanical tests, stating that factors related to the composition of fly ash, such as particle size distribution, degree of glazing and location of maximum glass diffraction play an important role in the fresh and cured properties of the resulting geopolymer.

Olivia M. and Nikraz H.R. presented studies on strength development, water absorption and water permeability in low calcium ash geopolitical concrete. No significant change in water permeability coefficient was found for a geopolymer with different parameters. The data from the studies showed that with proper parameterization and mixture design, good quality geopolymer concrete with low calcium ash content can be obtained.

Extensive laboratory tests on compression strength were also conducted in India by Prakash R.V. and Dave U.V., and their results are presented in the "Parametric Studies on Compressive Strength of Geopolymer Concrete" published in 2013. Twenty series were performed and various parameters were examined, where the results showed that the compressive strength increases with increasing curing time, curing temperature, resting period, sodium hydroxide solution concentration and decreases with increasing ratio of water to geopolymer solids to the mass and admixture dose respectively. The addition of a naphthalene based superplasticizer improved workability of fresh geopolymer concrete. Moreover, it was observed that water content in the mixture of geopolymer concrete plays a significant role in achieving the desired compressive strength.

Polish scientists from Mazury P., Mikuła J. in 2013 presented research on geopolymer as a new engineering material from which protective layers can be formed. They showed that it has a high ability to absorb moisture, but its composition is strongly alkaline and thus its soaking does not adversely affect the protected structure.

Ghosh R., Kumar A. and others published a scientific article presenting the scope of research on Fly Ash based geopolymer concrete as a future concrete, summarizing and critically analysing the most important results of the conducted analyses.

In 2014, Chen R., Ahmari S. and Zhang L. investigated the strengthening of the fly ash geopolymer with pre-treated alkaline sweet sorghum fibre. The results showed that the unit weight of the composite decreased with increasing fibre content. The inclusion of sweet sorghum fibre slightly reduces the compressive, tensile and bending strength, as well as causes an increase in peak impact strength with fibre content up to 2%, which then begins to decrease.

Abdollahnejad Z., Pacheco-Torgal F. and others studied the common impact of several parameters of the mixture on the properties of foam geopolymers. The blends with low thermal conductivity of about 0.1 W/(m-K) and compressive strength of about 6 MPa were obtained.

In 2016, Sarmin S.N. and Welling J. presented the basic mechanical and physical properties of geopolymer composites based on fly ash/methacaolin reinforced with wood particles 3-5 mm in size. They made samples with dimensions of 50×50×50 mm^3 which were subjected to compression in order to obtain basic mechanical properties and determine optimal proportions of fly ash and methacaolin. It was observed that the inclusion of different types of wood raw materials affected the properties of geopolymers. It was shown that the size and shape of wood aggregates affect the properties of geopolymer composites.

The article published in 2016 by Xiao Yu Zhuang Liang C., Sridhar K. and others summarizes and analyzes scientific progress in the preparation, the study of the properties and application of fly ash-based geopolymers. The production was mainly based on alkaline activated geopolymerization, which can take place under mild conditions and is considered to be a cleaner process due to significantly lower CO_2 emissions than cement production. The main problems concern the mechanical properties of the fly ash-based geopolymer, including compressive strength, bending and tensile strength and durability and resistance to chlorine, sulphate, acid, heat, freeze-thaw and blooms.

Research on geopolymers based on fly ash was started in the 1980s and is still carried out around the world. Geopolymer samples were tested using different waste materials, activators of different concentrations, taking into account temperature and sintering time. They allowed concluding that the geopolymer composite showed much better physical and mechanical properties than ordinary concrete based on Portland cement. After analysing the national and world literature, it was decided to carry out studies on lightweight, alkaline-activated fly-ash concretes with the addition of ash aggregate, which has not yet been used in any analyses. All the studies so far have been carried out on the basis of natural aggregate with the addition of raw materials in the form of fibres, chips and wood flour and foam.

Justification of the test technology used

The requirements for modern construction products are increasingly restrictive. In addition to high strength properties, low density or low absorption capacity, they must also have adequate thermal insulation, high acoustic properties and be environmentally friendly. Integration with ecology is not only focused on the lack of negative impact on the environment, but also on the use of waste, which is not deposited on landfills and thus does not cause slow degradation of the environment. In order to meet these requirements, numerous studies are carried out to modify the composition of light concrete

by replacing its basic components with alternative raw materials, assuming that the properties of the final product will not be impaired.

A number of tests carried out on lightweight concretes with modified composition allowed to draw conclusions that they meet the requirements for modern concretes. Various waste aggregates were used in their production, such as waste from the production of coconut oil (Alengaram, 2013), aggregates in the form of pumice stone, expanded perlite or waste rubber aggregates (Oktay, 2015), and in addition to artificial aggregates, additives such as sawdust, wood shavings, straw or reed were used.

The development of construction, and thus concrete consumption, has made it necessary to improve their recipe in order to determine the possibility of using substitute raw materials, so their properties are increasingly being studied, focusing not only on the properties of the aggregate itself but also the product made with it. Among the recycling aggregates, ash-ash is becoming more and more common in recent times. It is an artificial raw material, produced according to a new technology consisting in the sintering of ashes from the process of burning hard coal, leading to a lightweight, porous ceramic aggregate with high thermal insulation and high resistance to atmospheric, chemical, fungi, insects or rodents, which is an odourless, highly resistant and relatively low absorbency material. Due to its properties, it is used in construction or road construction, and for a long time, it has been used in concrete production, allowing to obtain products with reduced weight and much better strength parameters.

Studies on the properties of lightweight concrete based on alkaline-activated waste materials were conducted in stages. In the first stage, lightweight cement composites based on ash-bearing aggregate were designed as a comparative sample to alkaline-activated lightweight concretes with an average compressive strength of 10.68 MPa. In the second stage, alkaline-activated lightweight concretes were made, assuming ash to activator ratio of 2, using sodium hydroxide activators at concentrations of 2, 6, 8 and 10 mol/dm^3 and aggregates at 4 in relation to ash.

Procedure for producing lightweight concretes based on alkaline-activated waste materials and analysis of results

For the production of lightweight concretes based on alkaline-activated waste materials, ash, artificial ash aggregate of 0-2 mm, 1-4 mm and 4-9 mm fractions and NaOH solution of 2, 6, 8 and 10 mol/dm^3 concentrations were used. It was accepted to make 5 samples for each concentration of the NaOH solution.

The appropriate amount of each of the ingredients was measured. The aggregate of 4-9 mm fractions was surface impregnated with NaOH solution of appropriate concentration for 10 s, then sieved and weighed. Cement and ash-associated aggregate of 0-2 mm and 1-4 mm fractions and impregnated aggregate of 4-9 mm fractions were poured into the mixer drum. All the components were mixed for 60 s, then the mixer was stopped and the components were mixed manually. The components were mixed again for 60 s. The mixer was stopped, NaOH solution of appropriate concentration was added to the drum and everything was mixed for 60 s. For the fourth time the mixer was stopped, the components were mixed by hand in order to separate the components from the drum walls and the mixer was switched on again for 60 seconds. The last operation was repeated twice.

The finished mixture was placed in 10x10x10 cm steel moulds conforming to PN-EN 12390-1 standard, previously covered with a release agent in order to protect them from sticking the mixture. It was decided to thicken the moulds by vibro-pressing, by vibrating for 30 s. and then vibro-pressing for another 30 s. The samples were left in an air-dry condition for 24 hours and then placed in a dryer heated to 60°C for another 24 hours. After that time the samples were disassembled and placed over water for 3 days. After this period they were subjected to compression strength test with the following results:

- the samples of lightweight concrete based on artificial ash aggregate activated by alkaline NaOH solution with a concentration of 2 mol/dm^3 obtained results of compressive strength from 2.80 MPa to 5.73 MPa. The average compressive strength was 4.20 MPa,
- lightweight concrete samples based on artificial ash aggregate activated by alkaline NaOH solution with a concentration of 6 mol/dm^3 obtained results of compressive strength from 16.25 MPa to 18.00 MPa. The average compressive strength was 16.89 MPa,
- lightweight concrete samples based on artificial ash aggregate activated by alkaline NaOH solution with a concentration of 8 mol/dm^3 obtained results of compressive strength of 14.20 MPa – 14.85 MPa. The average compressive strength was 14.57 MPa,
- lightweight concrete samples based on artificial ash aggregate activated by alkaline NaOH solution with a concentration of 10 mol/dm^3 obtained results of compressive strength from 20.90 MPa to 24.20 MPa. The average compressive strength was 21.82 MPa.

Table 1 below the results of the compressive strength of individual samples are presented. In figure 1 presents a compilation of the shear strength of light alkali-activated composites with surface impregnated aggregate.

Table 1. Compressive strength of light concretes activated with alkali with NaOH solution with a concentration of 2, 6, 8 and 10 mol/dm^3

	GEOPOLYMER 2M	GEOPOLYMER 6M	GEOPOLYMER 8M	GEOPOLYMER 10M
Compressive strength [MPa]	4.15	17.00	14.20	22.7
	4.10	18.00	14.70	20.1
	2.80	16.25	14.60	20.9
	3.40	16.95	14.85	24.2
	5.73	16.25	14.50	21.2
Medium compressive strength [MPa]	4.20	16.89	14.57	21.82

Source: author's work.

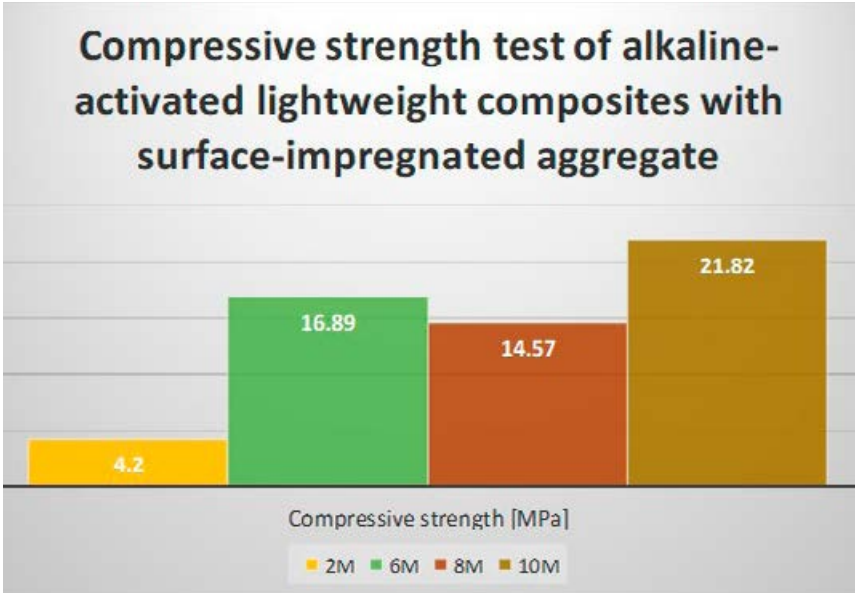

Figure 1. Compressive strength test of alkaline-activated lightweight composites with surface-impregnated aggregate

Source: author's work.

In figure 1 we can see that with the increase of NaOH concentration added to the concrete mix of lightweight concrete, the compressive strength of the finished sample increases.

It should be noted, however, that the obtained results of compressive strength are high compared to lightweight concretes based on Portland

cement and ash-pore aggregate. The research of L. Domagała showed that the use of ash-pore aggregates in concrete mixes significantly reduces strength by up to 42%, up to 86% compared to traditional concrete based on natural aggregate. In the above tests, the results of strength were obtained, which do not differ from the results of traditional lightweight concretes based on ash-pore aggregate, and even show higher results due to their initial impregnation with alkali, which resulted in minimizing the water demand of the aggregate added to the concrete mix.

Conclusions

This study focused in particular on the properties of lightweight concretes based on alkaline activated waste materials. This is important not only because of getting rid of the excessive amount of residual construction or industrial waste but also due to the drastically decreasing amount of natural aggregate deposits. In addition to the problem of less and less aggregate, there is a problem with greenhouse gas emissions from cement manufacturing processes. The use of fly ash is aimed at the complete elimination of Portland cement from the concrete composition, the production of which causes greenhouse gas emissions in the range of 7-8% on a global scale, including CO_2 emissions that account for almost half of the emissions. It is estimated that the synthesis of geopolymers is twice as energy-consuming as the production of Portland cement and produces 4-8 times less carbon dioxide. The production of geopolymers can therefore lead to a significant reduction in the environmental burden.

The analysis of the research results to date shows that samples of light alkali-activated composites achieve compressive strength at a level that allows them to be used in construction instead of traditional lightweight concretes based on Portland cement. It is particularly important to emphasize that in the production of concrete samples, the ash-pore aggregate was used, which is ecological, but at the same time very difficult in the production of concrete. Their high water demand is a problem at the time of production of the concrete mix and significantly reduces the strength of the finished sample. The impregnation of the aggregate applied before adding it to the mixture allowed to eliminate the problem and obtain a sample with the appropriate compressive strength. It should also be noted that samples of light alkali-activated composites at higher concentrations have much higher strength properties. These studies show that light alkali-activated concretes based on waste materials are the future of the construction industry.

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THE PROFITALBILITY OF INVESTING IN PASSIVE HOUSING IN POLAND

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ABSTRACT: The article discusses the problem related to the profitability of investing in passive construction from the point of view of economic calculation and benefits related to environmental protection and energy conservation. The analysis was made to compare the costs of construction and operation of a single-family residential building in two variants: in traditional technology and in passive building standard. The analysis was aimed at providing an answer to the question of whether the construction of a passive house will bring sufficient energy effects to be profitable for the investor. The ROE method was used and is interpreted as a rate of return on the investment financed by the investor. Using the simple payback period method, the number of years after which the investment outlays invested in the project will return on the benefits obtained from the project was calculated. Finally, the economic viability of the investment was assessed by calculating the NPV index. The essence of the article is to indicate optimal solutions that would promote passive construction in Poland by offering, among others, beneficial subsidies for such projects.

KEYWORDS: passive building, residential building, investment in passive construction, the profitability of investing in passive buildings

Introduction

The changing preferences of future owners are a big challenge in 21st-century residential construction. More and more often, apart from factors such as location, purchase or construction price, they take into account the standard of finishing, applied technologies or costs of building maintenance during its later operation. Residential construction in Poland offers not only many different architectural solutions but also technical ones, which are in line with environmental protection and are oriented towards saving usable energy. It is estimated that the demand for energy, along with the development of the world economy, is constantly growing, and the rate of this growth is extremely fast. Studies show that the highest energy consumption is in the residential sector. It is one of the main energy consumers in the modern economies of developed countries, and it is mainly during the exploitation phase of these facilities (Lis, Sekret, 2016).

An innovative idea in the approach to energy saving in modern construction was included in the concept of the passive house, focusing primarily on improving the parameters, elements and systems of the existing building (Gołąbeska, 2019). The name "passive building" is related to the fact that such buildings use energy from solar radiation in a passive way, i.e. passively without using active installation solutions.

The EU's 2010 directive on the energy performance of buildings assumes that from 1 January 2021 all new buildings are to be nearly zero-energy buildings. The same regulations also oblige to significantly reduce energy consumption in existing buildings. Currently, about 40 percent of all primary energy is consumed by buildings, so it is in them that the greatest reduction potential lies. Achieving high energy efficiency of buildings becomes necessary in the context of achieving overall primary energy savings both in Poland and all European Union countries. The emerging variety of energy-efficient buildings is a response of the market not only to the EU requirements but also to the growing awareness of the society about sustainable construction.

According to the available analyses, the costs of building low-energy residential houses are in Polish conditions about 10 to 15 percent higher than the costs of a house built according to the energy standard specified in the regulation of the Minister of Infrastructure on the conditions to be met by buildings and their location. In the case of passive houses, in turn, these costs are higher even by about 25 to 30 percent. (Węglarz, 2009). It follows that not all investments beneficial from the environmental point of view are economically viable. To determine the profitability of such investments, it is enough to compare the benefits achieved during the operation of the building with the costs incurred for a given investment. The investor should

approach the planned project with special care (Gołąbeska, 2018). He faces a dilemma whether it is worthwhile to build energy-efficient and passive houses. Implementation of the passive construction concept is connected with a big challenge, because the investor has to reckon with the necessity of incurring higher costs of building the object, taking into account the long period of return of these costs through savings on energy consumption.

An overview of the literature

The topic of energy-efficient and passive construction is addressed by many authors in various studies. In Poland, the analysis of economic and environmental profitability of such solutions is dealt with by, among others Kaczkowska (2009), Markiewicz (2017), Lis (2018) and others. The essence of the considerations is primarily energy efficiency achieved through modern technological solutions and ways of using renewable energy in various types of buildings, including residential buildings. Analyses contained in the work Kapuściński and Rodzoch (2010) indicate that the unit heat demand of residential buildings in Poland has changed with the period of their construction. This may give hope for the development of energy-efficient and passive construction in the near future.

The subject of numerous studies is the promotion of the idea of a passive house and the cost-effectiveness of the use of construction solutions that guarantee beneficial economic effects (Kaczkowska, 2009). Feist (2012) explains the concepts associated with passive construction perfectly. It addresses all aspects related to reducing energy consumption by increasing the thermal protection of the building, the use of solar energy, methods of heating and ventilation in energy-efficient and passive construction, hot water solutions as well as electricity generation. All elements characteristic for energy-efficient buildings should be taken into account already in the design phase. Integrated energy design of single-family, energy-efficient residential buildings is the starting point for passive construction (Markiewicz, 2017). Therefore, at the stage of investment planning, the investor should take into account factors that may significantly contribute to obtaining the most favourable conditions from the point of view of energy conservation and environmental protection. Numerous studies of companies involved in this type of construction emphasize the importance of the passive building's orientation towards the world, the type of roofing or the number of windows in the building. These issues significantly affect the level of energy consumption during operation.

The number of engineering studies presented at conferences, symposiums or publications shows a great interest in this issue.

Passive construction

The era of passive housing construction began in Western Europe in the 1990s. Wolfgang Feist is considered to be the creator of the concept of such construction, who together with the staff of the Institute of Housing and Environment developed in 1988 an innovative concept for a passive building. The first project of such a building was created in Darmstadt, Germany in the early 1990s. The energy crisis in the 1970s forced the need to save energy, which resulted in a policy to significantly reduce the energy consumption of buildings.

The assumptions for a passive house were mainly related to the energy consumption needed to operate it. The energy consumption for a conventional building is about 120 kWh/m^2/year. The passive house was to have a demand of no more than 15 kWh/m^2/year, which corresponded to the consumption of 1.5 litres of heating oil, 1.7 m^3 of natural gas or burning 2.3 kilograms of hard coal (at least 23 thousand kJ/kg) (https://www.pasywny-budynek.pl/technologie/historia-i-definicje/historia budownictwa-pasywnego, 2020).

An important element in the development of energy-efficient and passive construction was the development of technologies related to the use of renewable energy sources to cover the energy needs of buildings. It should be emphasized that along with the reduction of consumption of energy carriers (electricity, heating oil, gas) the emission of pollutants into the atmosphere decreases, which is crucial in the idea of passive construction.

However, ecological housing, supported by the European Union, has not caused its revolutionary popularity. Admittedly, the number of energy-efficient and passive buildings in the world is constantly but relatively slowly increasing, especially in Western European countries. In Poland, for the time being, one can meet rather with the promotion of technologies conducive to the construction of energy-efficient or passive houses, but one should still wait a little bit for their construction. The first Polish passive building was built only in 2004 in Wólka near Warsaw and it is hard to say that it started a dynamic growth of this kind of building in our country. The National Fund for Environmental Protection and Water Management has even developed a special program, which assumes support for building energy-efficient houses and apartments. Large savings, which are undoubtedly brought by buildings erected in energy-efficient or passive technology, can be an attractive offer

for many people undertaking the construction of their own homes. However, it is necessary to stimulate the awareness that although the average cost of construction is higher than traditional constructions, it will pay off with time.

Energy-efficient and even more so passive construction requires a lot of knowledge and skills from construction companies and contractors, i.e. companies producing elements of these houses (e.g. window and door joinery, other building materials and equipment and installations necessary to achieve the passive building standard). Currently, there are already investors in Poland who are very willing to realize new buildings in the passive standard. Awareness in this area is slowly growing. Passive building guarantees, above all, comfort and health for people staying in it every day. The most important thing, however, is the issue of energy savings (the price of which will continue to rise) and environmental protection in its broadest sense.

In 2004 the Passive Building Institute was established in Poland. It is a non-profit institution that deals with a number of important issues related to passive technology. The Institute of Passive Building deals primarily with the dissemination of knowledge about this type of solutions and renewable energy sources. It is accredited by PHI to certify all types of passive buildings in Poland. It also provides consulting services related to passive construction, giving opinions on passive house designs, as well as cooperation with scientific entities and manufacturers of components for passive construction (https://kb.pl/porady/budownictwo-pasywne-w-polsce, 2020).

In order to consider the construction of a passive house, it is necessary to first define the requirements characterizing such a building, and then to assess the financial, material and technological possibilities. The key assumptions for the construction of a passive house are among others: (https://kb.pl/porady/domy-pasywne-liczymy-czy-dodatkowe-wydatki-sie-zwracaja, 2020):

- the compact body of the building,
- the windows are located on the southern side (solar radiation constitutes about 40% of the used heat energy),
- installation of a ventilation system with heat recovery,
- no conventional heating system,
- high insulation parameters of external partitions,
- using any kind of energy coming from the ground, from the air, the sun, the heat of residents, solar collectors, heat from the ventilation air, from electrical devices,
- maximum reduction of heat loss,
- impermeability and total tightness of all materials used to build the house,
- use of a thorough heat exchanger,

- doors that open inwards, not outwards,
- giving up too large glass surfaces, which force the heating demand to increase, and in the summer cooling,
- maintaining the right colour balance of the building: bright surface colours quickly cool the building without taking the sun's rays, while dark ones make the building heat up quickly by absorbing the sun's energy, but give it back more slowly.

The essence of a passive house is the use of excellent quality thermal insulation materials that would guarantee heat retention without allowing it to be lost. The basis is therefore external partitions with low heat transfer coefficient. The technical characteristics of materials used in the construction of a passive house are defined, indicating the following (https://kb.pl/porady/domy-pasywne-liczymy-czy-dodatkowe-wydatki-sie-zwracaja/, 2020):

- external partitions (walls, roof, floor) with heat transfer coefficient $U < 0{,}14 W/m^2 K$,
- windows with a heat transfer coefficient of $0.8 W/m^2 K$,
- maximally reduced thermal bridges of internal partitions,
- recuperator with a capacity of over 75%.

An important issue for a passive house is the heating source. Significant reduction of heat demand for heating purposes caused the main role in the energy balance of the building to be played by the heat demand for hot water preparation. The average value of heat demand for water heating is between 18 and 35 kWh/m^2/year (according to the Passive Building Institute).

As far as water for household and sanitary purposes is concerned, it is usually heated in a passive house by a solar collector installed on the roof, and partially also by a heat pump, with heat shortages from these sources covered by an electric heater of little power.

As already mentioned, the use of renewable energy sources is crucial in passive buildings. This reduces the demand for non-renewable primary energy and reduces greenhouse gas emissions. The use of renewable energy sources should be individually analysed economically.

It should be kept in mind that not all investments that are beneficial from the environmental point of view turn out to be profitable and have a chance to pay off in the short term. It is estimated that the installation of a photovoltaic cell in a single-family building, taking into account the savings on fees, will pay for itself after about 25 years, so in the absence of external funding, it is difficult to consider such an investment as profitable. In passive buildings it is recommended to use the following renewable energy sources (Węglarz, 2009):

- solar radiation energy, e.g. solar collectors for hot water preparation and photovoltaic panels for electricity production,
- biomass energy, e.g. biomass boilers for heating and domestic hot water preparation,
- the energy accumulated in the ground, e.g. for preheating of ventilation air – GWC as the lower heat source for heat pumps,
- wind energy for the production of electricity by small wind power plants.

Experts estimate that, given the constant development of technology, it can be expected that in the near future, passive construction, not only in the world but also in Poland, will become commonplace. Aspects of environmental protection and energy conservation will cause almost all facilities to be adapted to extremely low levels of energy consumption. This will require the use of better materials, advanced tools, innovative solutions, supported by the awareness, knowledge and skills of contractors.

Research methods

The starting point for the implementation of the passive construction concept is primarily the proper calculation of the costs of construction and maintenance of such facilities and the payback time of the invested capital. Simple rates of return, which are a relative measure of absolute profitability of investment projects and express the relation of net benefits from a given investment project to the amount of capital involved in them, may prove to be a useful method, which works well in assessing the profitability of investing in this type of solutions. Among them, a simple ROE (return on equity) expressed by the formula can be indicated:

$$ROE = \frac{net\ income}{total\ capital\ expenditure\ financed\ by\ equity} \cdot 100\ (\%) \qquad (1)$$

which in the course of subsequent calculations will be determined by *r*.

The ROE method, from the owner's point of view, is interpreted as a rate of return on investment outlays financed by the owner. This method is not a decision criterion, however, the principle of achieving a value greater than the limit rate is adopted. The construction of the limit rate is subjective in nature and alternative rates of return can be adopted for it as, for example, the interest rate on a long-term bank deposit with a maturity close to the life cycle of the investment project (Janik, 2020).

In the case of profitability of investing in passive construction, the simple payback period (PP) method may be more appropriate, which determines the length of time it takes for the investment outlays incurred for the implementation of a given investment project to be balanced with the net benefits generated by that project. The algorithm of this method is presented in the formula (2):

$$PP = \frac{capital\ expenditure}{net\ profit+amortization+interests} \quad . \tag{2}$$

PP is interpreted as the number of years after which the investment outlays invested in the project will return the net benefits obtained from the project. The obtained result from this method can also be compared with the limit period of return, for which in this case the loan repayment period can be assumed, or the average period of return from similar projects carried out in a given industry (Janik, 2020).

The investor starting the construction of the house assumes that the profits achieved in the future due to minimizing energy costs will cover the initial outlay and will additionally bring a profit. Seemingly, the bill may seem simple. However, in reality, it looks a bit different. An economic evaluation of investment profitability can be made by one of the simple ways of calculating *NPV* (Net Present Value), i.e. the value of current future cash flows. Calculated *NPV* determines how much the future cash flow from the venture is really worth (according to their present value), after deducting the present expenses.

The key figure that influences the size of the *NPV*, in addition to the actual performance of the new business, is the value used to calculate the discount rate, which, expressed in %, determines the amount of devaluation of money over time.

$$NPV = \sum_{i=1}^{n} \frac{CF_i}{(1+r)^n} - I_0 \ , \tag{3}$$

where:
CF_i – cash flow,
I_0 – initial charge value,
n – number of periods,
r – a required rate of return.

The *NPV* indicator should always be higher than zero within the assumed time horizon. Its lower value means that in real terms the expenses incurred will not return to the investor, even if he will nominally recover his money. This means that the higher the *NPV* value, the better.

Proper evaluation of the profitability of investing in a passive building is a starting point for the investor to take up such a challenge.

Results of the research

According to data from the Polish Institute of Passive Construction and Renewable Energy (PIBP), a passive house uses 8 times less energy than a house built in the traditional technology. However, the cost of building an energy-efficient/passive house is 8-15% higher than a traditional house. However, depending on the selected materials, a passive house can be up to 35% more expensive to build than an ordinary building (Gwardecki, Passive House or energy-efficient house – price and profitability, https://enerad.pl/aktualnosci/dom-pasywny-czy-dom-energooszczedny-cena-i-oplacalnosc/).

The calculations concerning the profitability of such investments depend on many factors (e.g. type of photovoltaic or heat pump, type of window joinery, method of building insulation and others).

The analysis of economic efficiency, carried out for the purposes of this article, is based on the estimated unit costs of a single-family, detached, single-storey building with a usable attic built in traditional brick technology, heated by an eco-pea oven and a similar passive building with a heat pump. Construction costs and annual estimated operating costs of the facilities in question were compared, with operating costs taking into account the expenses for fuel used for heating, ventilation and hot water preparation, as well as electricity used by auxiliary equipment.

Table 1. Estimated costs of construction and annual exploitation of the building in traditional technology and passive building

	Traditional building	Passive building
Construction costs [in PLN/m^2]	3038.94	3516.63
Operating costs of central heating and hot water [in PLN/m^2 year]	30.52	15.53

Source: author's work.

Based on an as-built cost estimate for a traditional building, the total unit construction cost was PLN 3038.94 per square meter. In turn, the passive house generated costs of PLN 3516.63 per square meter. In the case of the passive standard, the costs of construction and operation of auxiliary equipment are higher (the air handling unit uses additional electricity), while the operating expenses are lower.

To assess the economic viability of the investment, the cumulative cost method can be used, which is the sum of construction costs for the analyzed energy standard and the discounted cost of operation over a specific period of time. It should be mentioned that in the long run the change of costs should

be taken into account, which is connected with inflation and a possible increase in energy costs. The expenses related to the servicing of central heating and hot water preparation systems can be considered equal for both standards. In order to compare the cumulative costs, the lifetime of both facilities should be indicated. In this type of analyses, usually, 25-30 years are assumed.

On the basis of the construction and operation costs included in table 1, the estimated period of return on investment can be calculated. Both analyzed buildings have a usable area of about 130 m^2.

Table 2. Estimated costs of construction and the annual operation of the building in traditional technology and passive building

	Traditional building	Passive building
Construction costs [in PLN/m^2]	3038.94	3516.63
Construction cost [in PLN]	395062.20	457161.90
Operating costs of central heating and hot water [in PLN/m^2 year]	30.52	15.53
Operating costs of central heating and hot water [in PLN/year]	3967.60	2018.90

Source: author's work.

The difference between the total costs of building a passive and a traditional building is:

$$457\ 161.90 - 395\ 062.20 = 62\ 099.70 \text{ PLN}$$

The difference in operating costs between a traditional building and a passive building is:

$$3\ 967.60 - 2\ 018.90 = 1\ 948.70 \text{ PLN}$$

On the basis of the above results you can calculate a simple payback period, i.e. the time needed to return the invested capital:

$$PP = \frac{62099.70}{1948.70} = 31.87 \text{ years}$$

The calculations did not take into account depreciation and interest and the assumptions that, in accordance with the environmental protection policy, which supports the use of renewable energy sources, the prices of fuels used in traditional buildings will increase. Therefore, it should be stressed that in the long run, higher construction costs may pay for themselves slightly faster thanks to lower operating costs.

To make an economic assessment of the profitability of the investment, it is enough to calculate the NPV index. The discussed example shows that building a passive building requires 62 099.70 PLN more than building such a building in the traditional technology. This amount should therefore be treated as an investment contribution. The investor expects that the realization of this project will be the source of 32 cash flows occurring once a year in the amount: 1 948.70 PLN (this is the estimated annual energy savings). On the basis of the analysis of the cost of capital raised, the annual rate of return can be easily calculated using formula (1):

$$r = \frac{1948.70}{62099.70} \cdot 100 = 3.14\%$$

By substituting all values to formula (3) we obtain the value of NPV indicator. The calculations are presented in table 3.

Table 3. Calculations to NPV index for passive building

n	cash flow	r	discount factor	discounted cash flow
0	-62 099.70	3.14	1.0000	-62 099.70
1	1 948.70	3.14	0.9696	1889.37
2	1 948.70	3.14	0.94	1831.83
3	1 948.70	3.14	0.9114	1776.07
4	1 948.70	3.14	0.8837	1722.07
5	1 948.70	3.14	0.8568	1669.55
6	1 948.70	3.14	0.8307	1618.79
7	1 948.70	3.14	0.8054	1569.51
8	1 948.70	3.14	0.7809	1521.71
9	1 948.70	3.14	0.7571	1475.39
10	1 948.70	3.14	0.7341	1430.45
11	1 948.70	3.14	0.7117	1386.88
12	1 948.70	3.14	0.69	1344.67
13	1 948.70	3.14	0.669	1303.74
14	1 948.70	3.14	0.6487	1264.08
15	1 948.70	3.14	0.6289	1225.6
16	1 948.70	3.14	0.61	1188.3
17	1 948.70	3.14	0.5912	1152.05

n	cash flow	r	discount factor	discounted cash flow
18	1 948.70	3.14	0.5732	1116.99
19	1 948.70	3.14	0.5558	1083.03
20	1 948.70	3.14	0.5389	1050.06
21	1 948.70	3.14	0.5224	1018.08
22	1 948.70	3.14	0.5065	987.08
23	1 948.70	3.14	0.4911	957.03
24	1 948.70	3.14	0.4761	927.86
25	1 948.70	3.14	0.4617	899.64
26	1 948.70	3.14	0.4476	872.25
27	1 948.70	3.14	0.434	845.68
28	1 948.70	3.14	0.4208	819.92
29	1 948.70	3.14	0.408	795
30	1 948.70	3.14	0.3955	770.79
31	1 948.70	3.14	0.3834	747.2
32	1 948.70	3.14	0.3718	724.56
NPV				-23 114.47

Source: author's work.

The calculated NPV ratio = PLN 23,114.47 means that there was no surplus of updated net revenue over the initial outlays incurred, nor was it balanced. It is therefore difficult to talk about the profitability of such an investment. If the result was greater or equal to zero (NPV≥0), the investment should be realized because it would meet the investor's expectations. In this case, the project should not be realized from an economic point of view. However, taking into account the environmental benefits, on the basis of the obtained result, it is possible to consider the number of possible subsidies for the implementation of the planned investment.

Conclusions

The analysis confirmed that building a passive house in financial terms is much less profitable than a house in the traditional technology. Therefore, it is important that in such situations the investment is supported by the state – offering e.g. subsidies for photovoltaics, heat pumps and others.

Contrary to appearances, building a passive house does not have to be much more expensive than a traditional one. This investment, however, requires an appropriate plan and calculation, but ecological buildings may prove to be an attractive solution. The passive house gives a better guarantee of increasing the value of the property and brings huge savings in its use.

The right approach at the stage of their design can be a guarantee of lucrative investment because within the same budget it is possible to design and build a building with much lower energy demand while maintaining its utility and aesthetic values. It is true that a passive house requires more expenditure on insulation, special window joinery or ventilation system, but you save on the heating system, which a passive house usually does not require. Insulation of walls, windows and ventilation are needed in every building, but in passive houses, all these elements must be optimized for energy saving, which requires more expensive materials. The growing popularity of passive houses makes them more and more common and thus can be expected to be cheaper over time. Work is constantly underway to reduce the costs of passive construction so that it becomes more accessible. It is to be hoped that the differences between the cost of building a traditional house and a passive house will diminish over time. On the other hand, the profits resulting from exploitation, given the growing costs of energy, will increase over time. The passive construction is not supported by the economic calculation for the time being, but by the high comfort of use and care for the environment. These are the arguments that have the greatest influence on the development of the idea of passive construction. What is needed is its popularization, both among professionals in the construction industry and those who want to live in passive houses for their own benefit (https://www.muratorplus.pl/technika/konstrukcje/budowa-domu-pasywnego-aa-7w2n-N2gZ-fvkR.html, 2007).

It should also be borne in mind that in Polish climatic conditions it may be better to build energy-efficient, not necessarily passive buildings. The passive solution is characterized by an unreasonably high return on investment.

In order to save energy in the national and EU dimension, Poland should strive, as developed Western countries do, to develop construction in an energy-efficient standard, or maybe in the near future – passive, offering favourable subsidies for such projects.

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GENERAL ENVIRONMENTAL AND SOCIAL PROBLEMS

PROBLEMATYKA OGÓLNOEKOLOGICZNA I SPOŁECZNA

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SOCIAL EVALUATION OF THE IMPLEMENTATION OF HOUSEHOLD-LEVEL SEWAGE TREATMENT PLANTS ON THE EXAMPLE OF THE MUNICIPALITY OF JUCHNOWIEC KOŚCIELNY

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ABSTRACT: The aim of the article is to present the public reception of the implementation of household-level sewage treatment plants in the Municipality of Juchnowiec Kościelny. The CVM method of conditional valuation was used to learn the opinion of residents on the implementation of domestic sewage treatment plants, using the willingness test for payment (WTP). The method of conditional valuation was carried out on the basis of a survey. The research trial was conducted by means of direct interview among 100 inhabitants of the commune of Juchnowiec Kościelny. The questionnaire contained, among other things, questions about the types of sewage collection and treatment system in the municipality. For the purposes of the article, the answers of the commune residents who were not connected to the sewage system or had a holding tank were taken into account.

KEY WORDS: contingent valuation method, the social acceptability of the investment, WTP questions, home sewage treatment plants

Introduction

In rural areas, when designing investments to protect the environment, it is necessary to take into account the sewage treatment plant and sewage system of a given region, including local conditions. The construction of a sewage treatment plant as well as the expansion of the sewage system should be connected with the financial possibilities of the municipality. The cost of building a sewage system supplying sewage to a sewage treatment plant is often several times higher than the cost of building the plant itself. In areas with dispersed development, which is characteristic of the village, for technical and economic reasons, holding tanks are used. However, taking into account their leakage, which significantly contributes to the pollution of the environment, and especially the surface and underground waters, the inhabitants of the communes are proposed to build household-level sewage treatment plants.

He costs of sewage disposal and neutralization will continue to increase. This is due not only to legal restrictions in the environmental policy but also to pressure from organizations working for environmental protection.

It is also important for the municipal authorities to know the degree of social acceptability of sewage management projects in the municipality. In order to get to know the opinion of the residents on the implementation and operation of sewage treatment systems, a conditional valuation method (CVM) can be used, using the willingness to pay (WTP) test. The information obtained by this method will allow determining how much the local community is able to pay for using the sewage treatment system.

The aim of the article is to present the results of a survey of willingness to pay by the residents of the commune of Juchnowiec Kościelny, located in the Podlaskie Voivodeship, for the improvement of the standard of wastewater treatment. To get to know the opinion of the residents on the ways of wastewater treatment, the conditional valuation method (CVM) was used, using the willingness to pay (WTP) test. The survey of the local community's opinion was based on a survey conducted in the municipality.

Selection criteria for wastewater collection and treatment systems

Sewerage systems and sewage treatment plants require large investment outlays, therefore choosing the right sewage system and sewage disposal system is of fundamental importance for rural residents as well as for the national economy. The choice of an appropriate sewage collection and treat-

ment system consists primarily in finding the right length and configuration of sewage networks, discharging sewage to a specific sewage treatment plant, so that minimum investment outlays and operating costs can be achieved. In rural areas, the gravitational sewage system dominates, but it is a system characterized by high implementation and operating costs. Collective wastewater treatment plants, on the other hand, are characterized by the higher efficiency of pollution removal and low unit costs of wastewater treatment.

The choice of an appropriate wastewater collection and treatment system should be based on 4 basic criteria:

1. The technical criterion, which takes into account land gradients, location of the sewage receiver, groundwater level, the nature of the buildings and existing underground infrastructure and roads.
2. The economic criterion which presents the possibilities of financing investments by the municipality in the field of construction of an appropriate sewage system, collective sewage collection and treatment, or, if it is not possible, domestic sewage treatment plants, as well as the costs of operating these facilities.
3. The environmental criterion, which contains information on protected areas in the municipality and groundwater pollution.
4. The social criterion, which provides all the arrangements between the authorities and the residents of the municipality for the implementation and operation of collective wastewater collection and treatment systems and domestic wastewater treatment plants.

The municipality, when deciding to implement a collective sewage collection and treatment system or a domestic sewage treatment plant, is based on two criteria: technical and economic. The technical criterion determines the conditions that must be met for a particular type of sewage system, sewage treatment plant and domestic sewage treatment plant. Some solutions, even though they ensure the fulfilment of ecological requirements, cannot be realized due to the second criterion, namely economic criterion. Such a situation occurs mainly in conditions of dispersed development, where the construction of a sewage system and a collective sewage treatment plant requires large investment outlays and operating costs. Therefore, for economic reasons, holding tanks (septic tanks) or domestic sewage treatment plants are built.

However, when implementing public investments, the opinion of society is important. So far, the commune authorities did not have a tool that would enable them to get to know the inhabitants' opinion on the implementation of wastewater management investments. The assessment of social acceptability of this type of projects is of great importance, especially in relation to the construction of the collective sewage collection and treatment system, as these are long-term investments and their lifetime is several dozen years.

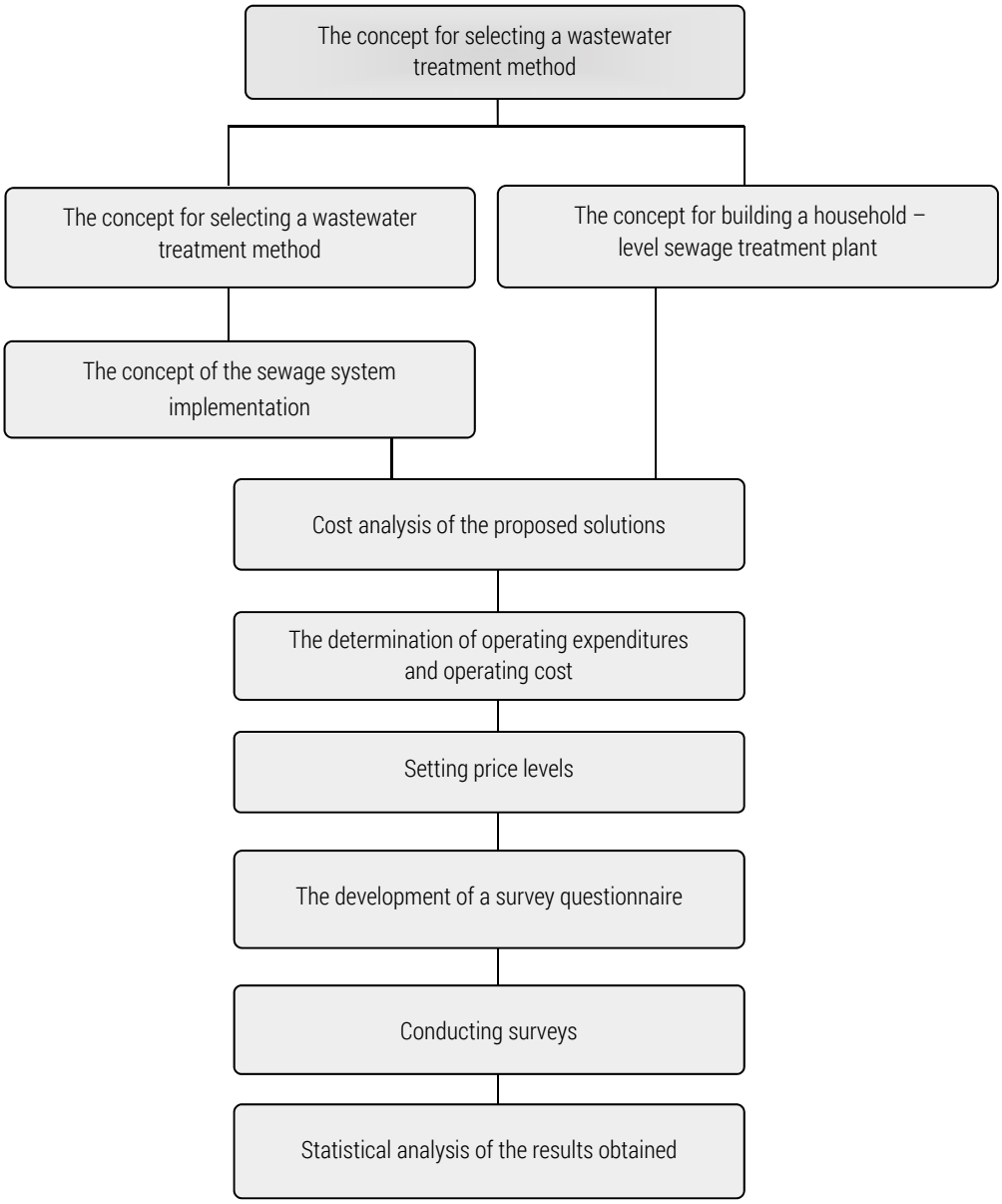

Figure 1. The procedure of assessing the social acceptability of the implementation of the wastewater collection and treatment system with a developed technical and economic solution

Source: author's work.

Prior to the construction or expansion of collective wastewater collection and disposal systems, as well as the construction of septic tanks or household-level wastewater treatment plants, municipalities should have developed a wastewater collection concept taking into account the solutions selected in accordance with the above criteria.

Figure 1 presents the procedure for assessing the social acceptability of the implementation of wastewater management systems with the developed technical, economic and social solution.

The first step in this procedure is the selection and concept of the implementation and construction of an appropriate sewage collection and treatment system (municipal or domestic sewage treatment plant). In case of a municipal sewage treatment plant, the amount of sewage that will be treated at the plant is taken into account and the daily amount of sewage and annual costs of sewage treatment are calculated. The collective wastewater treatment and discharge system consist of a sewage system in addition to the municipal wastewater treatment plant. Therefore, based on the analysis of local conditions, one of the sewage systems (gravitational, pressure, or vacuum) should be chosen. Then, depending on local conditions – technical criterion, the appropriate sewage collection and treatment system should be selected, and then the cost analysis of selected technological solutions – economic criterion. The next step is to determine the investment outlays and operating costs for the selected sewage system (it is necessary to determine the approximate length of the sewage system that will serve the planned number of residents) and the selected sewage treatment plant. At this stage, it is also possible to determine the annual costs of the entire sewage treatment and discharge system. The last stage of the procedure is the statistical elaboration of the results obtained on the basis of surveys conducted among the local community – a social criterion. In the case of the proposed method of social acceptability of the implementation of the sewage treatment method, it is proposed to conduct the survey in the form of a direct interview. It is known that the results obtained by this method are burdened with systematic error, but an experienced interviewer is able to conduct the interview in a proper way. In the case of the problem the method concerns, it is important to be able to explain the purpose of the survey, what the investment concerns and what the particular price levels resulting from.

Contingent valuation method

The Contingent Valuation Method (CVM) can be used to examine residents' opinions on the implementation of wastewater management investments. This method is based on surveys conducted among respondents interested in a given good or service. The researcher may ask the respondents questions in the form of WTP (Willingness to Pay), i.e. if they are able to pay for access to a given good or service. Most often these are closed questions in which information is obtained in an indirect way whether the respondent's WTP is above or below the amount specified in the question (Czajkowski, 2011; Graczyk, 2005). An important problem related to closed-ended questions is the so-called confirmation effect, where some respondents tend to give positive answers to the asked questions, regardless of their content (Holmes et al., 2002).

Questions about WTP should be applied when the respondent is entitled to the current level of a given good and then the question concerns the improvement of his situation and when the respondent is entitled to the current level of a given good and then the question concerns the possibility of its deterioration. Surveys are usually conducted in several variants, differing in the amount of the sum, which allows for more accurate estimation of the WTP distribution (Perman et al., 2003).

A variant of a closed question is a double closed question, in which, depending on the answer to the first question, another one is asked, in which the amount is reduced in case of a negative answer or increased in case of a positive answer (Bateman et al., 1996).

The beginnings of the method of conditional valuation date back to 1947. This method was used in 1958 for the valuation of recreational activities in the Delaware river basin (Mack et al., 1965) In 1963 Davis spread the use of this method (Davis, 1963) However, it was not until 1979 that the CVM in the USA was officially accepted after the Water Resources Council had revised the rules and standards used to evaluate water projects (Hanemann, 1992; Navrud, 1992). In 1980, a conditional valuation was accepted in the USA, along with other environmental assessment methods, as since then government agencies have increasingly used this valuation technique (Carson, 1998; Turner et al., 1992; Carson, 2002).

In 1993, after the Exxon Valdez oil tanker disaster, environmental organizations used the results of the conditional valuation method used to estimate the value to American society of the destroyed ecosystems of Alaska. This case, which was originally intended to discredit the method, contributed to the recognition that conditional valuation could be used as a reliable means of measuring value, provided certain principles of the study were fol-

lowed. These rules specify how to construct a survey scenario and then conduct a survey to limit the effects of WTP revaluation (Carson et al., 1992; Harrison et al., 1998).

The Contingent Valuation method has been used e.g. for the valuation of rare and endangered species of plants and animals (Loomis, 1996), or for the valuation of measures aimed at reducing flood risk (Shabman et al., 1996; Liziński, 2007).

Surveys based on WTP questions were conducted in France, for example. They concerned readiness to pay for the improvement of water quality in rivers. The results of the surveys showed that both industry and agriculture do not bear the costs resulting from water pollution. Households had the largest share in the expenditure on water protection (Cost recovery analysis or economic water cycle, 2005).

The research using the contingent valuation method was also carried out in three municipalities on the island of Crete in Greece. The research was carried out by a team of employees of the Economic Department of the University of Crete in Rethymno in 2005. The questionnaire for the research was developed in such a way as to reveal the willingness of residents to pay for the implementation of municipal wastewater treatment plants in these municipalities (Genius, 2005).

Attempts have also been made to use the contingent valuation method in Poland. The best known is the study (it was called "Baltic"), which formulated the question of how much Polish citizens would be willing to pay to stop the eutrophication of the Baltic Sea. As a result of the undertaken actions, the minimization of the number of closed bathing sites and the renewal of life in the sea was presented (Markowska, Żylicz, 1996).

The contingent valuation method was also used to examine the readiness of residents of three communes in the Podlaskie Voivodeship, namely Miastkowo, Zbójna and Dubicze Cerkiewne, to pay for improving the standard of wastewater collection and treatment, within the framework of the Polish-Greek project entitled: "Assessment of readiness to pay for wastewater treatment and closure of water circuits", carried out at the Bialystok University of Technology in 2008-2010.

Comparison of the results of the research conducted in Poland and Greece shows that in the surveyed municipalities, located on the island of Crete, almost all the surveyed residents (97.5%) expressed willingness to pay for the construction of municipal sewage treatment plants, while in the surveyed municipalities of Podlaskie Voivodeship such willingness was shown by only 47% of the residents. This difference can be explained by the fact that in the communes on the island of Crete, the majority of the population lives from

tourism and attaches great importance to the sanitary level in their area (Report on the implementation of the Polish-Greek research project, 2008).

Method for assessing the social acceptability of the implementation of a wastewater treatment system in the municipality of Juchnowiec Kościelny, located in the Podlaskie Voivodeship

The Commune of Juchnowiec Kościelny is located in Podlaskie Voivodeship, in the southern part of Bialystok County and is part of the Green Lungs of Poland. The area of the commune is 172 km^2. The population of the commune is 15 994 people (as of 20018). In Juchnowiec Kościelny Commune there are 46 settlements.

Sewage from the northern part of the commune is discharged into the sewage system of the city of Bialystok. There is a mechanical and biological sewage treatment plant in Juchnowiec Dolny, to which 13 villages are connected. About 75% of residents have access to the sanitary sewage system. The total length of the sanitary sewage system is 105.26 km. In localities where there is no access to the collective sanitary sewage system (Brończany, Koplany, Lewickie, Lewickie Kolonia, Hermanówka, Niewodnica Nargilewska and Niewodnica Nargilewska Kolonia) sewage is collected in holding tanks and transported to a water catchment point, which takes place at the sewage treatment plant in Juchnowiec Dolny, or to Bialystok. Some farms have domestic sewage treatment plants (186 in total).

In 2017, a document was created, entitled "The concept of collective disposal of domestic wastewater from the northern part of the municipality of Juchnowiec Kościelny". The aim of this document was to facilitate the planning of municipal investments in the area of organized sewage disposal in the municipality of Juchnowiec Kościelny. The concept also included the construction of household-level sewage treatment plants in localities where no sewage system is planned.

The research tool was a survey questionnaire, consisting of three parts. The first part included questions related to the issue of wastewater management in the analyzed community. There were also questions concerning the development of sewage management. The second part of the questionnaire consisted of questions concerning the preferred amounts for the use of the sewage management system by inhabitants. The third part of the questionnaire concerned personal data and general socioeconomic characteristics of the respondents, which consisted of questions concerning their age, gender, education, income and place of residence.

The research trial was conducted by means of direct interview among 100 inhabitants of the commune of Juchnowiec Kościelny. The questionnaire contained, among other things, questions about the types of sewage collection and treatment system in the municipality. For the purposes of the article, the answers of the commune residents who were not connected to the sewage system or had a holding tank were taken into account.

The conducted research has shown that the inhabitants of the commune are aware of the fact that the expansion of the sewage system is a profitable investment only in urbanized areas, while an alternative to dispersed areas is home wastewater treatment plants. The residents are aware of the fact that they will not have a sewage system, which is why the survey showed support for building a household-level sewage treatment plant. Some of them claimed that everything is better than a holding tank, which threatens the environment. The survey also showed that the residents of the Municipality of Juchnowiec Kościelny are aware of how sewage management is conducted in the municipality.

The respondents were also asked how much they would be willing to pay for the construction of a household-level sewage treatment plant (figure 2).

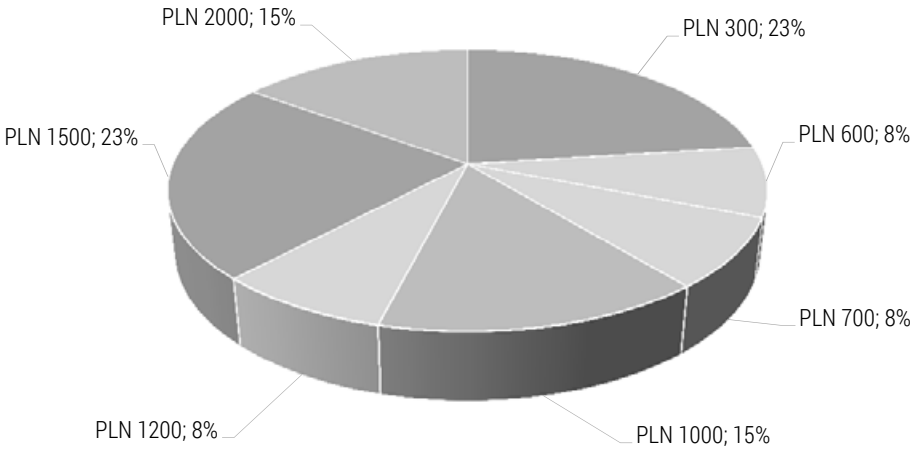

Figure 2. Amounts declared by the respondents for the construction of a household-level sewage treatment plant

Source: author's work.

The largest number of respondents – 23% – gave 300 PLN and 1500 PLN as the maximum amount they are able to pay for the liquidation of septic tanks for the benefit of a household-level sewage treatment plant. 15% of the respondents stated that they were able to pay 1000 PLN and 2000 PLN. 24%

of the respondents declared that they were able to pay 600 PLN (8%), 700 PLN (8%) and 1200 PLN (8%) respectively.

On the basis of the conducted surveys, socioeconomic data of the residents of the commune of Juchnowiec Kościelny were also obtained. On their basis, it was possible to calculate the correlation coefficient between these characteristics. With the help of Microsoft Excel 2007, the relations between the obtained socioeconomic features were examined. The tool "Pearson's linear correlation coefficient" was used for this purpose. If the value of this coefficient is:

- positive – means that with the increase of the X characteristic, the Y characteristic increases,
- equal to 0 – it means no correlation (with the increase of the X characteristic, the Y characteristic increases or decreases),
- negative – it means that with the increase of X characteristic the value of Y characteristic decreases.

On the basis of the obtained figures concerning: age, the number of children, the amount of waste disposal at one time (in the range 120-210 PLN), the declared amount that the respondents are able to bear for the construction of a household sewage treatment plant, correlation coefficients were determined.

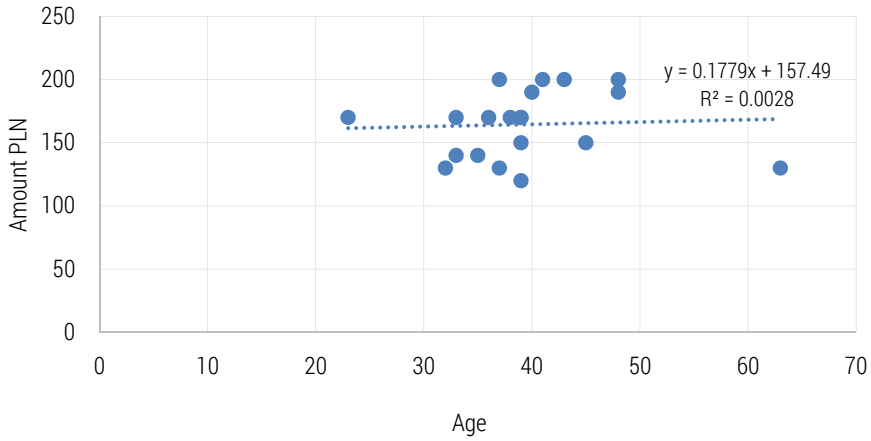

Figure 3. The correlation coefficient between the age of the respondents and the amount allocated for one-time waste disposal

Source: author's work.

The first two features that were taken into account in the case of respondents who wanted to liquidate a holding tank for the benefit of a household-level sewage treatment plant were the age of the surveyed person and

the amount of money spent on sewage disposal at one time. The research has shown that the age of the respondent increases while the amount spent on sewage disposal decreases and there is no correlation between these characteristics (figure 3).

Then the age of the respondent and the declared amount he or she is able to pay to liquidate the septic tank for the benefit of the household sewage treatment plant were examined. The research has shown that as the age of the respondent increases, the declared amount increases. In this case, too, there was no correlation between the examined features (figure 4).

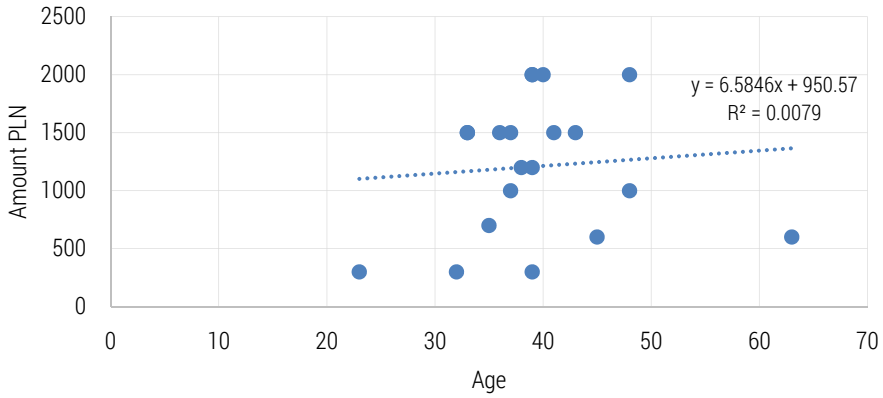

Figure 4. The correlation coefficient between the respondents' age and the amount declared by them for the construction of a domestic sewage treatment plant

Source: author's work.

Then the number of children owned by the respondents and the declared amount for the construction of a household-level sewage treatment plant were examined. The research have shown that as the number of children increased, the declared amount decreased and there is no correlation between the examined features (figure 5).

In addition, socioeconomic research has shown that residents who are entrepreneurs have declared higher amounts, i.e. 1000 PLN – 15.39%, 1500 PLN – 7.69% and 2000 PLN – 15.39%. On the other hand, farmers and pensioners declared low amounts: 700 PLN – 7.69% and 300 PLN – 15.39% respectively, while people employed in companies declared that they were ready to pay 1200 PLN – 7.69%. One can say that one characteristic is dependent on the other, because the better the status on the labour market, the more respondents were able to pay (figure 6).

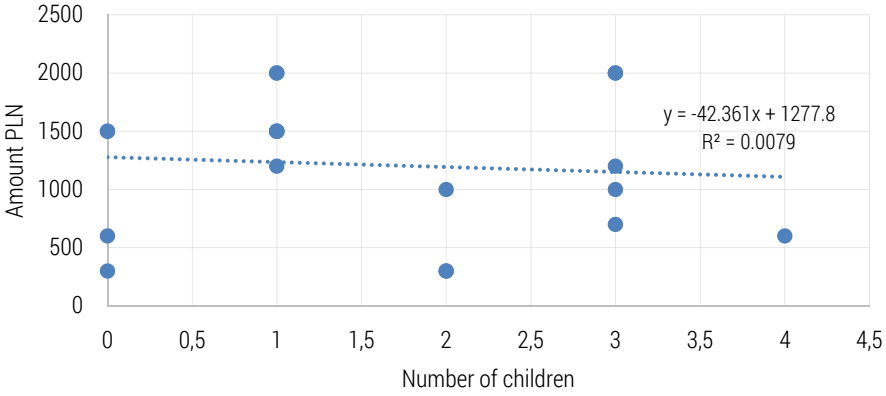

Figure 5. The correlation coefficient between the number of children owned by the respondents and the amount declared by them for the construction of a domestic sewage treatment plant

Source: author's work.

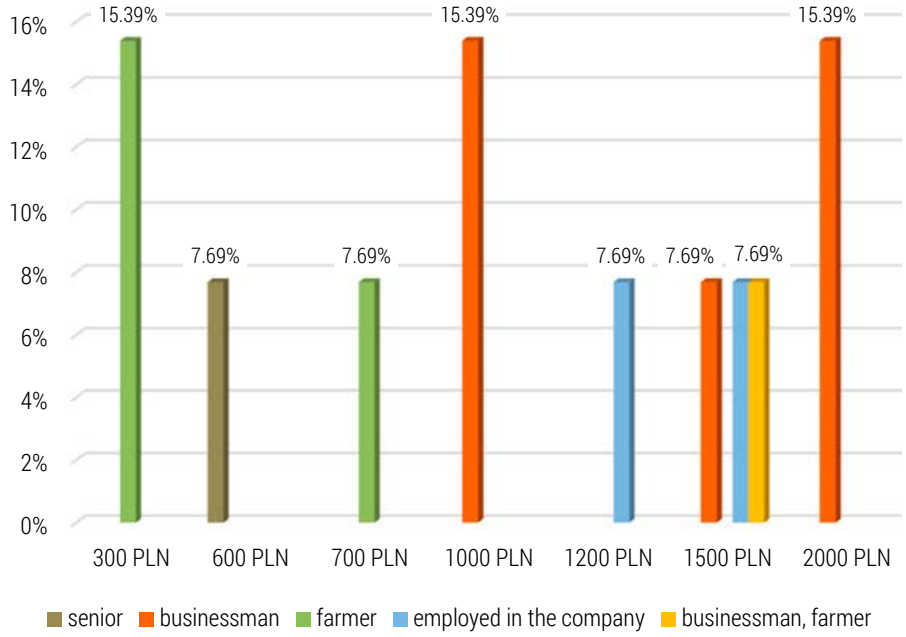

Figure 6. The amounts declared by the respondents for the liquidation of a septic tank for the benefit of a household sewage treatment plant by labour market status

Source: author's work.

Furthermore, people with gross income per 1 person 2101-3000 PLN declared that they are able to bear the cost of 1500 PLN – 15.39% and 2000 PLN – 7.69%. On the other hand, persons whose gross income per 1 person was below 500 PLN declared 300 PLN – 7.69% and persons whose income was between 501-800 PLN declared 300 PLN – 15.39% and 600 PLN – 7.69%. It follows that the declared amount strongly depends on the income, because the greater the income, the greater the declaration of the respondent (figure 7).

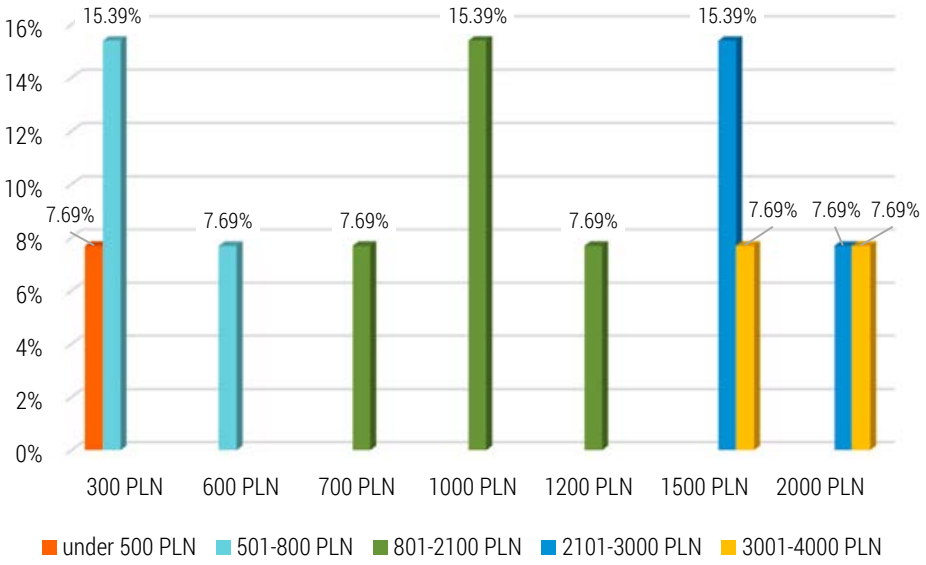

Figure 7. Declared amounts for the liquidation of a septic tank for a household sewage treatment plant according to gross income per capita

Source: author's work.

The research also showed that people with higher education declared high amounts for the construction of a household-level sewage treatment plant: 23.09% – 1500 PLN, and 15.39% – 2000 PLN. Persons with secondary and higher education (38.45%) declared amounts below 1000 PLN. On the basis of this it can be concluded that with the increase in education, the amount declared increases.

Conclusions

Research carried out in the municipality of Juchnowiec Kościelny has shown that the majority of residents agree to the construction of a household-level sewage treatment plant and are willing to finance its construction and operation, believing that this will contribute to the improvement of surface and groundwater quality in the municipality and will allow for the decommissioning of holding tanks and environmentally harmful transport of this sewage by slurry tankers.

In the case of questions about WTP, it was found that the respondents who wanted to eliminate the holding tank for the benefit of a household-level sewage treatment plant are 23% and are able to pay 300 and 1500 PLN for the construction of a household-level sewage treatment plant. 2000 PLN and 1000 PLN were declared by 15% each. The smallest amounts that were declared were: 600 PLN – 8% of people, 700 PLN – 8% of people and 1200 PLN – 8% of people.

Then, as a result of a general analysis of the respondents' answers, the relationship between their socioeconomic characteristics was considered, which was achieved by the so-called correlation coefficient. A correlation coefficient was found in the group of people who had a holding tank and wanted to have a domestic sewage treatment plant – as the age of the respondent increased, the amount for one-time sewage disposal increased. It was also noted that the status on the labour market was important for the declared amount for the construction of a household-level sewage treatment plant. The largest amounts were declared by entrepreneurs, while the lowest by farmers. In this case, the declared amount was influenced by the education of the respondent. The respondents with higher education were willing to pay a higher amount than residents with lower education. The declared amount was also influenced by the gross income per capita. It was found that the higher the income, the higher the declared amount.

All the above-described declarations of the respondents on sewage management and their readiness to pay to depend on many factors. The monthly costs of sewage disposal and willingness to pay for the construction of a household-level sewage treatment plant are influenced both by age, the number of children and gross income per capita. Older people, like farmers, are able to pay less for the construction of domestic sewage treatment plants than people of working age. This is due to the lower financial resources of this social group.

The Commune Office prepares documents related to investments aimed at the development of sewage management in the commune. The authorities are making efforts to increase the length of the sewage system from year to

year, which guarantees an improvement in the quality of the environment. For localities where it is not possible to expand the sewage system due to dispersed development, the commune has prepared a concept of planned areas for household-level sewage treatment plants. Those who decide to liquidate the holding tanks for the benefit of the household-level sewage treatment plants will be able to take advantage of the municipal grant.

To sum up, the impact of the environmental protection principles and activities of the European Union determines the development of technical infrastructure related to wastewater management in Poland. However, insufficient awareness of the inhabitants in the field of sewage management and low level of economic development in the commune makes the deficiencies in this field still visible.

Acknowledgements

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The contribution of the authors

Krystyna Rauba – 100% conception; 100% literature review; 50% analysis and interpretation of data.

Karolina Szerenos – 100% acquisition of data; 50% analysis and interpretation of data.

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DISCUSSION AND REVIEWS

RECENZJE OMÓWIENIA, PRZEGLĄDY

Kazimierz GÓRKA

The review of the book EKONOMIA I ZARZĄDZANIE W INŻYNIERII ŚRODOWISKA

Broniewicz, E., Godlewska, J., Lulewicz-Sas, A., Miłaszewski, R., 2019. Oficyna Wydawnicza Politechniki Białostockiej, Białystok

Publikacja została przygotowana przez znany już zespół autorski w składzie: Elżbieta Broniewicz, Joanna Godlewska, Agata Lulewicz-Sas i Rafał Miłaszewski, a wydrukowana przez Oficynę Wydawniczą Politechniki Białostockiej. Jest to piąta pozycja w tej dziedzinie opublikowana przez Politechnikę Białostocką we współpracy z Fundacją Ekonomistów Środowiska i Zasobów Naturalnych, a wśród autorów najczęściej powtarza się nazwisko prof. Rafała Miłaszewskiego (Zespół Badawczy Ekonomiki Zaopatrzenia w Wodę i Ochrony Wód, działający na Wydziale Budownictwa i Nauk o Środowisku Politechniki Białostockiej).

Książka ma tylko 135 stron, ale warto od razu podkreślić, że jest udana i pożyteczna ze względu na sprzyjanie współpracy inżynierów i ekonomistów oraz jej duży ładunek merytoryczny a także poprawność formalną. O zawartości merytorycznej mówią już tytuły rozdziałów, z których składa się książka:

1. Podstawy ekonomii środowiska i zasobów naturalnych;
2. System zarządzania środowiskiem w Polsce;
3. Zarządzanie środowiskowe w organizacji;
4. Ekonomiczna efektywność przedsięwzięć w inżynierii środowiska.

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Rozdział I traktuje najpierw o znanych już ekonomicznych aspektach zarządzania ochroną środowiska naturalnego. Mam tu dwie istotne uwagi. Otóż, po pierwsze, termin „zarządzanie środowiskiem" (także w tytule rozdziału II) jest wprawdzie powszechnie stosowany i zgodny z rzeczywistością, gdyż człowiek aż nazbyt ingeruje na tym polu, to jednak poprawniejszym określeniem okazuje się zarządzanie ochroną środowiska. Po drugie, w licznych odsyłaczach do literatury można umieścić jeszcze znamienną pozycję: The Limits to Growth. The 30-Year Update. Chelsea Green Publishing, 2004 (o tym, co autorzy "Granic wzrostu" piszą na ten temat po 30 latach). Ponadto za mało jest odsyłaczy do literatury polskiej z okresu po 2005 roku. Skoro Autorzy podają w nawiasach angielskie terminy, to powinny się tu znaleźć także „externalities". Kontrowersje budzi stwierdzenie Autorów, że ekonomika ochrony środowiska i ekonomia środowiska mają ten sam zakres badań (s. 10), powołując się na literaturę zagraniczną. W Polsce – i nie tylko – przyjęło się jednak, że ekonomika dotyczy poziomu mikro i mezo (przedsiębiorstwo, branża) a ekonomia jest nauką typu makro i mega oraz bardziej teoretyczną i interdyscyplinarną. Natomiast kolejne podrozdziały zawierają już dużo nowości na temat wyceny środowiska a zwłaszcza gospodarki o obiegu zamkniętym.

Rozdział II został słusznie poświęcony systemowi zarządzania ochroną i kształtowaniem środowiska jako nauce oraz działalności praktycznej. Najpierw objaśniono istotę i zasady polityki ekologicznej państwa w Polsce oraz szczegółowo przedstawiono funkcjonujące obecnie instytucje i ich zadania w zarządzaniu ochroną środowiska. Równie szczegółowo i dobrze zaprezentowano instrumenty zarządzania ochroną środowiska. Do tej klasyfikacji warto dorzucić instrumenty informacyjno-perswazyjne (które uwzględniono pod innymi nazwami).

Rozdział III obejmuje kwestie zarządzania środowiskowego na szczeblu przedsiębiorstw i to zarówno od strony teoretycznej jak również praktycznej. Autorzy odróżniają zarządzanie środowiskowe jako zasób wiedzy i umiejętności w zarządzaniu przedsiębiorstwem – w uproszczeniu – zgodnie z wymaganiami ochrony środowiska naturalnego od zarządzania środowiskiem jako kategorii typu makro, z czym łatwo się zgodzić, nie licząc niewłaściwości terminu „zarządzanie środowiskiem". Na szczególne podkreślenie zasługują podrozdziały dotyczące norm ISO oraz ekozarządzania i audytu (EMAS) a także marketingu produktów i usług ekologicznych, w tym etykietowania (znaków ekologicznych). Jest to najmocniejsza część książki, obejmując m.in. ogólne zasady, praktyczne rady i przykłady zastosowań.

Rozdział IV przedstawia sposoby oceny efektywności ekonomicznej projektów chroniących środowisko naturalne, które często charakteryzują się efektami trudno mierzalnymi lub niemierzalnymi. Obok tzw. analizy kosztów i korzyści duże znaczenie ma tu w praktyce analiza efektywności kosztowej, którą także podjęto. Szkoda, że w tej ostatniej kwestii pominięto publikację Tomasza Żylicza „Cena przyrody" z 2014 roku, w której został przypomniany jego udział w dyskusji na ten temat w latach 2008-2009 na łamach czasopisma „Aura". Brał w niej udział również niżej podpisany.[1]

[1] K. Górka, Trzeci głos w sprawie efektywności kosztowej. „Aura", 2008, s. 11.

Na zakończenie kilka uwag natury terminologicznej i formalnej. Przede wszystkim ostrej krytyce należy poddać stosowanie przez Autorów terminu „zrównoważony rozwój" (np. s. 5, 38). Dobrze wiedzą, że inne zdanie mają Tomasz Żylicz czy Jerzy Śleszyński, do których ostro kiedyś dołączył autor recenzji. Otóż nie jest usprawiedliwieniem powszechne stosowanie ani zapisanie go w Konstytucji. To nie jest sprawa poglądów tych czy innych autorów. Otóż, po pierwsze, niektórzy autorzy są nieuczciwi, gdy piszą: zrównoważony rozwój (sustainable development), gdyż w żadnym słowniku angielsko-polskim nie ma takiego tłumaczenia. Początkowo tłumaczono go jako rozwój samopodtrzymywany lub samopodtrzymujący się, a wymienieni autorzy preferują „rozwój trwały". Po drugie, z gramatyki języka polskiego jasno wynika, że jeśli tak, to termin ten powinien brzmieć rozwój zrównoważony, podobnie jak kredyt bankowy, instrument ekonomiczny, niedźwiedź brunatny (to nazwa rasy, w istocie jest czarny). Wtedy, jeżeli „rozwój zrównoważony" zdefiniujemy jako rozwój o cechach trwałości i troski o przyszłe pokolenia, to staje się kategorią ekonomiczną. Natomiast „zrównoważony rozwój" oznacza równoważenia powodujące stabilizację i stagnację a nie żaden wzrost!

Reasumując, polecamy tę książkę Czytelnikom a Autorów zachęcamy do przygotowania nowej publikacji z zakresu polityki ekologicznej oraz rozwoju zrównoważonego i trwałego.

prof. Kazimierz Górka

SUMMARIES IN POLISH

STRESZCZENIA POLSKOJĘZYCZNE

Dariusz PIEŃKOWSKI

RAMY KONCEPCYJNE DLA PROJEKTOWANIA ZRÓWNOWAŻONEJ POLITYKI EMERYTALNEJ

STRESZCZENIE: Zaproponowane są ramy koncepcyjne dla projektowania zrównoważonej polityki emerytalnej w celu rozwiązania problemu wzajemnych zależności pomiędzy różnymi determinantami z punktu widzenia polityki gospodarczej i koncepcji zrównoważonego rozwoju. Badanie głównych społeczno-ekonomicznych uwarunkowań przedstawionych w literaturze doprowadziło do opracowania całościowych ram koncepcyjnych, które mają wspierać decydentów i badaczy, którzy muszą zrozumieć determinanty określonych programów politycznych i ich długoterminowe społeczno-ekonomiczne konsekwencje. W rezultacie pomaga się określić i zaprojektować zrównoważoną politykę emerytalną. Zrównoważone ramy koncepcyjne kładą nacisk na ideologiczne tło debat gospodarczych, ścieżki historyczne ujęte w modelu 4s zależnej ścieżki oraz kluczowe argumenty za i przeciw kapitałowych i repartycyjnych systemów emerytalnych. Niniejsze ramy koncepcyjne wskazują na wiele celów polityki emerytalnej, przepływy zasobów i debaty o tworzeniu kapitału w ekonomii, a także globalną perspektywę przepływu kapitału.

SŁOWA KLUCZOWE: model 4S zależnej ścieżki, ramy zrównoważonej polityki emerytalnej, systemy emerytalne, globalna perspektywa gospodarcza

Grażyna KARMOWSKA, Nino MIKIASHVILI

OCENA KONWERGENCJI KRAJÓW POST-SOCJALISTYCZNYCH Z WYKORZYSTANIEM WYBRANYCH INDEKSÓW

STRESZCZENIE: Celem artykułu była diagnoza poziomu konwergencji państw postsocjalistycznych i zachodzących w tym zakresie zmian. Zakres badań obejmował lata 2000-2018. Obiektem badań było 25 krajów postsocjalistycznych (11 należących do UE, 7 z Europy wschodniej oraz 7 azjatyckich). Analizowane były indeksy HDI, EPI i EFW. Wykorzystano metody statystyczne oraz modele ekonometryczne. We wszystkich badanych obszarach stwierdzono zjawisko słabej konwergencji. W obszarze rozwoju społecznego na poziomie ok. 5%, wydajności środowiskowej ok. 2% a wolności gospodarczej ok. 1%. Wszystkie badane kraje zostały zaliczone do wysoko rozwiniętych pod względem rozwoju społecznego (HDI>0.79). Również pod względem wolności gospodarczej EFW>0.6 zalicza je do Mostly free. Większe zróżnicowanie występuje pod względem wydajności środowiskowej. Jedynie 16 krajów z 25 uzyskało EPI>60. Grupa krajów należących do UE osiągała wyższe wartości indeksów od pozostałych krajów, jednakże wyższe tempo wzrostu uzyskały kraje azjatyckie.

SŁOWA KLUCZOWE: konwergencja, indeks HDI, indeks EPI, indeks EFW, kraje postsocjalistyczne

Natalya ANDRYEYEVA, Hanna TIUTIUNNYK, Borys BURKYNSKYI, Nina KHUMAROVA, Larysa KUPINETS

METODOLOGICZNE PODEJŚCIE INWESTYCJI I INNOWACJI REGIONALNEJ POLITYKI EKOLOGICZNEJ Z WYKORZYSTANIEM MODELI INTELIGENTNEJ SPECJALIZACJI I QUINTUPLE HELIX

STRESZCZENIE: Celem artykułu jest sformułowanie metodologicznego podejścia do określenia dominant inwestycji i innowacji w regionalnej polityce ekologicznej. Metodologia opiera się na modelach inteligentnej specjalizacji i pięciokrotnej helisy. Niniejszy artykuł przedstawia autorską wizję połączenia metodologii Quintuple Helix i Smart Specialization w celu określenia strategicznych priorytetów polityki inwestycyjnej i innowacyjnej gospodarki narodowej. Określono wyjątkowość regionów w oparciu o potencjał naukowo-technologiczny z uwzględnieniem priorytetów poszczególnych Celów Zrównoważonego Rozwoju. Proponowane badania są dodatkowym argumentem w stosunku do istniejących oficjalnych osiągnięć. Opracowano podejście uwzględniające metodologię „inteligentnej specjalizacji" w kontekście istniejących doświadczeń europejskich.

SŁOWA KLUCZOWE: Quintuple Helix, inteligentna specjalizacja, cele zrównoważonego rozwoju, polityka inwestycyjna i innowacyjna, potencjał zasobów naturalnych

Marta NALEWAJKO

WYKORZYSTANIE SUROWCÓW ODPADOWYCH W BETONACH LEKKICH AKTYWOWANYCH ALKALICZNE

STRESZCZENIE: Artykuł prezentuje koncepcję wykorzystania odpadów energetycznych, jako materiału alternatywnego dla kruszywa naturalnego i cementu, jako jeden z aspektów budownictwa zrównoważonego. Z uwagi na fakt, że ilość wytwarzanego rokrocznie popiołu przez zakłady energetyczne jest bardzo duża, jego wykorzystanie w sektorze budownictwa pozwoliłoby na znaczne jego wyeliminowanie z hałd składowych zanieczyszczających środowisko. Wykorzystanie popiołu w zastępstwie cementu, a także zastąpienie kruszywa naturalnego kruszywem popiołoporytowym, powstałym w procesie spiekania popiołu, do produkcji betonów lekkich stanowiłoby duży krok w kierunku budownictwa zrównoważonego, którego integralnym punktem jest wdrażanie technologii pozwalających na współgranie budownictwa ze środowiskiem. Współczesne technologie oraz wiedza pozwalają na opracowanie technologii wytwarzania betonów lekkich na bazie surowców odpadowych energetycznych przy wykorzystaniu alkaliów o właściwościach zbliżonych bądź lepszych od właściwości tradycyjnych betonów lekkich. Jest to niezwykle istotne z punktu widzenia ochrony środowiska, a także stanowi alternatywną technologię wytwarzania betonów lekkich w razie wyczerpania surowców naturalnych.

SŁOWA KLUCZOWE: surowce odpadowe, kruszywo popiołowe, beton, beton lekki, budownictwo zrównoważone

Elżbieta GOŁĄBESKA

OPŁACALNOŚĆ INWESTOWANIA W BUDOWNICTWO PASYWNE W POLSCE

STRESZCZENIE: W artykule omówiono problem związany z opłacalnością inwestowania w budownictwo pasywne z punktu widzenia rachunku ekonomicznego oraz korzyści związanych z ochroną środowiska i poszanowania energii. Analizie poddana została kwestia porównania kosztów budowy i eksploatacji jednorodzinnego budynku mieszkalnego w dwóch wariantach: w technologii tradycyjnej oraz w standardzie budynku pasywnego. Analiza miała na celu przyniesienie odpowiedzi na pytanie: czy budowa domu pasywnego przyniesie wystarczające efekty energetyczne aby mogła okazać się opłacalna dla inwestora. Zastosowano metodę ROE, interpretowaną jest jako stopę zwrotu z finansowanych przez inwestora nakładów. Stosując metodę prostego okresu zwrotu, obliczono liczbę lat, po jakich zainwestowane w przedsięwzięcie nakłady inwestycyjne, zwrócą się z uzyskiwanych z przedsięwzięcia korzyści. Wreszcie dokonano ekonomicznej oceny opłacalności inwestycji obliczając wskaźnik NPV. Istotą artykułu jest wskazanie optymalnych rozwiązań, które sprzyjałyby propagowaniu budownictwa pasywnego w Polsce oferując m.in. korzystne dofinansowania do takich projektów.

SŁOWA KLUCZOWE: budynek pasywny, budynek mieszkalny, inwestowanie w budownictwo pasywne, opłacalność inwestowania w budynki pasywne

Krystyna RAUBA, Karolina SZERENOS

SPOŁECZNA WYCENA REALIZACJI PRZYDOMOWYCH OCZYSZCZALNI ŚCIEKÓW NA PRZYKŁADZIE GMINY JUCHNOWIEC KOŚCIELNY

STRESZCZENIE: Celem artykułu jest przedstawienie społecznego odbioru realizacji przydomowych oczyszczalni ścieków na terenie Gminy Juchnowiec Kościelny. Do poznania opinii mieszkańców w kwestii realizacji przydomowych oczyszczani ścieków posłużono się metodą wyceny warunkowej CVM, wykorzystującą badanie gotowości do zapłaty (WTP). Metoda wyceny warunkowej została zrealizowana w oparciu o przeprowadzone badania ankietowe. Próba badawcza przeprowadzona została metodą wywiadu bezpośredniego wśród 100 mieszkańców gminy Juchnowiec Kościelny. Ankieta zawierała między innymi pytania dotyczące rodzajów systemu odprowadzania i oczyszczania ścieków na terenie gminy. Na potrzeby artykułu wzięto pod uwagę odpowiedzi mieszkańców gminy, którzy nie byli podłączeni do kanalizacji lub mieli zbiornik bezodpływowy.

SŁOWA KLUCZOWE: metoda wyceny warunkowej, społeczna akceptacja inwestycji, pytania dotyczące oczyszczalni ścieków, przydomowe oczyszczalnie ścieków

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